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The Role of Domestic Policies and the Clean Development Mechanism on the Deployment of Small Scale Renewable Energy Technologies

The Case of Solar Water Heating in Mexico

by
Jose Luis Castro Negrete

A report submitted in partial fulfilment of the requirements for the MSc and/or the DIC

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Name of Student: Jose Luis Castro Negrete

Names of Supervisors: Professor Dennis Anderson and Mr. Robert J K Gross

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Abstract

This research aims at assessing the role of domestic policies and the Clean Development Mechanism (CDM) on the deployment of small scale renewable energy technologies through the study case of solar water heating (SWH) technology in Mexico.

The paper reviews the current situation and trend of the energy demand in the residential sector and its related GHG emissions, describes the drivers and barriers faced by the SWH technology, and examines relevant issues regarding CDM definitions and procedures. This is followed by a cost-benefit comparison of SWH and liquefied petroleum gas (LPG) projects under a business as usual, capital grant supported; CDM supported and combined efforts scenarios. Then, it is appraised the separated and collective effect of several domestic policies and CDM incentives on SWH diffusion, and CDM related challenges and risks. Finally, the paper proposes a wide range of domestic and international strategies, and cooperation schemes which should be undertaken by different participants to establish an integrated policy framework for SWH promotion in Mexico.

It is proved that SWH technology for residential applications has huge development potential in Mexico under present conditions, but it faces several barriers for its deployment at large scale. These difficulties could be tackled by implementing domestic policies and using international support mechanisms like the CDM within an integrated policy framework. This would give adequate signals towards market development, driving new participants such as international financial institutions, national development banks and private banks to enter the market providing new investment streams to finance large scale deployment of SWH technology, which could increase importantly its share in the water heating services supply over the next fifteen years.

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Acronyms and Abbreviations

AAU	Assigned Amount Units
Banobras	National Bank of Infrastructure
CDM	Clean Development Mechanism
CDM-EB	CDM Executive Board
CDM-SWH	SWH Project under CDM
CMBI	Cooperative Market-based Instruments
CERs	Emission Reduction Certificates
CERSA	Certified Emission Reduction Sale Agreement
COP	UNFCCC Conference of Parties
DNA	Designated National Authority
DOE	Designated Operational Entity
ER	Emission Reduction
ESCO	Energy Service Company
FDI	Foreign Direct Investment
ERPA	Emissions Reduction Purchase Agreement
ERU	Emission Reduction Units
GHG	Greenhouse Gas
IRR	Internal Rate of Return
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land Use Change and Forestry projects
Nafin	National Development Bank
NG	Natural Gas
NPV	Net Present Value
PDD	Project Design Document
RE	Renewable Energies
RETs	Renewable Energy Technologies
S-CDM	Sectoral CDM
SSC	CDM Small Scale Project
SWH	Solar Water Heating
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

It is widely recognised that SWH systems have achieved substantial technological progress during the last three decades and could supply energy for water heating services on a cost-effective way, while mitigating climate change and improving local air quality. However, investment, financial, technical and institutional barriers must be overcome to fully unleash the potential of this technology. In this sense, domestic policies and international market based instruments like CDM could play an important role on tackling these obstacles. Yet, there are issues to be understood.

Firstly, is the deployment of SWH feasible without any kind of national or international support? SWH market is Mexico has grown considerably during the last five years; yet, it could be possible to boost its deployment further by providing additional support.

Secondly, could CDM boost SWH deployment on its own or domestic policies are to be devised? If so, is there any way to adopt progressive policies and regulations to enhance SWH market with out diminishing CDM's benefits? Indeed, market based instruments may contribute to SWH deployment; however, domestic strategies could also be needed, and CDM would have to be considered to avoid a reduction on its implementation potential.

Thirdly, could domestic policies increase the competitiveness of CDM-SWH projects in the international market by tackling the implementation challenges set by current CDM procedures and methodologies? SWH projects compete for resources against other kind of projects (e.g. energy efficiency, industrial process change and LULUCF). Hence, projects developers that formulate the best strategies to manage projects' financial, technical and institutional risks, reduce transaction costs and formulate reliable verification techniques will have advantages in the carbon market. In this sense, domestic policies could facilitate the implementation of CDM-SWH projects by enhancing institutional and technical capacity among SWH project developers.

Finally, are any modifications on CDM definitions or procedures needed to facilitate SWH industry to fully benefit from the CDM? The current project-based approach of CDM could set barriers for project developers when bundling and aggregating small scale SWH projects, reducing their competitiveness in the international market.

This work addresses these questions by analysing the energy demand in the residential sector and reviewing the current GHG emissions in Mexico, especially those generated by activities in the residential sector. Then, it describes the drivers and barriers faced by the SWH technology, based on previous studies undertaken in Mexico. In addition, the role of CDM is addressed by explaining its objectives and procedures as well as three main issues transcendent for SWH technology: the small scale procedures and methodologies, the unilateral CDM and the controversial sectoral or policy driven CDM.

The project estimates the potential and feasible markets for SWH technology in Mexico by reviewing its historical and current situation and analysing the possible trends and future demand of water heating services in Mexico. Then, aided by a financial model, a detailed investment assessment is performed to understand the economics behind SWH projects under a business as usual scenario and its implications for project developers and consumers.

In addition, the financial model is used in combination with a policy appraisal of CDM procedures and methodologies to undertake an additionality test in order to determine its potential impact on the barriers faced by SWH technology. In addition, it identifies the risks related to the implementation and performance of SWH projects and describes the strategies to manage those risks.

The current domestic policies and proposals for SWH promotion are also appraised in terms of their impact on SWH diffusion and CDM potential. In this regard, it is discussed how these policies could remove barriers, influence the additionality of CDM and their effect on reducing project-related risks of potential CDM-SWH projects. The policies established on several European countries are also reviewed in order to identify successful practices.

The combined effect of domestic policies and CDM on diminishing investment, financial, technical and institutional barriers is also analysed and discussed using both financial modelling and policy appraisal. Strong emphasis is made on understanding the challenges and risks which result from the integration of domestic and international instruments.

Finally, a group of strategies and cooperation schemes are proposed to the Mexican government, the SWH community (academics, manufacturers, retailers and installers) and the CDM-EB to establish an integrated policy framework aimed to promote the deployment and penetration of SWH technology in Mexico.

2 Aim and Specific Objectives

The main objective of this research is to assess the combined role of several domestic policies and the Clean Development Mechanism in boosting SWH market in Mexico. The following activities will be carried out to accomplish this objective:

- Assess the economic and policy context on which SWH market is developed in Mexico.
- Assess the potential institutional and economic impact of CDM and public policies in reducing barriers for the successful diffusion of SWH projects/market in Mexico.
- Propose possible strategies and cooperation schemes to increase the overall competitiveness of SWH projects in Mexico in three possible main streams:
    a. Policies and regulations at local and national level
    b. Improvement of CDM definitions, rules and procedures
    c. Cooperation schemes among stakeholders

3 Research Methods

In order to accomplish the objectives describe above a desk-based research was done using six specific methods: literature review, a linear regression model, a bottom-up demand model, a project financial model, policy appraisal and an additionality test.

The literature review was used to analyse and understand the energy demand of the residential sector, the current situation and trends of the SWH in market in Mexico, and the impact of SWH technology on GHG emissions. This review was complemented with a linear regression and a bottom-up demand models to determine possible scenarios for SWH market development under a business as usual scenario and estimate the future demand of water heating in the residential sector respectively (see Annexes I and II for details).

Afterwards, a project financial model was developed to compare several financial indicators of three typical SWH systems and one LPG system under a business as usual scenario. Two optional modules were designed to assess the financial impact of CDM incentives and capital grants on a combined and separated basis resulting on three further scenarios.

Detailed domestic and international policy appraisals were carried out to assess the combined and separated impact of current national policies and CDM on SWH diffusion. There were also reviewed and appraised the successful policies for SWH technology deployment in other European countries such as Austria, Italy, Spain and UK.

Finally, the results from the project financial model and the policy appraisal were employed to perform an additionality test based on CDM guidelines determining the likeliness of the development CDM-SWH projects in Mexico.

4 Background

The background describes the energy demand in the residential sector. Then it reviews the current situation of GHG emissions in Mexico and presents the main drivers and barriers faced by SWH technology in this country. Finally, address CDM by explaining briefly its objectives, the “Project Cycle”, the main trends of the market, and relevant issues for implementing CDM-SWH projects such as the small scale procedure and methodologies, the unilateral CDM and the sectoral or policy driven CDM.

4.1 Energy Services and Residential Sector in Mexico

The energy demand of the residential sector has been rising accordingly with the population and per capita income growth. Figure 1 shows the behaviour of energy demand over time. In 1980 energy consumption was 456 PJ, increased to over 600 PJ in 1990 and finally reached 720 PJ in 2003.

Demand responds to diverse energy services needed in Mexican livelihoods which varies widely from one household to another according with the local climate conditions and consumers’ habits. The main energy services are lighting (electric power included), cooking and space/water heating or cooling. The extent on which the demand of such services is fulfilled and the fuels preferred depends on the family income level.

In this sense, low income livelihoods are not supplied with proper energy services. This situation becomes a considerable problem in areas with extreme climate conditions where heating or cooling services are needed in some season like summer and winter.

Different energy sources are use to supply services to households. As Figure 1 shows, five main energy sources are used by Mexican households. The major fuel used is wood which share dropped from 49% in 1980 to 36% in 2003, followed by LPG which has increased its share from 30% to 40% in the same period. Electricity consumption grew from 8% to 20% while NG has remain more less constant with 4% (although in latest years the government is promoting the consumption of this fuel in the sector due to its environmental advantages and strong retail companies' lobby). Kerosene which had 9% of the share has been almost substituted by other fuels. Of special attention is the wood consumption given that it is the most used fuel probably to supply cooking, space and water heating for low income livelihoods. This share profile suggests a low efficiency in the sector and therefore a potential for its improvement.

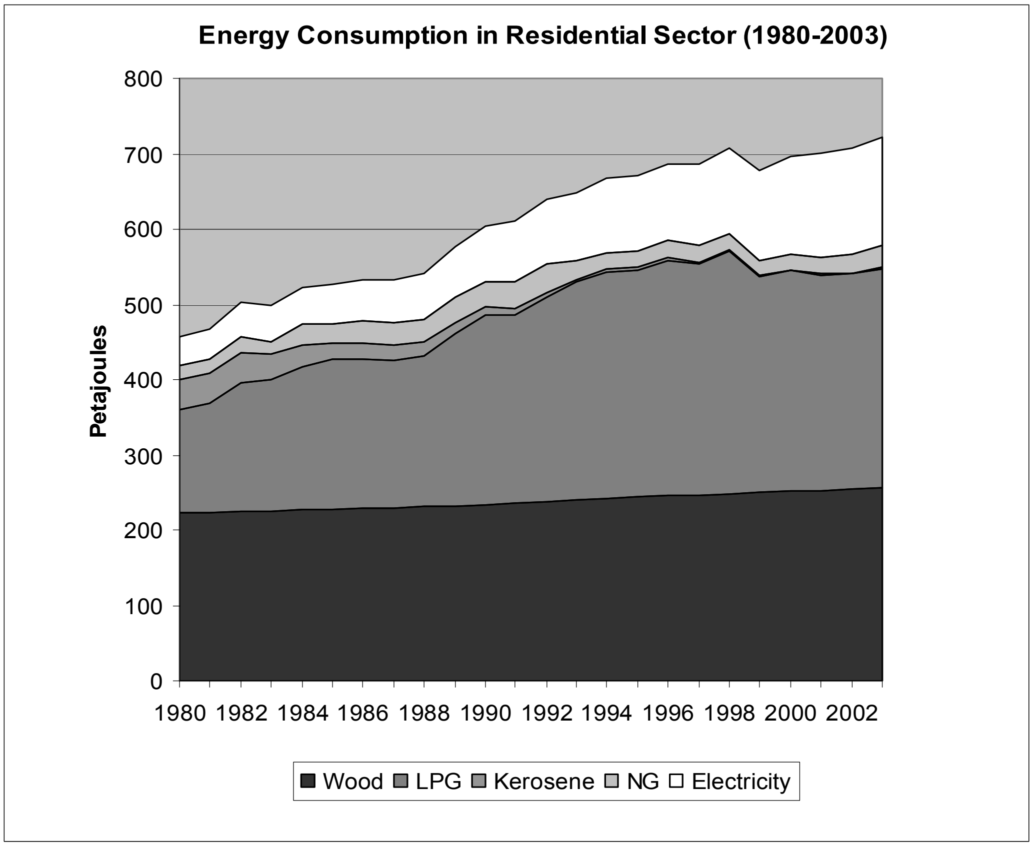

Figure 1 Energy Consumption in Residential Sector (1980-2003)
Source: (INEGI, 2005)

4.2 GHG Emissions in Mexico

According with the National Inventory of GHG Emission in 1990, Mexico produced 297 millions tons of CO_2. Emissions from the transport, power generation, land use and forestry sectors produce 76.3% of the total emissions, while the residential and commercial sector emits 23.55 millions tons of CO_2 representing 5.3% of total emissions (INE,1999).

In 2000 Mexico emitted around 363 millions of tons of CO_2. The transport sector contributed with 116.2 (32.01%) followed by the electric sector with 111.7 million (30.77%). The industrial sector emitted 55.8, oil sector with 48.5, agriculture 6.4 and commercial 4.3 millions tons of CO_2. (Quintanilla, 2005)

Several scenarios are feasible in the future depending on two variables: the GDP growth and the fuels' share in the energy production structure. The National Autonomous University of Mexico (UNAM) developed four likely scenarios assuming an optimistic (5%) and moderate (3%) economic growth; and no growth restrictions of hydro, nuclear, geothermic and carbon energy utilities and an energy production growth based on natural gas with restrictions to other sources. The CO_2 emissions estimated under these scenarios range from 464.2 millions to 630.6 millions of tons by 2010.

With regards to the residential sector in 2000 it emitted 20.2 millions tons of CO_2 representing 5.56 percent of national emissions. The principal contributors to GHG emissions in this sector were LPG with 91.4%, natural gas 8.1% and kerosene 0.5%. The future CO_2 emissions from residential sector will be determined by the population, economic growth and the share of energy sources used. In this sense, a higher penetration of natural gas will result in the reduction of GHG emissions compared with a scenario dominated by LPG. (Quintanilla, 2005)

This research has no intention to determine accurately the GHG emission reduction that could be achieved by increasing the penetration of SWH technology in the energy basket for water heating services. However, based on the information presented above it is estimated that SWH technologies could reduce around 10 million tons of CO_2 in the residential sector alone (based on 2000 figures).

4.3 Drivers and Barriers for SWH Technologies

There are several forces driving SWH technology in Mexico. Firstly, the technology provides environmental benefits such as GHG emission reduction and the improvement of local air quality in livelihoods. Secondly, the enhancement of SWH technology certainly promotes economic and social development.

Under present conditions, SWH projects have good return on the investment of consumers helping to reduce households' fuel costs in the long run. Additionally, the aggregated fossil fuel savings may reduce energy system's inefficiencies and increase not only the security of energy supply but also the Mexican exports of LPG to Central America. SWH technologies may fulfil the needs for hot water services of low income households improving its quality of life, while promoting industrial and commercial development through renewable energy markets.

Nevertheless, SWH technology faces several barriers which hold its deployment in Mexico. The most important economic barrier is the high upfront investment costs of the technology combined with low average familiar income. Figure 2 illustrates that more than 70% of households in Mexico expend less than 680 USD per year in fuels, electricity and home refurbishment; hence, most Mexican families are not able to buy a SWH system regardless its long term benefits.

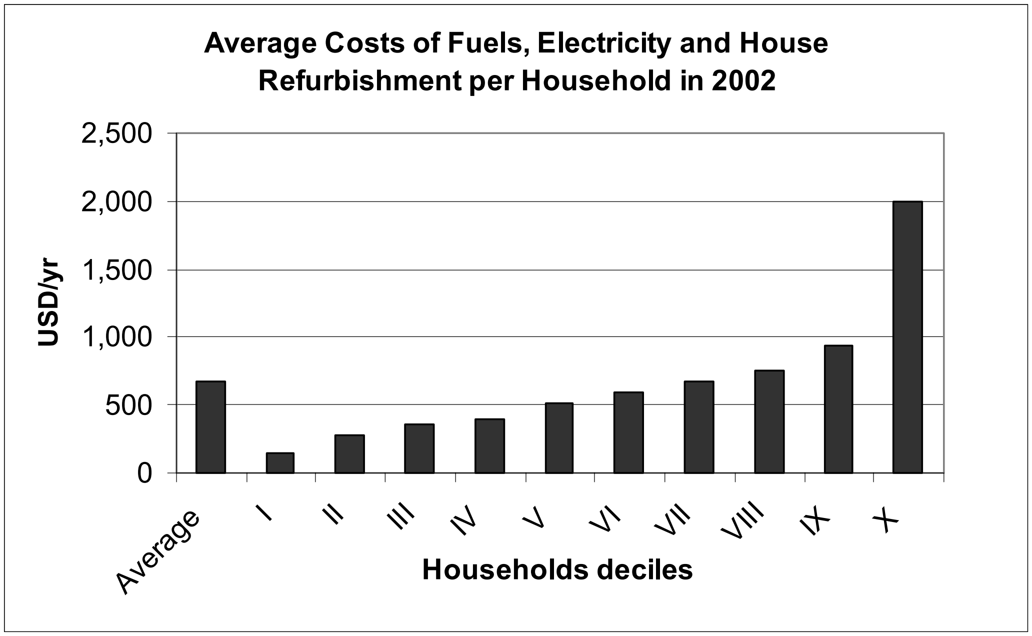

Figure 2 Household Expenditure on Fuels, Electricity and House Refurbishment
Source: (INEGI, 2005)

This barrier could be easily removed by establishing support schemes such as capital grants or soft loans to increase the affordability of SWH systems. However, such schemes do not exist in Mexico although it has been proven in other countries that financial schemes and capital grants can achieve the latter.

Even though economic and financial barriers could be eliminated SWH technology face technical and institutional barriers related with the way the market and the public policy are structured. Several cases in Mexico have been analysed in the past showing low quality of equipments and installations, or absence of proper maintenance. These situations diminish SWH technology’s benefits and acceptance among the public, reducing its potential market. The lack of awareness among the public about SWH technology’s environmental and economic benefits also represents a barrier for its development. (Quintanilla et. al. 2000b)

4.4 The Clean Development Mechanism

After the UNFCCC was ratified in 1992, UN member states began the negotiation of the Kyoto Protocol aim to establish concrete instruments to mitigate climate change. These instruments are an International Emissions Trading Systems, the Joint Implementation and the Clean Development Mechanism (CDM). The last two are project-based strategies to reduce GHG emissions in Annex B and non Annex I countries respectively.[1] Russia's ratification of the Kyoto Protocol in February 2005 meant the beginning of its enforcement, increasing the interest of project developers in developing countries and CERs buyers on CDM. (Grubb et. al., 1999)

The objectives of the CDM are to "…assist Parties not included in Annex I to the Convention in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under… the Kyoto Protocol…" (UNFCCC, 2005a: p.4)

It is expected that CDM would provide several benefits to developing countries (e.g. technology transfer, foreign direct investment, income stream from CERs sales, and localised environmental improvement) when implementing projects with GHG emission reduction potential like energy efficiency in households, commercial and industrial facilities; methane recovery from animal and agriculture waste, mines, landfills, sewage or industrial waste treatment facilities; improvement of industrial process, low carbon energy generation technologies (e.g. biomass, cogeneration, SWH, photovoltaic systems); improvement of transport sector efficiency by increasing vehicles efficiency, switching fuels and public transport, and land use activities like afforestation and reforestation. (UNEP FI, 2005)

[1] See www.unfccc.org for detail information about the member states on each Annex of the Kyoto Protocol.

4.4.1 Main Trends of the Market

CDM market has grown importantly over the last years driven not only by ratification of Kyoto Protocol but also by domestic and regional commitments and regulations devised in Annex I countries to meet their commitments on abating climate change (e.g. EU Emission Trading System for 2008-2012, climate change mitigation plans in Japan and Canada).

Between 2003 and 2004 project-based transactions grew 38% from 78 to 107 $MtCO_2e$. Until April 2005 over 43 $MtCO_2e$ were exchanged due to the increase of JI and CDM supply. Most of these transactions are agreed under a commodity model where CERs are purchased on delivery, while few investment model transactions (that is a direct investment into the project in form of equity or debt in exchange of CERs) are observed even though they could increase its volume on the long term. (Lecocq and Capoor, 2005)

In addition, the stream of unilateral projects has risen importantly during this year, while the funds and facilities have increase in number and resources available for investing on CERs and ERUs reaching over 1 billion USD. Driven by the EU Directives, public and private institutions in this region have purchase 60% of carbon assets world wide followed by the Japanese public entities (21%) and private firms in Canada (4%). Similarly, the supply of carbon assets is highly centralised among few countries leaded by India, Brazil and Chile, while China and Mexico are seen as potential participants in years to come. (Lecocq and Capoor, 2005)

The features of technologies, host countries, and current CDM rules determine the projects' competitiveness in the market. Therefore HFC_{23} destruction and methane and N_2O recovery from animal waste projects represent 25 and 18 percent of the volume exchanged respectively followed by hydro, biomass and methane landfill capture projects. Moreover, Based on information provided by brokers, project developers and CER purchasers it is know that the CERs price range between 3 and 7.15 USD/tCO_2e (weighted average of 5.63) depending on whether the payment is made on delivery or in advance. (Lecocq and Capoor, 2005)

CDM in Mexico

Since Mexico ratified the Kyoto Protocol in 2000 and established its DNA in April 2005, CDM activities have started to be developed within the country. So far Mexican portfolio is compound by 106 projects (e.g. mini hydro, wind, methane recovery from landfills, organic waste and coal mines, energy efficiency, transport, $HCFC_{23}$ incineration and LULUCF) which represent GHG emission reductions of 11.02 $MtCO_2e$/yr. Yet, eight projects have been approved by the DNA (accounting for 3.6 $MtCO_2e$/yr), from which only four are completing the stakeholder consultation period resulting in no registered projects by the CDM-EB up to date. (Estrada M., 2005 and Point Carbon, 2005)

Due to the potential increase of GHG emission and a competitive country risk in terms of investment Mexico is recognised among the top five countries for implementing CDM projects. However, it is accepted that the institutional capacity among public and private sector must be improved identifying and developing potential projects faster to increase the share on CDM projects' supply. Consequently, CERs buyers should invest on capacity building, project identification and scouting activities to wider the CDM portfolio in Mexico. (Point Carbon, 2005a and Estrada M., 2005)

4.4.2 The Project Cycle

The registration of projects under CDM framework requires following a specific procedure which starts with identification of the project through a Project Idea Note (PIN). Then a Project Design Document (PDD) must be developed to calculate GHG baselines, determine the monitoring and verification plans and perform barrier and investment analyses proving the additionality of the project. When the PDD is finished it is required to perform a consultation with stakeholders and then get approval from the DNA of the host country.

Only then the project is validated by a Designated Operation Entity (DOE) which submits and registers the project before the CDM-EB. CERs are issued on annual basis after a DOE have verified and certified the project's performance according with the PDD.

Besides the DOE, the DNA and the CDM-EB the most important participants involved in the process are the project developer/operator who implements and operates the project (e.g. NGO, governmental bodies, municipalities, foundations, financial institution or member of the private sector), and the CDM investor/CER purchaser who provides the financing for the CDM project.

4.4.3 Relevant CDM Issues for Developing CDM-SWH Projects

Since the Marrakech Accords were signed in 2002 efforts have been made by the CDM-EB to increase the competitiveness of small scale projects within the CDM framework and reduce the transaction costs for all projects. Among these efforts are the development of simplified baselines and procedures for small scale projects and the consent to develop CDM project unilaterally. Additionally, the current discussion regarding the possibility to devise sectoral or policy driven projects is also important for small scale technologies like SWH.

Eligibility and Simplifications for Small Scale Projects

The CDM-EB recognised that the costs related to the registration of projects under the CDM are very high for small scale projects given the little amount of CERs produced on their operation. Therefore, the CDM-EB have devised and continually updated a group of simplified baseline methodologies and procedures for such cases. Among these simplifications are a project design document for small scale projects (SSC-PDD), fifteen baseline and monitoring simplified methodologies, and provisions to avoid debundling of large scale projects and prove the CDM project's additionality more easily. (UNFCCC, 2005d)

Of special consideration for this research is the "Thermal energy for the user" methodology (AMS-I.C.) which considers small scale energy technologies that supply electricity, mechanical or thermal energy to the user directly, SWH technologies included. (UNFCCC, 2005d) This methodology and its implications for potential CDM-SWH projects will be discussed in Chapter 7.

An activity is eligible for this simplified procedure when it is either a renewable energy project with an energy output capacity up to 15MW, an energy efficiency project that will reduce energy consumption in either supply or demand side by up to 15MWh/yr, or other project activity that will result in a reduction of up to 15ktCO_2e/yr. (UNFCCC, 2005c)

Unilateral CDM

As mentioned above the registration of projects under the CDM requires complying with every step of the project cycle. Yet, each step represents a cost for project developers who have to pay in advance. Initially, the developer needed to find a CERs buyer to get its project register before the CDM-EB, yet this require sometimes paying brokers' fees, increasing even more the transaction costs of projects.

In February 2005, the CDM EB agreed on allowing the registration of CDM projects without the involvement of any Annex I Party, this have significant implications. Firstly, most of the equity may come from host country actors only. Secondly, projects' developers are able to continue with the registration process after the DNA have issue the approval letter. Thirdly, non Annex I participants may invest on CERs production and hold its ownership until a purchase agreement is settle with a CERs purchaser. (Jempa, 2005)

This may increase the business opportunities for consultants in developing countries whom could start developing CDM projects without involving and competing with experts from industrialised countries. Transaction costs may also be reduce as local consultants are native speakers and may have better knowledge of how to proceed with developers and host country authorities. Besides, institutional capacity for CDM could be promoted in host countries and efforts could be made to develop projects which represent strategic efforts to decarbonise developing countries economies rather than implementing isolated activities which look above all to improve investment streams increasing projects' revenue. (Jempa, 2005)

Sectoral or policy driven CDM

Until now, the mitigation of GHG emissions by CDM has been driven completely by a project based approach since it reduces the risk of leakage[2] among project activities and allows greater control and accountability of benefits from GHG emission reductions. In other words, double counting of reduced GHG emissions is avoided. Other approaches have been proposed to strength the international policy framework for climate change mitigation and increase the participation of developing countries in this matter.

This is case of the sectoral or policy driven CDM (S-CDM) aimed to develop wider CDM projects with a regional, sectoral, sub-sectoral or cross-sectoral scope which could result in the device of new domestic policies promoting sustainable development while reducing GHG emissions.

Samaniego and Figueres (2002) explore this approach as one way forward as it could level the playing field between developed and developing countries in reducing GHG emissions, and contribute in financing the transformation of entire sectors or regions reducing its carbon intensity and improving local environment. Besides, it is recognised that S-CDM may reduce enormously the transaction cost for all the component activities within the project and facilitate the generation of CERs by activities which could not be feasible to develop on its own under a project-based approach.

On the other hand, Samaniego and Figueres (2002) recognise that implementing a S-CDM may no be always technically and politically feasible as current CDM definitions would have to be modified (e.g. project boundary, baselines, additionality), and efforts would have to be done at domestic level providing meticulous GHG emission inventories and

[2] "Leakage is defined as the net change of anthropogenic emissions by sources of greenhouse gases (GHG) which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity. Reductions in anthropogenic emissions by sources shall be adjusted for leakage in accordance with the provisions of Appendix B for the relevant project categories. The Executive Board shall consider simplification of the leakage calculation for any other project categories added to Appendix B." (UNFCCC,2005g: 12)

projections to develop sector baselines and undertaking monitoring and verification plans for the component activities of the S-CDM projects.

Still the authors insist on developing pilot S-CDM projects as they could supply valuable information to policy markers, CDM-EB and project developers on how to face the challenges of a sectoral approach. In this sense, they propose the implementation of a pilot S-CDM project in Mexico City region aggregating activities in seven sectors: energy efficiency in buildings, industry, new housing, transportation, public services, solid waste management and reforestation. SWH technologies are mentioned as one strategy to reduce GHG emissions in the housing sector. (Samaniego and Figueres, 2002)

On December 2004, the government of Ghana submitted the first S-CDM project to reduce GHG emissions by introducing a compulsory regulation to establish energy efficiency standards on room air conditioners. This policy-based CDM project could avoid the emission of 15MtCO_2e over the next 21 years, while reducing the energy expenses of consumers. More importantly it could be a precedent for the development of other projects with this approach. (Anderson, 2005)

However, the CDM-EB have not agreed in recognising the sectoral/policy driven approach since the implementation of domestic policies such as compulsory regulations are usually related to politics and national priorities. Members of the CDM-EB argue that if domestic policies offer so many benefits, governments should find the ways to attract investment for implementing such regulations. Finally, if policy driven or S-CDM is consented, the additionality of domestic regulations would have to be grounded on analysing the economic rationale of government decisions which is much more complicated to perform than the assessment and comparison of investment, technical and institutional barrier between projects. (Anderson, 2005)

4.5 Summary and Conclusions

Bearing in mind that SWH technologies may reduce around half of the emissions of the residential sector in Mexico which accounts for 10 millions tons of CO_2 based on 2000 data; and recognising that Mexico has ratified and established a DNA CDM incentives could be used to reduce the barriers faced by the technology. In this sense, considering the current CERs price band the potential investment flow from CDM to SWH industry could reach between 30 and 70 million USD.

Finally, the existence of simplified procedures and methodologies for small scale technologies like SWH and the consent to develop unilateral CDM projects facilitate the involvement of SWH project developers in Mexico on structuring CDM-SWH projects. Moreover, the acceptance of sectoral or policy driven CDM approach may increase the benefits to SWH technologies.

5 Water Heating Demand and SWH Technology in Mexico

Chapter 5 Analyses the possible trends and future demand of water heating services in Mexico. Then addresses the current situation of the SWH market in Mexico by reviewing several features such as the historic development of the market, the production capability, the capacity installed and energy produced; the different applications of SWH technology, the existence of norms and standards, the research activities undertaken by national institutions, and the SWH market in the global context. Finally, it discusses briefly the trends of the SWH market in the future, and the potential and feasible markets for this technology at a national level.

5.1 Trend and Future Demand of Hot Water in Mexico

There is no information to determine accurately the percentage of energy used for each energy service in the residential sector. In consequence, little is known about the historic behaviour and future trend of hot water demand in this sector at a national level. Yet, it is recognised that energy consumption in the residential sector is determined mostly by population dynamics like the urbanisation process and population growth. (Quintanilla, 2005)

Studies undertaken in Mexico City provide valuable information to understand the drivers for hot water demand. The average consumption of hot water (at 50°C) ranges from 30 to 80 litres per capita per day depending on population habits and income (see Table 1), and it is estimated that by 2020 53.06% of the LPG consumption in the residential sector will be used to heat water. (Quintanilla, 2000b)

Hot Water Consumption in Mexico City

Income level	Low	Medium	High
Hot Water Consumption (lts/capita)			
Lower Limit	30	50	60
Upper Limit	45	65	80

Table 1. Hot Water Consumption in Mexico City

Source: Modified from Quintanilla (2000a)

Combining the figures shown above with the historic consumption of LPG and NG in the residential sector, the official households' growth trend from 2000 to 2030, the national average water service coverage (88.8%) and the LPG saturation which would increase at an annual rate of 0.15% starting at 54.4% in 2000 and ending at.57.8% in 2020 a trend of the demand of hot water services can be estimated by constructing a bottom-up model as shown in Figure 3.

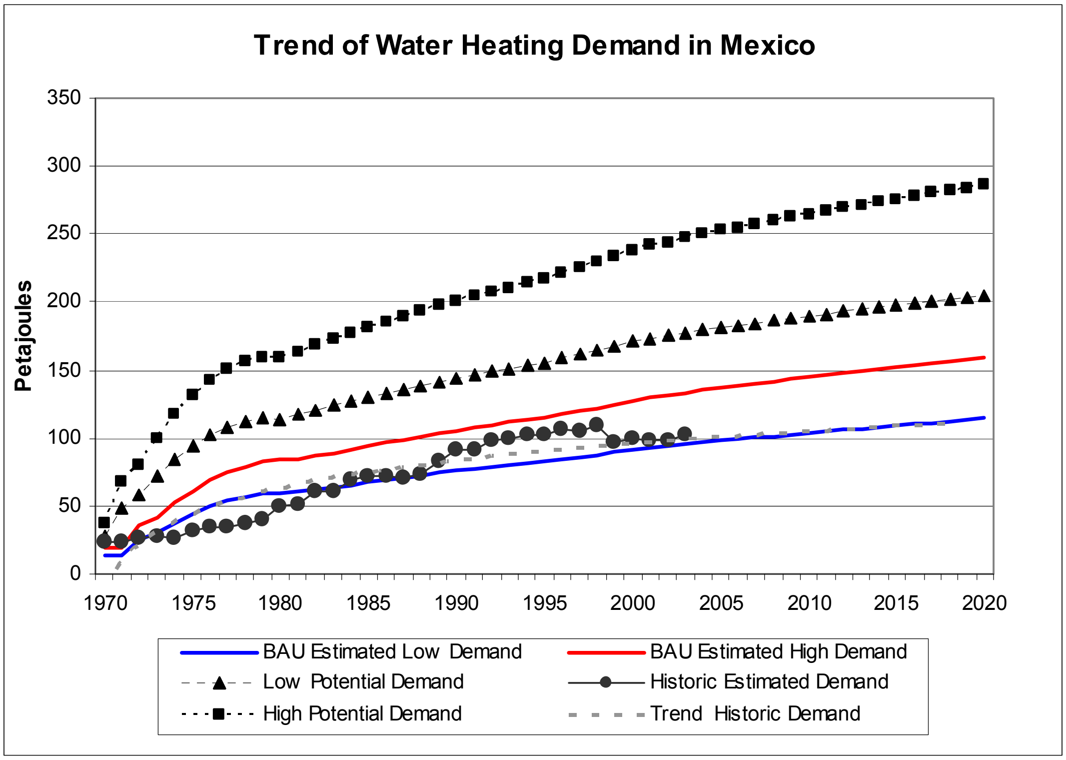

Figure 3 Trend of Energy Demand for Water Heating in Mexico

Source: bottom-up model (see Annex I for details)

Although the model is not sensible to variations on family income and habits across population, the low and high limits of energy demand calculated along time match quite good with the trend of the historic demand estimated.[3] Additionally, it is shown the potential demand of energy under a low and high demand scenarios assuming all households could be provided with water heating services. As shown below, the difference between the historic and potential demands could mean either an unsatisfied water heating

[3] The historic demand of energy for hot water heating was estimated from the historic consumption of LPG and NG in the residential sector, multiplied by a factor of 0.5306 (related to the proportion of energy use to water heating), and 0.6(assuming an efficiency of 60% on fuel fired boilers).

service on low income households or a provision by consuming other fuels such as wood (and kerosene in the past) since over the last years higher LPG prices have lead rural population to switch from LPG to wood to fulfil their heating needs. (T. de Jong, 2005)

This demand could be fulfilled with different combinations of fuel and energy sources depending mostly on future domestic policies and fuel prices, yet Figure 4 and 5 illustrate a two plausible business as usual scenarios of future fuel and energy sources shares based on the current domestic policies regarding LPG and NG, and an estimation the future development of residential SWH market (see section 5.3 for detailed information on the SWH market model). These two figures correspond to the low and high energy demand scenarios for water heating shown in Figure 3.

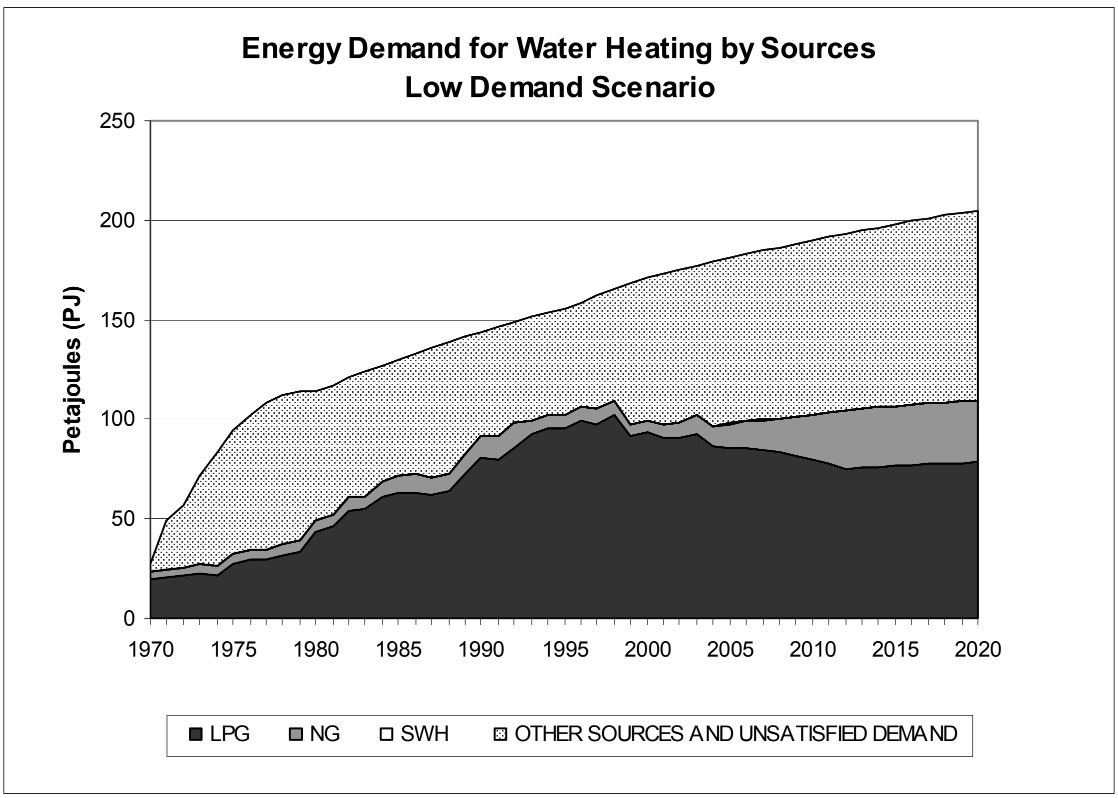

Figure 4 Energy Demand for Water Heating by Source (Low Demand Scenario)
Source: bottom up model (see Annex I for details)

Figure 5 shows a sharp increase of water heating demand between 2005 and 2006. This is unlikely to happen since it would imply drastic modifications on familiar habits and income level. In reality, an increase on energy demand for water heating would evolve over the years reaching almost 150PJ by 2020.

Although it is not within the limits of this research to perform an exhaustive analysis of the development of energy demand for water heating services in Mexico, this estimations provide enough information to understand the context on which SWH technology develops.

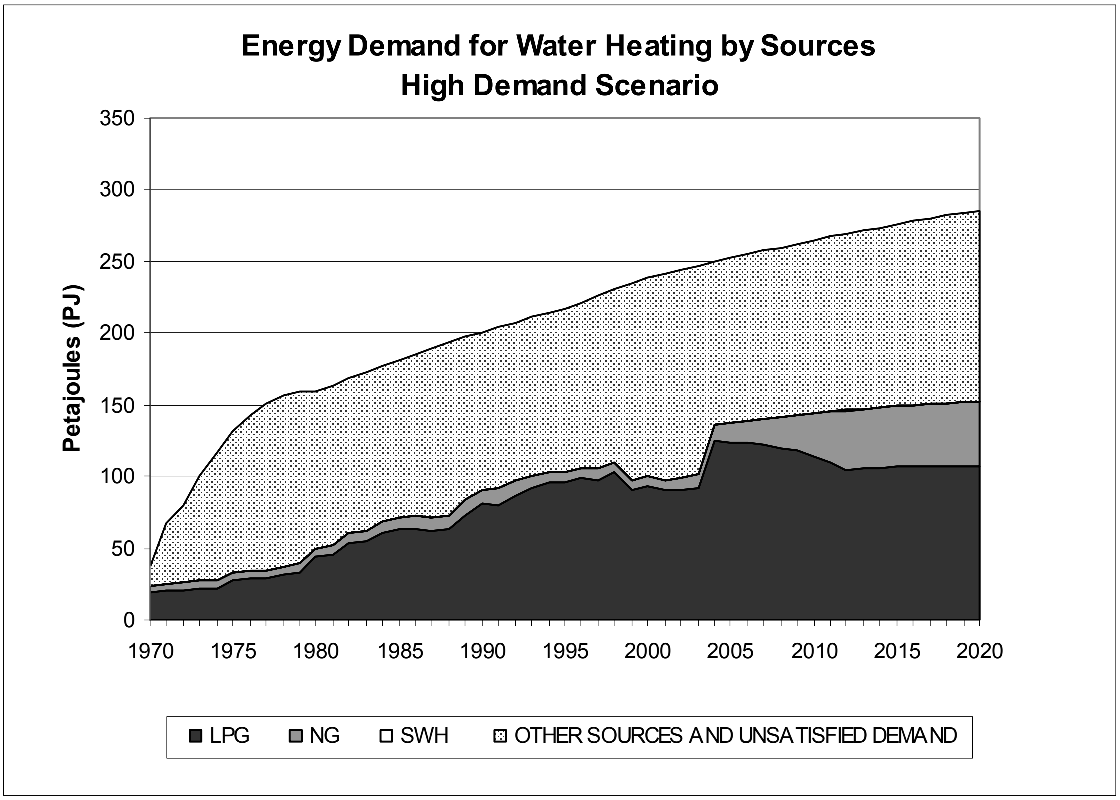

Figure 5 Energy Demand for Water Heating by Source (High Demand Scenario)
Source: bottom up model (see Annex I for details)

5.2 Current Situation of the SWH Market in Mexico

Market development

Although SWH technology's share in energy consumption for water heating service is not noticeable, the SWH market has developed at an exponential rate since 1990.

As shown in Figure 6, from 1990 to 1996 the area installed remained constant at around 12,000 m^2/yr and then grew steadily to almost 45,000m^2/yr in 2000. In 2001 the market increased to 74,600m^2, felt to 50,900m^2 in 2002 to finally reaching its peak in 2003 with 75,300m^2. It will be discussed later in Chapter 7 how fuel prices have been the most important driver behind SWH market development in Mexico.

Production Capacity

According with the Institute of Electric Research (IIE), the production capacity installed in 2000 was around 70,000m^2/yr and half of it was not used due to low market volumes.[4] This figure has not changed significantly as low quality and semi-handmade processes are employed by most manufacturers depending on their economic capacity and their relation with R&D institutions.

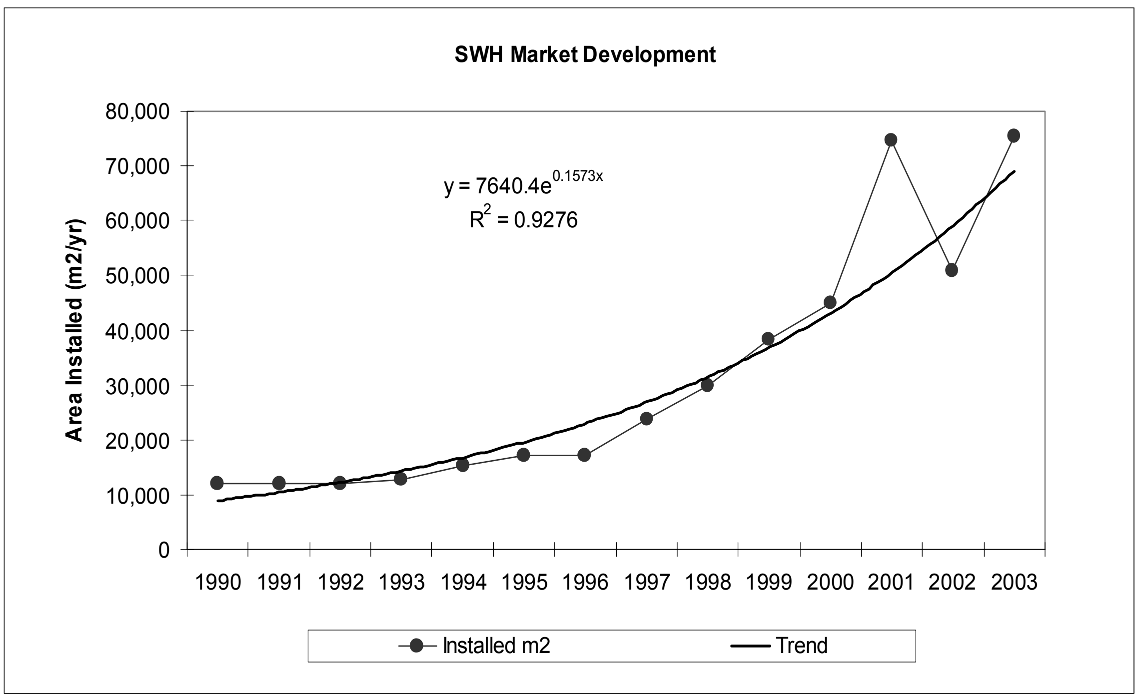

Figure 6 SWH Market Development in Mexico (1990-2003)

Source: Modified from (Martínez R., 2005)

In 2000, there were 48 national manufactures and 19 retailers of SWH systems in Mexico, sixteen of them national and three importers. Yet, given the low market volumes and the

[4] The production capacity mentioned refers mostly to glazed collectors manufacture as there is only one company which produces unglazed plastic collectors for pool heating applications.

manufactures' features describe above the number of participants fluctuates considerably over time. (Quintanilla, 2000b)

Capacity Installed and Energy Production

In 1990 there were around 150,000m^2 of solar thermal collectors installed in Mexico. As shown in Figure 7 this number reached almost 574,000m^2 in 2003. Yet, during 2001 only 430,490m^2 were operational representing 96% of the total capacity installed. Neglecting such difference, the estimated thermal energy production was 55,240 MWh/yr in 1990 and climbed to 216,250 MWh/yr in 2003. (Weiss Bergmann and Faninger, 2004)

SWH Applications

SWH technologies are employed for water heating applications in different sectors resulting on a wide range of products available in the market; from unglazed collectors for pool heating applications, to glazed collectors for residential, commercial and industrial water heating services. In addition, during the last years imports of vacuum tubes technologies from China have increased. Although this technology is a direct substitute for glazed collectors no information was found to determine its share on the market.

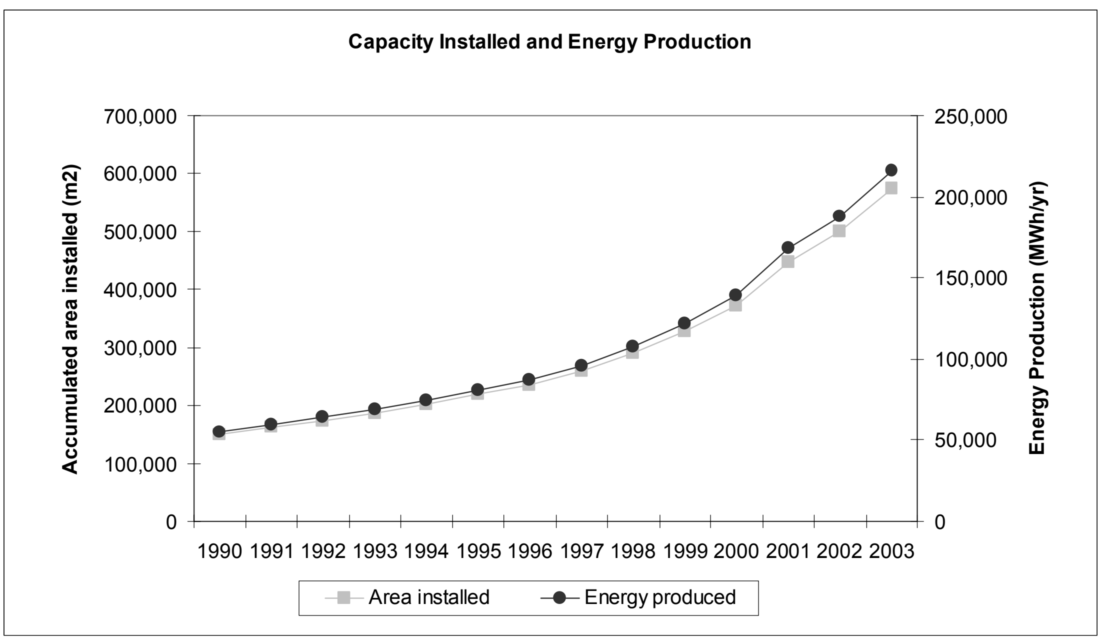

Figure 7 Capacity Installed and Energy Production

Source: Modified from (Martinez R. 2005 and Quintanilla, 2000b)

Figure 8 shows the share of the main three SWH applications in Mexico. The most developed market is pools water heating with 78% followed by industrial and commercial applications with 14% and finally the residential with 8% of the whole market. These shares have not change considerably overtime even though it is expected a decline on pool heating applications in the near future as a result of high penetration of SWH technologies in this sector. Consequently, the residential, commercial and industrial applications may increase its participation in the SWH market within the next decade.

<u>Standard and Norms</u>

The Solar Energy Chapter within the National Chamber of the Transformation Industry (CANACINTRA) and the Solar Energy National Association supported the creation of a voluntary norm called: "Performance of solar thermal collectors for water heating- Tests and Labelling Methods" (NESO-13). This initiative was officially published on February 2005 and its implications will be discussed later on Chapter 8.

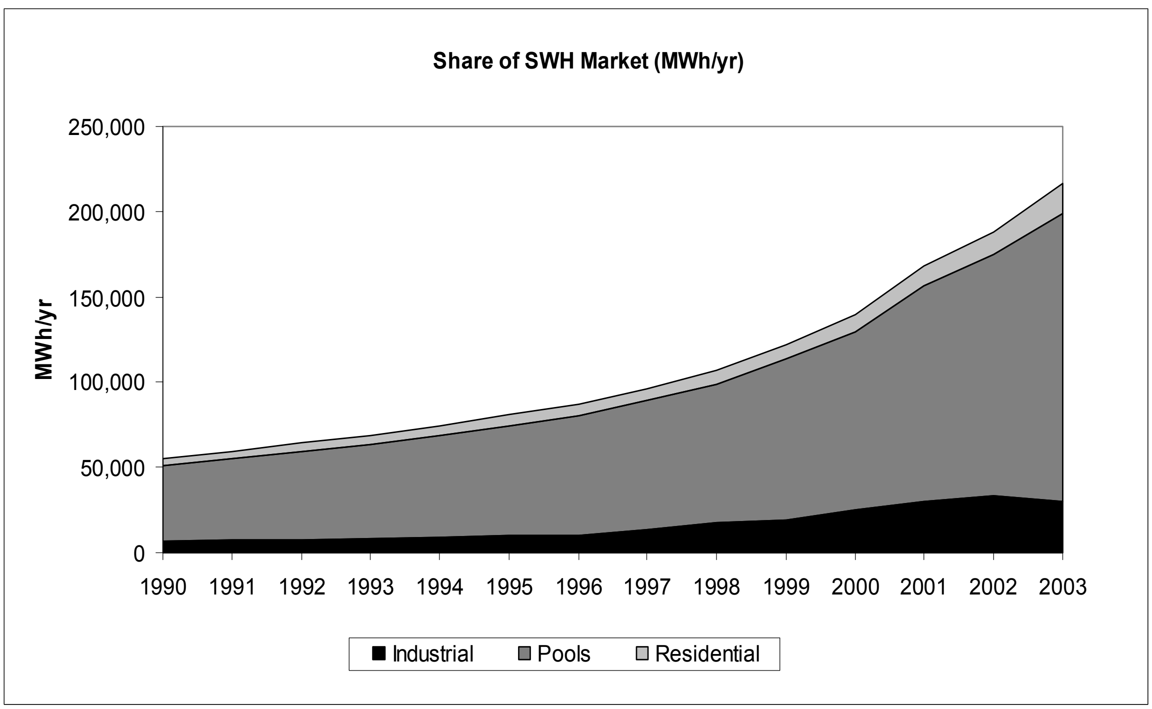

Figure 8 Applications of SWH technology in Mexico

Source: Modified from (Martínez R. 2005)

Research and Development Activities

Research and development activities are carried out mainly by academic and research institutions such as the Institute of Electric Research (IIE), and the Centre for Energy Research (CIE), The Engineering Institute and the University Programme for Energy at the National Autonomous University of Mexico (UNAM). Additionally, some manufacturers have small R&D areas aimed to improved their designs and installations.

Mexican SWH Market in the Global Context

Although the SWH market in Mexico for residential, commercial and industrial applications has grown considerably in the last decade. Its volume is small compared with other countries such as China, Israel, Austria, Greece, Italy, Spain or United States; where the capacity installed each year have overpass 10,000m^2 since the early 1980s.

Figure 9 illustrates the development of the glazed solar collectors in such economies. These behaviours are mostly driven by the combination of several issues, such as security of supply (e.g. Israel), population growth increasing energy demand (e.g. China); high fuel prices (e.g. US and UK and Mexico), domestic policies (e.g. Austria, Spain and China) and, in some cases, exceptional solar resource (e.g. Greece and Israel).

SWH markets in Austria, Spain and China are very interested cases since they have grown between 4 and 8 times in volume during the last decade as a result of domestic policies established by local and federal governments (see Chapter 8 for further analysis of European markets). In contrast, Mexican market has grown 9 times in the same period without any support schemes. Consequently, it could be assumed that SWH market in Mexico could grow more than these markets by devising proper domestic policies.

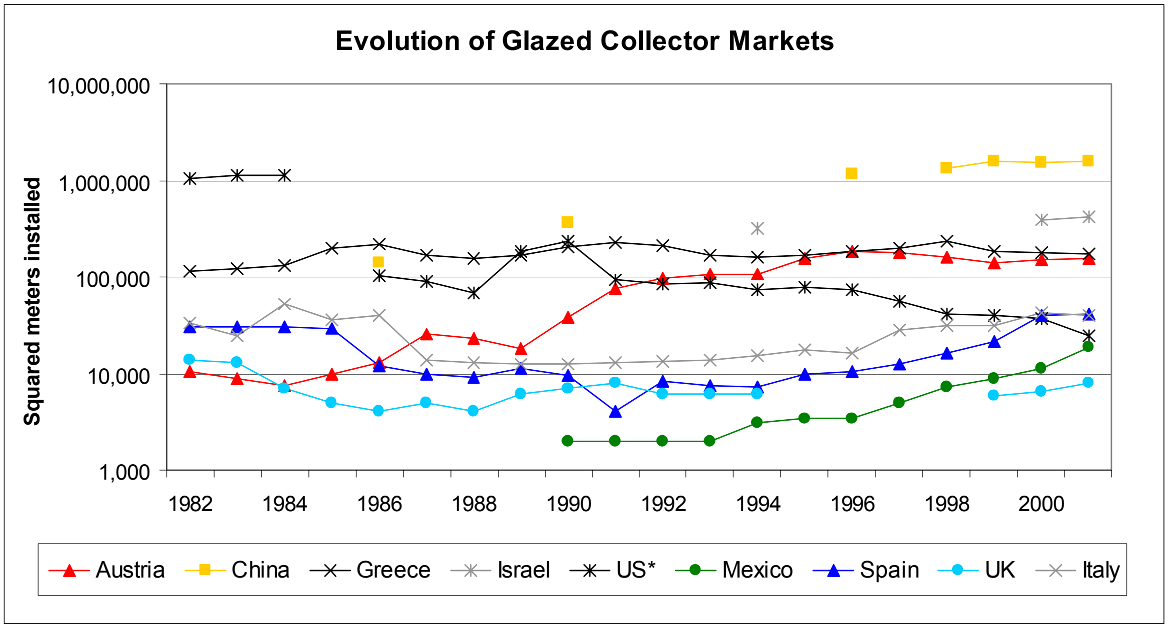

Figure 9 Evolution of Glazed Collector Markets

Source: Modified from (ESTIF, 2003b). US*: Not import or export considered.

In addition, one could assume that economies of scale have an important role on SWH markets around the world. In other words, the higher the volume of the market, measured in capacity installed the lower the price of equipments per m^2. However, this relation is not entirely true (see Figure 10). For instance, Mexico and UK which had similar market volumes in 2001 have differences of more than 5 times on equipment costs. Moreover, Mexico, Israel, Greece and China, which equipment's cost range is between 143 to 250 €/m^2, have completely different scales of markets. Then the costs of SWH technologies are closely related to the economic features of each country which determine the production costs of equipments.

The relation between the cost of SWH technology and average solar radiation in each country is also relevant to understand the competitiveness of the each national market based on the cost of producing heat from solar energy. As Figure 11 illustrates Mexico and Israel are the most competitive markets in these terms.

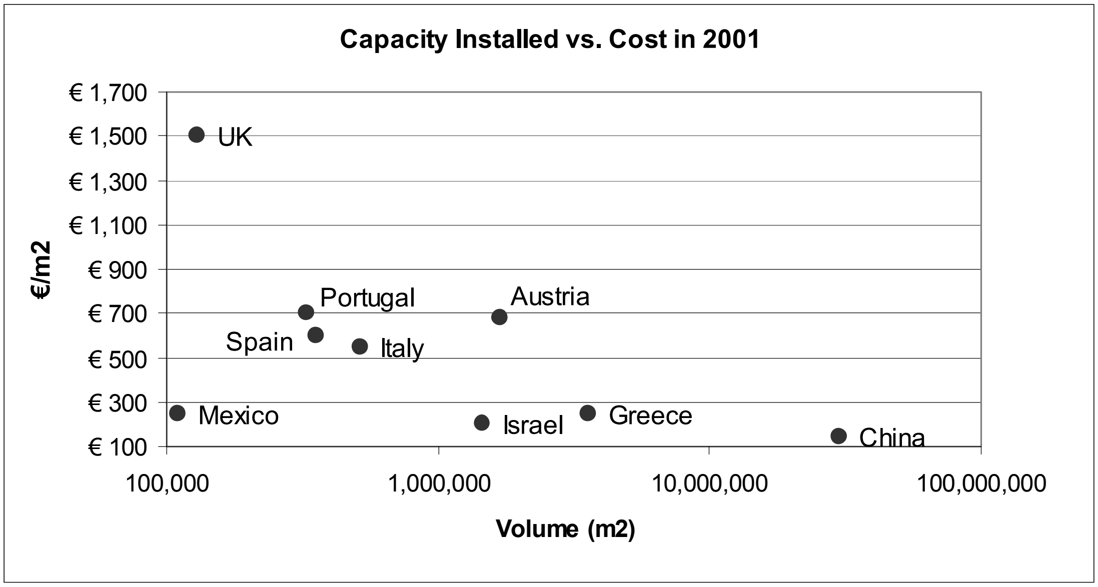

Figure 10 Capacity Installed vs. Equipment Cost in 2001

Source: Modified from (ESTIF, 2003b)

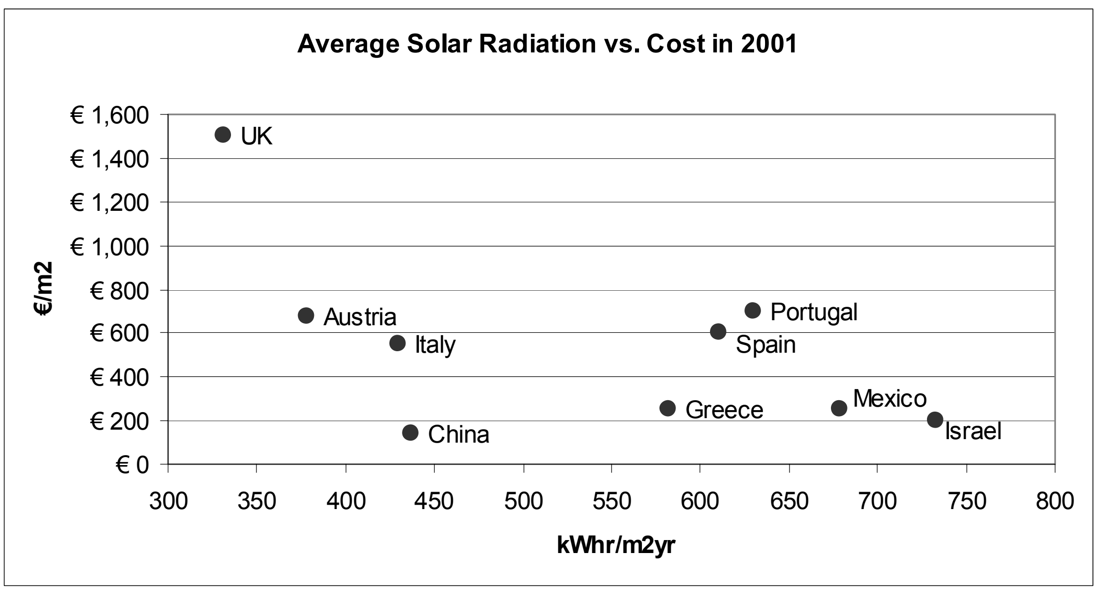

Figure 11 Average Solar Radiation vs. Equipment Cost in 2001

Source: ESTIF (2003b) modified with information from (Weiss Bergmann and Faninger (2004)

5.3 Future Trends of the SWH Market for Residential Sector in Mexico

The potential market for SWH technology in the residential sector is equal to the hot water demand which was estimated to be around 100 PJ in 2000 and could increase between 115 and 160 PJ by 2020 depending on familiar income and habits. Yet, there are some technical restrictions related to households' features such as the availability of area in the roof, its structural yield to support SWH systems' weight, and water and LPG services accessibility. (Quintanilla et. al., 2000b)

Assuming that 86.5% of the households in Mexico have adequate space on the roof to install SWH systems and that 88.8% of these households have access to water services the potential market is reduced to 76.8% due to technical restrictions, resulting on 88 to 122 PJ of energy which could be provided by this technology. (Quintanilla et. al., 2000b and INEGI, 2005)

Figures 12 and 13 illustrate the plausible development of the residential SWH market in the next fifteen years as a function of the growth on the construction and fuels, water and electricity sectors in Mexico. Two scenarios have been considered assuming growth rates of 3 and 5 percent respectively.

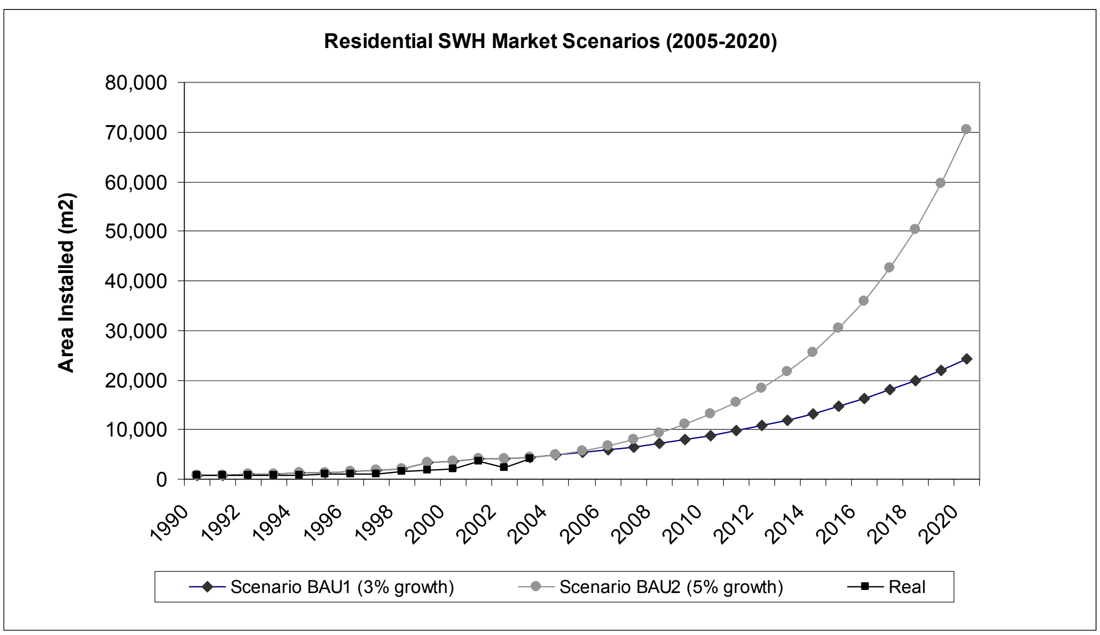

Figure 12 Residential SWH Market - Future Development Scenarios (2005-2020)
Source: Regression model (see Annex I for details)

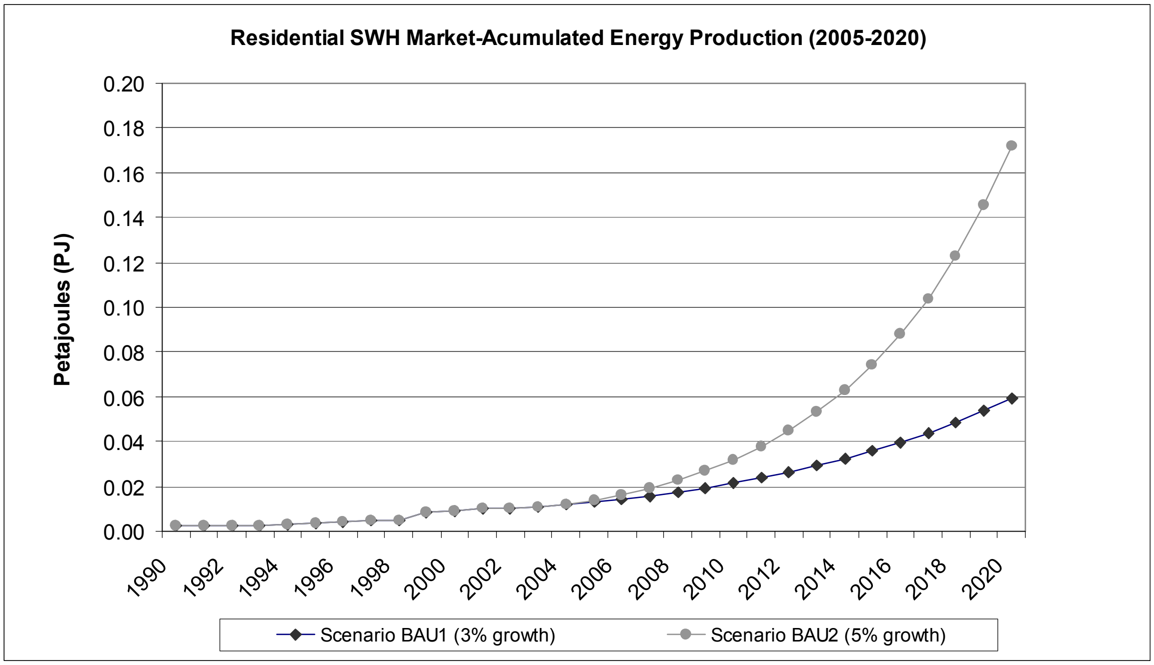

Figure 13 Residential SWH Market –Energy Production Scenarios (2005-2020)

Source: Regression model (see Annex I for details)

Although the future development of the SWH market for residential applications could grow from 6 up to 17 times on size in the next 15 years this would only be driven only by economic growth with out any support from domestic policies or international mechanisms. The share of SWH technology on heat energy supply for the residential sector would represent less than half percent of the total demand (between 0.06 and 0.17 PJ) implying that it would be far from unleashing its full potential under current trends.

A larger deployment of SWH technology will be determined by the efforts made to overcome investment, financial, technological and institutional barriers. The next section will address the investment barriers of the technology in Mexico increasing the understanding of the economics behind SWH projects' development.

5.4 Summary and Conclusions

Energy demand for water heating in Mexico will continue to grow driven by the population dynamics and economic growth. Yet, a large part of the demand, especially on low income households, is either meet with cheaper fuels than LPG and NG such as wood, or is not being fulfilled at all.

Additional research must be made to understand the environmental, economic and social impacts of wood consumption when fulfilling water heating services for low income households, and determine how SWH technologies could reduce these impacts while improving the quality of life and economy of this population.

SWH market in Mexico grew substantially during the last decade driven by higher fuel costs and a boost on pools water heating applications. Similarly, SWH technology for commercial and industrial applications also grew as these sectors have higher affordability and access to credit schemes than households.

However, the current share of SWH applications for water heating in residential sector remains almost inexistent due to the investment, technical and institutional barriers faced by this technology, and the lack of support schemes for renewable energies in Mexico. Yet, its has enormous potential for development not only because the urbanisation and population growth trends but also due to the high competitiveness of the country in terms of the cost of producing heat from solar energy.

6 Investment Analysis of SWH Technology in Mexico

As mentioned previously, investment and SWH systems' affordability are among the biggest barriers faced by the technology. This section analyses several financial aspects of SWH technology, identifies the costs of production, estimates an average retail price, and compares different financial indicators such as the upfront capital costs, net present value, relative price, internal return of investment, payback time and cost of CO_2 reduction between three different SWH projects and an average LPG system.

6.1 Bottom-up Financial Modelling

A bottom-up financial model (or cash flow analysis) is useful to compare the economic costs and benefits (or savings) of different options or projects along a given period of time. In these sense, three modules were created to assess the cash flow of each project under different scenarios: business as usual, capital grant supported, CDM supported and a combination of the last two (see Annex III for details).

Business as Usual Scenario (BAU)

Firstly, the SWH and LPG systems considered were chosen based on the water consumption profile shown in Table 1 and the average number of habitants per household. In this sense, it was assumed a hot water consumption of 60 litres per capita as this figure is within the limits of the medium and high income average households. The main characteristics of the systems assessed are shown in Table 2.

Secondly, it was determined the equipment, installation, operation, maintenance and fuel costs of each project over a 20 years period based on the experience of Mexican SWH manufacturers and installers. Additionally, the annual discount (10%), inflation (4.5%), and fuel increment (4.5%) rates where assumed to be constant over this period. This allowed the calculation of the upfront capital costs, net present value, internal return of investment, and payback time of each project. The relative price (SWH/LPG) was determined by dividing the net present value of the overall costs of each SWH system over the LPG system.

Thirdly, based on previous studies by Quintanilla et. al. (2000b) and Milton and Kaufman (2005) it was assumed that the SWH systems considered could reduce between 1.77 and 2.65 t/CO_2e per year. This permitted the calculation of the cost of CO_2 reduction

Capital Grant Supported Scenario

The results from the BAU scenario and the policy appraisal provided enough evidence to conclude that capital grants are one of the most effective strategies when reducing upfront capital barriers. Hence, it was decided to build a module within the model to assess the effect of a 10, 20 and 30 percent capital grants on the cash flow of every SWH project. The results from this scenario are presented in Chapter 9.

CDM Supported Scenario

As one of the objectives of this research is to assess the impact of CDM on reducing investment barriers an additional module was designed. This module include four more variables in the model: the price of CERs which range from 3 to 7.15 USD/tCO_2e (Lecocq and Capoor, 2005), the crediting period (up to 21 years), the number of household subscribed into a hypothetical CDM-SWH project, which range from 1 up to 10,000 households plus a sectoral-based project (assuming 10 million households), and the transactions costs (search, pre-implementations and implementations costs), which were estimated on 91,123 USD based on studies undertaken by Krey (2005) and Milton and Kaufman (2005). The results from this scenario are presented in Chapter 7.

Combined Efforts Scenario

The last two scenarios were employed to assess the combined effect of CDM incentives and capital grants of the upfront capital costs of the SWH systems considered. It is important to notice that for the scenarios considering CDM incentives a payment on delivery of CERs mode was assumed.

It is recognised the increasing importance of natural gas to supply energy for water heating services; however, the model does not include this fuel in the analysis since it has been proven that SWH systems can not compete against it at current prices, as payback time of SWH are around 12 years. (Quintanilla, 2000b)

Technical Features		SWH + New LPG Backup	LPG	SWH + Existent Backup	SWH No backup
Average inhabitants per household		4.4	4.4	4.4	4.4
Hot water consumption (per capita)	litres/day	60	60	60	60
Average ocupation per year		100%	100%	100%	100%
Tap water average temperature	ºC	18	18	18	18
Design temperature	ºC	50	50	50	50
Storage ratio	litres/m2	51	-	51	51
Energy needs	MJ/day	35	35	35	35
Solar collector/ LPG efficiency		44.2%	60.0%	44.2%	44.2%
Solar collection area	m2	6	-	6	6
Storage capacity	litres	300	-	300	300
Expected savings		78.32%	0.00%	78.32%	78.32%
LPG Backup systems		Yes	-	Existent	No

Table 2. SWH Systems Features Assumed on the Model

Source: Bottom-up Financial Model (see Annex III for more details)

6.2 Relevance and Implications of Financial Indicators

Each financial indicator under analysis is relevant to understand the situation faced by SWH projects in Mexico and its implications at a market level. Firstly, the determination of upfront capital costs provides information about the investment barriers faced by each technological option and in combinations with households' annual expenditure and income figures it allows determining the best support schemes to enhance technology. Secondly, the net present value and unitary energy cost show which technological option is cheaper, reducing the costs of energy delivery for consumers and overall economy. Thirdly, the relative price is a useful marker to understand the penetration potential of SWH technology in the Mexican market under present conditions. The closer this ratio is to cero, the higher would be the SWH penetration if no barriers hold its deployment. Fourthly, the payback time indicates how long it will take for consumers to see the economic benefits of their investment, then it is relevant to structure adequate support schemes such as soft loans, leasing and capital grants. Fifthly, the IRR indicates how good is for consumers to invest on SWH technology in terms of the costs and fuel savings benefits along time. The higher this figure the better is the choice. Finally, CO_2 abatement cost is useful to contrast several types of projects and technologies which reduce GHG emissions and choose the most cost effective strategy. This figure is useful for policy makers when choosing strategies for climate change mitigation.

6.3 Results of Financial Modelling

Up front capital costs

As shown in Figure 14 the upfront investment (equipment and installation costs) of SWH projects is between 2.93 and 3.47 times higher than the LPG depending on whether a LPG backup system is already in place or not. Thus, SWH technology face a disadvantage against the LPG system since consumers and households' developers usually prefer a less capital intensive option

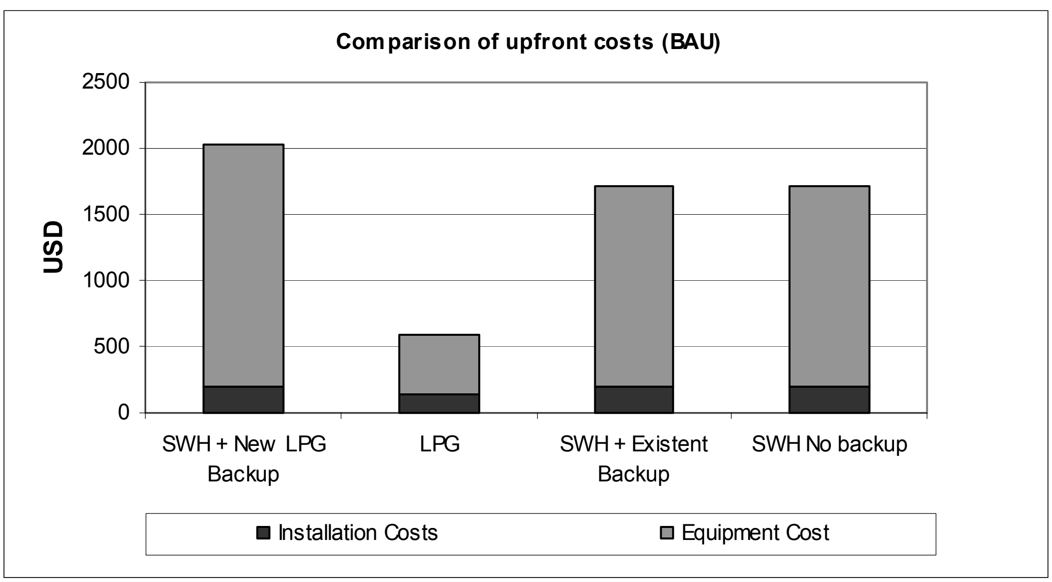

Figure 14 Comparison of upfront costs (BAU)
Source: Bottom-up Financial Model

According with the literature reviewed, equipment costs represent over 85% of the upfront investment, while installation costs account for 25%. This is the case of the three SWH systems considered in this analysis where equipment costs range from 88 to 90 percent of upfront investment.

During the lifetime of the project additional investments may be needed to keep it running. This is the case of SWH systems with auxiliary backup where a new LPG boiler is needed after ten years of operation. Stand alone LPG systems require more often investments for retrofitting as its approximate lifetime is seven years.[5]

Maintenance and Operation Costs

Annual maintenance and operation costs for SWH system usually represent 1% of capital costs and require a corrective maintenance every five years which is around 10% of capital investment. These costs continue up to a period of 20 years which is average lifetime of the equipments. SWH systems have no operation costs unless a LPG system is running as auxiliary backup.

Similarly, LPG systems also need annual maintenance which costs approximately 3% of capital investment. Its operation costs are determined by fuel prices and equipment efficiency that is usually around 60%.

Net Present Value

Although SWH systems face an economic barrier due to high capital investment costs, the net present value of the costs over a 20 years period is lower than the LPG system. This is because of its lower operation costs compared with LPG system which have low resilience to changes in fuel prices.

Figure 15 demonstrates that costs at net present value of a LPG system are between 29 and 43 percent higher than the SWH systems under the current economic scenario in Mexico.

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[5] No disposal costs are considered in any case but in practice consumers may have to pay some fee due to system retrieval.

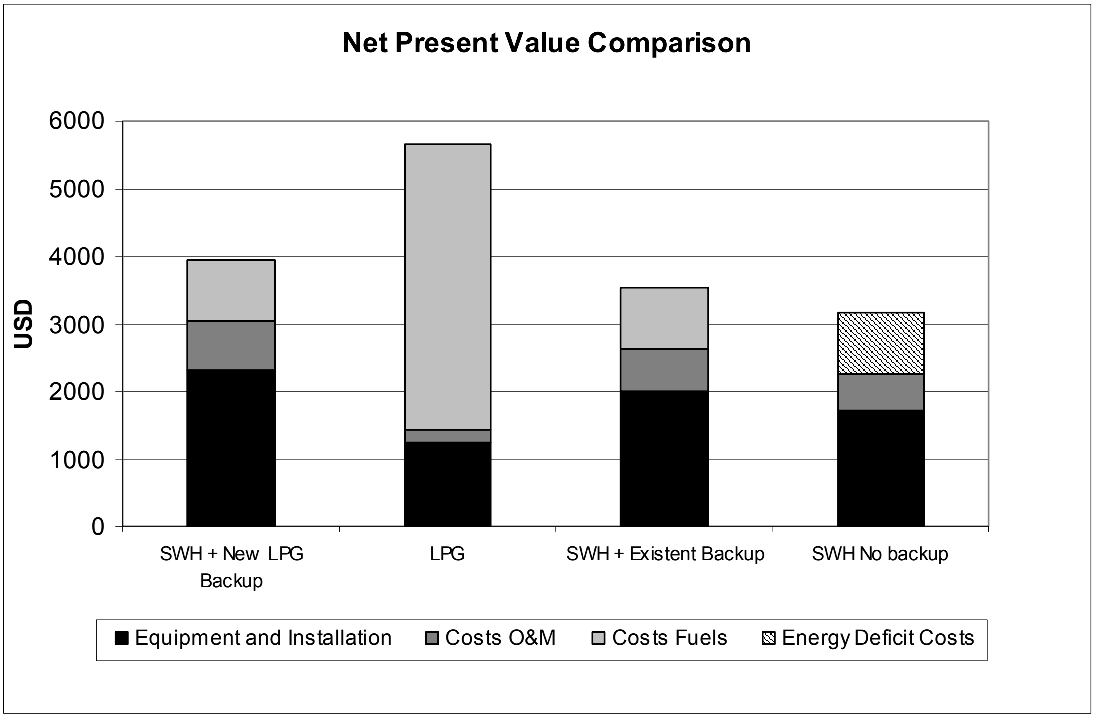

Figure 15 Net Present Value Comparison (BAU)

Source: Bottom-up Financial Model

Consequently, the prices per unit of energy produced (US cents/kWh) by SWH systems keep the same relation except for those without backup. This difference exists since the project has lower energy output than the others increasing its price per kWh. (See Table 3)

Unitary Costs (UScents/kWh)	**SWH + LPG Backup**	**LPG**	**SWH + Existent Backup**	**SWH No backup**
Equipment and Install.	7.47	4.04	6.36	6.93
M&O	2.33	0.59	1.98	2.19
Fuel Costs	2.95	13.62	2.91	3.71
Levelised tariff	12.75	18.27	11.25	12.84
Relative Price (SWH/LPG)	0.70	1.00	0.62	0.70

Table 3. Heat Energy Production Unitary Costs (BAU)

Source: Bottom-up Financial Model

Return of the Investment of SWH Technologies

To calculate the IRR and payback time of each SWH project some assumptions were made to establish a comparison between the relative costs and benefits of these projects and the stand alone LPG option. The latter is relevant to understand what does each IRR actually mean. Firstly, the relative benefits and costs from the SWH project with new backup are the difference of all cash flows between this option and the stand alone LPG system (including cash flows from E&I, M&O and fuel costs). Secondly, the relative benefits and costs from the SWH system with existent LPG backup is calculated in the same way but the LPG backup's capital cost is not considered given the assumption that it already exist. It is also assumed that after ten years of operation a new LPG backup system will be needed. Finally, to quantify the relative benefits and costs from the SWH system with out LPG backup it is assumed that the consumer have no hot water services at the moment and faces the choice of whether acquire a LPG system or a SWH system but no both. Hence the relative costs and benefits are the difference of all cash flows between the SWH and the LPG system. Moreover, since no backup is used, the lack of solar resource to fulfil hot water demand at any time is a potential opportunity cost. The model considers this situation by assuming that such cost is equal to the fuel cost of a virtual LPG backup system.

Based on these assumptions the IRR, payback time and cost of CO_2 reduction for each project is shown in Table 4.

Financial Features	SWH + LPG Backup	LPG	SWH + Existent Backup	SWH No backup
IRR of consumer	24.10%	-	20.71%	34.57%
Payback time (years)	5.03	-	6.06	3.54
Cost of CO2 reduction (USD/tCO2)	58.11	-	56.43	50.76

Table 4. IRR, Payback Time and CO_2 Reduction Cost of SWH Systems

Source: Bottom-up Financial Model (see Annex III for more details)

These results are consistent with previous studies on which similar SWH systems have an IRR between 22.5 and 27 percent, payback time from 4 to 4.6 years, and costs of CO_2 reduction of 53.9 USD per tCO_2e. (Quintanilla et al, 2000a)

Economies of Scale in SWH Projects

It has not been consider the effect of economies of scale as system's size does not varies greatly enough to produce such economic behaviour. However, economies of scale do exist since on larger projects better equipment, installation and labour costs can be bargained and engineering optimisation is possible at the design stage (see Figure 16). This not only applies to SWH systems but also to LPG systems.

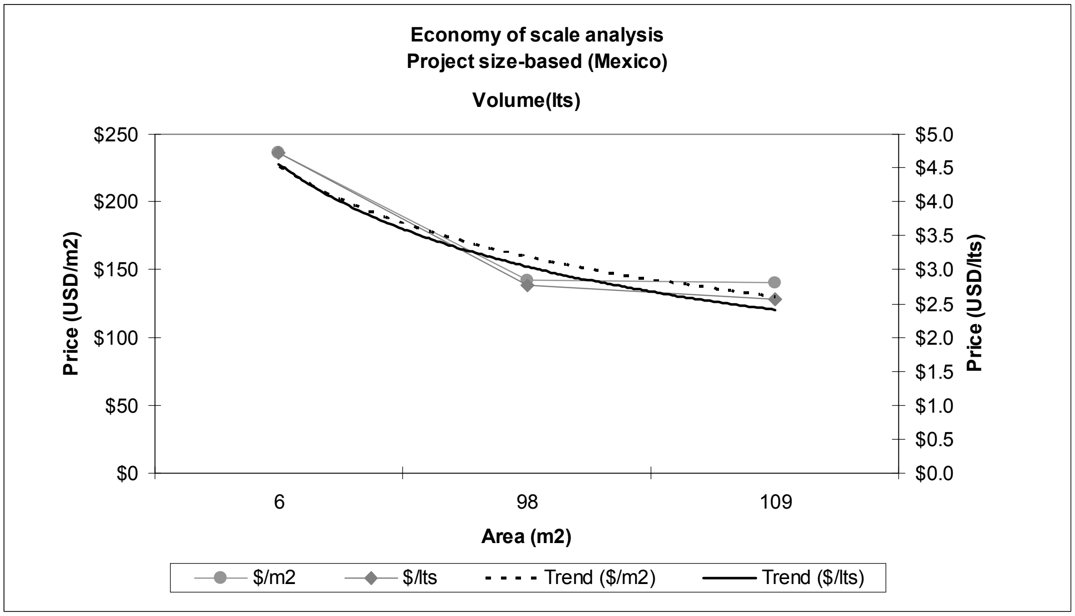

Figure 16 Economy of Scale of SWH Projects

Source: (Imprema, 2005)

6.4 Summary and Conclusions

Upfront capital costs are the biggest economic barrier for SWH projects in Mexico. To tackle this problem by using international and domestic policies is determinant for enhancing SWH market regardless the technological and institutional barriers faced. Such schemes should include capital grants and soft loans helping buyers to face investment barriers and allow them to perceive the SWH technology's benefits sooner.

Considering that economies of scale in SWH markets are mostly driven by domestic production costs and recognising Mexico's SWH production capacity is under used, higher market volumes could lead to a reduction on equipment costs abating investment barriers. Yet, under a business as usual scenario the production capacity would still be under use over the next 15 years diminishing the possibility to cut down equipment costs. Consequently, the implementation of support schemes for SWH market is determinant to increase its penetration and enhancement in the medium and long terms.

Such schemes, which would assure stable conditions for market development in the long term, combined with high competitiveness of the Mexican market (in terms of solar resource available and potential reduction of equipment costs) and the potential demand for this technology could drive new participants and investment streams into the market.

SWH diffusion in Mexico could reduce the cost of energy for hot water services between 30 and 40 percent. This will have a beneficial impact on low and medium income households and the overall economy.

7 International Dimension: CDM and SWH Technology

Chapter 7 analyses and discusses the relation between CDM and SWH technology in two mainstreams: the additionality of potential CDM-SWH projects and the competitiveness of such projects within the CDM framework in terms of risk to which are subjected. The additionality test consists on the identification of other technological alternatives available in Mexico and its comparison against SWH technology; and an analysis and discussion on how CDM may contribute to overcome investment, financial, technical and institutional barriers faced by SWH technology in Mexico. Moreover, the competitiveness of SWH within the CDM framework is determine by analysing and discussing several risks (host country, project and CDM process related) and the strategies to manage them.

7.1 Additionality Test

The objective of the additionality test is to find out what would be the GHG emissions (baseline scenario) if no CDM benefits were available. Therefore, the first step is to establish a GHG emissions baseline according with CDM-EB directives. Then project's participants must provide evidence that the project activity would not have occurred with out the support of the CDM due to at least one of the following barriers: investment, technological, institutional, lack of financial resources or organisation capacity among others. (UNFCCC, 2005e)

To prove the latter the CDM-EB suggests undertaking the following steps. Firstly, alternatives to the project activity must be identified since if no options are proven to exist the project is not additional. Secondly, either an investment or/and a barrier analysis needs to be develop to prove that the incentives provided by the CDM allow the project activity to occur reducing GHG emissions. Finally, the impact of CDM registration on the project activity must be assessed considering the overall costs and benefits.

This section identifies and discusses the possible alternatives to the potential SWH project subscribed under CDM. World Bank's Carbon Fund considers that alternatives may rise from: dissimilar options available to project participants or similar project developers;

projects with comparable qualities, properties and application area; the proposed project not undertaken as CDM project, or even different scenarios of the project activity. (Heister, 2005)

Conventional Technologies Used for Water Heating

Generally, consumers and household's developers prefer to install and use LPG or NG boilers to provide hot water services. Firstly, from the consumers' point of view it has been mention that these technologies have lower up front capital costs than SWH systems, usually fuel supply is not a problem, its operation is straight forward, and in case of boiler's failure manufacturers and retailers provide an efficient service and warranties to costumers. Secondly, households' developers prefer this technology since no highly qualified work force is needed for its installation and up front capital costs are smaller which increase their profits.

Consequently, since conventional technologies do not face the financial, technological and institutional barriers that SWH technology does, in many cases these are business as usual scenarios and in consequence and baselines for a potential CDM-SWH projects.

Technologies with Comparable Qualities

Other projects can be developed using technologies with comparable qualities. That is the case of heat pumps which are commonly used for district and pools water heating.

This technology provides between four and five units of energy output per unit of energy input, since it transfer the heat from the environment to the water. The installations costs represent around 30% of the upfront capital costs and the annual maintenance costs are around six percent of the capital costs. The operation costs depend on the local electricity tariffs.

In terms of energy consumption and GHG emissions heat pumps are more efficient than the LPG or NG commercial boilers, and competes directly against SWH technologies. Firstly, its installation and maintenance is faster and easier than solar systems. Secondly, although technical capacity is needed to install and operate the equipment, heat pumps manufacturers have developed very efficient customer services reducing the problems between retailers and users. Hence, project developers usually prefer this technology because it provides similar revenues than SWH technology with fewer efforts.

Since heat pumps require electricity to run projects using this technology can not avoid CO_2 emissions entirely like SWH systems do. Their GHG emissions depend on the shares and types of fuels used for electricity generation. Mexican electricity network produces 0.6539 kilograms of CO_2 equivalent per kWh produced. (Vázquez and Del Valle, 2005)

From this, even though heat pumps have lower GHG emissions reduction potential than SWH technologies they face fewer commercial barriers, diminishing the additionality of potential CDM-SWH projects.

Other potential alternatives may arise from either the development of the SWH project with out CDM incentives (which has been discussed before) or different scenarios of the CDM-SWH project (to be discussed in sections below).

7.2 Investment Analysis: CDM and SWH projects

It has been mentioned the need to perform a financial assessment to determine the potential additionality of CDM-SWH projects. This section analyses the financial impact of CDM's incentives on conventional SWH systems using the bottom-up financial model described previously in Chapter 6. In this sense, five financial features are considered (up front capital costs, net present value, relative price, internal rate of return of the consumer, and payback time) under several scenarios to determine the impact of key variables such as the price of CERs, crediting period, the form of payment agreed between the project developers and the CERs buyers; and the amount of SWH systems bundled into one project.

Specifically, the first three variables are related one to each other and are highly determined by the competitiveness of the project in terms of the risks it faces. Regardless the components of these risks (which are discussed latter) it can be expected that upfront payments will lead to lower CERs price since the buyer is taking all the risk. In addition, the longer the crediting period the lower the CER price as future revenues from CERs loose their present value according with the time and the discount rate agreed. Yet, longer crediting periods certainly increases CERs revenue for a CDM project.

7.2.1 CDM Impact on Financial Indicators

Up Front Capital Costs

Given that up front capital costs of SWH systems represent a barrier for the technology's deployment, it is of interest to analyse CER revenues in terms of its contribution in reducing up front capital costs. The Table 5 presents this relation under different scenarios sensible to the CERs price, length of crediting period and amount of GHG emissions reduced per SWH system[6].

Although previous studies state that the incentives of CDM could reduce up front capital costs between 4 and 17 percent, a lower price for SWH systems, and no discounted CER revenues are considered. Despite such difference it is clear that the additionality of the CDM on SWH projects is determined by the retail price of the systems, the hot water consumption habits, and the discount rate, crediting period and CER price agreed between the project developer and the CER buyer. (Milton and Kaufman, 2005)

GHG emissions reduction (tCO2/hh)	CER price (USD/tCO2) / Crediting period (yrs)	Price of system (USD)*	Estimated CER revenue from SWH system**			CER value as proportion of systems price		
			7	14	21	7	14	21
1.77	$3.00	$1,710	$28.88	$43.70	$51.31	1.69%	2.56%	3.00%
	$5.63		$54.20	$82.02	$96.29	3.17%	4.80%	5.63%
	$7.15		$68.84	$104.16	$122.29	4.02%	6.09%	7.15%
2.21	$3.00	$1,710	$35.61	$53.89	$63.27	2.08%	3.15%	3.70%
	$5.63		$66.83	$101.13	$118.73	3.91%	5.91%	6.94%
	$7.15		$84.88	$128.43	$150.78	4.96%	7.51%	8.82%
2.65	$3.00	$1,710	$42.60	$64.46	$75.68	2.49%	3.77%	4.42%
	$5.63		$79.94	$120.97	$142.02	4.67%	7.07%	8.30%
	$7.15		$101.53	$153.63	$180.36	5.94%	8.98%	**10.54%**

Table 5. Contribution of CERs Revenue to Upfront Capital Costs

Source: Bottom-up financial model. *No LPG backup considered. **No transaction costs considered

[6] The variation of GHG emissions reduction per SWH systems corresponds to the uncertainty of the hot water consumption per household. Therefore, the higher the GHG emissions reduction corresponds to low hot water consumption.

Net Present Value

It has been mentioned that despite the use of LPG boilers as backup for SWH systems, the cost per unit of energy delivered is always lower for SWH technologies under current fuel prices. Subsequently, this financial indicator illustrates the additionality of CDM in terms of a potential lower energy cost for households whom prefer to participate on a CDM-SWH project. Figure 17 shows a reduction of 3.68% on the cost per kilowatt hour delivered by a SWH system with LPG backup; representing better opportunities for project developers to establish financial schemes and increase the diffusion of SWH technologies.

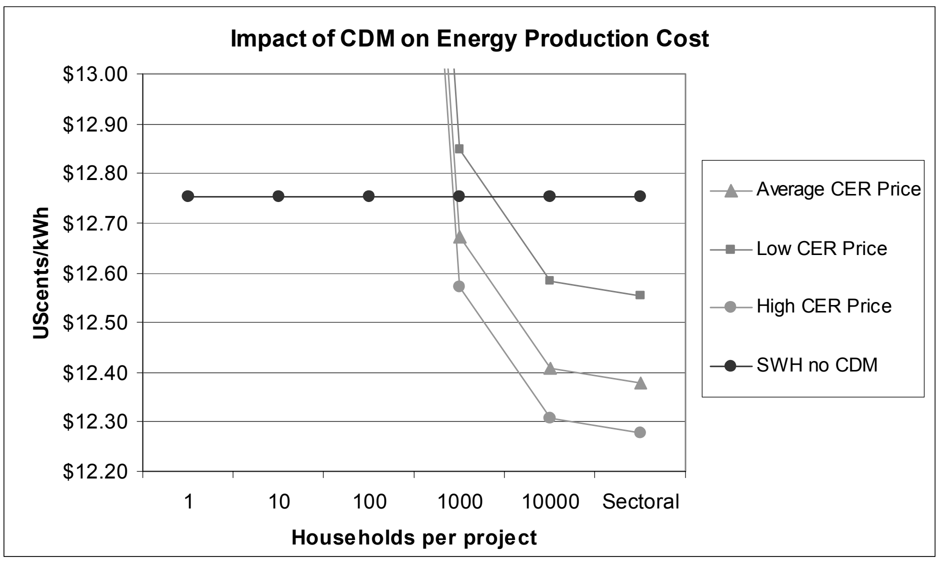

Figure 17 Impact of CDM on Energy Production Cost

Source: Bottom-up financial model.

IRR and Payback Time

As Figure 18 illustrate the profits from selling the CERs produced by SWH systems increase the IRR of the consumer. Yet, it must be considered that the improvement of the IRR is determined by the CERs price and the CDM transaction costs which are diminished when bundling several household's SWH systems.[7]

Under the assumptions made by the financial model the CDM is additional for SWH projects despite the existence of a LPG boiler as backup system. For instance, in the worst

[7] The model assumes that transaction costs for small scale CDM projects are 91,123 USD based on the literature reviewed.

scenario (SWH system with new LPG backup) CDM increases the IRR of the consumer of from 24.10% to a maximum of 25.52% considering a high price of CERs. Similarly, the payback time is slightly improved from 5.03 to 4.66 years.

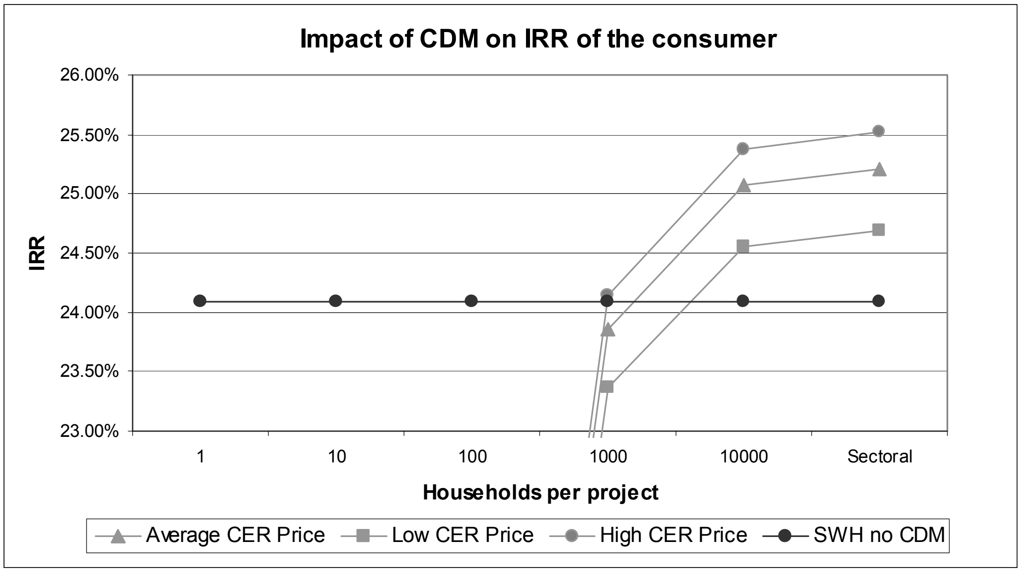

Figure 18 Impact of CDM on the IRR of the Consumer

Source: Bottom-up financial model.

<u>Relative Price</u>

The relative price SWH/LPG also improves 3.73% for SWH systems with LPG backup when CERs revenues are considered proving the additionality of CDM. Figure 19 illustrates that such improvement is determine by the CERs price and size of the CDM-SWH project.

This indicator has great importance to determine the potential diffusion of SWH technology if upfront capital costs were not a barrier. Hence, it can be expected that when removing this barrier a fast deployment of SWH technologies could be experienced if CDM incentives are available.

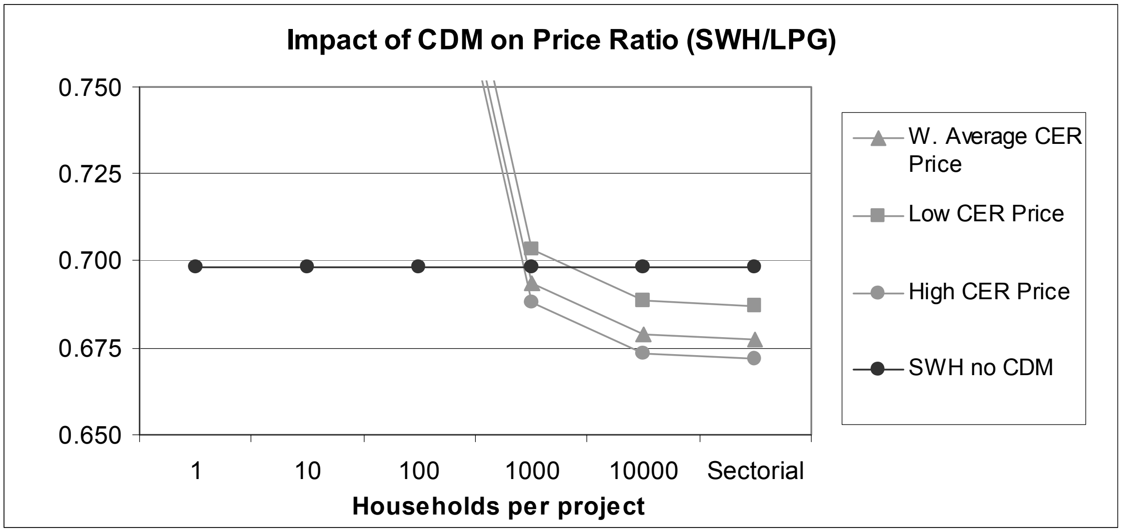

Figure 19 Impact of CDM on Price Ratio (SWH/LPG)

Source: Bottom-up financial model.

7.3 Barrier Analysis

It has been proven that potential CDM-SWH projects are additional as investment barriers are reduced. In practice that would be enough to continue with the project development under the CDM procedures. Yet, this mechanism helps to overcome other barriers faced by SWH technology in Mexico such as inexistent financial schemes, low quality of equipments and installations, absence of proper maintenance and lack of public awareness about the economic and environmental benefits of SWH technology. This section addresses the financial, technical, and institutional barriers that CDM could diminish enhancing the SWH market in Mexico.

7.3.1 Financial Barriers

CERs revenues represent a flow of foreign investment which could promote the establishment of several types of financial schemes depending on the nature of the transaction and the project. If the purchase of CERs is agreed as a commodity basis a payment on delivery scheme is likely to be established, hence the ERPA can be used by project developers as a warranty to access existent financial schemes more easily.

In contrast, the potential production of CERs by a specific CDM-SWH project may increase the interest of private participants in investing directly in the project and then take the CERs ownership as one product of their investment. Under this mode, upfront capital cost could be substantially reduce enhancing significantly the SWH market.

7.3.2 Technical Barriers

The annual certification of CERs requires a constant monitoring and verification of the project activity's performance during the crediting period. Then project developers willing to participate on the CDM will require increasing the quality standards of equipments and installations and establishing strategies to provide proper maintenance to SWH systems within the CDM project. These efforts will improve the public perception of the technology and eventually enhance market development by helping project developers to increase its revenues and share.

7.3.3 Institutional Barriers

If the size of a certain SWH project can not face the transaction costs on its own it will be required to bundle similar projects to make a CDM-SWH project which may reduce the transactions costs per tCO_2e. In some cases, this could require the cooperation among different project developers who compete against each other in the market, but find some benefits from bundling projects together. Despites how this mechanisms could operate, (Chapter 10 further address this issue) CDM promotes the generation of SWH market information and the improvement of its industry's organisational capacity in many ways such as developing and strengthening the chains of dealers and installers, improving its technical capacity or even financing project demonstrations of high quality SWH systems. (Milton and Kaufman, 2005)

7.4 Competitiveness of SWH Projects under CDM Framework

The validation and registration of a CDM project is not enough to for a CDM-SWH project to be successful since an ERPA has to be signed with a CERs buyer. This means all CDM-SWH projects will compete against other type of projects to get the money from CERs. Despite the fact that CDM market is facing a surplus of demand meaning a short in the supply of CDM projects, The lower the risks faces by the project, the more competitive a project is likely to be for CERs buyers.

Although the risks may vary between specific situations, SWH projects in Mexico face risks which reduce it competitiveness in the global market requiring strategies to manage and mitigate such risks. This section discusses the competitiveness of SWH projects based on three types of risks: host country, project and CDM process risks. (UNEP FI, 2005)

7.4.1 Risks Analysis

Host Country Risks

CDM projects face risks depending on the host country where they are developed. Issues such as the expropriation or nationalisation of project, potential war, national credit problems, new legislation either national or local, administrative bureaucracy among others may reduce the feasibility of the project in the long term. (UNEP FI, 2005)

Mexico is ranked among the five most attractive countries to invest in CDM projects after India, Brazil, Chile and China, considering the existent institutional framework conditions to approve CDM projects and government's attitude towards the CDM; the stability of capital and service markets and amount of FDI received; and the CDM potential as well as the number of projects approved by the DNA and registered by the CDM-EB. (Point Carbon, 2005a)

Since SWH market is completely privatised as well as the LPG retail market, the potential development of CDM-SWH projects in Mexico is not under peril unless dramatic changes occur on the climate change national policies and LPG regulations. Still, the actual initiatives promoted by the private and academic sectors aim to promote SWH technologies could undermine the additionality of projects under CDM (this issue is further discussed in Chapter 8).

SWH Project Risks

All types of CDM projects face risks according with its nature, jeopardising its performance along the crediting period and increasing the probability of non delivery of CERs. SWH projects are subject to specific risks.

An underperformance of SWH systems due to climate variations (e.g. solar radiation, ambient temperature, wind velocity, etc.), lower performance of equipment than assured by the manufacturer's specifications (this is of great importance in Mexico where most SWH manufacturers do not comply with any standard); smaller equipment's warranty period than crediting period, low quality installation; lack of maintenance (due to economic insolvency of the project developer or denied access from of the owner of the SWH system).

Higher costs (capital, maintenance and operation) than expected and change in macroeconomic situation (e.g. currency exchange rates, inflation, commercial loan rates, etc.) could lead to an economic insolvency of the developer endangering the performance of the project on the long run.

In addition, given the small scale of SWH systems, some CDM-SWH projects would exist only if small or medium sized projects are bundle aiming to reduce marginal transaction costs. Bundling may increase project's risks since the number of participants could be higher when bundled projects have been developed by different companies. In this case, risks grow exponentially depending on the number of participants.

CDM Process Risks

Besides host country and project related risks, activities subscribed under CDM face additional risks associated with the CDM process. According with UNEP Finance Initiative, the most important risks are the following:

1. The institutional barriers established by the DNA such as the lead times to approve the project and the compliance with the sustainable development criteria. In the case of Mexico, the DNA has established a lead time of 30 working days to approve any PDD and the sustainable development criteria has straight forward guidelines for compliance. (Semarnat, 2005)

2. The public consultation could delay the project during the validation process if nuisance is expected to occur by any member of the public. For SWH projects it is not expected to have any public opposition given the small environmental and social impacts of the technology for users and third parties.

3. Inaccurate monitoring or verification procedures. In the case of SWH projects the systems' owners could deny the access to maintain or monitor the system for any reason.

4. CDM-EB decisions which validate the development of baseline and monitoring methodologies establish the guidelines for project's registration and CERs issuance and modify the rules and procedures of CDM. This has resulted in long lead times which endanger the registration of the projects under CDM given the current eligibility criteria set by the Executive Board (this is further address in Chapter 9).

5. Once the CERs is issued, problems regarding the legal ownership of the certificates may become a risk for the project's implementation over the crediting period if ERPA or parallel contracts did not clarified this situation among the project participants from the beginning.

6. CDM faces a big risk regarding the lack signs from governments which signed and ratified the Kyoto Protocol to establish proper targets to mitigate GHG emissions after 2012. On this regard, little can be done directly, but proving its efficacy in complying with Kyoto targets is the best strategy to be followed by CDM market's participants (this is further address in Chapter 9).

7.4.2 Risk Management: Agreements and Contracts

Despite the model of the CERs transaction (commodity or equity investment), some of the risks describe above could be hedge by devising agreements and contracts between the project's participant.

Under the commodity mode it is recommended to sign an ERPA or CERSA which clearly define the risks taken by each party. This contract may consider either an advance payment or a sale on delivery and it should include a description of the conditions precedent, the sale of CERs and the mechanisms to solve disputes among parties in case of undelivered CERs. The conditions precedent are events which have to take place for the agreement to be effective and it may include the confirmation that both countries have ratified Kyoto, the registration of a national DNA, and receive all permits required by the government to proceed with the project implementation. (Monroy M, 2005)

CERs sale issues such as the type of commodity to be sold (CERs or ERs), amount and price of CERs, transfer and delivery mechanisms and invoicing and payment procedures should be considered by the contract among the project developer and the CERs buyer. On the other hand, under an equity investment model the investor assume all the risks related with project but it could get CERs at cost basis and expand its business. The latter will require additional contracts to be signed among participants besides the ERPA or CERSA. (Monroy M, 2005)

In either way, its is recommended to SWH project developers to hedge project-related risks by choosing reliable and solvent manufacturers, establishing liability agreements with manufacturers in case equipment's performance is under the specifications; barging longer warranty periods with manufacturers or estimate additional capital to retrofit malfunctioning equipments outside the warranty's conditions, increasing the quality standards of installations though technical education, and supervising suppliers, retailers and installers involved in the project. Also, assuring the correct maintenance of equipments through a correctly estimation the costs of the project along its lifetime and signing contracts with SWH systems' owners to avoid lack of cooperation during maintenance, monitoring and verification procedures; and contracting full coverage insurance for the SWH systems bundled as a project in case of damage by earthquake, extreme weather conditions or other natural causes.

7.5 Summary and Conclusions

Consumers and project developers have several alternatives to fulfil the water heating demand of households, either by using conventional LPG and NG boilers or more sophisticated technologies such as heat pumps. In most cases a potential CDM-SWH project would be additional under CDM rules as it provides the highest benefits in terms of GHG emission reductions and faces barriers other alternatives do not.

CDM incentives could reduce the investment barriers faced by SWH technology as CERs revenue may be used to reduce upfront capital costs. This would reduce the cost per unit of energy delivered, improve the IRR of the consumers, and cut back SWH systems payback time; motivating consumers with purchase power to switch from the conventional water heating systems to a SWH system, increasing the accessibility to financial schemes, while promoting the deployment of SWH technology as relative price is reduced.

Furthermore, CERs revenues may also be used to reduce technical and institutional barriers faced by SWH technology in Mexico as the implementation of CDM-SWH projects would require not only higher quality standards assuring its optimal performance over time, but also a stronger cooperation between project participants reducing project related risks and achieving successful aggregation and bundling of small and medium size projects.

Although SWH projects are subjected to several risks which may slice it competitiveness in the CDM market these could be manage by devising contracts and agreements among participants. Of great importance is the development of mechanisms and agreements to manage risks related to the aggregation and bundling of SWH systems into CDM projects and portfolios.

8 National Dimension: Domestic Policies and SWH Technology

Chapter 8 describes the policy making process undertaken by several stakeholders during the last years. Then, it analyses the current domestic policies, programs, and proposals made by the private and academic sectors; and their impact on SWH diffusion and CDM potential of SWH projects. In this sense, it is discussed how domestic policies may reduce the barriers faced by SWH technology and its influence on the additionality and competitiveness of potential CDM-SWH projects. Finally, successful domestic policies adopted in European countries are analysed and discussed with the same scope.

8.1 Policy Making Process for SWH Technology

Mexican companies and academic associations have begun to coordinate themselves to advocate in favour of the solar agenda with local and federal governments. In 2000, members of solar thermal and photovoltaic industries came together to create the Solar Energy Chapter within the organisational structure of National Chamber of the Transformation Industry (CANACINTRA). Moreover, the Solar Energy National Association (ANES) has been organising activities aimed to strength the industry such as the formulation of initiatives to establish solar thermal equipment standards, the organisation of technical workshops for solar thermal installers, and the promotion of solar energy among the general public. The ultimate goal of these efforts is to increase the market for solar thermal technology.

As a result of such activities several programs and initiatives have been set in place to support SWH technology. The National Commission for Energy Saving (CONAE), governmental institution in charge of renewable energy issues at national level, promoted the creation of an Advisory Council for the Promotion of Renewable Energy (COFER). This council seeks to advice the government in the formulation of policies to promote renewable energies across the country and is formed by representatives of several governmental, academic and private institutions. (CONAE, 1997)

In addition, CONAE implemented a three years Pilot Programme aimed to encourage the sales of solar thermal equipments, and gather information about the performance of SWH systems, the quality of the service of installers and satisfaction of consumers. The program also provides some benefits for the enrolled households, such as a five years warranty on the equipment and one year of free maintenance service (CONAE, 2003).

The current government of Mexico City is also promoting SWH technology by negotiating the installation of SWH systems in 50,000 homes over a five years period. This is part of city's strategy to improve air quality in the metropolitan area. This initiative has started with the development of a pilot project aim to install SWH systems in 5,000 households. (CAM, 2000 and The Climate Group 2005)

Although smaller in scale, similar ideas have been undertaken in the past and some of them have face great financial and technical problems. If this project is fully implemented considering earlier mistakes, it could help to deploy the SWH market in the residential sector very quickly.

Due to these efforts, several programs, policies and initiatives have been devised or proposed to enhance SWH market in Mexico. In the following sections it will be analysed and discussed the impact of each of them on SWH diffusion and the CDM potential of this technology.

8.2 Current Public Programs: Impacts on SWH Diffusion and CDM Potential

SWH Equipment and Installation Standards

Although this policy has no positive effect in overcoming investment or financial barriers it contributes directly to improve SWH systems' performance, leading to a greater acceptance of the technology among the public.

The improvement of quality standards of equipments and installations usually increases the costs for manufacturers and installers. Part of this costs could be transferred to final consumers by increasing the retail prices of SWH systems; however, given the high upfront capital costs already faced by consumers, such strategy could lead to a reduction of the market size, aggravating even more the manufacturers.

Consequently, it is estimated that the costs product of higher quality standards will be absorbed on its majority by manufacturers and installers. Still, this strategy improves costumer's service and in the long run increases the reliability of the SWH industry leading to an increment of SWH market's volume.

The establishment quality standards of equipment and installation would contribute directly in reducing the technology-related risks of SWH projects increasing its competitiveness regardless its registration under the CDM. Moreover, it does not attempt against the additionality of potential CDM-SWH projects since although institutional and social barriers are overcome in some degree, financial and investment barriers would still be present, holding consumers and households' developers from choosing SWH technologies over conventional fossil fuel boilers.

<u>Promotion of SWH Systems: CONAE's Pilot Programme</u>

This public programme is aimed to produce substantial information regarding the performance of SWH systems and the clients' satisfaction under different circumstances in order to devise an adequate national policy for SWH technology in the future. Hence, these kinds of programmes could have an indirect impact on the barriers faced by SWH technologies if proper public policies are set in place.

Public programmes with these characteristics should always be welcomed as they have no impact on the additionality of potential CDM-SWH projects in Mexico. On the contrary the information gathered should be use to devise national policies aimed to reduce the risks faced by SWH projects.

<u>Fuel Prices Related Policy</u>

Fuel prices may affect the competitiveness and diffusion of SWH projects against conventional LPG systems. In this sense, is relevant to explain briefly what is the government policy regarding this issue.

According with the Energy Regulation Commission (CRE), it is the duty of the Mexican government to determine the maximum retail price (or price cap) of LPG for consumers according with the economic situation. On the other hand, PEMEX establishes a retail price for commercial retailers based on the cost of LPG at Mount Belvieu, Texas which is the biggest market of this fuel in North America.[8]

Due to the highly volatile fuel prices during the last years and recognising that Mexican families depend on LPG to fulfil basic energy services, in March 2001 the government decided to set a price cap on this fuel to protect consumers. This cap is constantly changed depending on the degree of price's volatility and the government's effort to sustain the commercial benefit of LPG retailers (which has been aggravated only by inflation over the last three years). The Economy Ministry published in March 2005 the formula and figures related with this price which varies from 0.3572 to 0.4410 USD per litre. In Mexico City the price was set at 0.3931 USD per litre considering the retail price of PEMEX, plus transportation fees, commercial revenue for retailers and taxes. (T. de Jong, 2005 and SEGOB, 2005a)

Fuel price caps, such as the one established by the Mexican government on LPG and volatility of fossil fuels in the North America's market directly impacts the diffusion on SWH technology. The higher the annual increment on fuel prices (meaning either a lower price cap or higher fuel prices) the lower the relative price (SWH/LPG) and the higher the IRR of the SWH project. In other words, an increment on fuel prices indirectly improves SWH systems' profitability.

As illustrated by the Figure 20 this has an impact on the whole SWH market. Lower fuel costs could modify this situation although (see Figure 21) LPG prices should decrease al least 8% to revert this situation and such scenario is not likely to happen under present conditions.

[8] If PEMEX set a lower price for LPG to retailers than the one established in Mount Belvieu, Mexican retailers would have incentives to sell this fuel to the US market, causing a short of supply in Mexico.

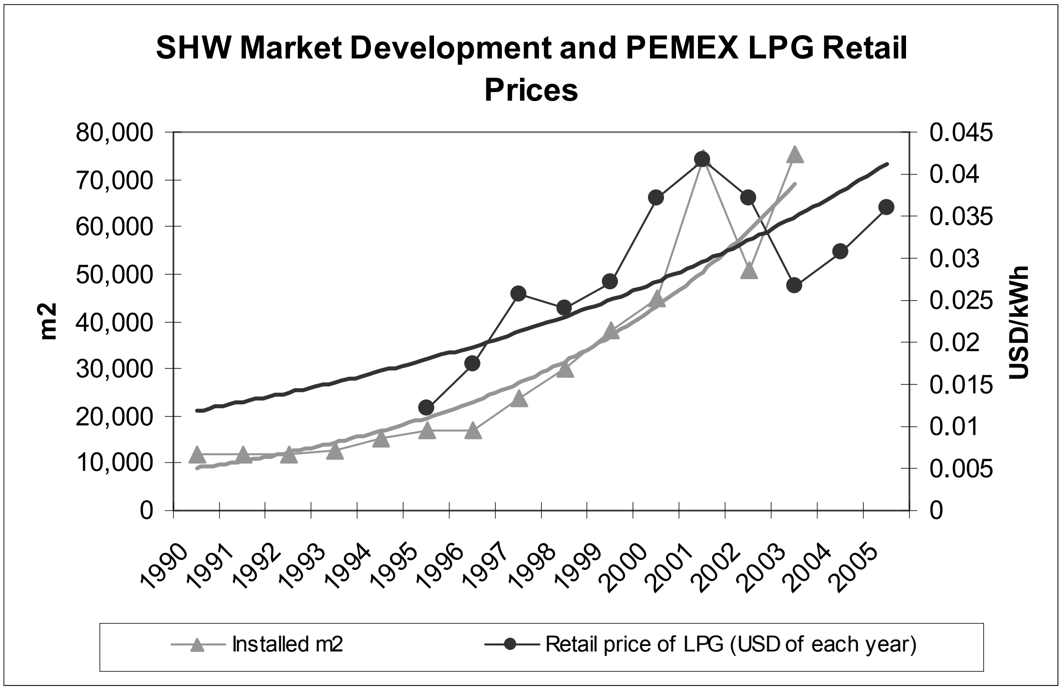

Figure 20 Relation between SWH Market and LPG Retail Price

Source: (PEMEX, 2005), (Quintanilla et al, 2000b) and (Martinez R, 2005)

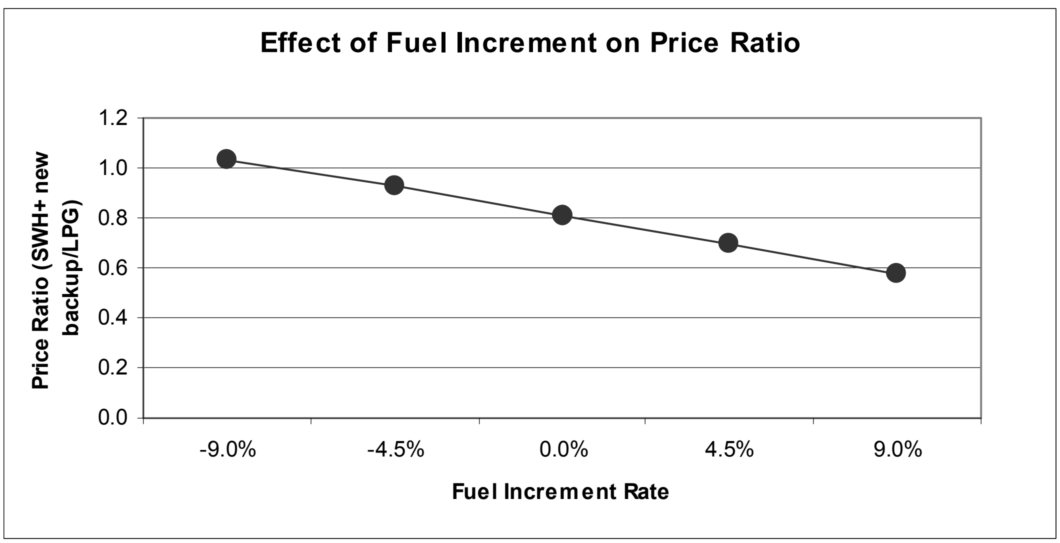

Figure 21 Effect of Fuel Increment on Price Ratio (SWH/LPG)

Source: Bottom-up Financial Model

Although the price cap is devised to protect consumers from volatile fuel markets, it must be recognised that the best long run strategy to protect consumers from volatile fuel prices is to find the way to reduce LPG consumption and SWH technologies provide such opportunity with additional environmental benefits.

8.3 Proposals: Impacts on SWH diffusion and CDM Potential

National Trust Fund for SWH

In 2000 The National Autonomous University of Mexico (UNAM) developed studies for World Bank to create a pilot programme aimed to install SWH systems on 320 households in Mexico City and Toluca (both in the central region of the country). Among the most important proposals of the study is the creation of a "National Trust Fund" to promote the deployment of SWH technology on large scale. This trust could be either public or private but with participation of government, academic, private and social institutions.

It was proposed that the "National Trust Fund" should use existent financial structures developed by the government (to collect taxes or electricity and water services), or commercial banks. This trust fund should be supported by several institutions such as Mexico City and State of Mexico governments, PEMEX, World Bank, Global Environmental Facility (GEF) and the Private Sector. It was estimated that each donor should give an initial support of 10 million of USD to the "National Trust Fund". (Quintanilla et. al. 2000b)

Although this mechanism could be useful to deploy SWH systems in old households, UNAM's study also recognise that the credit schemes structured for new household loans has been very useful in the past to finance SWH technologies as an additional appliance of new homes.

A trust fund either public or private provides the opportunity to establish financial schemes overcoming the high upfront capital costs faced by potential consumers interested on SWH systems, but with no capital capacity to invest on this technology. Technical and institutional barriers are not necessarily removed through a trust fund, although its operational policies can promote the development of technical capacity among manufacturers and installers.

Nevertheless, the effectiveness of the trust fund depend entirely on the operational policies, the management costs, the expected return on the investment of supporters and the financial scheme used. A poorly managed trust fund could increase the costs of SWH technology for consumers, diminishing the benefits of this scheme and the technology provided.

Overall, a trust fund aimed to promote the deployment of SWH technology is a good strategy to remove investment and financial obstacles and could contribute significantly in diminishing some technical and institutional barriers if proper operational rules are established.

The creation of a trust fund aimed to promote the deployment of SWH could reduce the additionality of some CDM-SWH projects under the current project-based approach of CDM since it may reduce the investment and financial barriers faced by the SWH technology. Nevertheless, a case by case analysis should be done determining if SWH systems are in fact the most attractive option for households' developers and consumers when the financial schemes provided by the trust fund are used. The latter given that the managing cost, operational rules of the trust fund or even technological and institutional barriers could drive consumers to prefer conventional LPG and NG systems.

Under a sectoral or policy-driven CDM approch CERs benefits could still be canalised through this support scheme to final consumers reducing project related risks and improving the competitiveness of CDM-SWH projects (this is further discussed in Chapters 9 and 10).

Indirect Support and Capital Grants

Indirect support and capital grants to enhance SWH market have not been used at national level. Yet, Mexico City's government established a tax deducible regime for low pollutant technologies through which several local taxes such as labour and land fiscal burdens can be reduced for SWH owners including households, commercial and industrial buildings. As explain further in this Chapter, capital grants could enhance SWH market in Mexico based on experiences in other countries.

Although this type of support scheme directly reduce the investment barriers faced by SWH technology, it would not challenge the additionality of potential CDM-SWH projects as long as it is prove that conventional LPG systems are not subjected to similar barriers.

Compulsory Use of SWH Technologies

Efforts have been made by several private and academic stakeholders to devise compulsory regulations to enforce the installation of SWH systems in specific sectors such as low income households' developments and private and public sports facilities. Until now, no regulations with these characteristics have been approved at local or national levels, yet as it will be discussed further, this type of regulations most be framed within an integral policy to avoid undesirable effects in the long term.

Given the present discussions within the CDM-EB regarding the policy driven approach for CDM projects, it is difficult to determine the extent on which this type of support could undermine the additionality of SWH projects in Mexico. Under a conservative interpretation of current CDM's rules and definitions a compulsory use of SWH technologies would not be additional since it could become the business as usual scenario; however, in order to support domestic action the CDM-EB stated any policy promoted after 2000 would not be consider undermining additionality. Finally, this policy does not reduce the project related risks by itself; on the contrary, they could be enhanced if no integral policy framework is set up in coordination with it.

8.4 Review of Successful Policies for SWH Technology Deployment

Capital Grants

As mentioned above, capital grants have not been established in Mexico, yet a revision of its application in some countries is relevant to understand its impact on SWH markets. In several European countries, direct incentives, such as capital grants and tax deductions for SWH technology have been set in place to reduce investment barriers and enhance the market.

For instance, during the 1990's in Austria national and local governments provided direct support to SWH systems for households and commercial buildings where up to 30% of the up front capital costs were subsidised. Other incentives were available such as a tax deducible regime for SWH technologies on annual income statement. These policies represent an overall annual support of 3 million euros which allowed the state to control the quality of equipments installed and increased the penetration of SWH technology in the country from 18,000m^2 installed in 1989 to over 150,000m^2 in 2000. (ESTIF, 2003b)

Moreover, UK government established the Program "Clear Skies" aimed to promote the development of renewable energies. In the case of SWH technologies households may receive a 500 pounds grant per equipment regardless its size representing around 30% of investment costs. Similarly, Italian authorities provide grants to cover up to 30% of capital costs for SWH systems in households. This program is co-financed between regional and national governments. (Clear Skies, 2005 and ESTIF, 2003b)

Although capital grants require substantial budget from national and local governments it is the one of the most effective schemes to tackle the high upfront capital costs face by SWH projects. In all cases the drivers behind these initiatives are the diversification of energy resources, the increment on security of supply or strong commitments to support renewable energies reducing CO_2 emissions.

Compulsory Use of SWH Technologies

The compulsory use SWH technology is an effective strategy to promote the deployment of renewable technology at a large scale. Yet, it does not provide by itself the means to tackle either investment, financial, technological or institutional barriers. Such a strategy would need to work within a policy framework for SWH technology that is devised with the participation of all stakeholders involved, and considers the improvement of quality standards, and financial schemes aimed to remove barriers while market is developed.

For instance, the SWH market in Barcelona, Spain has been enhanced strongly due to the implementation of a solar thermal ordinance, in force since 2000. This law requires the compulsory installation of SWH systems to supply at least 60% of hot water demand in new and rehabilitated residential building with more than 14 homes, hospitals, clinics, schools, hotels, shopping centres and swimming pools. If compliance is no achieved fines can reach up to 3 million euros. (Stirzaker P, 2004)

This statutory law has not only enhance SWH market in Barcelona providing environmental and long term economic benefits to consumers, but also is a model for other

Spanish cities and municipalities. Yet, the reasons behind its success must be analysed carefully since is not the compulsory installation of SWH systems what triggers the development of the market, but its integration within a wider policy framework for SWH technology.

The solar thermal ordinance in Spain is accompanied with compulsory quality standards for SWH equipments and certification of installers. Additionally, a wide range of financial schemes are available for final consumers and property developers. These include an interest free financial scheme and credit backups of up to 70% of capital investment offered by the Spanish Institute for Diversification and Energy Saving (IDAE) in partnership with Official Credit Institute (ICO). Regional and local authorities also provide financial credits and tax relief programs for property developers and SWH systems' owners. (Stirzaker P, 2004)

Moreover, authorities in charge of devising and improving this statutory regulation consider seriously the inclusion of stakeholders' perspectives and ideas with in the policy framework. By doing so, the implementation costs of the regulation were distributed among participants in a fairly way. In the long term this enhances confidence among property developers, architects, financial institutions, SWH manufacturers and installers, and consumers.

If compulsory regulations in Mexico are done differently from the Spanish experience, the whole SWH market could be dragged into a perverse cycle featured by high upfront costs, low quality equipments and services, and low benefits for costumers. In the long term, this situation could cause a permanent lack of confidence in SWH technology and stakeholders who supported such regulation with out a proper analysis.

8.5 Summary and Conclusions

Current domestic policies aimed to enhance SWH technology in Mexico have a long way to go before achieving a large scale deployment of SWH technology. Yet, the increasingly participation and cooperation among stakeholders, the improvement of quality standards and the proposals developed by the academic community show that right steps have been made to devise an integral policy framework for SWH technology.

This framework should include a wide range of support schemes at domestic and local levels, from compulsory certification of equipments and installers to financial schemes and capital grants making SWH technology more attractive to consumers and households' developers.

There is a wide range of policies at hand which could be use to boost SWH technology, while promoting the use of international mechanisms like the CDM. Of special interest are capital grants and compulsory regulations which have proven to be effective strategies to increasing the penetration of SWH technology in European markets.

Special attention must be taken on fuel prices related policies as they have been the main indirect economic driver behind the development of the SWH market in Mexico. Considering the economic and environmental benefits provided by SWH technology more efforts are to be done on this matter balancing the playing field for renewable energies.

Finally, the existence of international mechanism like CDM should be considered when devising domestic policies not only because statutory regulations and support schemes could weaken the potential of SWH projects to get financial support through these instruments, but also since project-related risks could be diminished with specific policies increasing the competitiveness of SWH technology in international markets.

9 Combined Efforts: CDM and Domestic Policies

In previous chapters it has been analysed and discussed separately the impact of international instruments like CDM and domestic policies on diminishing the barriers faced by SWH technology in Mexico. This chapter addresses the combined impact CDM incentives and domestic polices could have on removing investment, financial, technical and institutional barriers holding SWH market deployment. In this sense, the impact on investment barriers is analysed by combining the revenue from CERs and capital grants as one of the most effective support schemes to tackle upfront capital costs.

Finally, it is discussed the challenges imposed by the CDM framework in developing CDM-SWH projects. These include the post Kyoto uncertainty, the eligibility criteria for CDM projects, and the current project based approach of CDM; and other issues related with the identification and development of potential CDM-SWH projects such as the need of bundling or aggregating a wide range of projects within a portfolio to reduce transaction costs, and develop capacity for CDM among the private, academic and governmental sectors to succeed on structuring projects.

9.1 Impact on Investment Barriers

Several European countries use capital grants as one of the main support schemes to increase the penetration of SWH technology in the energy market. The effectiveness of this scheme relays on the fact that it has a positive impact on all the financial indicators of SWH projects. CDM incentives have similar effect when improving such indicators. This section addresses the combined effect of capital grants and the CDM incentives on the economics of SWH projects.

Upfront Capital Costs

As reviewed previously, capital grants in European countries usually represent up to 30% of the upfront investment. Figure 22 illustrates the improvement of the upfront capital costs ratio from a business as usual scenario to a 10, 20 and 30 percent of capital grant and CDM incentives assuming a CER price of 7.15 USD/tCO_2e. Yet, the upfront capital cost barrier is far from being eliminated as under the best scenario SWH systems still are around two times more expensive than conventional LPG systems.

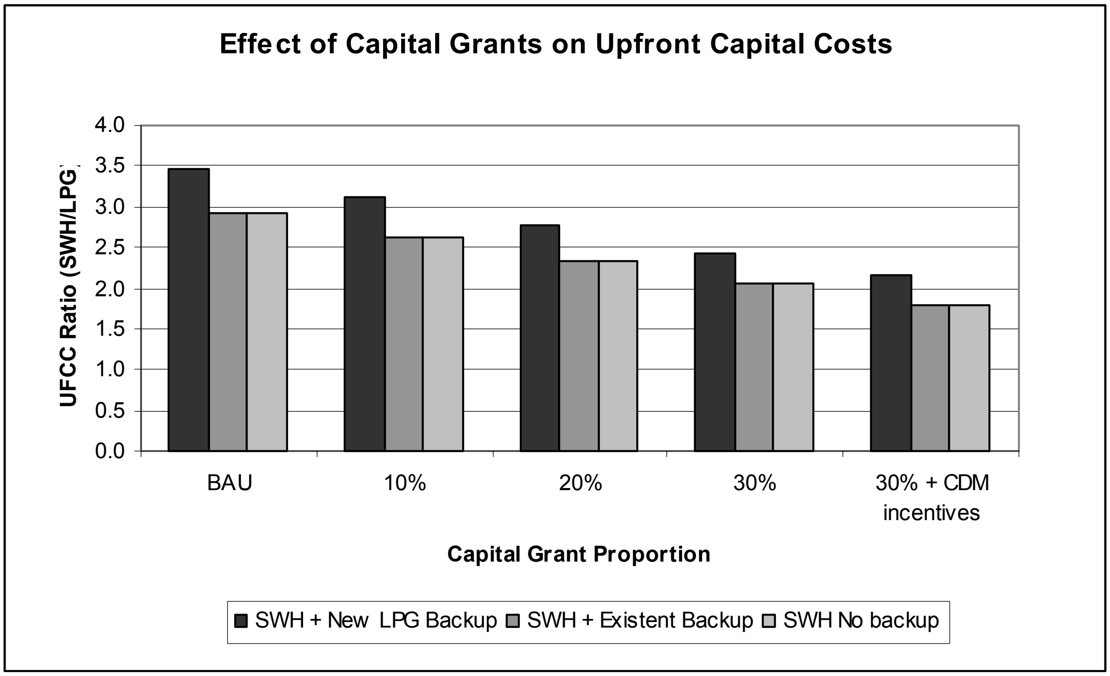

Figure 22 Effect of Capital Grants on Upfront Capital Costs
Source: Bottom-up financial model

However, the combination of CDM incentives and capital grants may allow high and medium income families to invest on SWH systems as a result of lower capital costs. In addition, if parallel financial schemes are devised to eliminate the financial gap, SWH systems could compete directly with LPG systems (see Figure 23). Only as a reference, the red dashed line represents the annual expenditure on water, energy services and home refurbishment of an average medium income household in Mexico in year 2002.[9](INEGI, 2005)

For the average Mexican family the access to capital grants, CDM incentives and proper financial schemes is even more important as in 2002 the annual expenditure on water, energy services and home refurbishment was 680 USD, implying that even the purchase of

[9] The fact that the annual average expenditure corresponds to upfront costs of SWH and LPG systems is just a coincidence with no causal relation between them.

an LPG system represents a strong investment driving families to choose cheaper fuels like wood. If proper incentives are set in place low income households, which are economically restrained to access this service, could fulfil its needs by using SWH technology.

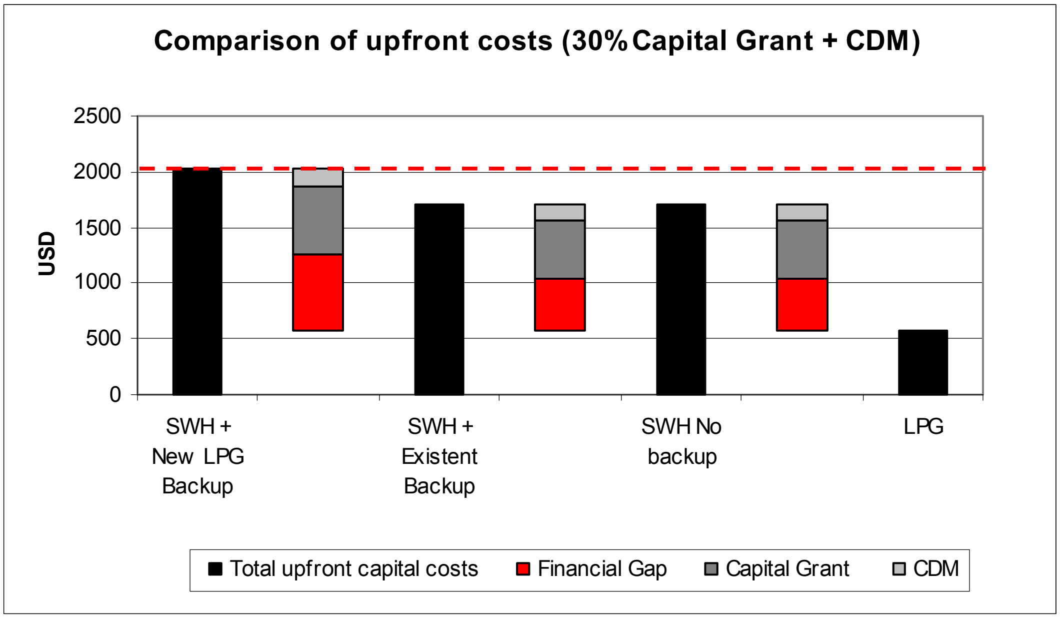

Figure 23 Comparison of Upfront Costs (BAU vs. Combined Efforts)
Source: Bottom-up financial model

Net Present Value and Relative Price

Capital grants and CDM incentives also impact directly the overall costs (capital, maintenance, operation and fuel) of the project. As shown on Figure 24 when all costs are considered at net present value the long term economic benefit of SWH technology is even bigger compared with a LPG project. This has important implications for consumers since households with access to water heating services will reduce their expenditure on energy.

Although lower in magnitude than capital grants, CDM incentives impacts SWH projects in the same way improving the competitiveness of the technology in the Mexican market and reducing even more the energy delivery cost for households and beneficiating the overall economy.

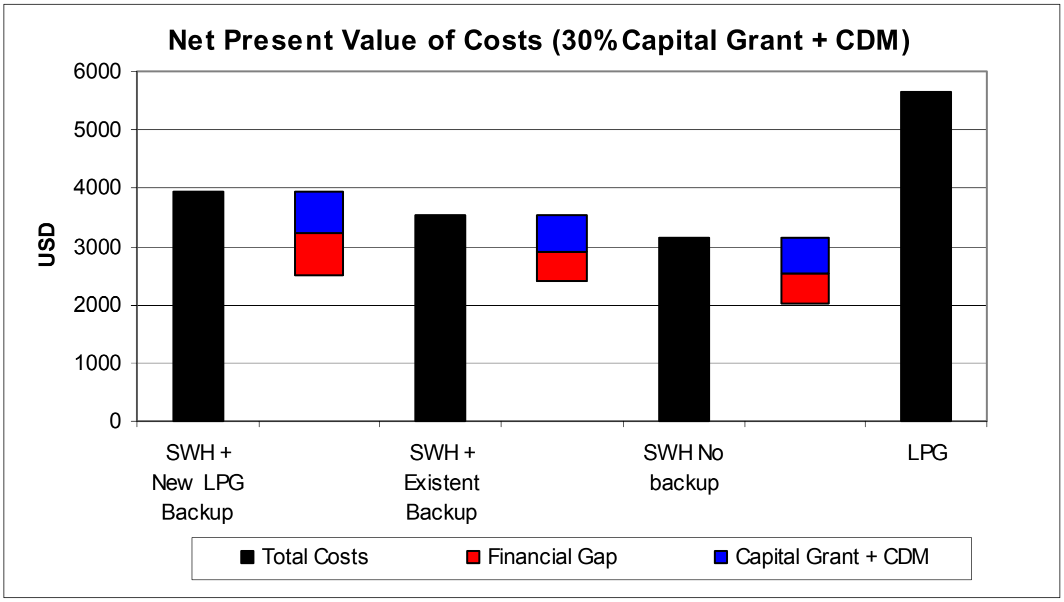

Figure 24 Net Present Value of Costs (BAU vs. Combined Efforts)

Source: Bottom-up financial model

Figures 25 illustrates how the costs per unit of energy delivered by a SWH system with LPG backup could be reduced up to 18.27% if capital grants and CDM incentives were combined. Consequently, relative price (see Figures 26) could be reduced from 0.67 to 0.57. Obviously, CDM incentives face scale-related restrictions as CDM-SWH project with less than 1000 households would not be viable due to current transactions costs.

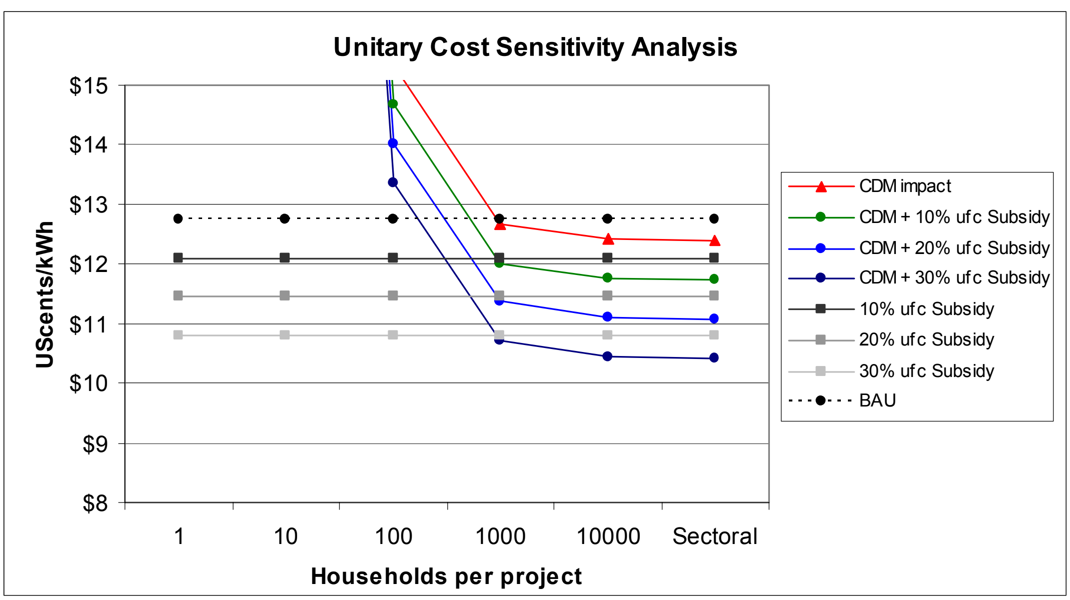

Figure 25 Combined Efforts (Unitary Cost Sensitivity Analysis)

Source: Bottom-up financial model

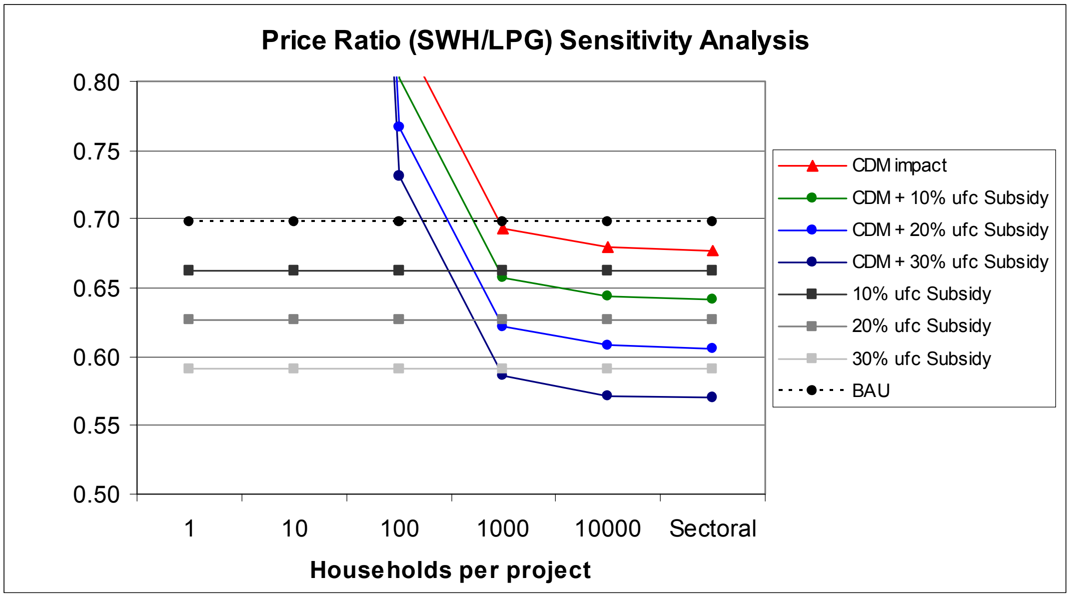

Figure 26 Combined Efforts (Price Ratio Sensitivity Analysis)

Source: Bottom-up financial model

<u>Return of the Investment on SWH Technologies</u>

The benefits of combining capital grants and CDM are can be observed by analysing the IRR of SWH projects. Although under a business as usual scenario the IRR is attractive, capital costs represent a high risk for consumers driving them to choose the LPG system which is more expensive in the long term. Yet, capital grants and CDM incentives diminish this barrier and also improve the IRR of the SWH options, increasing the attractiveness of this technology for consumers.

As shown on Figure 27 the attractiveness of SWH technology increase at an exponential rate when increasing linearly the proportion of capital grants. Similarly, higher capital grants also increase exponentially the benefits provided by CDM incentives. This not only proves the effectiveness this support scheme has on increasing SWH diffusion, but also demonstrates the beneficial effect of CDM and domestic polices when facing investment barriers.

Higher IRR of projects also mean lower payback times of SWH technology. This effect is illustrated on Figure 28 where the payback time of a SWH system with new LPG backup is substantially reduced from 5.03 to 2.34 due to the combination of capital grants and large aggregation of SWH systems into one CDM-SWH project.

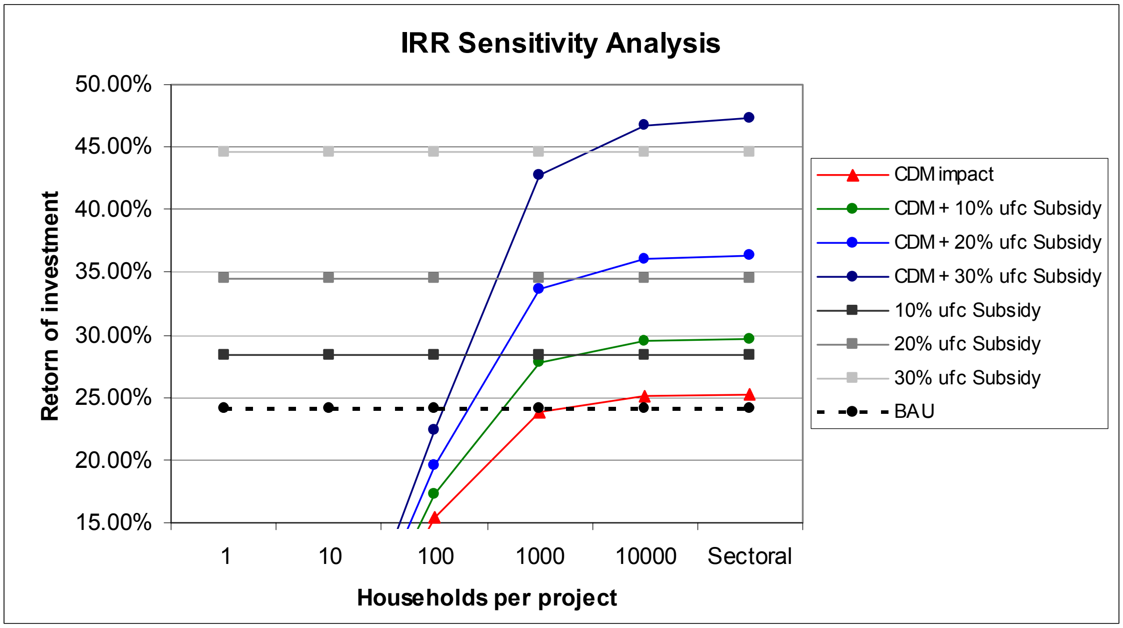

Figure 27 Combined Efforts (IRR Sensitivity Analysis)

Source: Bottom-up financial model

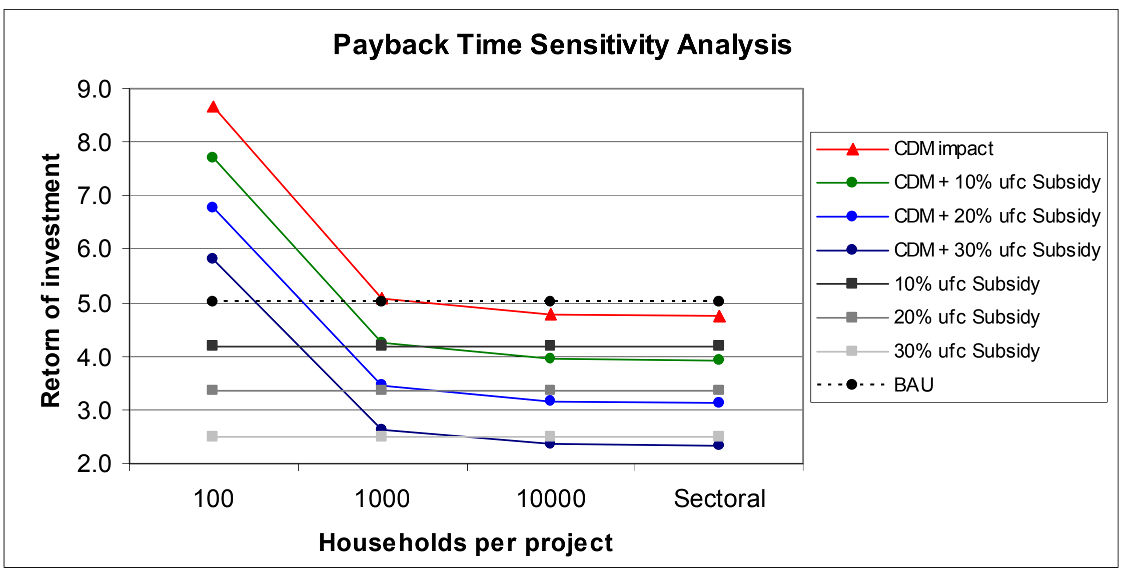

Figure 28 Combined Efforts (Unitary Cost Sensitivity Analysis)

Source: Bottom-up financial model

9.2 Combine Impact on Other Barriers

Financial Barriers

The establishment of *ad hoc* financial mechanisms like soft loans, leasing and ESCO or the use of existent instruments such as commercial loans or housing credit schemes is determinant to deploy SWH technology at a large scale. CDM incentives could be use to facilitate project developers accessing to this schemes since they represent a flow of foreign investment.

If the CDM transaction is made under a commodity mode, developers may use the ERPA as a guaranty to access existent financial schemes. In the contrary, under an investment mode CERs buyers would provide money directly to the project which could be use, among other things, to cover part of the financial interests avoiding an increment of costs for the consumer.

In either way CDM incentives clearly supports the financial schemes that would have to be developed to increase the penetration of SWH technology. Yet the design of innovative mechanisms and institutions able to integrate financial schemes with CDM incentives are determinant for achieving a successful deployment of SWH technology (this is further addressed in Chapter 10).

Technical barriers

The combination of domestic policies and CDM incentives has important benefits in eliminating technical barriers face by SWH technology. This relation can be analysed from different perspectives.

Firstly, as mentioned in Chapter 8, even though compulsory quality standards are needed they could represent higher production and installation costs for manufacturers and installers, then CERs revenues could reduce these costs either by investing directly on standards improvement or indirectly by diminishing investment barriers for consumers which consequently could increase market volumes and reduce overall costs. Since market would take some time to develop, in the short and medium terms this efforts could be support by governmental initiatives through deducible tax regimes for consumers who buy SWH systems from certified manufacturers and installers.

Secondly, the enrolment of manufactures and installers on developing CDM-SWH projects requires the voluntary improvement of quality standards as CERs delivery risks would be diminished. Moreover, annual monitoring and verification activities required by CDM-EB represent and opportunity for installers to devise proper maintenance plans including part of the costs within the transaction costs of CDM.

As a result, compulsory quality standards and CDM requirements and incentives reinforce each other improving the performance of the equipments in the long run, increasing the feasibility of CDM-SWH projects and beneficiating the consumers and the public perception of the technology.

Institutional Barriers

Domestic policies and CDM incentives could also reduce institutional barriers face by manufacturers and installers, and the overall SWH industry. On the company level, CDM incentives could be use to strength distribution and retail networks by investing CERs revenues on extending the network or increasing its technical capacity, and using such networks to develop a join pool of SWH projects which could be use to ensemble a CDM-SWH portfolio. (Milton and Kaufman, 2005)

Institutional barriers faced by the SWH industry as a whole could also be diminish if initiatives such as the trust fund for SWH promotion were developed considering CDM. These instruments could not only establish support schemes, but also generate more detail information about the market, promote the technology by financing SWH project demonstrations, raising awareness among the public, and advocating for SWH industry interests with governmental and other private sectors. (Milton and Kaufman, 2005)

Although the development of CDM-SWH projects face several challenges which are discussed on detail in the next section, domestic policies and initiatives like the trust fund could contribute on solving these challenges, while increasing the funds available for support schemes by selling CERs.

9.3 Challenges and Barriers for CDM-SWH Projects Development

Strong efforts have been made by the CDM-EB to reduce the transaction costs faced by SSC-CDM projects and enhance their competitiveness when fostering registration. In the case of SWH projects, the SSC methodology AMS-I.C. (Thermal energy for the user) certainly facilitates the registration of SWH projects. For instance, simplified procedures to develop baseline and monitoring methodologies, and bundling related definitions allow SWH project activities to be structured easier and then grouped under one project activity or portfolio as long as the distinctive characteristics of each component (e.g. technology/measurement, location and application of simplified baseline methodology) remain the same.

However, the development of large amounts of successful CDM-SWH projects face challenges and barriers related with the scale of SWH technology and current rules and procedures of the CDM such as the bundling and aggregation of projects to face CDM transaction costs and meet the criteria established by funds and facilities, the strategies to perform accurate and low cost monitoring and verification activities; the eligibility criteria for CDM projects, the uncertain existence of CDM after 2012, and the current project-based approach of CDM.

9.3.1 Bundling, Monitoring and Verification

The implementation CDM-SWH projects which have a low GHG emission reduction potential individually (between 1.77 and 2.65 tCO_2/yr per household), but a large one if aggregated, require to either bundle large amounts SWH systems or aggregate them with other type of project activities such as efficient lighting, isolation improvement, and saving water devices in households. (Milton and Kaufman, 2005 and Monwabisi, 2003)

As mentioned earlier, CDM projects face transaction costs related to the identification of opportunities, documentation and validation of baselines, monitoring and verification plans during the crediting period, and registration of the project with CDM-EB. For small scale projects, Milton and Kaufman (2005) and Krey (2005) estimate these costs to be between

90,000 and 100,000 US dollars. Hence, according to the financial model developed the minimum size of CDM-SWH project would have to be around 1000 households (2,800MWhr/yr) reducing marginal transaction cost down to less than 10 US cents/tCO_2e and maximising the profit from the CERs.

Although this limit is not difficult to accomplish in practice the eligibility criteria of international funds and facilities is an additional problem when setting the minimum size of a CDM-SWH project. In order to cover its internal costs, most funds and facilities will only show interest for projects and portfolios which represent over a 100,000 tCO_2e/yr. Even the Community Development Carbon Fund (CDCF) managed by the World Bank accepts only transactions above 30,000 tCO_2e/yr. (Milton and Kaufman, 2005) This situation increase even more the challenge for SWH project developers whom would have to structure portfolios as big as 14,000 SWH systems with an overall energy output of 39,200MWhr/yr. Given the current state of the SWH market in Mexico (see Chapter 5) portfolios this big represent about 20% of the energy produced in all applications by SWH technology in 2003.

The aggregation of several types of projects with GHG emission reduction potential is other way to meet funds and facilities requirements. This is the case of the "Kuyasa low-cost urban housing energy upgrade project" developed by Cape Town's authorities in South Africa. The project aggregates three low carbon activities (insulated ceilings, SWH systems and energy efficient lighting) in the construction of more than 6,000 households and the retrofitting of all low-cost housing units in the area. It is expected to reduce 2.846tCO_2e/yr per household which represent at least 17,000tCO_2e/yr considering new houses only. (Monwabisi, 2003)

Strong institutional capacity and high degree of cooperation is needed within the SWH industry to identify and bundle medium and small scale SWH projects on a quick and effective way or develop projects with enough size to meet transaction costs and funds' criteria. In some cases several small or medium SWH developers (which actually compete on daily basis) would have to come together in structuring portfolios to take advantage from CDM incentives

Either bundled or aggregated, the number of participants needed to structure projects and portfolios would rise, increasing the costs and complexities of agreements aimed to assign responsibilities, liabilities and benefits among parties (CERs ownership included) and manage the risks related with each project within the portfolio.

Moreover, monitoring and verification plans have to be established for each component to confirm all SWH systems are performing adequately and CERs are being delivered along the crediting period agreed. This involves the enhancement of accurate measure techniques and the development of technical skills among participants' personnel. Strong institutional and technical efforts are to be done in this regard to avoid an increment of transaction costs.

9.3.2 Eligibility criteria and Post Kyoto uncertainty

The eligibility criteria for CDM projects for the first commitment period (2008-2012) established by the COP and the CDM-EB, and the uncertainty about the rules or even the existence of CDM for the second commitment period (after 2012) add more challenges to CDM-SWH projects' developers.

The eligibility criteria for CDM projects agreed on the Marrakech Accords states that "…a project activity starting as of the year 2000… shall be eligible for validation and registration as a clean development mechanism project activity if submitted for registration before 31 December 2005. If registered, the crediting period for such project activities may start prior to the date of its registration but not earlier than 1 January 2000…" (UNFCCC, 2005a: p.5) If this is not the case, the "…crediting period may only start after the date of registration of the proposed activity as a CDM project activity." (UNFCCC, 2005g: p.10)

Up to date there is not information regarding the validation of any CDM-SWH project in Mexico and given the challenges mentioned above it is unlikely to see a registered project within the next three months being able to credit CERs for its operation in the past years. Consequently, all SWH projects developed up to date would not be eligible for CDM registration.

Given Kyoto's first commitments are to be complied within the 2008-2012 period, the window of opportunity to develop CDM-SWH projects could be reduced after 2008 if CDM is not providing enough CERs to meet Annex I countries' targets as they will look to fulfil their obligations by devising domestic policies and buying ERUs from Joint Implementation projects and AAU from Russia and Ukraine.

This international context on which CDM projects are to be developed increases the importance of creating CDM capacity within the SWH industry in Mexico so CDM-SWH projects and portfolios can be structured, validated and registered before the window of opportunity is closed.

9.3.3 Project-based Approach of CDM

Although capital grants and credit schemes not necessarily undermine the additionality of potential CDM-SWH, the revision of the Spanish case have shown that a compulsory regulation for SWH promotion is one the most likely outcome after structuring a policy framework for SWH technology. In fact, the compulsory installation of this technology in households combined with adequate financial schemes could improve the standards of living and economy of low income families, while reducing the environmental impacts of water heating energy services. Still, the establishment of compulsory regulations would eliminate the possibility of SWH projects to prove its additionality under the current project-based approach of CDM.

Moreover, it would be impossible in practice to bundle or aggregate every SWH system installed into a CDM-SWH project or portfolio fulfilling the project-based CDM requirements as the spatial dispersion of SWH systems, and the large numbers of suppliers and consumers involved would result in a very complex and costly bundling process reducing CDM's capability to finance SWH technology.

Overall, the current project-based approach represent a barrier for CDM-SWH projects' development as it does not allow taking full advantage of the financial capability of CDM and deter the possibility of combining CDM incentives with domestic policies like compulsory regulations. What is more, the implementation of CDM-SWH projects in Mexico under a project-based approach faces the same institutional and technical challenges as the sectoral/policy driven CDM based on Samaniego and Figueres (2002) findings (see Chapter 4).

If the deployment of SWH technology requires the integration of a domestic policy framework and the efforts needed to take advantage from CDM incentives are the same regardless the approach of the mechanism, then SWH technology in Mexico represents a solid case for allowing the existence of a sectoral or policy driven CDM since its benefits contribute on unleashing the full potential of SWH technology.

If correctly designed, a sectoral CDM project or portfolio could eliminate the barriers set by the transaction costs allowing all manufacturers and installers to aggregate their SWH systems within the project regardless its size and location. This would allow all consumers to enjoy the benefits of CDM in one way or the other.

Obviously, sectoral GHG inventories, right procedures and rules within the project/portfolio would have to be developed assuring additionality and determining the criteria to subscribe SWH systems on the portfolio. Besides, it is of great importance to establishment of strategies aimed to assuring the establishment of monitoring and verification plans; avoiding cheating, streaming CDM incentives in a fair way among participants; hedging risks if some participants do not deliver CERs on time and quantity and allowing the integration of these incentives with other support schemes such as capital grants and soft loans (this is further addressed in Chapter 10).

Moreover, the development of regional CDM projects as the proposed for Mexico City should consider a profound analysis of the current situation and features of each technology avoiding the formulation of any rule or procedure (or the lack of it) which could diminish participants' capacity of claming benefits from CDM.

9.4 Summary and Conclusions

The combination of domestic policies like capital grants with CDM incentives could reduce substantially the investment barriers faced by SWH technology and improve Mexican households' economy by reducing the costs of energy delivered for water heating services. Furthermore, the additionality of potential CDM-SWH is not jeopardised when combining these support schemes as investment barriers are not completely removed. In this sense, devising financial schemes is determinant to level the playing field between SWH technology and conventional LPG systems and CDM may represent a guarantee to access additional financial support.

Moreover, if capital grants are provided to face investment barriers, CDM incentives could be use to either finance efforts aimed to complying with equipment and installation standards or extending distribution and retail networks and increasing its technical capacity.

CDM requirements would increase the need to establish voluntary strategies aim to improving quality standards and devising annual monitoring and verification plans which will assure CERs delivery, while improving SWH systems' performance, beneficiating consumers and increasing the positive perception of the public towards this technology. Similarly, the scale of SWH technology will also challenge project developers willing to structure CDM-SWH projects as strong efforts are needed to bundle and aggregating projects with in portfolios.

These challenges could be diminished if sectoral or policy driven CDM is consented by the CDM-EB, reducing the transaction costs and assuring CDM financial capability is fully used to contribute with SWH technology deployment.

Overall, domestic policies and CDM could reinforce one another if this international mechanism is considered when devising strategies to enhance SWH market in Mexico.

10 Possible Strategies and Cooperation Schemes to Boost the Deployment SWH Technologies in Mexico

It has been recognised the importance of considering the CDM when devising domestic policies and establishing concrete strategies to integrate both international and national supports schemes. In addition, it has been distinguished the role of private stakeholders on agreeing mechanisms to face the challenges imposed by the CDM and devising financial schemes to remove investment barriers. It has been also mentioned the value of the sectoral or policy driven CDM approach on reducing transaction costs and facing bundling and aggregation of SWH projects.

This chapter proposes guidelines for possible strategies and cooperation schemes which could be undertaken by the government and private stakeholders to guarantee the successful deployment of SHW technology; and presents recommendations and arguments for the CDM-EB aim to support the idea of a sectoral or policy driven CDM for small scale technologies like SWH. Finally, it is discussed what could be the expected development of the SWH market in the next fifteen years if proper domestic and international incentives are integrated within a policy framework.

10.1 Revision of Public Policy for SWH Technology

10.1.1 Capital grants

Although capital grants are useful support scheme to abate the investment barriers faced by SWH technology. There is always the problem of getting the money to provide such support. One way to raise the resources required with out jeopardising the budget of other governmental support programmes is by establishing carbon tax for LPG which could be transfer to support SWH technology. A tax of 1 USD/tCO_2 would be enough to start the deployment of SWH technology in Mexico with no considerable effect on current LPG prices which may rise only between 0.38 and 0.47 percent.[10]

This could provide resources for supporting the installation of around 377,000m^2 of SWH per year with a 30% capital grant, while reducing energy delivery cost for consumers with SWH systems. In addition, this measure could reduce the domestic consumption of LPG increasing the possibility to export this fuel to Central America on the long term.

However, the establishment of a carbon tax on LPG and the transfer of resources to capital grants for SWH technology face some challenges. Firstly, it is required the participation of several governmental agencies and companies such as the Energy and Environmental Ministries, PEMEX and The Treasury which could slow down its implementation due to a lack of coordination and dissimilar interest. Secondly, LPG retailers may oppose to this measure as it represent the empowerment of competition; hence, it is expected to observe some kind of regulatory capture during the policy making process. Thirdly, some institutional framework would be needed to receive the resources and transfer them to consumers.

In this sense, Quintanilla et. al. (2000b) has documented several undesirable experiences between SWH firms and governmental institutions were manufacturers and installers did not receive their money on time. Therefore, it is important to undertake further research determining what is the most efficient strategy to provide the support (e.g. directly to the consumer or through a public or private mezzanine financial institution).

If more resources are need the government could use international development funds and banks such as the World Bank, the Inter-American Development Bank, and the Global Environmental Facility to obtain these resources. This strategy is feasible as some of these institutions like World Bank have shown their interest in supporting SWH technology in the past. What is more, the interest rates of this banks and funds are usually very competitive representing cheap investment streams to SWH market.

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[10] LPG produces around 1.68kgCO_2/lt.

However, this investment would be received by governmental development banks such as Banobras or Nafin and then transferred to the institution responsible of providing the capital grants. This could delay the flow of resources due to internal bureaucracy. In this sense, political will is determinant to overcome any possible hurdles within governmental financial institutions.

10.1.2 Deducible Tax Regimes

Deducible tax regimes may not reduce the investment barriers for all households as low and medium income families would not find the way to pay for a SWH systems even if it is income tax deducible. Still, it may encourage high income families to acquire a system reducing the amount of taxes paid to the Treasury. Although out of the scope of this research, commercial and industrial companies with water heating needs may receive this measure with pleasure as it provides the opportunity to reinvest in the company, while reducing its operational costs and the environmental impacts of its activities.

However, the establishment of this measure requires the consent of the Treasury, which usually tries to find ways to obtaining more resources rather than reduce them. Hence, strong lobby would be needed by the SWH community to achieve a deducible tax regime for SWH technology. In this sense, the Energy and Environmental Ministries should facilitate and endorse this measure.

10.2 Consent for a Sectoral or Policy driven CDM

As mentioned earlier, the CDM-EB has found controversial the consent for developing sectoral or policy driven CDM as it is unclear how to measure the additionality of domestic policies and even though the sector or region could define the project boundary, accurate sectoral or regional baselines must be established prior project registration avoiding any possibility of leakage. This innovative approach not only reduces the transaction costs of CDM projects, but also encourages the decarbonisation of entire sectors and regions, and allows the harmonisation of domestic policies and international support schemes promoting climate change mitigation from an integral perspective. (Anderson, 2005)

Furthermore, the sectoral or policy driven CDM is of great importance for increasing the competitiveness of small scale technologies with GHG emission reduction potential like SWH as under the current situation strong efforts are needed to bundle and aggregate enough units to meet carbon funds and facilities criteria increasing even more their transaction costs.

In this sense, SWH technology represents a strong case for consenting sectoral or policy driven CDM were project developers face the same challenges when structuring proposals regardless the approach (project-based or policy-based), but the benefits from CERs revenue can be spread to a larger number of project developers and consumers despite its size.

10.3 Cooperation Schemes among Private Stakeholders

Private stakeholders like academic institutions and SWH manufacturers, retailers and installers have leaded the promotion of the technology over the last years and should continue to due so in the future by establishing cooperation schemes aimed to take full advantage from international support schemes like CDM and devising the implementation of financial schemes which respond to the needs of different types of consumers. Taking steps forward on these two streams is determinant for the deployment of the SWH technology in the future.

10.3.1 Facing CDM Challenges

As mention earlier, CDM incentives may provide additional resources which could be use to reduce investment, financial, technical and institutional barriers. Yet, the implementation of CDM-SWH projects faces challenges requiring the design of specific strategies aimed to overcome them. In this sense, the establishment of pools or portfolios of SWH projects and agreements between participants could help to bundle or aggregate projects more effectively and manage the non CERs delivery-related risks.

CDM-SWH projects and portfolios

Three modes of pools or portfolios are expected to exist depending on the characteristics of the participants. Firstly, if a retailer or installer has developed enough projects during a certain period of time (lets say a year) it could develop its own portfolio looking to bundle all its projects into a CDM-SWH project. Secondly, if no retailer or installer has the capacity to bundle its own projects (which is the case with the majority of retailers in Mexico) it could be expected to see portfolios being bundled by a manufacturer and its network of retailers and installers. Regardless of whether the manufacturer is national or an importer the CDM benefits could be transferred from manufacturers to retailers by reducing retail prices. In addition, this mode of portfolio could reduce bundling efforts and monitoring and verification costs as retailers (and installers) already have strong links with manufacturers which usually know what the technical capacity of its retail network is and how many square meters are being sold. Finally, given that most manufacturers in Mexico are small business with little share of the market, it may be possible to observe a group of manufacturers, retailers and installers to come together in bundling their projects into a CDM portfolio despite they compete on a daily basis.

Although these three modes of CDM-SWH portfolios offer the advantage of project bundling, the cost and efforts will differ from one to another. Obviously, market leaders with higher market shares and economic solvency will be able to reduce bundling, monitoring and verification costs and hedge risks more easily than small manufacturers, retailers and installers which would have to establish smart strategies to bundle projects effectively, while reducing the additional risk and costs when number of participants is increased.

Agreements to manage risks

Regardless the mode of CDM-SWH portfolio, agreements should be established between projects' participants aimed to manage project-related risks and assure the delivery of CERs as agreed with buyers. In this sense, manufacturers, retailers and installers should consider that higher quality standards of equipments and installations, longer warranty periods, periodical maintenance of SWH systems, and strong relation with clients and consumers will increase the overall performance of their projects reducing non CERs delivery risks.

Moreover, when structuring CDM-SWH projects and signing ERPA it should be considered that: firstly, efforts from manufacturers and installers to reduce the costs of SWH systems will result in more additional CDM-SWH projects because although barriers for selling equipment would be lower, projects developers' profits could be reduce driving participants out of the SWH market and joining the promotion of conventional technologies such as LPG and NG; secondly, upfront payments of CER revenues have a positive impact in reducing the upfront capital costs of SWH systems. If no upfront payments can be bargain the ERPA could be used as a warranty to find other sources of finance to tackle such barrier; and finally, to take full advantage of the incentives provided by the CDM long crediting periods should be agreed with CERs buyers. Considering that SWH systems' lifetime is 20 years, a crediting period of this length is reasonable for both developers and buyers.

10.3.2 Devising Financial Schemes

Several financial schemes could be available for covering the financing gap of SWH technology. All of them should be considered as they can be use depending on the characteristics of the consumer.

<u>ESCOs</u>

The energy service companies or ESCOs are specialised firms which provide energy services by installing the equipment and selling the energy produce to the consumer. This financial scheme has not been widely explore by the SWH industry in Mexico, but it certainly removes all financial barriers. Yet, it must be considered that strong collecting schemes are required to receive the payments from every household and in some cases it would be risky for ESCOs to enter markets with lack of economic solvency. In this sense, the scheme provided by ESCOs could be use on housing units were managerial and collecting structures are already set in place for selling several services to households, and were a centralised SWH system could provide water heating services to all houses.

Commercial Credits and Leasing

Commercial credits and leasing schemes have increase in Mexico over the years allowing consumers to acquire all sorts of goods and services. Given that SWH technologies reduce the cost of energy delivered, while reducing GHG emissions and improving the local air quality, banks and financial institutions in cooperation with SWH developers should establish schemes to facilitate the purchase of SWH systems to consumers.

This would not represent high risks for any party involved if financial institutions establish criteria to determine which consumers can cope with this debt and SWH developers guarantee the optimal performance of the equipment along its lifetime.

In this sense, several financial institutions have support and signed the London Principles by which they compromise to establish initiatives aimed to finance sustainable development. Some of these institutions operate in Mexico and SWH technology could represent an opportunity for them to accomplish their goals in this matter. (Corporation of London, 2003)

Housing Credit Schemes

In Mexico, new housing credit schemes for low and medium income level families are featured by long payment periods (fifteen to twenty years) and soft interest rates. If a SWH system is installed as one more appliance in the house this scheme could be use to cover the financing gap without increasing significantly the debt of house owners.

Even though a SWH system would only increase the price of the household around two percent, property developers usually get the construction contracts after competing against each other on an auction. In this sense, developers who promote SWH technology would face higher cost reducing their possibilities to get the contract. A close relation with SWH manufacturers and installers could be useful on finding ways to avoid loosing competitiveness when installing SWH systems. Moreover, CDM incentives could provide supplementary resources facilitating the installation of SWH systems in low and medium income housing units.

10.4 Integrated Policy Framework for SWH Technology

Public and private stakeholders should promote an integrated policy framework aimed to increase the penetration of SWH technology on the residential sector by reducing the investment barriers by providing capital grants, devising *ad hoc* financial schemes to cover the financing gap; promoting the development of CDM-SWH projects, guaranteeing the optimal performance of SWH systems along its lifetime and promoting the benefits of SWH technology among the public.

When devising this policy framework government should get involved not only by providing capital grants and deducible tax regimes, but also by facilitating and supporting the efforts done by the private sector.

In this sense, local and federal governments should promote the compulsory installation of SWH systems only when effective financial schemes are available for different types of consumers, and compulsory quality standards for equipments and installations are set in place assuring the optimal performance of SWH systems during its lifetime.

Either local or federal initiatives promoting the compulsory use of SWH systems should consider that they could damage the additionality of potential CDM-SWH projects within the legislation geographical limits, avoiding the possibility to draw foreign investment from CDM. Similarly, if allowed by the CDM-EB, it is strongly recommended to promote the implementation of a policy driven pilot CDM-SWH project to learn more about how to mitigate the costs and risks related to activities such as bundling, aggregation, monitoring and verification.

Moreover, public and private stakeholders should consider seriously the proposal made five years ago by Quintanilla et. al. (2000b) about developing a trust fund to promote SWH technology as it may represent an effective strategy to establish the institutional framework required to integrate several domestic and international support schemes and undertake activities to remove technical and institutional barriers. Yet, although supervised by public authorities, this “National Trust Fund for SWH Promotion” should be managed by private institutions to evade any lack of effectiveness or delay on providing support as a result of public institutions bureaucracy.

10.5 Impact on Future Development of SWH Market

The establishment of a long term and properly design policy framework would increase the volume of the SWH market in Mexico. Consequently, two effects could be expected, firstly a breakthrough effect by which SWH technology could increase the water heating demand providing water heating services to those families who have not; and secondly, a substitution effect on which SWH technology will increase its share on water heating services, reducing the participation of other fuels like wood, LPG and NG. This effect is the most likely scenario.

The existence of capital grants for SWH residential applications and its combination with proper financial schemes could increase the volume of this market up to 400,000m^2 installed per year. This has several implications. Firstly, the domestic capacity of production or the imports of SWH technology could increase; in either way this may represent flows of direct investment to the sector. Secondly, SWH for residential applications could increase its share within the SWH market displacing the pools heating applications. And finally, since the same technology (glazed solar collectors) is use for commercial and industrial applications it is likely to observe a growth on this segment of the market driven by lower prices and availability of financial schemes.

Therefore, given the business as usual trends of the SWH market for residential applications (see Chapter 5) and considering the existence of a carbon tax for LPG (1 USD/tCO_2), it could be expected to observe an exponential growth of SWH market in Mexico which could provide between 5.5 and 8.4 PJ of heat energy by 2020 in the residential sector only. This growth represents around five percent of the total estimated water heating demand in this year.

10.6 Summary and Conclusions

The establishment of an integrated policy framework for SWH technology is determinant for the successful deployment and penetration of this renewable energy in Mexico. In this sense, the active participation of the government is important on providing resources and devising support schemes such as capital grants and deducible tax regimes aimed to remove the investment and financial barriers faced by the technology

Moreover, the participation of financial institutions such as international and national development banks, and private banks, as well as the whole SWH community (academics, manufacturers, retailers and installers) is of the highest importance on devising financial schemes to cover the financing gap of SWH technology and establishing strategies to guarantee the optimal performance of equipments and promoting the economic and environmental benefits of this technology among the public.

All these efforts should consider the integration of international supports schemes like CDM since it represent a flow foreign investment to the domestic SWH market. In this sense, strategies and cooperation schemes should be developed aimed to cope with the challenges of implementing CDM-SWH projects. Similarly, by consenting the existence of sectoral or policy driven CDM could help in reducing some of this challenges, while doing accessible the benefits of CDM to all project developers and consumers.

In conclusion, if proper steps are taken, a boost on SWH market could be observed in the next fifteen years increasing the share of this technology in the water heating services supply up to 5 percent.

11 Conclusions

- Although SWH for residential applications in Mexico is almost inexistent, it has huge development potential since water heating demand would continue to grow driven by the urbanisation and population growth trends. In addition, higher fuel prices will drive low and medium income consumers to find cheaper alternatives to fulfil their water heating needs. SWH industry could benefit from this trend as costs of energy delivery for water heating services could be reduced between 30 and 40 percent when using SWH systems.

- However, SWH technology faces several barriers for its deployment. Upfront capital costs, lack of financial, technical and institutional capacity, and small public awareness about the benefits of the technology are among the biggest obstacles for implementing SWH projects in Mexico.

- These difficulties could be tackled by implementing several domestic policies within an integrated policy framework. Of special interest is the combination of capital grants, financial schemes and compulsory certification of equipments and installers which have proven to be effective strategies for levelling the playing field between SWH and LPG industries, increasing the penetration of SWH technology, and guaranteeing the optimal performance of equipments during their lifetime.

- In addition, special attention must be taken on fuel prices-related policies as they have been the main indirect economic driver behind the development of the SWH market in Mexico during the last decade, and could continue to do so if adequate measures are implemented in the short-term. In this regard, on of the most important measures to be considered by the government is the establishment of a carbon tax on LPG (1USD/tCO_2e) which could provide the means to support the mass deployment of SWH through capital grants.

- Although CDM offers small benefits on reducing investment barriers if compared with capital grants, its implementation requirements increase the need to improve the quality standards and technical capacity of distribution and retail networks, and devise annual monitoring and verification plans for SWH projects. This would result on the improvement of SWH systems' performance and costumer services, beneficiating consumers and increasing the positive perception of the public towards this technology. In this regard, flows of foreign investment from CDM could be streamed to financing part of these activities.

- The actions mentioned above are opportunities for increasing SWH diffusion but also represent obstacles when implementing CDM-SWH projects. In this sense, domestic strategies and cooperation schemes should be developed by project developers aimed to cope with these challenges. Similarly, by consenting the existence of sectoral or policy-driven CDM some of these challenges could be reduced, while making the benefits of CDM accessible to all project developers and consumers.

- A policy framework involving the participation of private and public sectors, and integrating domestic policies and CDM could give adequate signals towards SWH development, driving new participants into the market such as international financial institutions, national development banks and private banks. These would provide new investment streams to finance a greater deployment of SWH technology with the potential to increase importantly its share in the water heating services supply in the next fifteen years.

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Annex I. Bottom-up Model: Energy Demand for Water Heating Services

	MODEL RESULTS (PJ)												
	ESTIMATIONS					BAU LOW DEMAND				BAU HIGH DEMAND			
Year	TOTAL POT. LOW DEMAND	TOTAL POT. HIGH DEMAND	BAU LOW DEMAND	BAU HIGH DEMAND	HISTORIC DEMAND	LPG	NG	SWH	WOOD AND UNSATISFIED DEMAND	LPG	NG	SWH	WOOD AND UNSATISFIED DEMAND
1970	27	38	14	19	23	20	4	0	4	20	4	0	14
1971	49	68	14	20	24	20	4	0	25	20	4	0	44
1972	58	80	26	35	26	21	5	0	32	21	5	0	54
1973	72	100	30	42	28	23	5	0	44	23	5	0	72
1974	84	117	37	52	27	22	5	0	57	22	5	0	90
1975	94	131	44	61	32	27	5	0	62	27	5	0	99
1976	102	143	49	69	35	29	6	0	68	29	6	0	108
1977	108	151	54	75	34	29	5	0	74	29	5	0	117
1978	112	157	57	79	37	32	6	0	75	32	6	0	119
1979	114	159	59	82	39	33	6	0	75	33	6	0	120
1980	114	159	60	84	50	43	6	0	64	43	6	0	110
1981	117	164	60	84	52	46	6	0	66	46	6	0	112
1982	121	168	62	87	61	54	7	0	60	54	7	0	108
1983	124	173	64	89	61	56	6	0	63	56	6	0	112
1984	127	177	66	92	69	61	8	0	58	61	8	0	108
1985	130	182	67	94	72	63	8	0	58	63	8	0	110
1986	133	186	69	96	73	63	9	0	61	63	9	0	113
1987	136	190	71	99	71	62	9	0	65	62	9	0	118
1988	139	194	72	101	73	64	10	0	65	64	10	0	120
1989	141	197	74	103	83	73	10	0	58	73	10	0	114
1990	144	201	76	105	91	80	11	0.00	53	80	11	0.00	110
1991	147	204	77	108	91	80	12	0.00	55	80	12	0.00	113
1992	149	208	79	110	98	86	12	0.00	51	86	12	0.00	110

MODEL RESULTS (PJ)

	ESTIMATIONS					BAU LOW DEMAND				BAU HIGH DEMAND			
Year	TOTAL POT. LOW DEMAND	TOTAL POT. HIGH DEMAND	BAU LOW DEMAND	BAU HIGH DEMAND	HISTORIC DEMAND	LPG	NG	SWH	OTHER SOURCES AND UNSATISFIED DEMAND	LPG	NG	SWH	OTHER SOURCES AND UNSATISFIED DEMAND
1993	151	211	80	112	100	92	8	0.00	52	92	8	0.00	111
1994	153	214	81	114	103	96	7	0.00	51	96	7	0.00	112
1995	156	217	83	115	102	96	7	0.00	53	96	7	0.00	115
1996	159	221	84	117	106	99	7	0.00	52	99	7	0.00	115
1997	162	226	86	120	105	98	7	0.00	57	98	7	0.00	121
1998	165	230	88	122	109	103	7	0.00	56	103	7	0.00	121
1999	168	234	90	125	97	91	6	0.01	71	91	6	0.01	137
2000	171	239	91	127	100	93	6	0.01	71	93	6	0.01	139
2001	173	242	93	130	98	91	7	0.01	75	91	7	0.01	144
2002	175	244	94	132	99	91	8	0.01	76	91	8	0.01	146
2003	177	247	96	133	102	93	9	0.01	75	93	9	0.01	145
2004	179	250	97	135	-	**86**	**11**	**0.01**	**82**	**125**	**11**	**0.01**	**114**
2005	181	252	98	137	-	**86**	**12**	**0.01**	**83**	**124**	**13**	**0.01**	**115**
2006	183	255	99	138	-	**85**	**14**	**0.01**	**84**	**123**	**15**	**0.02**	**116**
2007	185	258	100	140	-	**84**	**15**	**0.02**	**85**	**122**	**18**	**0.02**	**118**
2008	186	260	102	142	-	**83**	**18**	**0.02**	**86**	**120**	**21**	**0.02**	**119**
2009	188	262	103	143	-	**82**	**20**	**0.02**	**86**	**117**	**25**	**0.03**	**120**
2010	190	265	104	145	-	**80**	**23**	**0.02**	**87**	**114**	**30**	**0.03**	**121**
2011	191	267	105	146	-	**78**	**26**	**0.02**	**88**	**110**	**35**	**0.04**	**122**
2012	193	269	106	148	-	**75**	**29**	**0.03**	**89**	**105**	**41**	**0.04**	**123**
2013	195	272	107	149	-	**76**	**29**	**0.03**	**90**	**105**	**42**	**0.05**	**124**
2014	196	274	108	151	-	**76**	**30**	**0.03**	**90**	**106**	**42**	**0.06**	**126**
2015	198	276	109	152	-	**77**	**30**	**0.04**	**91**	**107**	**43**	**0.07**	**127**
2016	199	278	110	154	-	**77**	**30**	**0.04**	**92**	**107**	**43**	**0.09**	**128**
2017	201	280	111	155	-	**77**	**31**	**0.04**	**93**	**107**	**43**	**0.10**	**129**
2018	202	282	112	156	-	**78**	**31**	**0.05**	**94**	**108**	**44**	**0.12**	**131**
2019	204	284	113	158	-	**78**	**31**	**0.05**	**95**	**108**	**44**	**0.15**	**132**
2020	205	286	114	159	-	**78**	**31**	**0.06**	**95**	**108**	**44**	**0.17**	**134**

The results shown in the previous pages were calculated based on the following data and assumptions.

Physical Thresholds of SWH	MX City	MEX
Flat area on roof and good structural yield	86.5%	86.5%
Water services accesibility	97.2%	88.8%
LPG services saturation 2000	54.4%	30.0%
LPG services saturation 2020	57.5%	33.0%
Rate of LPG saturation	0.16%	0.15%
Water Network Temperature	18°C	18°C
Hot Water Temperature	50°C	50°C
Energy Share 2020		
Cooking	46.94%	-
Water heating	53.06%	-

Source: Quintanilla (2000b), INEGI (20005) and Imprema (2005)

Distribution of Households per Income Level (2002)

	Income Level		
	Low	Medium	High
Distribution	58.6%	31.0%	10.4%
Average Annual Expediture on Fuels, Water and Refurbishment	989	2,029	5,138

Source: INEGI (20005)

Additional Data Employed

- Households and inhabitants projections published by CONAPO (2000a) were also employed as an input for the model.
- Hot water consumption in Mexico City by Quintanilla (2000a) shown in Table 1.

Annex II. Regression: Future Scenarios of SWH Market in Mexico

The data contained in these tables shows the inputs employed to run the regression analysis and the results for the whole SWH market and specifically for the residential sector.

DATA USED FOR REGRESSIONS

Periodo	Mexican GDP per Sector @ 1993			Whole SWH Market (m2)	Residential SWH Market (m2)
	Total	Construction Sector	Fuels and Water Sectors		
1990	4,567,997,294	192,160,528	69,081,052	12,000	960
1991	4,760,527,181	201,541,616	69,347,377	12,000	960
1992	4,929,102,324	215,014,104	71,474,612	12,000	960
1993	5,024,783,882	221,516,064	73,306,012	12,800	1,024
1994	5,248,801,721	240,190,768	76,803,792	15,400	1,232
1995	4,922,431,918	183,833,535	78,455,064	17,000	1,360
1996	5,175,436,431	201,794,608	82,046,847	17,030	1,362
1997	5,526,100,685	220,529,577	86,320,612	23,770	1,664
1998	5,797,240,239	229,845,088	87,917,940	30,000	2,400
1999	6,021,782,162	241,314,229	101,827,561	38,212	2,675
2000	6,419,339,278	251,436,572	104,867,776	44,883	3,142
2001	6,409,261,930	237,169,205	107,269,856	74,609	5,223
2002	6,462,246,310	242,262,160	108,309,387	50,911	3,564
2003	6,553,183,790	250,245,956	110,044,320	75,304	6,024
2004	6,839,121,248	263,579,373	112,606,738		

Source: (INEGI, 2005 and Martinez R., 2005)

COEFICIENTS OF REGRESSIONS

	Whole SWH Market	Residential SWH Market
Intercept	-36.68252	-55.31984
ln(GDPcost)	0.10116	-0.10665
ln(GDPfuels)	2.46108	3.55241

Source: Regression Model

RESULTS OF REGRESSION - WHOLE SWH MARKET

	Scenario BAU1 (3% growth)			Scenario BAU2 (5% growth)		
	Area (m2)	Energy Produce (PT/yr)	Energy Accumulated (PT)	Area (m2)	Energy Produce (PT/yr)	Energy Accumulated (PT)
1990	15,857	0.04	0.04	15,857	0.04	0.04
1991	16,086	0.04	0.08	16,086	0.04	0.08
1992	17,441	0.04	0.12	17,441	0.04	0.12
1993	18,618	0.05	0.17	18,618	0.05	0.17
1994	21,052	0.05	0.22	21,052	0.05	0.22
1995	21,592	0.05	0.27	21,592	0.05	0.27
1996	24,335	0.06	0.33	24,335	0.06	0.33
1997	27,823	0.07	0.40	27,823	0.07	0.40
1998	29,229	0.07	0.47	29,229	0.07	0.47
1999	42,164	0.10	0.57	42,164	0.10	0.57
2000	45,519	0.11	0.68	45,519	0.11	0.68
2001	47,845	0.12	0.80	47,845	0.12	0.80
2002	49,099	0.12	0.92	49,099	0.12	0.92
2003	51,225	0.13	1.05	51,225	0.13	1.05
2004	54,496	0.13	1.18	54,496	0.13	1.18
2005	58,784	0.14	1.32	61,753	0.15	1.33
2006	63,409	0.15	1.48	69,977	0.17	1.50
2007	68,398	0.17	1.64	79,295	0.19	1.69
2008	73,780	0.18	1.82	89,854	0.22	1.91
2009	79,585	0.19	2.02	101,819	0.25	2.16
2010	85,846	0.21	2.23	115,377	0.28	2.44
2011	92,600	0.23	2.46	130,741	0.32	2.76
2012	99,886	0.24	2.70	148,151	0.36	3.13
2013	107,745	0.26	2.96	167,879	0.41	3.54
2014	116,222	0.28	3.25	190,234	0.46	4.00
2015	125,366	0.31	3.55	215,566	0.53	4.53
2016	135,230	0.33	3.88	244,271	0.60	5.13
2017	145,870	0.36	4.24	276,799	0.68	5.80
2018	157,346	0.38	4.62	313,658	0.77	6.57
2019	169,726	0.41	5.04	355,426	0.87	7.44
2020	183,080	0.45	5.49	402,755	0.98	8.42

RESULTS OF REGRESSION - RESIDENTIAL SWH MARKET

	Scenario BAU1 (3% growth)			Scenario BAU2 (5% growth)		
	Area (m2)	Energy Produce (PT/yr)	Energy Accumulated (PT)	Area (m2)	Energy Produce (PT/yr)	Energy Accumulated (PT)
1990	871	0.00	0.00	871	0.00	0.00
1991	879	0.00	0.00	879	0.00	0.00
1992	972	0.00	0.00	972	0.00	0.00
1993	1,059	0.00	0.00	1,059	0.00	0.00
1994	1,240	0.00	0.00	1,240	0.00	0.00
1995	1,376	0.00	0.00	1,376	0.00	0.00
1996	1,597	0.00	0.00	1,597	0.00	0.00
1997	1,894	0.00	0.00	1,894	0.00	0.00
1998	2,013	0.00	0.00	2,013	0.00	0.00
1999	3,374	0.01	0.01	3,374	0.01	0.01
2000	3,729	0.01	0.01	3,729	0.01	0.01
2001	4,067	0.01	0.01	4,067	0.01	0.01
2002	4,199	0.01	0.01	4,199	0.01	0.01
2003	4,428	0.01	0.01	4,428	0.01	0.01
2004	4,779	0.01	0.01	4,779	0.01	0.01
2005	5,291	0.01	0.01	5,653	0.01	0.01
2006	5,858	0.01	0.01	6,689	0.02	0.02
2007	6,486	0.02	0.02	7,913	0.02	0.02
2008	7,182	0.02	0.02	9,362	0.02	0.02
2009	7,952	0.02	0.02	11,076	0.03	0.03
2010	8,805	0.02	0.02	13,103	0.03	0.03
2011	9,749	0.02	0.02	15,502	0.04	0.04
2012	10,794	0.03	0.03	18,340	0.04	0.04
2013	11,951	0.03	0.03	21,698	0.05	0.05
2014	13,233	0.03	0.03	25,671	0.06	0.06
2015	14,651	0.04	0.04	30,370	0.07	0.07
2016	16,222	0.04	0.04	35,930	0.09	0.09
2017	17,962	0.04	0.04	42,508	0.10	0.10
2018	19,887	0.05	0.05	50,291	0.12	0.12
2019	22,020	0.05	0.05	59,498	0.15	0.15
2020	24,381	0.06	0.06	70,391	0.17	0.17

Annex III. Bottom-up Financial Model: Investment Analysis of SWH Technology

The data presented in the tables below correspond to the inputs used to construct the four scenarios described in Chapter 6.

RATES AND PRICES	
Discount rate	10.0%
U.S. inflation rate	2.5%
Mexican inflation rate	4.5%
Mexican fuel increment rate	4.5%
Exchange rate (MX/USD	10.86
Fuel Price (USD/kWh)	0.054

COSTS	
Corrective Maintenance	10.0%
Annual Maintenance Solar	1.0%
Annual Maintenance LPG heater	3.0%
Efficiency of LPG domestic boiler	60%

Source: (Imprema, 2005)

CER PRICE(USD/tCO2e)	
Low Limit	3
W.Average	5.63
High Limit	7.15

Source:(Lecocq and Capoor, 2005)

CO2 REDUCTION PER HOUSEHOLD (tCO2e/hh)	
Low Limit	1.77
Average	2.21
High Limit	2.65

Source:(Quintanilla et. al. 2000b and Milton and Kaufman, 2005)

CDM CREDITING PERIOD

Crediting Period (Between 1 to 21 years only)

CDM TRANSACTION COSTS

SEARCH COSTS (USD)		
Finding a buyer	$	19,000
Search activity	$	-
Project documentation costs	$	16,000
Project Idea Note (PIN)	$	2,000
Project Concept Note (PCN)	$	2,000
Letter of Endorsement (LoE)	$	1,000
Due diligence and other documents	$	10,000
Letter of Intention (LoI)	$	1,000
Finding seller	$	-
Negotiation costs	$	10,500
PRE-IMPLEMENTATION COSTS (USD)		
PDD costs		
Baseline costs	$	2,600
Monitoring plan costs	$	1,600
Social and environmental impact	$	2,000
Others	$	300
Approval costs	$	-
Validation costs	$	6,000
Registration costs	$	5,000
IMPLEMENTATION COSTS IN PRESENT VALUE (USD)		
Monitiring costs	$	1,000
Verification and Certification costs	$	3,000
Adaptation fee costs (percentage of CERs issued)		2%

Source: Krey (2005) Modified

	GENERAL CONVERSIONS
3.60	MJ/kWhr
4,186.00	J/Kcal
0.026	thosands T oil eq. / mill. ft^3
41.868	Pentajoules (10x15 Joules)/mill. T oil eq
7.40	kWh/lt of LPG
6,364.00	Kcal/lt of LPG
158.99	lts/barrel of LPG
6.28981	barrel/m3 of LPG
3.79	lts/gallon
0.54	kg/lt of LPG

Source: (SENER, 2003)

	CO2 EMISSIONS
1.68	kgCO2/lt of LPG
0.99	Fraction of carbon oxidized
17.20	tCO2/TJ from LPG
15.30	tCO2/TJ from NG
3.66	tC/tCO2

Source: (UNFCCC, 2005 and Quintanilla et. al. 2000b) Modified