The Mexican Experience with Top-Down Models

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Mexico - US Economic, Environmental and Energy Modeling Workshop

21-22 November 2002

Mexico Energy Demand Model MODEMA

Programa Universitario de Energía - UNAM

***simulation model of the energy system**
- primary & final energies -
*** short (3 years) & medium term (10 years)**
*** "top-down" drivers for**
productive and consumer sectors

Mexico Energy Demand Model MODEMA

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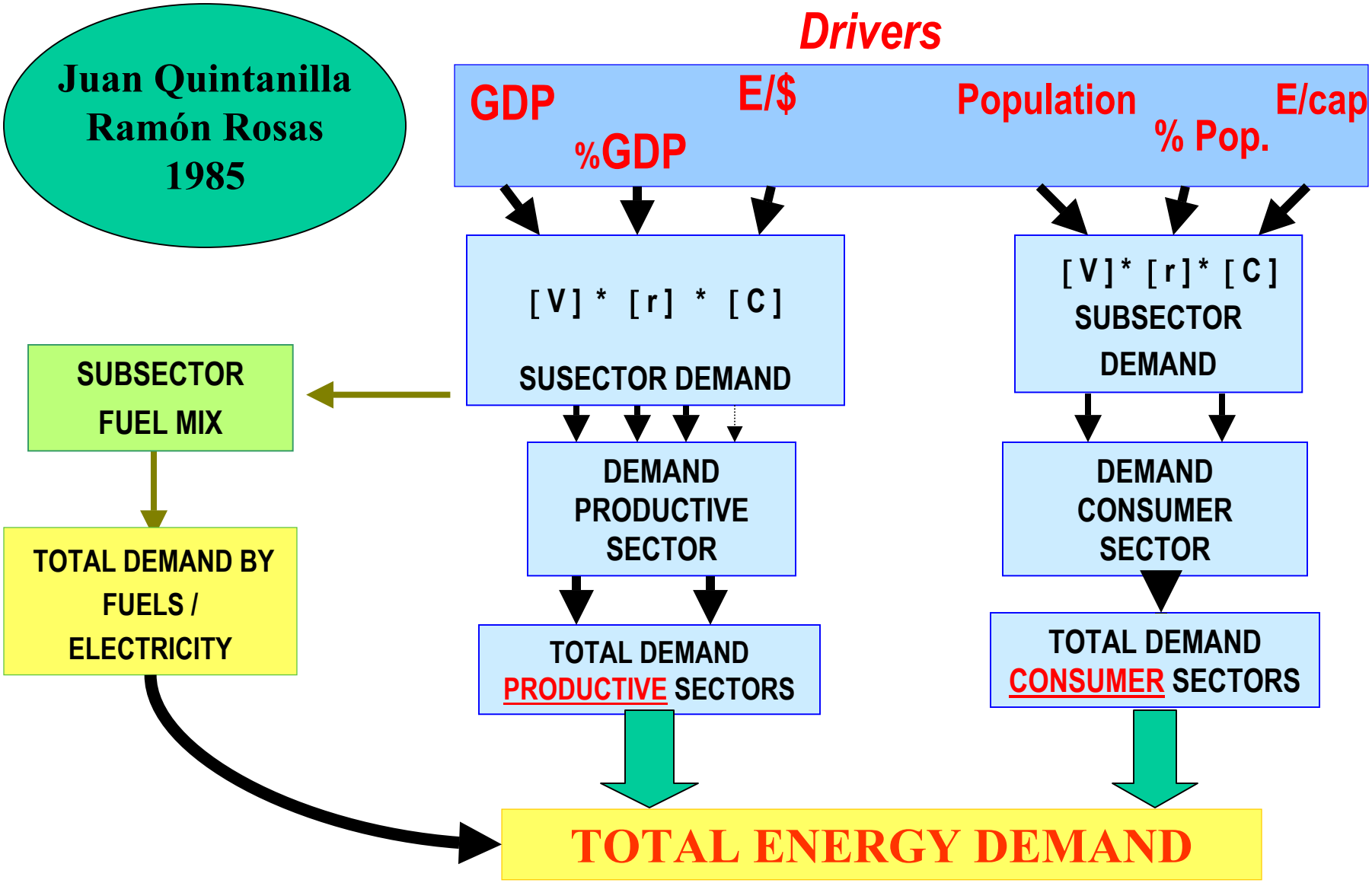

Mexico Energy Demand Model MODEMA

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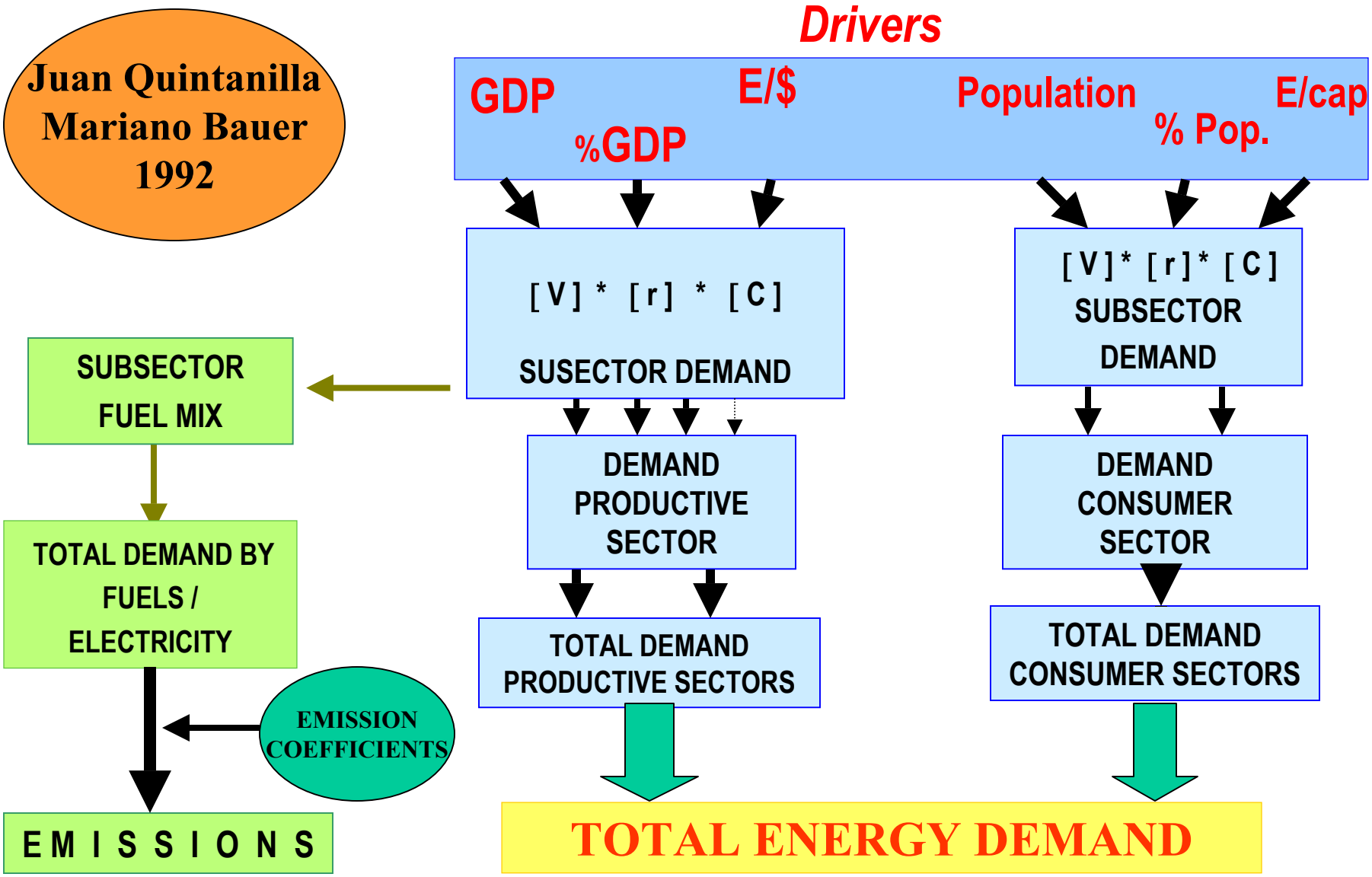


Sectors, subsectors, sources, feedstocks & emissions

SECTORS	SUBSECTORS
Energy (3)	PEMEX, CFE, Coking
Agriculture	
Transport (5)	Road, Air, Rail, Sea, Electric
Industry (17)	PEMEX petrochem. Siderurgy, Cement, Chemicals, Sugar, Paper, Glass, Beer, Soft drinks, Rubber, Auto, Construction, Fertilizers, Mining, Aluminum, Tobacco, Others
Commercial	
Public & Services	
Residential (2)	Urban, Rural

SOURCES

Oil, Coal, Condensates
Natural Gas (As&Nas)
Bagasse, Fuelwood,
Coke, Kerosines,
Gasoline, LPG, Diesel
Fuel oil, Dry NG,
Electricity *(Nuclear, Geothermal, Hydro, Wind)*

FEEDSTOCK

Coke, Gasoline, LPG
Natural Gas, Fuel oil,
Kerosene, Bagasse,
Non energy products

EMISSIONS

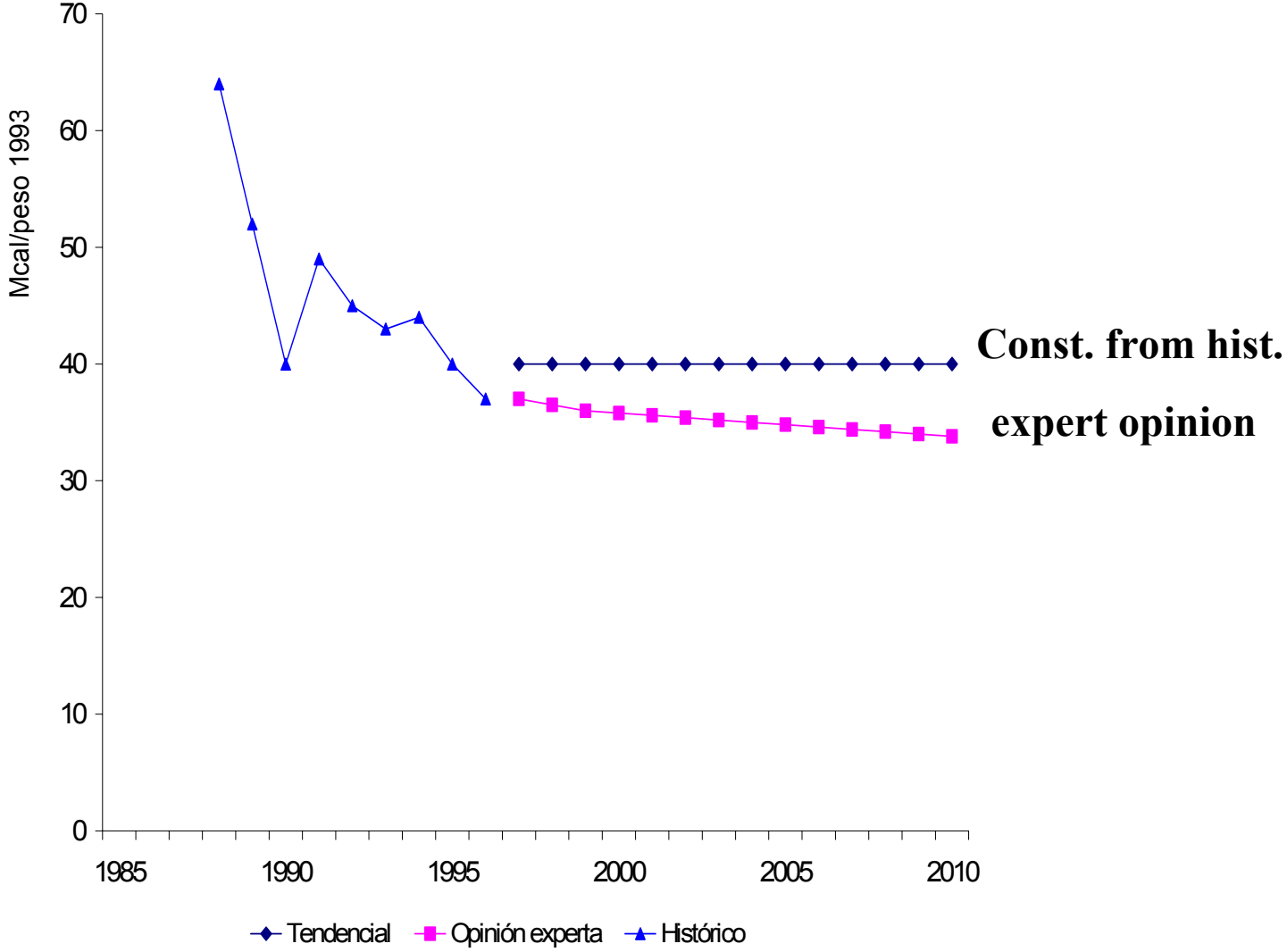
(7)

CO_2, CH_4, CO,
SOx, NOx, HC,
Particulates

DRIVERS	*SCENARIOS*
GDP	- different growth rates
% GDO	- structural changes: expected or policy driven
E/$	- economic & technological trends or policies
Population	- impact of economy&policies on growth rates
% pop	- trend changes of rural to urban displacement
E/cap	- changes in consumption patterns
sector energy mix	- technology changes, environmental policies, renewable energies
emission coefficients	- technology, environmental constraints

Energy intensity

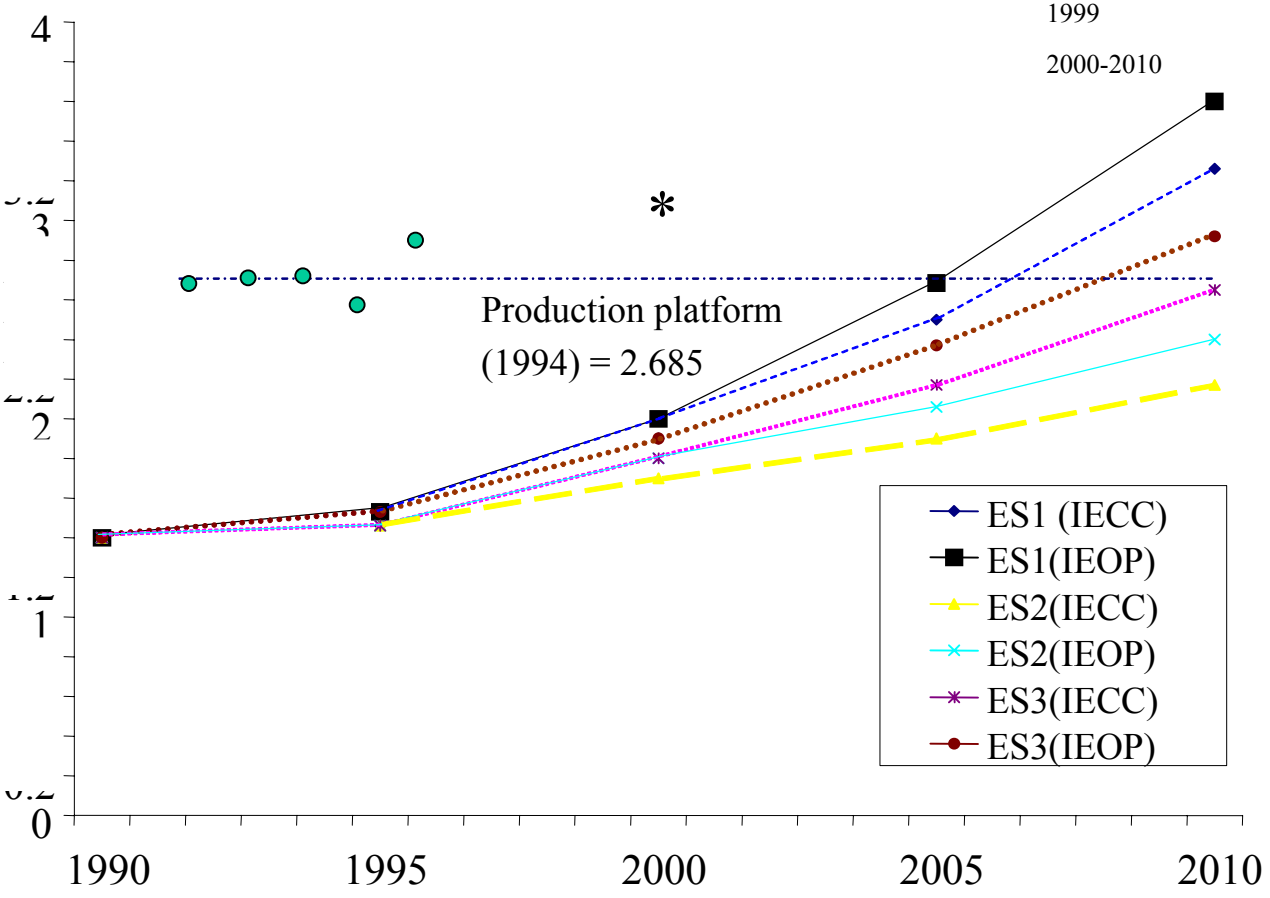
Subsector: PEMEX Petrochemicals



Mexico: Internal oil demand 1992-2010
(million barrels per day)

Economic Scenarios
GDP growth rate

	ES1	ES2	ES3
1995	-4.8	-4.8	-4.8
1996	2.0	2.0	2.0
1997	4.7	2.0	3.5
1998	5.5	2.0	3.5
1999	5.0	2.0	3.5
2000-2010	5.0	2.0	3.5



Some applications of MODEMA:

* Prospective of GHG emissions - Country Study, for INE

* Mexico GHG Assessment (mitigation) - for The World Bank

* Economy, Energy, Environment Study for SENER

* "Conflicting EEE Policies in Mexico", M.Bauer and J. Quintanilla in Energy Policy V28, No.5, 2000

* "Modelación de políticas energéticas en México - una aplicación del modelo MARKAL -", M.Bauer et al., Oil&Gas Journal Latinoamérica, V6; No.1,2000

Currently at IMP:

*** implantation of MODEMA on LEAP platform:**

demand, transformation, primary and secondary energies modules

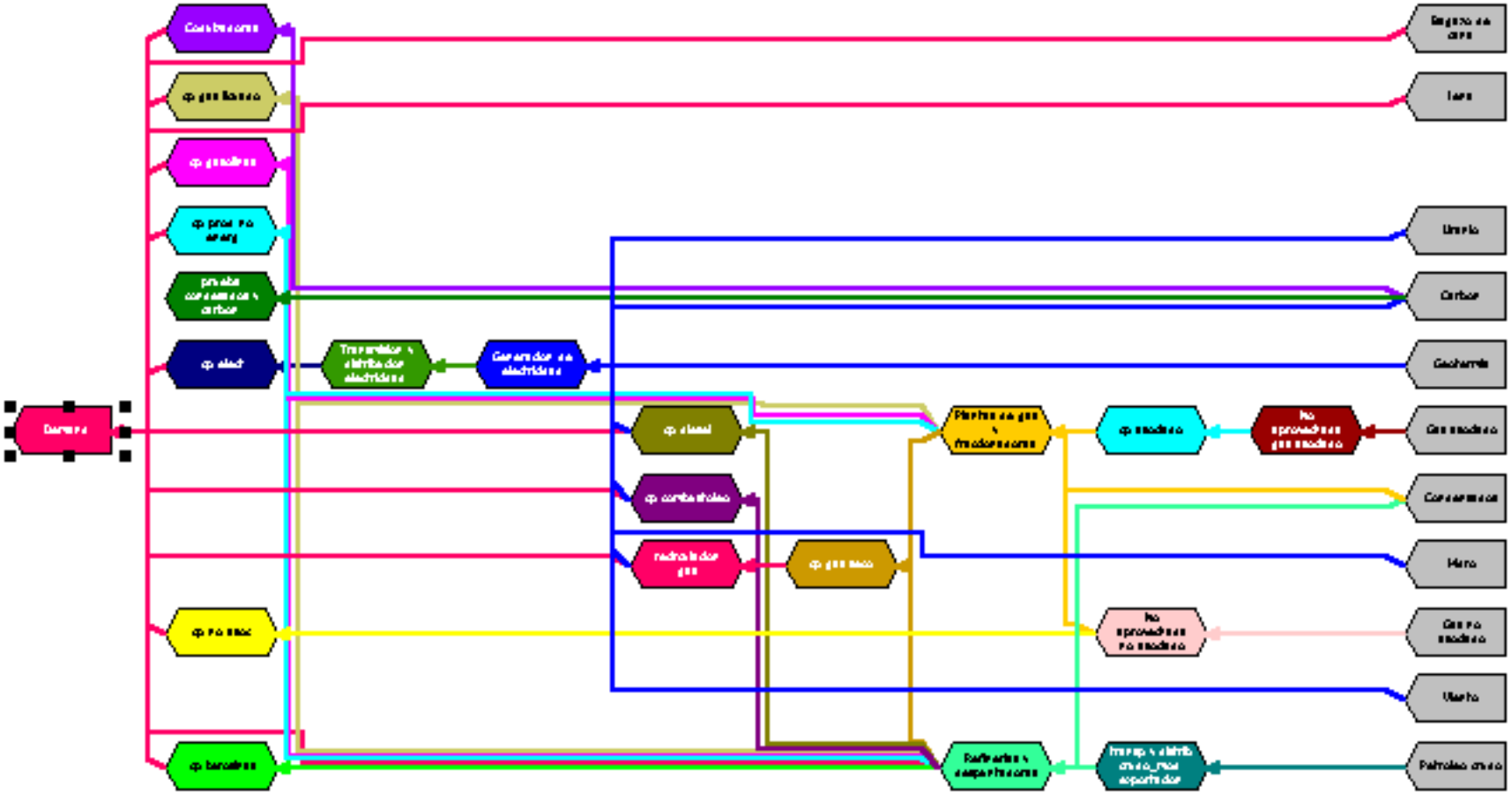
(Lon-range Energy Alternatives Planning system of the Stockholm Environmental Institute)

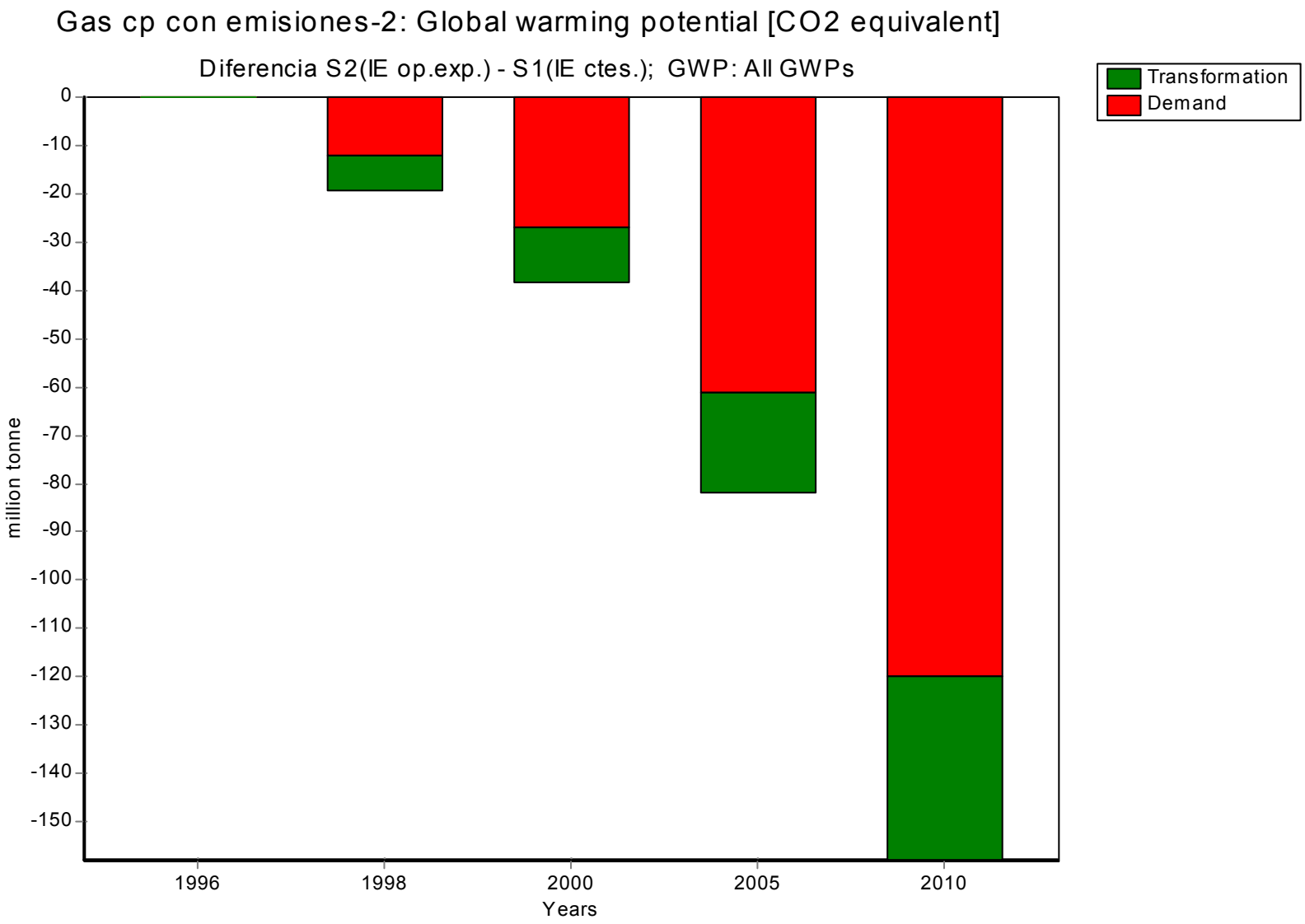
*** Project: "Technical-economical study of the environmental impact of the natural gas and LPG policies in Mexico"**

Módule 3 : Externalities, Prospective and Tehnological Alternatives

MEXICO REFERENCE ENERGY SYSTEM

- reproduces the energy balance of SENER -




Gas cp con emisiones-2: Global warming potential [CO2 equivalent]
Diferencia S2(IE op.exp.) - S1(IE ctes.); GWP: All GWPs
Transformation
Demand
million tonne
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
1996
1998
2000
2005
2010
Years

Current applications of MODEMA at DGSCA-UNAM:

- Escenarios de Emisiones Futuras en el Sistema Energético Mexicano, Cap. IV.1 en "El Cambio Climático en México", INE

- Energy Demand Growth Rates for the National Database of the ENPEP Model (Energy and Power Evaluation Program), DGSCA-UNAM, FI-UNAM, IMP and SENER

- Energy Demand Vectors for the MARKAL database

México: Total Energy Projections

	Base case		Natural Gas*		Gas, Coal, Geothermal*		Coal, Geothermal, Nuclear*	
Year	**EOIA**	**EOIB**	**EOIAGN**	**EOIBGN**	**EOIAGN1**	**EOIBGN1**	**EOIAGN2**	**EOIBGN2**
	PJ	*PJ*	*PJ*	*PJ*	*PJ*	*PJ*	*PJ*	*PJ*
1965	1 387.18	1 387.18	1 387.18	1 387.18	1 387.18	1 387.18	1 387.18	1 387.18
1970	1 875.96	1 875.96	1 875.96	1 875.96	1 875.96	1 875.96	1 875.96	1 875.96
1975	2 647.30	2 647.30	2 647.30	2 647.30	2 647.30	2 647.30	2 647.30	2 647.30
1980	4 169.07	4 169.07	4 169.07	4 169.07	4 169.07	4 169.07	4 169.07	4 169.07
1985	4 730.38	4 730.38	4 730.38	4 730.38	4 730.38	4 730.38	4 730.38	4 730.38
1990	5 161.29	5 161.29	5 161.29	5 161.29	5 161.29	5 161.29	5 161.29	5 161.29
1995	5 487.11	5 487.11	5 487.11	5 487.11	5 487.11	5 487.11	5 487.11	5 487.11
2000	6 368.41	6 368.41	6 368.41	6 368.41	6 368.41	6 368.41	6 368.41	6 368.41
2001	6 546.59	6 182.33	6 531.56	6 208.60	6 531.81	6 208.60	6 531.81	6 208.60
2002	6 831.44	6 340.11	6 756.79	6 329.76	6 757.04	6 329.18	6 757.04	6 330.02
2003	7 214.71	6 602.47	7 087.36	6 559.26	7 087.61	6 559.51	7 087.61	6 559.51
2004	7 669.94	6 943.17	7 495.12	6 855.39	7 507.43	6 855.64	7 507.43	6 855.64
2005	8 187.59	7 352.00	7 923.55	7 212.48	7 935.89	7 212.73	7 935.89	7 212.73
2006	8 817.16	7 871.55	8 447.18	7 651.54	8 459.64	7 663.97	8 474.83	7 663.97
2007	9 229.48	8 210.54	8 784.15	7 933.51	8 808.73	7 945.95	8 823.91	7 945.95
2008	9 625.40	8 546.58	9 148.36	8 255.51	9 172.95	8 267.96	9 188.13	8 267.96
2009	10 214.37	9 062.89	9 674.26	8 729.44	9 710.98	8 754.01	9 726.16	8 754.01
2010	10 863.22	9 641.28	10 212.70	9 219.72	10 249.44	9 244.31	10 264.62	9 259.49

*	Power sector	Hydro grows on the basis of 5 hydro projects (Chicoasén 2da. etapa, Copaínala, Boca del Cerro, El Cajón y La Parota) Combined cycle. Nuclear and Coal grow on the basis of units of 280 MW, 678 MW and 350 MW, respectively; fuel oil contribution is fixed to its value in year 2000; Geothermal grows on the basis of the geothermal resources in Tres Vírgenes, Baja California.
	Transport sector	Natural gas substitutes a relatively small fraction of gasoline in the motor transport.
	Residential sector	Natural gas substitutes part of the LPG consumption.

México: Total CO_2 emissions

	Base case		Natural gas*		Gas, Coal, Geothermal*		Gas, Coal, Geo, Nuclear*	
Year	**EOIA**	**EOIB**	**EOIAGN**	**EOIBGN**	**EOIAGN1**	**EOIBGN1**	**EOIAGN2**	**EOIBGN2**
	10^6 ton	*10^6 ton*	*10^6 ton*	*10^6 ton*	*10^6 ton*	*10^6 ton*	*10^6 ton*	*10^6 ton*
1965	66.44	66.44	66.44	66.44	66.44	66.44	66.44	66.44
1970	89.74	89.74	89.74	89.74	89.74	89.74	89.74	89.74
1975	139.12	139.12	139.12	139.12	139.12	139.12	139.12	139.12
1980	219.16	219.16	219.16	219.16	219.16	219.16	219.16	219.16
1985	249.31	249.31	249.31	249.31	249.31	249.31	249.31	249.31
1990	285.11	285.11	285.11	285.11	285.11	285.11	285.11	285.11
1995	305.57	305.57	305.57	305.57	305.57	305.57	305.57	305.57
2000	363.02	363.02	363.02	363.02	363.02	363.02	363.02	363.02
2001	375.50	353.89	374.43	355.13	374.39	355.13	374.39	355.13
2002	392.01	362.33	387.53	361.45	387.50	361.41	387.50	361.41
2003	414.34	377.00	405.89	373.36	405.86	373.33	405.86	373.33
2004	441.07	396.50	428.02	389.43	430.54	389.39	430.54	389.39
2005	471.54	420.14	453.29	409.04	455.80	409.01	455.80	409.01
2006	508.78	450.53	484.33	434.49	486.84	437.00	485.15	437.00
2007	532.94	470.21	503.99	450.69	509.05	453.20	507.37	453.20
2008	556.44	490.09	523.12	467.19	528.17	469.69	526.49	469.69
2009	591.75	521.01	552.68	493.52	560.29	498.58	558.61	498.58
2010	630.59	555.66	585.03	522.93	592.64	527.99	590.96	526.31

* Power sector: Hydro grows on the basis of 5 hydro projects (Chicoasén 2da. etapa, Copaínala, Boca del Cerro, El Cajón y La Parota)
Combined cycle. Nuclear and Coal grow on the basis of units of 280 MW, 678 MW and 350 MW, respectively; fuel oil contribution is fixed to its value in year 2000; Geothermal grows on the basis of the geothermal resources in Tres Vírgenes, Baja California.

Transport sector: Natural gas substitutes a relatively small fraction of gasoline in the motor transport.

Residential sector: Natural gas substitutes part of the LPG consumption.

National Power System: Capacity Expansion (MW)

	EOIA			EOIAGN*		EOIAGN1*		EOIAGN2*	
VM y	***2000***	***2005***	***2010***	***2005***	***2010***	***2005***	***2010***	***2005***	***2010***
m	14 282.50	19 618.68	27 513.78	14 282.50	14 282.50	14 282.50	14 282.50	14 282.50	14 282.50
C.C.	2 913.62	3 929.12	5 510.31	11 368.51	23 863.86	10 638.73	21 692.64	10 638.73	21 106.11
TG	2 359.78	3 146.08	4 412.53	2 359.78	2 359.78	2 359.78	2 359.78	2 359.78	2 359.78
CI	115.66	154.53	216.75	115.66	115.66	115.66	115.66	115.66	115.66
D	2 100.00	2 894.11	4 058.78	2 100.00	2 100.00	2 100.00	2 100.00	2 100.00	2 100.00
C	2 600.00	3 659.67	5 132.44	2 600.00	2 600.00	3 300.00	4 700.00	3 300.00	4 700.00
N	1 364.88	1 877.01	2 632.36	1 364.88	1 364.88	1 364.88	1 364.88	1 364.88	2 047.32
G	854.90	1 175.54	1 648.61	854.90	854.90	866.60	871.60	866.60	871.60
E	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
H	9 619.15	13 226.94	18 549.82	10 555.15	12 810.15	10 555.15	12 810.15	10 555.15	12 810.15
Total	36 212.67	49 683.87	69 677.57	45 603.56	60 353.91	45 585.48	60 299.39	45 585.48	60 395.29

	EOIB			EOIBGN*		EOIBGN1*		EOIBGN2*	
	2000	***2005***	***2010***	***2005***	***2010***	***2005***	***2010***	***2005***	***2010***
S	14 282.50	17 447.17	23 616.72	14 282.50	14 282.50	14 282.50	14 282.50	14 282.50	14 282.50
C.C.	2 913.62	3 494.22	4 729.83	7 931.75	17 696.01	7 920.23	16 243.06	7 920.23	15 656.52
TG	2 359.78	2 797.85	3 787.21	2 359.78	2 359.78	2 359.78	2 359.78	2 359.78	2 359.78
CI	115.66	137.42	186.02	115.66	115.66	115.66	115.66	115.66	115.66
D	2 100.00	2 573.77	3 483.89	2 100.00	2 100.00	2 100.00	2 100.00	2 100.00	2 100.00
C	2 600.00	3 254.60	4 405.47	2 600.00	2 600.00	2 600.00	4 000.00	2 600.00	4 000.00
N	1 364.88	1 669.25	2 259.52	1 364.88	1 364.88	1 364.88	1 364.88	1 364.88	2 047.32
G	854.90	1 045.43	1 415.10	854.90	854.90	866.60	871.60	866.60	871.60
W	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
H	9 619.15	11 762.91	15 922.42	10 495.22	12 810.15	10 495.22	12 810.15	10 495.22	12 810.15
Total	36 212.67	44 184.80	59 808.36	42 106.87	54 186.06	42 107.05	54 149.81	42 107.05	54 245.71

S: Steam
TG: Turbogas
C. C.: Combined cycle
CI: Internal combustion
D: Duals
N: Nuclear
C: Coal
G: Geothermal
W: Wind
H: Hydro

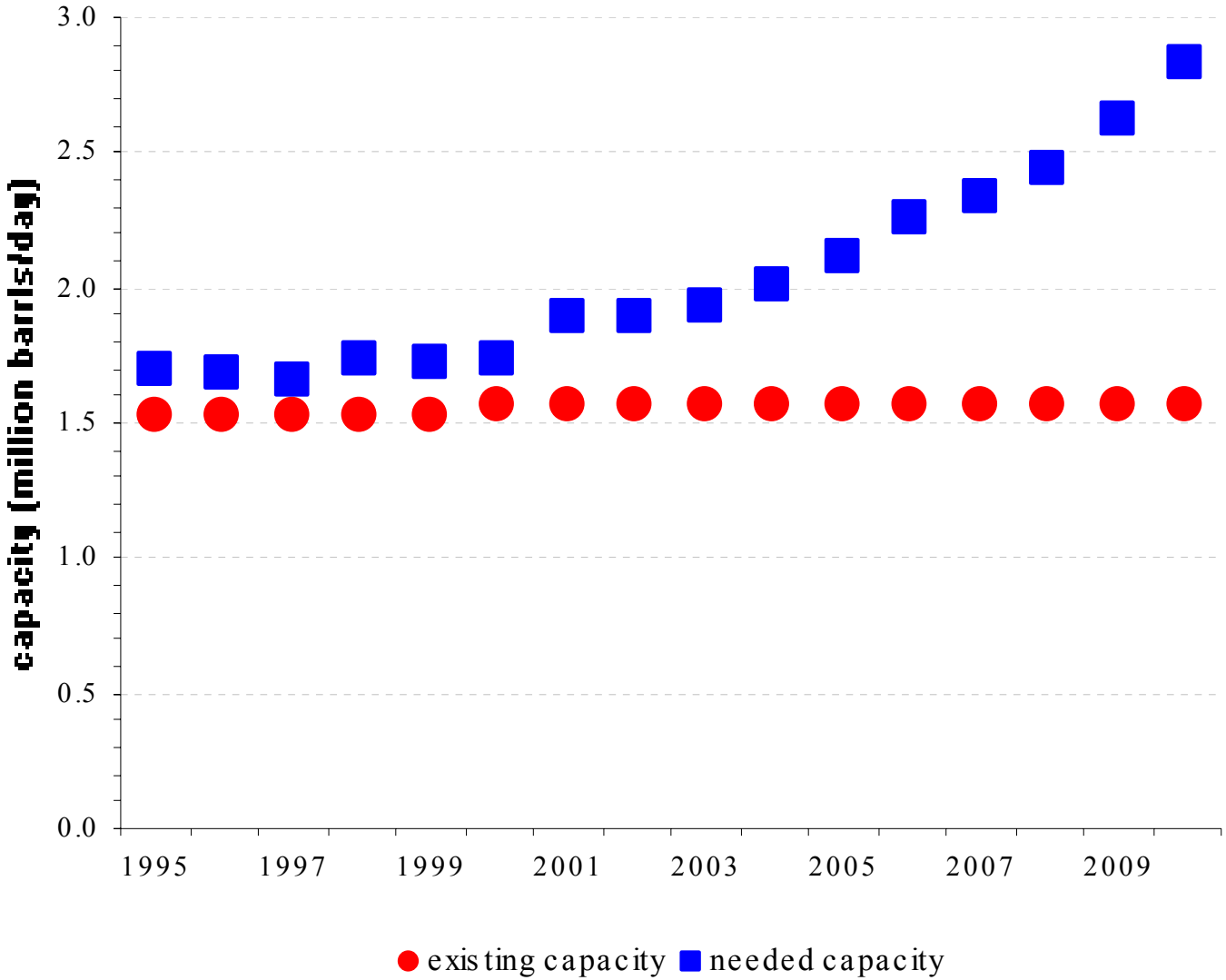
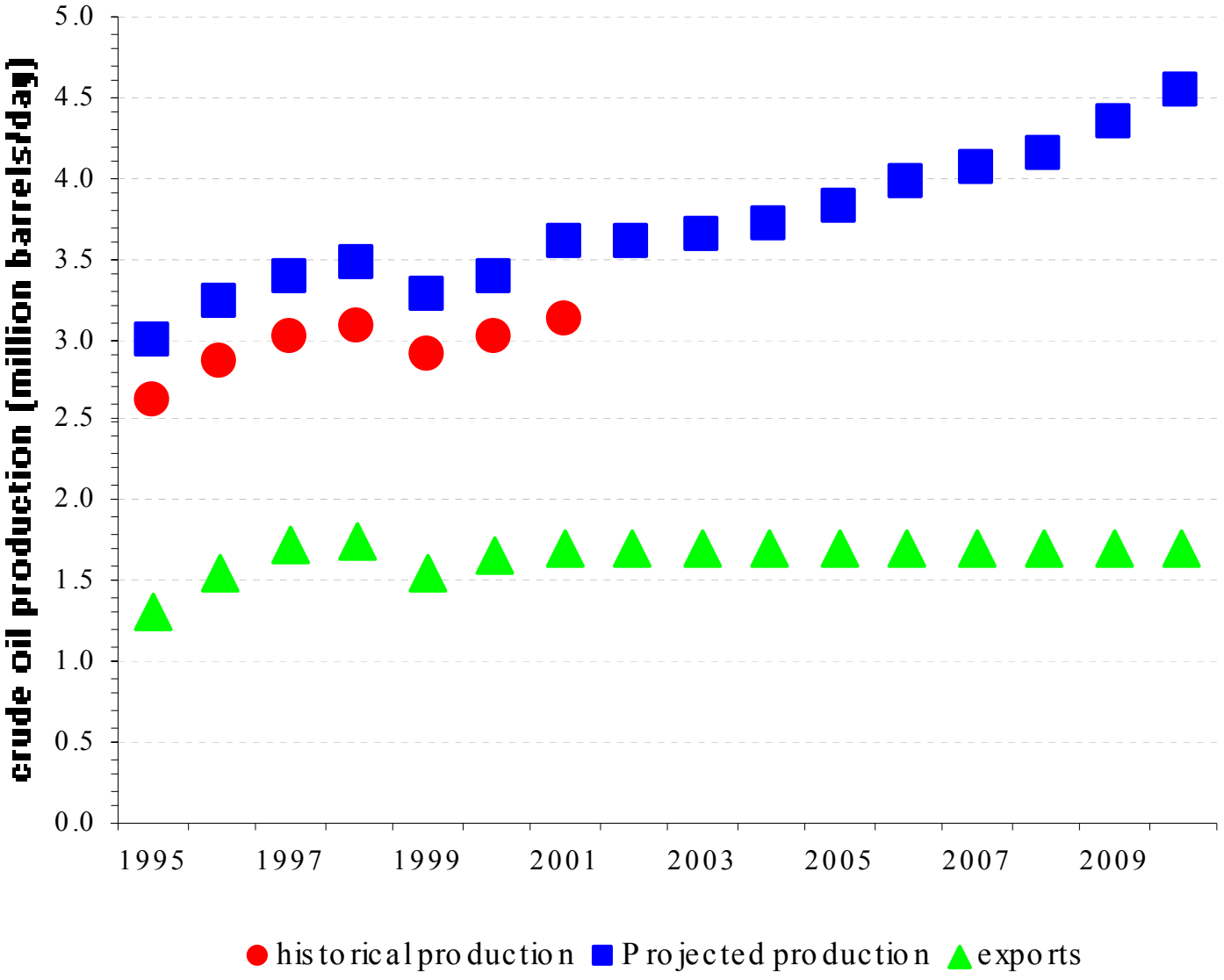
* Hydro grows on the base of 5 hydro projects (Chicoasén 2nd. phase (936 MW), Copaínala (250 MW), Boca del Cerro (560 MW), El Cajón (680 MW) y La Parota 765 MW))

Power Sector: Evolution of the fossil energy demand

Fuels	Scenario EOIA			Scenario EOIAGN			Scenario EOIAGN1			Scenario EOIAGN2		
	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010
Coal (10^6 ton)	9.6	13.2	18.5	9.6	9.3	9.3	9.6	11.9	16.9	9.6	11.9	16.9
Diesel (10^6 bls)	4.4	6.0	8.5	4.4	4.7	4.7	4.4	4.7	4.8	4.4	4.7	4.8
Fuel oil (10^6 bls)	149.3	205.4	287.9	149.3	148.9	148.9	149.3	148.9	148.9	149.3	148.9	148.9
Nat. gas (10^6 m^3)	9412.3	12942.5	18150.9	9412.3	21805.6	39837.1	9412.3	20752.5	36703.9	9412.3	20752.5	35857.5

Fuels	Scenario EOIB			Scenario EOIBGN			Scenario EOIBGN1			Scenario EOIBGN2		
	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010
Coal (10^6 ton)	9.6	11.7	15.8	9.6	9.3	9.3	9.6	9.3	14.4	9.6	9.3	14.4
Diesel (10^6 bls)	4.4	5.4	7.3	4.4	4.7	4.7	4.4	4.7	4.8	4.4	4.7	4.8
Fuel oil (10^6 bls)	149.3	182.6	247.2	149.3	148.9	148.9	149.3	148.9	148.9	149.3	148.9	148.9
Nat. gas (10^6 m^3)	9412.3	11509.9	15579.9	9412.3	16846.2	30936.6	9412.3	16829.6	28839.9	9412.3	16829.6	27993.6

Projection for the refining capacity



Projection for the crude oil extraction