Economic and Social Dimensions of Sustainable Development

Workshop on Capacity for Mainstreaming Energy Sustainable Development Goals (SDGs), Targets and Indicators into Statistical Programmes in Selected Latin American Countries

Prof. Roberto Schaeffer

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Panama City, Panama

Special thanks to …

The International Atomic Energy Agency (IAEA) and Giovani Vitoria Machado (from EPE, Brazil), from whom we borrowed many slides

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Definition of sustainable energy development

".. development that lasts and that is supported by an economically profitable, socially responsive and environmentally responsible energy sector with a global, long-term vision" (IEA, 2001)

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Some background

- In 1999, IAEA initiated the Project **Indicators for Sustainable Energy Development – ISED,** in cooperation with various international organizations, to:
  - Fill the need for a consistent set of energy indicators
  - Assist countries in energy and statistical capacity building required to promote energy sustainability
  - Supplement work of the Commission on Sustainable Development-CSD (general indicators for sustainable development)
- Original name has changed to **Energy Indicators for Sustainable Development – EISD** to avoid misunderstandings
  - Some considered that “sustainable energy development” refers only to renewable energy
  - This has not changed the basic concepts, the methodology and the indicators themselves
- **ISED/EISD Phases**
  - **First Phase (2000-2001):** identification of a set of potential indicators and development of the conceptual framework (definition and classification)
  - **Second Phase (2002-2005):** original set and framework refined and practical utility demonstrated (implementation)
    - Cases: Brazil, Cuba, Lithuania, Mexico, Russian Federation, Slovak Republic and Thailand

Concept and Methodology

- Indicators are statistical tools for systematic analysis, decision making, policy formulation and tracking policy effectiveness
- Evolutionary tool: Indicators are about trends and changes over time
- Indicators and their statistical requirements have to be in harmony with national capabilities and priorities
  - Users do not have to implement the full set, but can select those indicators that are relevant
  - Users do not have to be constrained by ISED/EISD proposed, but can create other indicators that are appropriate for their case
- Generating Indicators is only a beginning to:
  - Clarify statistical information
  - Monitor progress of past energy-related policies
  - Provide a reality check on policy proposals
  - Combinate with energy system modelling

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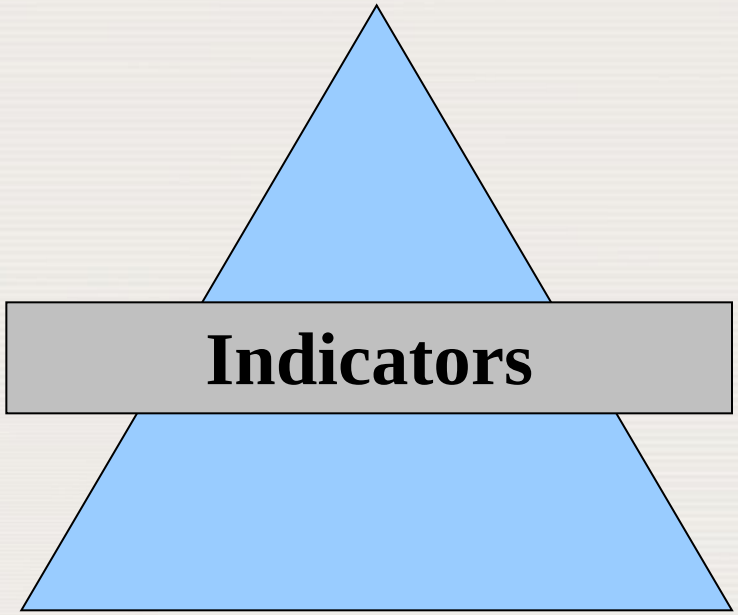
Indicators, statistics, models and analyses/policies

Analyses / Policies

Are bases for analyses and policies formulation and monitoring



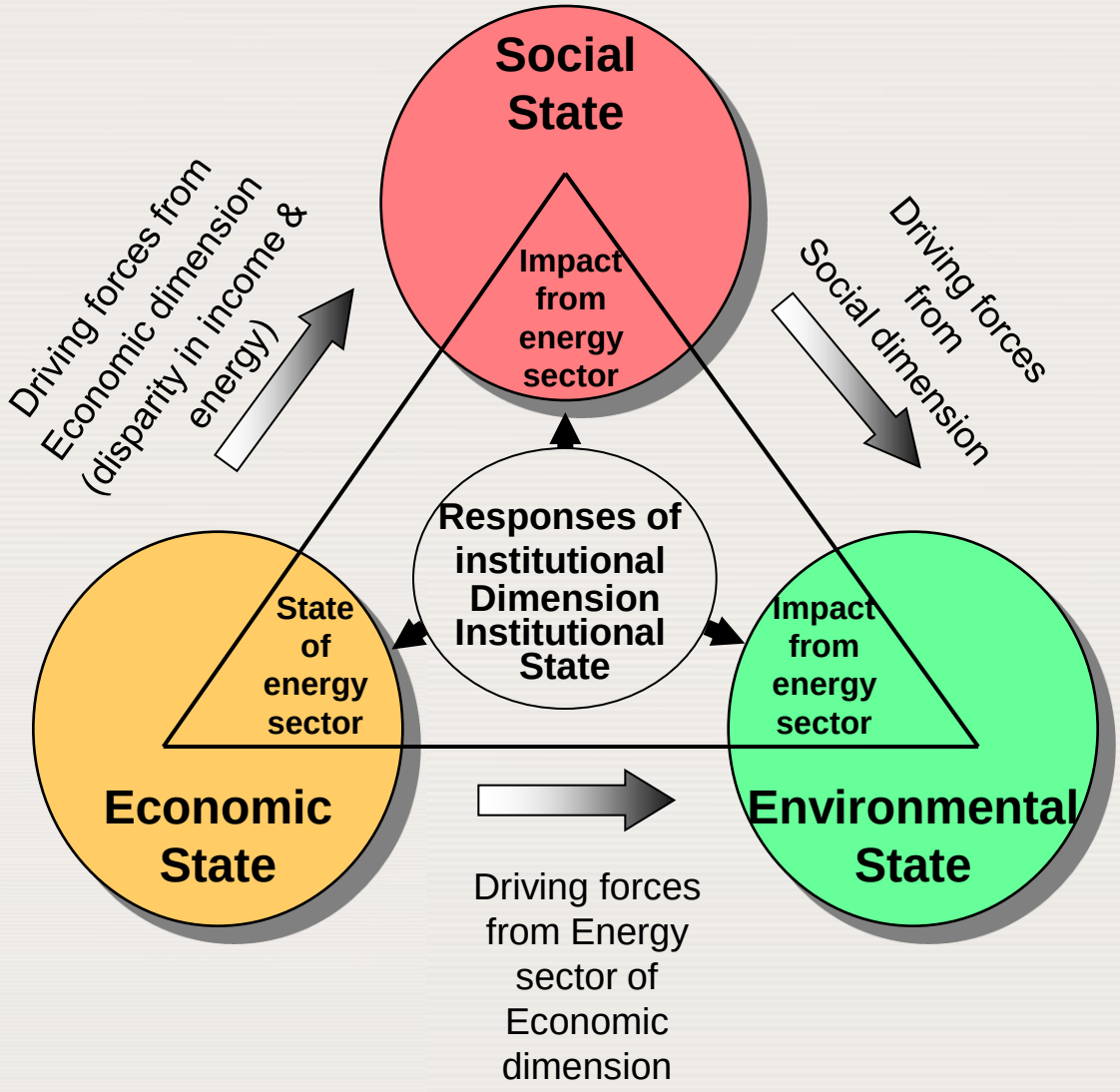
Can be incorporated on models or help checking and validating results

Statistics

Are derived from statistics

Models

Sustainability Dimensions of the Energy Sector



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Conceptual framework

- Originally, based on the relations of driving forces, states and responses (DSR)
  - following conceptual framework established by CSD
  - 41 ISED/EISD indicators
- The indicators categories encompassed the following aspects:
  - **Indirect Driving Forces**: underlying factors influencing a variety of causes, both direct and indirect;
  - **Direct Driving Forces**: directly cause (or may cause) social, economic and environmental impacts;
  - **State indicators**: show current conditions of a specific dimension: social, economic, environmental and institutional;
  - **Response actions**: agents/society actions and policy measures to solve the problems reflected in state variables.

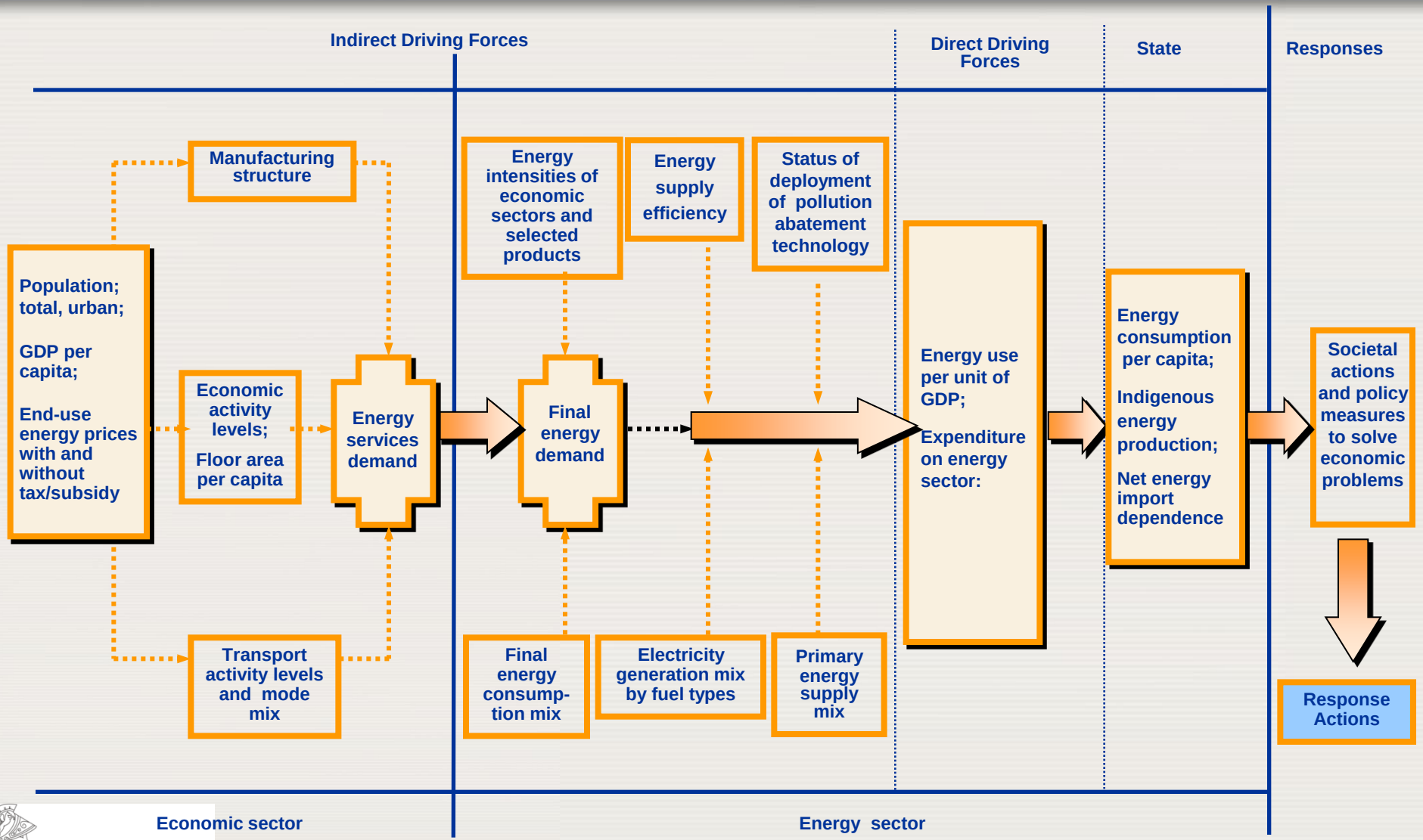
Full list of Original ISED/EISD

1. Population: total;urban
2. GDP per capita
3. End-use energy prices with and without tax/subsidy
4. Shares of sectors in GDP value added
5. Distance traveled per capita by transport mode
6. Freight transport activity
7. Home area per capita
8. Industrial structure (Manufacturing value added by selected energy intensive industries)
9. Energy intensity (Manufacturing, Transportation, Agriculture, Commercial&Services, Households)
10. End-use energy intensity of selected energy intensive products
11. Fuel mix (end-use energy, electricity generation, primary energy supply)
12. Energy supply efficiency
13. Status of deployment of pollution abatement technologies
14. Energy use per unit of GDP
15. Expenditure on energy (total investments, RD&D, environmental control, energy import expenses)
16. Energy production
17. Energy consumption per capita
18. Ratio of net energy imports(+)/exports(-) to consumption
19. Income inequality
20. Ratio of daily disposable income per capita of 20% poorest population to the prices of electricity and major households fuels
21. Fraction of private consumption spent on fuel and electricity by: average population; 20% poorest population
22. Fraction of households: heavily dependent on noncommercial energy; not using electricity
23. Amounts of air pollutant emissions (SO_2, NO_x, particulates, CO, VOC)
24. Ambient concentration of pollutants in urban areas (SO_2, NO_x, suspended particulates, CO)
25. Land area where acidification exceeds critical load
26. Amounts of green house gas emissions
27. Atmospheric radioactive discharges
28. Discharges of oil into coastal waters
29. Generation of solid waste
30. Accumulated quantity of solid wastes to be managed
31. Generation of radioactive waste from nuclear power fuel cycle chain
32. Accumulated quantity of radio-active wastes awaiting disposal
33. Area of land taken up by energy facilities and infrastructure
34. Dislocation of population by hydro reservoirs and open-cast coal mines
35. Fatalities due to accidents(energy sector with breakdown by fuel)
36. Proven fossil fuel recoverable reserve
37. Life time of proven fossil fuels reserves
38. Proven uranium reserves
39. Life time of proven uranium reserves
40. Intensity of use forest resources as fuelwood
41. Rate of deforestation

Main Topics Covered

Economic Dimension	Social Dimension	Environmental Dimension
Economic activity levels	Energy accessibility	Global climate change
Energy production, supply and consumption	Energy affordability	Air pollution
Energy pricing, taxation and subsidies	Energy disparities	Water pollution
End-use energy intensities (selected economic sectors, manufacturing industries)		Wastes
Energy supply efficiency		Energy resource depletion
Energy security		Land use
		Accident risks
		Deforestation

Framework Identifying ISED/EISD Flow of Economic Dimension



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Our Focus Here: Economic Dimension of Sustainable Development

- Energy balances introduction (already covered)

So, our focus here will be on:

- **Energy efficiency of supply systems**
- **Overall energy intensity (basic energy indicators)**
- **Efficiency of economic sectors (using energy indicators combined with value added or industrial production data)**
- **Fuel diversification and renewable energy**
- **Energy security**

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Energy Efficiency of Supply Systems

- What is energy efficiency?
  - First-law efficiency?
  - Second-law efficiency?
- What is a supply system?
- What is a demand system?
- Is distributed generation (DG) part of the supply or of the demand system?

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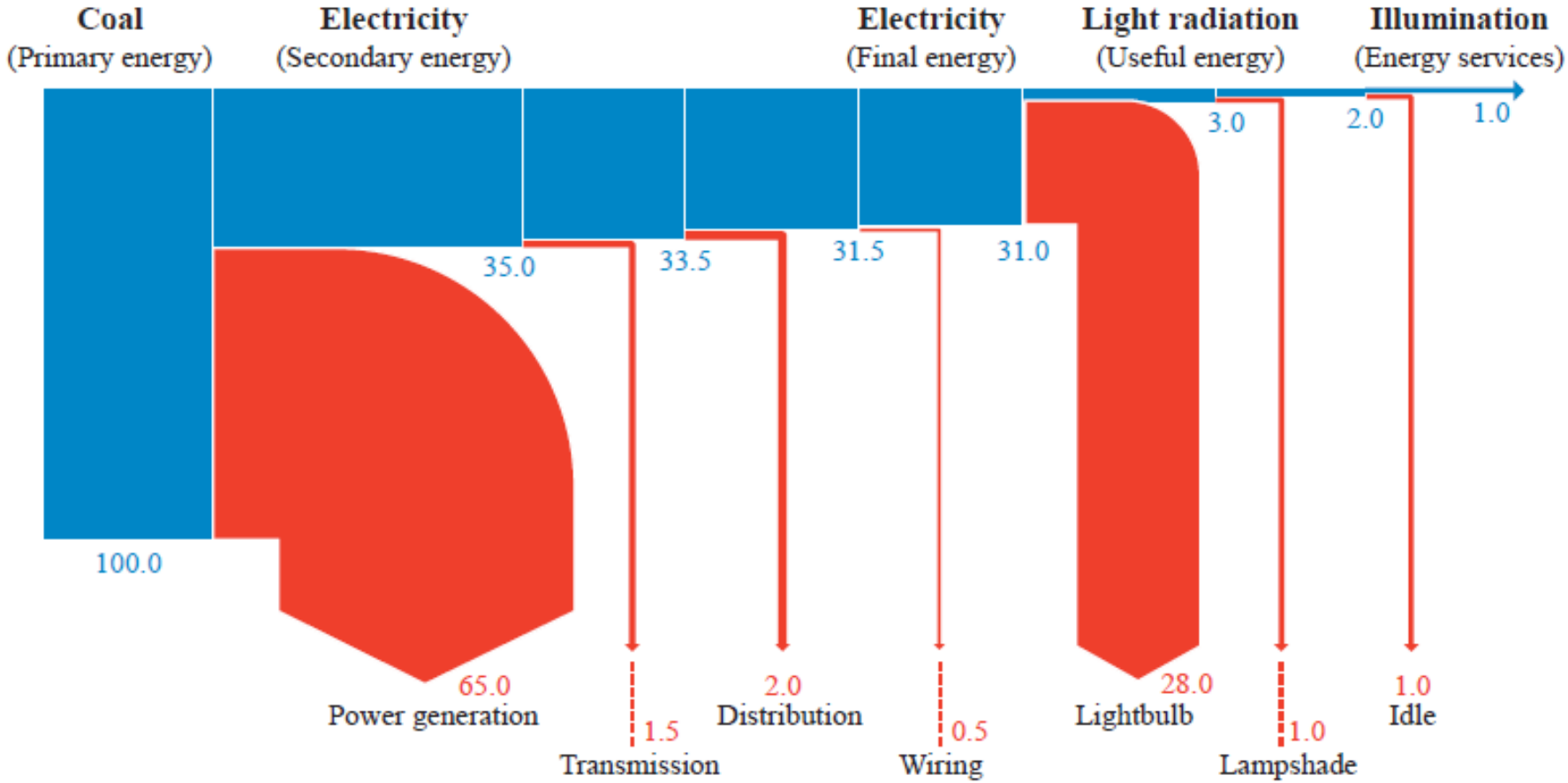
Energy Efficiency of Supply Systems



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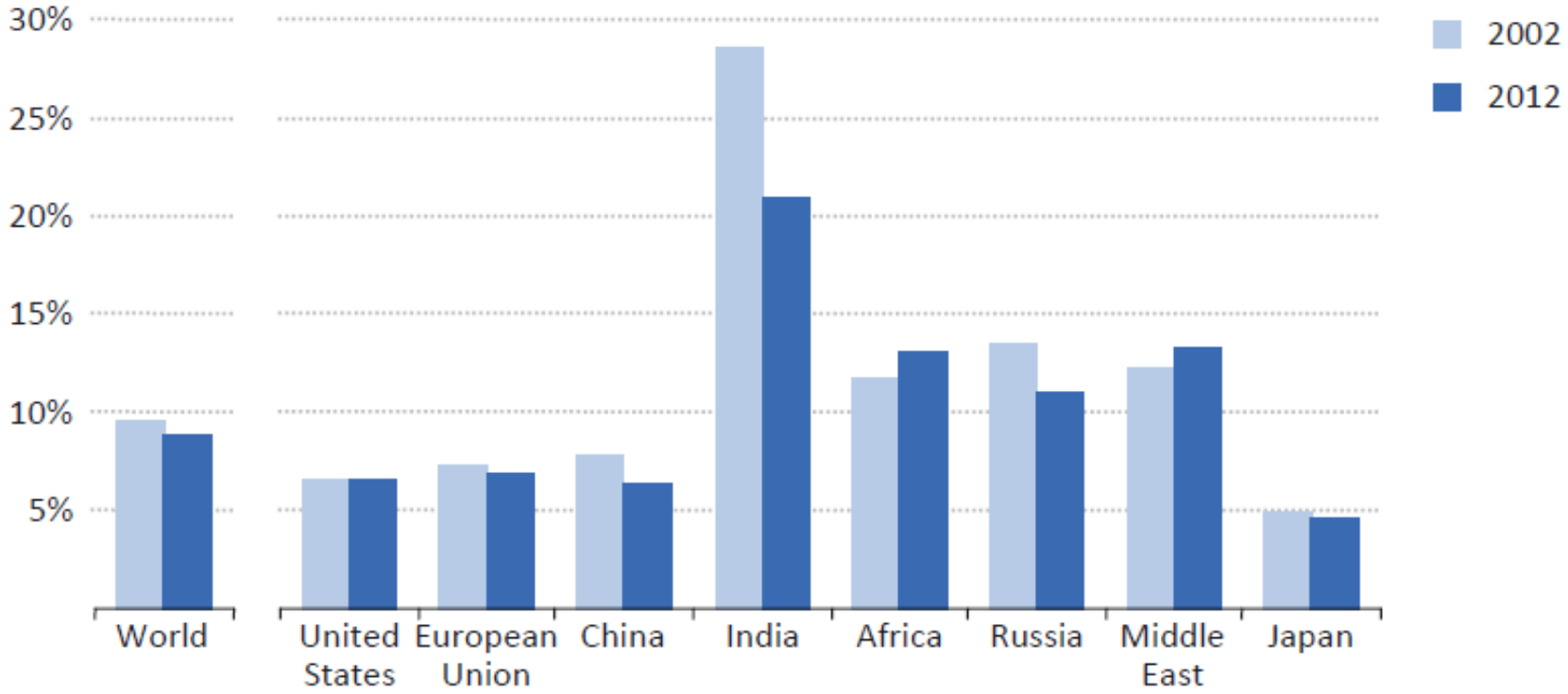
Efficiency of thermal power plants (public utilities only) in Brazil

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

Transmissions and Distribution Losses (IEA, 2014)



Note: T&D loss rates are calculated as a share of total supply (net generation plus imports less exports).

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Overall energy intensity (basic energy indicators)

- Economic energy intensity (or energy intensity - IE)
  - Energy (primary or final?) per GDP (MER or PPP?)
  - Energy (primary or final?) per VA
  - Energy (primary or final?) per capita
- Physical energy intensity (or specific energy intensity – SEC)
  - Energy (primary or final?) per physical unit (ton of product, pkm, tkm)
- How to deal with international trade?

Annual electricity consumption per capita (2007)

	kWh	World Average	USA
India	704	28%	5.2%
China	1,484	60%	11.0%
World	**2,465**	**-**	**18.3%**
USA	13,456	545%	-

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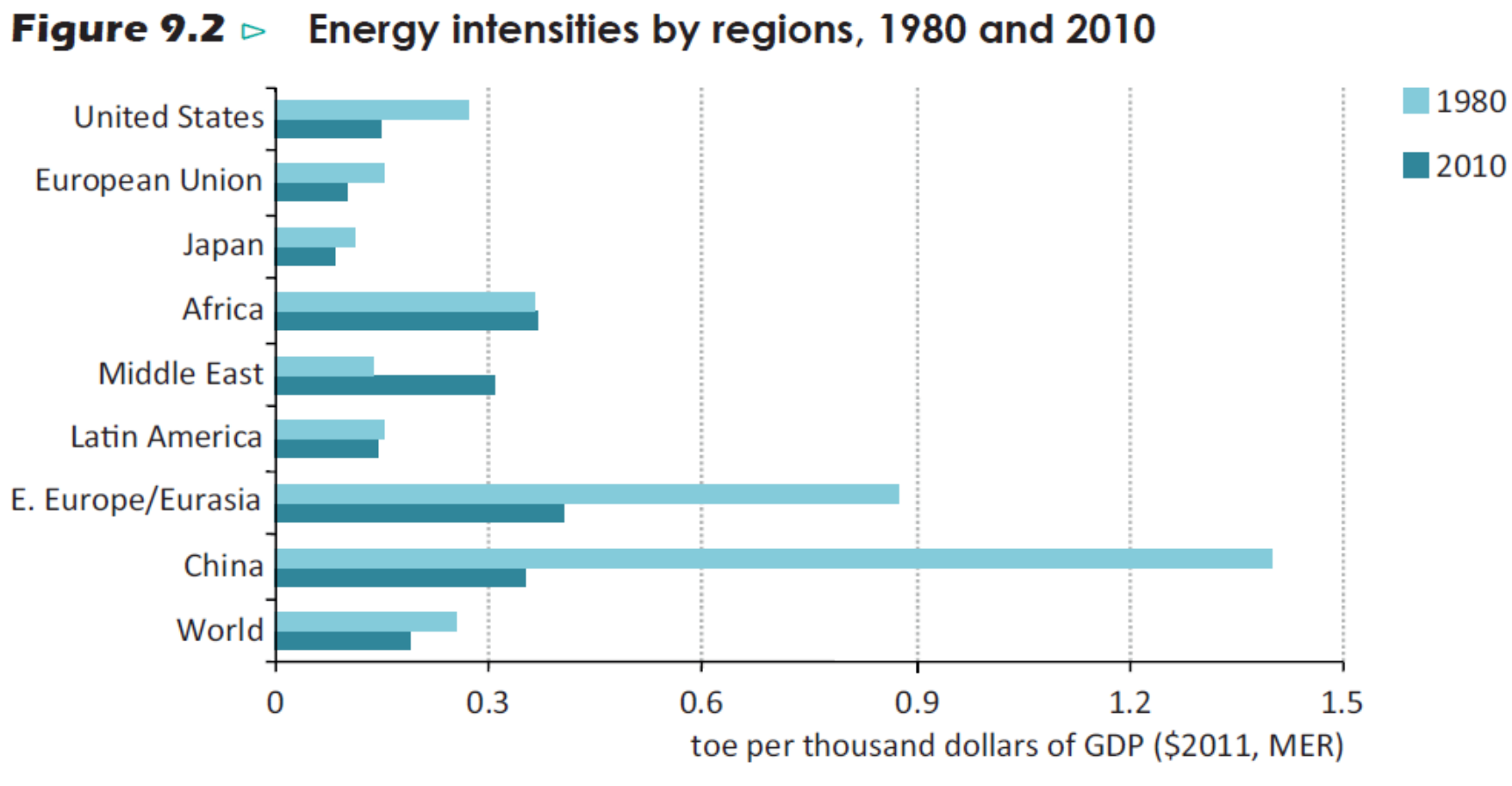
Overall energy intensity (basic energy indicators) (IEA, 2012)



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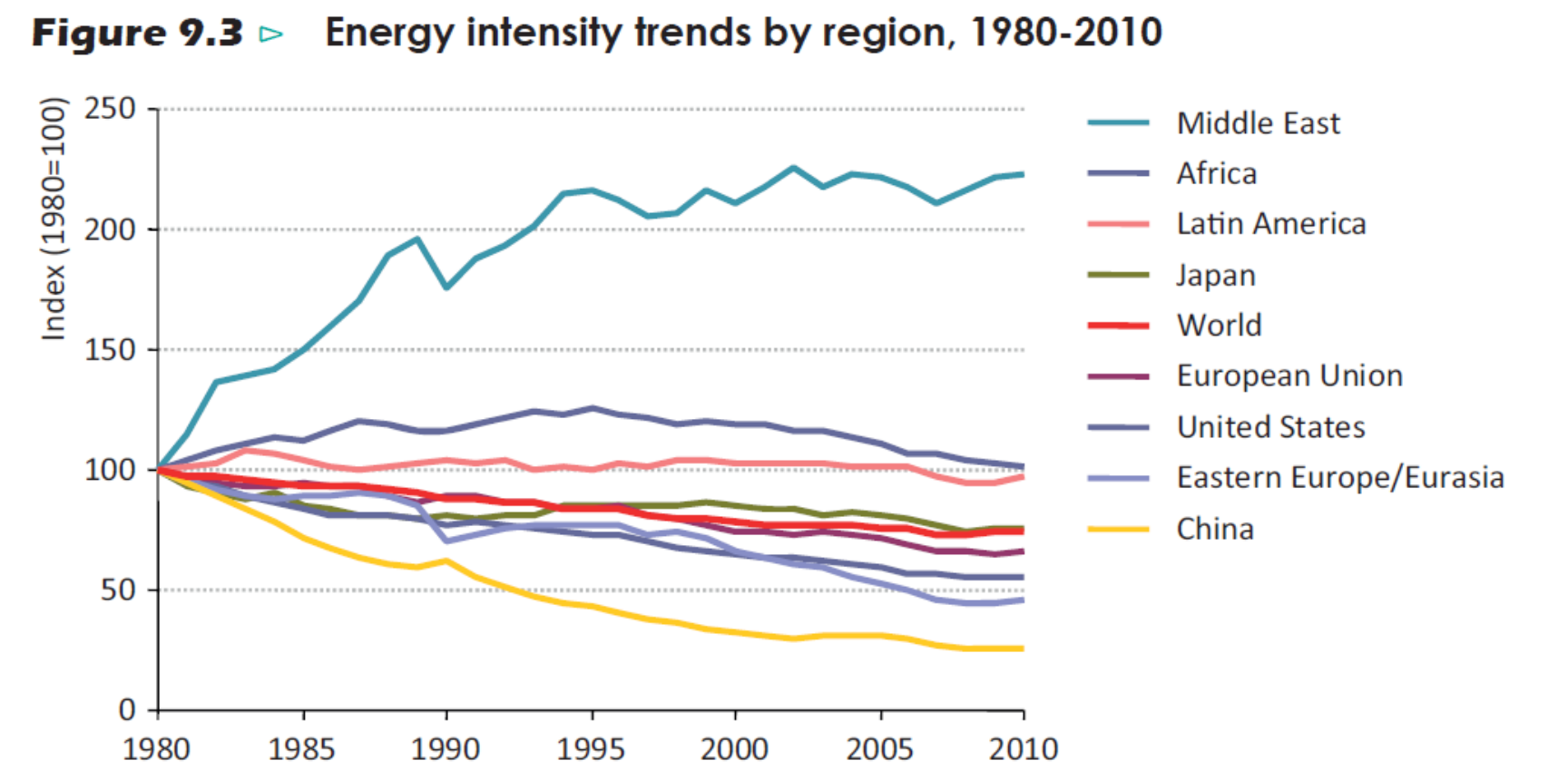
Overall energy intensity (basic energy indicators) (IEA, 2012)



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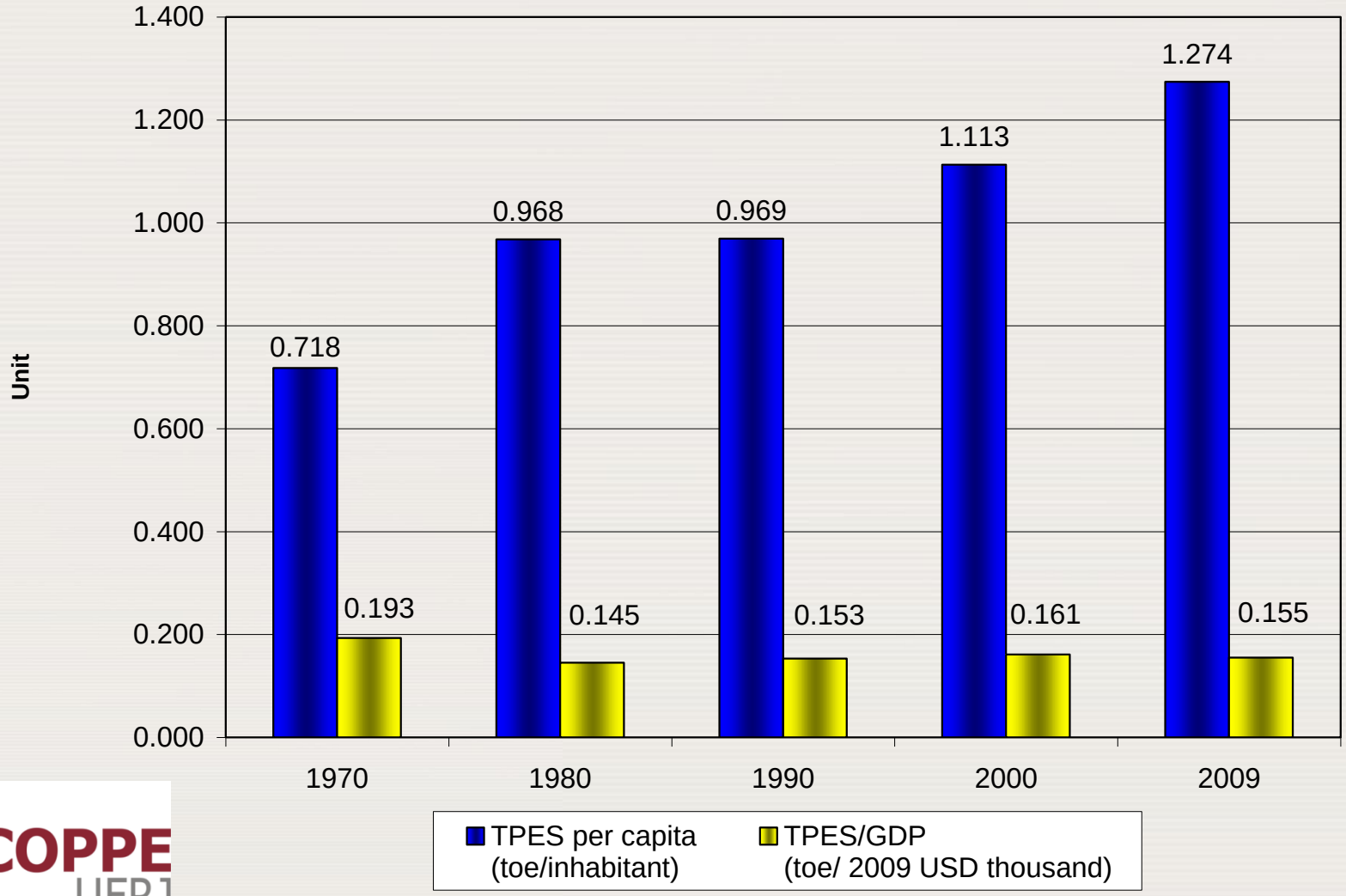
Energy per capita and primary energy intensity in Brazil



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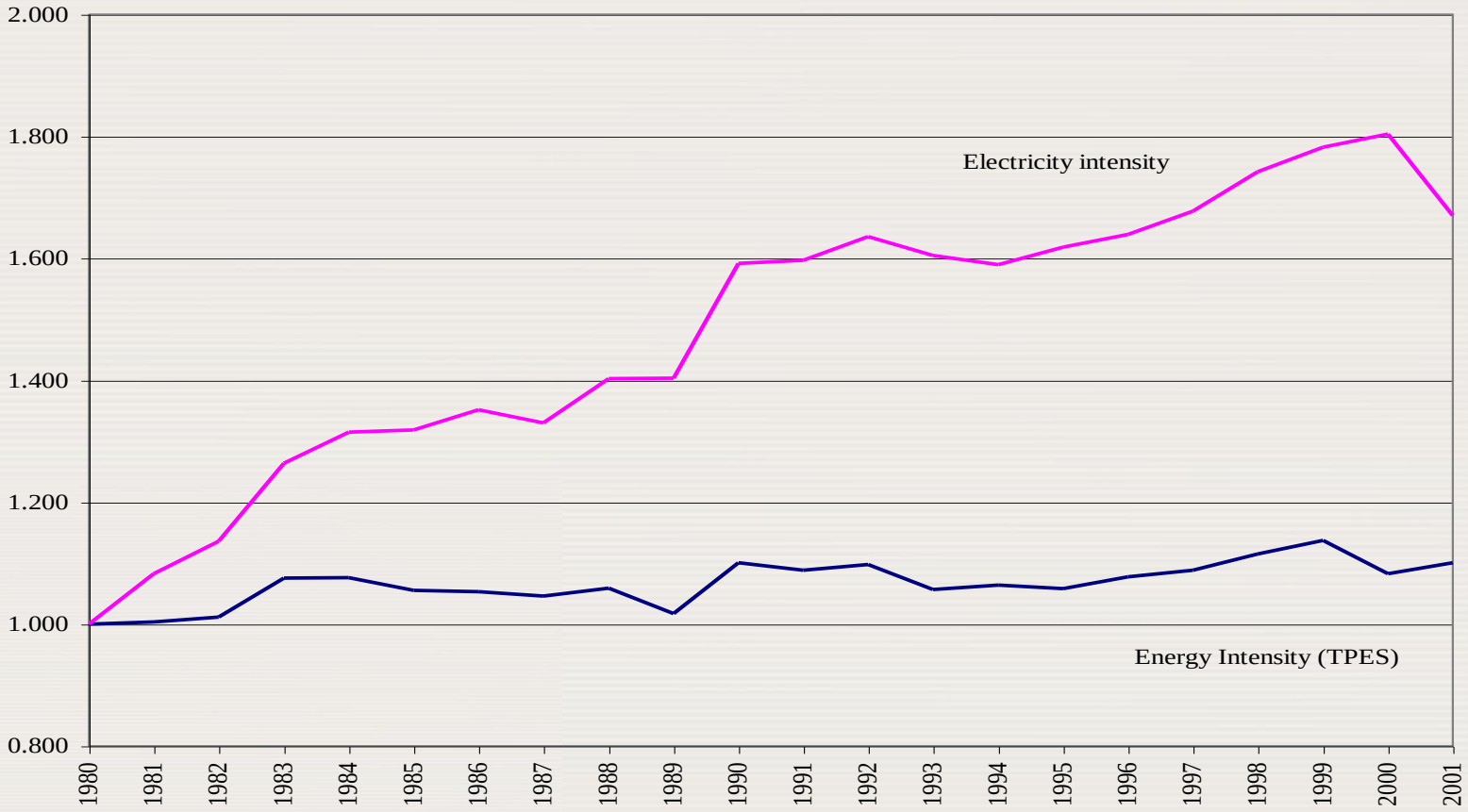
Energy and electricity use per unit of GDP in Brazil



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

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Efficiency of economic sectors

Using energy indicators combined with value added or industrial production data

- Economic energy intensities (IE)
- Physical energy intensities (SEC)

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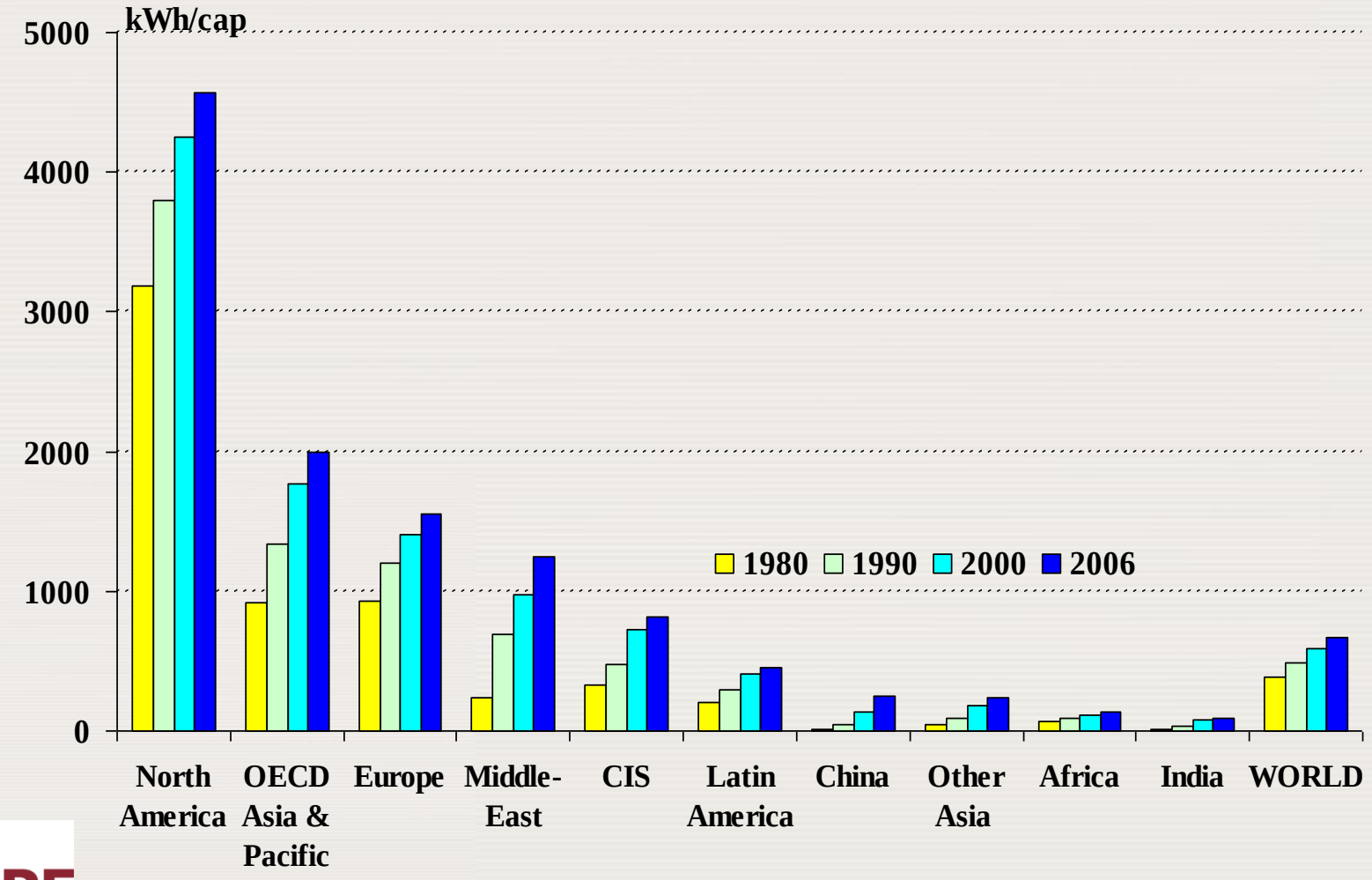
Household electricity consumption per capita per year



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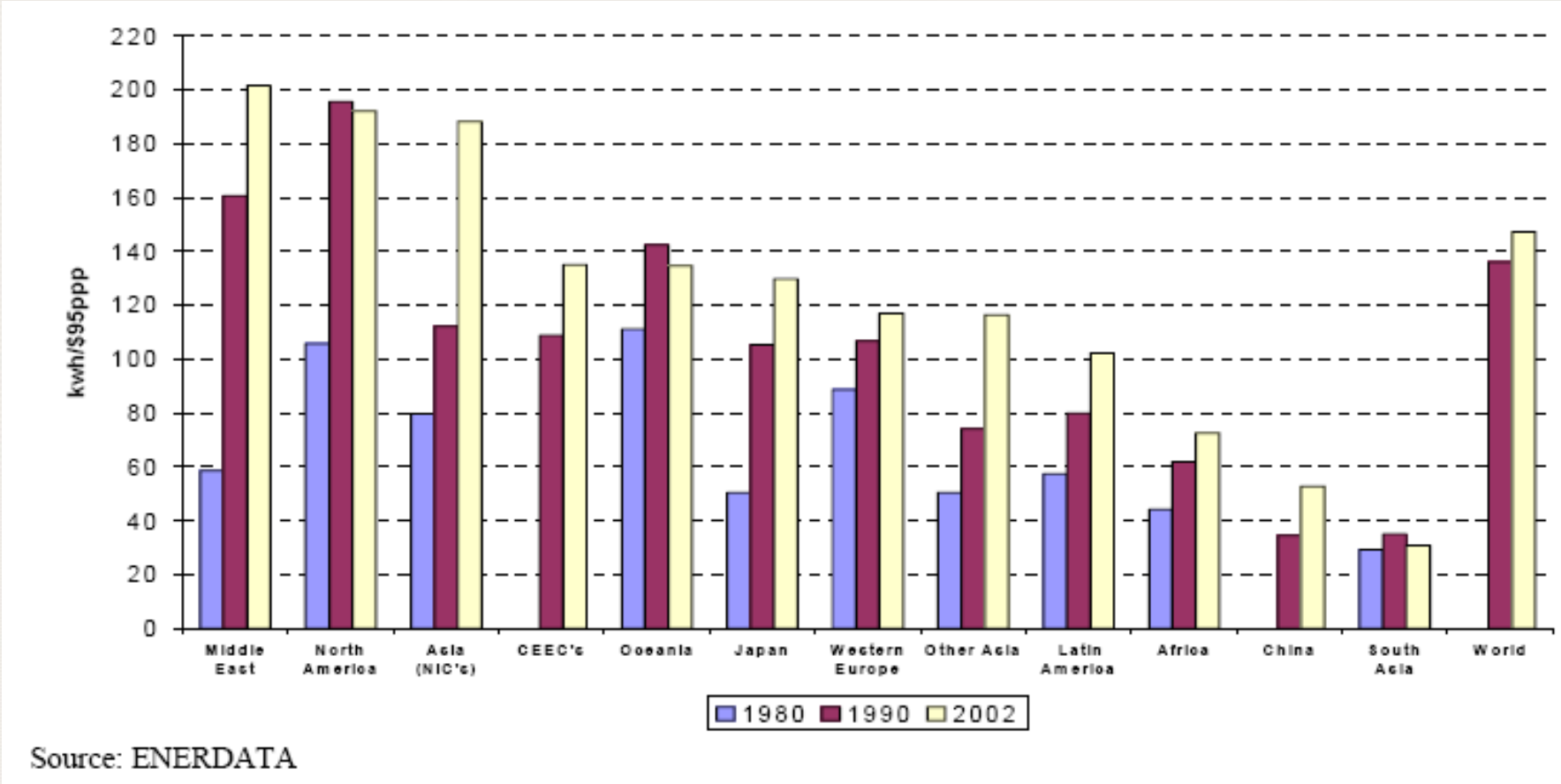
Electricity intensity in the Service Sector



Source: ENERDATA

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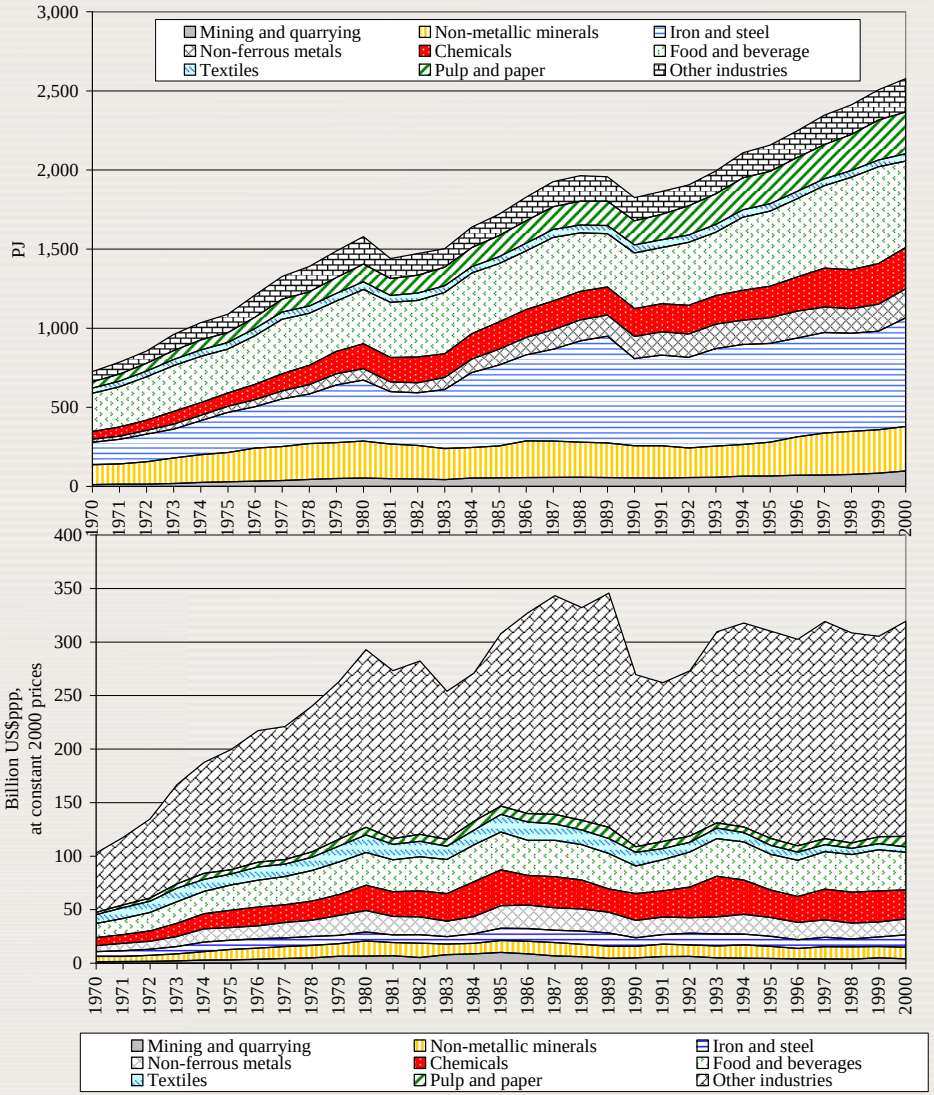
Final energy consumption and VA in the Brazilian Industry (Machado e Schaeffer, 2006)



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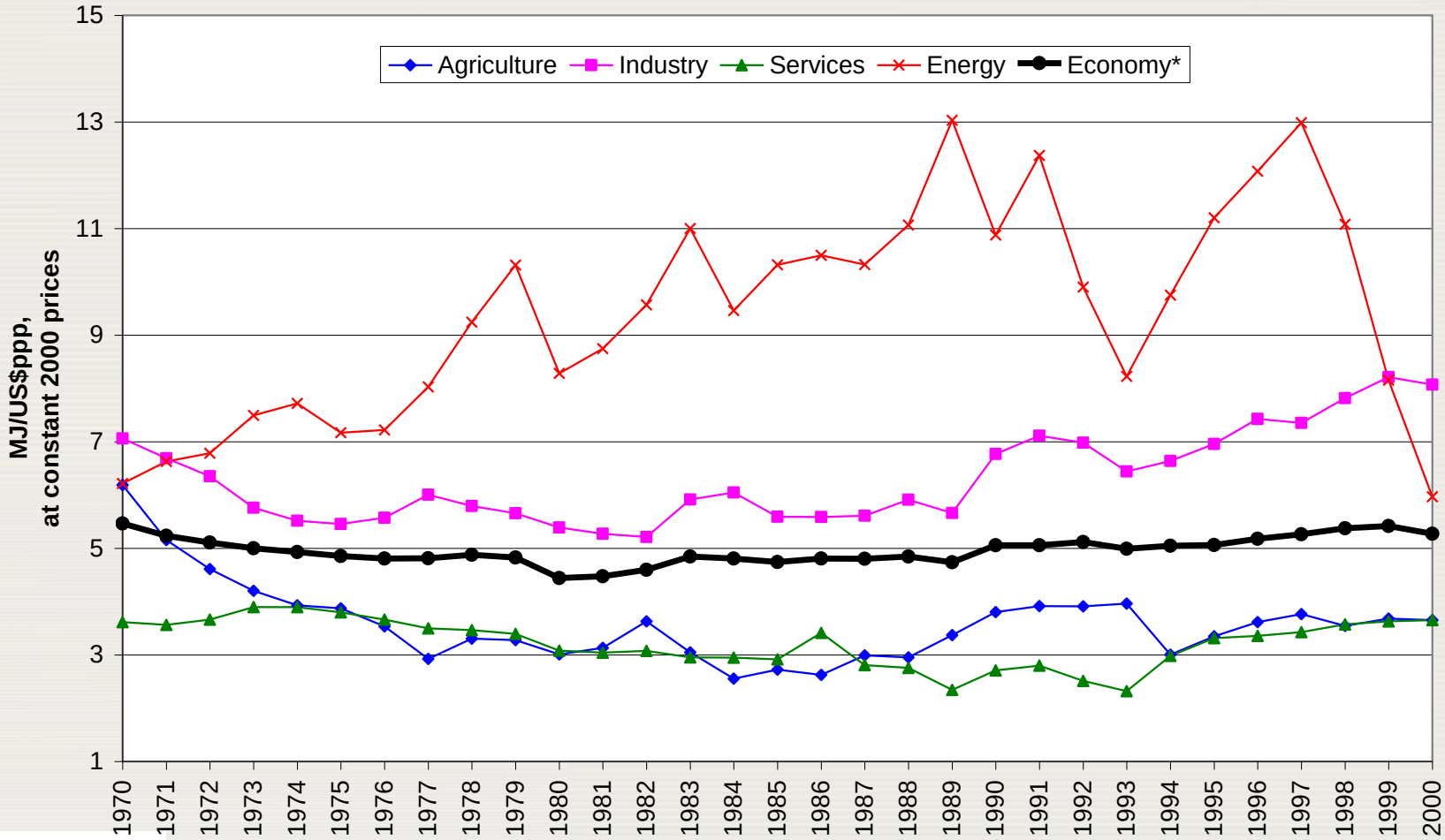
Final energy intensity trends in Brazil (Machado e Schaeffer, 2006)



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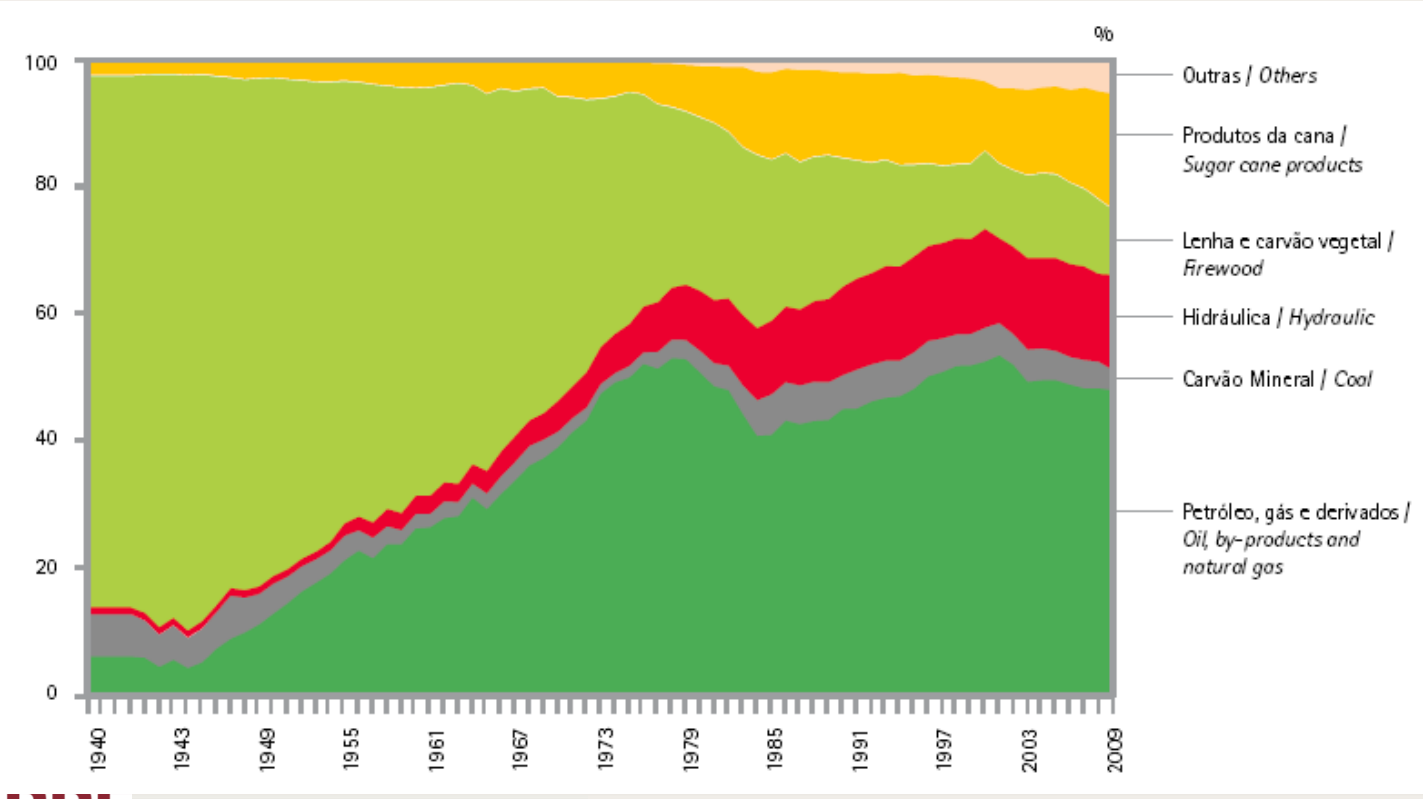
Fuel diversification and RE in Brazil

- Total Primary Energy Supply (%)
  - Overview in long-term changes:
    - strong fall in fuelwood vs. robust increase in oil
    - Sugar-cane products and hydro also increase



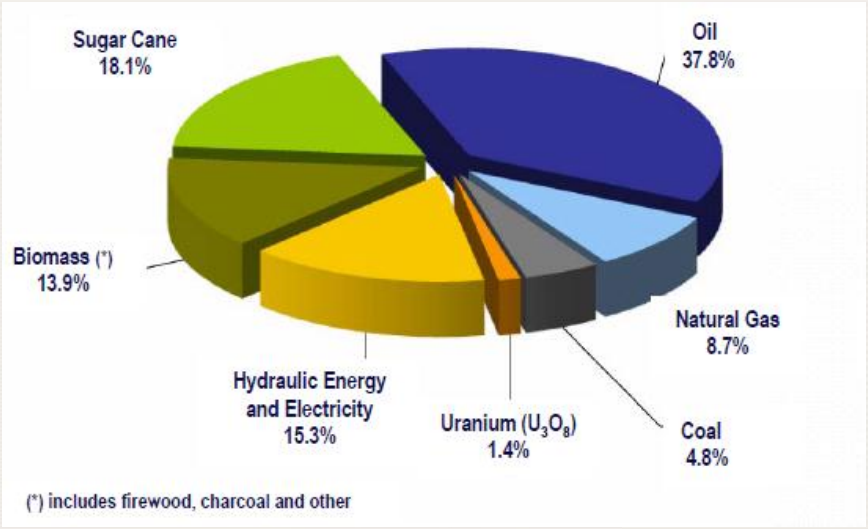
Source: MME-EPE (2010)

Fuel diversification and RE in Brazil

- Large share of renewable sources: 47% in 2009, 41% as of 2014

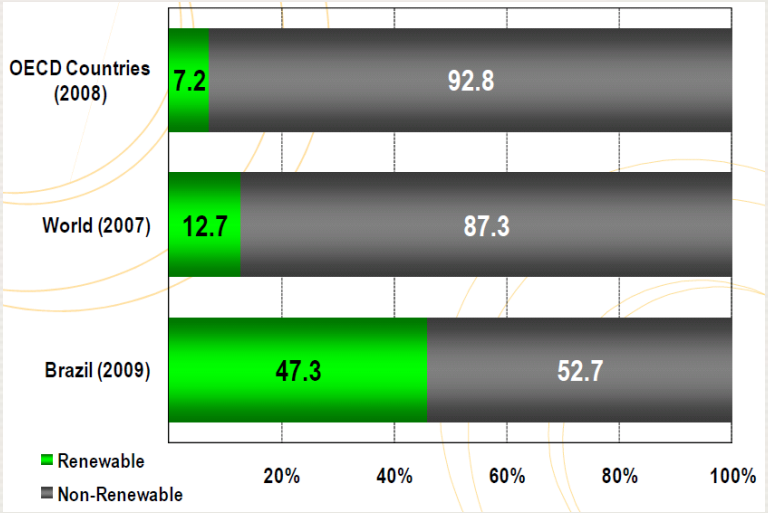
Total Primary Energy Supply

Brazil 2009



Source: MME-EPE (2010)

Brazil vs. World & OECD



Source: MME-EPE (2010), IEA (2009)

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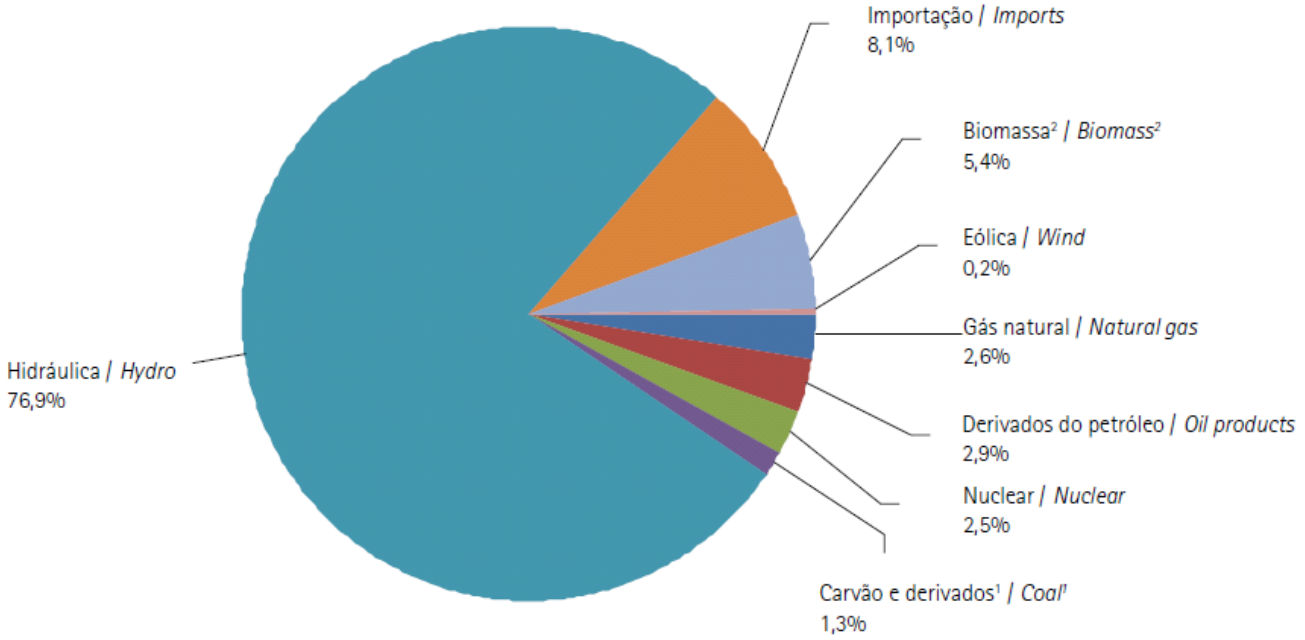
Fuel diversification and RE in Brazil

- Large share of electricity generation comes from renewables
  - 70-90% in Brazil (includes imports from Itaipu Binational)
  - 18% in the World (average – according to IEA, 2009)

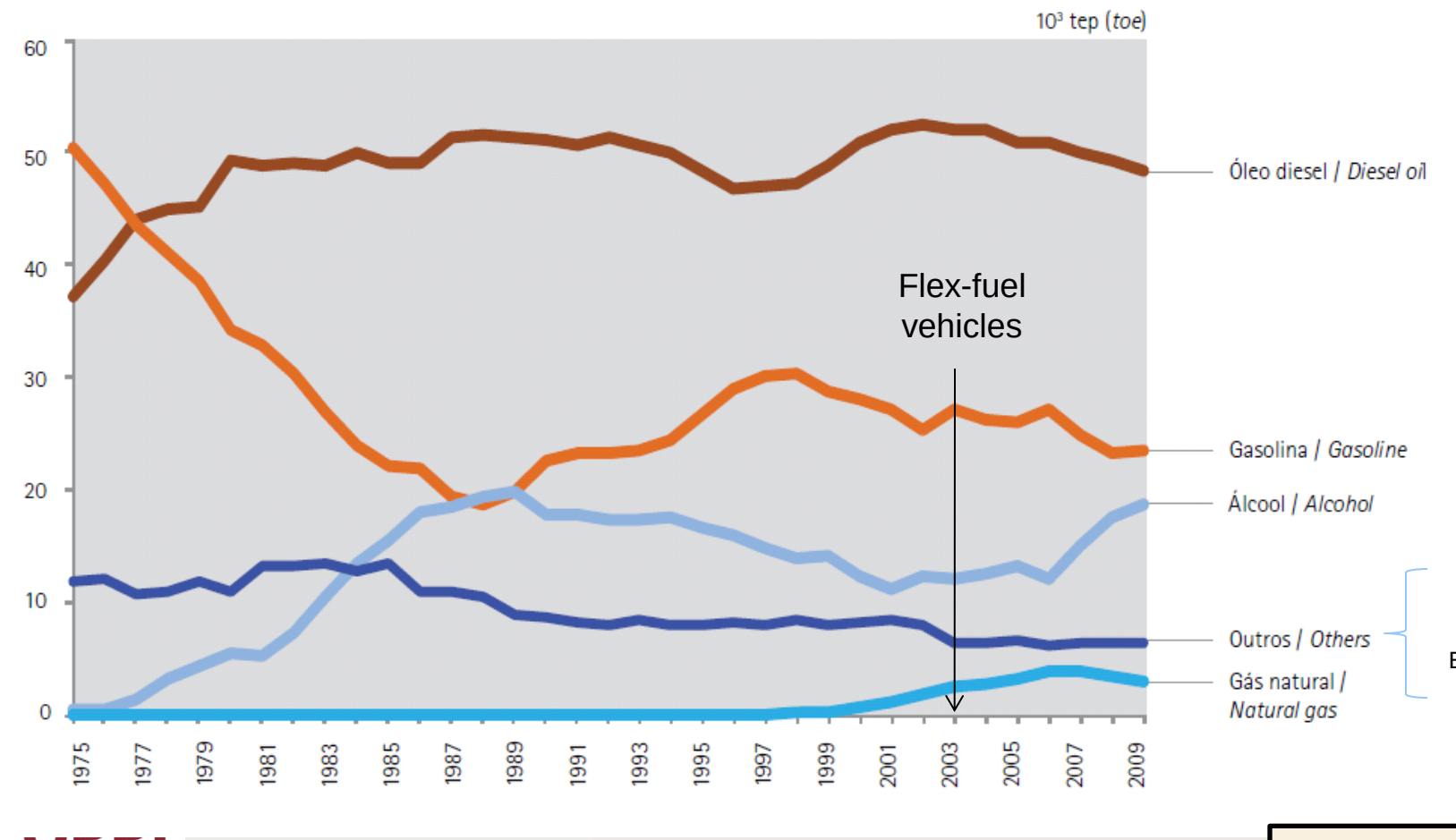


Notas/ Notes:
1 Inclui gás de coqueria / Includes coke gas.
² Biomassa inclui lenha, bagaço de cana, lixívia e outras recuperações / Biomass includes firewood, sugar cane bagasse, black liquor e other wastes.

Source: MME-EPE (2010)

Fuel diversification and RE in Brazil

- Large share of biofuels in transport: 21% in 2009 (15% today)
  - Anhydrous ethanol + Hydrated ethanol + biodiesel



Source: MME-EPE (2010)

1 Mtoe ~ 42 PJ

Energy security

- Net energy import dependency?
- Number of countries from where energy imports come from?
- Reserves-to-production ratio?
- How diverse is the energy mix of a country?

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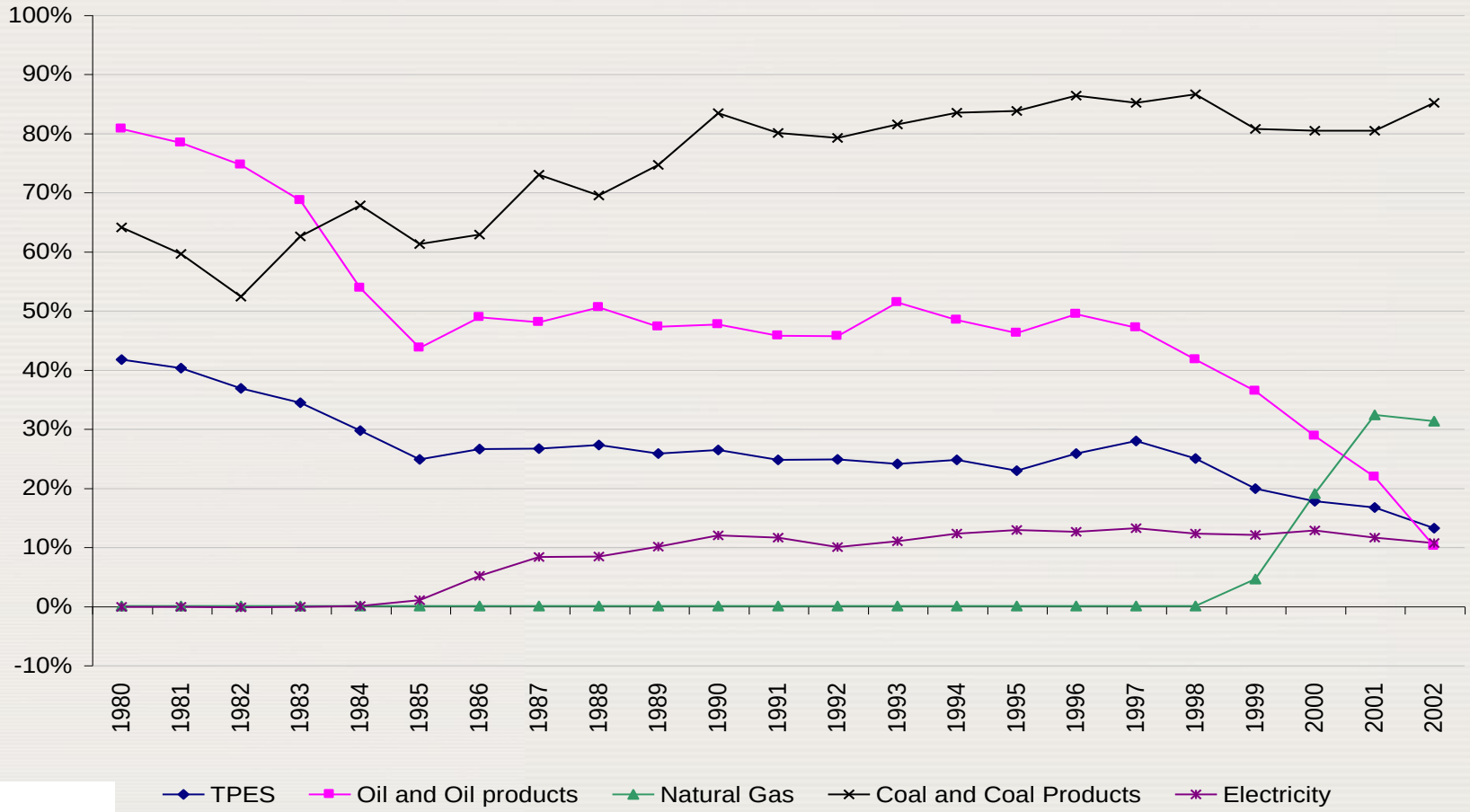
Energy imports dependency of Brazil



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Thanks.

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Social Dimension of Sustainable Development

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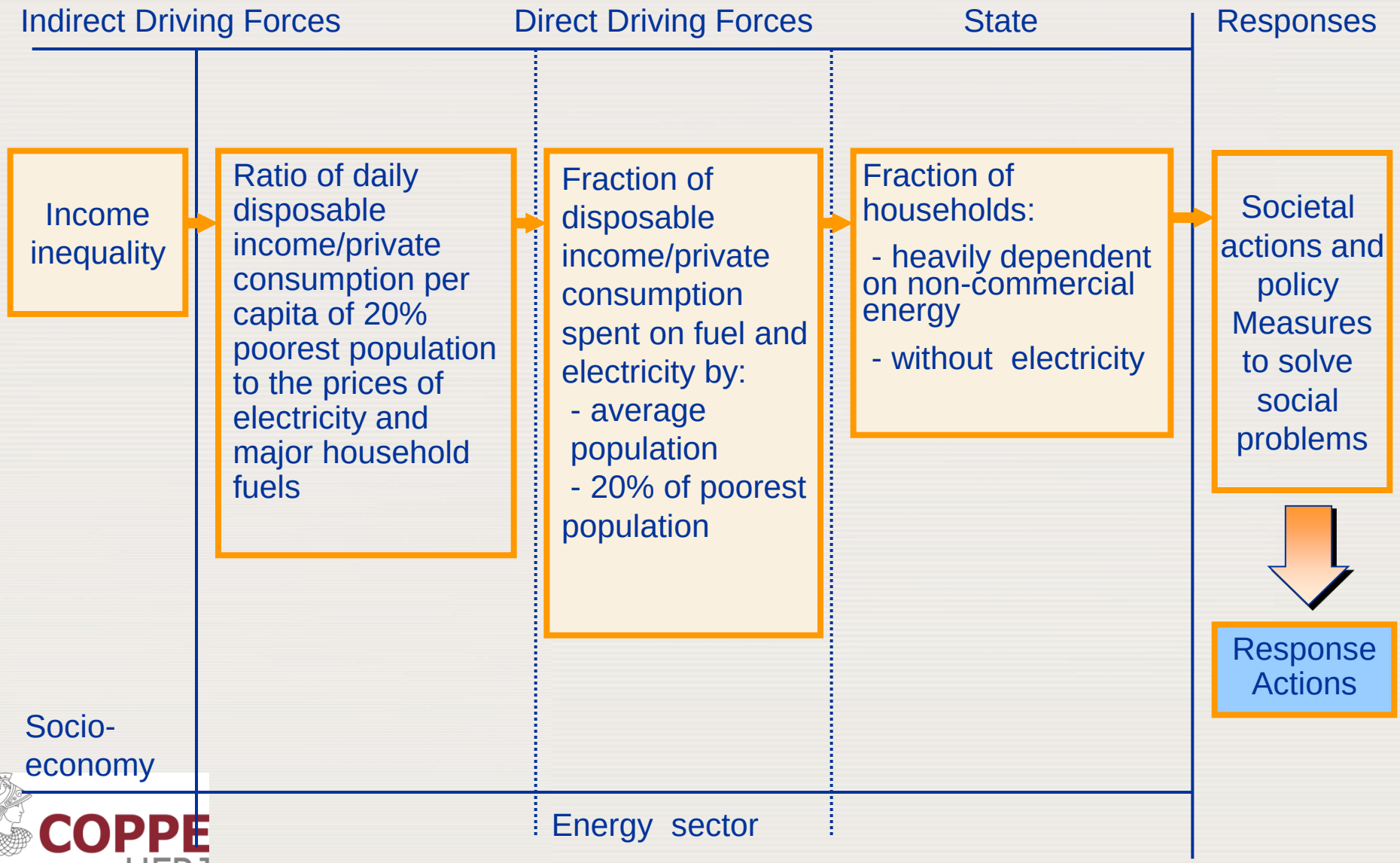
Framework Identifying ISED/EISD Flow of Social Dimension



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Social Dimension of Sustainable Development

- Energy Access
- Reliability
- Affordability
- Stand-alone systems for poor isolated communities

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Energy Access

- **"…universal access to modern energy is the physical availability of electricity and modern energy carriers and improved end-use devices such as cook stoves at affordable prices for all." (GEA, 2012)**
- **"…some national governments have defined … 20-50 kWh of final electricity per household per month to meet basic lighting, communication and entertainment needs, and the equivalent of 6-15 kg of LPG per household per month for cooking." (GEA, 2012)**

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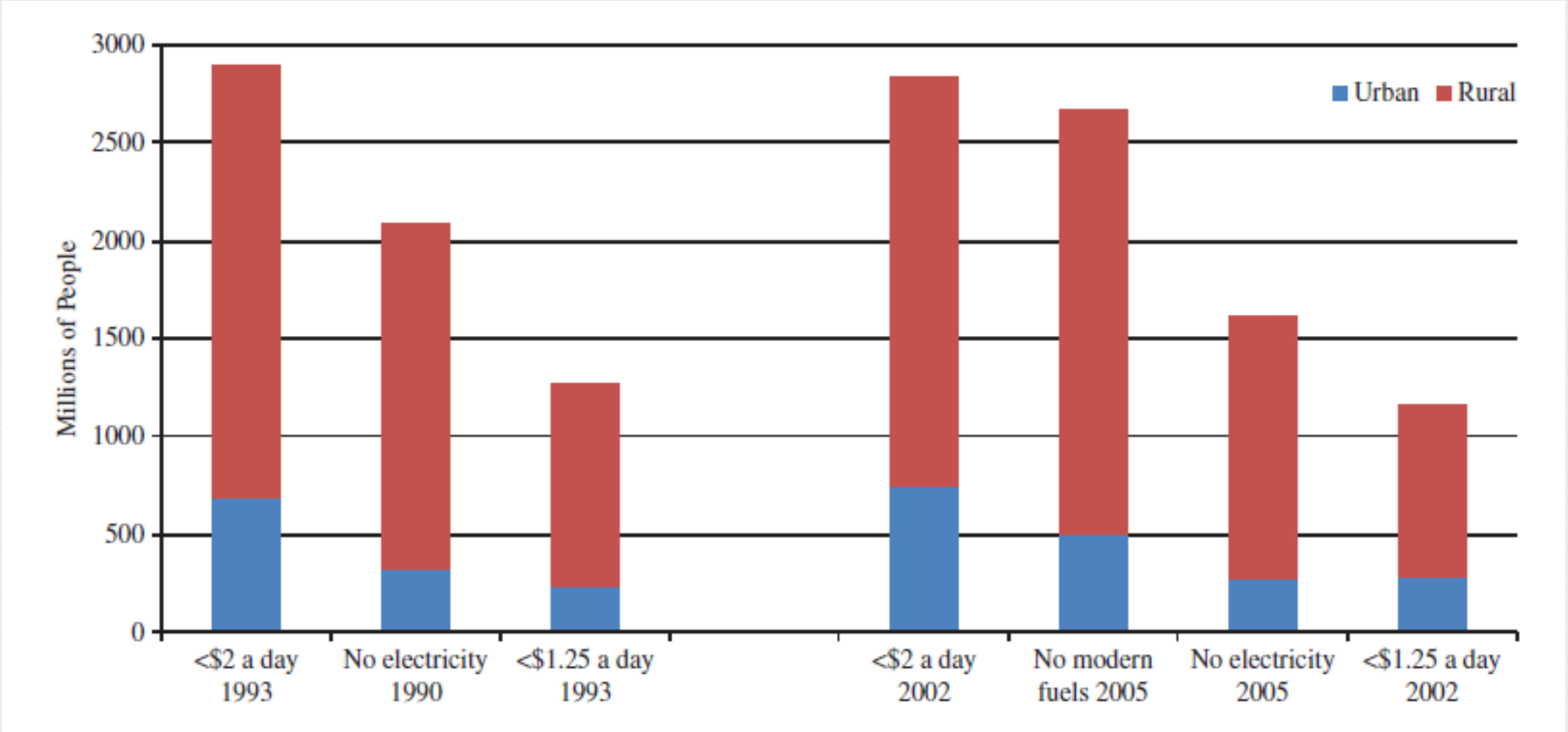
People living in poverty and with lack of access to electricity and modern fuels (GEA, 2012)



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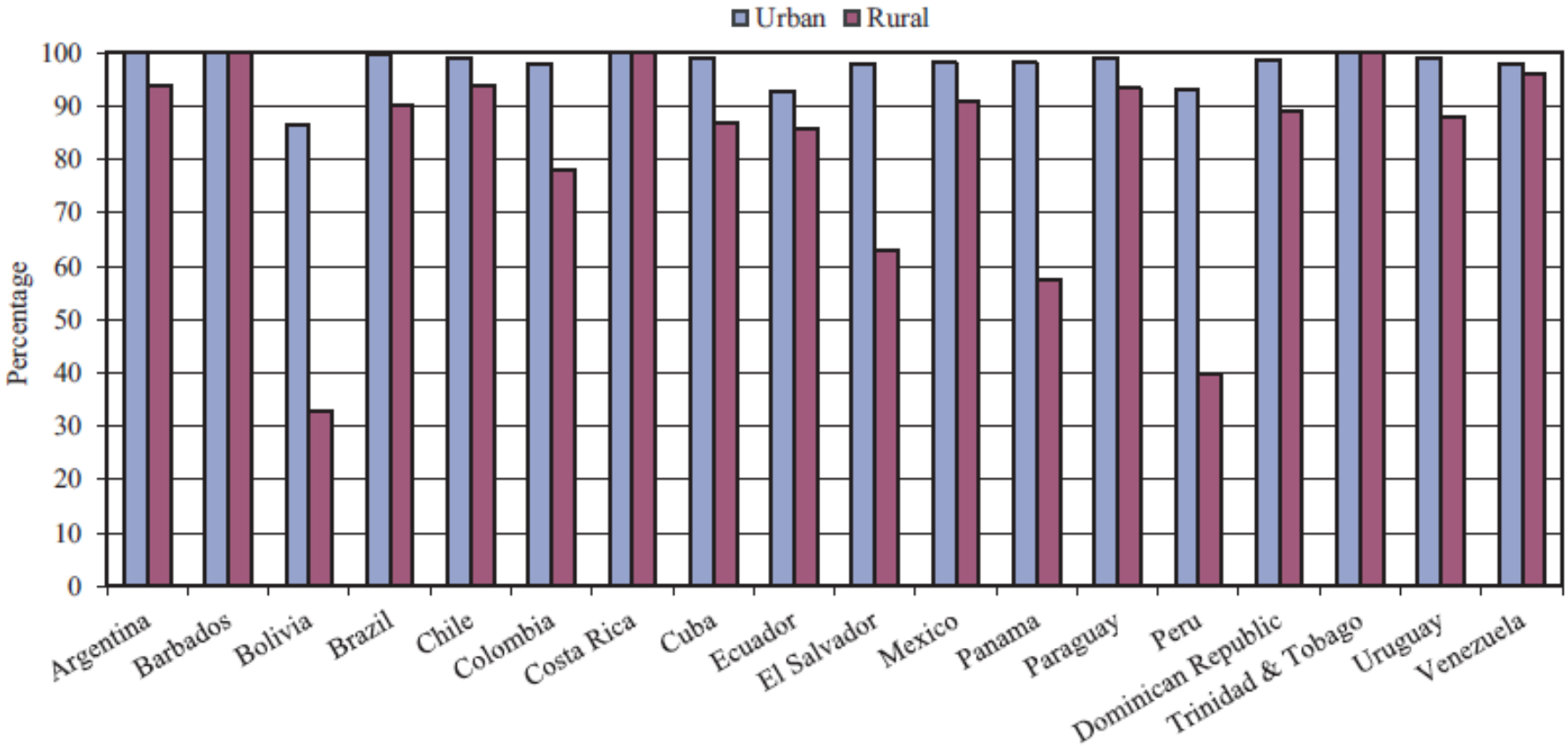
Access to electricity in urban and rural areas of Latin America (OLADE, 2008)



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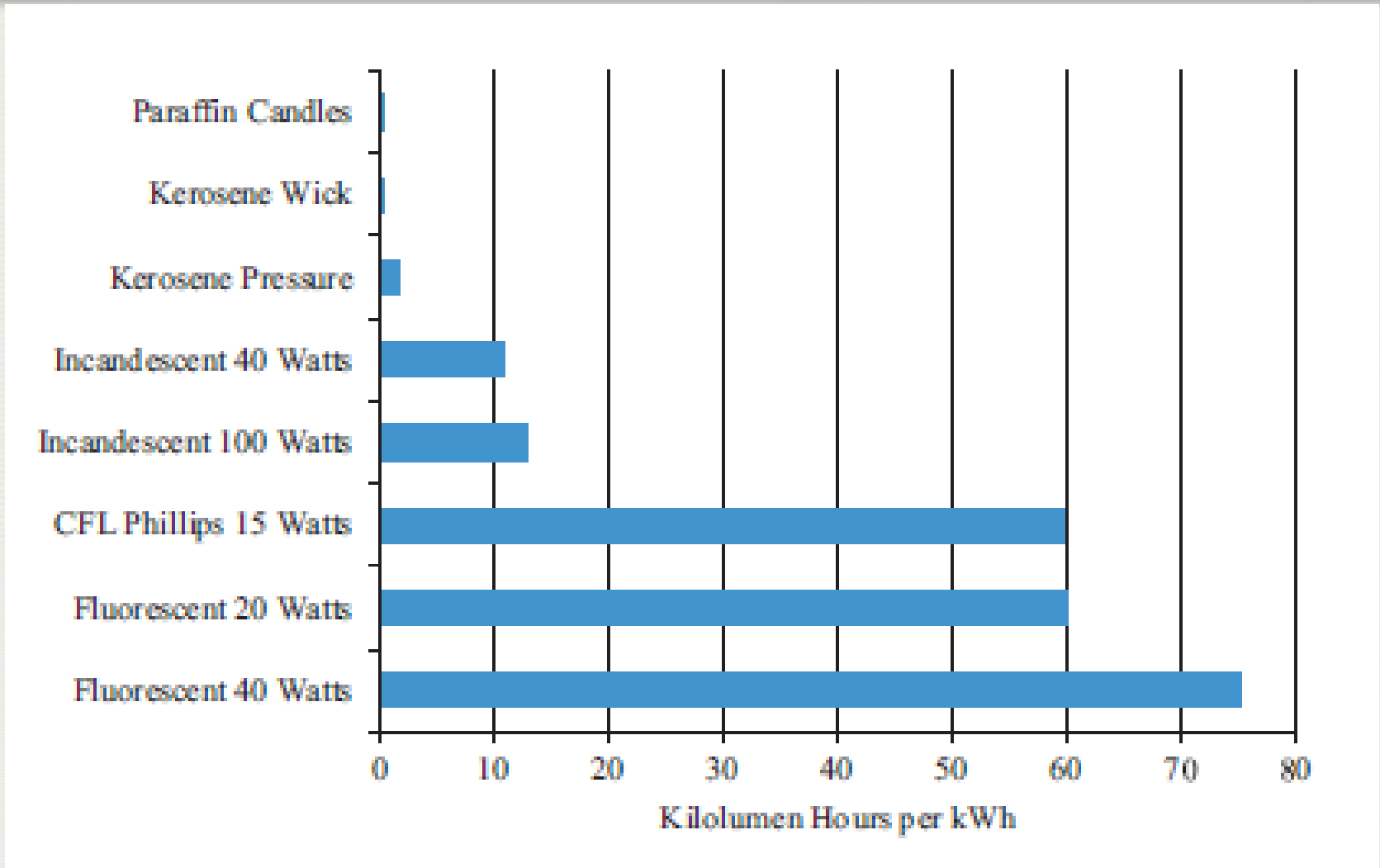
Relative efficiency of different sources of lighting (World Bank, 2010)



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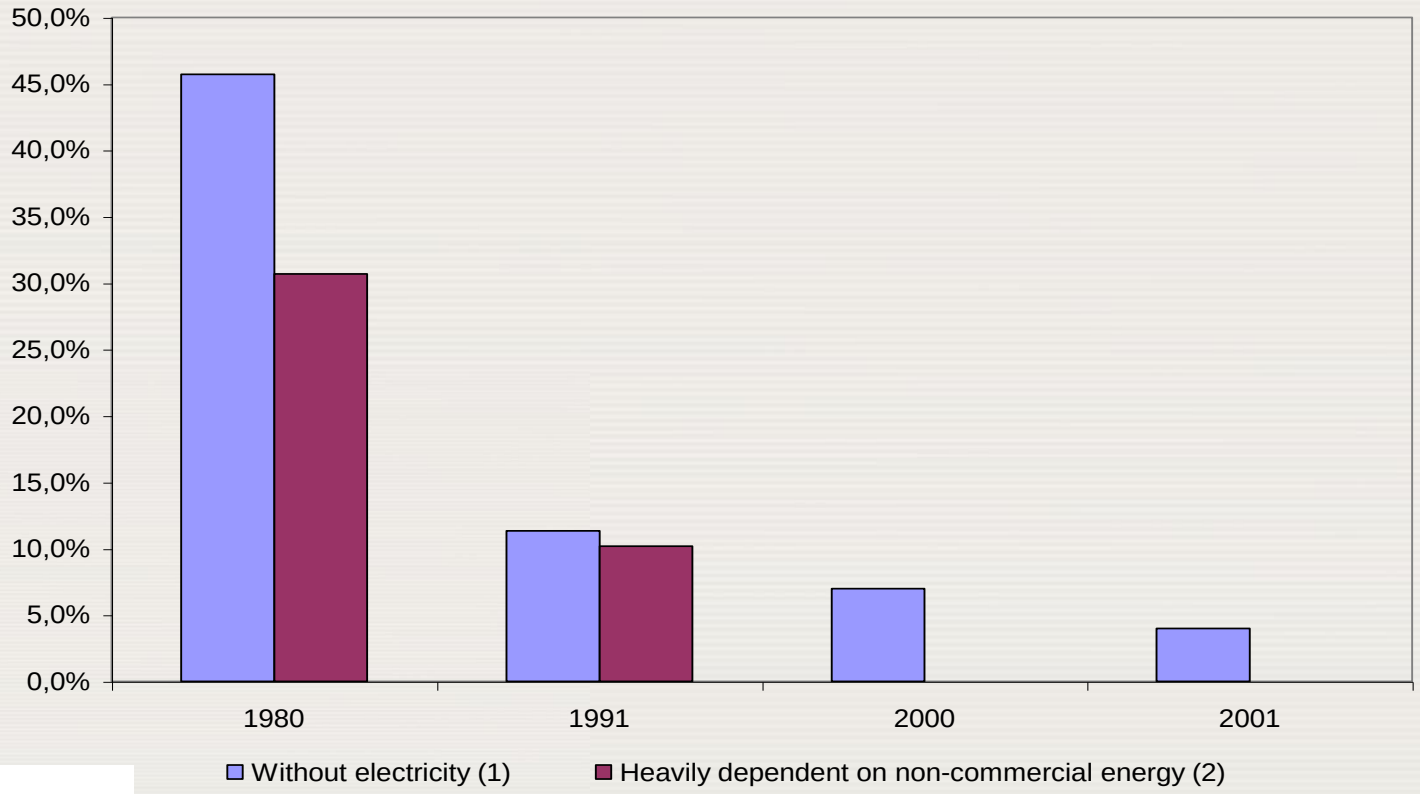
Fraction of households without electricity or heavily dependent on non-commercial energy in Brazil



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

Reliability

- Various indicators possible
- Frequently used indicators include:
  - Frequency of outages
  - Duration of outages
  - Depth of outages

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Affordability

- **Is energy affordable?**
- **Some times accessibility and affordability come together, as higher levels of minimum amount of energy is needed to meet both basic needs and facilitate the generation of income to empower growth and development**
- **Only the generation of income can really make energy affordable**

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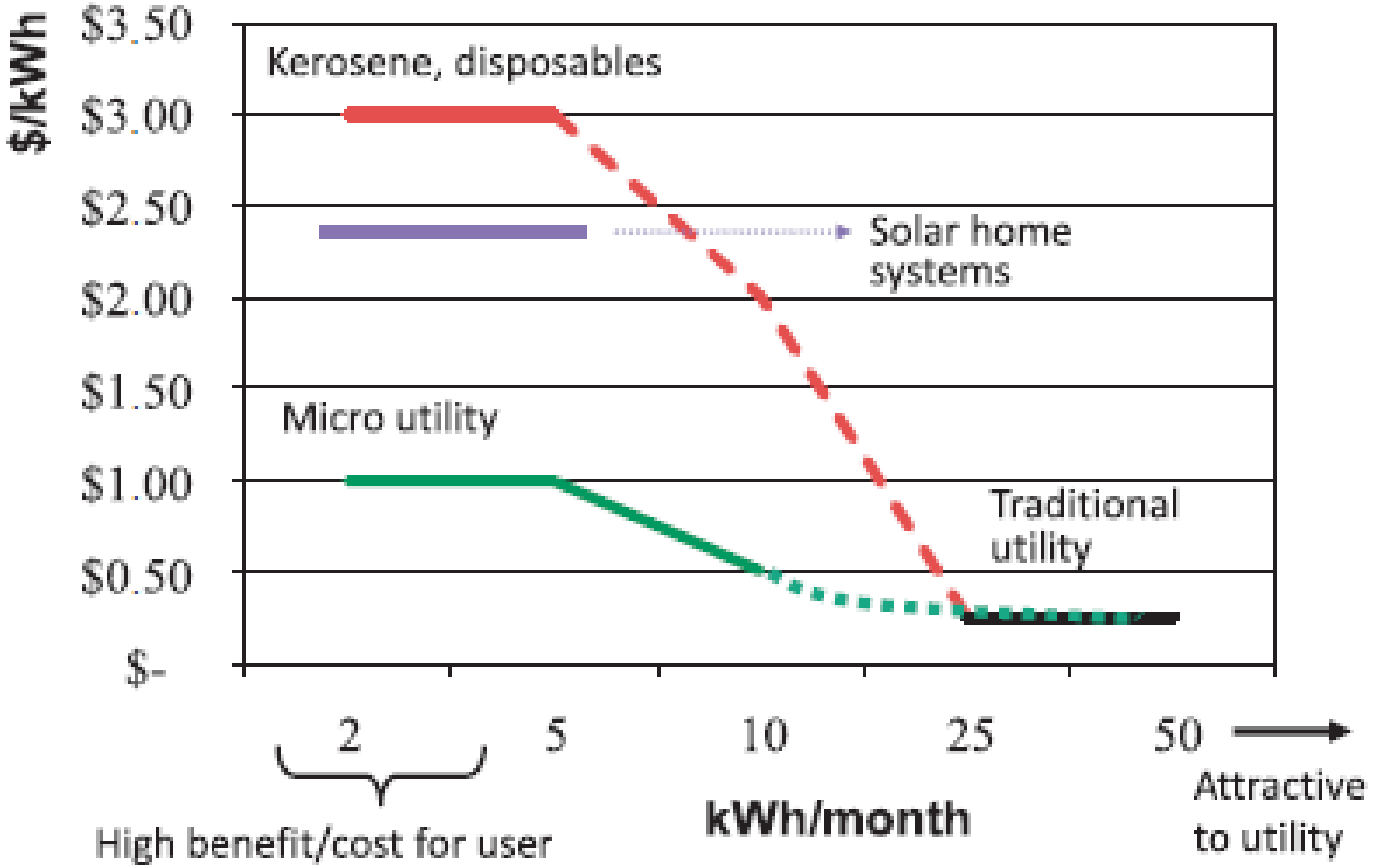
Effective costs for lighting services (GEA, 2012)



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Household energy expenditures in Brazil in 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.

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Stand-alone systems for poor isolated communities

- The case of the “Light for All Program” in Brazil (“Programa Luz para Todos”)

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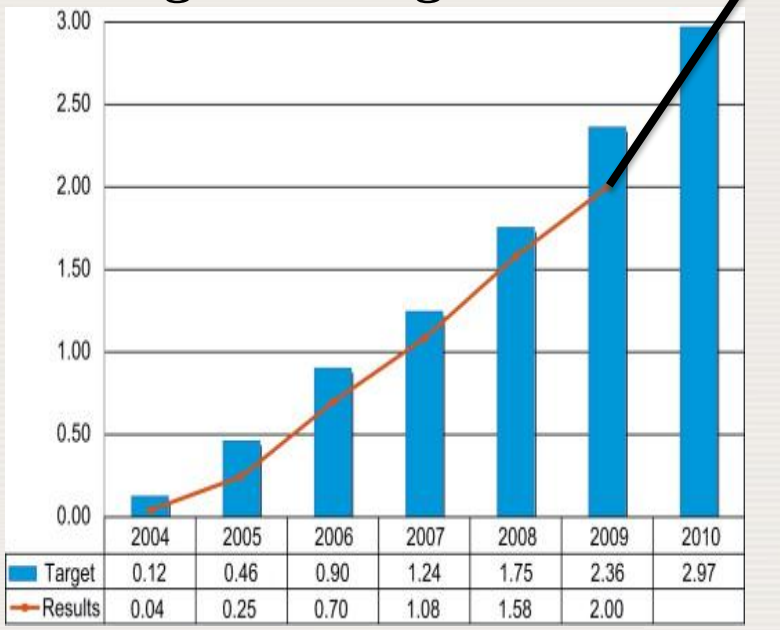
Light for All Programme

- Objective: universalization of electricity access in Brazil
- Created in 2003 by the Ministry of Mines and Energy, the *Luz para Todos* programme aimed at bringing electricity to 12 million people, 10 million of which in remote areas
  - focus on renewable energy projects

    (e.g. mini and micro hydro power plants; hydrokinetic systems; PV systems; wind and wind-solar hybrid systems)
  - population would either continue without access to electricity or relying on diesel-based generators
  - Operated by the country's largest power utility (Eletrobras) and executed by electricity concessionaires and cooperatives
- 2008 was the initial deadline, but is has been extended twice

Light for All Programme

Results against Targets



	2004	2005	2006	2007	2008	2009	2010
Target	0.12	0.46	0.90	1.24	1.75	2.36	2.97
Results	0.04	0.25	0.70	1.08	1.58	2.00	

Source: ANEEL, 2005 and ANEEL, 2009b; MME, 2009a. *Apud* Gomez and Silveira, 2010

- 3.2 million rural families connected
- ~15.3 million people now have access to electricity
  - Increased their quality of life by 91%
  - Increased family income by 36%
  - Increased work opportunities by 34%
- R$ 22.6 billion (~US$ 10 billion) invested between 2004 and 2013
  - 73% paid by the federal government: transferred to distributors
- ~474,000 new jobs said to be created

Source: MME 2014

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Light for All Programme

- 500,000 households still not connected
- Some 250,000 are too remote and/or too small to be economically served through grid extension
  - R$ 17.3 billion claimed to be necessary
  - R$17 thousand (~US$ 8.5 thousand) per connection
- Isolated, small-scale systems are the most economical option
  - Diesel based power generation is the cheapest
  - But...
    - Difficult logistics make for high diesel costs (transport)
    - Inconsistent delivery reduces reliability and availability of systems
    - Small-scale wind and PV seen as good alternatives

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Light for All Programme

Minimum access vs. productive access

Discounts offered through LfA

Índices da Tarifa Social para Consumidores enquadrados na Subclasse Baixa Renda	
Consumo kWh/mês	Desconto
Até 30	65%
De 31 a 100	40%
De 101 a 220	10%
Superior a 220	0%

Índices da Tarifa Social para Consumidores Quilombolas e Indígenas	
Consumo kWh/mês	Desconto
Até 50	100%

Source: MME

However, the inclusion of electricity for productive uses has gained acceptance as a necessary part of access universalization (GEA, 2012):

- In São Paulo, repressed demand raised consumption from 50 to 175 kWh/month for new connections (Coelho & Goldemberg, 2013)
- Inclusion of ice factories, saw mills, fruit processing plants will raise demand beyond original project targets

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Light for All Programme

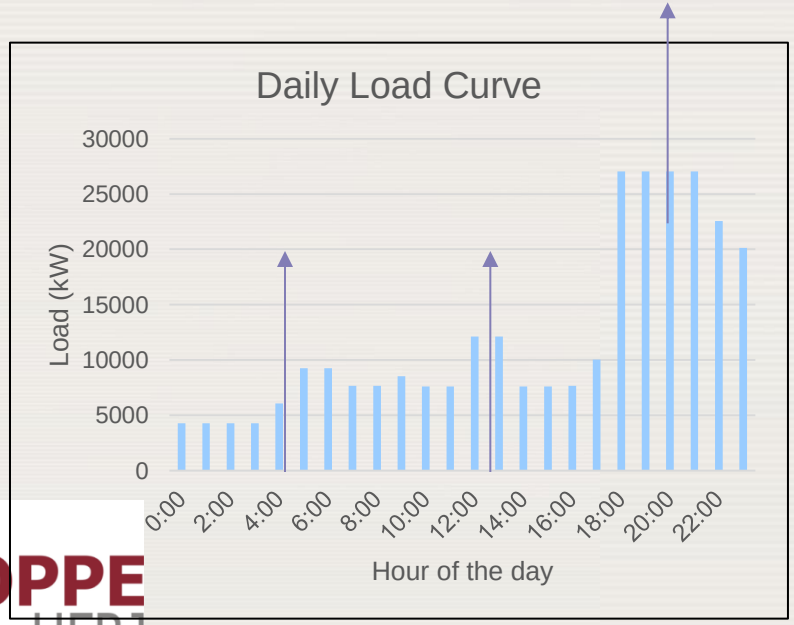
A Tabela 1 mostra dados levantados dos principais equipamentos encontrados (CARTAXO, 2000).

TABELA 1: Dados dos equipamentos da Vila

Descrição	Consumo (kWh/mês/ aparelho)	Potência Média (W)	Índice de Posse
Televisor	12,0	59,6	0,29
Ventilador	14,1	55,1	0,90
"Freezer"	54,1	225,6	0,22
Geladeira	51,8	172,7	0,11
Lâmpada	10,5	58,9	2,70
Rádio	3,9	23	0,38

Fonte: CARTAXO, 2000

Repressed demand begins to be satisfied =====➔



ASPIRAÇÕES FUTURAS			
Equipamento	**Nº Famílias**	**Potência por equipamento (W)**	**Potência total por equipamento(kW)**
Ventilador	15	100	1,5
Freezer	5	200	1
Geladeira	33	200	6,6
Televisores (TV)	11	60	0,66
DVD	1	20	0,02
Ferro Passar	3	1000	3
Liquidificador	3	300	0,9
SOM	4	80	0,32
Maq. Lavar	1	500	0,5
Computador	2	180	0,36
Chuveiro	12	3500	42
Microondas	2	1200	2,4
Estufa	1	200	0,2
Batedeira	1	120	0,12
	Nº de pontos de luz	**Potência por equipamento (W)**	**Potência total por equipamento(kW)**
Iluminação Pública	40	40	1,6
	Total		61,18

Fonte: Tavares Pinho et al, s/d

= shift upwards of the load curve

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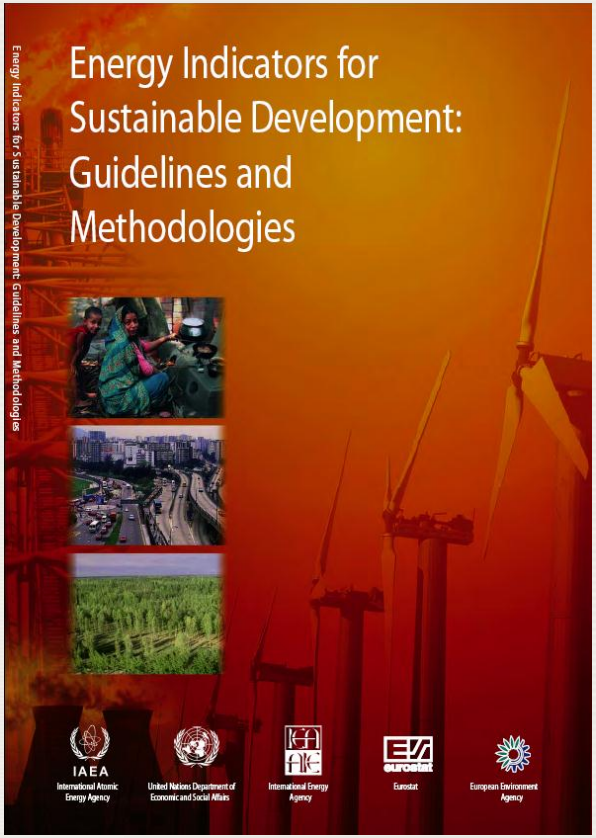
Recommendation for further reading

- Check detailed guidelines and methodologies in:



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