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juny 2001

Metodologies GENIe i GLOBESIGHT d'estudi d'escenaris de futur sobre emissions de CO2 a CATALUNYA

Diana Cayuela, Juan José de Felipe,
Juan Martínez, Bernat Palau,
Bárbara Sureda, Josep Xercavins

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TECNOLOGIA, DESENVOLUPAMENT SOSTENIBLE, DESEQUILIBRIS I CANVI GLOBAL

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Tel: 00 34 93 739 80 50
Fax: 00 34 93 739 80 32
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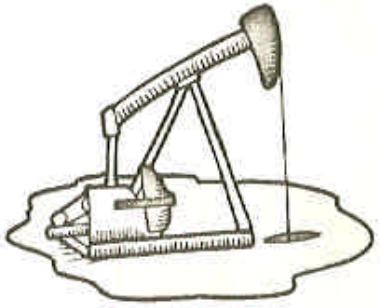
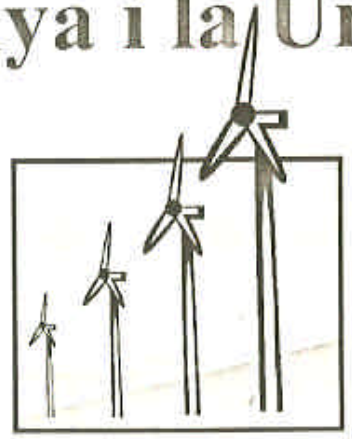
Seminari tècnic intern,

per al Departament de Medi Ambient de la Generalitat de Catalunya,

sobre les metodologies GENIe i GLOBESIGHT d'estudi d'escenaris de futur sobre emissions de CO2 a CATALUNYA, Espanya i la Unió Europea





20-06-01

El seminari ha estat preparat pels professors i col·laboradors de la **GENIe European Office**:

Diana Cayuela; Juan José de Felipe; Juan Martínez; Bernat Palau; Bàrbara Sureda; Josep Xercavins

PROGRAMA

- 1. GENIe I GLOBESIGHT
- 2. EMISSIONS DE CO2: ELS CONCEPTES
- 3. EL MODEL UTILITZAT
- 4. LES DADES INICIALS
- 5. EL CD LLIURAT
- 6. GLOBESIGHT
- 7. ESCENARI BaU EMISSIONS DE CO2
- 8. ESCENARIS DE FUTUR

1. GENIe I GLOBESIGHT

UNESCO

UNI TWIN

GENIe

GENIe European Office

UNESCO CHAIR AT UPC

Generalitat de Catalunya
Government of Catalonia

CWRU

UPC

Generalitat de Catalunya
Government of Catalonia

United Nations Educational, Scientific and Cultural Organization.

UNI TWIN

GENIe

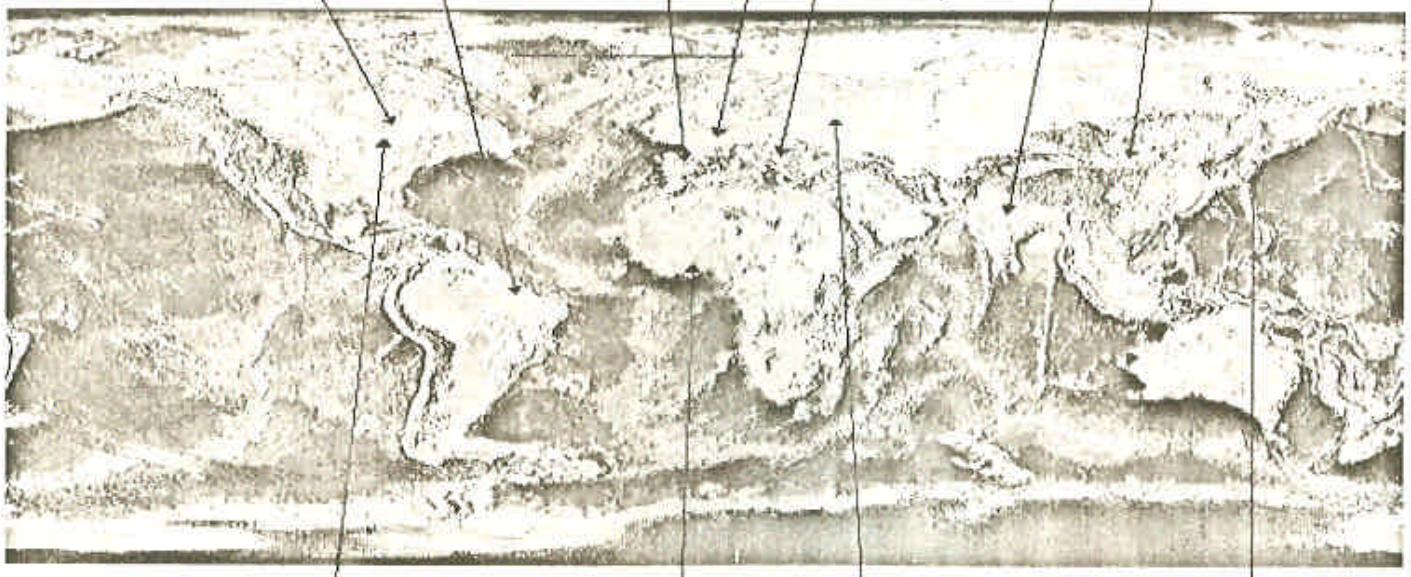
Global-Problematique

Education

Network

Initiative

First GENIe Workshop
Confirmed University Participants



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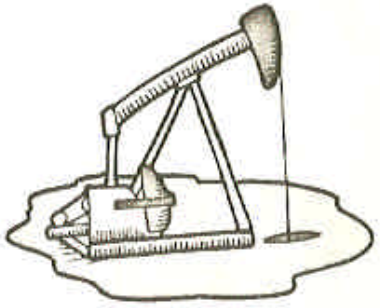

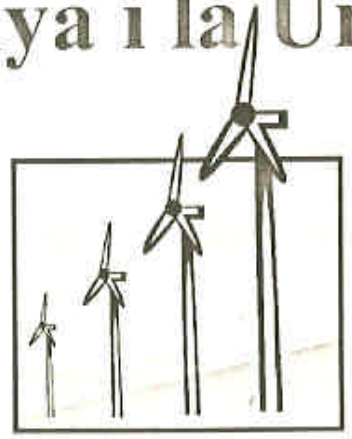

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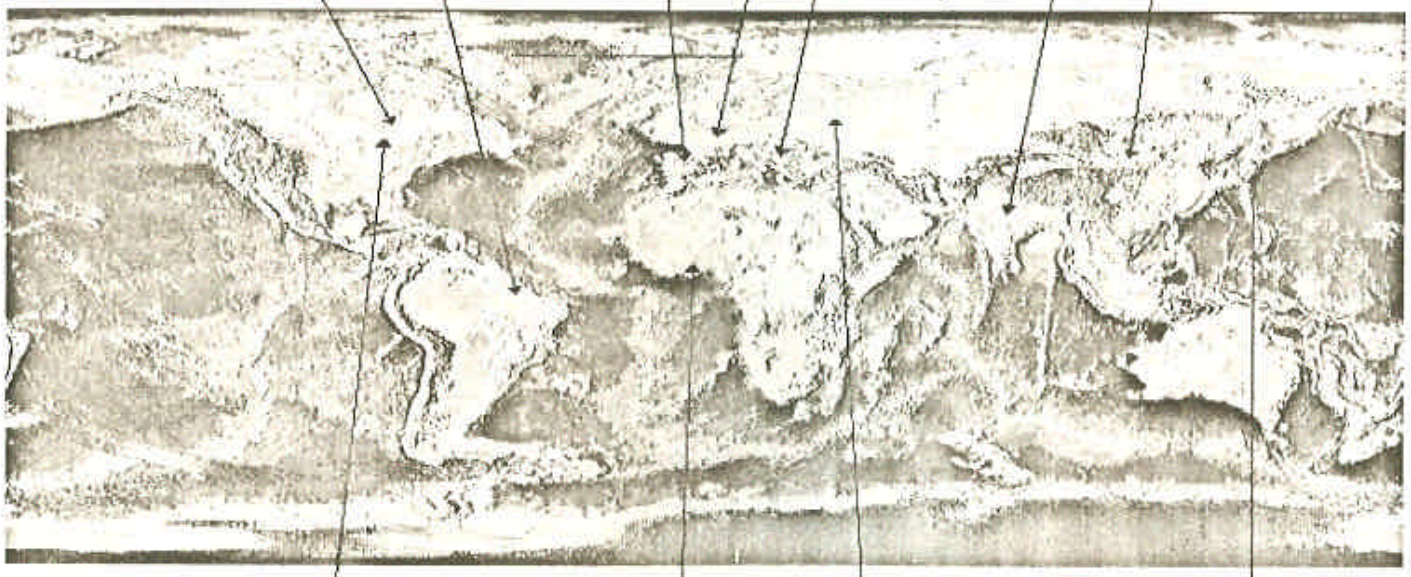


PRESENTATION

- GENIe is a broad-based educational effort, addressed the need to educate the next generation of leaders, and initially aimed at the following audience:
  - **Decision makers and Scientists**
  - **University undergraduate and graduate College Students**
  - **Secondary School Students**

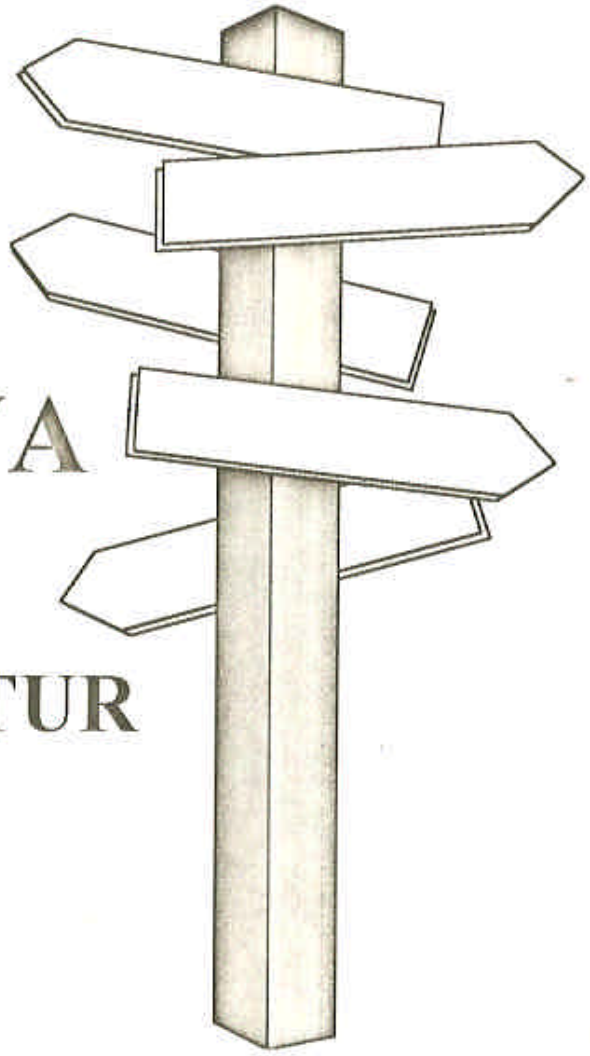
PRESENTATION

- GENIe is a broad-based educational effort, addressed the need to educate the next generation of leaders, and initially aimed at the following audience:
  - **Decision makers and Scientists**
  - **University undergraduate and graduate College Students**
  - **Secondary School Students**

- Furthermore a series of **workshops** entitled "**Bridging the Gap between Science and Decision-Making**", is being organised. The first two workshops (Venice, Italy, 1993, and Santiago de Chile, 1995) will be followed by one on the **Nile River Basin (Cairo 1997)** and another one on the **Europe CO2 Emissions (Terrassa 1998)**

PROSPECTIVA

ESCENARIS DE FUTUR



"REFLEXIÓ PRÈVIA"

- La interdependència i la rapidesa de tot plegat i les percepcions de **complexitat i incertesa**

més necessitat que mai de "pensar" en el futur!

PROSPECTIVA
FUTURE STUDIES

- En sentit ampli la Prospectiva engloba totes les següents accepcions: futurologia o predicció, planificació o gestió estratègica, previsió

PROSPECTIVA
FUTURE STUDIES

- Futurologia o predicció (forecast)
  - fer pronòstics; prediure
- Planificació estratègica (prospectiva en sentit estricta)
  - construir el nostre futur desitjat; és a dir, engloba la planificació
- **Previsió (foresight)**
  - **millorar la qualitat de les nostres decisions en funció de l'anàlisi de llurs conseqüències**

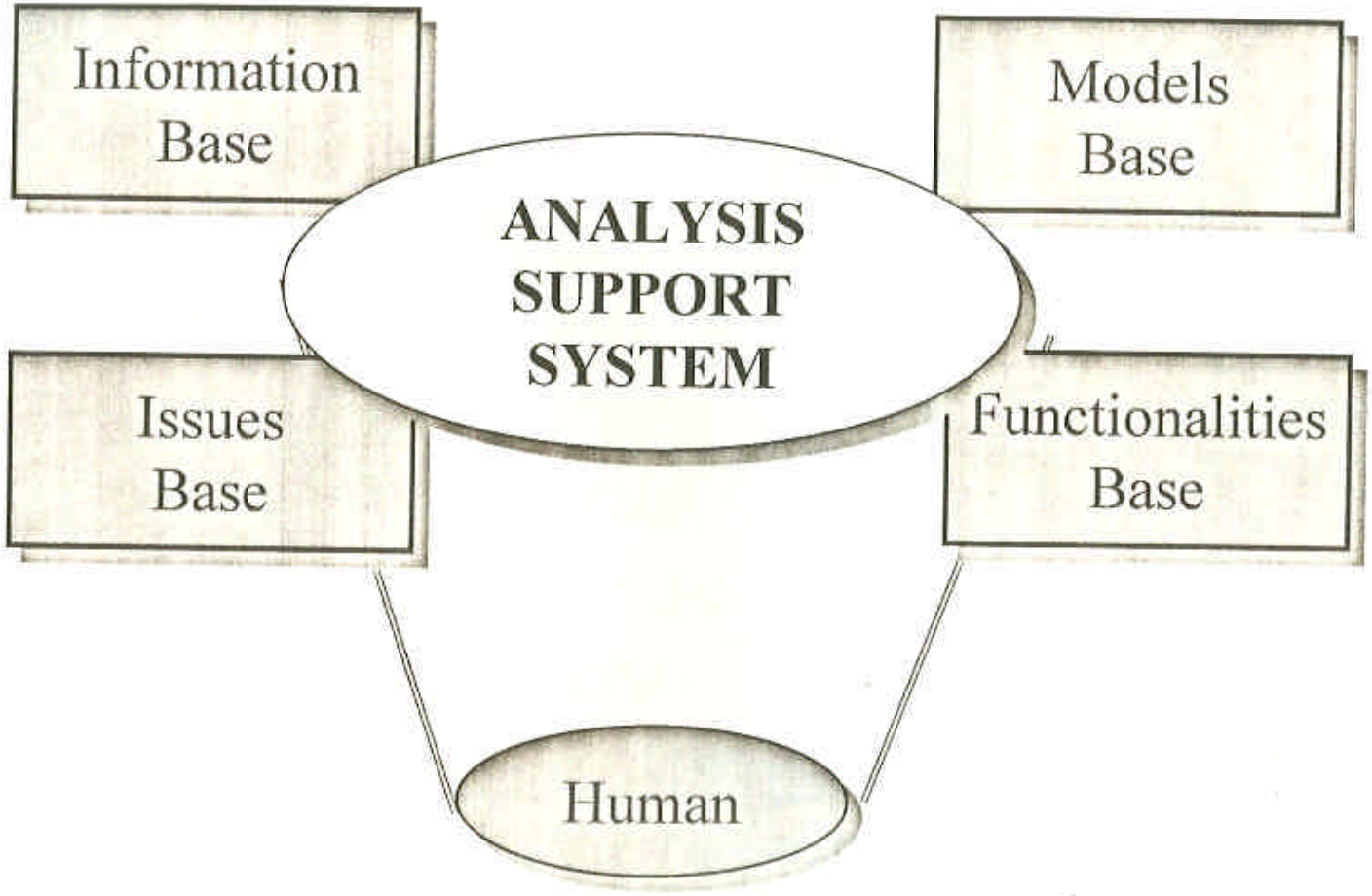
GLOBESIGHT (GLObal forESIGHT) (previsió global)

- En aquesta direcció, una altra eina (menys desenvolupada estructuralment però potser més clara, més oberta i més transparent metodològicament) és la construïda i contínuament desenvolupada per en Mesarovic (Club de Roma; anys 70) i que permet, amb relativa facilitat, la construcció (la previsió) de possibles escenaris de futur dels sistemes socials-naturals

GLOBESIGHT
(GLObal forESIGHT)

METHODOLOGY:
TOWARDS INTEGRATED ASSESSMENTS WITH REASONING SUPPORT TOOLS

GLOBESIGHT Architecture



- **From the cybernetic viewpoint, integrated assessment is a human-based process of reasoning about the future in which all available tools and information are used in contrast to the computer-based approach, such as in integrated modeling plus sensitivity analysis. The process is akin to the decision support (goal seeking) approach used in management science and practice.**

- **In the process that begin in understanding the past, evaluating the present and looking into different feasible futures, GLOBESIGHT, playing a role of a "consultant", requires the human to represent the subjective and qualitative aspects of the issue at hand whereas known data, procedures, models are inherent in it.**

- **Models that we use will be reduced form models. This approach is one of the latest new trend in complex system modeling particularly for policy analysis (the "goal" in our study). Reduced form models also reflect the final audience for our approach who are from decision-making, education and the public domain. Rather than building complex and/or complicate models dominant relationships –usually identities- having a strong interaction between variables are identified with the parameters; complexity is traded for uncertainty in parameter changes.**

Basic Principles

- **Scientific Integrity:**

  Model only if scientific data and scientific knowledge is available. "Do not model what is not modelable."

- **Transparency:**

  Reduced form models for decisonmaking, education and the public domain.

- **Focus on "Problematique":** Integrated assessment.

- **Participatory "Symbiotic" Reasoning Process:**

  Interactive assessment; "human inside models".

GENIe

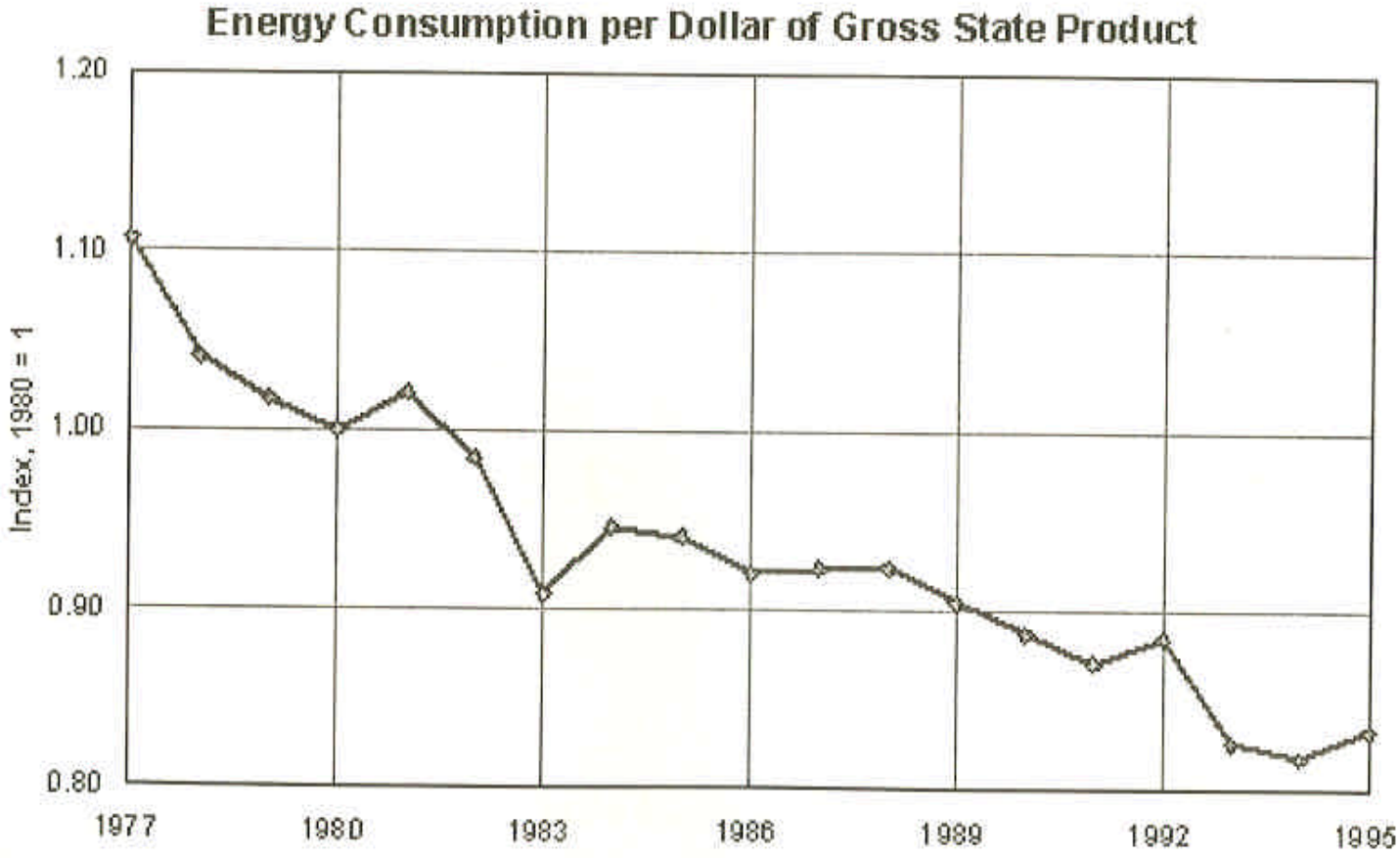
2. EMISSIONS DE CO2: ELS CONCEPTES

ECONOMY, ENERGY AND CO2 EMISSIONS

Energy Intensity

$$\text{Energy Intensity} \equiv \frac{\text{Energy Used}}{\text{GNP}}$$

- We can always compute it from the past; it takes into account efficiency of production, transport and use of energy



Sources: Energy Information Administration, Bureau of Economic Analysis

Energy Demand

- GNP ↑
- Energy Intensity ↓! (efficiency) ↑!
- Energy Demand ↑

Energy Supply and CO2 Emissions

- Energy Demand ⟺ Energy Supply
- **Energy Supply (energy vector, energy mix)**
  - Coal (carbon intensity ⇧)
  - Oil (carbon intensity ⇧)
  - Gas (carbon intensity ⇧)
  - **Nuclear** (carbon intensity 0)
  - **Renewable** (carbon intensity 0)
    - hydraulics
    - others (biomass; wind; sun; ...)

Kaya Identity and CO2 emissions

$$\text{Emissions CO2} \equiv \underbrace{\underbrace{\text{GNP} * \frac{\text{Energy}}{\text{GNP}}}_{\text{Energy Intensity}}}_{\text{Energy Demand}} * \frac{\text{Emissions CO2}}{\Sigma\ \text{Energy}}$$

3. EL MODEL UTILITZAT

CO_2 EMISSIONS MODEL

Based on Kaya Identity!

e i c o d i

```
/*************************************************************
 *
 * model.cpp :
 *
 *    Global Warming model using Kaya Identity
 *      Created: Oct 12, 1999 by Ali Vali & Mike Meskovic
 *      Modified: June 01, 2001 by J.J. de Felipe & Xerca
 *
 *************************************************************/


#include "stdafx.h"
#include <stdio.h>
# include <math.h>
#include "mediamabient2.hh"

static float sgnp[reg],senint[reg], sendm_dstvc[reg][fuel];
static float nendml_dstvc[reg];

int r,f;

long model(long firstYear, long year, FILE *fp1)
{

      /*  Compute GNP growth rate */
      for (r=0; r<reg; r++) {
            rgnp[r] = rgnpd[r]*rgnpm[r];
      }

      /*  Compute GNP */
      if (year > firstYear){
            for (r=0; r<reg; r++) {
                  gnp[r] = (sgnp[r]*(1.+rgnp[r]/100.));
            }
      }

      /*  Compute Energy Intensity rate */
      for (r=0; r<reg; r++) {
            renint[r] = renintd[r]*renintm[r];
      }

      /*  Compute Energy Intensity  */
      if (year > firstYear) {
            for (r=0; r<reg; r++) {
            enint[r]=(senint[r]*(1.+renint[r]/100.));
            enint_scn[r]=enint[r]*menint[r];
            }
      }

      /*  Compute energy demand */
      for (r=0; r<reg; r++) {
            endm_scn[r] = gnp[r]*enint_scn[r];
      }

      /*  Compute energy distribution coefficients rate */
      for (r=0; r<reg; r++) {
            for (f=0; f<fuel; f++) {
                  rendm_dstvc[r][f] = rendm_dstvc_d[r][f]*rendm_dstvc_m[r][f];
            }
      }
```

```
/*************************************************************
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      }

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      for (r=0; r<reg; r++) {
            for (f=0; f<fuel; f++) {
                  rendm_dstvc[r][f] = rendm_dstvc_d[r][f]*rendm_dstvc_m[r][f];
            }
      }
```

```
	/*  Compute energy distribution coefficients */
	if (year > firstYear) {
		for (r=0; r<reg; r++) {
			for (f=0; f<fuel; f++) {
			endm_dstvc[r][f]= (sendm_dstvc[r][f]*(1.+
rendm_dstvc[r][f]/100.));
			endm_dstvc_scn[r][f]=endm_dstvc[r][f]*mendm_dstvc[r][f];
			}
		}
	}

	/*  Normalize energy distribution coefficients */
	for (r=0; r<reg; r++){
		nendml_dstvc[r]=0;
		for (f=0; f<fuel; f++){
			nendml_dstvc[r]= nendml_dstvc[r] + endm_dstvc_scn[r][f];
		}
	}

	/* Recompute normalized energy distribution coefficients */
	for (r=0; r<reg; r++) {
		for (f=0; f<fuel; f++) {
			endm_dstvc_scn[r][f] = endm_dstvc_scn[r][f]/nendml_dstvc[r];
		}
	}

	/*  Compute energy demand by fuel source */
	for (r=0; r<reg; r++) {
		for (f=0; f<fuel; f++) {
			endm_vc[r][f] = endm_dstvc_scn[r][f]*endm_scn[r];
		}
		endm_ff[r] = endm_vc[r][oil] + endm_vc[r][coal] + endm_vc[r][gas];
		endm_nonff[r] = endm_scn[r] - endm_ff[r];
	}

	/*  Compute CO2 Emissions */
	for (r=0; r<reg; r++) {
		em[r] = 0.;
		for (f=0; f<fuel; f++) {
			em[r] = em[r]+((co2int[f]*endm_vc[r][f])/1000.);
		}
	}

	/* Backup Variable */

	for (r=0; r<reg; r++) {
		sgnp[r] = gnp[r];
		senint[r] = enint[r];
		for (f=0; f<fuel; f++) {
			sendm_dstvc[r][f] = endm_dstvc[r][f];
		}
	}

  return 1;
  }
```

RGNP

$$RGNP(\%) \equiv \frac{GNP - SGNP}{SGNP} * 100$$

GNP

"physical" rate	"data" "historic"	scenario multiplier

rgnp[r] = rgnpd[r] * **rgnpm[r]**

gnp[r] = sgnp[r] *(1 + rgnp[r]/100)

model or equation or definition!!!!!

incertesa!

Energy Intensity

- renint[r] = renintd[r] * **renintm[r]**
- enint[r] = senint[r] * (1 + renint[r]/100)

and/or

- enint_scn[r] = enint[r] * **menint[r]** ⇦

Energy Demand

endm_scn[r] = gnp[r] * entint_scn[r]

Energy Category or Vector or Mix (Coal, Oil, Gas, Nuclear, Other -Hydro,...-: f)

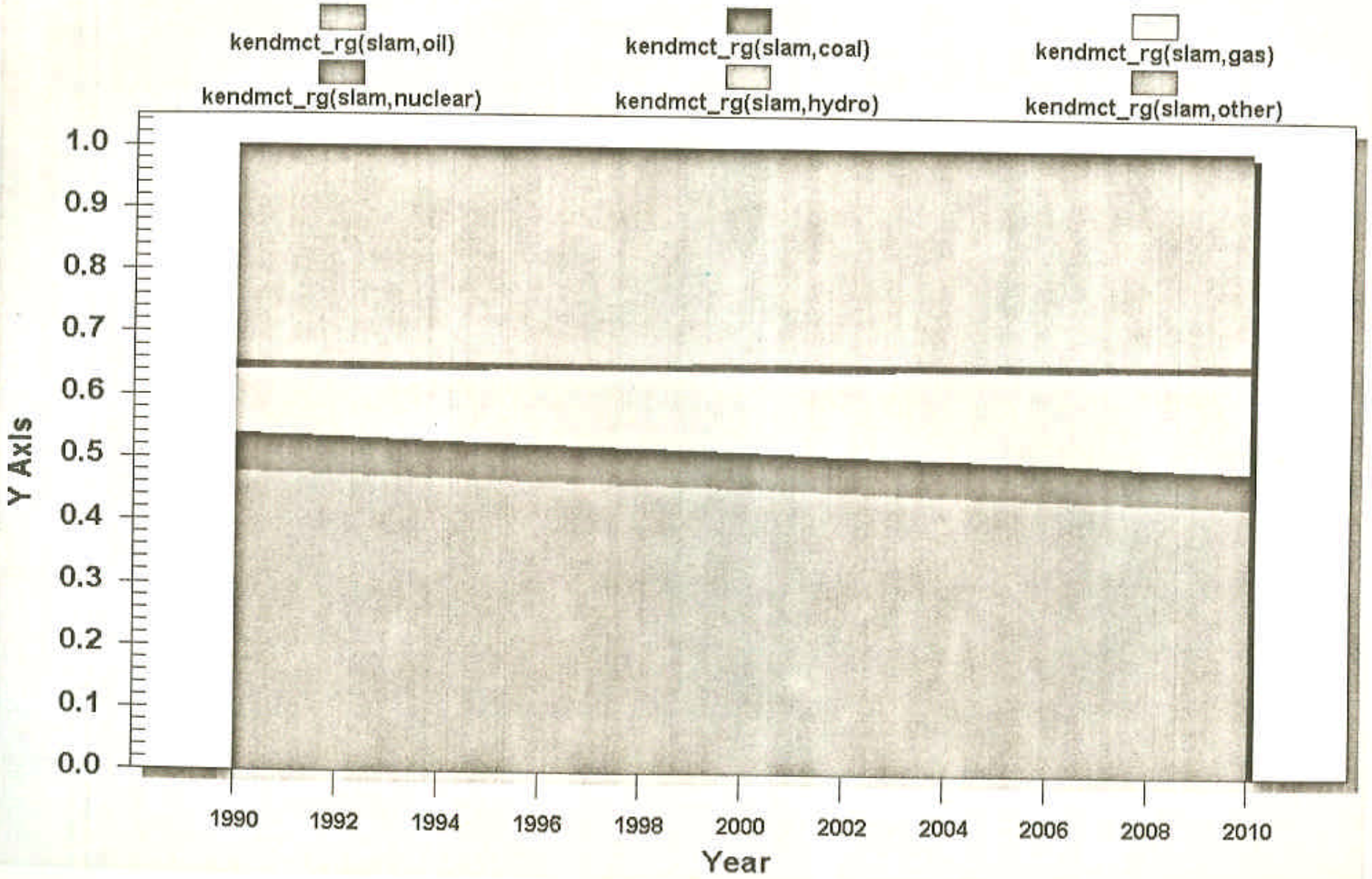
5 equacions

- rendm_dstvc[r][f] = rendm_dstvcd[r][f] * **rendm_dstvcm[r][f]**
- endm_dstvc[r][f] = sendm_dstvc[r][f] * (1 + rend_dstvc[r][f]/100)

and/or

- endm_dstvc_scn[r][f] = endm_dstvc[r][f] * **mendm_dstvc[r][f]**

ENERGY VECTOR OR ENERGY MIX

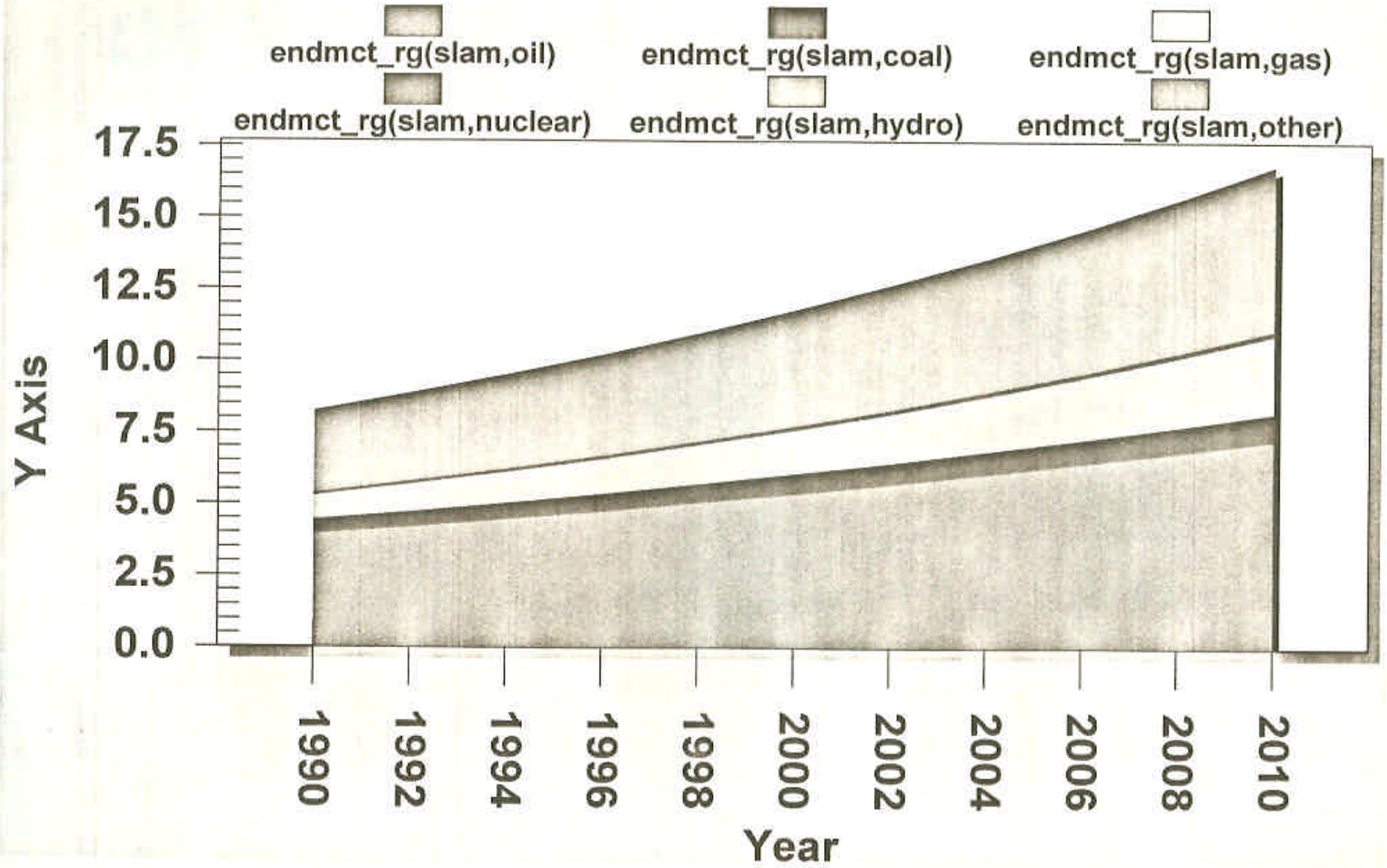


Energy supply by category

- endm_vc[r][f] = endm_dstvc_scn[r][f] * endm_scn[r]

notació desafortunada?

ENERGY SUPPLY TOTAL AND BY CATEGORY



CO2 Emissions

- $em[r] = \sum_{f} co2int[f] * endm\_vc[r][f])$

⇩

Intensitat de carboni (constant física) de cada combustible fòssil (IPCC)

4. LES DADES INICIALS

Dades IDESCAT i ICAEN

CATALUNYA	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mitjana de les mitj.
PIB (Miliards de pesetes=10^3*Milions)											
Aprox.(preus const. 1990)	9513,036	*9741,677*	*9975,814*	*10215,58*	*10461,11*	*10712,53*	*10970*	*11233,66*	*11503,66*	*11780,14*	
Mitjanes variació (%) PIB		3,048257	1,372232	-1,0461	2,72191	3,200008	2,514437	3,345175	3,379456	3,892263	2,403454319
Consum d'energia (ktep)											
	17147,08	17675	17943,7	18221,8	18869	19407,8	20756,1	21181,2			
Intensitat energètica	1,802482	1,814369	1,79872	1,783727	1,803729	1,811691	1,892078	1,885511			
Mitjanes variació intensitat energètica		0,006595	-0,00862	-0,00834	0,011214	0,004414	0,044371	-0,00347			0,659465748
Vector (%) 1990	Energia consumida per categoria (ktep)								Vector (%)1997		
Carbó	*498,3*	480,8	315,9	250	266,1	237,1	297,5	336,4			
0,029057853		-3,51194	-34,297	-20,861	6,44	-10,8982	25,47448	13,07563	0,015962		-3,511146079
Petroli	*9059,24*	9353,7	9512,9	10051,1	10410,2	10944,2	11617,1	11302,5			
0,528285364		3,250382	1,702	5,657581	3,572743	5,129584	6,148462	-2,70808	0,536313		3,250382346
Gas	*1724,663*	1891,3	2013,3	1887,5	1990,8	2215,3	2497,6	3203,85			
0,100572892		9,662034	6,45059	-6,24845	5,472848	11,27687	12,7432	28,27715	0,152025		9,662034022
Nuclear	*5434,846*	5469,8	5430,3	5371	5537,5	5241,2	5628,1	5658,6			
0,31693053		0,643141	-0,72215	-1,09202	3,099981	-5,35079	7,381897	0,541924	0,268505		0,643140732
Altres	*431,3395*	454,9	559,1	457,1	467,8	453,5	615,4	573,1			
0,025153361		5,462174	22,90613	-18,2436	2,340844	-3,05686	35,70011	-6,87358	0,027194		5,462173677
Total	*17148,38*	17650,5	17831,5	18016,7	18672,4	19091,3	20655,7	21074,45			

: dades inicials pel globesight

5. EL CD LLIURAT

CARPETES CD

- 0. Presentacions seminari intern 20-06-01
- 1. Instal.lació Globesight i manuals
- 2. Model i escenaris emissions CO_2
  - **Copiar-les al disc dur!!!**
    - Fitxers de només lectura!!!

1. INSTAL.LACIÓ GLOBESIGHT

- 0. Globesight v_1.3.1 Setup
  - Executar el **Setup.exe**
- 0. Globesight v_1.3.4 after v_1.3.1. Setup
  - Llegir el **Readme.Doc** i fer el que diu
- 1. Manuals
  - Tot el que no recordeu d'avui (instal.lació, utilització –tutorial microGWIM!!!-, desenvolupament,....)

6. GLOBESIGHT

- Obrir el Globesight
- Obrir un model –**Open Project**

2. MODEL I ESCENARIS

- 0.Model escenari BaU sense vistes (View)
  - Preparat per la UE, tots els seus estats individualment (Espanya inclòs) i Catalunya
- 1.Model escenari BaU amb vistes Catalunya
- 2. ...

PASES CLAUS 1

- Anar a la carpeta model-projecte que es volguí obrir i clicar-registrar el fitxer executable que està a la sub-carpeta **debug**

- Obrir el Globesight des de l'escriptori

- Obrir el model-projecte -**Open Project**- en el menú **File** del Globesight
  - **mediamabient2** ← **notació d[illegible]fortunada!**

PASES CLAUS 1

- Veure el sub menú **Entities** (**View**)

- El sub menú **Set** (**View**)

- El sub menú **Run** (**Build**)

- El sub menú **Show** (**View**)

7. ESCENARI BaU

8. ESCENARIS DE FUTUR

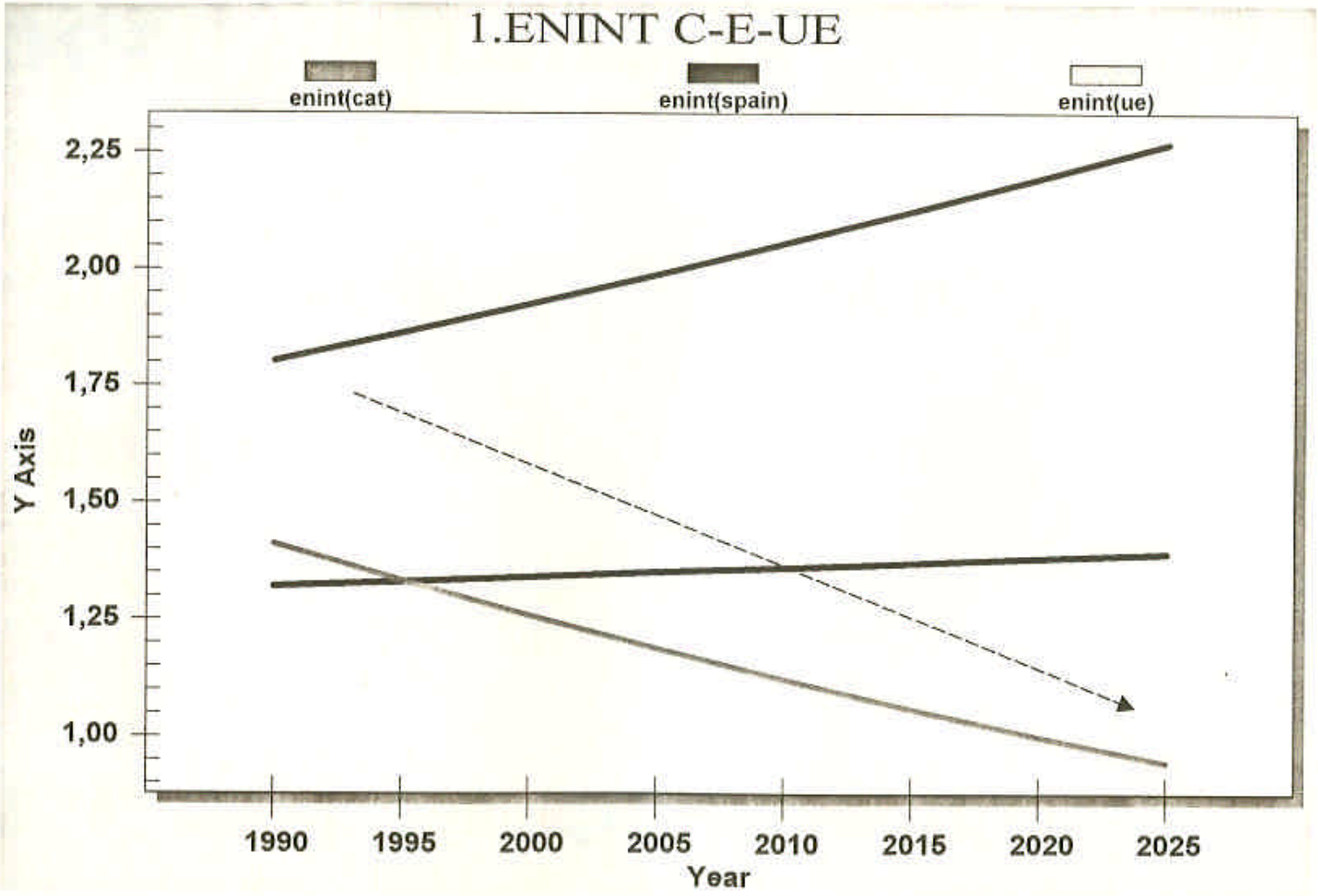
BaU (Bussines as Usual) Scenario

all the multipliers = 1

projectained passed cal cul ator

ESCENARI INTENSITAT ENERGÈTICA

- Construïm un escenari en el qual la intensitat energètica catalana evolucioni de tal manera que a l'any 2025 tingui el mateix valor que es preveu (objectiu) tingui a la Unió Europea en mitjana


1.ENINT C-E-UE
enint(cat)
enint(spain)
enint(ue)
2,25
2,00
1,75
1,50
1,25
1,00
Y Axis
1990
1995
2000
2005
2010
2015
2020
2025
Year

Energy Intensity

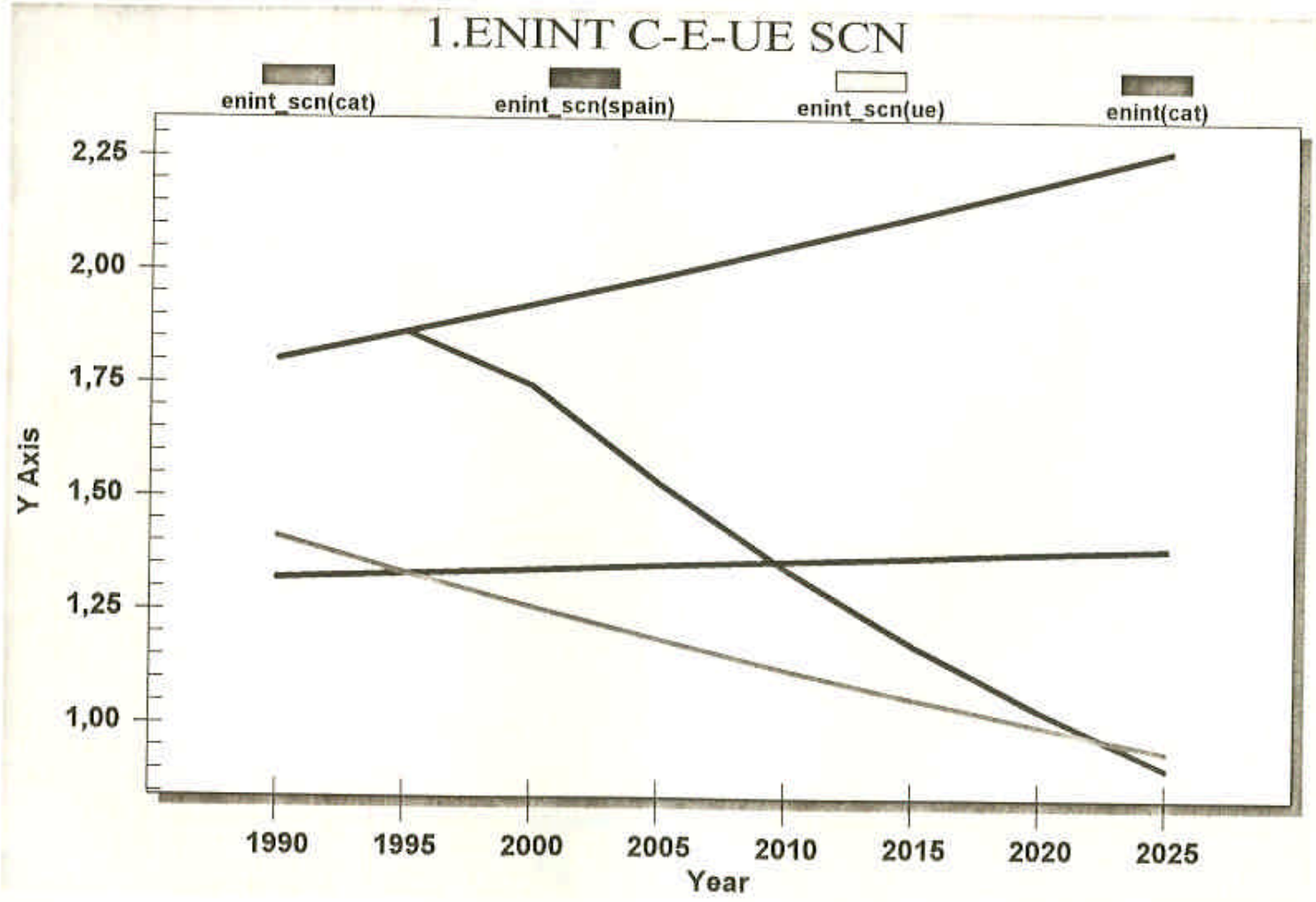
- renint[r] = renintd[r] * **renintm[r]**
- enint[r] = senint[r] * (1 + renint[r]/100)

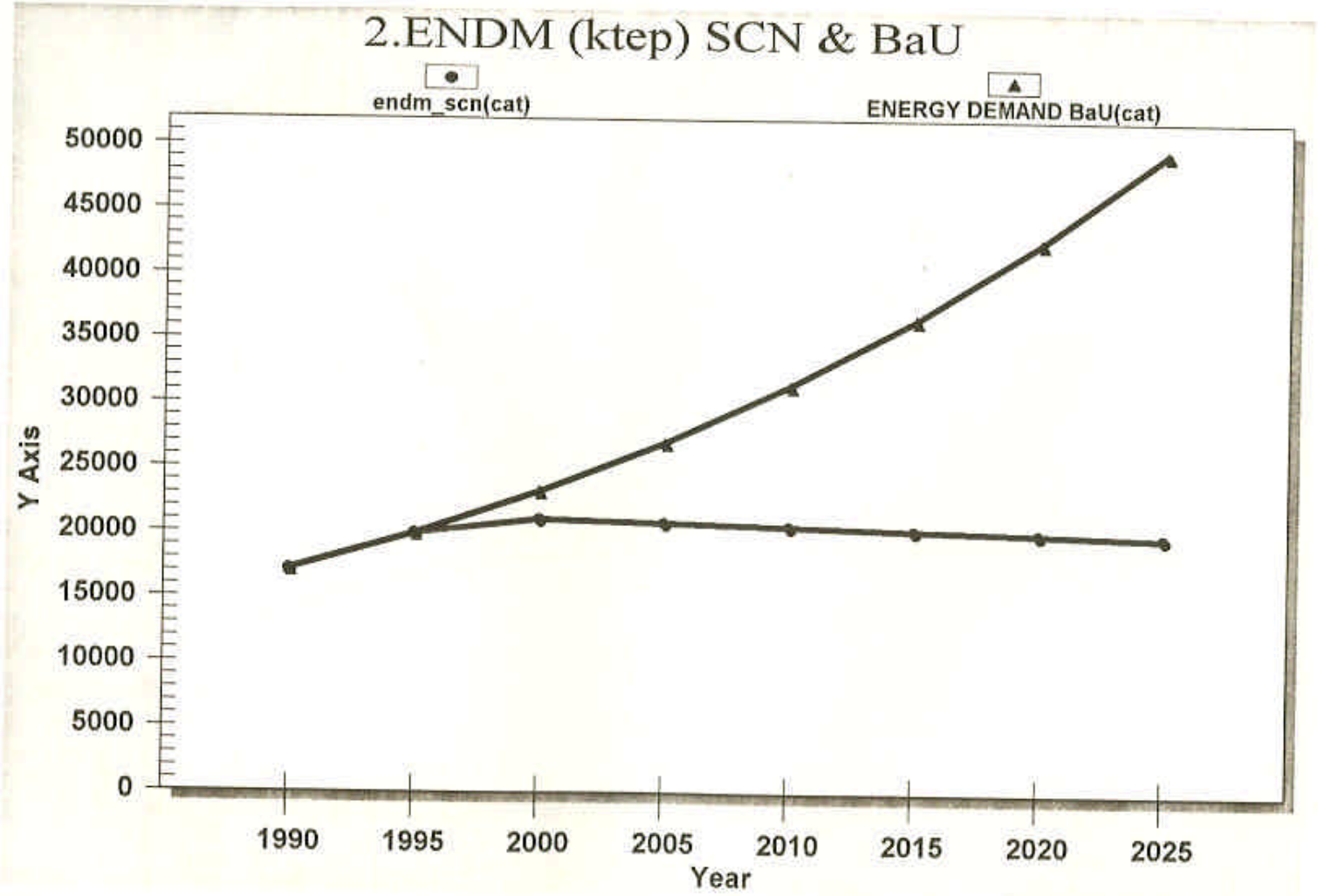
and/or

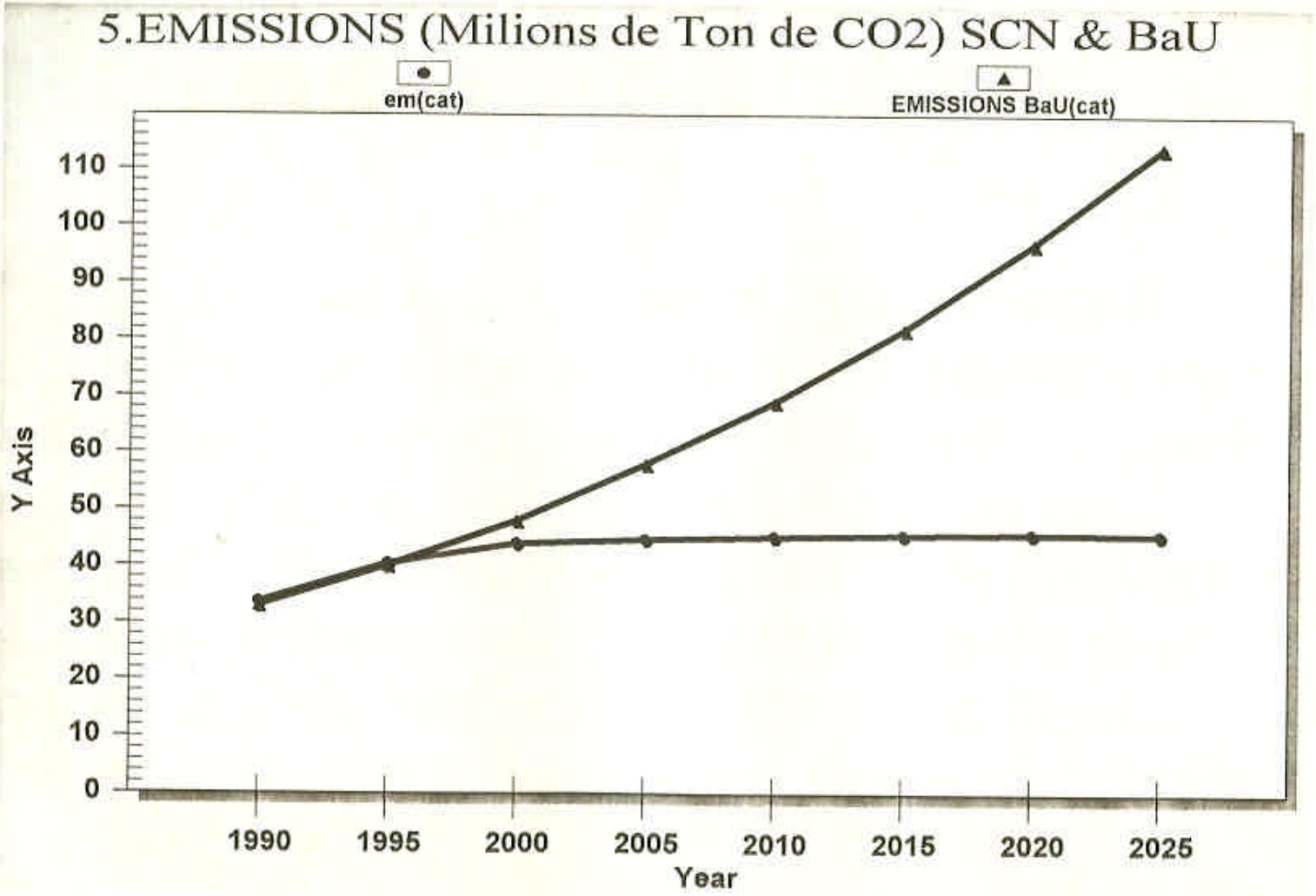
- enint_scn[r] = enint[r] * **menint[r]**

Energy Intensity

- enint_scn[r] = enint[r] * **menint[r]**
- **0,9 = 2,25 * meint[r] : 2025**
- **menint[r] = 0,4 : 2025**


1.ENINT C-E-UE SCN
enint_scn(cat)
enint_scn(spain)
enint_scn(ue)
enint(cat)
2,25
2,00
1,75
1,50
1,25
1,00
Y Axis
1990
1995
2000
2005
2010
2015
2020
2025
Year

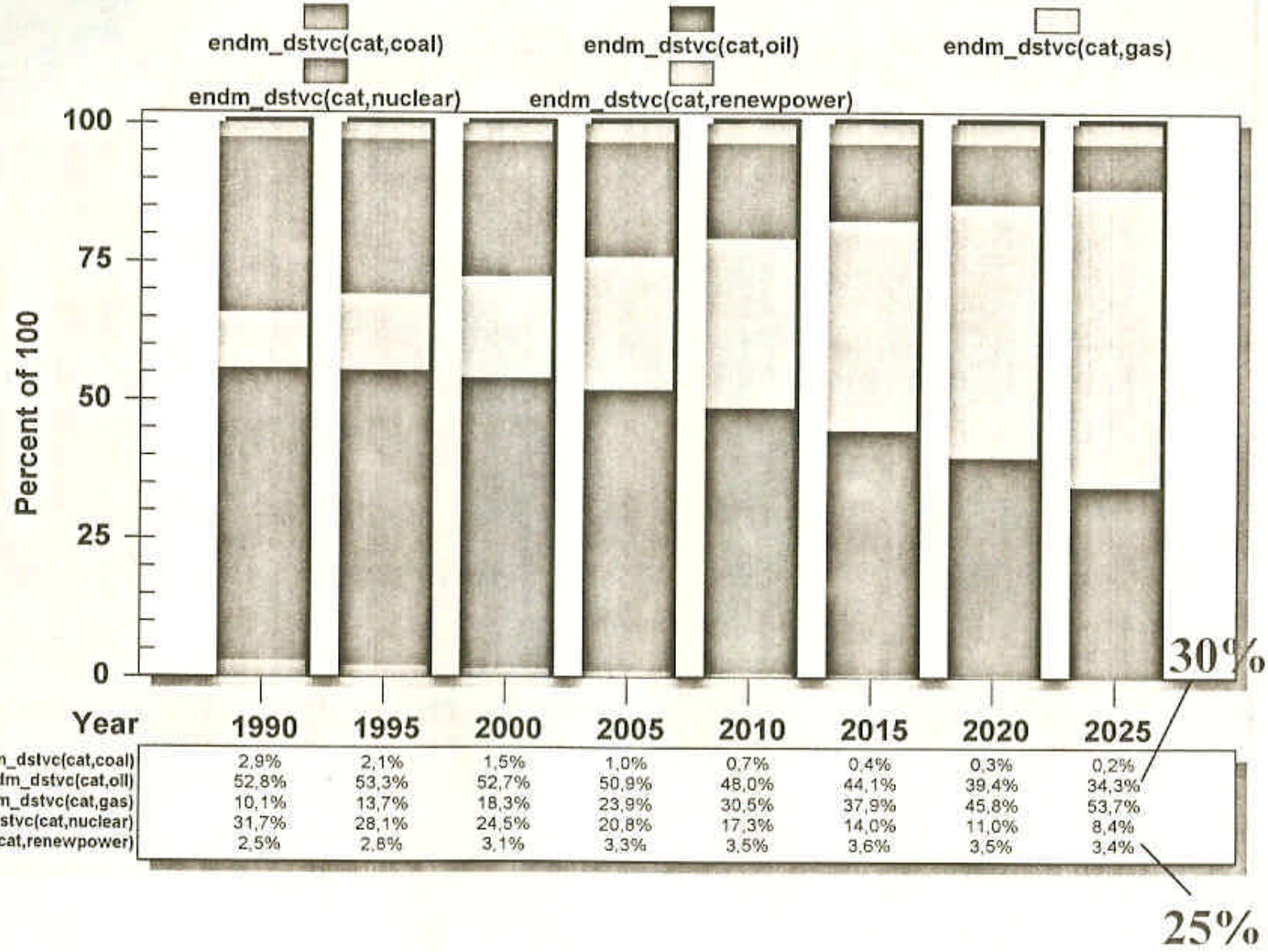

2.ENDM (ktep) SCN & BaU
endm_scn(cat)
ENERGY DEMAND BaU(cat)
Y Axis
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1990
1995
2000
2005
2010
2015
2020
2025
Year


5.EMISSIONS (Milions de Ton de CO2) SCN & BaU
em(cat)
EMISSIONS BaU(cat)
Y Axis
110
100
90
80
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020
2025
Year

ESCENARI VECTOR ENERGÈTIC

- Construïm un escenari en el qual el vector energètic català evolucioni de tal manera que a l'any 2025 les energies renovables en suposin un 25% (objectiu de la Unió Europea en mitjana), tot acceptant que un 30% del vector segueixi corresponent al petroli (doncs és el mínim que de moment es considera lligat indefectiblement al transport mitjançant aquest combustible)

3.ENDM_DSTVC



Year	1990	1995	2000	2005	2010	2015	2020	2025
endm_dstvc(cat,coal)	2,9%	2,1%	1,5%	1,0%	0,7%	0,4%	0,3%	0,2%
endm_dstvc(cat,oil)	52,8%	53,3%	52,7%	50,9%	48,0%	44,1%	39,4%	34,3%
endm_dstvc(cat,gas)	10,1%	13,7%	18,3%	23,9%	30,5%	37,9%	45,8%	53,7%
endm_dstvc(cat,nuclear)	31,7%	28,1%	24,5%	20,8%	17,3%	14,0%	11,0%	8,4%
endm_dstvc(cat,renewpower)	2,5%	2,8%	3,1%	3,3%	3,5%	3,6%	3,5%	3,4%

Energy Category or Vector or Mix (Coal, Oil, Gas, Nuclear, Other -Hydro,...-: f)

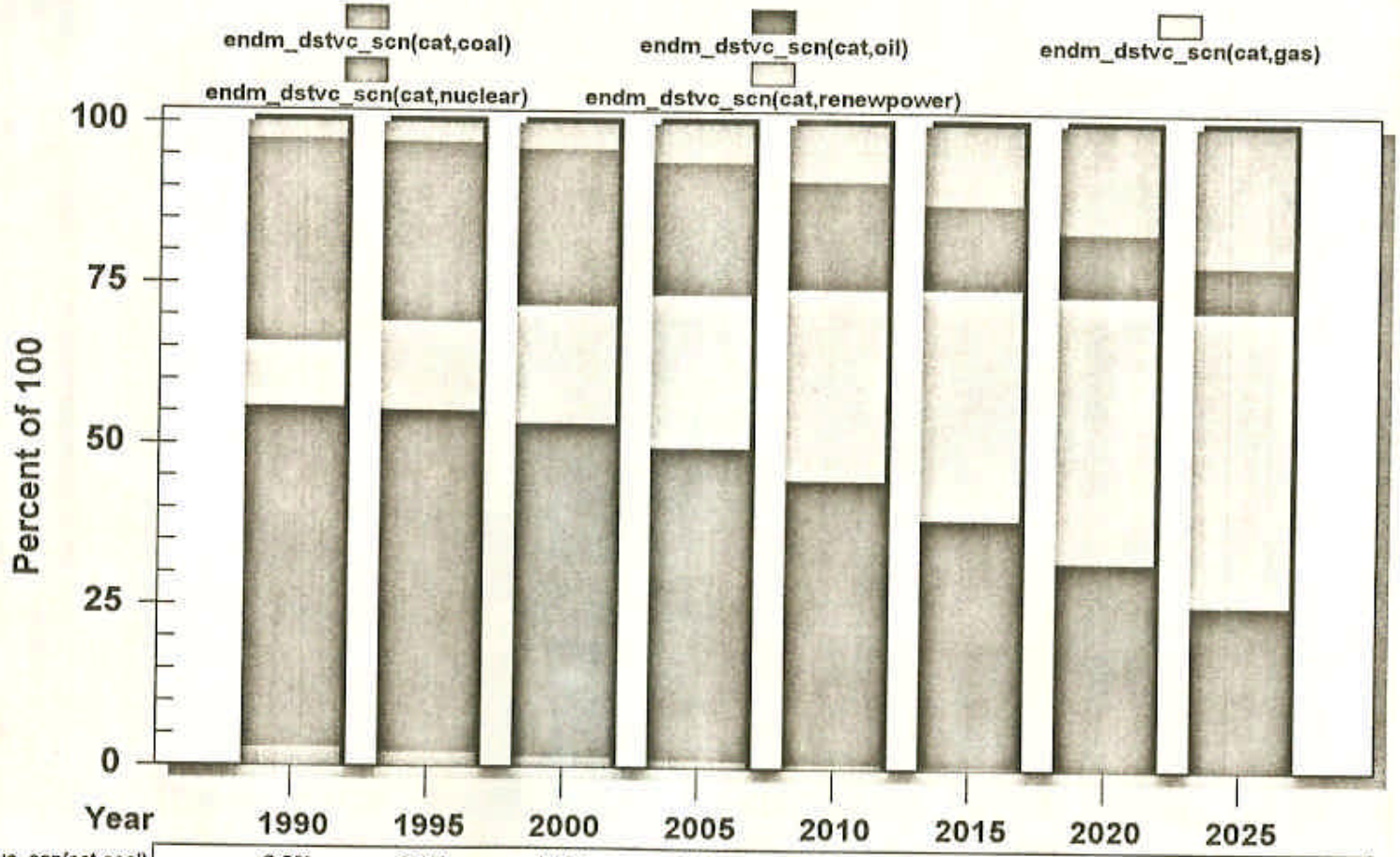
5 equacions

- endm_dstvc_scn[r][f] = endm_dstvc[r][f] * **mendm_dstvc[r][f]**

- **25% = 3,4% * mendm_dstvc[r][other] : 2025**
- **mendm_dstvc[r][other] = 7,4 : 2025**

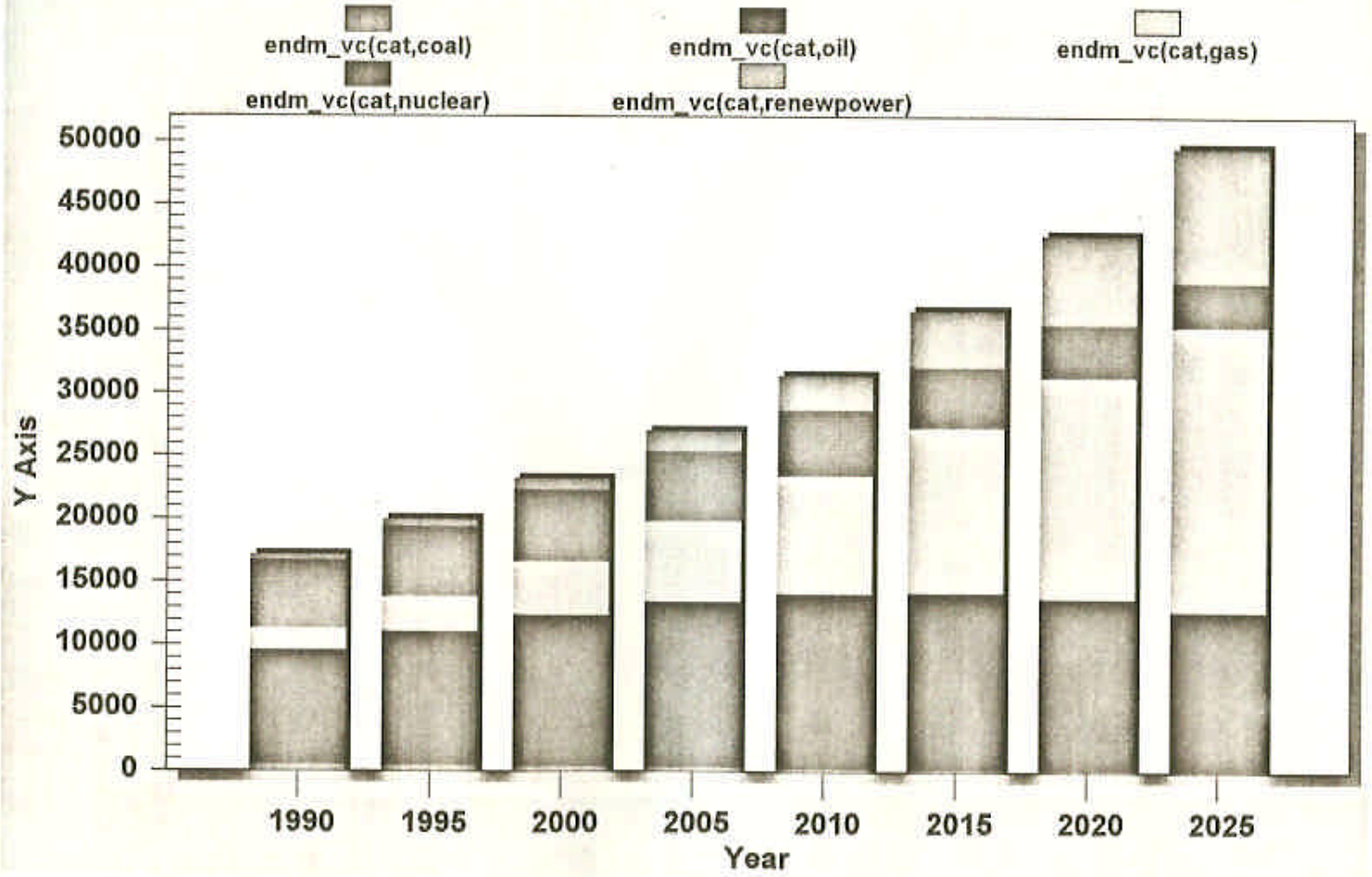
- **30% = 34,3% * mendm_dstvc[r][oil] : 2025**
- **mendm_dstvc[r][oil] = 0,875 : 2025**

3.ENDM_DSTVC SCN

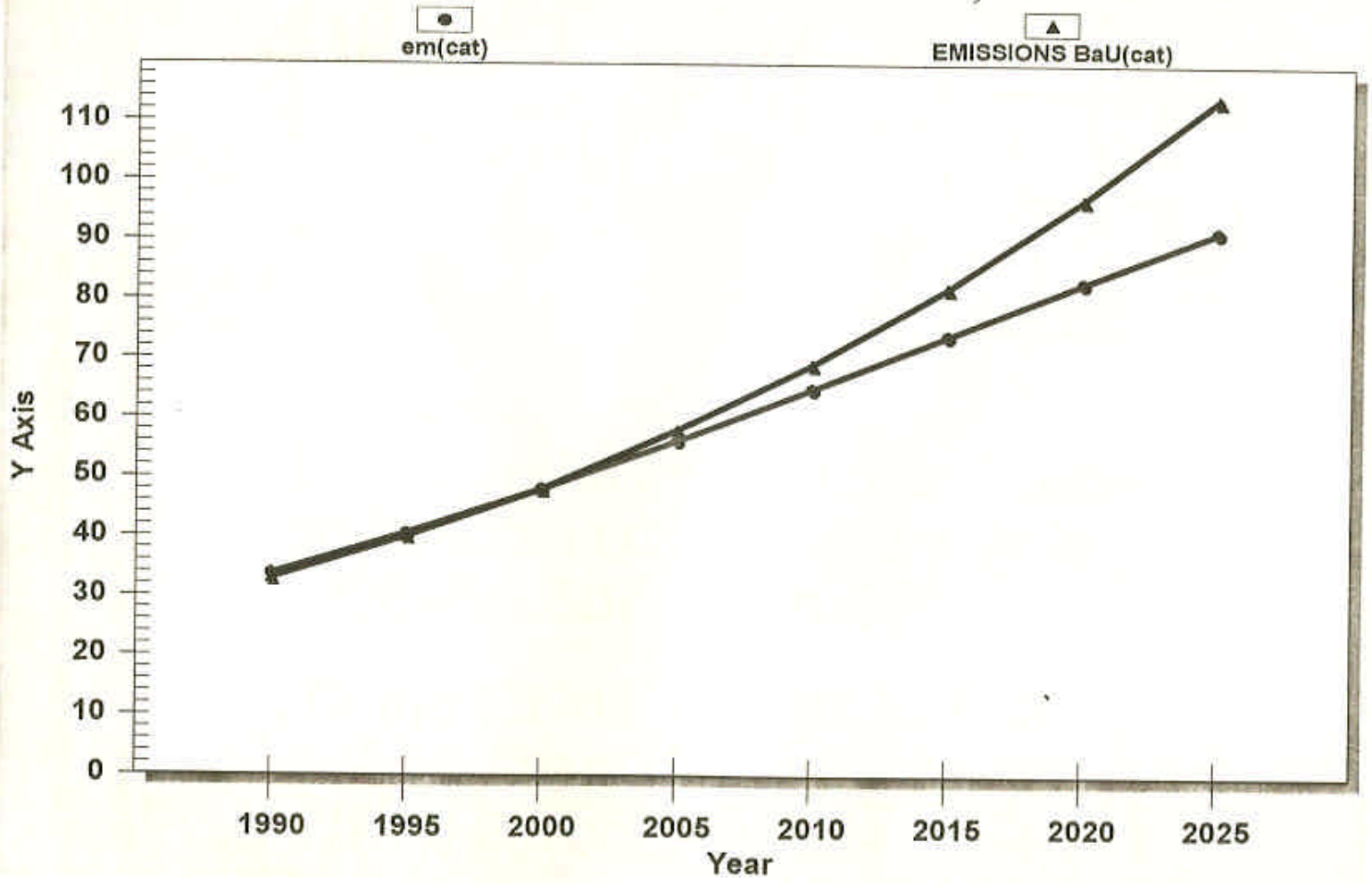


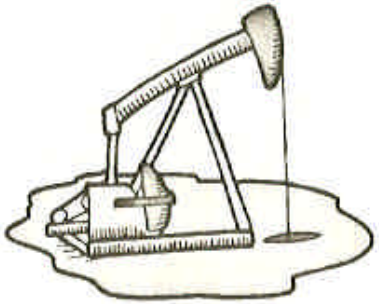
	1990	1995	2000	2005	2010	2015	2020	2025
endm_dstvc_scn(cat,coal)	2,9%	2,1%	1,5%	1,0%	0,7%	0,4%	0,3%	0,1%
endm_dstvc_scn(cat,oil)	52,8%	53,3%	51,9%	48,7%	44,1%	38,3%	31,9%	25,5%
endm_dstvc_scn(cat,gas)	10,1%	13,7%	18,3%	23,8%	29,8%	35,8%	41,3%	45,7%
endm_dstvc_scn(cat,nuclear)	31,7%	28,1%	24,5%	20,7%	16,9%	13,2%	9,9%	7,1%
endm_dstvc_scn(cat,renewpower)	2,5%	2,8%	3,8%	5,9%	8,6%	12,2%	16,6%	21,5%

4.ENDM BY SECTOR



5.EMISSIONS (Milions de Ton de CO2) SCN & BaU





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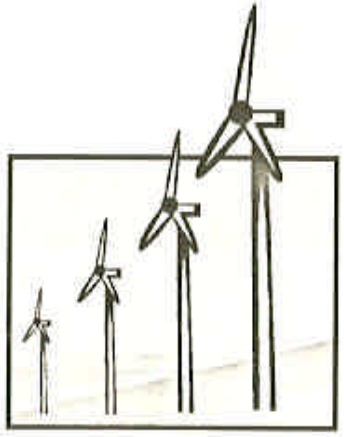

El seminari ha estat preparat pels professors i col·laboradors de la **GENIe European Office:**

Diana Cayuela; Juan José de Felipe; Juan Martínez; Bernat Palau; Bàrbara Sureda; Josep Xercavins

CÀTEDRA UNESCO A LA UPC

TECNOLOGIA,
DESENVOLUPAMENT SOSTENIBLE,
DESEQUILIBRIS I CANVI GLOBAL

"L'Escola Industrial de Terrassa"
Colom, 1 · 08222 TERRASSA
Tel. 00 34 93 739 80 50
Fax: 00 34 93 739 80 32
sostenible@catunesco.upc.es
www.catunesco.upc.es

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