Appendix C-2

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ENERGY and EMISION MATRIX

A NATIONAL ENERGY EMISSION MATRIX
FROM A NATIONAL ENERGY MATRIX(*)

International Workshop on Economical and Environmental Modeling Regarding Strategies for Mitigating the Emission of Greenhouse Effect Gases
March 19-20, 2001

(*) Work Supported by the Brazilian Science and Technology Ministry

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ENERGY and EMISION MATRIX

e&e Team for
ENERGY EMISSION MATRIX FROM A NATIONAL ENERGY MATRIX
Carlos Feu Alvim - Coordinator
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Othon Pinheiro da Silva
Frida Eidelman
Aumara Feu
Eduardo Marques

http://ecen.com

Energy Matrix

CONTENTS

Energy Matrix Importance, Methodology

Emission Matrix Methodology
Energy Matrix Products

Macro Economic Model

Equivalent Energy: Total, Electricity, Agriculture

Equivalent Energy: Transport

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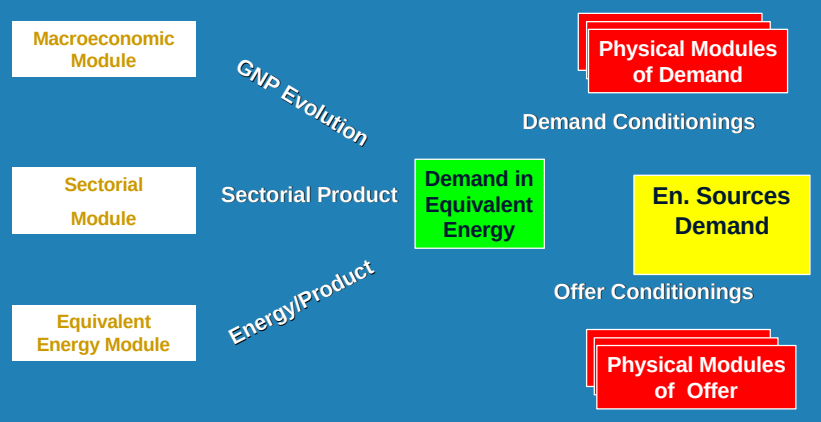
Energy Matrix: Importance

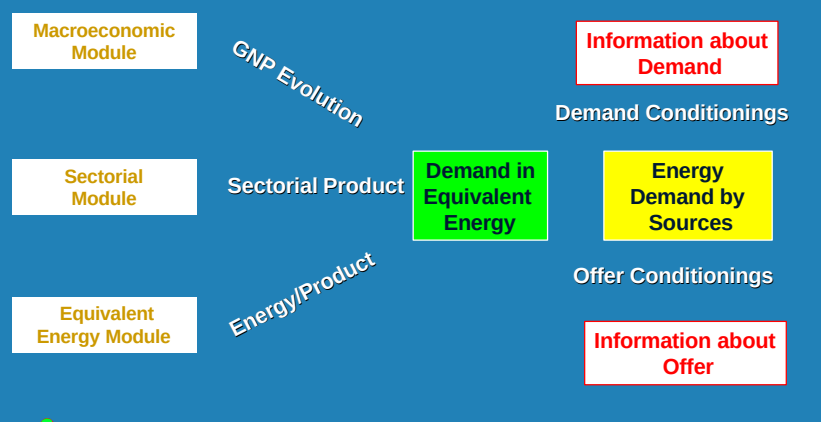
- Instrument of Energy Policy
- Energy is a Strategic Input
  - Growth and Social Welfare Vector
- Energy has Economic Impact
  - Investment Intensive
  - Long Term of Investments Maturation
  - Impact on Commercial Balance
- Energy is a Complex Matter
  - Inter-penetration of Markets
  - Many Sectors Involved

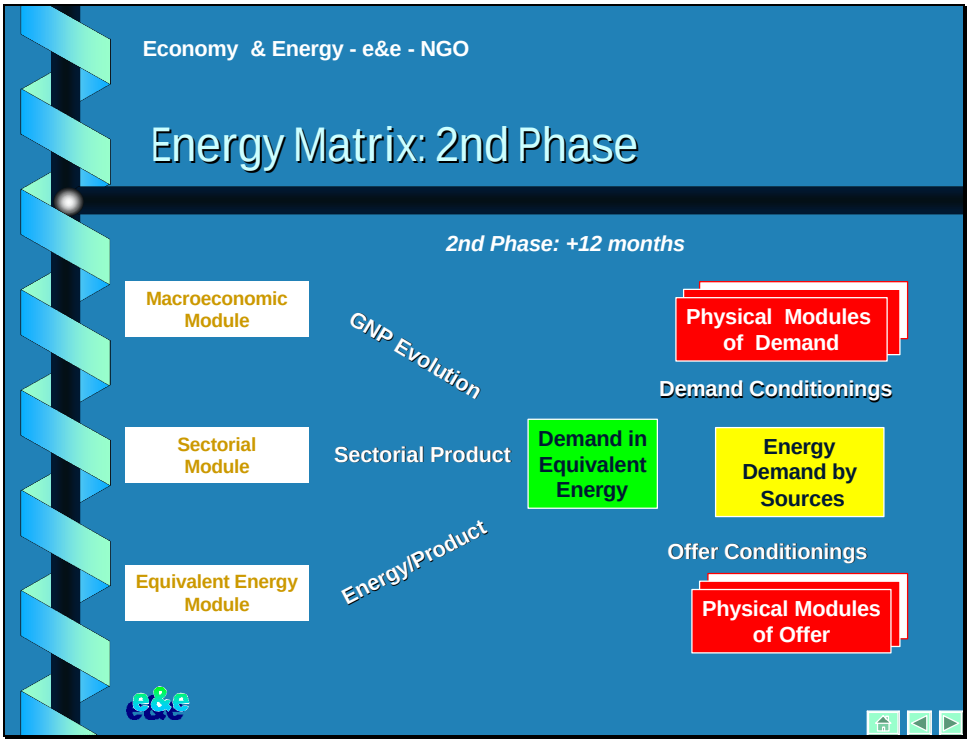
Energy Matrix: Methodology

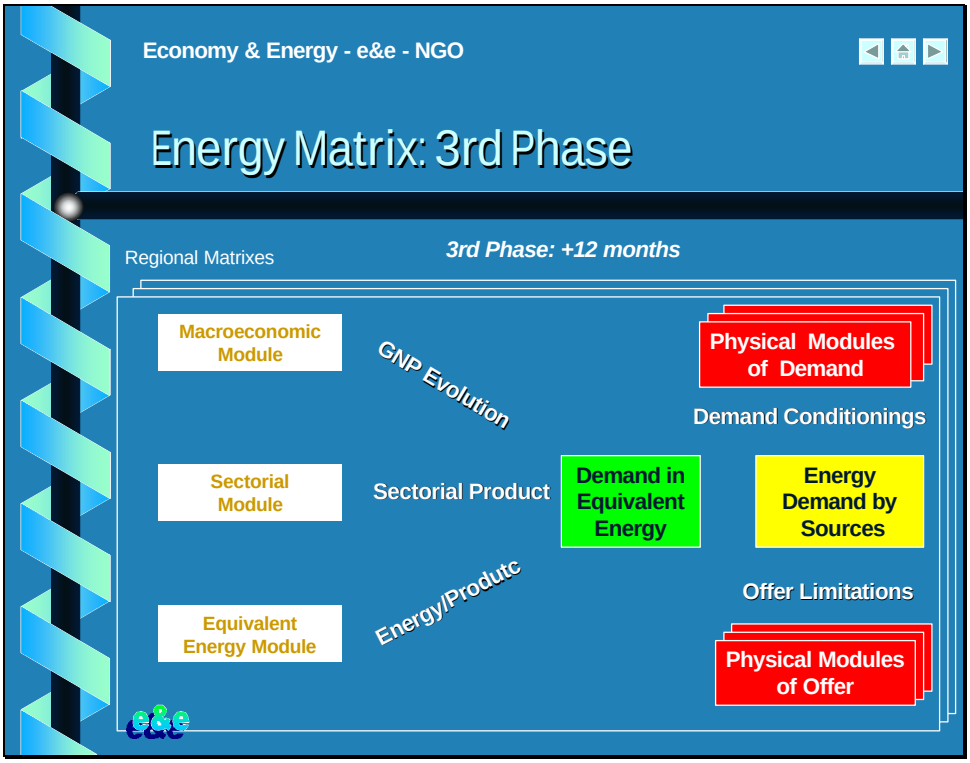


Energy Matrix : 1st Phase

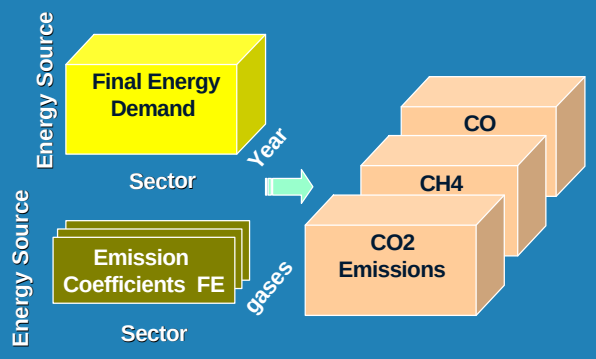
1st Phase: 6 months




Economy & Energy - e&e - NGO
Energy Matrix: 2nd Phase
2nd Phase: +12 months
Macroeconomic Module
GNP Evolution
Physical Modules of Demand
Demand Conditionings
Sectorial Module
Sectorial Product
Demand in Equivalent Energy
Energy Demand by Sources
Equivalent Energy Module
Energy/Product
Offer Conditionings
Physical Modules of Offer
e&e


Economy & Energy - e&e - NGO
Energy Matrix: 3rd Phase
Regional Matrixes
3rd Phase: +12 months
Macroeconomic Module
GNP Evolution
Physical Modules of Demand
Demand Conditionings
Sectorial Module
Sectorial Product
Demand in Equivalent Energy
Energy Demand by Sources
Equivalent Energy Module
Energy/Produtc
Offer Limitations
Physical Modules of Offer
e&e

Emission Matrix : Methodology



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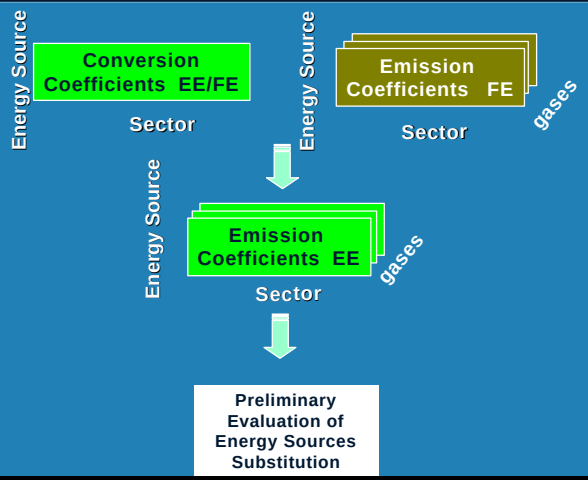
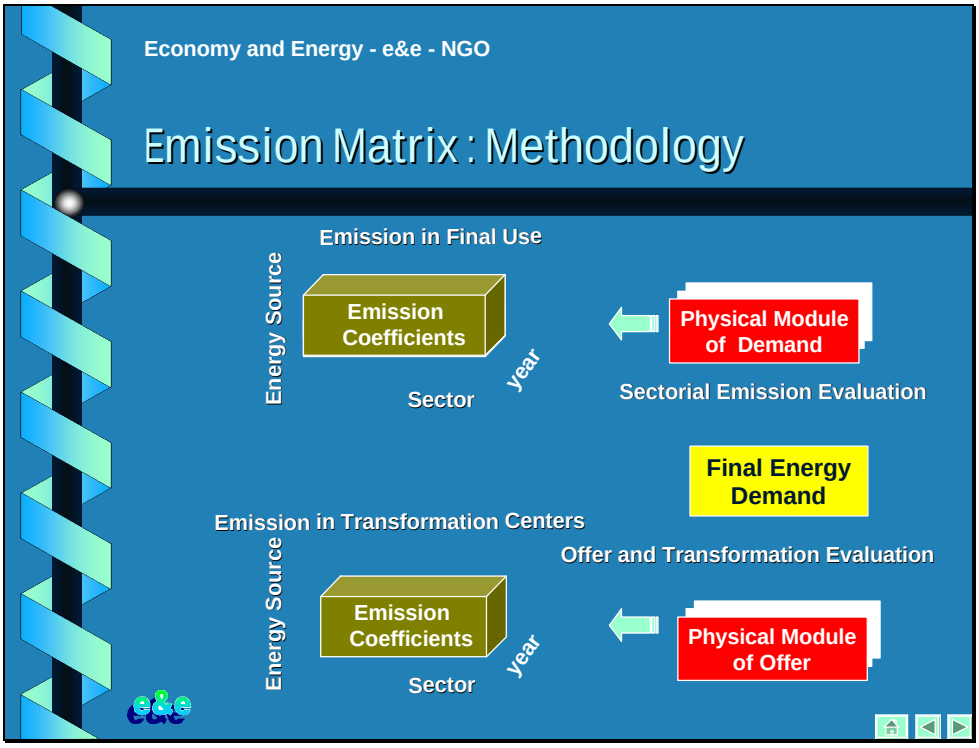
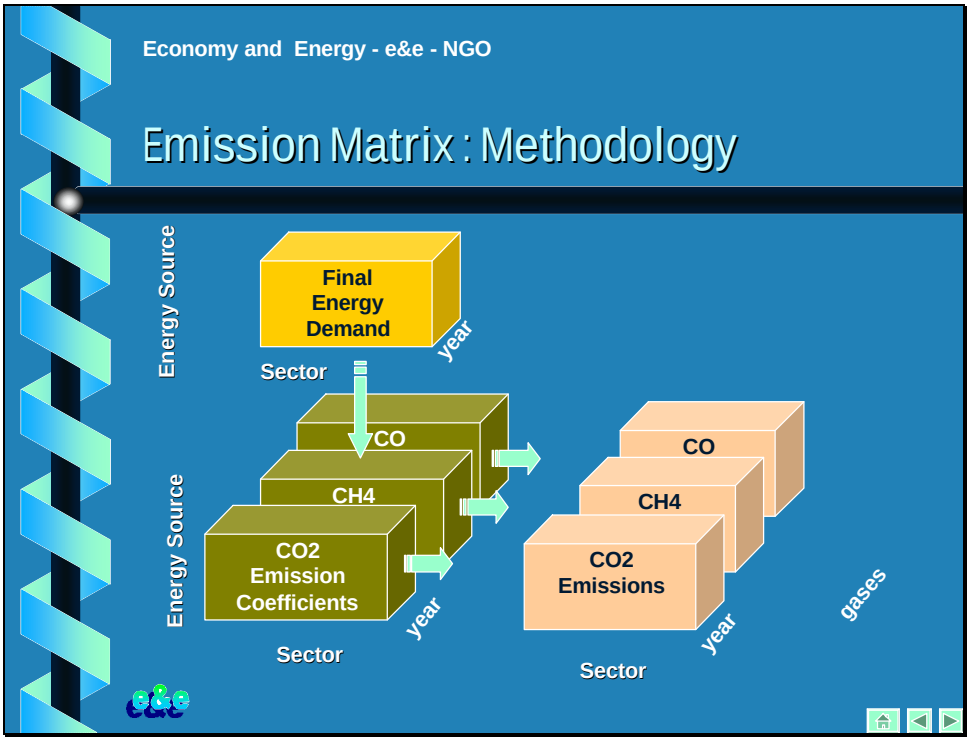
Emission Matrix : Methodology




Economy and Energy - e&e - NGO
Emission Matrix : Methodology
Emission in Final Use
Energy Source
Emission Coefficients
Sector
year
Physical Module of Demand
Sectorial Emission Evaluation
Final Energy Demand
Emission in Transformation Centers
Offer and Transformation Evaluation
Energy Source
Emission Coefficients
Sector
year
Physical Module of Offer
e&e


Economy and Energy - e&e - NGO
Emission Matrix : Methodology
Energy Source
Final Energy Demand
Sector
year
CO
CH4
Energy Source
CO2 Emission Coefficients
Sector
year
CO
CH4
CO2 Emissions
Sector
year
gases
e&e

Energy Matrix: Products I

- Microcomputer Friendly Programs
  - Macroeconomic Module
  - Sectorial Module
  - Equivalent Energy Module
  - Equivalent Energy/Product and
  - Equivalent Energy/Other Variables Module
  - Demand in Equivalent Energy and Final Energy
  - Demand by Type of Energy Source

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Energy Matrix: Products II

- Progress Report
  - Reference Economic Scenario (20 years)
  - Sectorial Economic Scenario (20 years)
  - Projection in Equivalent Energy by Sector (20 years)
  - Projection by Type of Energy Source (5 years)
  - Analysis of Offer x Demand (5 years)
- Matrix 20/5 Years(*) - Preliminary Version

(*) 20 years demand and 5 years offer X demand

Energy Matrix : Products III

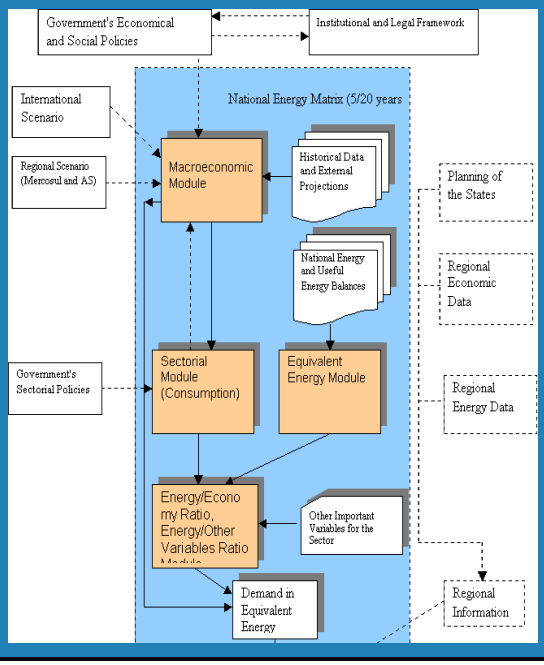
- Technical Reports
  - Description of Macroeconomic Model
  - Conversion from Final to Equivalent Energy
  - Specific Consumption by Sector in Equivalent Energy
  - Description of Methodology

Energy Matrix: Products IV

- Specific Reports
  - Demand of the Residential Sector
  - Petroleum, Petroleum Products and NG Offer
  - Regional Aspects of Offer and Demand
  - Biomass Offer
  - Correspondence between BEN and IBGE Sectors
  - Others that may be necessary

Energy Matrix

Phase 1 Diagram 1a



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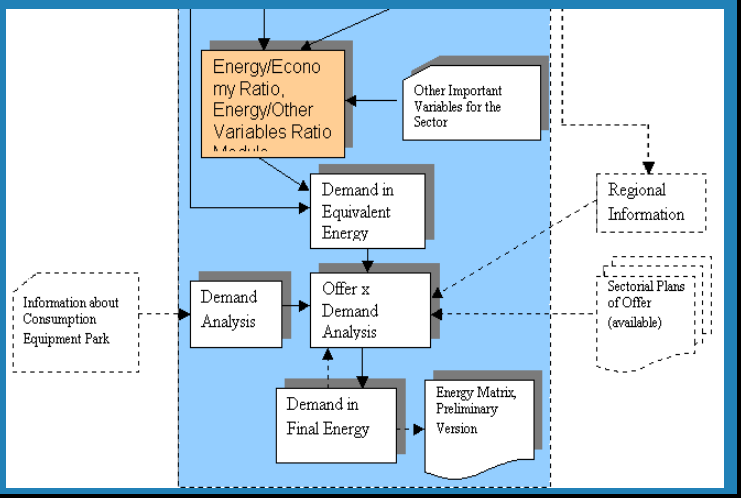
Energy Matrix Phase 1 - Diagram 1b



Energy Matrix : Examples Links

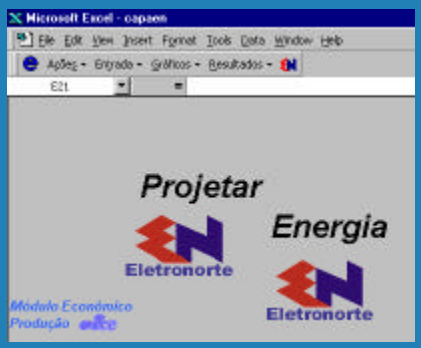
- Macroeconomic Module (Program)
- Energy Demand (Global and Electricity)
- Physical Modules (Transport)

Macroeconomic Module Projetar_e: Principles

- Friendly software, via Menu
- Few input data of high structural meaning
- Intensive use of graphics to help the process of scenario creation
- Combination of econometric relationships with scenarization of parameters in the future
- Automatic updating of econometric relations

Projetar_e: Navigation via Menu

- Menu permits navigating through the program
- User loads a scenario as a starting point and
- Can analyze results or change input data in order to obtain a new scenario



Projetar_e: Scenario Bases

- Will the Country be a Saver or a Consumer ?
  - Territorial Saving
- Will the Economy be Modern or Traditional ?
  - Capital / Product Ratio
- Will the Economy be Open or Closed to Foreign Countries ?
  - Commercial Balance , Opening to Foreign Countries and External Interests Rates

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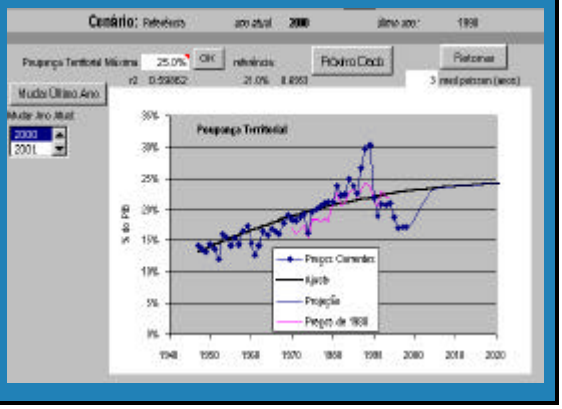
Territorial Saving: Saver or Consumer Country ?

- In the Menu, choose *Territorial Saving* (%GNP) input
- Future value of the scenario (25,0 % in infinite) is introduced
- Logistic curve fit that contains the introduced future value
- Transition curve from the present to the future
- The Graphic changes immediately, permitting to evaluate the coherence of the hypothesis



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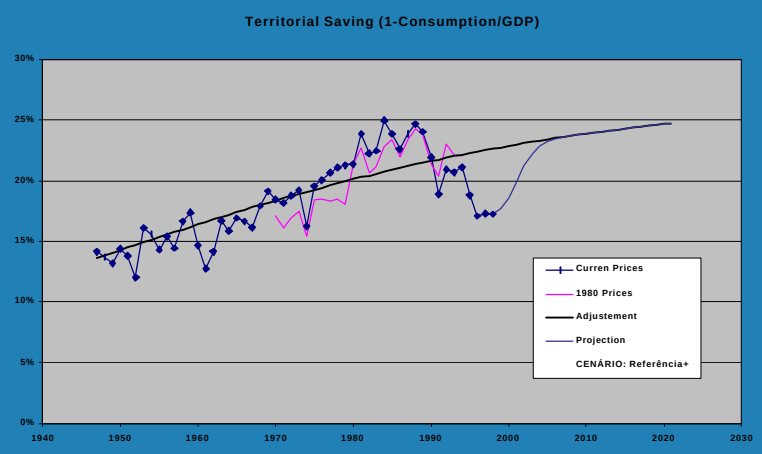
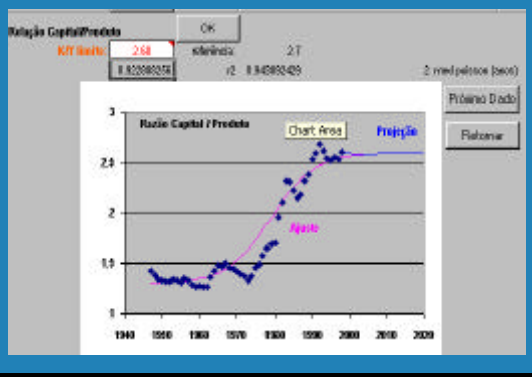
Territorial Saving 2:



Capital / Product Ratio
Global or Domestic Based Economy ?

- In the Menu, choose Capital / Product Ratio input
- The Graphic shows the Capital / Product Ratio series
- The scenarized future value (2,60) is introduced
- The model fits an S curve and the transition curve
- The Graphic changes immediately, permitting to evaluate the coherence of the hypothesis



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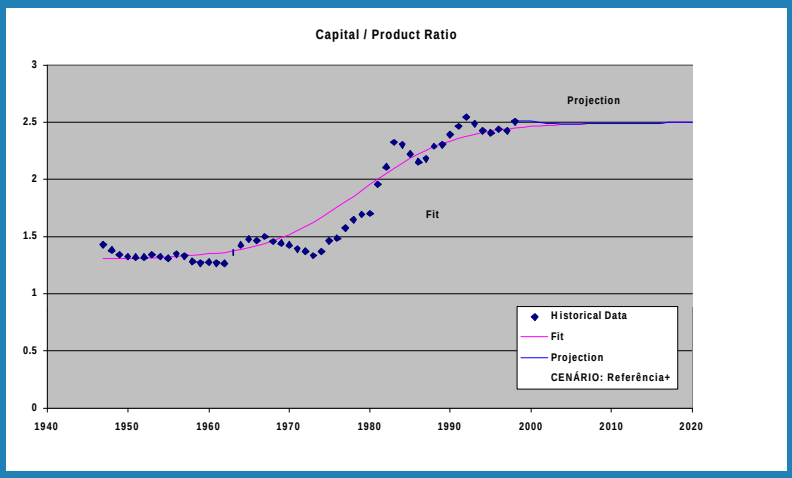
Capital / Product Ratio
Global or Domestic Based Economy ?

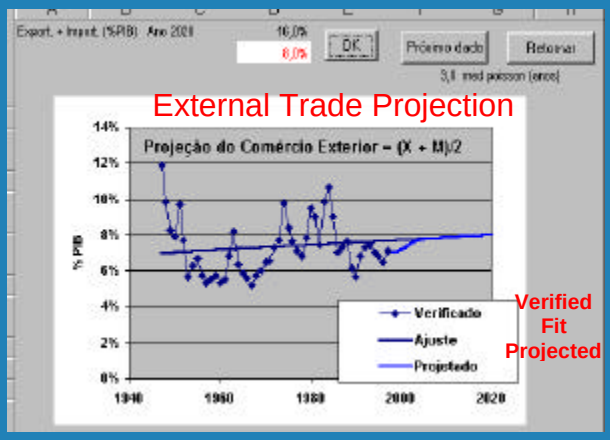


Relation with Foreign countries
Open or Closed Economy ?

- In the Menu, choose the inputs:
- Commercial deficits (% GNP) in the chosen years
- Foreign Commerce Variable (% GNP) in the Scenario's Horizon:

  [(Exports + Imports)/ GNP]/2
- External Interest Rates (% ann.)

Relation with Foreign Countries
External Commerce : (X+M)/2



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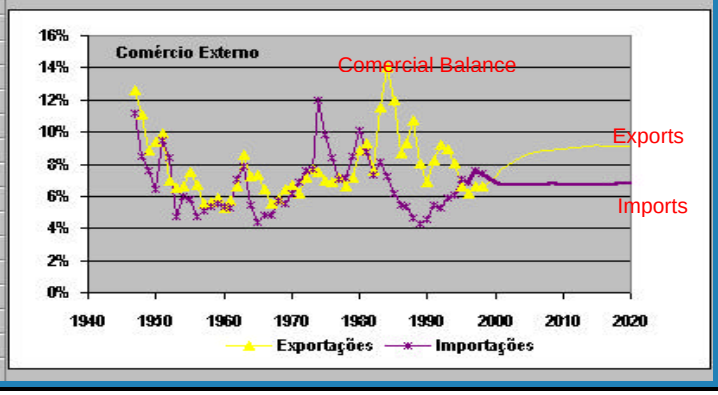
Relation with Foreign Countries
Commercial Balance (% GNP)

	1998	1999	2000	2001	2005	2010	2015	2020
Balança Comercial (% PIB)	-0,8%	-0,2%	0,3%	1,0%	2,0%	2,2%	2,5%	2,3%
Trasnsferências para o Exterior	0,0%	-1,3%	-0,8%	-0,1%	1,0%	1,2%	1,5%	1,3%

Commercial Balance

External Transfers



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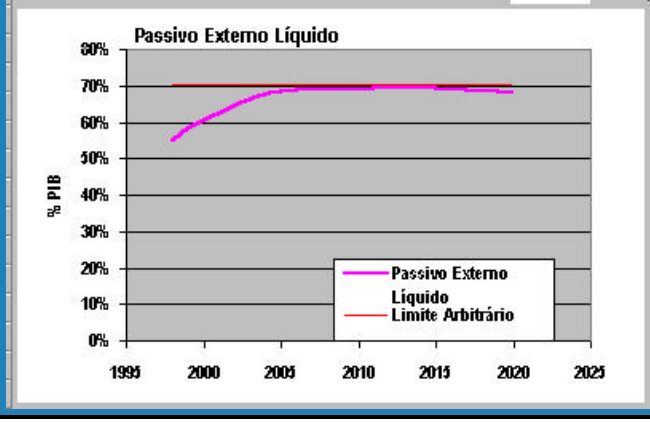
Relation with Foreign Countries
Interest Rates, External Liability

Taxa de Juros Dívida Externa Líquida	5,5%	
Taxa Líquida de Remuneração de Investimentos Externos	3,5%	
limite arbitrário	27%	do estoque de capital (*)

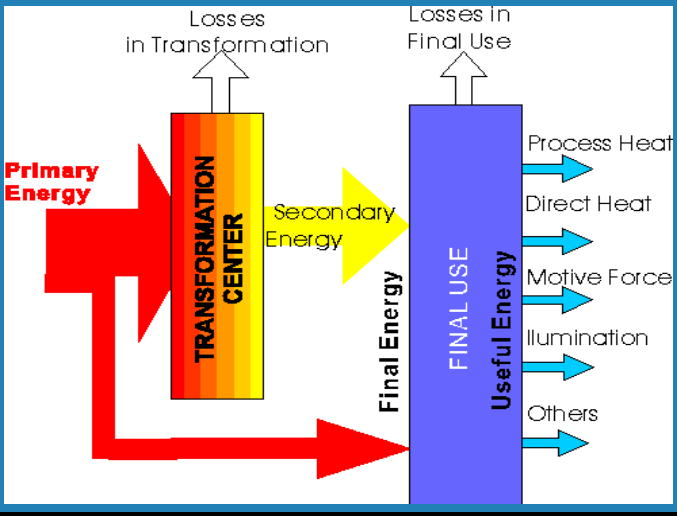
Próximo dado



Energy Matrix

Equivalent Energy Module

Energy Matrix: Equivalent Energy



Advantages of the Equivalent Energy Concept

- Need to find a concept that presents a more regular behavior relative to the economy
- Permits to compare countries with different development degrees
- The useful energy concept requires the focus on each use, which renders it very difficult for a large number of uses, energy sources and sectors
- Equivalent energy permits to add consumption calculated for different uses

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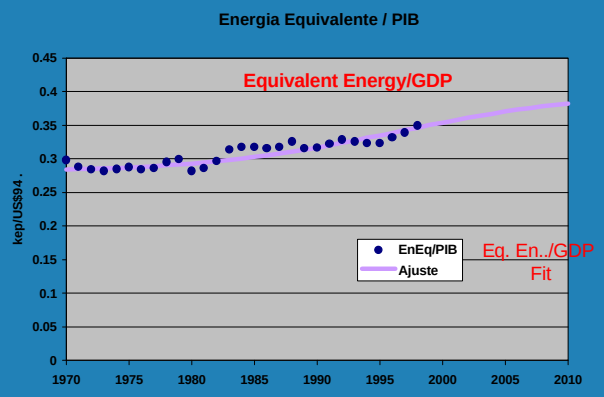
Equivalent Energy /GNP

The Equivalent Energy / GNP ratio presents a rather regular behavior, increasing and tending to saturation.

Projection of Equivalent Energy / GNP Variable



Relations among Energy Concepts

- For a fuel i in use j
- Final Energy : FE(i,j)
- Useful Energy : UE(i,j)
- Equivalent Energy : EE(i,j)
- Efficiency of fuel i in use j: E(i,j)
- Efficiency of reference fuel in use j: E(r,j)

$$EE(i,j) = UE(i,j)/E(r,j) = FE(i,j)*E(i,j)/E(r,j)$$

Flexibility of the Model

The model permits, through a Menu command, to express the Matrix in Equivalent Energy or Final Energy

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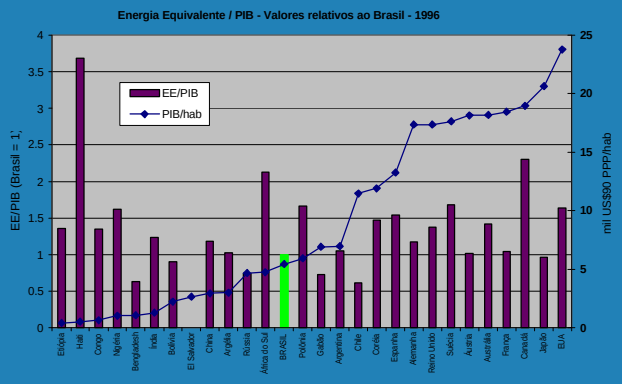
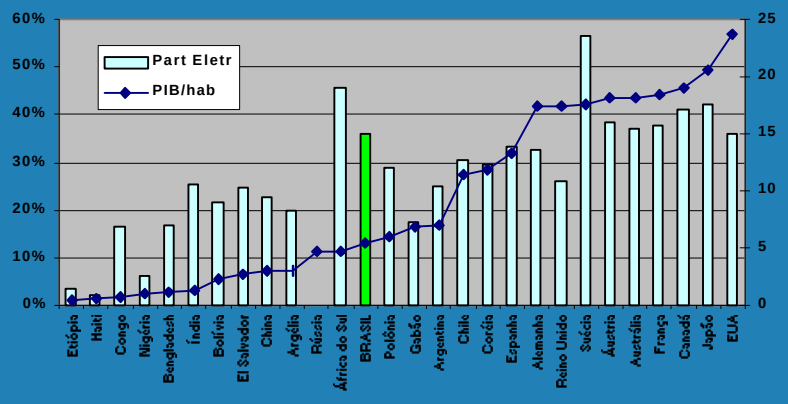
Equivalent Energy and Economy



Equivalent Energy and Economy

Examples of Method Application

Electricity and Equivalent Energy in the World



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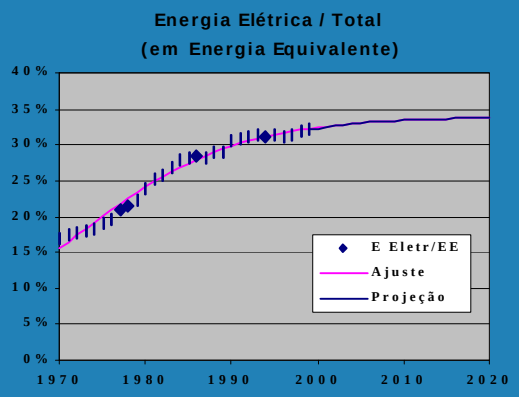
Electricity and Equivalent Energy in Brazil



Média 9 países mais ricos	0,39
Brasil 1996	0,31
Melhor ajuste Brasil	0,33

Valor Limite	34%

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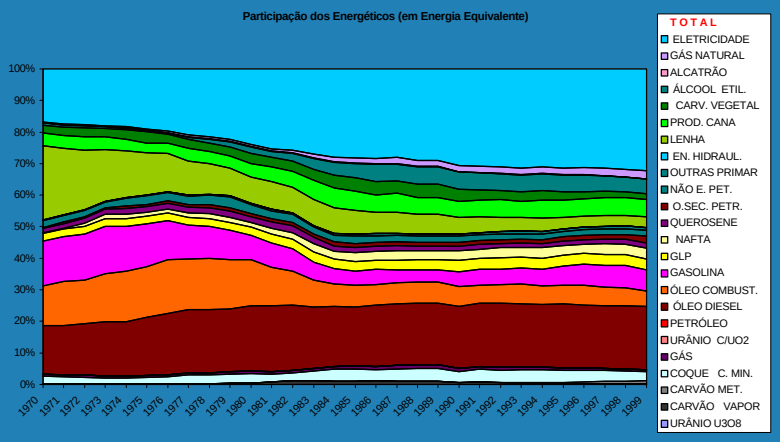
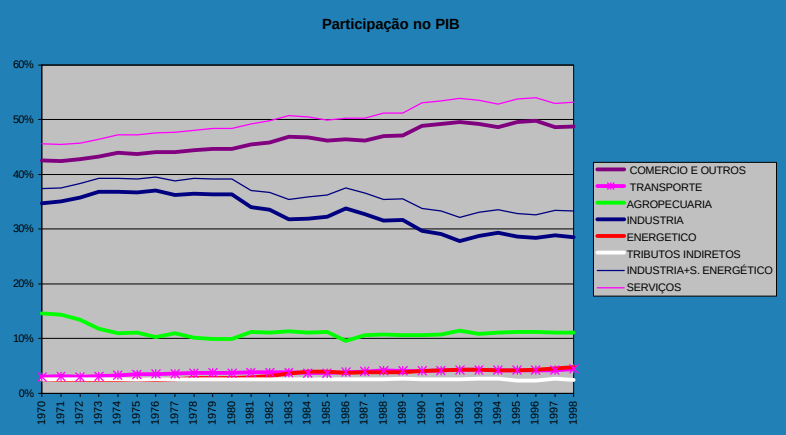
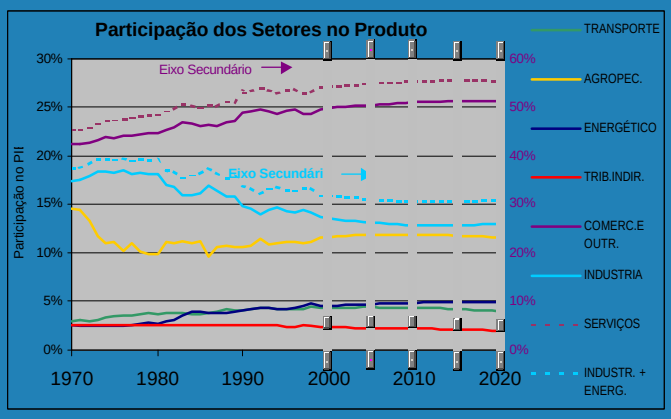
Consumption Sectors (Combination BEN x IBGE)



Example: Agriculture



Mechanism for Scenarizing Participation in the GNP



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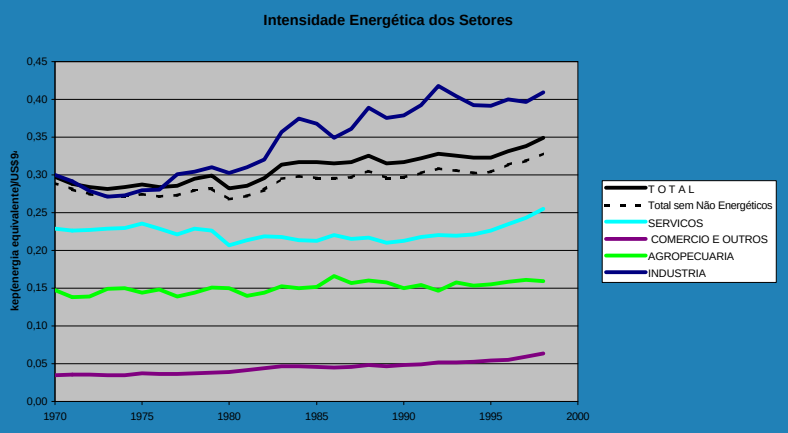
Example: Agriculture



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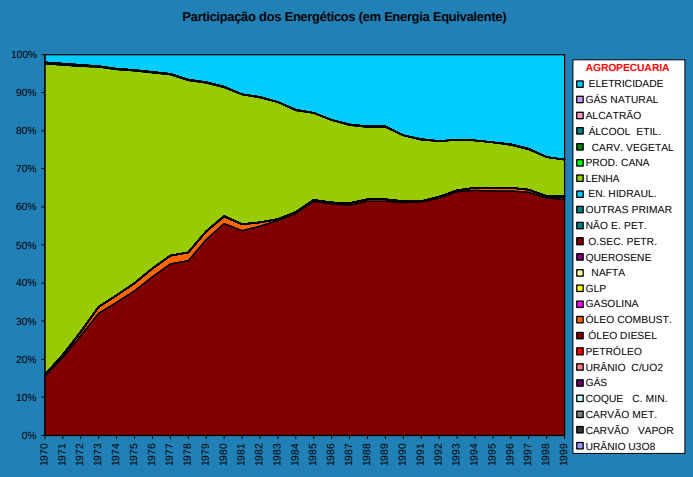
Example: Agriculture



Remaining Sectors

The same procedure will be adopted to obtain consumption in equivalent energy in other sectors of the economy

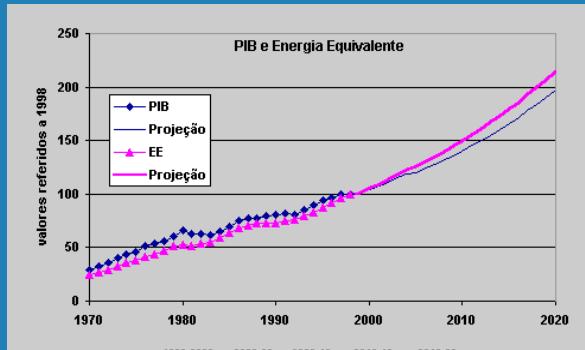
Residential and Individual Transport have different treatments (they are not correlated with the Product)

Energy Matrix

Transport Module

Matrix: Transport Module

Projection in Equivalent Energy from the GNP

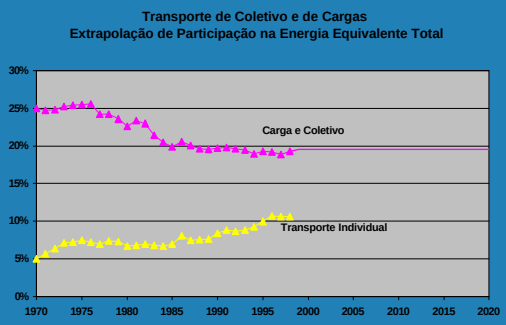


	1995-2000	2000-05	2005-10	2010-15	2015-20
PIB	2,1%	2,8%	3,2%	3,4%	3,5%
Energia Equivalente	3,8%	3,6%	3,6%	3,6%	3,7%

Matrix: Transport Module 2

Load Transport from the Participation in Total in Equivalent Energy

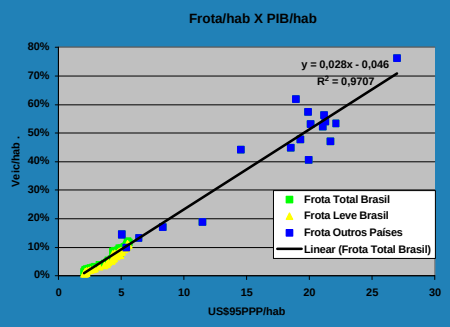
Individual Transport must be obtained from the Fleet



Matrix: Transport Module 3

Study on the Fleet as a Function of Sales and Scrapping

Fleet Projected from the GNP/inhab in Brazil and other countries



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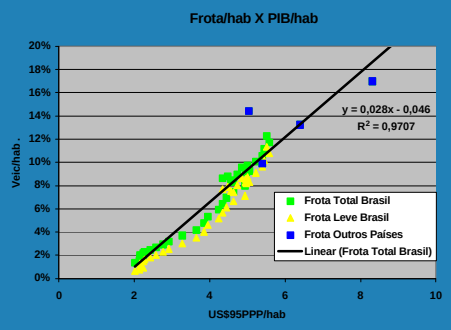
Matrix: Transport Module 4

Behavior of other Countries as a Help for Projection in Brazil

Studies on Annual Consumption relative to Age

Composition of Fleet by Age

Determination of future consumption of the present Fleet

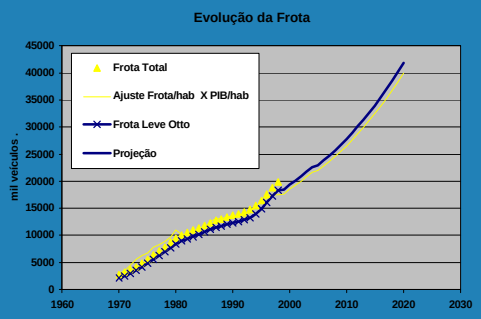


Matrix: Transport Module 5

Brazilian Fleet from Population and GNP/inh Forecasts

Studies on annual Consumption relative to Age

Determination of future consumption of the Present Fleet

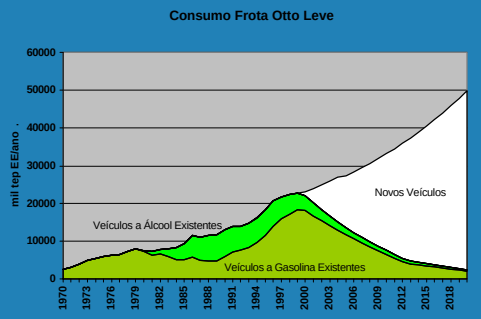


Matrix: Transport Module 6

Consumption of the Existing Fleet based on scrapping and consumption relative to age

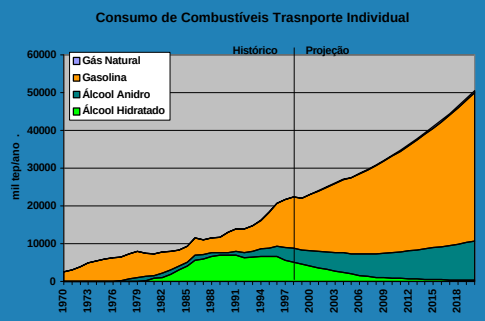
Future Consumption depends on Future and Present Fleet

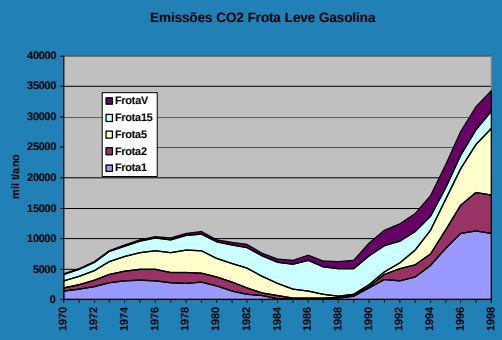
Consumption of New Fleet Reflects the Adopted Vehicle Sales Profile



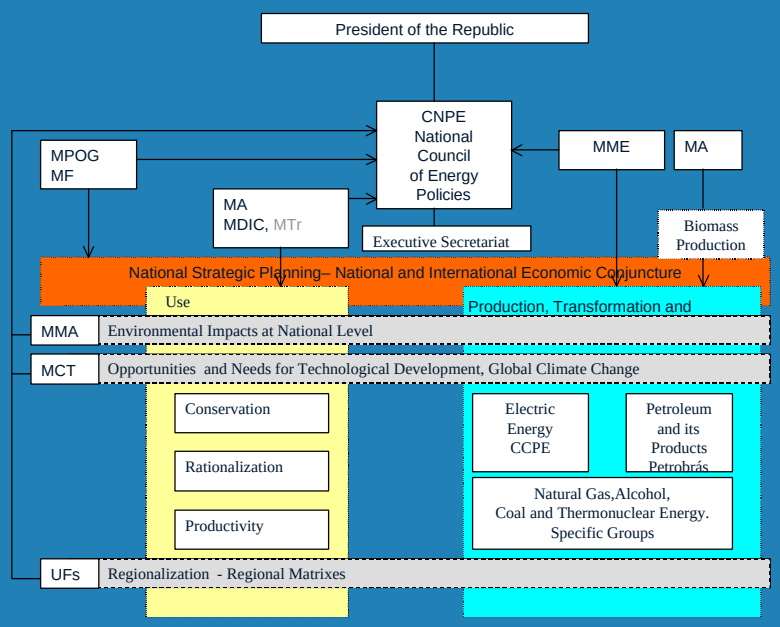
Matrix: Transport Module 7

Consumption for input of 10 000 alcohol vehicles per year





Energy Planning Structure



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Economy and Energy Data (1996)

Classif. PIB PPP	Classif. PIB PPP/ Hab	País	População 10^6 habit.	PIB PPP 10^9 US$(90)	Energia 10^6 tep	EE/ Equiv. tep/ hab.	PIB/ hab. hab 10^3 US$(90)/ hab.	PE/ PIB kep/ US$	FE/ PIB kep/ US$	UE/ PIB kep/ US$	EE / PIB kep/ US$
5	23	India	945,5	1.224,5	308,5	0,33	1,30	0,37	0,29	0,11	0,25
2	20	China	1.215,0	3.594,0	869,8	0,72	2,96	0,31	0,24	0,13	0,24
9	18	Rússia	147,7	687,9	104,5	0,71	4,66	0,90	0,08	0,05	0,15
8	16	Brasil	161,4	877,7	178,7	1,11	5,44	0,19	0,16	0,08	0,20
15	15	Polônia	38,6	229,1	77,6	2,01	5,93	0,47	0,31	0,16	0,34
14	13	Argentina	35,2	245,5	52,4	1,49	6,97	0,24	0,16	0,09	0,21
11	11	Coréia	45,6	542,9	163,0	3,58	11,92	0,30	0,22	0,13	0,30
12	10	Espanha	39,3	521,3	163,8	4,17	13,27	0,19	0,23	0,14	0,31
4	9	Alemanha	81,9	1.421,8	339,1	4,14	17,36	0,25	0,18	0,09	0,24
7	8	Reino Unido	58,8	1.021,2	286,4	4,87	17,37	0,23	0,22	0,14	0,28
13	5	Austrália	18,3	332,6	96,4	5,27	18,19	0,30	0,20	0,11	0,29
6	4	França	58,4	1.077,2	228,6	3,92	18,45	0,24	0,15	0,08	0,21
10	3	Canadá	30,0	568,7	266,7	8,90	18,98	0,42	0,32	0,18	0,47
3	2	Japão	125,6	2.590,9	509,3	4,06	20,63	0,20	0,13	0,07	0,20
1	1	EUA	265,6	6.316,4	2.108,8	7,94	23,79	0,34	0,23	0,12	0,33
		Média						0,34	0,27	0,12	0,27
		Desvio Padrão						0,18	0,18	0,10	0,12
		Desvio Padrão Relativo						52,3%	69,2%	80,2%	45,5%

Ausentes notáveis (maiores PIB PPP/Hab): Áustria (6), Suécia (7), Chile (12), Gabão (14)

Macroeconomic Model
Treated Variables

Variáveis	US$ bi	% aa	% PIB	Per Capita
PIB	√	√		√
Consumo	√	√	√	√
Investimentos	√	√	√	√
Saldo da Balança Comercial	√	√	√	
Exportações	√	√	√	
Importações	√	√	√	
Transferências para o Exterior	√	√	√	
Exportações BSNF	√	√	√	
Importações BSNF	√	√	√	
População - milhões de habitantes	-	-	-	-
Saldo da Balança Comercial	√	√	√	√
Balanço de Serviços	√	√	√	
Transferências Unilaterais Líquidas	√	√	√	
Saldo em Conta Corrente	√	√	√	
Saldo da Balança Comercial	√	√	√	√
Saldo de Não Fatores	√	√	√	
Renda Líquida Enviada ao Exterior	√	√	√	
Saldo em Conta Corrente	√	√	√	
Passivo Externo Líquido	√	√	√	