United Nations Development Programme
GLOBAL ENVIRONMENT FACILITY (GEF)

10 February, 1999

Evelyn:

Dear Ms. Nielsen,

Subject: **Revision of Project: "Reduction of GHG's in Chile"**

Attached, please find the letter and revised project document which we forwarded to the CEO of the Global Environment Facility, Mr. Mohamed El-Ashry with respect to the above-mentioned project.

I am pleased to authorize you to begin the implementation of the revised project activities, as described in the revised project document.

I wish you well in this new endeavor and I trust that you will keep my office informed of progress in the implementation of this activity.

Sincerely,

Rafael Asenjo
Executive Coordinator.

Ms. Evelyn Nielsen
Officer-in-Charge
UNDP
Chile

Street Address: 304 East 45th Street, 10th Floor
Mail Address: One United Nations Plaza, Room No. 1094, New York, N.Y. 10017
Telephone: (212) 906 5044
Fax: (212) 906 6998
Website: www.undp.org/gef

United Nations Development Programme
GLOBAL ENVIRONMENT FACILITY

20 January 1999

Dear ~~Mr. El-Ashry~~: Mohamed:

Subject: Revision of Project Contents, "Reduction of GHG's in Chile" CHI/93/G31

This Pilot Phase project approved in 1993 originally was designed to pursue two avenues of reducing greenhouse gas emissions in Chile. The first component was to encourage the production of methanol from biomass residues for use in the transport sector. The second component was designed to establish energy service companies (ESCO's) to promote the utilization of newer, more efficient motors in the copper mining sector.

As you will recall, two years ago, UNDP felt that developments in the Chilean energy sector had overtaken the first component as methanol (derived from natural gas) was being produced and sold commercially in Chile for the cheapest price found nearly anywhere in the world. That component was reformulated to focus on electricity generation through biomass gasification. I am happy to say that the biomass electricity generator has arrived in Chile and is due to be commissioned in February 1999.

Now, I am writing to inform you that the second component of the project, focusing on the promotion of energy efficient motors in the copper mining sector, has also come to an impasse. Due to the falling price of electricity in Chile's northern grid, the mining companies have limited interest in working with outside ESCO's to replace motors in existing installations, and the interventions have become economically unattractive. However, newer mining installations in the country are making use of the more efficient motors. Therefore, UNDP has concluded that the goal of this component has been achieved to the extent possible, but that continuing to work on this project component is no longer fruitful.

As a result, we have authorized UNDP to utilize the remaining funds ($500,000) to undertake activities focusing on improving the efficiency of energy combustion in the small and medium enterprises in the greater metropolitan area. Traditionally, these enterprises are capital-short and have limited access to technology and technical assistance. It is estimated that by facilitating the replacement of older systems with newer ones that improve the use of air and the temperature controls, significant savings in GHG emissions will occur. The potential reduction in aggregate GHG emissions from these improvements in the small and medium enterprises has been estimated at 570,000 tons of CO_2 per year. This potential dramatically exceeds the potential GHG saving from the efficient motors component, most recently estimated at between 30,902 and 47,783 tonnes of CO_2 per year.

I am attaching for your information the revised project document that contains not only a summary of the proposed activities, but also an analysis of the abandoned energy efficient motors component

Sincerely,

Rafael Asenjo
Executive Coordinator
UNDP-Global Environment Facility

Mr. Mohamed El-Ashry
GEF CEO & Chairman
Global Environment Facility Secretariat,
1818 H Street, N.W.,
Washington D.C. 20433

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PROJECT CHI/93/G31

"REDUCTION OF GREENHOUSE GASES IN CHILE"

CONAMA / CNE / UNDP / GEF

REVISION OF PROJECT CONTENTS

SUBPROJECT: **"ENERGY EFFICIENCY OF COMBUSTION SYSTEMS IN CHILE'S SMALL AND MEDIUM SIZE INDUSTRY"**

ABSTRACT: The purpose of this document is to define the criteria necessary to restate the Subproject for Efficiency of Electric Motors in Mining, considering that it is not economically viable in the mining industry and therefore impractical in reducing the generation of greenhouse gases as originally proposed. In light of the above, this restatement aims at enhancing the energy efficiency of combustion systems in Chile's small and medium size industry (MEESC) and then reduce the emissions of CO_2. This project will be implemented by creating mechanisms to fund combustion system retrofitting projects and providing institutional incentives to encourage energy efficiency enhancements in combustion systems. This subproject will use a revolving fund for the development of previously selected and evaluated demonstrative experiences the ultimate results and benefits of which will allow the small and medium size industry (PYMI) to pay back these contributions and replicate similar projects. Potential aggregate emission reduction due to energy efficiency enhancements in combustion systems has been estimated at 570,000 tons of CO_2.

Santiago, December 1998

CONTENTS

ABBREVIATIONS

ASEXMA	Manufacturers Exporting Association.
ASIMET	Metallurgic Industrialist Association.
ASIQUIM	Chemical Industrialist Association
CNE	National Energy Commission, government dependant institution.
CONAMA	National Environmental Agency, government dependant institution.
CORFO	Development Corporation, government dependant institution.
CUREN	National Program for the Conservation and Rational Use of Energy.
CHILECTRA	Electrical Distribution Utility, enterprise which distribute electric energy in Santiago City.
FONTEC	Technological Development Fund, CORFO dependant entity.
GASVALPO	Natural Gas Distribution Utility in Valparaiso, 5th Region
IDT	Technological Development Engineering, local enterprise.
LIX-SX-EW	Lixiviation, Solvent Extraction and Electrowinning Mining Process
MEESC	Enhancing Energy Efficiency of Combustion System
METROGAS	Natural Gas Distribution Utility in Santiago, MR
MR	Metropolitan Region of Santiago, Chili.
NPC	National Project Coordinator
PEA	Project Engineer Advisor
PO	Project Office
PROCEFF	Program for Fixed-Source Emissions Control, Sesma dependant entity.
PYMI	Small and Medium Size Industry in Chili.
SESMA	Metropolitan Environmental Health Service, government dependant institution.
SIC	Central Inter-connected System or Central Electric Power Network.
SING	Northern Inter-connected System or Northern Electric Power Network.

1. BACKGROUND AND CONTEXT

1.1. Since 1995, the Government of Chile has been implementing the Project for the Reduction of Greenhouse Gases in Chile, through the National Energy Commission (CNE) as its executor arm and the support of the United Nations Development Program (UNDP), as well as with financing from the Global Environmental Facility (GEF). The main purpose of this project is to reduce the emissions of gases that increase global warming, mostly caused by emissions of carbon dioxide (CO_2).

1.2. This project defined two subprojects that would be instrumental in reducing said emissions. The first project aims at lowering CO_2 emissions from power generation at coal-fired thermoelectric plant by replacing standard-efficiency electric motors with high-efficiency electric motors in the mining industry. This activity is mainly located in Northern Chile, where electricity generated by the Great Northern Electric Power Network (SING) comes principally from fossil fuels. The second subproject consists in preventing emissions of CO_2 by introducing forest biomass gasification technology for electricity generation in remotest rural areas, which would replace electricity produced through the use of small size diesel engines.

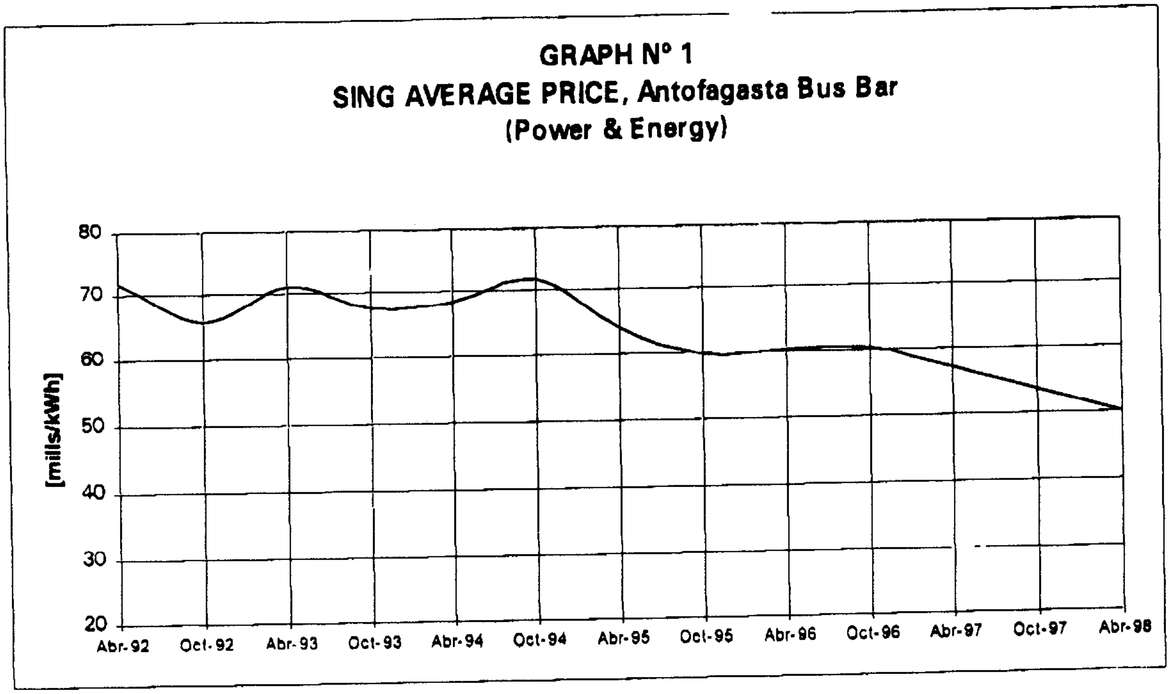
1.3. The specific objectives of the subproject for energy efficiency in electric motors in mining included the need to provide technical support in building up organizational, technical and financial capabilities to implement projects aimed at replacing standard-efficiency with high-efficiency electric motors in the mining industry. Further, the project was geared to creating economic and institutional incentives to encourage investments in these systems, which would help decrease CO_2 and other environmentally polluting emissions in an economically viable manner.

1.4. The growing demand for energy in the SING over the past five years, the free market policy propitiated by the Chilean government and the statutory regulations governing the electricity sector have encouraged free competition among the SING's power generation utilities. These, in turn, hold direct negotiations with the non-regulated consumers in medium and large-scale mining and consequently obtain substantial discounts in electricity prices. In the future, prices will be expected to follow a similarly downward trend with the recently startup of combined-cycle power plants fired by natural gas and the likely interconnection between the Central Electric Power Network (SIC) and the SING. Graphs 1 and 2 trace the progress of power and energy prices through time at the SING's largest nodes, established under a decree issued by the Ministry of the Economy, Development and Reconstruction.

1.5. The new scenario as defined by current conditions in the electricity market and the evolution of energy prices –which depart significantly from the scenario prevailing when the project was designed in 1992—have reduced the economic appeal of energy efficiency projects for the mining industry in Northern Chile. This was reflected in lower rates of return and lengthier payback periods for the projects under evaluation, and the mining industry consequently lost interest in developing projects to replace standard with high-efficiency electric motors. It thus became impossible to carry out demonstrative experiences and activate the revolving financing mechanism, established for this subproject to ensure the return of these funds and the execution of more new projects for high-efficiency motors in the industry. Appendix I is an economic analysis for the replacement of motors in mining, with economic results depending on various different energy rates and operating conditions.

1.6. Based on the above and in line with the Chilean government's policy to support enhanced energy efficiency as a mechanism to reduce greenhouse gases and keep environmental pollution in check, it has become necessary to refocus efforts in this subproject toward providing support for the industrial sector, particularly small and medium size industry (PYMI) and propose, discuss and design funding mechanisms to encourage the use of energy-efficient technologies in combustion systems that contribute directly in decreasing the emission of CO_2 into the environment. Appendix II is a summary of the Chilean industrial market, stressing the importance of small and medium size industry.

1.7. Even though the situation in the electric market and the starting up of natural gas projects call for reorienting the resources made available for the subproject of energy efficiency in electric motors for the mining industry, this does not represent an impediment to completing the activities currently underway, namely, preparation and dissemination of Induction Motor Repairing Manual and study for a draft project concerning Motor Efficiency Standards.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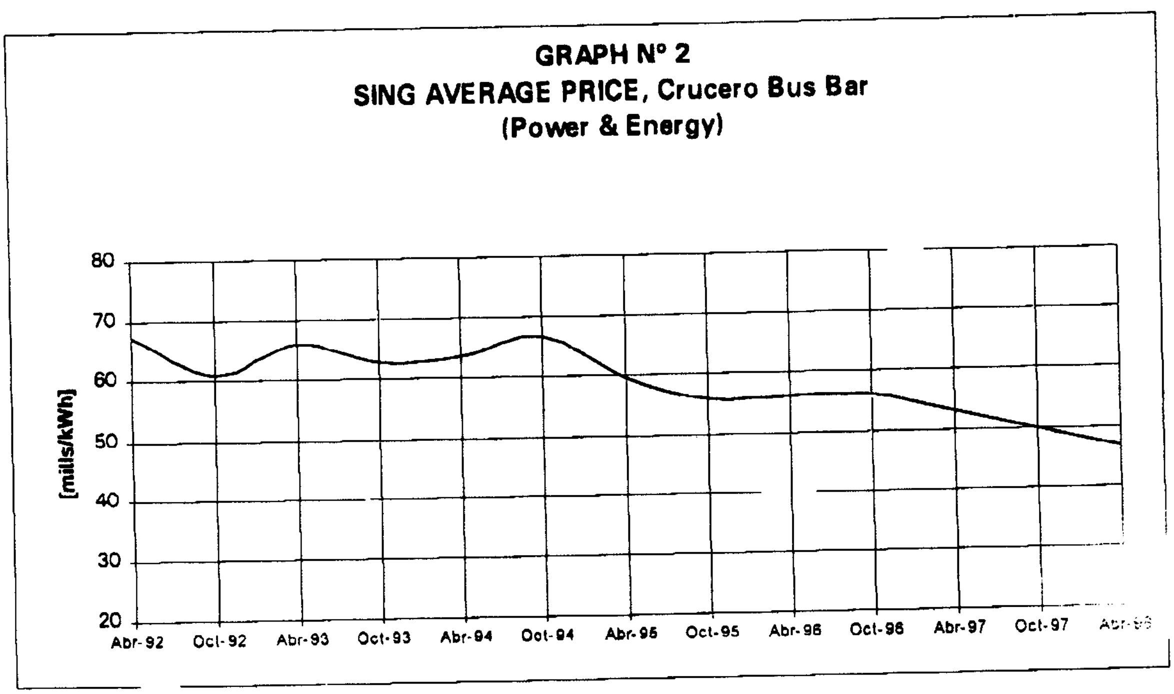
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2. FOUNDATIONS

2.1. Energy Efficiency in Chile's Small and Medium Size Industries

2.1.1. Small and Medium Size Industries in Chile (PYMI) are mostly integrated by companies engaged in the production of chemicals, plastics, paper, textiles, ceramic, bakeries, foodstuffs, glass, metallurgy, laundry parlors, dairy products and food products. The combustion systems used at present by these industries are principally boilers, furnaces and dryers. Furnaces are used for ceramic and glass processing, thermal treatments, bakeries and textile mills. Metallurgy, mainly smelter facilities, uses fire-blasted furnaces and heaters, as well as cupola furnaces fired with coke or other fuels.

2.1.2. The operating conditions of the combustion equipment used in the PYMI vary widely. Combustion systems are in very good condition in small and medium size industries that use modern technology. However, this is not the case in PYMI that are outfitted with older technologies, in which has been detected a great possibilities to enhance the energy efficiency of combustion systems. The operational and financial realities of PYMI both in Santiago and elsewhere in Chile bespeak a basic lack of effective equipment maintenance programs, which is further compounded by the considerable age of many units and insufficient knowledge of proper operating procedures to maximize equipment efficiency. There is a general bias among owners of small and medium size industries to favor production over productivity.

2.1.3. The replacement of cupola furnaces with electric induction furnaces or the use of filters to combustion systems at metal smelters will entail major investments that small and medium size industries are ill-prepared to fund as they lack financing mechanisms and suitable incentives. Generally, these modifications will not directly bring about significant improvements in energy efficiency during smelting or to productivity. They are consequently unappealing from an income-yield capacity perspective, with a lengthy payback period.

2.2. Experience in Energy Efficiency Projects in Chile

2.2.1. Chilean experiences in improving energy efficiency began in 1993, when the National Program for the Conservation and Rational Use of Energy (CUREN) was developed by the National Energy Commission (CNE) with support from the European Community. The key objective of this project was to encourage energy efficiency in the industrial, mining, commercial, public and residential sectors. The project called for the performance of energy audits and surveys of energy efficiency potential on a countrywide scale.

2.2.2. The results yielded by the CUREN project indicated that the greatest potential for energy savings were concentrated in large industrial and mining corporations, and the PYMI was thus relegated to a secondary plane in terms of countrywide potential. Unfortunately, the energy efficiency projects identified in this program could not be brought to fruition due to the existing barriers to implement the energy efficiency activity in the private sector.

2.2.3. In fact, the private sector poses significant barriers that have been sufficiently described in classic literature on energy efficiency. These are basically a lack of information on the concept of efficiency and on its technical and economic benefits, as well as on the modern and efficient technology currently available on the market; industrialists' decision-making criteria for investments based on short-term considerations; high income-yield capacity requirements for project evaluation; difficulties in securing financing for energy efficiency projects; insufficient economic incentives to develop energy efficiency projects and the low interest of some sectors toward addressing the energy issue, favoring solely production.

2.3. Energy Efficiency Projects in the PYMI and Financing Mechanisms

2.3.1. The emergence of natural gas in the Chilean energy matrix has brought about a substantial change in terms of incorporating energy efficiency projects to the different economic sectors of Chile. The price of natural gas is actually lower than that of the fuels currently used in the industrial, mining, commercial, public and residential sectors. The price is fundamental in the incorporation of this fuel as it entails using new technologies with equipment such as more efficient burners, furnaces and boilers. This equipment would replace the older combustion systems and energy efficiency would be considerably enhanced in industrial processes, with the added benefit of lower fuel consumption and consequently lower emissions of CO_2 into the atmosphere.

2.3.2. Natural gas distribution companies have recently conducted energy diagnostics for the industries, which have contacted them. Technical support has been forthcoming in terms of engineering studies to calculate the capital expenditure necessary for retrofitting and the payback periods for said investment. Support by the distribution companies also includes advising industries as far as their relations with equipment vendors and service providers in order to ensure that the retrofitting process is conducted at the lowest cost and in the shortest time possible. Yet another material aspect has to do with the funding for retrofitting projects, for which the distribution companies provide the required funds. These funds are recouped through monthly installments included in the monthly gas bill or invoice.

2.3.3. In the business community of small, medium and large size industries, the PYMI have been unable to retrofit their combustion processes until now. This is fundamentally so because gas distribution companies view the PYMI as less attractive than large size scale industry due to their inherent characteristics, low fuel consumption and low overall business profitability. The barrier thus erected hinders gas distribution companies from providing financial support to the PYMI on favorable terms for the owners of small and medium size industries.

2.3.4. Switching from cupola to electric induction furnaces at smelters would also be within the spectrum of energy efficiency projects to decrease the generation of greenhouse gases. The possibility to reduce CO_2 emissions is rather appealing since the efficiency of coal-fired and other combustion systems ranges from 40% to 70%, whereas the efficiency of induction furnaces is in the range of approximately 90% or higher.

2.3.5. The Chilean Development Corporation, CORFO, with the support of the National Environmental Agency CONAMA, funding by the Technological Development Fund FONTEC and active involvement by Ingenieria y Desarrollo Tecnológico S.A., IDT, has developed a breakthrough project to design and build induction furnaces for ferrous and non-ferrous metals to be used in the metallurgic industry. This equipment is manufactured entirely in Chile and incorporates the latest in power electronics semiconductor technology. The advantages over imported induction furnaces are significant, namely greater efficiency, lower expenditure, adaptability to various metals and furnace coil sizes, local technical assistance and enhanced productivity.

2.3.6. Considering the sustained drop in electricity prices, switching from fossil fuel to electric induction furnaces appears as a very attractive option. In fact, the Santiago Electricity Distribution Company CHILECTRA S.A. provides support in analyzing energy retrofitting efforts from pollutant furnaces to induction alternatives, discussion of related costs, efficiency in the use of electricity and special rate incentives on a case by case basis. These are all based on preferential power rate schedules to encourage retrofitting in the metallurgic industry.

2.3.7. The potential for retrofitting in the smelter sector averages 50 small to medium size facilities that could transform their smelting operations by replacing fossil fuels with induction furnace technology.

2.3.8. The PYMI in other large cities elsewhere in Chile, such as Concepción, Valparaiso, Antofagasta and Calama, have similar possibilities to encourage the introduction of new combustion technologies to enhance energy efficiency. The extent to which the project to be undertaken in the Santiago region is successful will be fundamental for the subsequent development of retrofitting projects in the above cities.

2.3.9. One of the key strengths of this project is its use of a Revolving Fund to finance energy efficiency undertakings in the PYMI. It is noteworthy that natural gas distribution companies in Santiago and Valparaiso have vast experience in terms of financing and technical know how. In fact, the most important gas distribution utility in Santiago, METROGAS, set up a USD 4 million fund to finance natural gas retrofitting projects in industries deemed highly attractive. This fund was used up almost entirely to finance equipment procurement and retain the necessary engineering and installation services in 1996 and 1997.

2.3.10. METROGAS has performed rather successfully in terms of large size industry financing. The mechanism deployed by this company to gage the credit applicants' ability to pay is of particular interest for the purposes of this project. The documentation requisite to secure METROGAS credit is the following: most recent corporate tax balance sheet, annual income tax return, value added tax returns and reports issued by the companies' banks. The applicant companies have repaid most of the credits extended by METROGAS. The only problem encountered was the recovery of USD 18,600 from a textile mill that went bankrupt.

2.3.11. In addition to METROGAS, which distributes natural gas in Santiago, there is also GASVALPO, in charge of distribution activities in Valparaiso Region. This utility has also funded of most of the region's large-scale corporate natural gas retrofitting endeavors. The loans are collected from user companies through the monthly gas bill. Companies can thus finance their retrofitting on an expense basis rather than as an investment and avoid the income tax payments applicable to the latter.

2.3.12. GASVALPO also provides technical support for companies planning to convert to natural gas. The procedure is similar to that of METROGAS, i.e. the technicians visit the companies and conduct energy diagnostics. The user companies then ask for quotes, evaluate and retain equipment and service providers, supervise setup activities, run checks on facility operations and assist the company if any subsequent operational problem arises. These diagnostics have identified major opportunities to upgrade the efficiency of combustion systems, which have proved elusive for lack of funding.

2.4. Experience of Equipment Suppliers

2.4.1. Combustion system equipment and service suppliers are experienced in many fields. Approximately 20 service and equipment suppliers are currently active in Santiago, offering different brands and origins. Furnace and burner names include Paradies, Gonella, Joanes, Johnston, Babcock Briones, Babcock Wilcox, Kewanee, Cleaver Brooks, Loos, Hauck, Klockner, Weishaup and Autoquem, FBR, among others.

2.4.2. In the past, the projects developed by these suppliers focused mainly on switching from wood-fired combustion technologies to heavy or diesel fuel, and they are presently engaged in conversions to natural gas systems.

2.4.3. A case study in this area is the experience of Juan Rompeltiem Combustion Industrial, a company that developed retrofitting projects at the Industrial Sumar textile mills by installing two dual burners (natural gas and diesel fuel) each with 308 m3/h and capacity at 2652 Mcal/h. At Industrias Sumar this company also undertook similar projects for the cotton and nylon mills. Another project was to install 11 FBR natural gas burners for the San Camilo S.A. bakeries, with a total consumption of 360 m3/h and 3060 Mcal/h maximum capacity. In all these cases, the combustion processes underwent noticeable efficiency enhancements and pollutant emissions decreased.

2.4.4. This company's portfolio of prospective projects includes a study to retrofit eight boilers at Santiago's Sotero del Rio Hospital. Eight dual burners will be installed for natural gas and diesel fuel, with consumption estimated at 1364 m3/h and total capacity estimated at 11593 Mcal/h.

2.4.5. Another equipment and service supplier worth mentioning is Equipos Industriales S.A.C.I., in charge of distributing and supplying Cleaver Brooks brand. This company has vast experience in the combustion field, chiefly in providing equipment to industries in the Metropolitan Region and mining companies in Northern Chile. This supplier has largely focused its efforts in converting liquid fuel units to natural gas technology within the same brand name. Considering its portfolio of customers to whom it has sold Cleaver equipment, this company would have 13 prospective small and medium size facilities to convert to natural gas, with equipment capacity ranging from 40 to 100 HP. The conversion of combustion systems by Equipos Industriales S.A.C.I. has led to improved efficiency, greater reliability and lower pollutant emissions.

2.4.6. Ingenieria y Desarrollos Tecnólogicos S.A. (IDT) has been active in the field of retrofitting fossil fuel furnaces for the metallurgic sector, switching to locally manufactured induction furnaces. This company has introduced innovations regarding induction furnace technologies and has launched what appears to be a solution to convert shaft furnaces at smelters. This equipment was introduced at the trade show hold by ASIMET (Association of Metallurgic Industrialists) and enthusiastically received on account of its advantages afforded over foreign alternatives.

2.5. Reduction of Carbon Dioxide CO_2 Emissions

2.5.1. Subproject for Motor Efficiency in Mining

This subproject, as originally addressed, did not provide estimated reduction of CO_2 emissions as a yardstick of its contribution to the reduction of greenhouse gases in Chile. The following brief discussion is intended to yield an accurate estimate on the basis of the data provided below:

Sale of SING Energy to Mining Companies in 1996[1]	4,359 GWh / year
Electric Motor Consumption Factor in Mining	70%
Motor Efficiency Improvement	2%
Mean Efficiency at SING Thermal Power Plants	40%
Average Emission Factor at Thermal Power Plants[2]	87 ton CO_2/TJ

On the assumption that all the motors in the mining industry be replaced with a 2% efficiency enhancement, the above data would yield an emission reduction of **47,783 tons of CO_2 / year.**

The 70% energy consumption factor in electric motors is a conservative estimate, considering that since 1991 most new mining developments in Northern Chile have adopted LIX-SX-EW technology, with consumption mostly generated by the electrochemical process of copper deposited in cathodes. Additionally, the idea of introducing high-efficiency electric motors became a recurrent feature in all new mining projects starting in 1991. Consequently, it is plausible that the rise in consumption between 1994 (2,819 GWh) and 1996 (4,359 GWh) be due to the exclusive use of high-efficiency motors. The resulting reduction in emissions with thus be **30,902 tons of CO_2 / year.**

2.5.2. Subproject for Energy Efficiency in the PYMI

A study was performed to determine the aggregate potential for CO_2 emission reduction in the PYMI through efficiency enhancements in combustion systems, reduction of excess air and lower exhaust fume temperatures, as well as through improved maintenance, substitution of modern equipment for old ones or the transformation of liquid fuel technologies to natural gas. This research was conducted by the Gaseous Emissions Laboratory of the Pontificia Universidad Catolica de Chile based on data provided by the Program for Fixed-Source Emissions Control (PROCEFF), an entity that reports to the Metropolitan Environmental Health Service (SESMA).

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[1] Source: Reports issued by SING, and the Economic Load Dispatch Center, CDEC

[2] IPCC Draft Guidelines for National Greenhouse Gas Inventories, Vol. 3, UN Energy Statistics Yearbook 1992

From the PROCEFF database, those sources that had already been converted to natural gas were eliminated, as well as those in the heating boiler group. Also, an operating rate of 60% of full capacity was considered. The result yielded a reduction of **570,000 tons of CO_2 / year**. This figure was broken down into **500,000 tons of CO_2 / year** due to efficiency upgrades from technology transformation or retrofitting and reduction of excess air in combustion systems, and **70,000 tons of CO_2 / year** due to lower gas or exhaust fume temperatures.

2.6 Basic Organizational Framework to Develop the Subproject for Energy Efficiency in Chile's PYMI

2.6.1 The generic functions and responsibilities for each entity involved in the energy efficiency subproject for the PYMI will be as follows:

2.6.2 The Project Committee will be composed of one representative from the National Energy Commission (CNE), one from the United Nations Development Program (UNDP), and one from the Chilean Production Development Corporation (CORFO). The role of this committee will be to: (i) draw up objectives, strategies and strategies for the project; (ii) lay the groundwork for work organization; (iii) approve the overall focus and supervise activity development; and (iv) arrange for specific action for the participation of representatives from the natural gas distributors such as METROGAS and GASVALPO, and from the industrial associations of the PYMI with concrete possibilities of improving their energy efficiency (ASIMET, ASIQUIM, ASEXMA, etc.).

2.6.3. The specific activities to obtain the defined results of this project, to contract consulting enterprises to select demonstrative experiences, to individually control retrofitting projects advance, and so all the activities defined in section 3, ahead, will be in charge of the Project Office in which is National Project Coordinator (NPC) and Project Engineering Advisor (PEA).

2.6.4. Promotion and dissemination of project activities would have to be carried out by the participating industrial associations. These are endowed with the necessary experience and capacity to taken on this kind of activity. The project office will help in preparing the materials related to project dissemination and promote it widely not specific to any particular line of business.

2.6.5. An organizational structure must also be defined to finance the project. The following criteria must be considered for this purpose: (i) fast and expeditious financing processing; (ii) decision making for financing approval must be based on objective parameters; (iii) red tape must be avoided in decision making; and (iv) a credit committee with a maximum of three members with the right to speak and vote must be established.

2.6.6. The credit committee will have the following members: the National Project Coordinator, one CNE representative, one UNDP representative, one natural gas distributor representative, one ASIMET representative, and delegates from other industrial associations to be subsequently defined. Only the NPC and the CNE and UNDP representatives have the right to speak and vote in the board. The other participants only have the right to speak, and this only to avoid conflicts of interest.

2.6.7. Past experience at natural gas distribution companies in financing matters is highly significant for project objectives. A private bank in fact ran the fund used by METROGAS to fund large-scale industrial retrofitting projects. This experience could be used in order that the project reach an agreement with a private bank to manage the Revolving Fund that would provide the funds for the MEESC actions at the PYMI. The companies deemed credit worthy will obtain the loan for its MEESC actions with the bank and accept that it be charged through their monthly gas bill in case they use this energy source.

2.6.8. A specific methodology must be defined to assign project priorities based on objective criteria so as to avoid arbitrary actions by those involved in allocating the credits. This methodology must take the following aspects into account: (i) short term project profitability; (ii) decrease in CO_2 emissions as a function of the investments; and (iii) amount of investment.

2.6.9. Implementation of the above methodology calls for running a diagnosis on the PYMI that will take part in the program. METROGAS and GASVALPO have performed the engineering work for all the retrofitting projects at these companies and this project have not considered MEESC actions because the distribution companies are interested in the sale of natural gas rather than in the former. It is therefore advisable to perform an independent diagnostics study to identify energy efficiency potentials at the PYMI.

2.6.10. To implement the projects at those companies, to which credit was extended, requisite bid documentation must be prepared to call for project equipment and service tenders. The project office will work in conjunction with the chosen credit applicants to define the calls for equipment and service bids, as well as to evaluate the offers received and the contracting of the respective services.

2.6.11. Oversight of MEESC activities and monitoring of completed projects must consider the following actions: (i) the project office will collaborate with the bidders and the beneficiary company in defining detailed work schedules; (ii) the bidders and the beneficiary companies must make the necessary arrangements to see that the agreed schedule is met; (iii) they must supervise delivery of the equipment, their installation and subsequent operation together with the technical staff of the beneficiary company.

2.6.12. The project office will be in charge of following up on the project's environmental outcomes with regard to the reduction of CO_2 emissions.

2.7. Management of the Revolving Fund

2.7.1. An important aspect of the Project for Energy Efficiency at the PYMI and Financing Mechanisms relates to defining a strategy for using the Revolving Fund whereby energy efficiency projects at the PYMI will be financed. This, in order to ensure its operation after project completion.

2.7.2. The general guidelines to define this strategy calls for the following activities: (i) preparation of Revolving Fund Management Bylaws; (ii) preparation of technical and administrative terms to bid out Revolving Fund management; (iii) implementation of technical and administrative prequalification procedures to select the organizations that will participate in the bid to manage the Revolving Fund; and (iv) Revolving Fund management bidding process.

2.7.3. The institution responsible for managing the Revolving Fund will not be in charge of determining which companies will be extended credit. As previously mentioned, selection of credit beneficiaries will be based on the methodology defined in 2.6.8 above.

2.7.4. As provided in 2.6.5 and 2.6.6 above, an organizational structure (credit committee) will be established for the purpose of selecting credit beneficiaries per the methodology set forth in 2.6.8. The final listing of credit beneficiaries will be completed in 1999, and the sole responsibility of the Revolving Fund manager will thereafter be to provide the funds for the companies selected by the credit committee.

3. IMMEDIATE OBJECTIVE

Objective No.3 of the Original Project is revised as follows:

Decrease CO_2 emissions by enhancing the energy efficiency of combustion processes in Chile's small and medium size industry.

Results:

3.1. Identify and implement demonstrative projects to improve the energy efficiency of combustion processes in small and medium size industry.

3.2. Identify and develop financing mechanisms for energy efficiency projects in small and medium size industry.

3.3. Define the operating mechanism for the Revolving Fund to support financing for energy efficiency projects in small and medium size industry.

To meet the immediate objective and accomplish results, the following **activities** must be carried out:

Result 3.1

3.1.1. Identify and prepare a portfolio of energy efficiency projects involving the enhancement of combustion systems in small and medium size industry in the Metropolitan Region. The aim is to select at least 10 projects to be implemented on a demonstrative basis.

3.1.2. Draw up a specific methodology to assign priorities within the portfolio of energy efficiency projects to be financed. This approach must consider the following aspects: (i) short term project profitability; (ii) reduction of CO_2 emissions as an investment function; and (iii) amount of investment.

3.1.3. Carry out engineering work for higher priority projects.

3.1.4. Construction and start-up of Demonstrative Projects.

3.1.5. Evaluate the results yielded by the demonstrative projects, in terms of their reduction of CO_2 emissions and energy efficiency.

3.1.6. Disseminate the implemented demonstrative projects among the relevant players who will take part in the project (PYMI, industrial associations, governmental entities, etc.).

Result 3.2

3.2.1. Discuss the financing mechanisms for energy efficiency projects, which were previously used in Chile and the possibility to reinsert them in the PYMI.

3.2.2. Define a financing mechanism to be implemented in energy efficiency projects for the PYMI, allowing for additional contributions from the public and private sectors.

Result 3.3

3.3.1. Draw up Revolving Fund Management Bylaws.

3.3.2. Draft technical and administrative terms to bid out Revolving Fund management.

3.3.3. Implement technical and administrative prequalification procedures to select the organizations that will participate in the bid to manage the Revolving Fund.

3.3.4. Implement the Revolving Fund management bidding process.

4. INPUTS FOR THE ENERGY EFFICIENCY SUBPROJECT AT THE PYMI

4.1. Staffing

Position	Term
National Project Coordinator	December '99
Project Engineering Advisor	December '99
Secretary	December '99

4.2. Subcontracts

Activity	Duration
Identification of Projects and Evaluation Methodology	2 months
Evaluation of Results	2 months
Definition of Financing Mechanisms	2 months
Preparation of Bylaws and Technical and Administrative Terms to bid out the Revolving Fund	2 months

4.3. Budget

The Project is estimated to have a balance of approximately **USD 500,000** to finance the changes set forth in this subproject revision document.

5. GANTT CHART

The schedule of the activities indicated in section 3 above is laid out in the Gantt Chart as showed in the next page.

GANTT CHART SUBPROJECT ENERGY EFFICIENCY OF COMBUSTION SYSTEMS AT PYMI

Activities	Month 1				Month 2				Month 3				Month 4				Month 5				Month 6				Month 7				Month 8				Month 9				Month 10				Month 11				Month 12			
	Week				Week				Week				Week				Week				Week				Week				Week				Week				Week				Week				Week			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Act. 3.1.1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																																
Act. 3.1.2							■	■	■	■	■	■	■	■																																		
Act. 3.1.3																	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																
Act. 3.1.4																									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Act. 3.1.5																																	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Act. 3.1.6																									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Act. 3.2.1	■	■	■	■	■	■	■	■																																								
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Act. 3.3.3													■	■	■	■	■	■	■	■																												
Act. 3.3.4																					■	■	■	■																								

APPENDIX I

ECONOMIC ANALYSIS FOR THE REPLACEMENT OF STANDARD EFFICIENCY MOTORS WITH HIGH EFFICIENCY MOTORS

1. OBJECTIVE

The objective of this analysis is to compare the economic results –stated as payback per type of motor power—obtained by replacing standard efficiency motors with high efficiency units. Several different scenarios have been taken into consideration, i.e. cost of energy, hours of operation per year, load factor, customs admission costs, freight and insurance, and cost of mounting and fittings.

2. EVALUATION METHOD

The analysis will be conducted by using the Simple Payback method, which consists of calculating the quotient between the value of the investment (Io) and the value of the annual profit generated by the project (BN). This is expressed mathematically as:

$$Payback = Io / BN$$

3. BASIS FOR THIS ANALYSIS

This analysis will be conducted on the basis of the following data:

a) The list prices for Reliance and WEG motors are used, and the analysis also includes the average cost of motors obtained in the studies conducted by FIDE[3] and ACEEE[4] in Mexico and the United States, respectively.

b) The above prices correspond to four poles, 50 Hz and TEFC (Total Enclosed, Fan Cooled) motors.

c) The prices for the Reliance and WEG motors correspond to the list prices used in the Huasco, Ojos del Salado and Taltal studies.

d) In order that the analysis resemble a real case as much as possible and due to the lack of any further data supporting the same, it uses estimated values for the cost of freight, customs admission and insurance. Estimated values are also used to incorporate the cost of mounting and fittings necessary to install the motors.

[3] FIDE, Fideicomiso de Apoyo al Programa de Ahorro de Energia del Sector Electrico, Mexico, 1996

[4] Steven Nadel et al., Energy Efficient Motor Systems, A Handbook on Technology Program and Policy Opportunities.

e) The evaluation considers the replacement of standard efficiency motors, with reference to the average efficiency values defined under the NEMA 77 standard.

f) The formula to calculate Annual Savings is the following:

Annual Savings = HP x 0.746 x (1/Efa-1/Eff) x (Load Factor) x (Hours of Operation, stated as USD / year.

Where:

HP	is the motor's rated power
Efa	is the current motor's efficiency (standard efficiency)
Eff	is the future motor's efficiency (high efficiency)

g) Simple payback is calculated as indicated below:

Payback = (Motor Cost) x (1 + CI + CM) / (Annual Savings), stated in years

Where:

CI	is the cost of customs admission, freight and insurance, in °/1
CM	is the cost related to mounting and fittings, in °/1

h) This analysis is conducted on the basis that the simple payback method introduces a certain margin of error in its results when compared to the results yielded by the traditional Internal Rate of Return (IRR) evaluation method. The simple payback does not account for the value of money trough the time, assumes that inflation is zero and, further, it does not consider all the profits yielded by the project during its useful life. This method favors liquidity over profitability and overestimates the evaluation.

i) The criteria used by author S. Navel[4] for the "decision to replace" appear plausible. Nadel states that the studies and discussion surrounding motor replacement have led to the conclusion that very few companies are willing to invest in equipment replacement when payback is over three years; moreover, many companies expect capital returns for this type of project within not more than two years. Generally speaking, the decision to accept or reject a motor replacement project must consider the criterion used by each company in order to compare the payback periods obtained in the study with the values accepted by said companies.

4. ANALYSIS PROCEDURE

This analysis evaluates motor replacement payback as a function of motor power. The influence of the following parameters is taken into consideration:

- Average Energy Cost, in USD / kWh
- Hours of Operation, in h/year
- Motor Load Factor
- Cost of Freight, Customs Admission and Insurance, in % of motor cost
- Cost of Motor Mounting and Fittings, in percentage of motor cost.

5. RESULTS

The results are shown in the attached graphs (pages 22, 23 and 24), under the various different scenarios indicated as detailed in section 4 above.

Case 1:

This case analyzes motor replacements considering the node prices in the Great Northern Electric Power Network effective as of April 1992. The mean price in this case was 67.29 mill/kWh.[5]

Case 2:

This is presently the best case scenario, considering the average cost of a non-regulated client in the mining industry, whose power source is the Great Northern Electric Power Network, 8,500 hours of operation per year, load factor equal to 1, and conservative figures in terms of freight, customs admission, insurance, mounting and fitting costs.

Case 2-a:

Case 1 above is sensitized by decreasing the hours of operation per year to 6.000 h/year and the load factor to 0,75.

Case 2-b:

This case discusses the effect of considering a discount rate to the simple payback period and applying a decrease to the motor list prices for the brands in question. This case resembles more a real life market situation.

[5] Source: National Energy Commission, CNE

Case 3:

This case considers a likely future scenario with the startup of combined cycle generators powered by natural gas, which will supply energy to the Great Northern Electric Power Network and bring about a significant drop in the costs of energy generation. Estimates indicate that the monomial value of energy under this scenario would be 26.8 mill/kWh.[6]

Case 3-a:

Case 3 above is sensitized by decreasing the hours of operation per year to 6,000 h/year and the load factor to 0.75.

6. CONCLUSIONS

a) The most favorable of all scenarios analyzed is given by the replacement of standard with high efficiency WEG motors.

b) Considering the lowest motor price on the market, i.e. WEG, and a scenario in which the actual price of energy averages 4,663 cUSD/kWh, with 8,500 hours of operation per year and a load factor equal to 1 (Case 2), all motor powers between 10 and 200 HP yield a payback period ranging from 1.8 and 3.9 years. However, the result obtained using the average motor prices in the United States yields a payback ranging from 3.1 to 7.2 years according to ACEEE data.

c) The analysis of future energy rates under a natural gas scenario (Case 3) yields higher paybacks than in Case 2, with values ranging from 3.1 to 5.8 years when motors are replaced with WEG units, and from 5.4 to 12.5 years when using the average prices provided by ACEEE.

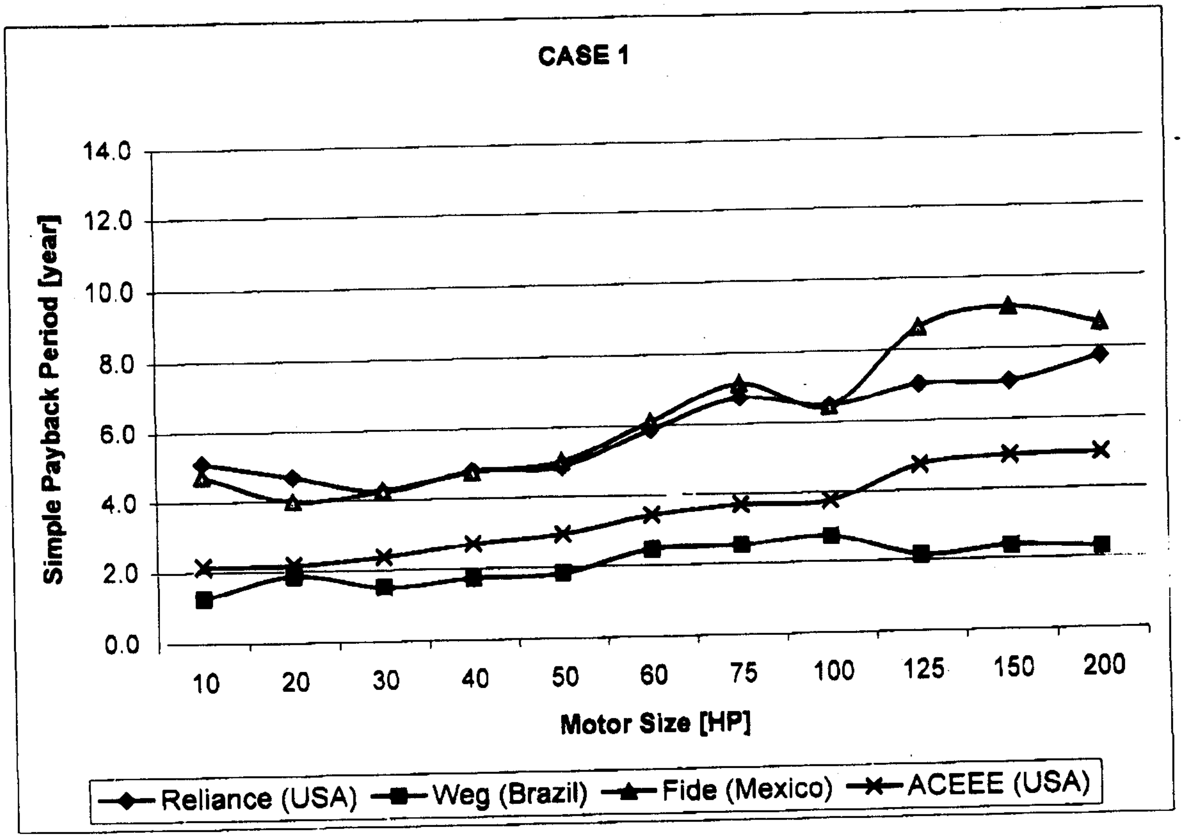
d) The results yielded by Case 1, when compared with Cases 2 and 3 indicate that the energy price is the single most important parameter to ensure the profitability of replacement projects in the mining industry. Energy price projections would considerably impair the liquidity of replacement projects with the startup of natural gas projects in Northern Chile, as shown in Case 3.

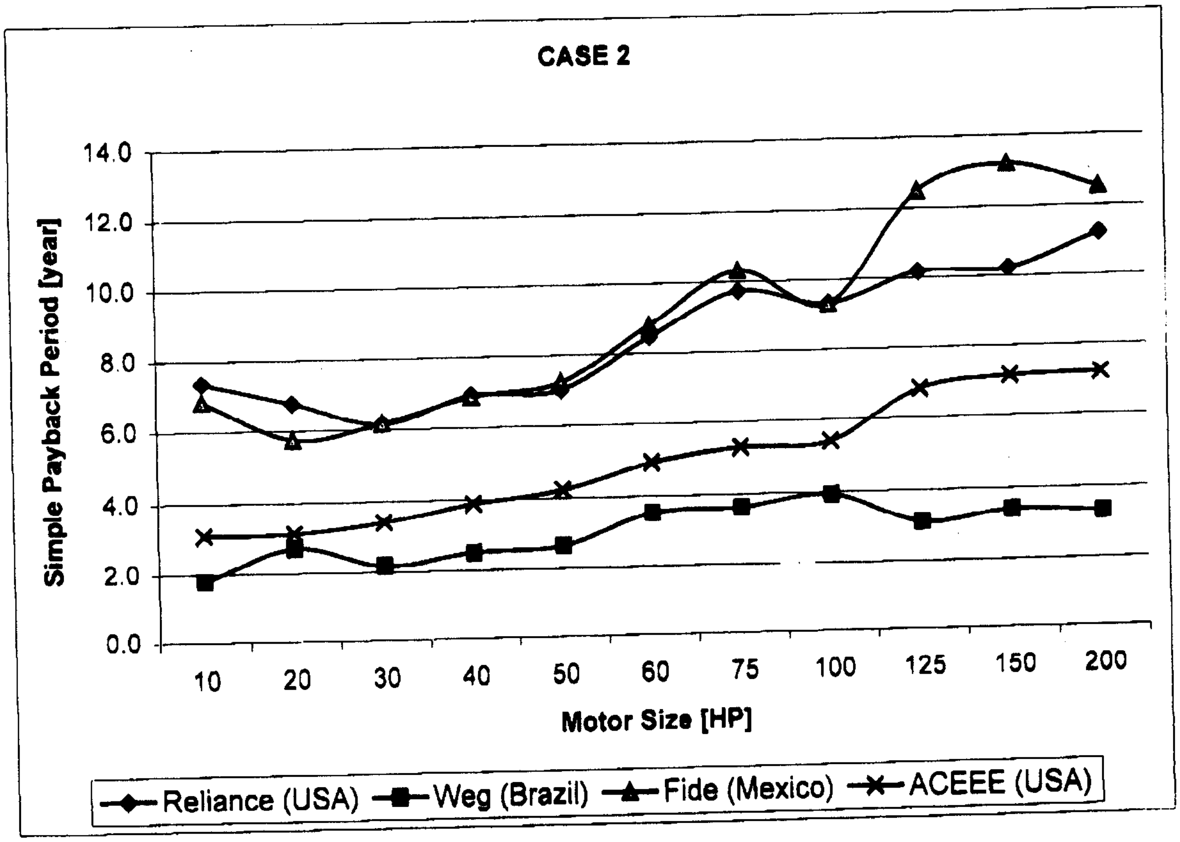
e) When comparing Case 2 with Case 2-b, it follows that a 30% discount on the list prices for the various different motor brands –a very common occurrence in the market— will not prevent the ensuing lower payback period from being neutralized by the effect of incorporating the value of money trough the time, with

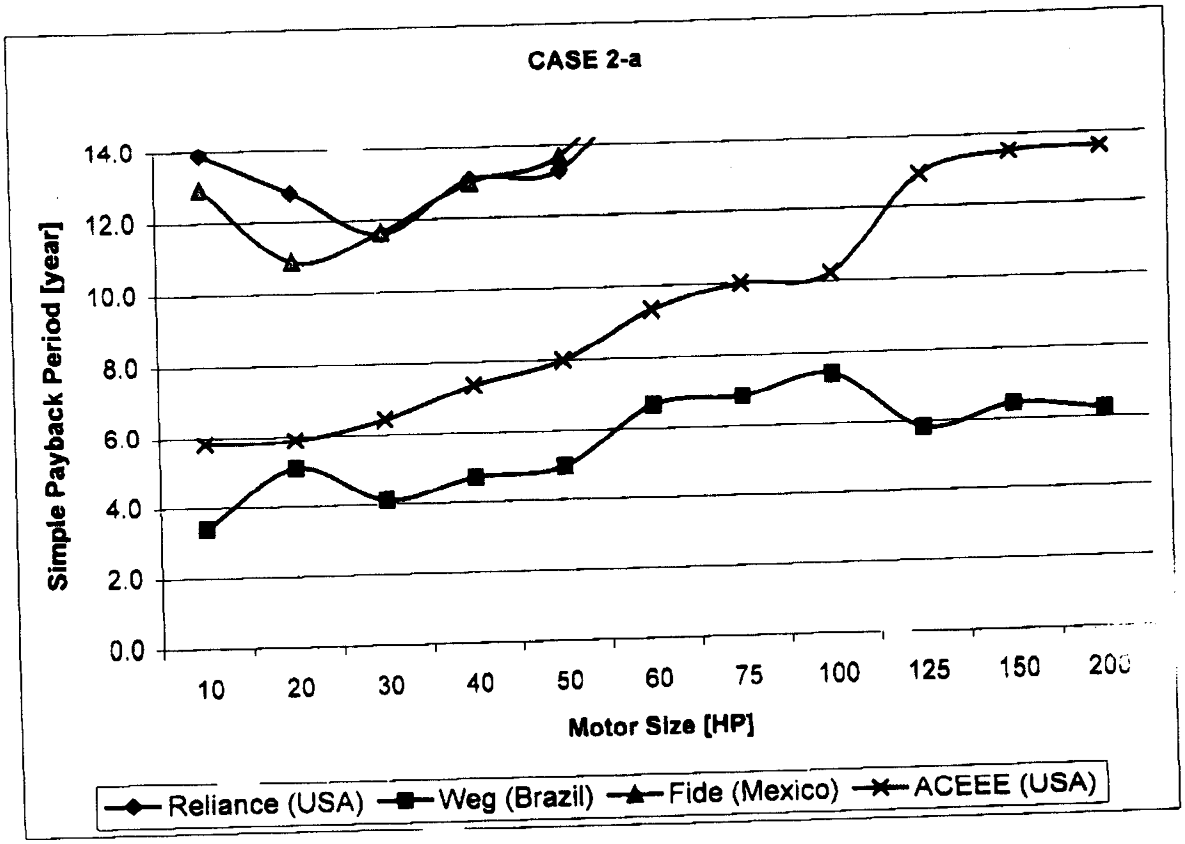
[6] "Electricidad Latinoamericana" magazine, issue 39, July 1998.

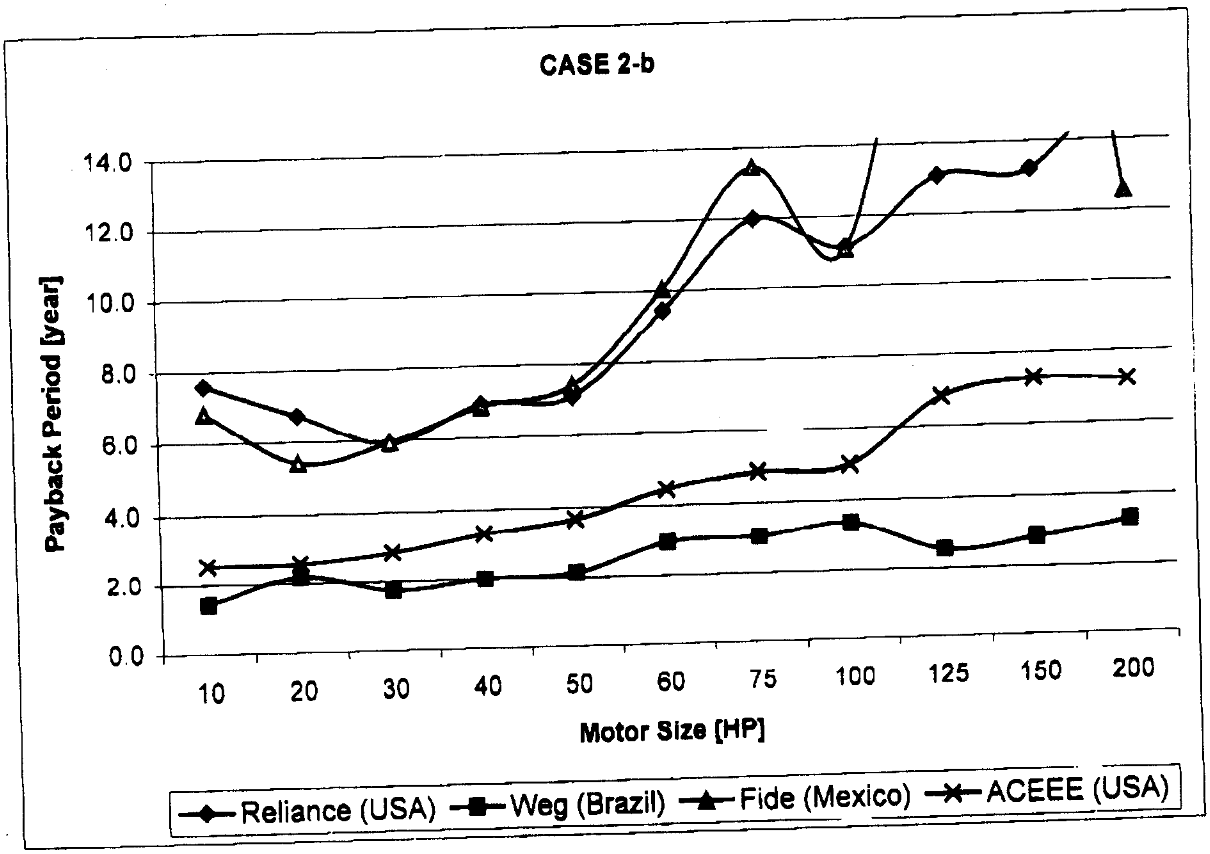
the application of a current discount rate of 10% to the payback evaluation method.

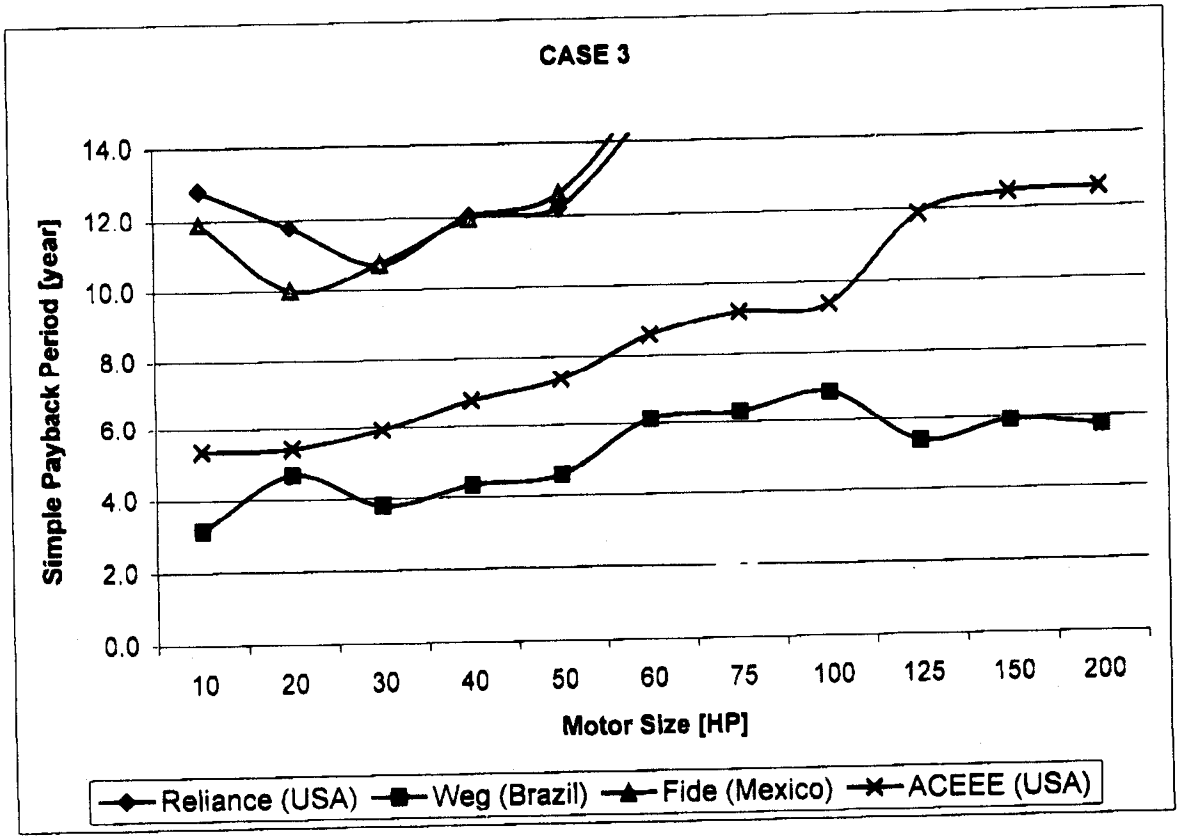
f) Each motor's annual operating hours is an important factor under consideration. This discussion includes cases with annual operating hours at 8,500 and 6,000 h/year. On comparing the results, one may appreciate that payback variation is inversely proportional to the annual operating hours.

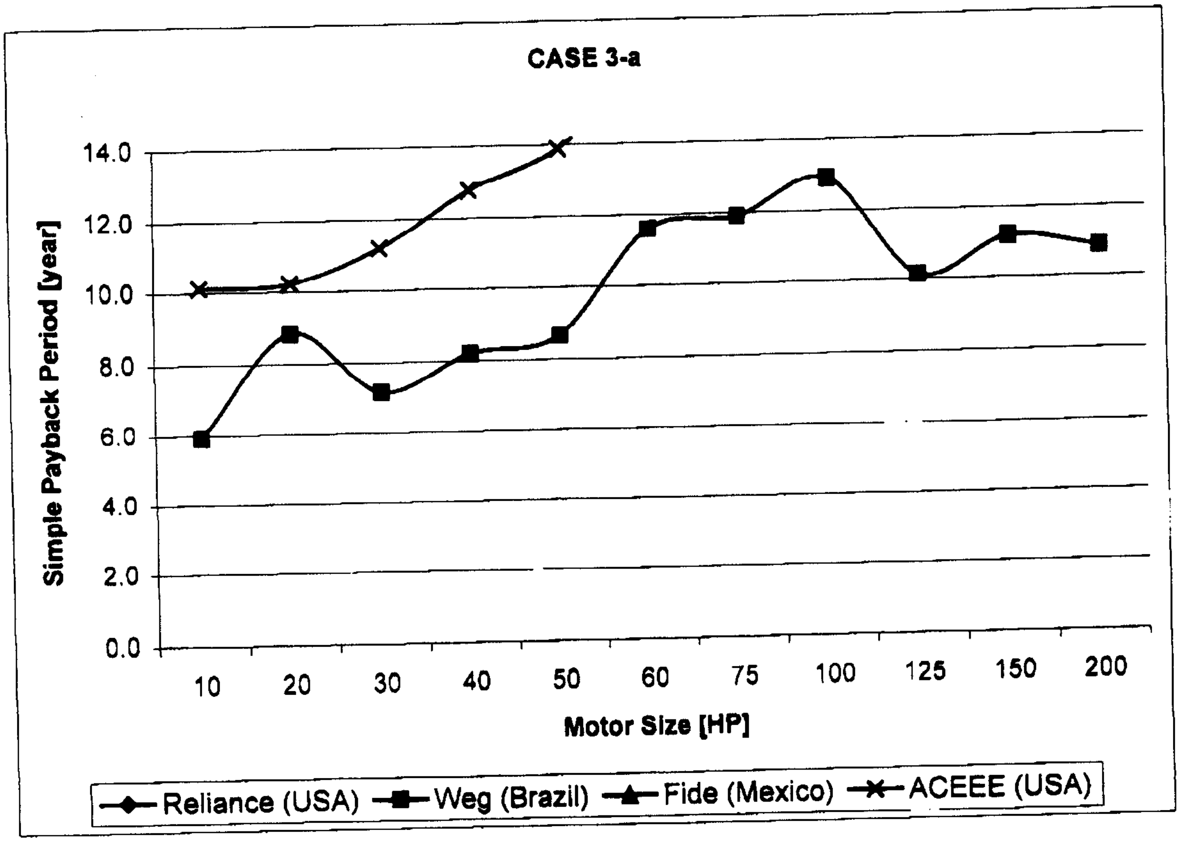

CASE 1
Simple Payback Period [year]
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10
20
30
40
50
60
75
100
125
150
200
Motor Size [HP]
Reliance (USA)
Weg (Brazil)
Fide (Mexico)
ACEEE (USA)


CASE 2
Simple Payback Period [year]
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10
20
30
40
50
60
75
100
125
150
200
Motor Size [HP]
Reliance (USA)
Weg (Brazil)
Fide (Mexico)
ACEEE (USA)


CASE 2-a
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Simple Payback Period [year]
10
20
30
40
50
60
75
100
125
150
200
Motor Size [HP]
Reliance (USA)
Weg (Brazil)
Fide (Mexico)
ACEEE (USA)


CASE 2-b
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Payback Period [year]
10
20
30
40
50
60
75
100
125
150
200
Motor Size [HP]
Reliance (USA)
Weg (Brazil)
Fide (Mexico)
ACEEE (USA)


CASE 3
Simple Payback Period [year]
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10
20
30
40
50
60
75
100
125
150
200
Motor Size [HP]
Reliance (USA)
Weg (Brazil)
Fide (Mexico)
ACEEE (USA)


CASE 3-a
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Simple Payback Period [year]
10
20
30
40
50
60
75
100
125
150
200
Motor Size [HP]
Reliance (USA)
Weg (Brazil)
Fide (Mexico)
ACEEE (USA)

APPENDIX II

ENERGY EFFICIENCY IN SMALL AND MEDIUM SIZE ENTERPRISES

Profile of Small and Medium Size Enterprises (PYME) in Chile

Prior to running a profile of the PYME in Chile, a definition is required as to what is understood by small and medium size businesses. The variables most often used to profile them are the number of jobs and sales volumes.

For the purposes of this document, the net sales variable[7] will be used. Table No.1 indicates the sales volumes that define the ranges for each level.

SIZE	VALUE OF ANNUAL SALES IN USD
Micro-enterprises	Under 74,500
Small enterprises	From 74,501 to 776,030
Medium enterprises	From 776,031 to 1,552,060
Large enterprises	Over 1,552,060

Table No.1: Sales volumes considered for enterprises ranking purposes.

The number of PYME active in Chile in 1993[8] was 75,636 companies engaged in various different economic activities in the country. Of these, 69,489 were small enterprises and 6,147 were medium ones.

This large group amounts to 15.6% of the Chilean business community, which in 1993 summed 483,479 companies. Together with micro enterprises, it accounts for 98.5% of said community as indicated in Table No.2:

SIZE	1990	1991	1992	1993
Micro	364,110	372,311	387,016	400,529
Small	52,473	59,429	65,611	69,489
Medium	4,528	5,327	5,797	6,147
Large	5,160	6,087	6,838	7,314
Total	426,341	443,154	465,262	483,479

Table No.2: Number of companies according to size, 1990-93. Source: CORFO, Investment Promotion Office, on the basis of data provided by the Chilean Internal Revenue Service (SII).

[7] The study prepared by the Ministry of the Economy, Development and Reconstruction is used as a reference to draw up uniform profiling criteria for the PYME, as regards the aggregate number of productive and service companies, rather than focusing exclusively on industrial facilities.
[8] Most recent information available.

Table No.2 indicates that the PYME underwent a vigorous expansion from 1990 to 1993. In fact, by 1993 the PYME accounted for 15.6% of the aggregate business community, that is, up two percentage points as against its market share in 1990 (13.4%).

Table No.3 illustrates how the PYME are distributed throughout the Chilean economic spectrum. Although the PYME do account for 15.6% of the Chilean business community, this percentage varies significantly when each economic activity is taken into account on an individual basis.

ACTIVITY	1990	1991	1992	1993
Agriculture and livestock	13.0	13.3	13.3	12.2
Agricultural services	0.5	0.5	0.5	0.5
Forestry	1.3	1.3	1.3	1.3
Fishing	1.1	0.9	0.7	0.5
Mining, oil and quarries	0.8	0.8	0.7	0.6
Manufacturing	15.5	14.9	14.6	14.4
Electricity, gas, water	0.2	0.2	0.2	0.1
Construction and installation	5.3	5.3	5.5	5.8
Wholesale and retail	41.2	40.7	39.6	38.9
Restaurants and similar activities	3.6	3.8	3.8	3.9
Transportation	8.6	8.6	9.0	9.2
Technical and professional services	5.3	5.8	6.4	7.6
Leisure and entertainment	0.2	0.2	0.2	0.3
Personal and housekeeping services	3.3	3.7	4.3	4.6
Total	100.0	100.0	100.0	100.0

Table No.3: Distribution of PYME by economic activity, 1990-1993, in percent. Source: CORFO, Investment Promotion Office, on the basis of data provided by the Chilean Internal Revenue Service (SII).

Out of the 75,636 small and medium size companies recorded in 1993, over 45,000 were in three sectors: commerce (39%), manufacturing (14.4%) and agriculture and livestock (12%).

These three sectors have dominated the scene since 1990 and no significant changes have taken place in the distribution structure of the PYME among the various different economic activities during the 1990-1993 period.

Concentration of market share in these top three sectors has nevertheless decreased, and an increase in the market share held by the other activities is also evident.

The most important sector within the PYME from the standpoint of energy consumption and the implementation of energy efficiency actions is manufacturing. Following is a detailed discussion of this sector:

Importance of the Manufacturing Sector[9]

Manufacturing has long been a key area of concern as regards production development policies due to its significant bearing on other areas of the Chilean economy, among other reasons because:

- it is a sector in which the value-added proportion over the gross value of its production is quite significant;
- it generates forward productive linkages (services, transportation, commerce);
- it generates backward productive linkages (agriculture, mining, forestry, fishing, capital goods, etc.).

The information currently available in Chile with regard to the industrial manufacturing sector uses individual facility occupancy for size differentiation purposes. It defines as:

- small and medium size industry (PYMI) those establishments with 10 to 49 workers; and
- large size industry (GI) those with more than 50 workers.

A few PYMI performance indicators point to a decrease in the number of companies over the 1979-1990 period. In fact, available information indicates that the number of industrial facilities fell during the period in question from 5,779 to 4,552 establishments.

This decrease was most significant in companies hiring 10 to 49 workers, as this sector recorded a drop to 2,919 establishments in 1990 from 4,506 in 1979. This trend began to revert in 1990. The decrease in the number of establishments impacted directly on the mean rate of employment, and the PYMI fared much worse than large size industries.

The PYMI suffered a drop in employment levels from 90,344 workers in 1979 to 70,537 in 1990. However, the gross value of production per establishment grew, in more consistent fashion in small and medium scale production.

With a base index of 100 in constant 1979 pesos, the value of production per establishment:

- at the PYMI, grew to 219.5 by 1990,
- at large industries, grew to 110.9.

[9] The information included in this section is based on data collected in the census and the annual reports issued by the National Institute of Statistics for the manufacturing industry. Its information levels are therefore not comparable with those generated by other sources.

The mean productivity of labor in the PYMI increased on average by 5.5% per year, from 1984 to 1990, versus 4.3% annual drop at large industries.[10] It could be inferred that both sectors responded differently to the economic crisis of 1982-1985.

The adjustment at the PYMI was more severe as numerous establishments went out of business. However, the ones that remained saw significant improvements in their labor productivity, average plant size and efficiency.

These figures are a telling reflection of the radical changes undergone by the PYMI starting with Chile's trade deregulation in 1979 and the recovery from the economic crisis of 1982.

A combined analysis of the progress made in terms of wages and relative productivity shows a trend in which the PYMI have improved their competitiveness in relation to the big enterprises in twofold fashion, i.e. via higher labor productivity and lower labor costs.

Presence in the Regions of Chile

One of the highest policy priorities of the Chilean government is to promote regional development and overall decentralization. In this sense, corporate behavior patterns and the penetration of productive enterprises in the various regions of Chile are worthy of observation. It is also interesting to study how business behavior varies with the size of the productive units. Table No.4 depicts the regional distribution of companies according to size. Following is a discussion on the data included in said table.

Regardless of size and in aggregate terms, it is clear that the distribution of companies is heavily concentrated in three regions: the Metropolitan, 5th and 8th Regions.

This general pattern of regional distribution and concentration of economic activities does reveal some differences when analyzed from a business size perspective. In fact, the Metropolitan Region records the highest concentration of large businesses when compared with the other regions of Chile, including important ones such as the 5th and the 8th.

In 1993, the Metropolitan Region was home to 31.5% of Chile's micro-enterprises, 49% of its small and medium size enterprises and 69.7% of all large enterprises. In other words, the larger the size, the highest the concentration in the Metropolitan Region.

In the other regions, the proportion of enterprises increases as enterprises size decreases, even in the 5th and 8th Regions. The latter two account for 9% and 11% of micro-enterprises, respectively, 9% and 9.4% of small and medium size enterprises, and 5.3% and 5.8% of large enterprises.

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[10] Agacino and Rivas, July 1993.

REGION	MICRO (%)	PYME (%)	LARGE (%)	TOTAL (%)
1ST	3.0	2.2	2.8	2.8
2ND	2.5	2.3	1.9	2.5
3RD	1.6	1.2	0.8	1.5
4TH	3.7	2.7	1.5	3.5
5TH	9.2	8.9	5.3	9.1
6TH	4.9	4.1	1.7	4.8
7TH	7.6	4.7	2.3	7.1
8TH	10.8	9.4	5.8	10.5
9TH	5.0	4.3	2.1	4.9
10TH	6.1	6.3	3.5	6.1
11TH	0.6	0.6	0.4	0.6
12TH	1.2	1.5	1.2	1.3
MR	31.5	49.1	69.7	34.8
TOTAL	100.0	100.0	100.0	100.0

Table N° 4: Regional distribution of companies according to size. Source: CORFO, Investment Promotion Office, on the basis of data provided by the Chilean Internal Revenue Service (SII).

APPENDIX III

DICTUC S.A.
GASEOUS EMISSIONS LABORATORY

Energy Efficiency Project for the Reduction of Greenhouse Gases

UNITED NATIONS DEVELOPMENT PROGRAM
Project CH/93/G31
November 10, 1998

"FINAL REPORT"

The results were obtained from the PROCEFF database on CO_2 emission sources in the Santiago Metropolitan Region. This database was converted to an Excel spreadsheet to calculate the estimated potential for CO_2 emission reduction by type of source.

The following activities were carried out on the basis of spreadsheet data:

- The sources previously retrofitted to natural gas were eliminated.
- The sources belonging to the heating boiler group were eliminated.

Once the sources were selected, the following was determined:

- Current consumption of each type of fuel for each source, in kg/year.
- Energy consumed by the process, in GJ/hour.
- The energy calculated above is used to calculate natural gas consumption for each source, in kg/year, assuming the same efficiency.
- The emission factors yielded allowed for calculating CO_2 emissions for each source with the fuel it currently uses, and also CO_2 emissions for the same sources once retrofitted to natural gas.
- The current efficiency for each type of source was determined on the basis of excess air and fume temperature.
- Efficiency increased when excess air was reduced to 10% in the case of boilers and bakeries. In the case of processes, it was assumed that excess air couldn't be modified due to process requirements.
- An additional improvement to efficiency was determined as a result of lower fume temperature, in all cases. For boilers, the concept of condensation boilers was taken into account, and air pre-heating was considered for bakeries and processes.
- The efficiency rates calculated were used in determining the new consumption of natural gas for each efficiency increase and type of source.
- The new CO_2 emissions were calculated for each new consumption.
- The CO_2 emission per source was used to calculate aggregate CO_2 emission and the potential for reduction per source type.

One should bear in mind that the potential for CO_2 emission reduction is a maximum that can be used as target. However, in practice this maximum is never achieved. The results obtained are indicated in Table No.1 below:

TABLE No.1

CO_2 EMISSION BY TYPE OF SOURCE

	Industrial Boilers		Processes		Bakery Ovens		Total CO_2	
	CO_2 10^{12} gr./year	Relative %	CO_2 10^{12} gr./year	Relative %	CO_2 10^{12} gr./year	Relative %	CO_2 10^{12} gr./year	Relative %
CURRENT	1.29	100	0.3	100	0.1	100	1.69	100
EFFICIENCY INCREASE FROM REDUCED EXCESS AIR	0.92	71.51	-	-	0.073	71.92	1.19	70.51
EFFICIENCY INCREASE FROM REDUCED FUME TEMPERATURE	0.87	67,35	0.18	59.85	0.072	71.27	1.12	66.27
TOTAL REDUCTION POTENTIAL	0.42	32.65	0.12	40.15	0.03	28.73	0.57	33.73