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China's Energy Policy and Energy Efficiency Policies for Mining Industry

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Improving Energy Efficiency in the APEC Mining Industry
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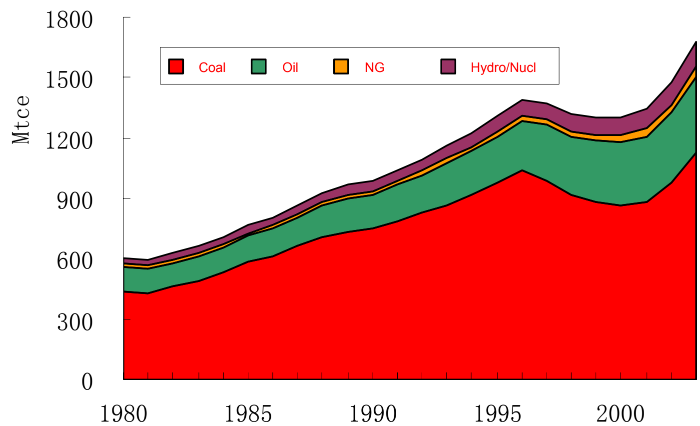
Outline

- Energy Aspects in China– General and New Situation
- Outline of Medium-Long Term Energy Development Planning (2004-2020) (Draft)
- General Energy Efficiency Policies
- Energy Efficiency Policies for Mining Industry

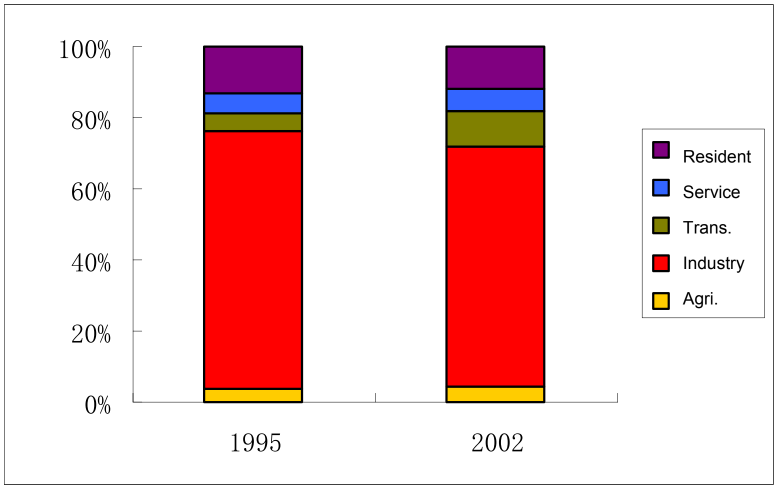
Primary Energy Consumption



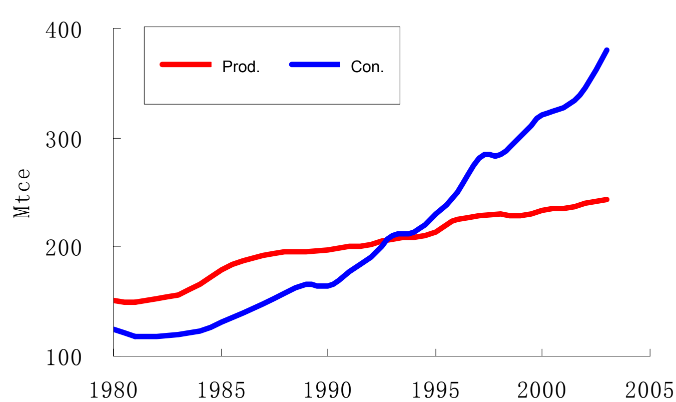
Primary Energy Mix（%）

	China				World
Year	1980	1990	2000	2003	2003
Coal	72.2	76.2	66.1	67.1	26.5
Oil	20.7	16.6	24.6	22.7	37.3
NG	3.1	2.1	2.5	2.8	23.9
Elec.	4.0	5.1	6.8	7.4	12.3

Industry is the Main Consumer



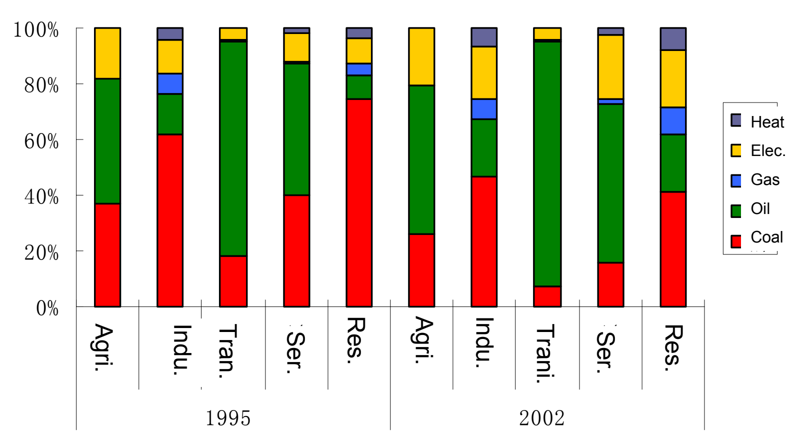
Higher and Higher Dependency on Import Oil



2nd Power Generation Industry in the World

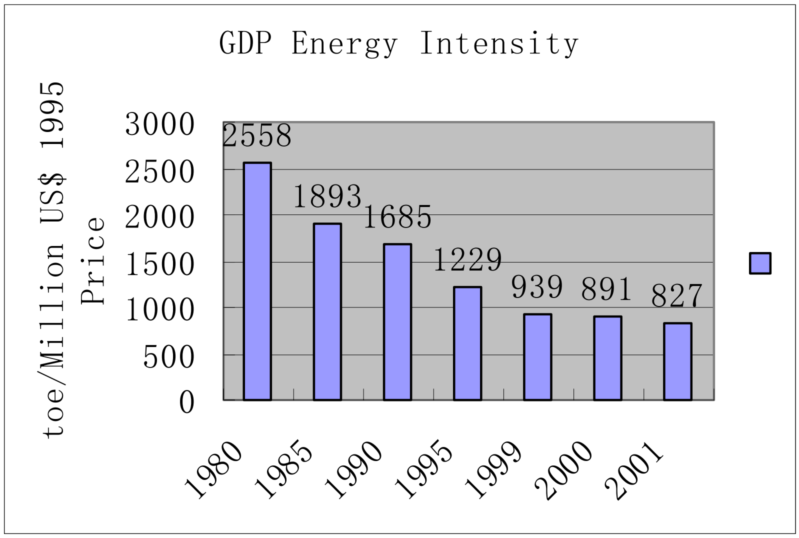
Year	Capacity/GW				Generation/TWh			
	Total	Thermal	Hydro	Nuclear	Total	Thermal	Hydro	Nuclear
1980	65.9	45.6	20.3		301	243	58	
1985	87.0	60.6	26.4		411	318	92	
1990	137.9	101.8	36.0		621	495	126	
1995	217.2	162.9	52.2	2.1	1007	807	187	13
2000	319.3	237.5	79.4	2.1	1369	1108	243	17
2001	338.5	253	83	2.1	1484	1205	261	18
2002	356.6	265.6	86	4.5	1654	1352	275	27
2003					1911			

Less Coal for Final Users

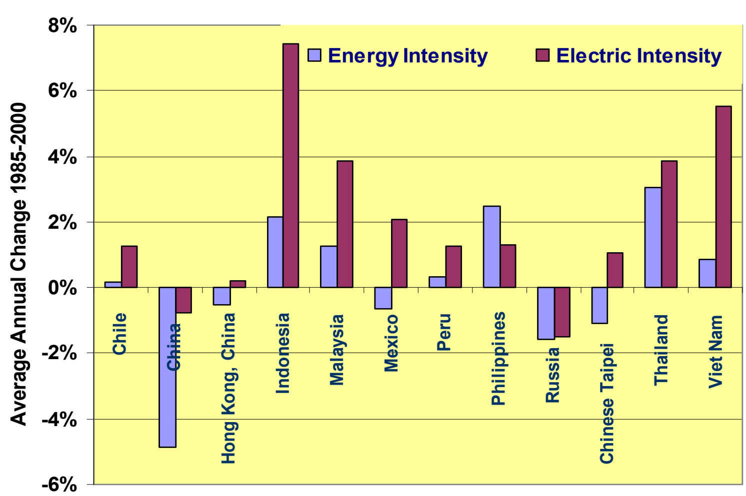


ENERGY EFFICIENCY IN CHINA

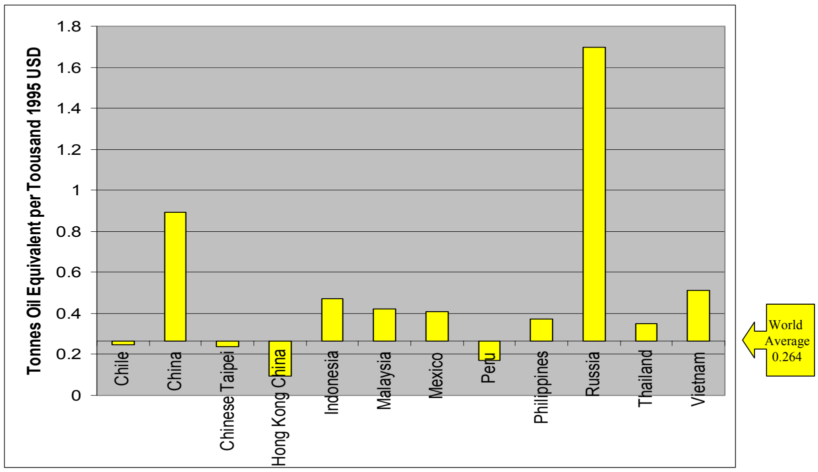
Source: Handbook of Energy & Economic Statistics in Japan, 2004



…has gone a long way



…but much remains …



Energy Intensity of Main Industrial Products

	Energy Intensity	1990	2000	2002	World Advanced
Power (including transmission loses)	gce/kWh	427	392	383	316
Steel (large-scale plant)	kgce/t	997	766	715	646
Cement (Large-scale)	kgce/t	201.1	193.8	172 (Estimated)	127.7
Ammonia (NG as feedstock)	kgce/t	1343	1273	1215	970

Driving Forces for Energy Conservation in China

- Energy shortage: black out, 3-day-stop and 4-day-run
- Cost reduction: pricing
- Pollution abetment: emission fee, fine
- Sustainable development

	1986		1996	
	Energy purchase cost (billion Yuan)	Proportion of energy cost (%)	Energy purchase cost (billion Yuan)	Proportion of energy cost (%)
Steel Industry	9.7	20.5	59.1	24
L/M plants	8.2	22	47.6	24.8

'Three Shortages and One Hot Topic'

- Three shortages: electricity, coal & oil
  - Quick switch from surplus to shortage
  - Broad range– 24 out of 29 provinces
  - Shortage in coal
- One hot topic: energy development strategy
  - Sustainable development strategy for oil and gas
  - Energy science and technology development planning
  - Outline of medium-long term energy development planning (2004-2020) (draft)

Outline of Medium-Long Term Energy Development Planning (2004-2020) (Draft)

- Main points:

1. Top priority given to energy conservation and efficiency improvement
2. To make adjustments on energy profile– coal dominant, power oriented, as well as oil, natural gas and new energy
3. Better distribution of energy facilities– east and west, urban and rural, transportation capacity

Outline of Medium-Long Term Energy Development Planning (2004-2020) (Draft)

- Main points:

4. Full utilization of domestic and overseas resources and markets– self sufficient and international cooperation
5. Rely on technology innovations
6. Make great efforts on minimizing environmental impacts by energy production and consumption

Outline of Medium-Long Term Energy Development Planning (2004-2020) (Draft)

- Main points:

7. Full attention given to energy security– diversification, stockpiles
8. Improvement of energy policy-making

Main Areas of Technology Development

1. Energy efficiency technologies
2. Higher efficient and cleaner utilization of coal
3. Technical system to support oil security
4. Advanced nuclear power technologies
5. Large-scale hydropower generation technologies
6. Increasing reliability of power grids
7. Renewable energy
8. Hydrogen and fuel cell

Energy Efficiency Policies

1. Administrative regulations
2. Energy efficiency management system
3. Laws and legal regulations
4. Financial incentives
5. Energy standards and labels
6. Voluntary agreements

Evolution of Energy Efficiency Policy in China

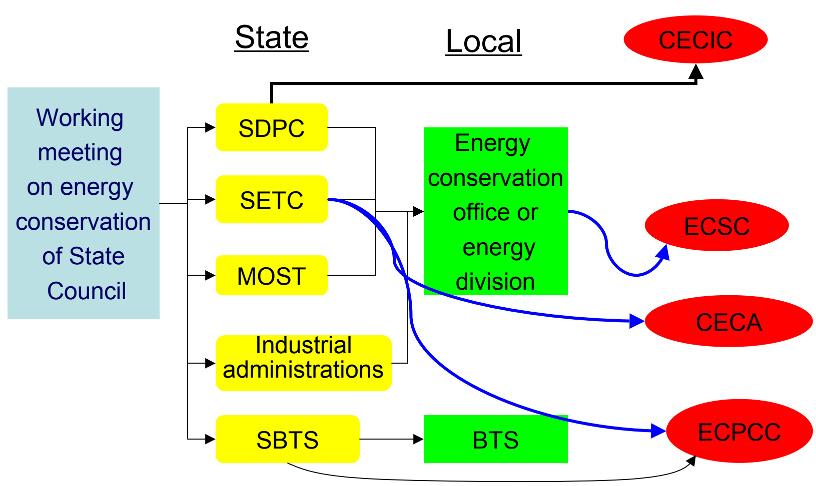
- ✓ Energy consumption quota (1980's)
- ✓ Publish guidance catalogues for technologies of comprehensive utilization and investment in energy conservation to provide investment direction for enterprises and financial organizations (1990's)
- ✓ Shutdown the small-scale, energy intensive industries (1990's)
- ✓ Policy Outline for Energy-Saving Technologies (1997)
- ✓ Outline for CHP Development (1998)
- ✓ Energy Conservation Law (January 1st 1998)

Evolution of Energy Efficiency Policy in China (cont'd)

- ✓ Energy conservation management system in key energy consuming entities(1999)
- ✓ Regulations on electricity consumption conservation (2000)
- ✓ Energy efficiency voluntary agreement for steel industry (pilot, 2002)
- ✓ Clean Production Promotion Law (Jan. 1st 2003)
- ✓ Environmental Impact Assessment Law (Sept. 1st 2003)
- ✓ Local regulations

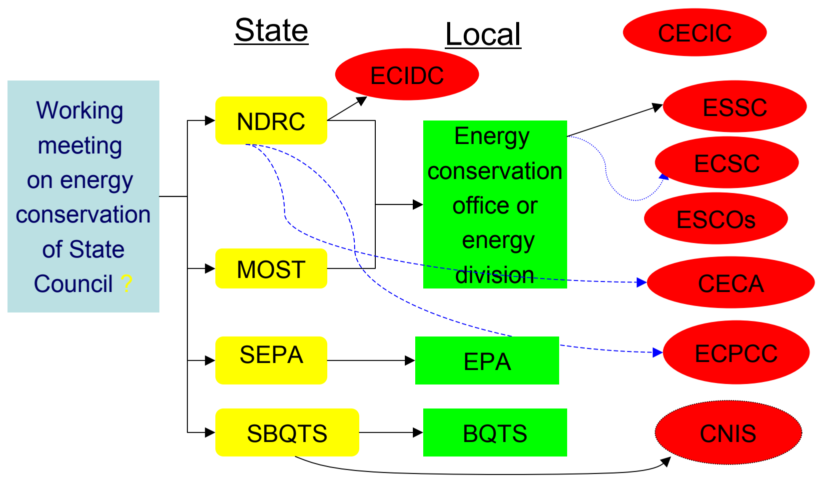
Energy Efficiency Management System

(planning economics orientated)



Energy Efficiency Management System

(take the advantages of market economics)



Energy Standards & Labels

- Appliance standards:Room A/Cs, audio radio receivers and recorders, clothes washers, fans, irons, refrigerators, rice cookers, TVs (1989 implementation, 1995 mandatory), fluorescent lamp ballasts (2000, mandatory) .
- Energy efficiency product certification system (1998)
- Appliance labelling (Voluntary): Refrigerator/freezers and combinations (1999), Lamps (2000)
- Energy-consuming equipment (design) standards: Industrial boiler, motor, fan, pump, transformer, automobile…
- Building codes for new buildings (Oct. 1st 2000, mandatory)
- New Standards for above products (2003-2006)

Financial Incentives

- Fixed asset tax exemption – investments in cogeneration facilities and energy efficient buildings(0%)
- Value added import tax exemption – importation of energy efficient and pollution reduction equipment
- Income tax exemption – projects that use advanced technology such as CBM are exempted from income taxes for the first 5 years
- Government subsidy low interest loan for energy conservation project(30% lower), technology demonstration project (50% lower) and pay the bank out of pretax income (before 1994)

Energy Efficiency Target

Double energy consumption to support fourfold GDP development target

- 50% reduction on energy intensity

Differences of Definition of Mining Industry

- Definition in China

  Mining and Quarrying Industry

  Ferrous Metals Mining and Dressing

  Nonferrous Metals Mining and Dressing

  Coal, Oil, NG, Nonmetal, Other Minerals, Timber and Bamboo

  Manufacturing Industry

  Smelting and Pressing of Ferrous Metals

  Smelting and Pressing of Nonferrous Metals

  Others

General Data of Mining Industry (2001)

Source: China Statistical Yearbook 2002

- Number of Enterprises: 7955 (4.64% of total industry)
- Gross Industrial Output Value: $106 billion(9.10% of total industry)
- Value-added: $ 28 billion(8.25% of total industry)
- Total Assets: $214 billion (10.23% of total industry)
- Total Final Energy Consumption: 164.7 million tce (26.4% of total industry)

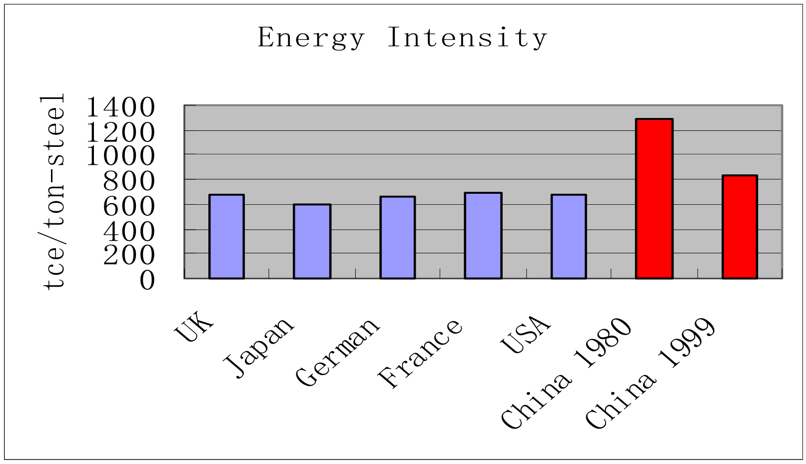
Energy Efficiency Policies for Mining Industry

- In general, no specific policies for mining industry
- More attentions given to downstream (energy consumption: upstream 2.3%, downstream 97.7%, iron & steel 85.6%)
- Tow steel plants were selected for demonstrating energy efficiency voluntary agreement

Adoption of Efficiency Technologies in Iron & Steel Industry

Available Technologies	Energy Recovery
Heat recovery from coke dry quenching (CDQ)	2000 kJ/ton-coke
Top pressure recovery turbine (TRT)	20-30 kWh/ton pig iron
Basic oxygen furnace gas recovery	0.37-0.84 GJ/ton-steel
Blast furnace gas recovery	2.24 GJ/ ton pig iron
Direct-current electric arc furnace (DC-EAF)	Decrease 3-5% electricity consumption

… a long way to go



ENERGY EFFICIENCY IN THE MINING INDUSTRY: OPPORTUNITIES AND INSTITUTIONAL DESIGN

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1. INTRODUCTION

1.1 The energy efficiency as a strategic option for the copper industry.

The goal of this paper is to show the potentials of an energy efficiency policy in the copper industry, the barriers and the main components of such a policy. In order to highlight the pertinence of the efforts performed in this direction by our research team and the copper industry professionals, it is necessary to point out that Chile represents around 40% of the world copper production [1], [2].

For the companies involved in this kind of initiative, a successful energy efficiency project will allow it to reduce the production costs, to improve the productivity and to introduce the energy management into the environmental integrated systems, established in the context of the ISO 14 000 certification

On the other hand, the copper industry is responsible for an important percentage of the Chilean direct and indirect emissions of greenhouse gases (GHG) [3]. Even if Chile is not a signatory of the Kyoto protocol, it doesn't mean that the country will not assume a part of the world efforts aiming to mitigate GHG, being the energy efficiency (EE) one of the most effective and profitable alternatives to achieve significant results in this field. It is almost certain that the Chilean copper industry will play an important role in the achievement of national GHG voluntarily assumed mitigation goals.

Even if most of efforts have been oriented to the improvement of the electricity use efficiency, it doesn't imply that the EE institutional building, the mechanisms, incentives and instructives conceived are not applied to fuels consumption as well.

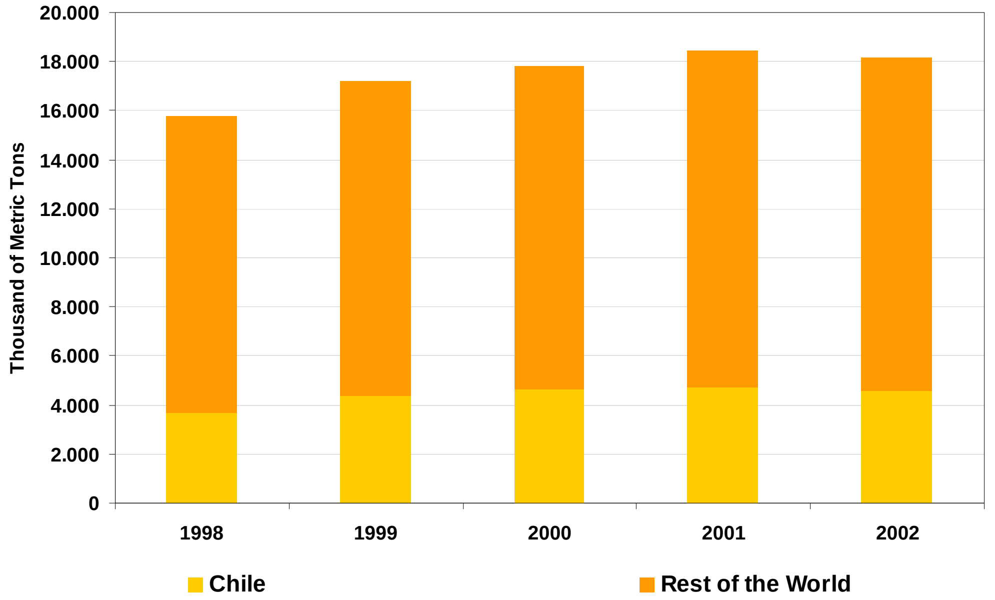
The importance assigned to the electricity is explained by the fact that the technological trends in copper smelters point to an autogenous operation, as a result of the extended use of technologies like the Teniente converter and Flash furnace replacing the reverberatory furnace and also due to the growing importance of the hydrometallurgical copper extraction process in relation to the conventional pirometallurgical process.

It should be said that the mining industry has performed some punctual and isolated efforts (the examples included in this paper show their results), but they should be considered as individual initiatives rather than a company policy. The results of the successful experiences, from the technical and economical point of view, had not been appropriately communicated and they are practically unknown to most of the workers of the related company. Finally, even if in some cases there are incentive payments for EE improvements, they don't have effectiveness because they are excessively global, voiding the expected motivation for technological innovation.

2. COPPER MINING INDUSTRY: PRODUCTION AND ENERGY CONSUMPTION

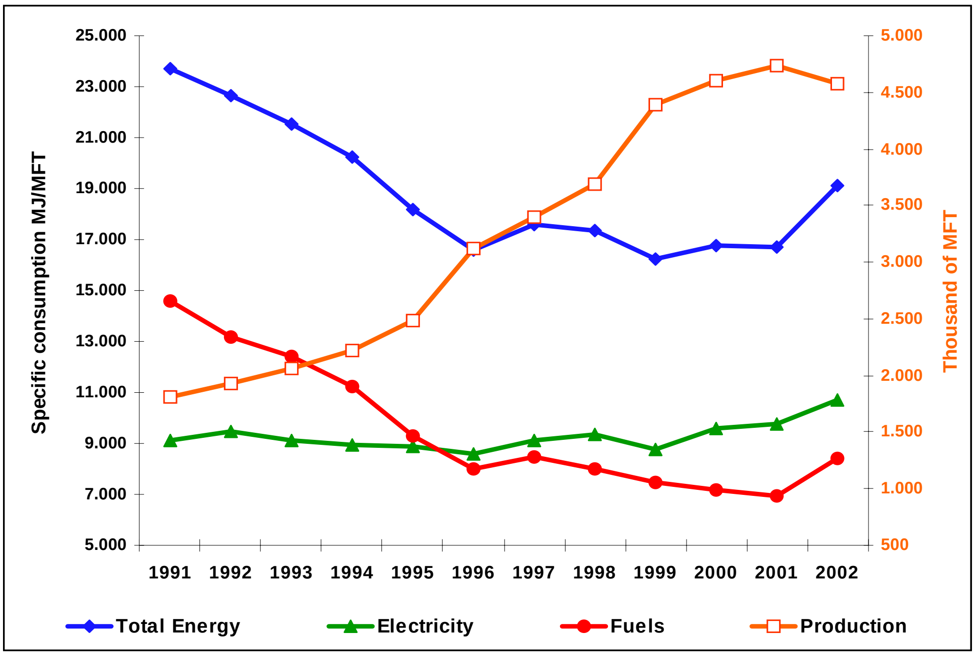
The following graph shows the relative importance of the Chilean copper production at the world level and their recent evolution.

Graph I:
World and Chilean copper production
(thousand metric tons of copper content)

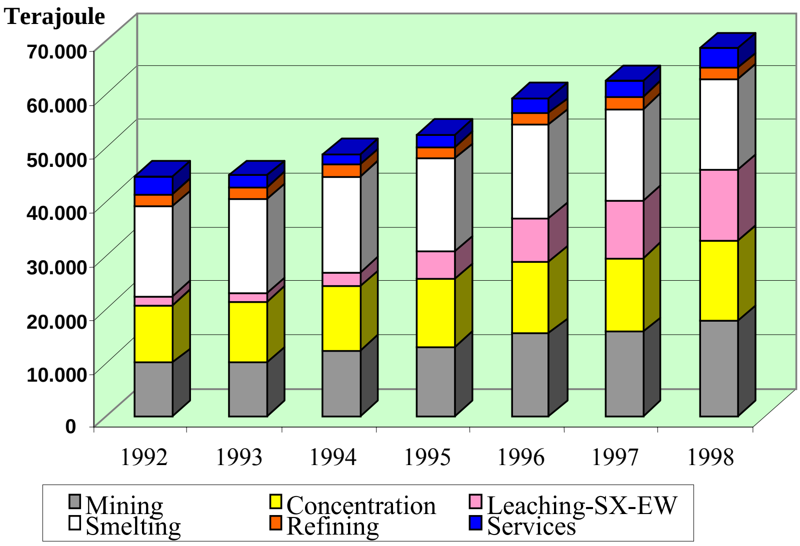


The following graphs summarized the evolution of the energy consumption by fuel and process. The technological changes already mentioned explain the significant trend changes shown in relation with the production and energy consumption, this is mainly the case of the fuels which reflects the effects of the refer change, by the other hand the slow increase of electricity consumption reflect the augmentation on oxygen requirements and the increasing importance of the hydrometallurgical process.

Graph II:
Copper mining specific energy consumption



Graph III:
Total Energy Consumption on Copper Mining



3. THE MINING INDUSTRY AND THE ENERGY EFFICIENCY CHALLENGES

It should be pointed out that the mining companies have unusual favorable conditions for a successful implementation of the EE measures. Indeed, those companies, because of their worldwide importance, have not only enough financial resources to invest in profitable EE projects but also a technical staff highly qualified, which, unfortunately, is not assigned to tasks related to energy management. Finally, in many cases the top management considers energy efficiency as an important subject. Cost reduction requirements and global competitiveness are also significant drivers for EE for the diffusion of energy efficiency technologies and good energy management practices. However, in spite of the favorable conditions described, the significant potentialities detected in some of them remain simply as mere potentials, because of the barriers detected by the University's research team .

3.1 Saving potentials

In one of the largest copper companies, object of the main analysis and source of the "replicable projects" described below, saving potential was estimated as a 15% of the present energy consumption. The EE actions considered were those technically feasible and also cost effective for the areas, processes or facilities where the selected technologies are supposed would be implemented.

Chart I
Saving potential results of the improvement options

Improvement options	Saving amount	Units
Operational improvements	226	GWh/year
Replicable projects	68	GWh/year
Benchmarking references	246	GWh/year
Others	99	GWh/year
TOTAL	639	GWh/year
% of the company consumption	15	%

If it is considered, for the referred company, an average electricity cost of 5¢/kwh, the estimated saving would be over US$30 millions/year, goal that would be reached in about ten years and under the conditions that an EE policy may modify the present situation. Indeed, the materialization of the savings indicated in the previous chart demands the implementation of a strong EE policy, whose success will depend on the highest management commitment. This commitment should be expressed by an adequate institutional framework; a master plan known by all workers, verifiable and periodically updated; a set of mechanisms and incentive payments; and control, follow up and monitoring systems [4].

3.2 Some examples of replicable projects

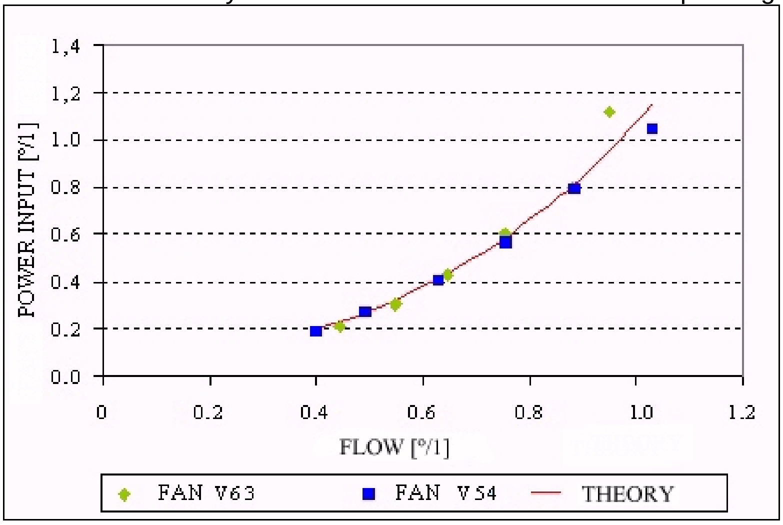
3.2.1 Application of frequency converters in the mine ventilation: savings achieved.

The introduction of frequency converters in the ventilation of an underground mine was evaluated during the first phase of the project [7], [8]. The analysis performed allows the empirical verification of the lineal relationship frequency-flow and the cubic relationship power-flow. The total savings estimated amount to 35%. The following graph summarizes the result obtained from two fans, 562 kW and 814.000 cfm and 341 kW and 717.000 cfm, respectively.

The theoretical model, relating flow and frequency, is Q = 1,15f–0,163;

And the model relating power consumed by the fan and the flow, is:
Pelectricity = 0,0214 (Q(0,318 (0,683 Q2)/0,951

Graph IV.
Power consumption versus air flow
Both models were confirmed by the field measurements of the corresponding parameters



3.2.2 Efficient lighting introduction in an specific area of one of the company facilities

It was analyzed the results of an efficient lighting project implemented in the smelter in one of the company facilities. The results show an improvement in the level of lighting, which presently are under the lighting standard requirements and a reduction in the energy consumption over 60% in relation to the present one.

The following chart shows the present consumption in lighting in the mentioned smelter. It should be noted that the lighting level was extremely below the international standards.

Chart II
Lighting levels before the project

Area of the smelter	**LIGHTING LEVEL [LUX]**			
	Minimum	Maximum	Average	Recommended
Anode and blister	40	250	141	300
Smelting	22	114	49	150
Oxygen and air	10	102	63	250
Load preparation	15	106	51	150

The next chart shows that the project under implementation not only reduces energy consumption but also improves in a significant way the level of lighting, fulfilling the standards requested by the smelter manager. The following table summarizes the project results.

Chart III
Project results: lighting levels and energy savings

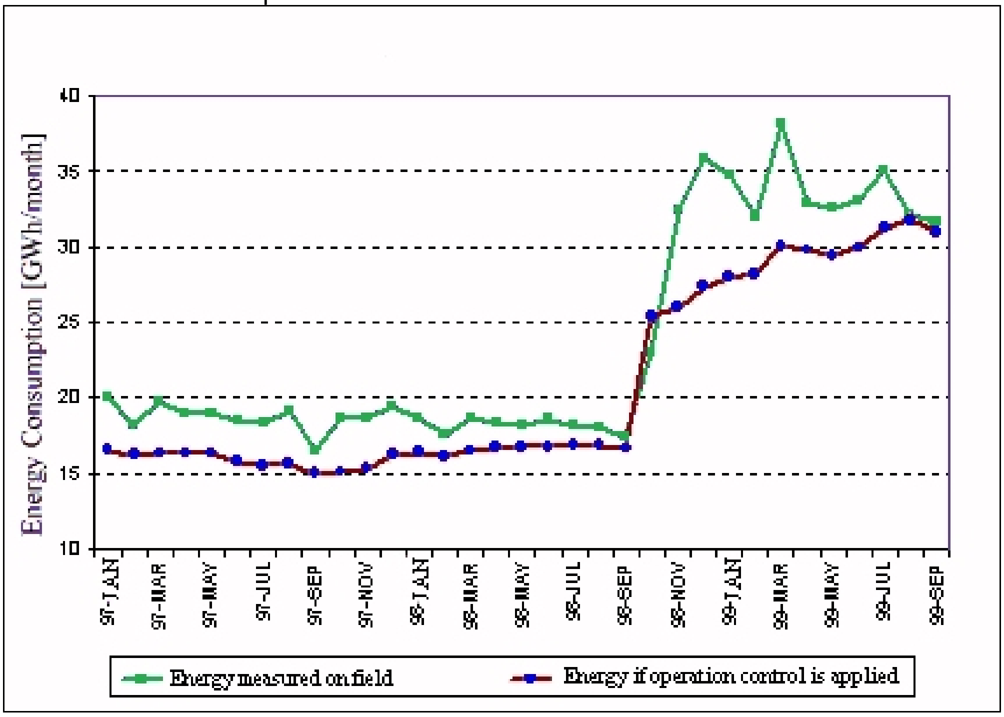
ÁREA OF SMELTER	**Lighting level [lux]**			**Power [kW]**		**Savings**
	present	proyect	standard	installed	proyect	MWh/year
Anode and blister	141	305	300	40.55	18.78	190.71
Smelting	49	180	170	99.06	37.50	539.26
Oxygen and air	63	257	250	33.73	11.10	198.20
Load preparation	51	137	123	39.51	16.59	485.39
TOTAL				**260.20**	**98.83**	**1,413.56**

3.2.3 Energy savings in the mineral concentration as a result of an improvement of operation control.

It was evaluated, for the concentration of minerals, the impact of a tight control of the operation in the different areas of the concentration process: primary and secondary crushing; tertiary and quaternary crushing; conventional milling; unitary milling; SAG milling and flotation. As a result of a simulation it was detected that an improvement in the operation control could be converted into savings amounting from 12% to 14% of the present consumption. The mineral concentration was selected as a demonstration example of the potential improvements to be obtained with a tight production control, as far as the same approach could be applied to other production areas.

The evolution of the specific consumption (EC) was followed during around 30 months, assuming that is adopted a tight operation control. In a conservative approach, it was considered as easily obtainable the third lowest specific consumption as an operational goal for the period of time analyzed (it should be pointed out that using monthly specific consumptions it is clearly, also a conservative approach) . The results are shown in the following graph, which compares the energy actually measured with the energy that the control will allow to obtain.

Graph V.
Operation control results in the concentrator



3.2.4 Load management: a successful experience.

In one of the facilities of the company it was carried out an effort to manage the maximum demand, being able to reduce this demand in 6 MW, what implied an annual saving of US $537.500, since according to the tariffs regulation, the impacts of the plan has effect 12 months after having adopted the corresponding change. Having this demand control, supposing constant the electric requirements (constant production), it is possible to reach a saving of US $758.900 and, as a result of the acquired learning it is possible to reach savings for US $1.012.000 per year in the near future.

3.3 Ex-post evaluation of high efficiency motor purchase

The company purchased 135 high efficiency motors adding up 18.000 HP (13 MW installed), with a consumption of around 94.000 MWh/year. The motor selection was done considering that are going to operate in a very aggressive environment. A suitable and tight predictive maintenance procedures and practices were implemented.

Even if the incremental investment due the purchase of more expensive motors was more than US$ 400.000, the benefits evaluated largely exceeded the investment cost, mainly due to the increase of the production reliability. In fact, the fails reduction, the increase on the maintenance span and the reduction of unexpected fails associated to the preventive maintenance generate higher monetary benefits than those related to the energy savings.

The following chart summarizes the results of an adequate motor selection and preventive maintenance program.

Chart IV
Benefits associated with motors in a risky scenario

Type of benefits	**Economic benefits (US$/year)**	**Assumptions**
Failure reduction	430.000	Annual failures reduced by one. Production reduced from 860 tons/day to 378 tons/day
Increased maintenance time span	175.000	A gain of 6 hours production due to maintenance delay
Reduction of unproductive time due to predictive maintenance	135.000	Time maintenance for unexpected failure: 12 hours and for planned stop: 6 hours
Energy savings	145.000	

3.4. Obstacles to energy efficiency

Although the main copper producers are relatively more sensitive to price signals than other industrial sectors and disposed to adopt investment decisions in function of their relative profitability, the national experience and even the international one, demonstrates that they invest insufficiently in energy efficiency for several reasons.

Even if some of the obstacles enumerated below (only the main obstacles are included here) are similar to those described by the specialized literature or they can be found in many international companies [5], it should be said that they are also present in most of the main Chilean copper companies. For the previous reasons, it is not necessary to describe in detail the barriers synthesized below:

- There isn't an explicit EE policy from which we can work out or establish objectives, goals, terms, procedures, incentive payments, resources and control, evaluation and monitoring programs.

- There isn't a specialized unit in charge of, among other tasks, mechanisms and incentive payments design, the identification and evaluation of technological options and the verification of procedure applications.

- There isn’t any goal for energy efficiency sufficiently scheduled in order to allow the evaluation of specific improvements and to consider the exogenous factors that affect the performance expected of the actions implemented.

- The incentives to EE, when they exist, are insufficient to motivate innovations and, in general, they don't give a reward to the people involved in the promotion and implementation of the EE project.

- There are difficulties to verify the accomplishment of the foreseen savings, because there aren’t any methodologies specially developed for this effect and recognized by the workers involved.

- Due to the investments approval procedures, it is easier to repair obsolete and highly expensive operation equipments than to purchase an efficient and cost effective equipment.

- Discontinuity in the efforts to improve the energy efficiency and lack of support to the teams or individuals that deploy those efforts.

- Insufficient endowment of instruments for electrical variables measurement in order to evaluate the efficiency of the installed equipments or to carry out reception test for equipment sent to the maintenance shop for important repairs (i.e. rewinding), difficulty to justify investments aiming at replacing inefficient equipments for others whose cycle of life costs are lower.

4. ENERGY EFFICIENCY POLICY

The barriers to EE mentioned above, and the research team experience, demonstrate that it is central and efficient to establish at the company a strong and deeply spread out energy policy. This policy should be made explicit by directives issued by the corporate top management, also is required an institutional framework devoted to energy efficiency, the existence of appropriate incentives and the corresponding guidelines.

4.1. Energy efficiency directives

Energy efficiency directives should be prepared for the top management consideration and approval. A detailed development of these directives is considered out of the scope in this paper. The main subjects to be included in the directives could be:

- Actions oriented to the development of the energy sources
- Actions in order to improve the efficiency on energy uses
- Energy management tools
- Legal and institutional aspects

4.2 Institutional framework

As it was pointed out, it becomes necessary to generate an institutional framework having a leadership, coordination, advisory, identification, evaluation, control and monitoring capability oriented to improve the efficiency in the company’s energy use. This should be understood in the context of an EE policy generated, introduced and supported by the highest level of the company management and turned into written and compulsory procedures that imply the production, service and administrative areas.

To reach the foreseen objectives and to insure that the important energy saving potentials are attained, it is suggested, in a schematic way, some of the elements that could define an organizational structure, at the holding and facility level, devoted to carry out the tasks deriving from the directives established in this field.

4.2.1 Holding level

At the holding level it is suggested to appoint an expert responsible for the application, follow up and evaluation of the holding EE policy, for the definition –jointly with facility staff- of facilities and holding goals, to evaluate the accomplishment of those goals, to evaluate the requirements of human and financial resources derived from the tasks demanded by the establishment and development of the company EE policy and inform results and to recommend to the company executive chairman the changes to the policy.

4.2.2 Facility level

At the facility level it is suggested the appointment of someone responsible for looking after the energy efficiency and the accomplishment of the global and detailed goals established for each of the main production and process areas, which concentrate the energy consumption (i.e. mining, mineral concentration, smelting, electrowinning and electrorefining). It is considered that this professional should have an exclusive and highly-priority dedication to the subject and should be directly below the area manager.

Also, it is considered necessary the existence –at each facility- of a specialized group in charge of the technical assistance given to the responsible of EE, in each of the main areas or processes mentioned previously, so as to accomplish the goals established to them.

After overcoming successfully this starting stage, the financial sources or incomes should derive from their services sale to the mentioned areas, this will be feasible if each area has to fulfill exactly the EE goals. In relation to the group size, it should be conformed by a specialist with a wide experience in the use of the energy, 2 to 3 engineers and 1 analyst.

4.3 Incentives and energy goals

An EE policy should overcome the internal barriers of the massive introduction of EE technologies. The experience shows that even if these technologies could be very attractive from the economic point of view, they are not always implemented in a spontaneous way, since they have to face technical, administrative and/or organizational barriers and, even, cultural obstacles. Obstacles such as: risk aversion to innovation, priorities assigned to other operation subjects and loose goals of energy consumption, are more important than the incentive payments. The EE subject is not included in the topics of concern for those in charge of operation audit and monitoring.

In order to insure that the efficiency indicators will fulfill what is expected, they should be simultaneously: global, detailed by areas, relevant from the energy consumptions point of view, representatives of an area or process or important machine, allow for comparison along the time and be linked to an instrumentation system insuring the energy consumption measuring of an area.

4.4 Guidelines and rules

4.4.1 Substitution of non profitable operation equipments.

It should be defined the rules for the substitution of: electric motors, distribution transformers, conductors and cables for distribution [6], lighting systems, considering the relative efficiency, differential investments (considering if the existing equipment should be repaired or not), efficiency estimation of the existing equipments, usual number of years considered in this type of analysis and financial parameters used by the company (the equipments to be replaced were identified by their serial number, power and installation place).

The suggested rule is based on the evaluation of the costs of the cycle of life of the alternatives in comparison, the existing equipment and the equivalent energetically efficient equipment. For instance, it was analyzed the case of electrical motors that present a high flaw rate (also defined as obsolete motors), normally operating under high mechanical stress or installed in areas contaminated with powder or corrosive substances.

The maintenance history of motors was analyzed, selecting those that had been subjected to more than 2 main repairs (rewinding or axle change). As a result of these analysis, it was estimated the probability of flaw for an obsolete motor and for an efficient new motor, in a 5 year-horizon. A simulation probability model was built in order to determine the moment and probability of occurrence for the next flaw.

Defined the respective flaw probabilities - for an installed motor that should be repaired or it is foreseen that it will fail soon and for an equivalent, but new and efficient motor-, the repair costs plus the costs of motor removing and reinstalling, it is estimated the cash flow that allows us to compare both alternatives. The approach developed should be considered as an innovation in relation to the conventional one, because in this new approach it is suggested a comparison between the present value of the cost of the possible future repairs corresponding to the eventual flaws of each alternatives.

4.4.2 Bidding specifications and bid evaluation method for electrical equipments required by new projects and facilities enlargement.

It should be defined, during the first phase of the project, the bidding procedures for new projects, including the specification, quotation conditions, analysis of alternatives and decision approach based on the life cycle costs of the different equipments: motors, transformers, cables and conductors, etc.

5. CONCLUSIONS

The author experience seems to prove that energy efficiency can be implemented in some specific enterprises, without a public policy in the field, but in order to get success in this challenge it is absolutely necessary to fulfill certain conditions [9].

The experience proves that the copper mining industry present favorable conditions to implement an energy efficiency program, because it is possible to obtain the support from the higher management level and also because financial resources for energy efficiency investment and a very qualified staff are potentially available, but this is not enough. Barriers to energy efficiency -similar to those existing in other companies around the world, not matter how sophisticated they could be, should be surmounted through the commitment of everybody and as the result of a relatively long process.

What is needed, additionally to those previously mentioned conditions, is to get in place a strong energy efficiency policy, defined by: the corresponding company directives; highly qualified and administratively supported groups, in charge of the implementation of those directives; the existence of a master plan, known by everybody at the company, controlled and periodically updated, specific goals by main areas and processes and incentives payments subject to the accomplishment of those goals; and specific instructions, concerning: the bidding process where the energy user equipment is involved, the methodology to evaluate if you will repair it or purchase a new one, and finally if we will replace the obsolete equipments or equipments subject to highly probability to fail.

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International Workshop
Improving Energy Efficiency in the APEC Mining Industry

ENERGY EFFICIENCY IN THE MINING INDUSTRY: OPPORTUNITIES AND INSTITUTIONAL DESIGN

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Santiago, Chile, October 21-23, 2004

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- THE MINING INDUSTRY AND THE ENERGY EFFICIENCY CHALLENGES
- INSTITUTIONAL AND MARKET BARRIERS
- ENERGY EFFICIENCY POLICY
- CONCLUSIONS AND RECOMMENDATIONS

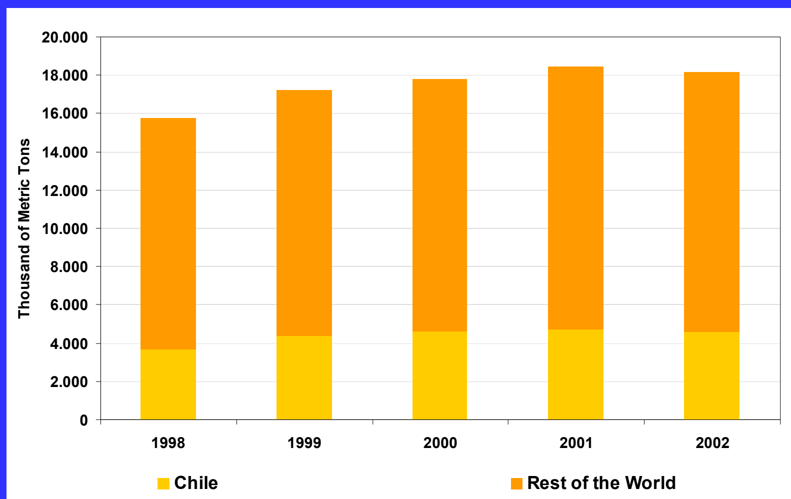
I. ENERGY EFFICIENCY: PRODUCTIVITY, GLOBAL COMPETITIVENESS AND MARKET EXPANSION

- Energy efficiency and cost reduction
- Energy management and the industry commitment with an environmental integrated system (ISO 14 000)
- Copper industry leadership on energy efficiency: an effective tool to increase world copper demand (International Copper Association initiative)

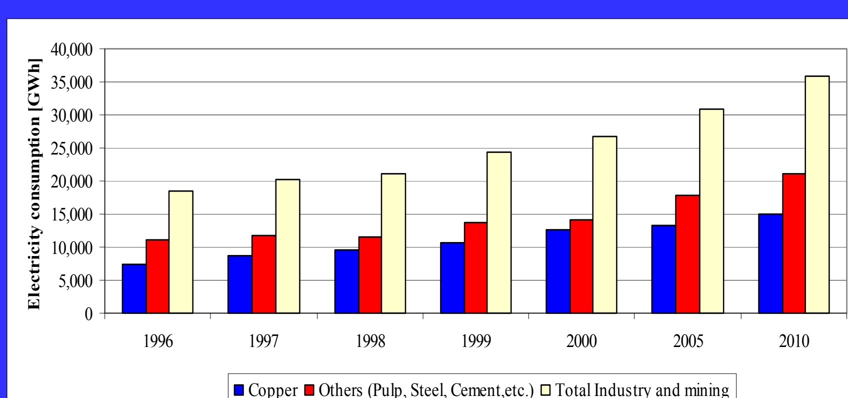
II. COPPER MINING INDUSTRY: PRODUCTION AND ENERGY CONSUMPTION

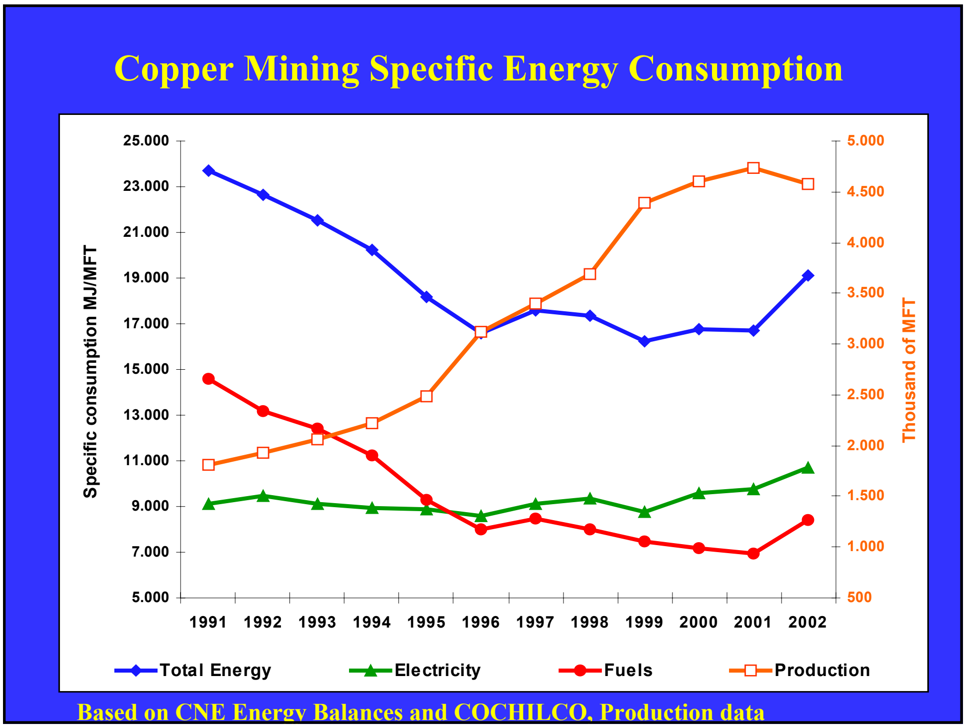
- Chilean copper production
- Electricity consumption of copper industry in relation to other industries' consumption
- Evolution of specific energy consumption
- Energy consumption distribution in the copper industry

World and Chilean copper production (thousand metric tons of copper content)

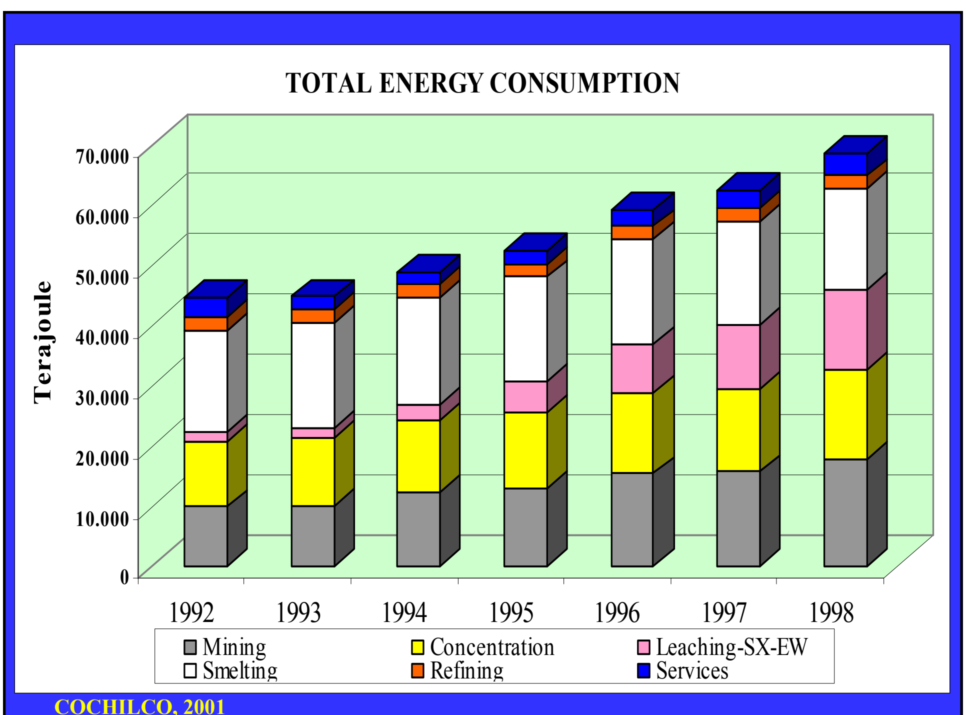


Industry and mining electricity consumption





Copper Mining Specific Energy Consumption
Specific consumption MJ/MFT
Thousand of MFT
25.000
23.000
21.000
19.000
17.000
15.000
13.000
11.000
9.000
7.000
5.000
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
500
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Total Energy
Electricity
Fuels
Production
Based on CNE Energy Balances and COCHILCO, Production data



TOTAL ENERGY CONSUMPTION
Terajoule
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
1992 1993 1994 1995 1996 1997 1998
Mining
Concentration
Leaching-SX-EW
Smelting
Refining
Services
COCHILCO, 2001

III. THE MINING INDUSTRY AND THE ENERGY EFFICIENCY CHALLENGES

- Industry drivers and comparative advantages for diffusion of energy efficiency technologies and good energy management practices
  - Cost reduction requirements
  - Global competitiveness
  - Significant financial resources
  - Highly-qualified technical staff
- Isolated but important efforts underway
- Saving potentials: 15% (operational improvements, replicable projects, benchmarking references, etc)
- Examples with replication interest

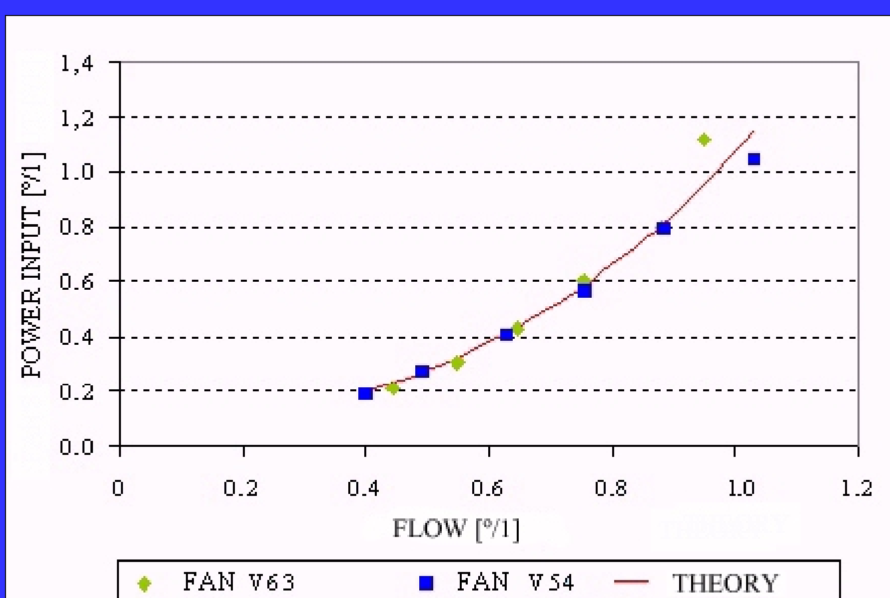
PROJECTS HAVING REPLICATION INTEREST

- Some examples of this kind of projects
  - Frequency converters in mine ventilation
  - Efficient lighting in the smelter area
  - Flotation cells multipole motor use
  - Load management
  - Operation control at the mineral concentration area
- Ex-post evaluation of high efficiency motor purchase

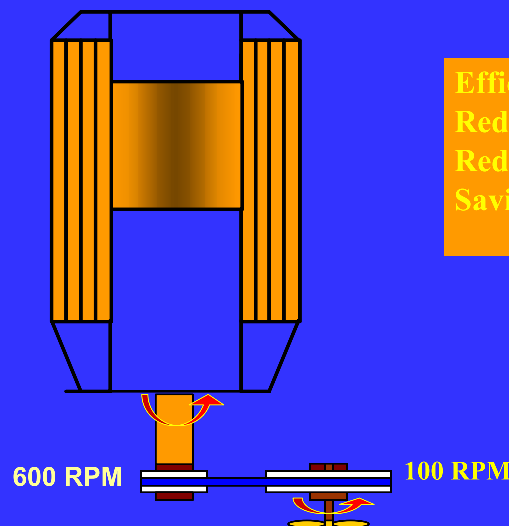
Project results: lighting levels and energy savings

SMELTER AREA	Lighting level [lux]			Power [kW]		Savings
	present	project	standard	installed	project	MWh/year
Anode and blister	141	305	300	40.55	18.78	190.71
Smelting and conversion	49	180	170	99.06	37.5	539.26
Oxygen and air	63	257	250	33.73	11.1	198.2
Load preparation	51	137	123	39.51	16.59	485.39
TOTAL				**260.2**	**98.83**	**1,413.56**

Power consumption versus air flow

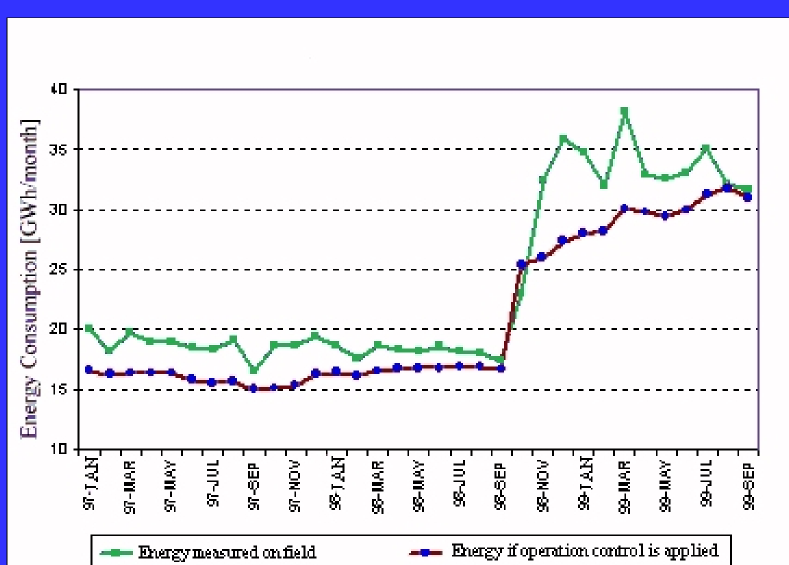


Multi pole motors for flotation cells

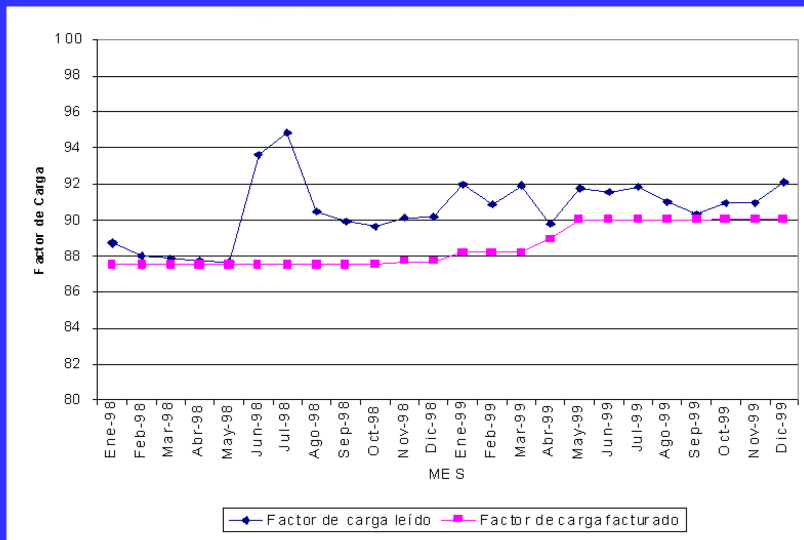


Efficient motor
Reduced flaws
Reduced noise
Savings around 10%

Operation control at the concentration area



Demand management



EX-POST EVALUATION OF HIGH EFFICIENCY MOTOR PURCHASE

• 135 high efficiency motors adding up 18.000 HP (13 MW installed), with a consumption of around 94.000 MWh/year were purchased to operate in a very aggresive environment and having very tigh predictive maintenance procedures and practices.

• The incremental investment was US$ 415.000

• Benefits were associated to the fails reduction, increase maintenance time span and reduction of unexpected fails due to preventive maintenance

Adequate selection and maintenance

Benefits associated with motors in a risky scenario

- **Failure reduction due to specific working environment motor selection**: US$ 427 177
- **Increased maintenance time span**: US$ 175 118
- **Reduction of unproductive time due to predictive maintenance**: US$ 133 297

Time maintenance for unexpected failure: 12 hours and for planned stop: 6 hours

Energy Savings: 143.833 US$/year

IV. OBSTACLES TO ENERGY EFFICIENCY

- Institutional and operational obstacles to energy efficiency
  - Non-existence of EE policy
  - EE organizational structure
  - EE procedures, incentives and goals
  - Instrumentation and maintenance

OBSTACLES TO ENERGY EFFICIENCY

- Lack of an explicit EE policy with established objectives, goals, procedures, incentives and resources, and of control, evaluation and monitoring programs
- Lack of a specialized unit at the holding and company divisions level in charge of the EE program
- The incentives to EE are insufficient to motivate innovations and, because they are so aggregate, they don't reward people involved in the identification and implementation of EE projects
- Investment approval procedures are an incentive to repair obsolete and expensive operation equipment instead of purchasing efficient ones
- Lack of infrastructure and methodologies to evaluate field and maintenance shop efficiency of existing motors

V. ENERGY EFFICIENCY POLICY

ENERGY EFFICIENCY DIRECTIVES

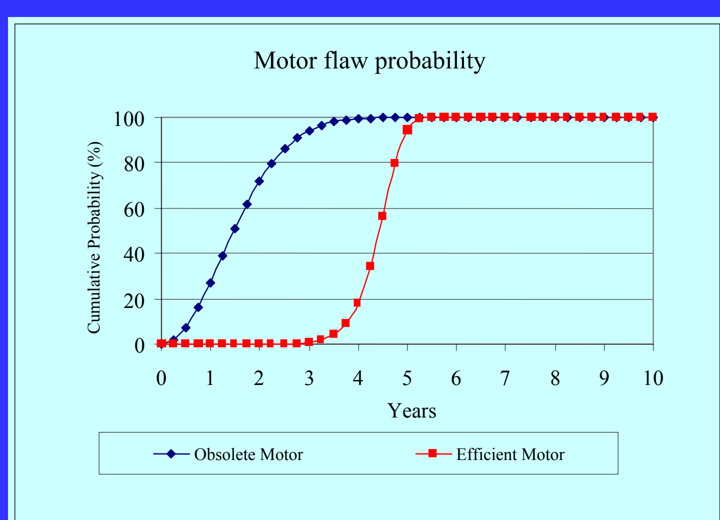
- Actions oriented to develop energy sources
- Actions oriented to improve the efficiency of energy use
- Energy management tools

INSTITUTIONAL FRAMEWORK

- Incentives and definition of energy goals
- Procedures

V. ENERGY EFFICIENCY POLICY(cont.)

- **Procedures**
  - **Substitution of non-profitable operation equipment**
  - **Bidding specifications and bidding evaluation method for new project equipment (motors, lighting, transformers and distribution cables and conductors)**
- **Technical handbook for efficiency measurement of electrical motors in the field or at the maintenance shop after a major maintenance (i.e. rewind)**



VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

- Innovation dynamics on EE should be introduced at the different facilities of the company
- The EE projects uses to generate synergies for transversal projects between
- Process reliability should be integrated for the substitution analysis of existing equipment

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS (cont.)

- The following concepts should be introduced in a quantitative way for bidding evaluation
  - Maintenance costs and reliability
  - Energy consumption

VI. CONCLUSIONS AND RECOMMENDATIONS

6.2 RECOMMENDATIONS

- Adoption by the highest management of the EE directives, procedures, incentives and corresponding organizational structure
- Generate a methodology to monitor EE projects
- Generate adequate energy indicators for the main processes
- Insure permanent behavioral changes aiming to get a wide commitment for EE in the company

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