Indicators for Sustainable Energy Development in Brazil

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Summary

- Identification of main priority areas
- Defining Sustainable Energy Development indicators for Brazil
- Key indicators: time-series analysis
- Identification of response actions and energy policies
- Conclusions

Identification of main priority areas

- Priority Area #1 - Diversify Energy Matrix while promoting sustainable energy development
  - Renewable energy supply expansion
    - Reduce risks of power shortages or price shocks
    - Diversify energy supply
    - Stimulate new industries and create new jobs
    - Contribute to economic and social development of poorer rural regions of Brazil
    - Reduce adverse environmental impacts

Identification of main priority areas

- Priority Area #2 – Promote energy efficiency while reducing energy consumption disparities and improving energy affordability
  - Save consumers income
  - Reduce cost and improve competitiveness of Brazilian enterprises
  - Reduce risks of energy shortages
  - Release pressure on government's budget related to infrastructure building
  - Improve standard of living of the poorest
    - Improve energy affordability
    - Create job opportunities in underdeveloped rural areas

Defining Sustainable Energy Development indicators for Brazil

- Brazil's energy database review
  - Energy and economic data are partially adequate
  - Better coordination and classification in order to bring compatibility to different data sources
  - Important information missing or unclear
  - Lack of reliable information on some renewable biomass (e.g. fuelwood)

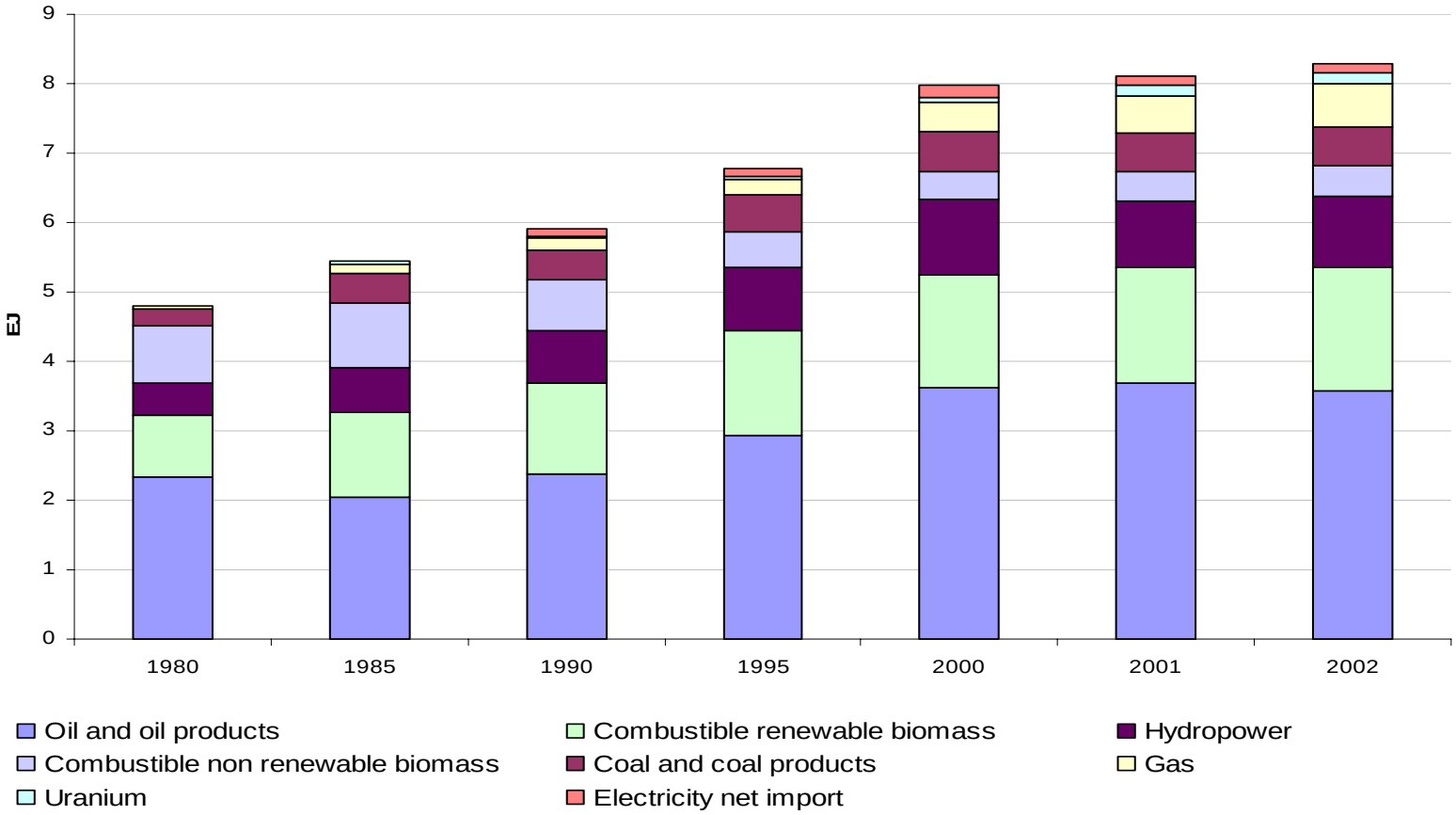
Defining Sustainable Energy Development indicators for Brazil

- ISED database assessment for the case of Brazil
  - Importance of ethanol as a motor fuel (neat or anhydrous)
  - Use of charcoal in the iron and steel industry
  - Importance of potential for different types of hydro, wind and biomass-based power generation (harvested land...)
  - Lack of appropriate indicators to identify regional and social disparities
  - Distinction between accessibility and affordability

Key Indicators: time-series analysis

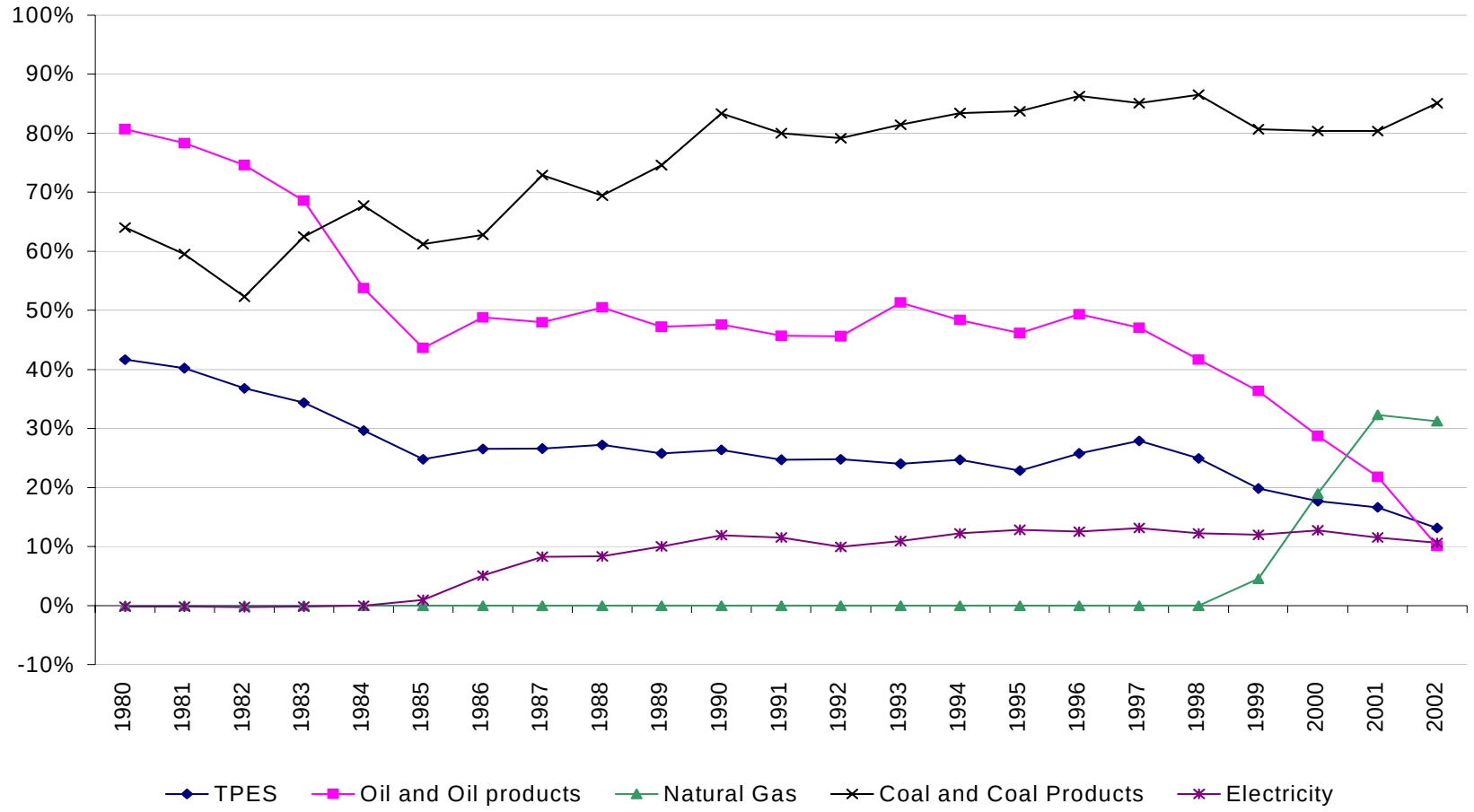
ENERGY BALANCE

- ISED # 11.3 – Total Primary Energy Supply



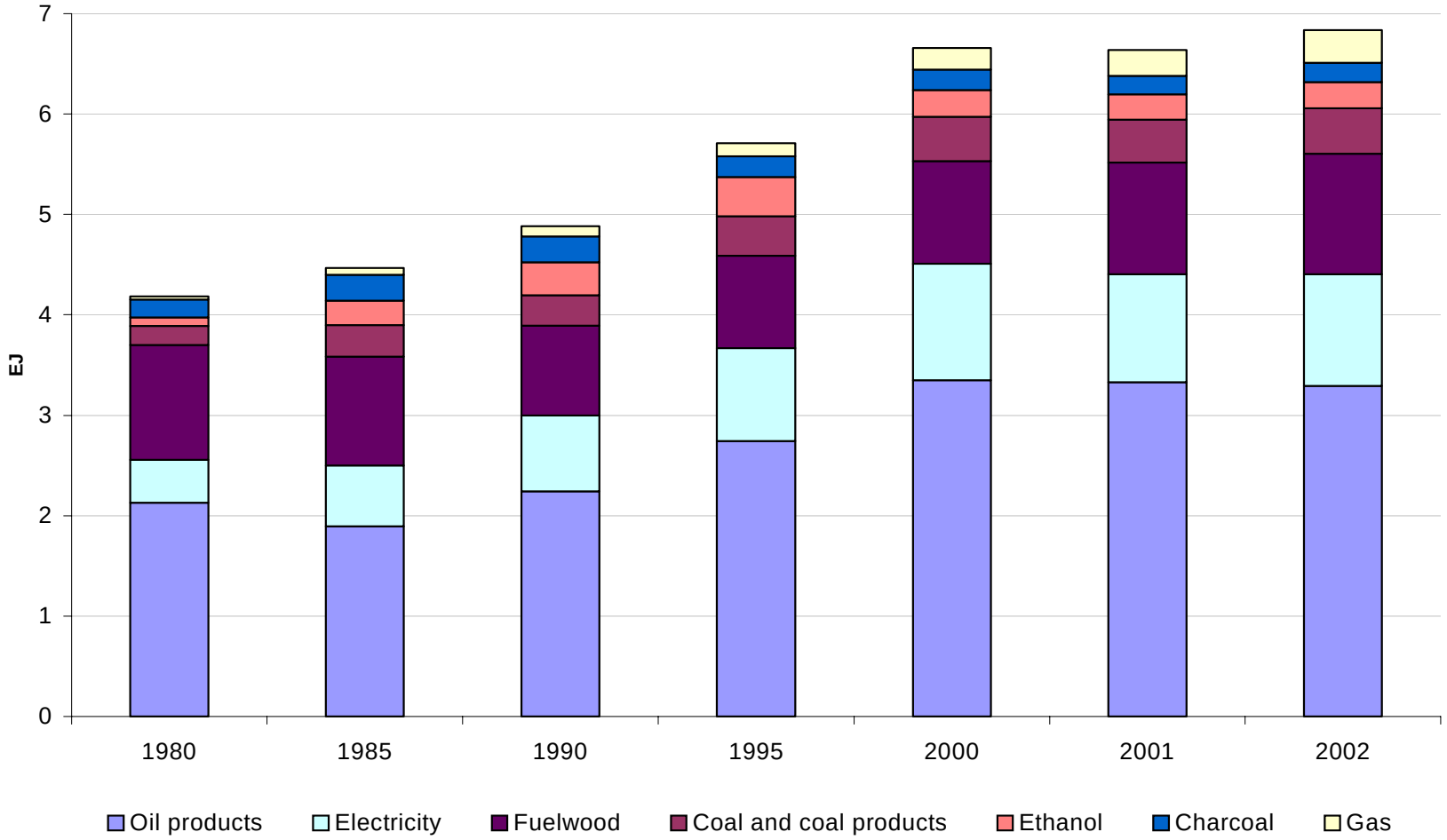
Key Indicators: time-series analysis

- ISED # 18 – Energy imports dependence



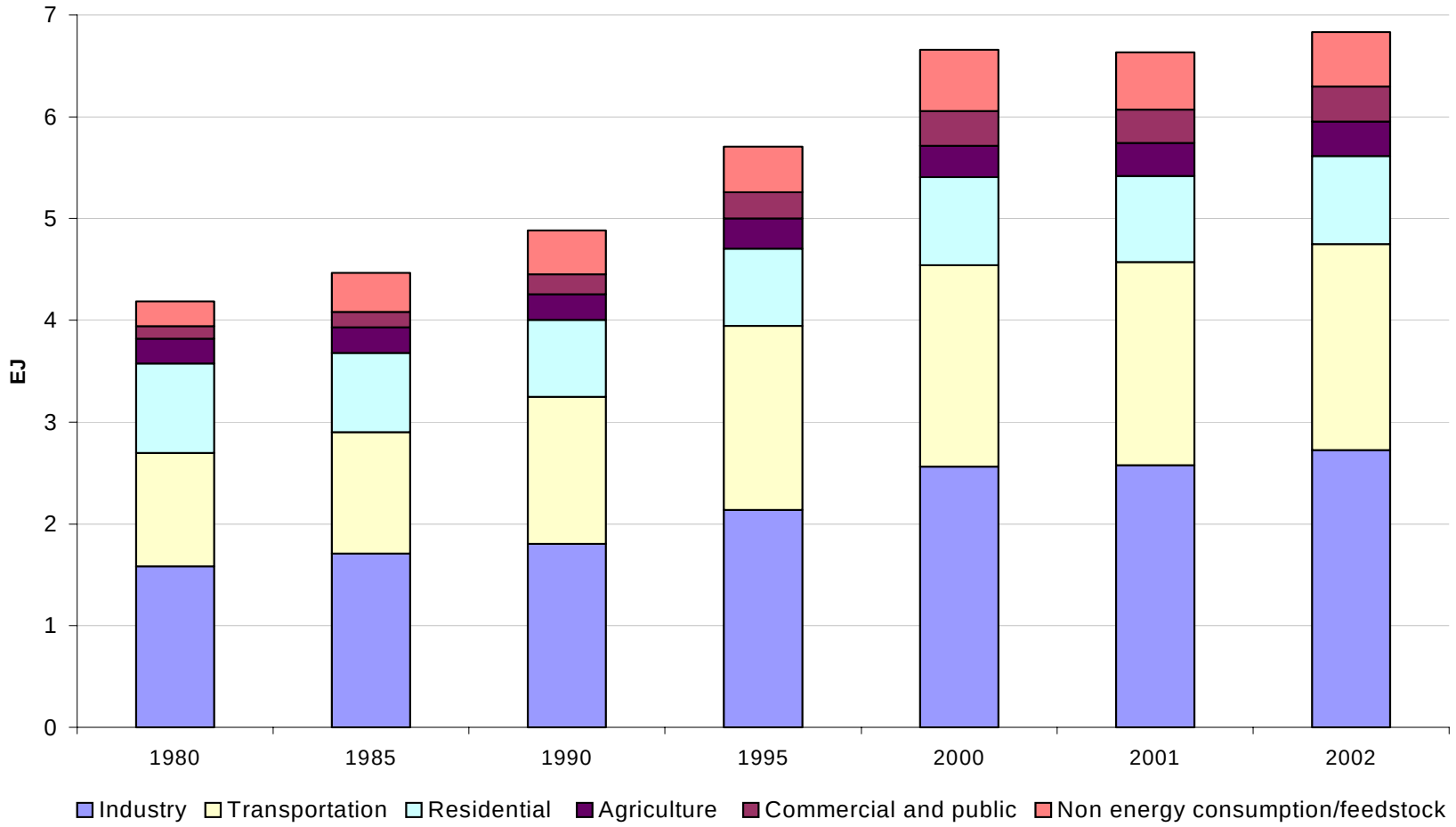
Key Indicators: time-series analysis

- ISED # 11.1 – Final energy consumption



Key Indicators: time-series analysis

- ISED # 11.1 – Final Energy Consumption Sectoral Analysis



Key Indicators: time-series analysis

- ISED # 5 – Evolution of total distance traveled by passengers (passenger activity) in Brazil

(pkm) (per capita)	Air	Rail	Road	Total
1980	78.60	114.26	3,374.33	3,567.19
1985	81.46	139.25	3,694.88	3,915.59
1990	102.76	123.09	4,115.03	4,340.88
1995	100.22	96.33	4,691.62	4,888.16
2000	121.10	n.a.	5,189.41	5,310.51

“n.a.” means not available

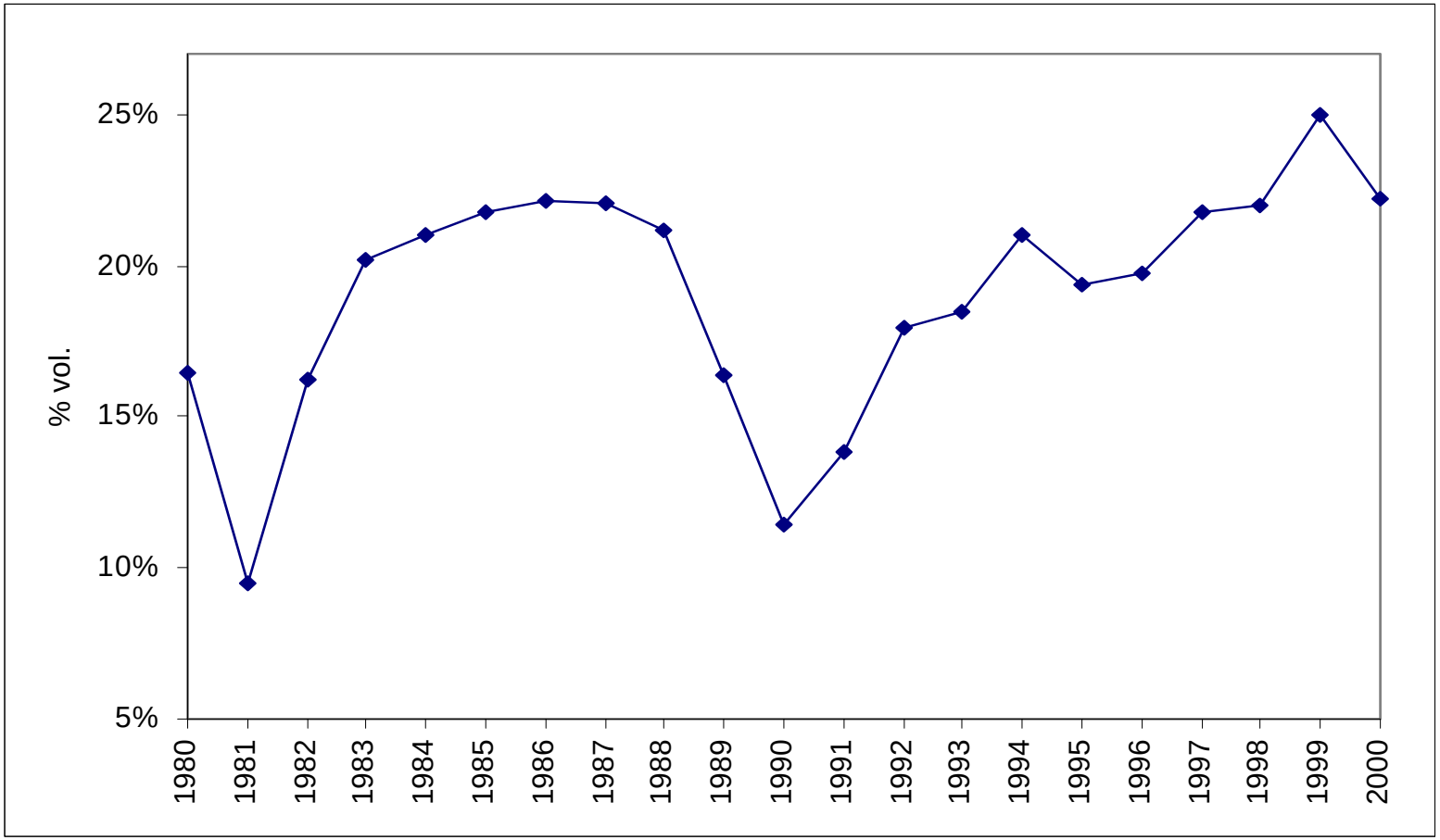
Key Indicators: time-series analysis

- ISED # 6 – Evolution of total freight transport activity per capita in Brazil

(t.km) (per capita)	Air	Island waters	Pipeline	Rail	Road	Total
1980	8.39	392.24	98.09	709.65	1,714.48	2,922.85
1985	9.91	577.72	131.50	741.83	1,686.08	3,147.06
1990	11.94	695.58	141.63	815.55	2,122.24	3,786.94
1995	12.28	444.04	151.61	858.15	2,383.45	3,849.54
2000	14.29	607.66	195.40	914.47	2,652.88	4,384.71

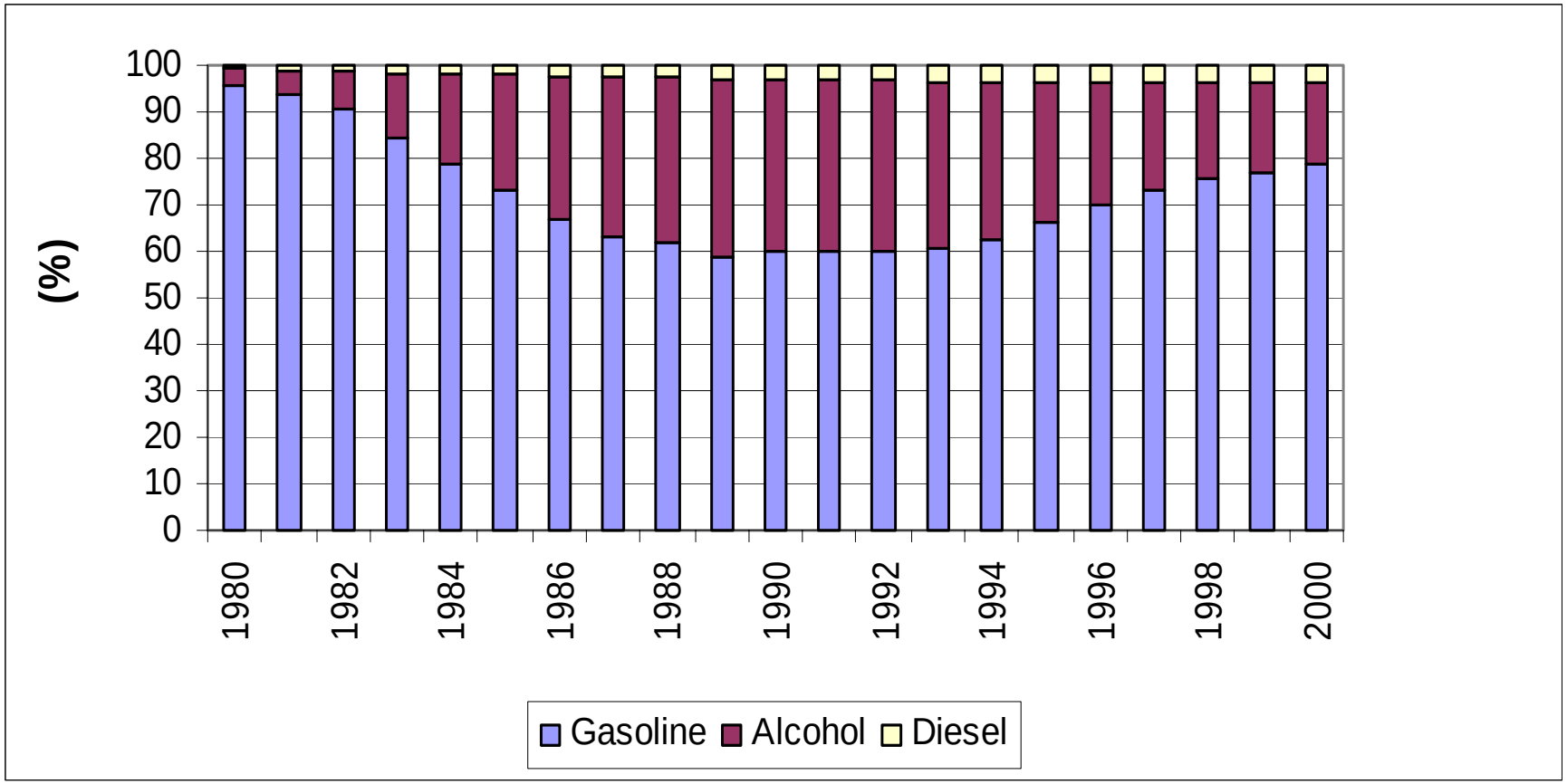
Key Indicators: time-series analysis

- Additional ISED # 11.4 – Anhydrous ethanol added to gasoline



Key Indicators: time-series analysis

- Additional ISED # 11.5 – Share of light fleet by fuel in Brazil



Key Indicators: time-series analysis

- ISED # 11.2 – Power generation mix (GWh) – public service

	1980	1985	1990	1995	2000	2001	2002
PUBLIC SERVICE							
HYDRO	126,103	175,334	203,594	250,456	298,563	262,665	278,656
FUEL OIL	1,560	1,151	848	1,337	6,187	6,070	3,682
DIESEL OIL	907	1,134	1,511	2,698	4,084	4,010	4,286
NATURAL GAS	0	0	12	0	1,571	6,942	9,786
NUCLEAR	0	3,381	2,237	2,519	6,046	14,279	13,837
COAL	2,470	3,336	2,711	3,668	7,448	7,352	5,062
FUELWOOD	0	20	0	0	0	0	0
TOTAL PUBLIC SERVICE	131,040	184,356	210,913	260,678	323,899	301,318	315,309
TOTAL PUBLIC SERVICE	139,383	193,682	222,820	275,601	348,909	328,508	344,644

Key Indicators: time-series analysis

- ISED # 11.2 – Power Generation Mix (GWh) – self-producer

	1980	1985	1990	1995	2000	2001	2002
SELF PRODUCER							
NATURAL GAS	0	0	314	560	2,497	3,014	3,358
COAL	126	102	103	276	219	242	247
FUELWOOD	202	549	612	646	763	585	677
SUGAR-CANE BAGASSE	1,000	1,740	1,864	2,574	3,653	4,655	5,360
BLACK LIQUOR	603	682	1,103	2,195	3,006	3,111	3,515
OTHER PRIMARY	661	1,059	1,649	1,373	3,474	3,925	4,184
DIESEL OIL	232	283	459	378	1,504	2,063	1,545
FUEL OIL	2,518	1,303	1,996	2,103	1,810	1,966	1,737
COKE GAS	181	525	438	304	583	624	693
OTHER SECONDARY	15	43	256	1,065	1,660	1,794	1,731
HYDRAULIC	2,803	3041	3,114	3,449	5,840	5,211	6,288
TOTAL SELF PRODUCER	8,343	9,326	11,907	14,923	25,010	27,190	29,335

Key Indicators: time-series analysis

- ISED # 35 & 35.5 – Potential capacity for hydro-power generation and fraction currently in use

Region	TOTAL (MW)	Installed Capacity in 2000 (MW)	Installed Capacity / Total Potential
North	112,495	4,867	4.3%
Northeast	26,710	10,143	38.0%
Southeast	42,776	21,204	49.6%
Mid-West	36,255	8,337	23.0%
South	41,859	17,169	41.0%
Brazil	260,095	61,720	23.7%

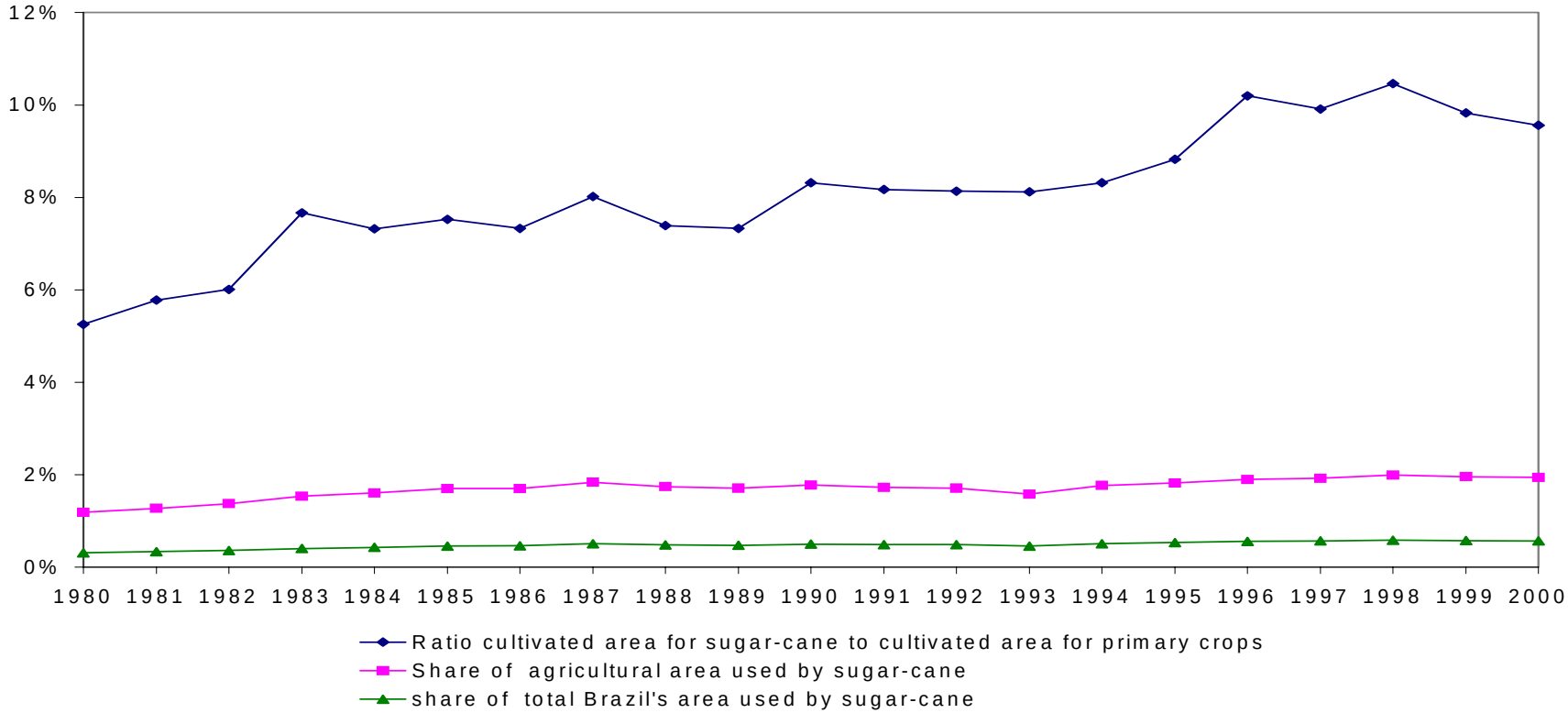
Key Indicators: time-series analysis

- Additional ISED # 35.2 – Estimated wind-power potential

Region	Capacity (GW)	Power Generation (TWh/ano)	Capacity Factor (%)
North	12.84	26.45	24
Northeast	75.05	144.29	22
Mid-West	3.08	5.42	20
Southeast	29.74	54.93	21
South	22.76	41.11	21
Brazil	143.47	272.2	22

Key Indicators: time-series analysis

- Additional ISED # 35.3 – Land use for sugar cane in Brazil



Brazil's total area corresponds to 854,740 (10^3 ha). Brazil's agricultural area varied over the period from 220,518 (10^3 ha) in 1980 to 250,200 (10^3 ha) in 2000

Key Indicators: time-series analysis

- ISED # 12 – First-law efficiency of thermal power plants (public utilities only)

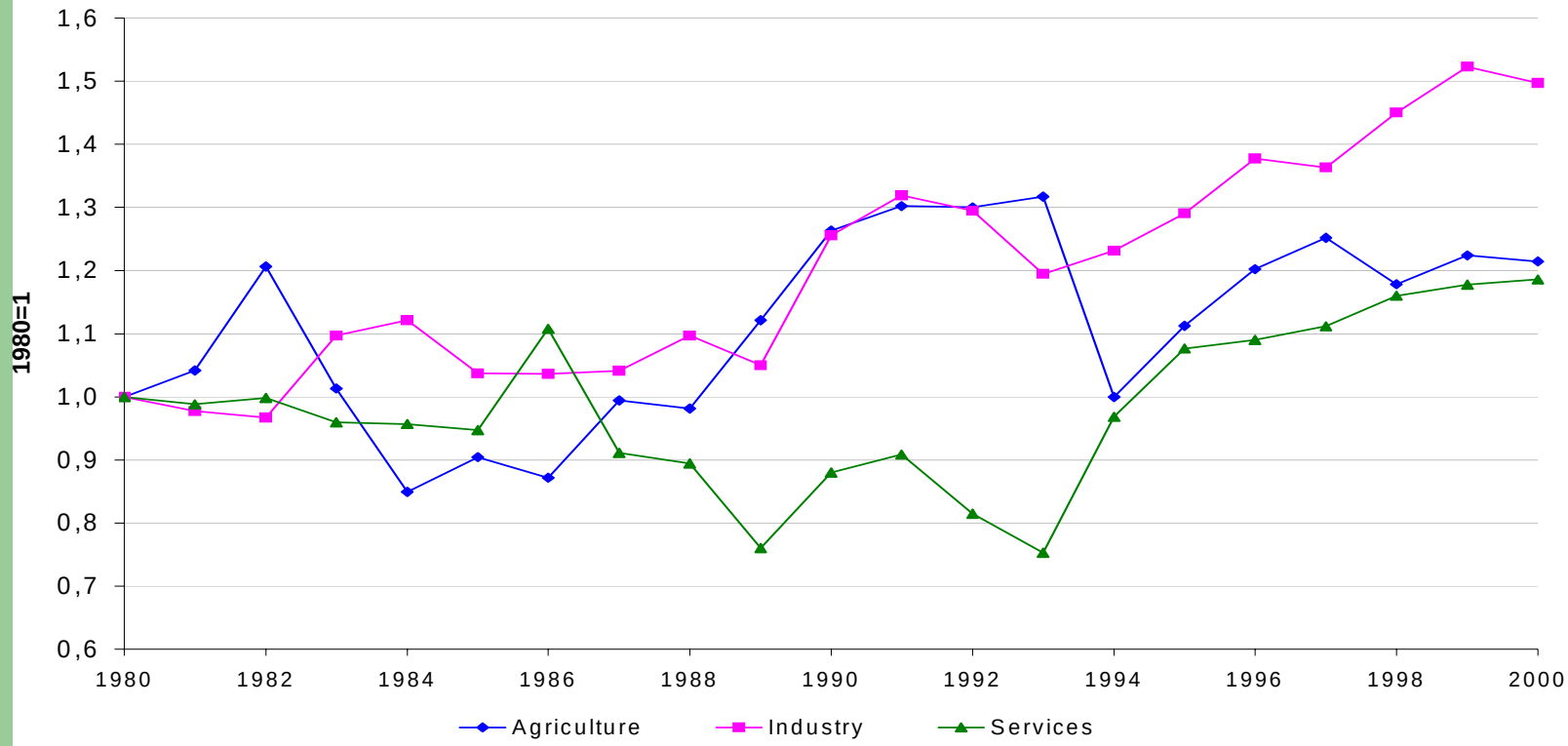
Year	%	Year	%
1980	34.0	1990	31.6
1981	30.9	1991	31.1
1982	32.5	1992	30.6
1983	34.5	1993	30.7
1984	28.8	1994	32.0
1985	31.6	1995	30.1
1986	31.7	1996	32.1
1987	30.4	1997	31.9
1988	30.1	1998	29.9
1989	32.3	1999	31.0

Expected start-up of operations for CCGT after 2000

Key Indicators: time-series analysis

ECONOMIC DIMENSION

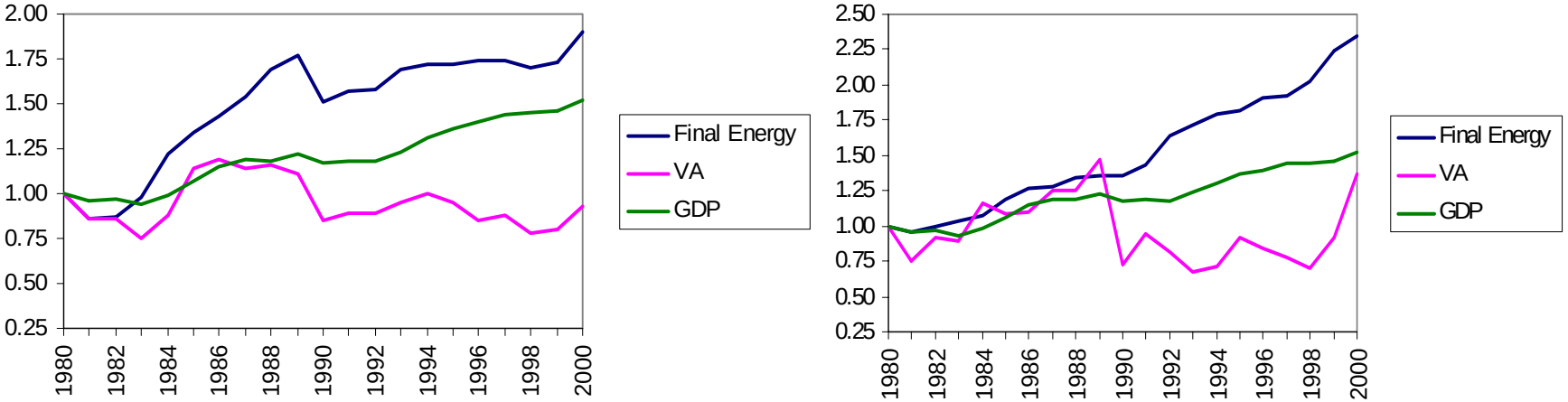
- ISED # 9 – Energy intensity by sector



In 1980, Agriculture energy intensity was 3.0 MJ/US$-2000 ppp, Industry energy intensity was 5.4 MJ/US$-2000 ppp and Services energy intensity was 3.1 MJ/US$-2000 ppp

Key Indicators: time-series analysis

- Shift to less-value added goods in the mix of industrial output: Metallurgy and Pulp & Paper sectors



Metallurgy

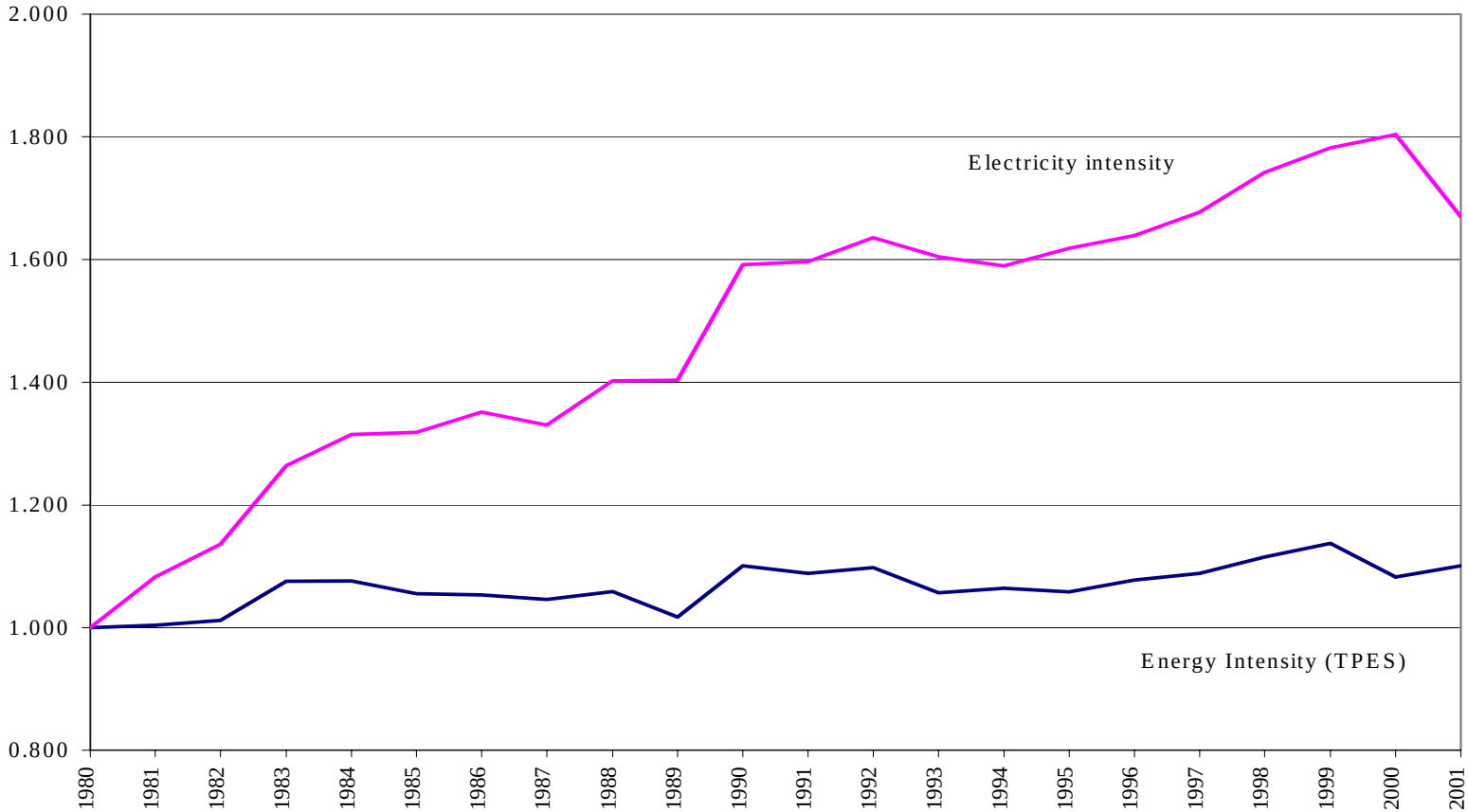
Pulp and Paper

In 1980, Metallurgy final energy use was 457,268 TJ, VA was million US$-2000 ppp 28,530 and GDP was million US$-2000 ppp 815,682

In 1980, Pulp and paper final energy use was 112,486 TJ, VA was million US$-2000 ppp 7,166 and GDP was million US$-2000 ppp 815,682

Key Indicators: time-series analysis

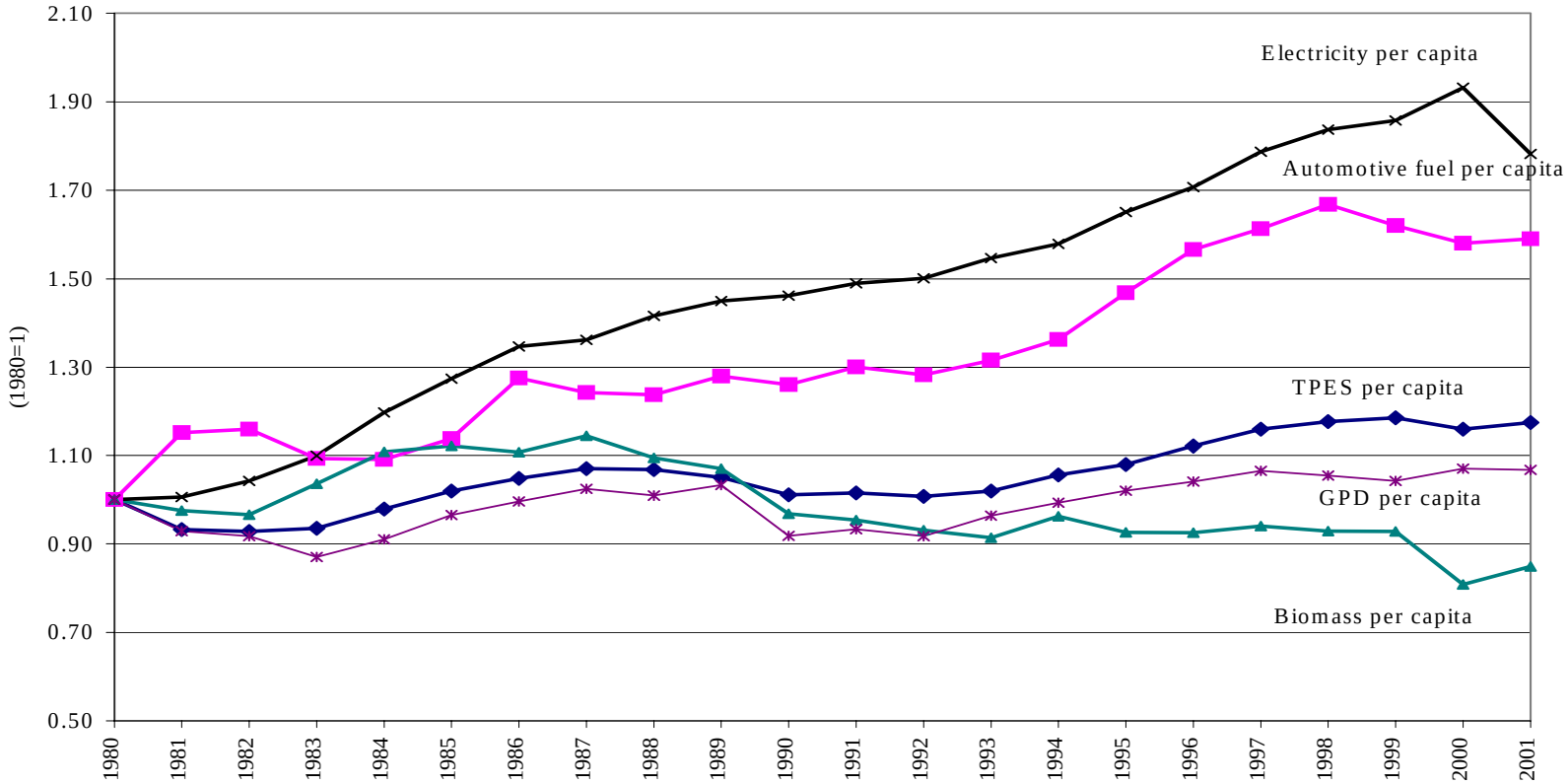
- ISED # 14 – Energy Use per GDP



In 1980, TPES/GDP was 6.53 MJ/US$-2000 ppp, and Electricity/GDP was 0.166 kWh/US$-ppp 2000.

Key Indicators: time-series analysis

- ISED # 16 – Energy Consumption per Capita

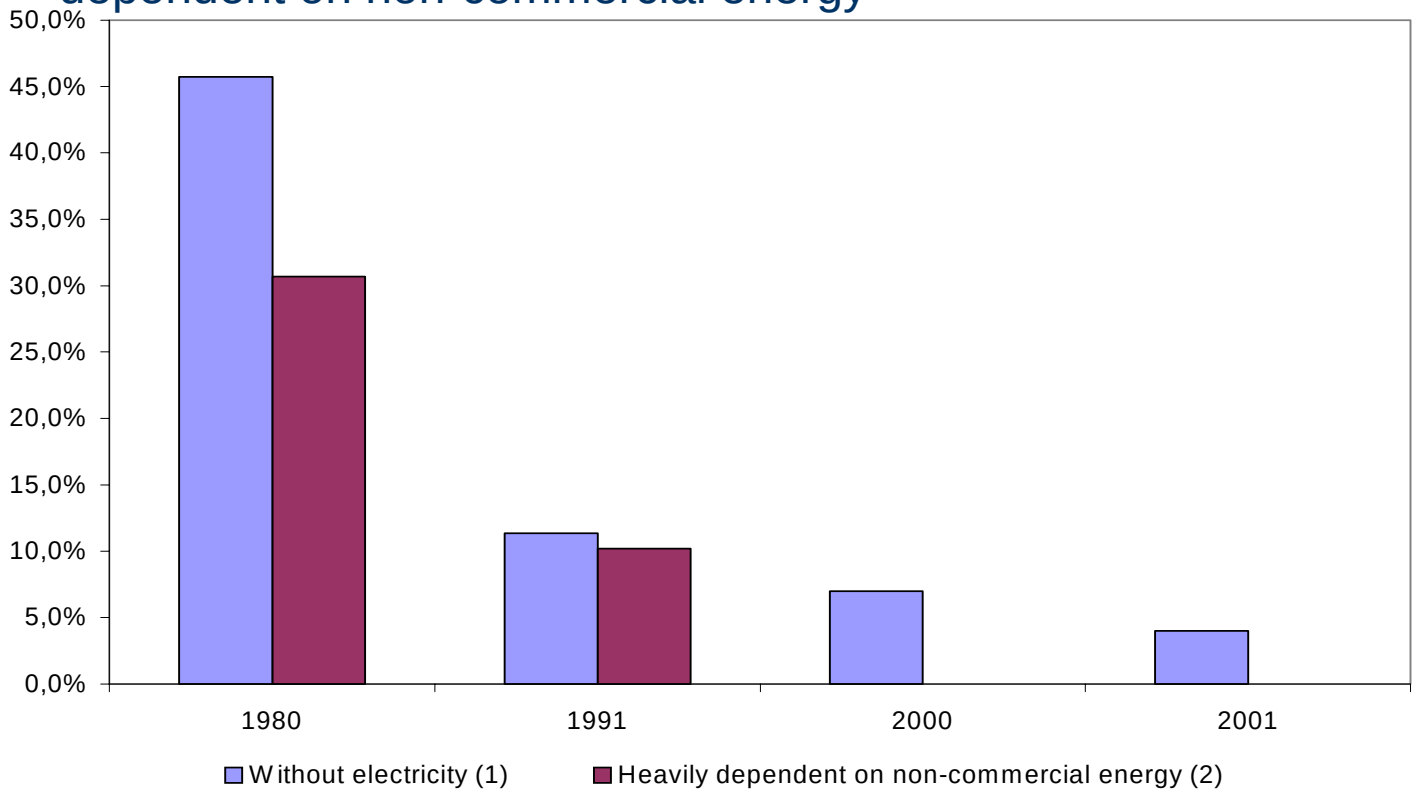


In 1980, per capita total electricity consumption was 3,631 MJ; per capita total biomass consumption was 12,318 MJ; per capita automotive fuel consumption was 7,726 MJ, per capita TPES was 39,554 MJ, and per capita GDP was US$-2000 ppp 6,062.

Key Indicators: time-series analysis

SOCIAL DIMENSION

- ISED # 22 – Fraction of Households without electricity or heavily dependent on non-commercial energy



(1) Families without electricity meter, (2) Families that own fuelwood oven

Key Indicators: time-series analysis

- Brazilian income inequalities and social disparities – Major Social Indicators

	Line of Poverty (1)	Gini Index(2)	Income share of 10% richest (%)	Income share of 20% poorest (%)
1992	40.8	0.571	45.81	2.32
1993	41.7	0.600	48.58	2.24
1995	33.9	0.585	47.92	2.29
1996	33.5	0.580	47.59	2.15
1997	33.9	0.580	47.70	2.20
1998	32.8	0.575	47.92	2.25
1999	34.1	0.567	47.45	2.34

(1) Percentage of people earning less than $2.0 per day, exchange rate values.
(2) This is the degree of income concentration, considering the income distribution for all workers with more than 10 years old; it varies between 0 (perfect equality) and 1 (maximum inequality).

Key Indicators: time-series analysis

- Average electricity consumption by household in kWh/household per month

	1980	1985	1990	1995	2000	2001	1980-90 (%)	1990-2000 (%)	2000-2001 (%)
North	127	135	154	150	165	152	1.97	0.67	-7.67
Northeast	85	85	96	102	111	93	1.19	1.44	-16.28
Southeast	156	152	176	189	201	164	1.24	1.30	-18.19
South	106	125	146	160	176	167	3.29	1.87	-4.82
Mid-West	133	141	161	174	183	151	1.94	1.32	-17.61
Brazil	133	135	152	162	173	146	1.34	1.30	-15.35

Key Indicators: time-series analysis

- ISED # 21 – Household energy expenditures – estimates for 2000

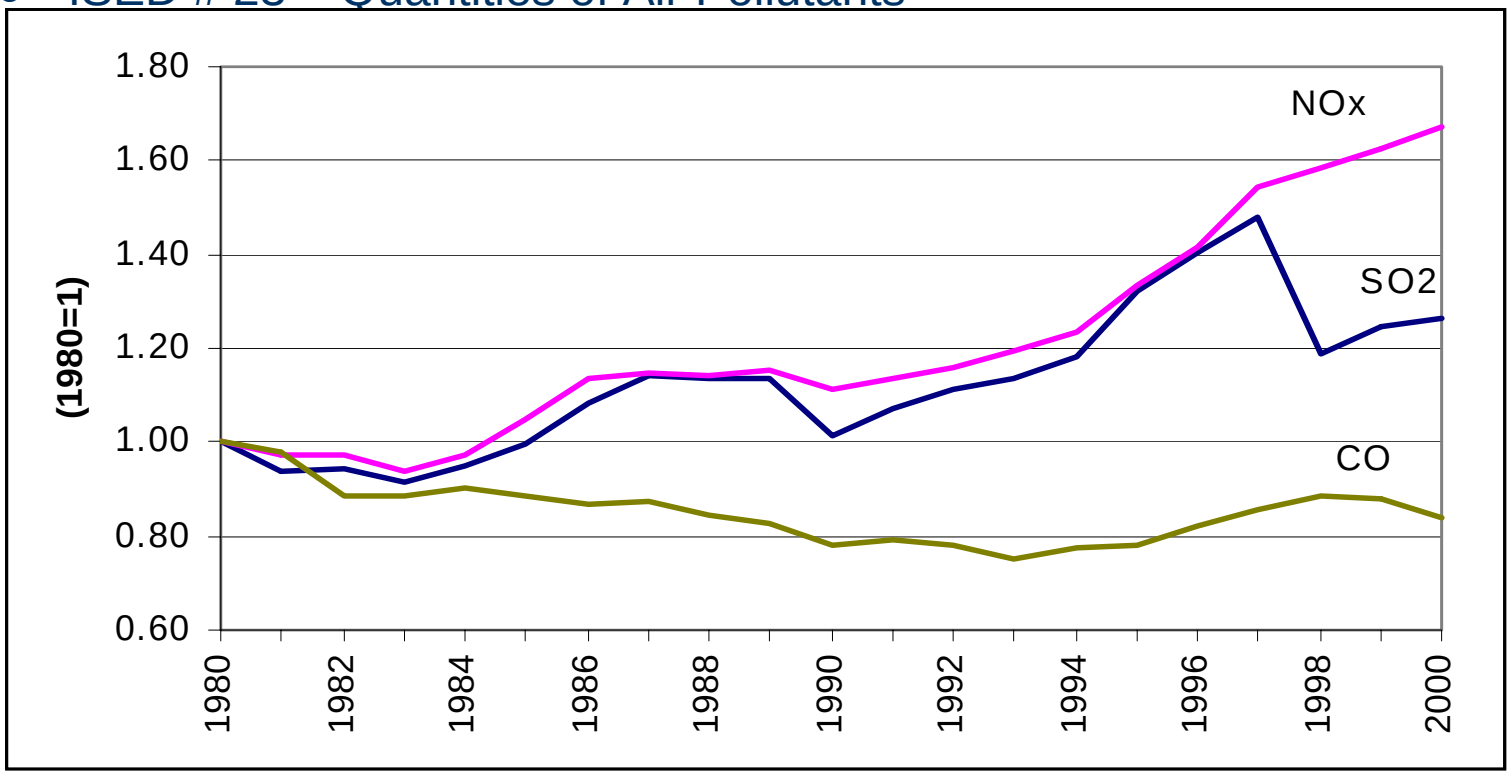
	Income classes – minimum wage[4]				
Montly Household Expenditures US$ PPP-2000[1]	<2	2-3	3-5	5-10	>10
Electricity -	13.22	25.51	29.31	50.35	82.86
LPG	10.92	14.96	16.9	18.58	21.10
Household by income class (%)	22.3	14.6	18.1	16.5	12.6
Electricity Tariff (US$-ppp 2000/kWh)	0.09	0.15	0.15	0.22	0.25
Electricity Consumption Estimate [2] (kWh/month)	151	172	197	225	333
Global Average Consumption Estimate [3] (kWh/month)	173				

(1) The only source of information on disposable income is the Family Budget Survey (IBGE, 1997),
(2) These estimates were based on assumptions about the identification of the different electricity tariffs with the income classes.
(3) The observed data for Brazil in 2000 was 173 kWh/month – i.e. equal to the average consumption estimated in the table.
(4) In 2000 minimum wage was equal to US$-2000 ppp 181.12.

Key Indicators: time-series analysis

ENVIRONMENTAL DIMENSION

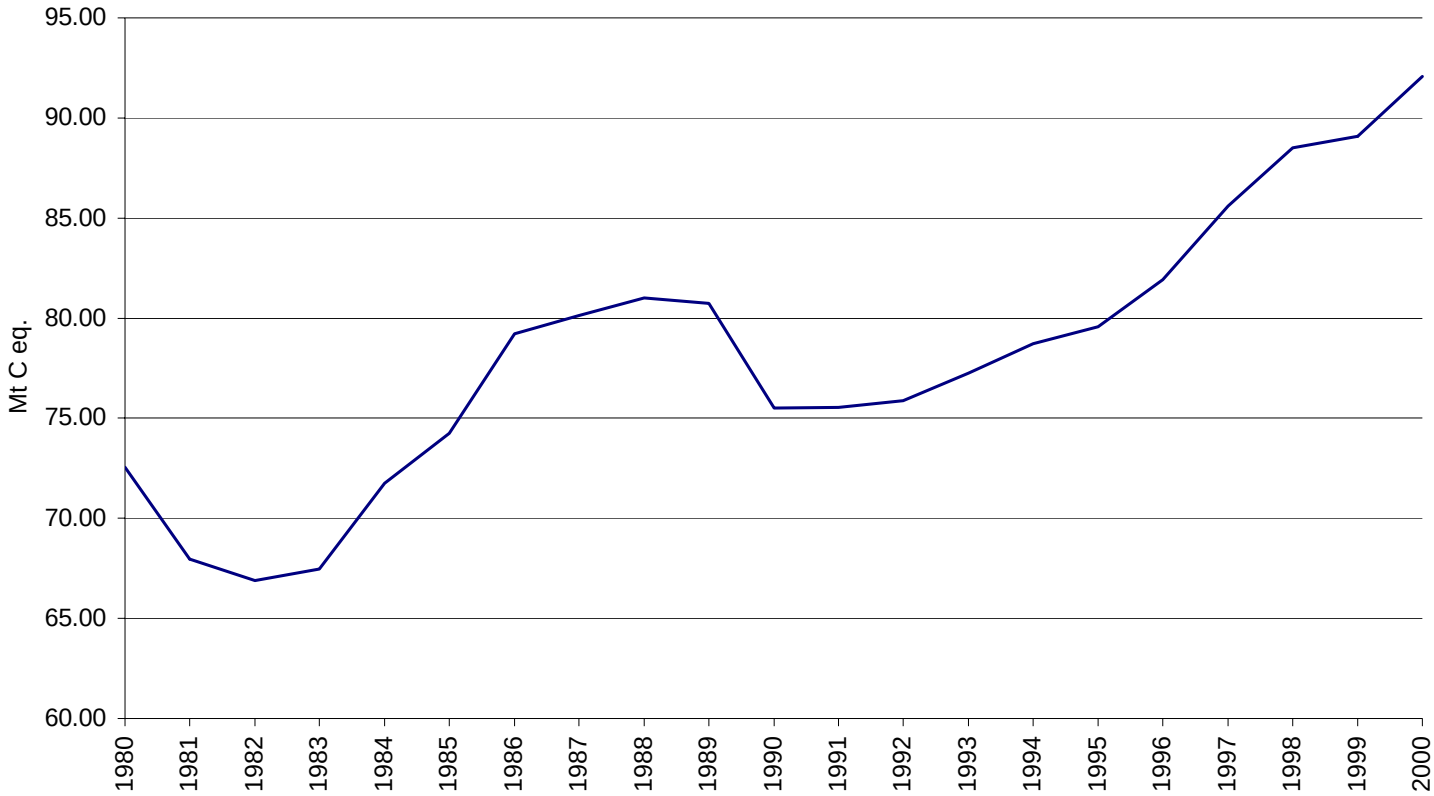
- ISED # 23 – Quantities of Air Pollutants



In 1980, SO2 emissions were 2,133 kt, NOx emissions were 1,423 kt and CO emissions were 19,403 kt

Key Indicators: time-series analysis

- ISED # 26 – Annual GHG emissions from the energy consumption



Key Indicators: time-series analysis

Carbon Dioxide Emissions and Uptake - 1990-94

Source	Average per year (million tons of carbon)
Energy	75.8
Fugitive car bon dioxide emissions from coal mining and handling	0.4
Land use change (deforestation)	139.9
Soils and liming	22.2
Total carbon dioxide emissions	238.3
Removals from planted forests	11.0
Net carbon dioxide emissions (emissions minus uptake)	228.3

Identification of response actions and energy policies

Priority Areas

1 - Diversify Brazil´s Energy Matrix while promoting sustainable development

2 - Promote energy efficiency whilst reducing regional disparities and improving energy affordability

Response Actions

- Diversify energy supply
- Increase efficiency of supply and use of CHP
- Decrease energy Intensities through end use energy efficiency
- Increase share of public transport
- Improve energy affordability of the poor

Priority Area #1 - Energy Policies

Stimulate ethanol automotive fuel and sugar-cane bagasse cogeneration

- Sugar cane production – sugar, ethanol (renewable liquid fuel) and bagasse (biomass for power generation)
- National Alcohol Fuel Program – PROALCOOL – Production of ethanol as a substitute for gasoline
  - Improve the country's balance of payment
  - Lower unemployment in the countryside
  - Local and global environments benefits
- Today:
  - Ethanol as an additive to gasoline (20-26% v.v.)
  - Increasing sales of Flex-fuel cars might stimulate production of ethanol as automotive fuel
- Combined heat and power generation (CHP) fueled by sugar-cane bagasse as a distributed generation alternative

Priority Area #1 - Energy Policies

Stimulate non-combustible new renewable energy sources for power generation

- Small-scale hydroplants (SSH), Wind Power and Solar Photovoltaic Energy – After 1999 subsides from Fuels Consumption Account (CCC)
- Alternative Energy Sources Incentive Program (PROINFA)
- SSH-COM program – Only 100 MW submitted so far
- Wind Power
  - Technical potential of 143,470 MW, only 21.2 MW installed
  - PROEOLICA – Launched during electricity supply crisis (2001)
- Photovoltaic energy
  - PRODEEM – 5,744 photovoltaic systems with an average capacity of 535 Wp (2001)
  - Target – Service 100,000 remote communities

Priority Area #1 - Energy Policies

Develop and stimulate the adoption of new biomass sources

- Production and use of vegetable oils and biodiesel in Brazil
  - Application of ethanol infrastructure onto the biodiesel industry
  - R&D on vegetable oil productivity and crop diversification
  - Enhance profitability and attractiveness – creation of markets for by-products of biodiesel
  - Implement time-bound or quantity-bound fiscal investments to spark the development of a sustainable biodiesel industry

Priority Area #1 - Energy Policies

Lift barriers to NGCHP implementation

- Interconnection of existing and future CHP enterprises to power grid with minimum requirement, avoiding excessive delays
- Awareness of advantages and the potential for CHP investments
- CHP projects in top priority list as new gas supplies become available
- Financial incentives
  - Long term loans at low interest rates
  - Tax incentives – accelerated depreciation
- Performance-based contract – ESCOS
- Review import taxes on CHP equipment
- Set-up of future incentives to manufacture of equipments in Brazil

Priority Area #2 - Energy Policies

Promote a more efficient use of electricity

- National Electricity Conservation Program – PROCEL
  - Promote end-use electricity efficiency and transmission and distribution loss reduction
    - Refrigerators and freezers – testing, labeling and voluntary agreement with manufacturers
    - Motors – testing labeling and R&D projects
    - Market for energy efficient lighting technologies
    - Reduce electricity waste – audits, workshops and information dissemination
    - Installation of electricity meters

Priority Area #2 - Energy Policies

Fully implement the appliance efficiency standards law

- Efficiency standards for manufacturers of electric-power consuming devices
  - major household appliances (refrigerators, freezers, clothes washers, stoves, and air conditioners)
  - lighting products (lamps and fluorescent lighting ballasts)
  - commercial sector air conditioning
  - standby power consumption of electronic devices (TVs, VCRs, microwave ovens, personal computers)

Priority Area #2 - Energy Policies

Expand utility investments in end-use energy efficiency

- ANEEL – Increase energy efficiency-spending requirement by distribution utilities
  - State and Federal energy efficiency programs (PROCEL)
  - Support energy efficiency investments made by households
  - Finance energy services – market for innovative energy efficiency measures, dissemination of information and training
- Compensation measures for utilities
  - Recover costs as part of electricity bills
  - Financial incentive (“bonus”) to operate effective programs

Priority Area #2 - Energy Policies

Adopt industrial energy intensity reduction targets and protocols

- Improving operating and management practices
- Using better equipment such as high efficiency motors and motor speed controls
- Adopting innovative industrial process technologies
- Great potential for energy use reduction
  - 30% in a wide range of energy-intensive industries
  - 19% in cement industry (better technologies)
  - 5-12% chemical industry (optimization of heat exchange network)

Priority Area #2 - Energy Policies

Promote fossil fuel savings

- 1993 - a tax incentive encouraging the production of small-engine automobiles (<1000 cc)
- 2001 - almost three quarters of domestic sales of new automobiles consisted of one-liter engine automobiles
  - Lower fuel consumption
  - Abatement in CO_2 emissions
- 2004 – Introduction of flex-fuel cars

Priority Area #2 - Energy Policies

Improve the efficiency of passengers transport, through transport planning and shifts to less energy-intensive modes

- Displacement of individual transportation by mass transportation -
  - Inter-modal integration and improved quality of service
  - Access to low-income consumers
- Improve infrastructure for buses – express bus lanes, efficient transfer stations and mass transit corridors
- Increase load factor of cars and light trucks
- Encourage pedestrian and bicycle trips
  - Dedicated pedestrian and bicycle lanes
  - Prohibit car use in very dense urban areas

Priority Area #2 - Energy Policies

Creation of a fund for helping poor people buying energy services

- Financial resources – energy tariffs or other government funds
- Provide low income segments of urban and rural areas of the country with a refund of part of their expenses with energy, such as gas and electricity
- Improve energy affordability among low income classes while maintaining a sufficiently high (real) energy price so as to stimulate energy efficiency

Conclusions

- Brazil's energy database – need for improvement
- ISED set – Brazil's specificities
  - Use of ethanol as automotive fuel
  - High potential for the use of alternative sources
  - Identification of regional and social disparities
- Priority areas and related response actions
  - Further develop current energy policies
  - Strategies for improvements in priority areas