

Future Action Dialogue

Developing Country Meeting

Electricity Emissions Reductions In Mexico:

Some Preliminary Results

Instituto Energeia
Mexico City

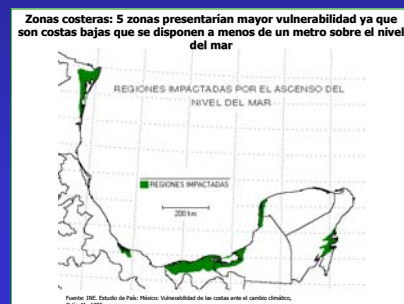
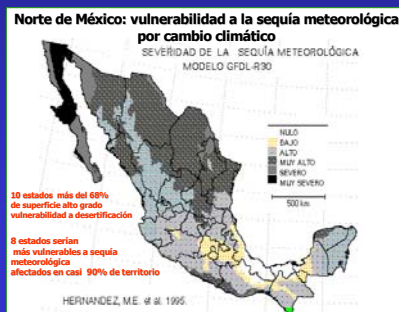
Oslo, Norway,
April 2005

General Info – Climate Change

- ❑ Mexico was the first country in the western hemisphere to sign Kyoto.
 - Original disagreements between energy and environment sectors overpassed by Congress decision to ratify.
- ❑ Mexico is relatively vulnerable to Climate Change.

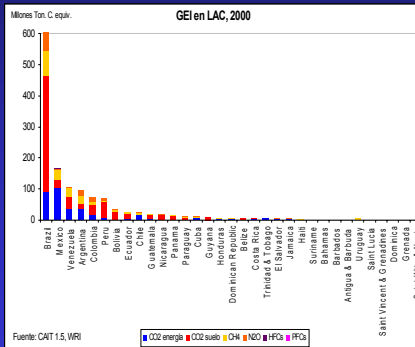
A 3 to 5 degree increase in temperature would imply:

- Drought in in 50% of all arable land.
- A 40 cm increase in sea level, with significant damage to the inhabited Gulf of Mexico coasts.



General Info – Energy

- ❑ Mexico is the largest CO₂ emitter from fossil fuel burning in Latin America, surpassing relatively clean Brasil.



- Mexico's energy base is predominantly based on hydrocarbons; aprox. 85% of its primary energy supply is based on them.
- Energy plays a key role within the country: explains around 5% of its GDP, around 8% of its exports, and around 40% of its fiscal income.
- Mexico is a net exporter of primary energy (5th largest oil producer), but is a net importer of secondary energy (it imports gasolines and gas for its internal markets)
- Mexico has world average per capita energy consumption numbers, due mainly to widespread poverty in large areas of the country.

General Info – Energy Sector

- ❑ Mexico has a state led energy sector.

LEGAL

Constitutionally, only State can generate, transmit and distribute electricity for public service. Private sector generation:

- For self-supply (e.g. consumer and supplier agree to form single firm)
- As IPPs utilities supplier (currently legally compelled to generate or buy electricity at minimum cost)
- For export purposes

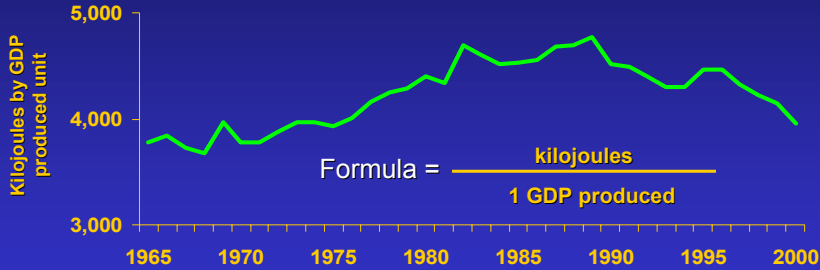
Institucional

- The state owns the two largest energy companies in the country, PEMEX (oil producing & primary derivatives monopoly) and CFE (largest electricity producer, almost 70% of installed capacity).
- Private sector participation in the electricity limited to export, import, auto supply, and small production. Independent Power Producer role still challenged politically. No success in two successive reform attempts (Presidents Zedillo and Fox) to open up sector.
- Scheme successful in expanding coverage (95% access in the country) but currently facing crisis as private investment lags and contingent debts guarantee schemes sap CFE's financial health.

Energy Intensity 1965-2002

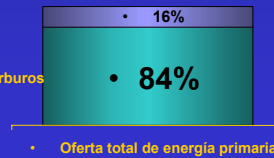
- Mexico has had a relatively positive energy and emissions intensity.
 - Underpinned by 1990s structural reforms –increased the economy’s overall efficiency through enhanced competition.

- Since the last decade, Mexico has been generating more wealth by energy of unit consumed.



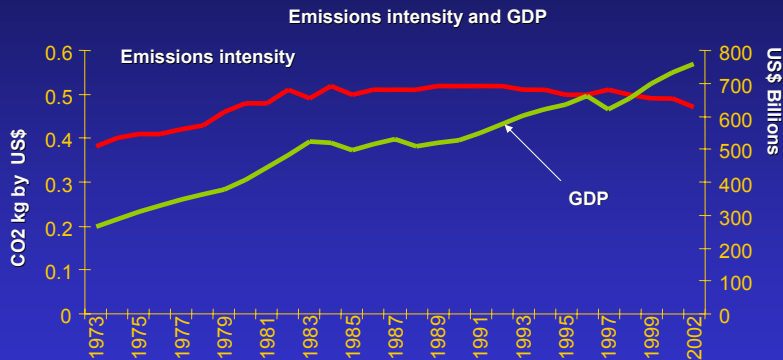
- Energy Consumption 2002:

- Otros
- Hidrocarburos



Emissions intensity 1971 - 2002

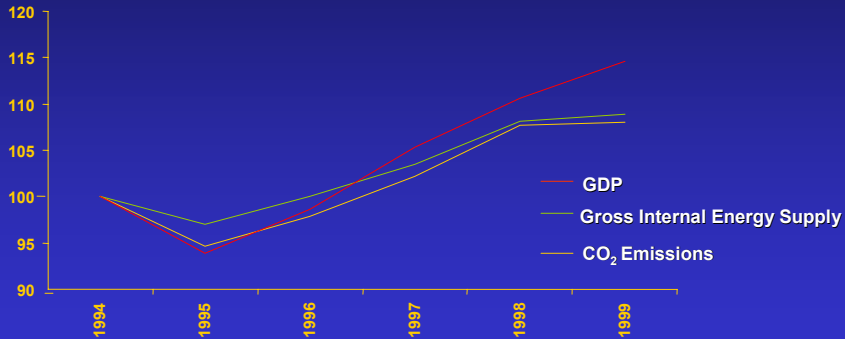
- Likewise, it produces less emissions per energy units.



Emissions and GDP growth

- Emissions growth has decoupled from GDP growth.

GDP, Gross internal energy supply and CO₂ Emissions (1994=100)



Source: AIE, CO₂ Emissions from fuel combustion, 2001.

Potential of Diversification

Cogeneration Potential in PEMEX

- Electricity 6,600 MWs
- Natural Gas 600 MCFD

- Hydraulic 10,000 MW
- Geothermal 2,500 MW
- Minihydraulic 700 MW
- Wind 5,000 MW
- Biogas 150 MW
- Biomass 550 MW
- Solar 5 kWh/m²/day

Proyecteds 2000-2004	Tecnology	MW	Mton CO ₂ /year	
			Min	Max
Electricity Federal Comission				
Cerro Prieto	Geothermal	100	175	438
Tres Virgenes	Geothermal	10	18	44
Los Azúfres	Geothermal	107	187	469
La Ventosa	Wind	100	176	438
CFE Total		317	467	1388
Private				
Tizayuca	Biomass	15	42	105
Monterrey	Biomass	12	29	74
Baja California	Híbrid	39	-	-
La Ventosa	Wind	71	124	311
La Ventosa	Wind	30	53	131
Hidro del Pacifico	Small hidro	8	18	46
Private Total		175	266	667
TOTAL		492	821	2055

Regulatory environment

General

- Policy Making is the result of the interaction between the Energy Ministry (energy policy), The environment ministry (environmental constraints) The Finance Ministry (tariffs, rates, and taxes), the National Energy Commission (private and public sector regulation), and the inputs from the state owned companies.
- Agreed policy is reflected within a ten year horizon planning, updated every year, through central planning documents called Prospectivas.

Costs

- Mexico's state utility have a legal mandate to supply electricity at least possible marginal costs.
- Current marginal generation cost is based on combined cycle gas, and is around 3.2 US cents/KwH. Most renewable energy sources have generation costs slightly higher than that.
- Programs to promote renewable energy have been seeking to provide an additional incentive to supplement marginal generation cost, and provide a competitive playing field.
- Promotion programs have included: Green funds, Regulatory frameworks, Carbon credits

Current Work - Energy & Climate Change

- Instituto Energeia and CCAP have been working together in an analysis of Mexico's power sector.
 - Covers 5 areas:
 - Institutional arrangements
 - Policy constraints
 - Overall structure: Market, planned expansion, renewables and Energy Efficiency
 - Policy options
 - Model Analysis
 - Conclusions
- Work has been completed in the background information, as well as with the baseline information for the power sector, and most fuels employed in the power sector.
- Institutional inertia and blockages within the energy sector play key role in shift towards lower carbon economy.

Modelling Info - the MOEEMA model

Summary Table

Model Type – Structure	Top down Hybrid (employs energy balances and math identities together with econometrically estimated coefficients)
Sectors Included	Energy as a whole. Possible expansion to specific analysis through fuel use. Forestry must be modelled externally.
Macroeconomic outputs / Impacts	GDP growth, employment, trade, social, investment and expenditure policies, income distribution, economic development.
Quantitative Analysis Emissions / Pollutants	Focus on CO ₂ , gases from fossil fuel burning easily added; other GHG require explicit modelling.
Quantitative analysis of other benefits	Energy policies, energy balances, infrastructure update requirements, local pollution.

- ❑ Formed by 5 blocks: macroeconomy, national energy consumption, supply, demand and imports of principal energetics, CO₂ emissions, and prices.
- ❑ Blocks are recursively determined, and solutions are simultaneous to each block.
- ❑ Short and long term prevision horizon
- ❑ Parameters estimated with data from the 1993 2001 period.
- ❑ Employs 2001 as base year (immediately after Mexico's Kyoto entry)

Specific Characteristics - MOEEMA

CCAP Summary Table – Characteristics

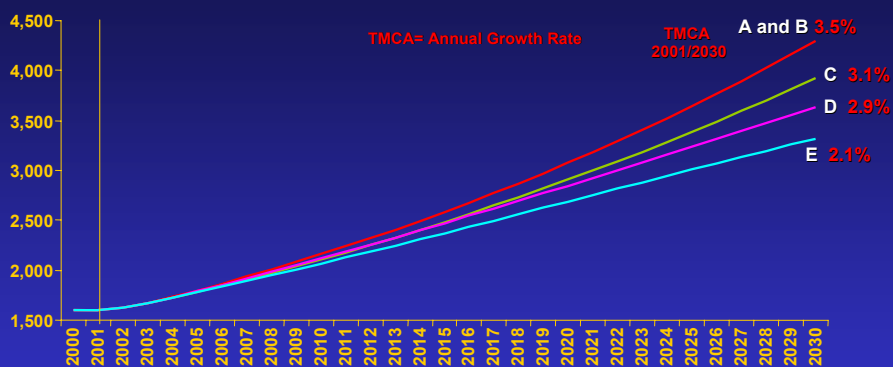
Basic Model Structure	
Time frame	Solves in one year intervals in a 30 year period. 2001- base year.
Broad sectors	Energy explicitly; transport, industry and residential sectors through consumptions.
Macroeconomic output variables	GDP, consumption levels, trade balance, inflationary pressures, expenditures, income distribution enter into analysis
Emissions/Pollutants?	CO ₂ emissions based on energy uses, balances, and policies, income distribution, demand elasticities by sectors, and emission factors. Other fossil fuel burn pollutants easily added.
Sub-regions	Takes Mexico as a unit
International trade?	The model allows specific treatment of export and import key energy products (fuels and electricity). It considers trade with the US as one of its key demand drivers.
Innovation and Technological Change?	Technological change is treated exogenously. Shifts in technological components must be treated by changes in coefficients. Non fossil fuel technologies are modelled ad-hoc, following national perspectives. However, shifts in energy intensity are modelled with relative ease.
Flexibility?	Changes in domestic and international economic growth, social policy, public consumption and investment, energy products uses and balances, energy efficiency, technological changes, and required increases in energy sector capacity can be modelled.

Principal assumptions

- Mexican GDP determined by US GDP and crude real price (1929-2001)
- Real Prices crude Oil general tendency (1929-2001) and constants to 2001
- Energy intensity associated to international activities
- Demand elasticity – GDP and price demands estimated with standard values
- Efficiency coefficients, energetics distributions and other parameters – 2001 base year
- Export demand of different energetics calculated according to the historic performance : fixed or annual growth average
- Parameters and emissions coefficients follow international standards (IPCC)
- Fuel oil to gas substitution analyzed in electric power plants.

GDP : Mexico 2002-2030

(Thousand million pesos at 1993 constant prices)

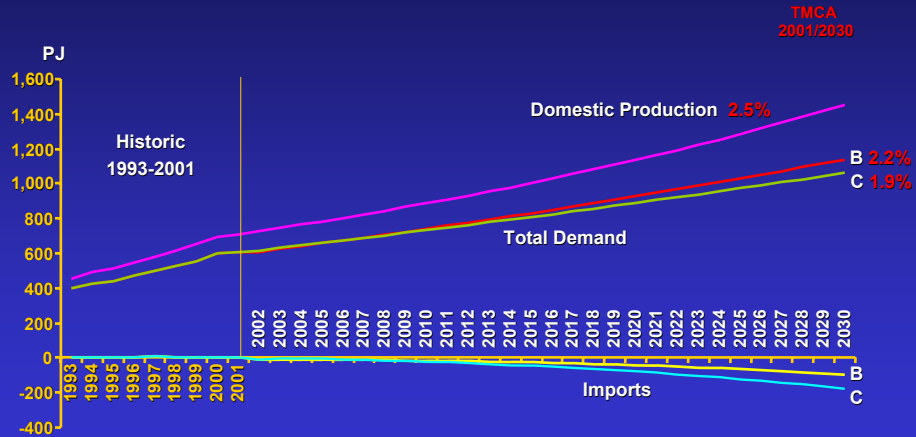


Annual Average population growth

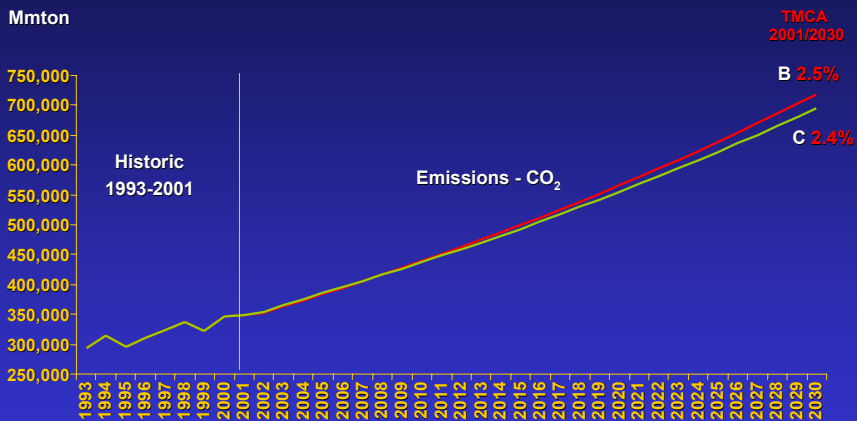
Period	1980-1990	1990-1997	1998-2015	2015-2030
Rate	2.2	1.8	1.1	0.6

Source: CONAPO

Electricity : Mexico 2002-2030

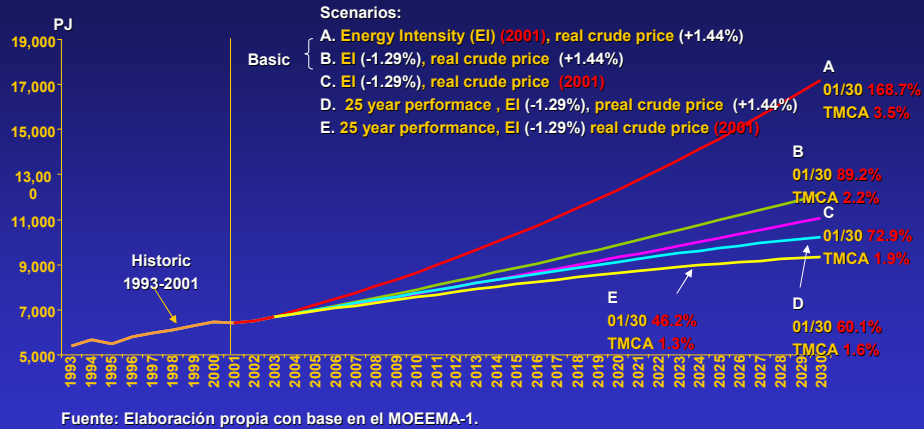


CO₂ emissions : Mexico 2002-2030



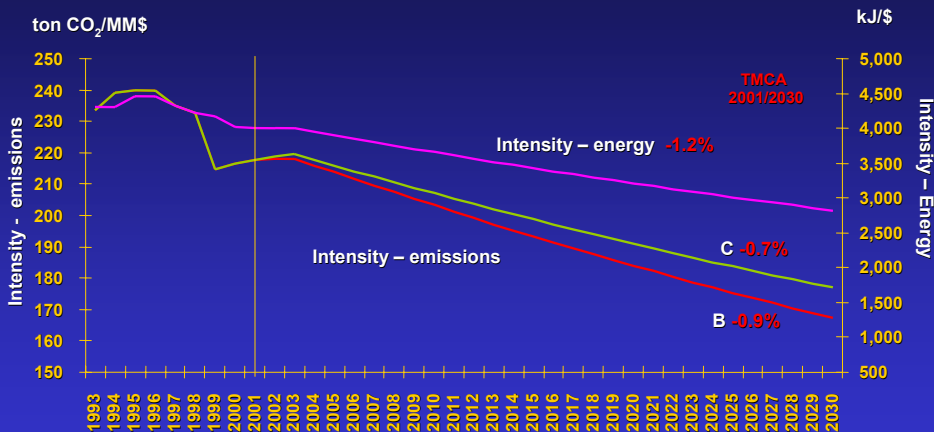
- CO₂ emissions from fossil fuel burning will grow towards 2030 between 99.8% y 106.6%

National Energy Consumption : México 2002-2030



- Assuming energy intensity reduction, the future does not seem that different from the past. National energy consumption would grow to 2030 between 72.9% y 89.2%.
- Variations in national energy consumption between 180% a 170% by modifications in the economic activity level, and between -60% a -70% by reductions in energy intensity

CO₂ emission intensity and Energy Intensity : Mexico 2002-2030



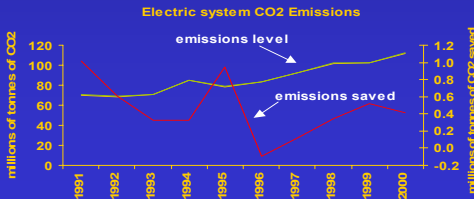
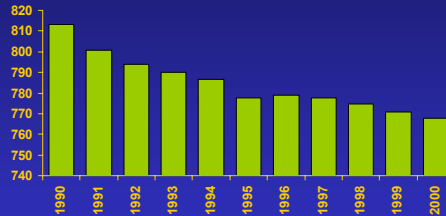
- CO₂ emissions by unit of energy (Gg/PJ) would be slightly higher in the 2001 – 2030 period. However, emissions intensity (ton/MM\$) is decreasing in both scenarios, as a result of a fall in energy intensity, in spite of GDP growth.

Some past successes – Fuel Switching

CO₂ emissions saved in the power sector

- ❖ The emissions per GWh generated in thermal plants have been declining.
- ❖ In 2002, natural gas was 22.3% of the total fuel consumption, while in 1990 it was 16.1%.

CO₂ emissions per GWh in thermal plants
(tonnes of CO₂/GWh)

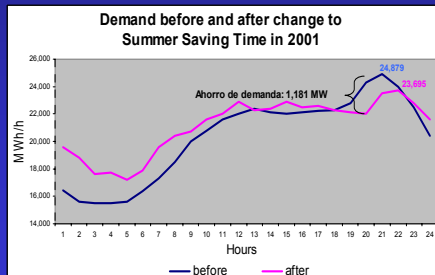
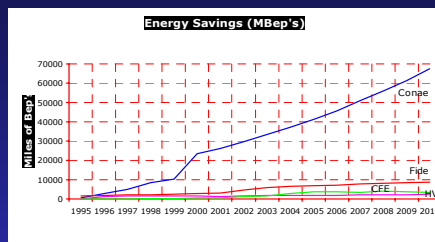


- ❖ The substitution of fossil fuels by natural gas in electricity generation, saved 513.4 thousand of tonnes of CO₂ in 2002.
- ❖ The accumulated saving since 1991-2002 is 5.5 millions of CO₂.

Some past successes - Energy Savings

Evolution and Projections

	ENERGY SAVINGS	AVOIDED CAPACITY	YEAR
Technical Standards	6,746 Gwh	1,000 Mw	2000
Summer Time Programme	6,329 Gwh	863 Mw	Since 1996
Energy Savings Programme	1,866 Gwh	625 Mw	1999



CO₂ emissions saved by Technical NOMs, FIDE activities and PEMEX programs alone amounted to 8.5 Mtons in 2002

Sucesses and Potential - Green Fund

Large-scale renewable energy development project (WB-GEF: US\$70M)

Based on California incentive scheme

Subsidy source, leveraging additional US\$500M in private investment

Competitive, performance-based 5-year subsidy

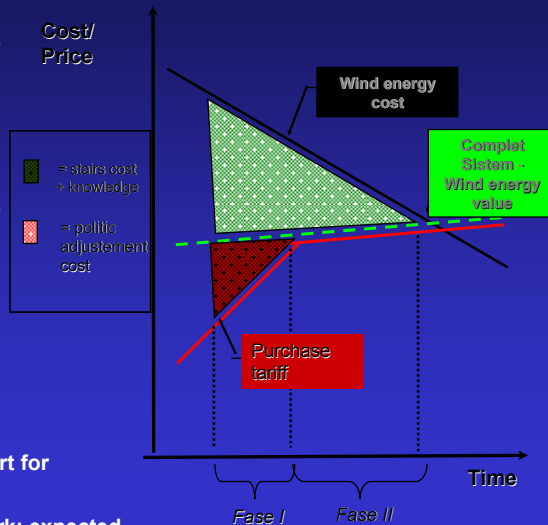
Rationale: Reduce costs and increase renewable energy value recognition: need for subsidy expected to eventually disappear

First stage focused on wind; second stage includes other sources

Status

Project document contemplates support for renewable energy exports.

Currently developing bidding framework; expected to run 2006.



Neither Reform nor Successful Tinkering

❑ Mexico has failed to open up its centralized policy structure in key points.

- Evolution of Energy sector is as much an issue of costs as of energy sector reform – political economy matters.
- Mexico's political and regulatory systems have failed to reform key aspects of its energy sector operation from a climate change perspective

❑ Consequences:

- ❑ Financial constraints has forced a dual pattern of development: extra clean Combined Cycle as plants being introduced at a slower rate, while old inefficient fuel oil plants are maintained.
- ❑ Shift to gas in power sector allowed for diminished CO2 growth rate, however, currently, gas hegemony undermined by shifts in relative prices favouring coal and fuel oil.
- ❑ Mexico has currently a 1000 MWs installed capacity goal for the 2000 – 2010 period and various large scale programs (mostly public and/of GEF funded) to develop new renewables in a climate change context; however, has failed to develop the regulatory framework to exploit them.

Against Forecasting

- Official planning has from 1995 to 1997 underestimated demand; while planning from 1998 to 2004 significantly overestimated expansion.
- Ovestment explained by political concerns (electric sector reform plus macro expectations)

Total Gross Electricity Sales 1995 - 2004
Differences - minimum, maximum and observed values

Año	Projected Value minimum GWh	Projected Value Maximum GWh	Observed Value GWh	Porcentual Deviation
1995	114,813	-	115,227	-0.4
1996	117,859	121,741	122,752	-0.8
1997	121,170	129,306	130,598	-1.0
1998	126,769	139,860	137,284	1.9
1999	132,998	147,471	145,127	1.6
2000	140,244	155,816	155,544	0.2
2001	148,294	165,123	157,475	4.9
2002	157,028	174,704	160,547	8.8
2003	166,408	184,593	161,337	14.4
2004	176,480	194,933	164,515	18.5

Notes: Percentual deviation is calculated as the difference between the maximum projected data and the observed data. For 1995, the deviation is calculated taking into account the unique projected value.
Source: Own elaboration, based on Sener, *Prospectivas del Sector Eléctrico 1995-2004 a 2004-2013*.

Overestimation of Demand

Official Electric Sector Gross Total Sales
Estimation Error 1995-2004

Document	Years Evaluated	Total Error ¹ GWh	Evaluated Error 5 years ² GWh	Evaluated Error 3 years ³ GWh
Prospectiva 1995-2004	10	9,329	8,610	6,137
Prospectiva 1996-2005	9	7,335	7,353	4,685
Prospectiva 1997-2006	8	10,664	2,022	750
Prospectiva 1998-2007	7	15,754	7,364	2,017
Prospectiva 1999-2008	6	13,886	9,995	3,130
Prospectiva 2000-2009	5	11,659	11,659	6,967
Prospectiva 2001-2010	4	11,996	N.A.	10,298
Prospectiva 2002-2011	3	7,157	N.A.	7,157
Prospectiva 2003-2012	2	3,645	N.A.	N.A.
Prospectiva 2004-2013	1	1,931	N.A.	N.A.

Notes:
1) Calculated following the formula $\sum_{i=1}^n (D_i - O_i)$ where D_i is the projected data, O_i is the observed y and n is the number of observations.
2) The previous formula is employed for the first five projected years.
3) Original formula employed for the first three years.
N.A.: None applicable.
Fuente: Elaboración propia con base a Sener, *Prospectivas del Sector Eléctrico 1995-2004 a 2004-2013*.

Year	Planned Expansion MW
1995-2004	13,039
1996-2005	12,762
1997-2006	13,189
1998-2007	21,743
1999-2008	22,248
2000-2009	26,281
2001-2010	27,357
2002-2011	28,862
2003-2012	25,757

Dual Technological Development

- A similar bias is likely in the official planned technological shift pattern:
- Official planning has increases in combined cycle gas coupled to a fuel oil retrenchment.
- Most likely scenario involves reduced gas expansion and maintenance of fuel oil plants, due to:
 - a) Reform retrenchment
 - b) Investment constraints.

	2004	2005	2010	2013
Capacity – December of each year	46,319	47,712	55,373	65,383
Capacity 2003	44,554	44,554	44,554	44,554
Accumulated additions	1,768	3,202	17,184	25,018
Accumulated retirements	3	43	2,822	4,188

Notes: Data not include total net capacity with supply.
Source: Own elaboration based on Comisión Federal de Electricidad.

Expected Evolution – Net Installed capacity by technology 2003 -2014 MW

Type	2003	2014	Absolute Change
Hydro	9,608	12,793	3,185
Combined Cycle	10,603	23,360	12,757
Turbogas	2,890	3,722	832
Internal Combustion	140	213	73
Wind	2	408	406
Free	0	6,446	6,446
Carboelectric	2,600	3,550	950
Fuel Oil	14,283	10,464	-3,819
Geothermal	960	960	0
Nuclear	1,365	1,365	0
Mobile Plants	3	3	0
TOTAL	44,554	65,383	20,829

Source: Own elaboration based on Sener, *Prospectiva del sector eléctrico 2004-2013*.

Regulatory environment - Renewables

Mexico's state utility have a legal mandate to supply electricity at least possible marginal costs.

Current marginal generation cost is based on combined cycle gas, and is around 3.2 US cents/KwH. Most renewable energy sources have generation costs slightly higher than that.

Programs to promote renewable energy have been seeking to provide an additional incentive to supplement marginal generation cost, and provide a competitive playing field.

Promotion programs have included:

- a) Green funds
- b) Regulatory frameworks
- c) Carbon credits

Interconnection & Carbon Incentives

Regulatory

Transmission

- Transmission costs multiplied by effective plant capacity.

Interconnection

- CFE and/or LFC agree to buy energy as it is generated
- Energy not consumed by the grantee can be transferred to CFE and LFC. These later return it to the grantee, who can request additional energy if needed.
- Energy paid at the going rate at the moment it is transferred into the grid

Carbon

- Mexico non annex 1 country to UNFCCC & Kyoto; can sell carbon emission reductions to other parties; could engage in regional carbon trading schemes
- Mexico estimates US\$ 200M revenue for renewable energy projects developed there

Mexico regulatory authorities and CFE have so far failed to agree on interpretation of interconnection and transmission regulations.

Differences with regard to accountable period for grid stored energy; the larger the period, the larger the benefit for private developers

Carbon incentives starting to operating in biomass, biogas & small hydro; still marginal.

Status

Where do we go from here?

❑ Modelling 5 scenarios.

- Overall constraints
- Renewable expansion (Interconnection – Green fund)
- Cogeneration (PEMEX & CFE)
- Energy efficiency
- Fuel Switching

❑ Modelling Political Economy.

- The decision on interconnection agreements – Regulatory interaction between CRE, SENER and CFE.
- The decision on gas pricing and relative prices with Fuel oil Interaction between IPP, SENER, and CRE
- Policy on self supply and private investment – Regulatory Interaction between CRE, SENER and Congress.
- Improved environment constraints on local air quality – SO₂ programs and local quality standards Interaction between SENER and SEMARNAT.

Where do we go from here?

- ❑ Carbon Finance has played marginal promotion role in large energy sector decisions
- ❑ Most effective on a small project by project basis
- ❑ Potential for large sectorial flexible mechanism in several areas.
- ❑ Modelling scenarios.
 - Outline possible outcomes of key decisions within electric sector in specific equal time period frame, taking subsequent decisions into account.
 - Include potential input from both domestic and international incentives, modelling sectorial straw approach.
 - Model scenario expansion accordingly.
- ❑ Expansion to other sectors within Mexico: Cement, transport, forestry.

Where do we go from here?

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