The Impact of IT Investment on the Energy Situation

Japan and U.S. Comparison in 2010

Yasuhiro Murota (Shonan Econometrics)

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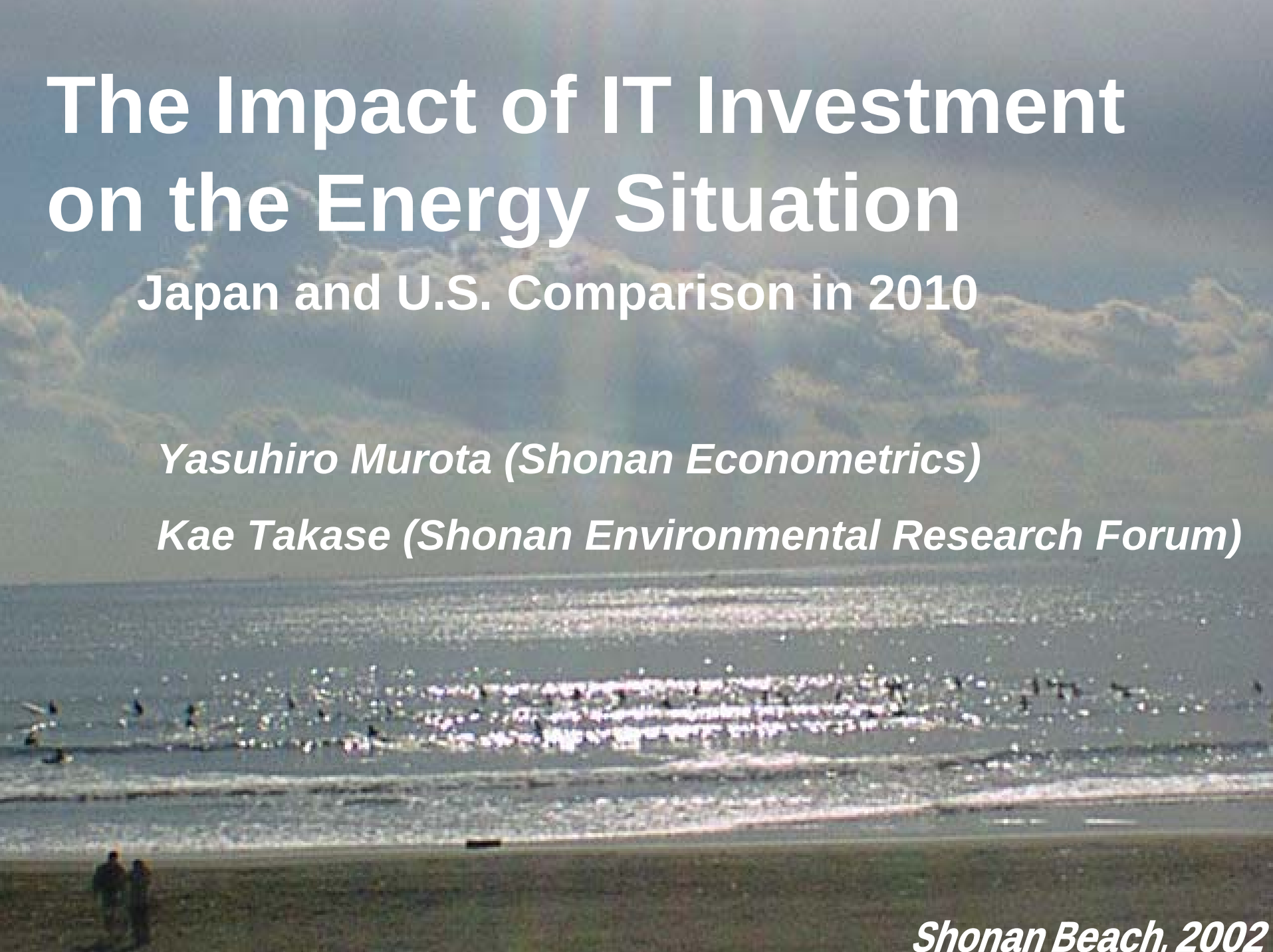


Shonan Beach, 2002

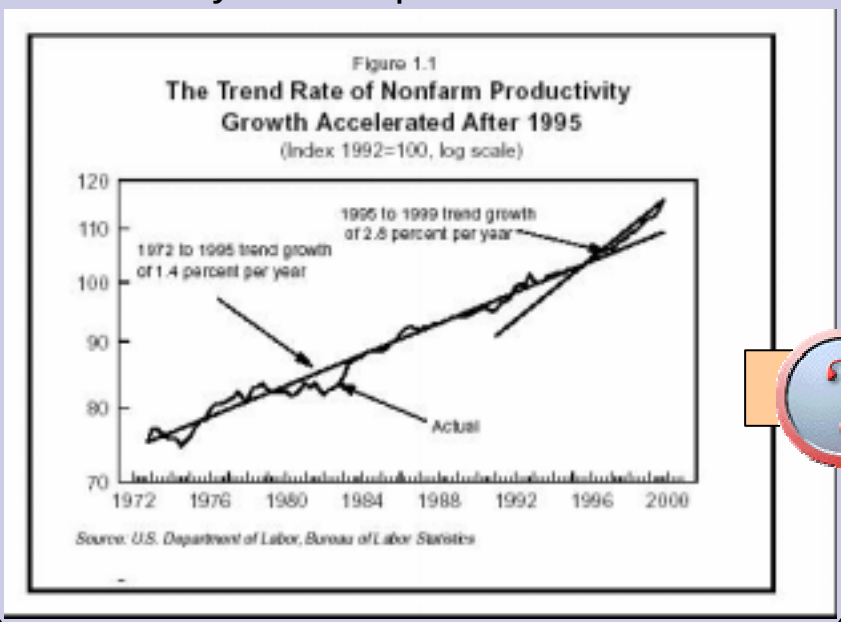
Socio-economic Impact of IT

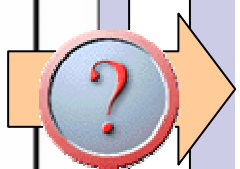
- Modern semiconductor-based electronics technologies fit Bresnahan and Trajtenberg's definition of a "general purpose technology (GPT)"

Delong & Summers (Aug. 2001)

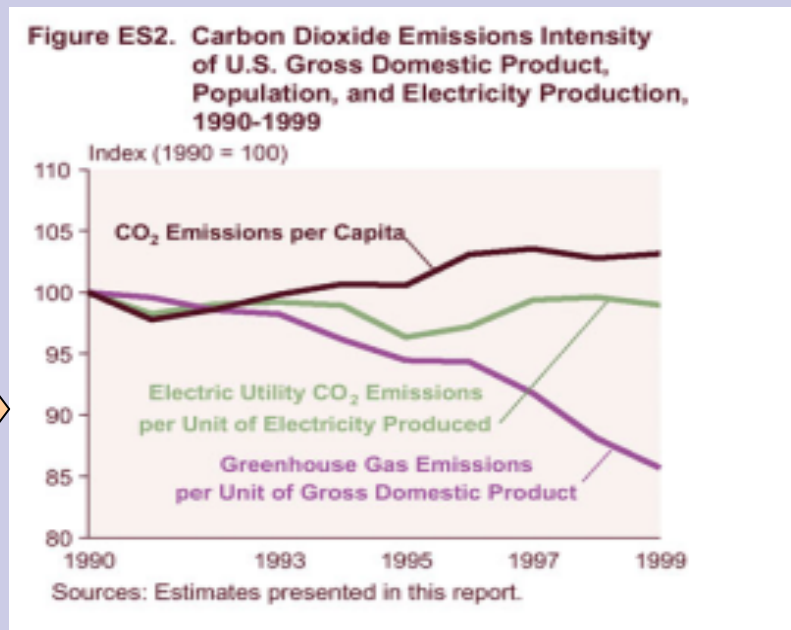
Productivity ↑ in late 1990's

By U.S. Department of Commerce





CO_2 intensity ↓ in late 1990's



By USEPA

Purpose of this study

- The IT revolution impact on
  - Volume of energy demand
  - Structure of energy supply & demand
  - Energy/CO2 intensity → Implication

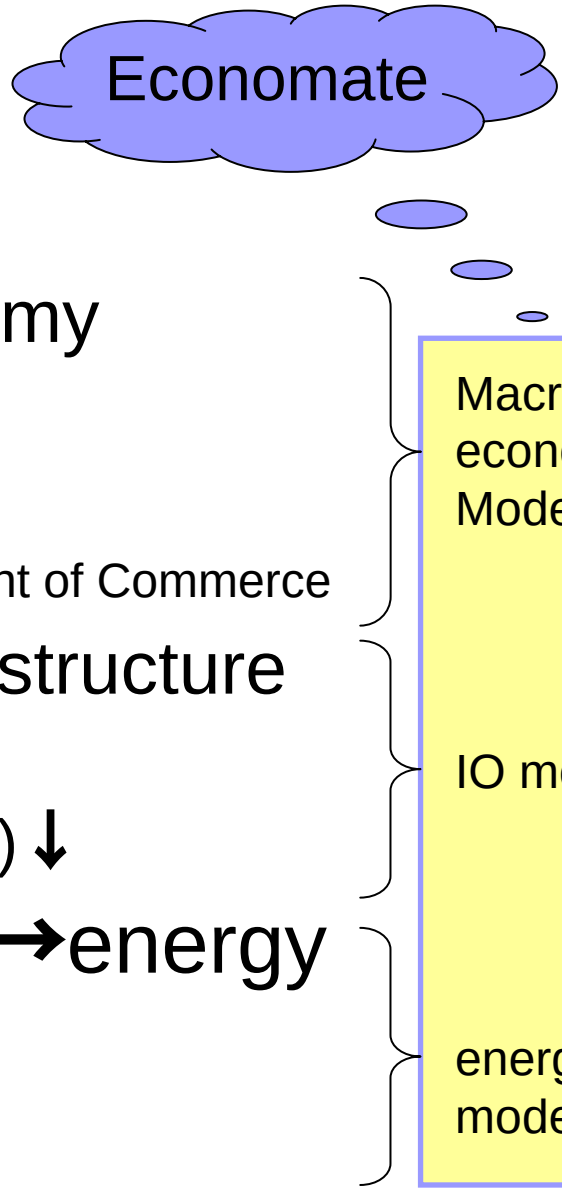
Divergent views on IT impact

- Impact on economy: “Productivity paradox”

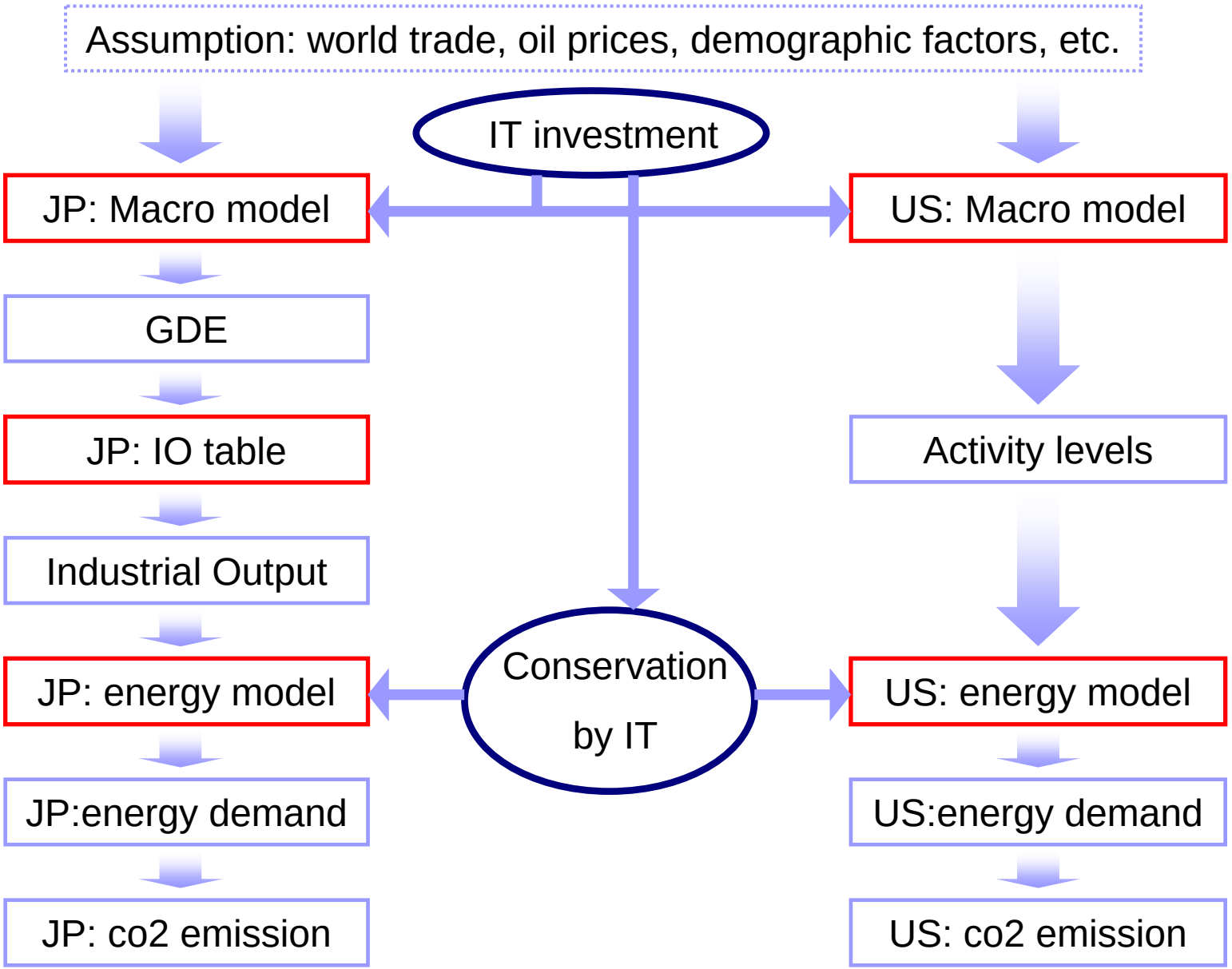
  See, for example, Solow(1987), Gordon(2000), David(2000)

- Impact on energy
  - Study has just begun:
    - CECS(1999), Laitner et. al.(2000), Kawamoto et. al.(2000), Murota(2001)
  - Bottom up & Top down
    - Bottom up: effect of individual technologies
    - Top down: macroeconomic impacts of IT investment

Methodology



- IT impact on economy
  - IT investment →macro economy
    - GDP growth rate ↑
    - Prices ↓
    - Unemployment ↓ by US Department of Commerce
  - Macro economy → Industrial structure
    - Electronics ↑
    - Old economy (Iron & Steel, etc.) ↓
- Macro & Industrial structure→energy
  - Economic impact→energy
  - Technological impact→energy


Assumption: world trade, oil prices, demographic factors, etc.
IT investment
JP: Macro model
US: Macro model
GDE
JP: IO table
Activity levels
Industrial Output
JP: energy model
Conservation by IT
US: energy model
JP:energy demand
US:energy demand
JP: co2 emission
US: co2 emission

BAU, Japan (Assumption)

World trade	00/85: 6.9%/y 10/00: 3.1%/y	
Oil price	2010: 23.4$/bbl	USEIA(2001.11)
IT investment	10/00: 6%/y	

BAU, Japan result (Macro Economy)

	2000/1995	2010/2000
Economic growth	1.1%/y	1.8%/y
WPI	-0.6%/y	-0.9%

	2000	2010
Unemployment	4.7%	6.9%
Exchange rate	111 yen/$	135 yen/$

Japanese economy will recover in 2000's, but not in the way ???

BAU, Japan result (Input-Output Model)

	2010/2000
Gross output	1.9%/y
electronics & communication	4.5%/y
communication and broadcast	4.0%/y
Business services	3.5%/y
Agriculture	-0.3%/y
Mining	-1.4%/y

Top 3

bottom 2

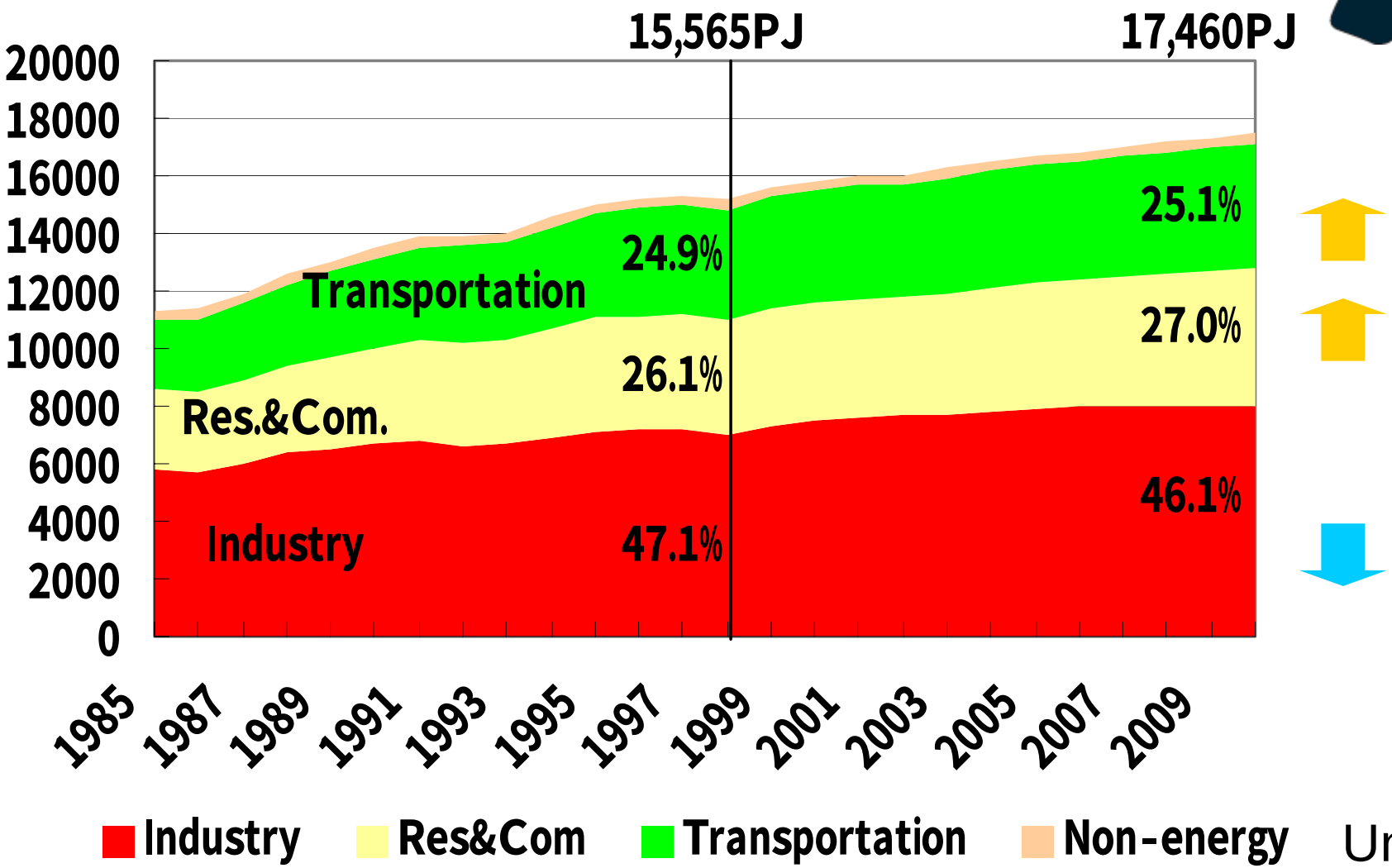
Even in the BAU case, leading industries is electronics, communication etc. (structural change toward IT economy)

BAU, Japan: input to energy model (from Macro & IO model)

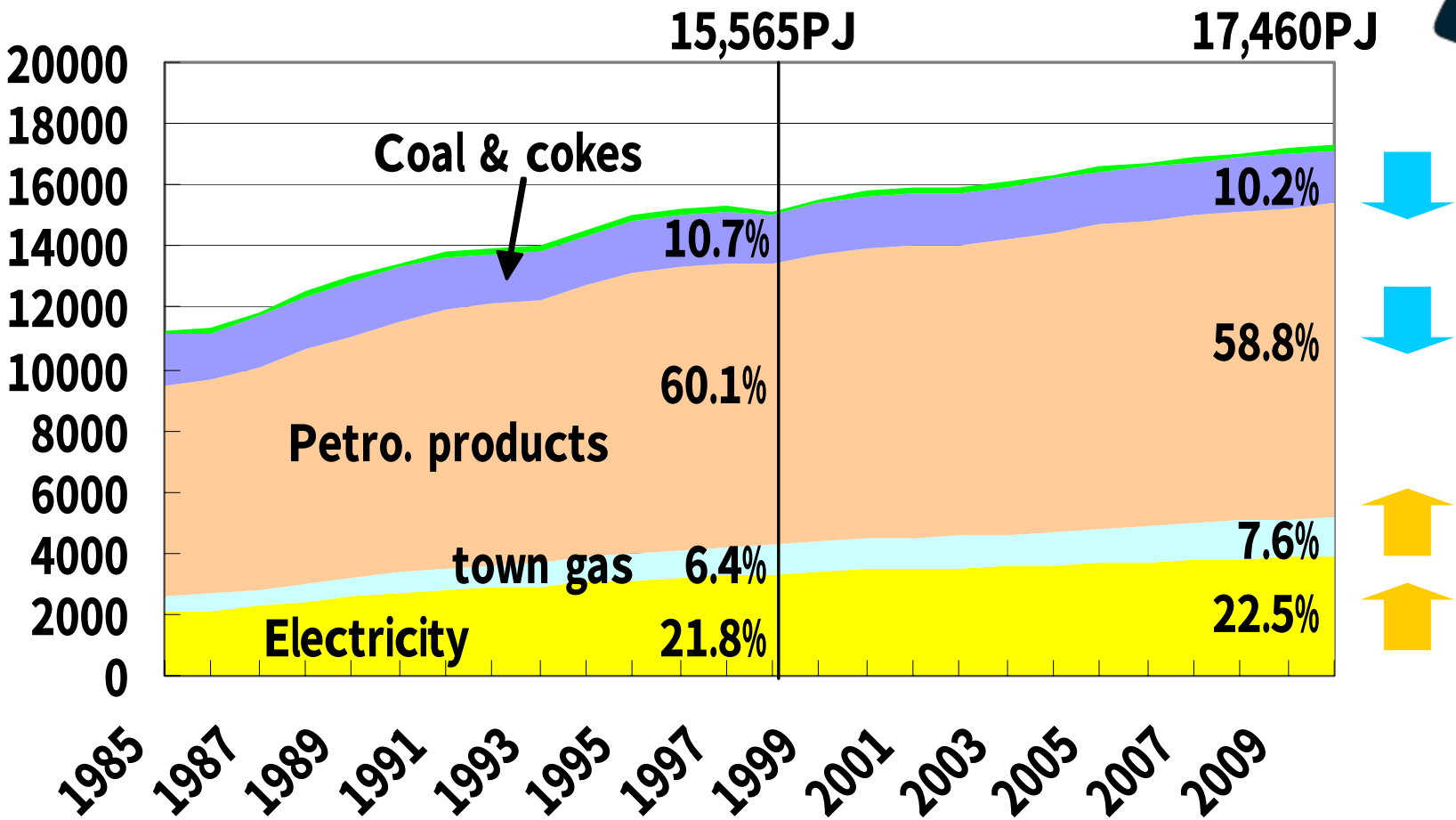
	1999	2010
Steel production	980 Mton	920 Mton
Cement production	806 Mton	730 Mton
Ethylene production	77 Mton	85 Mton
Commercial floorspace	1.6 Gm3	1.9 Gm3
Freight transportation	559 Gton-km	603 Gton-km
Passenger transportation	1.4 Tpas.-km	1.7 Tpas.-km

Industries of high energy intensity ↓

Final Energy Consumption by Sector

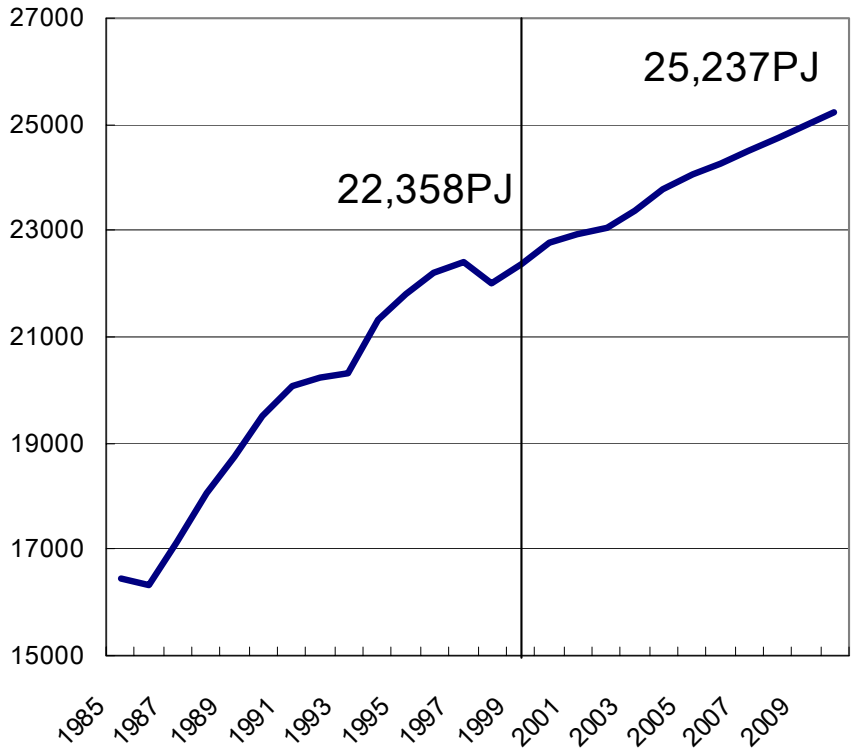


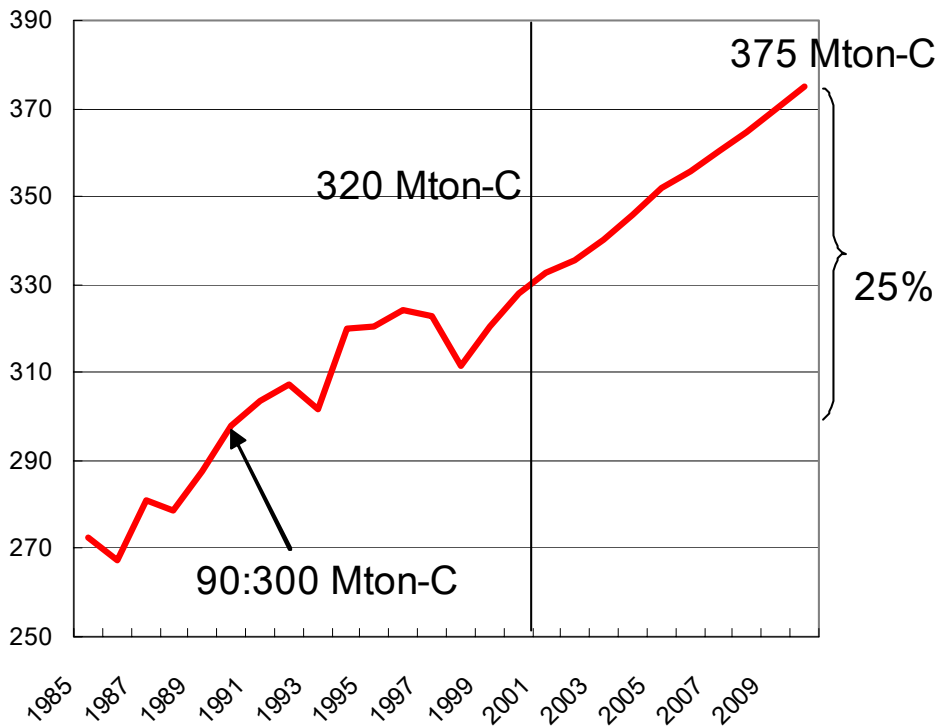
Final Energy Consumption by Energy



Unit: PJ

Primary energy supply & CO2





Primary energy demand:

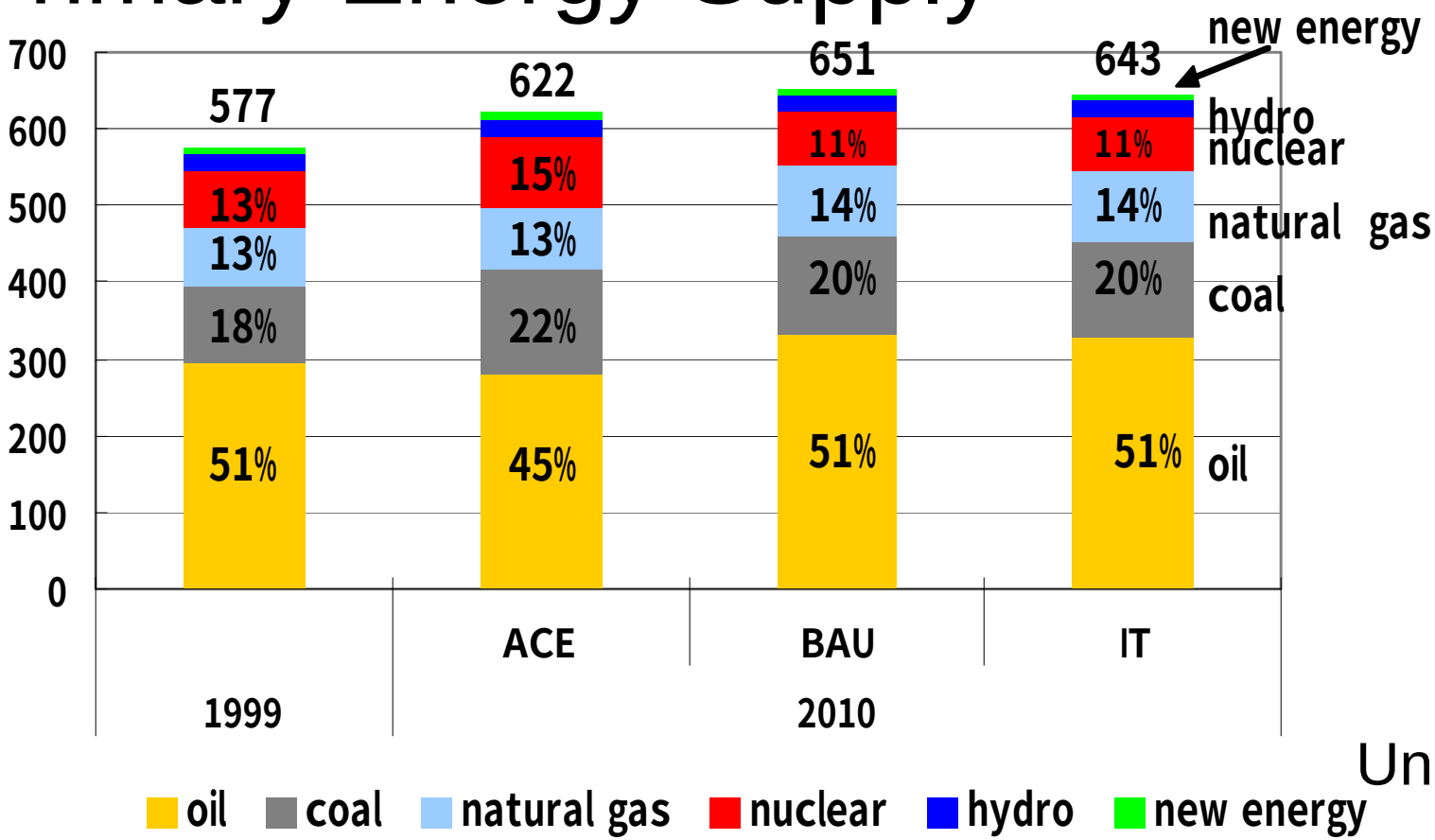
1999: 22,358 PJ→2010: 25,237 PJ

CO2 Emission

1999: 320 Mton-C

→2010: 375 Mton-C (25% ↑from 90)

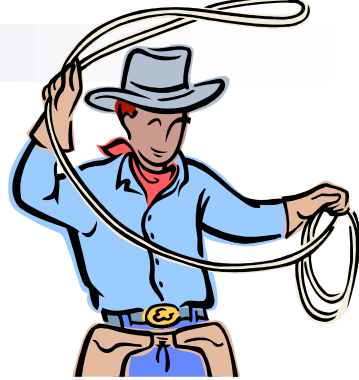
Comparison with gov. outlook
Primary Energy Supply



Unit: 10^6kL

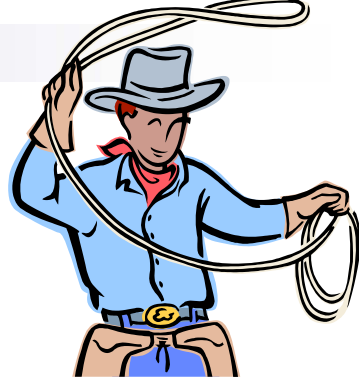
- Government: higher share of coal & nuclear
- This study: higher share of oil ←lower oil prices (IEA)

BAU, USA (Assumption)



World trade	00/85: 6.9%/y 10/00: 3.1%/y	*Same with Japan*
Oil price	2010: 23.4$/bbl	USEIA(2001.11) *Same with Japan*
IT investment	**10/00: 10%/y**	

BAU, USA result (Macro Economy)

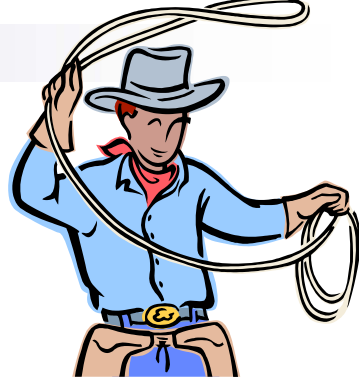


	1999/1987	2010/2000
Economic growth	3.2%/y	2.8%/y
WPI	2.0%/y	1.3%

	1999	2010
Unemployment	4.2%	4.8%

US economy will grow at moderate speed.*****

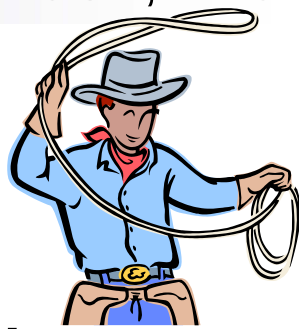
BAU, USA: (equation in the energy model) energy related activity level

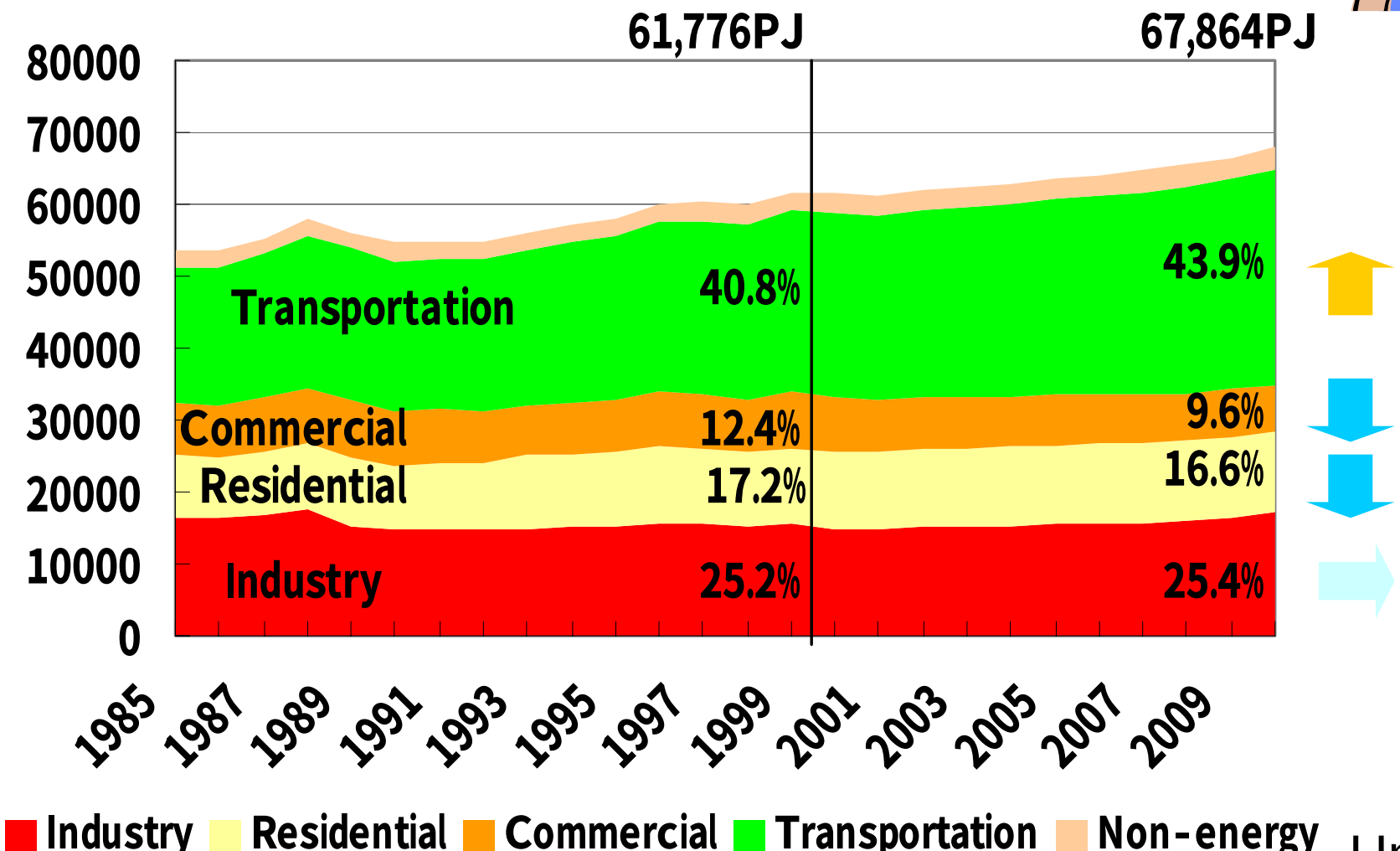


	1999	2010
Car hold	218 mil.	254 mil.
Steel production	97 mil.ton	120 mil.ton
Commercial floorspace	67.3 bil.m^2	61.1 bil.m^2

※Figure for estimated commercial floorspace in 2010 might seem low, but this is because the equation include negative effect. Neverthless, the data itself needed further improvement.

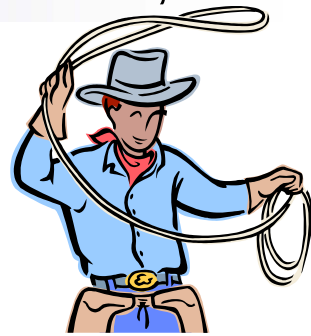
Final Energy Consumption by Sector

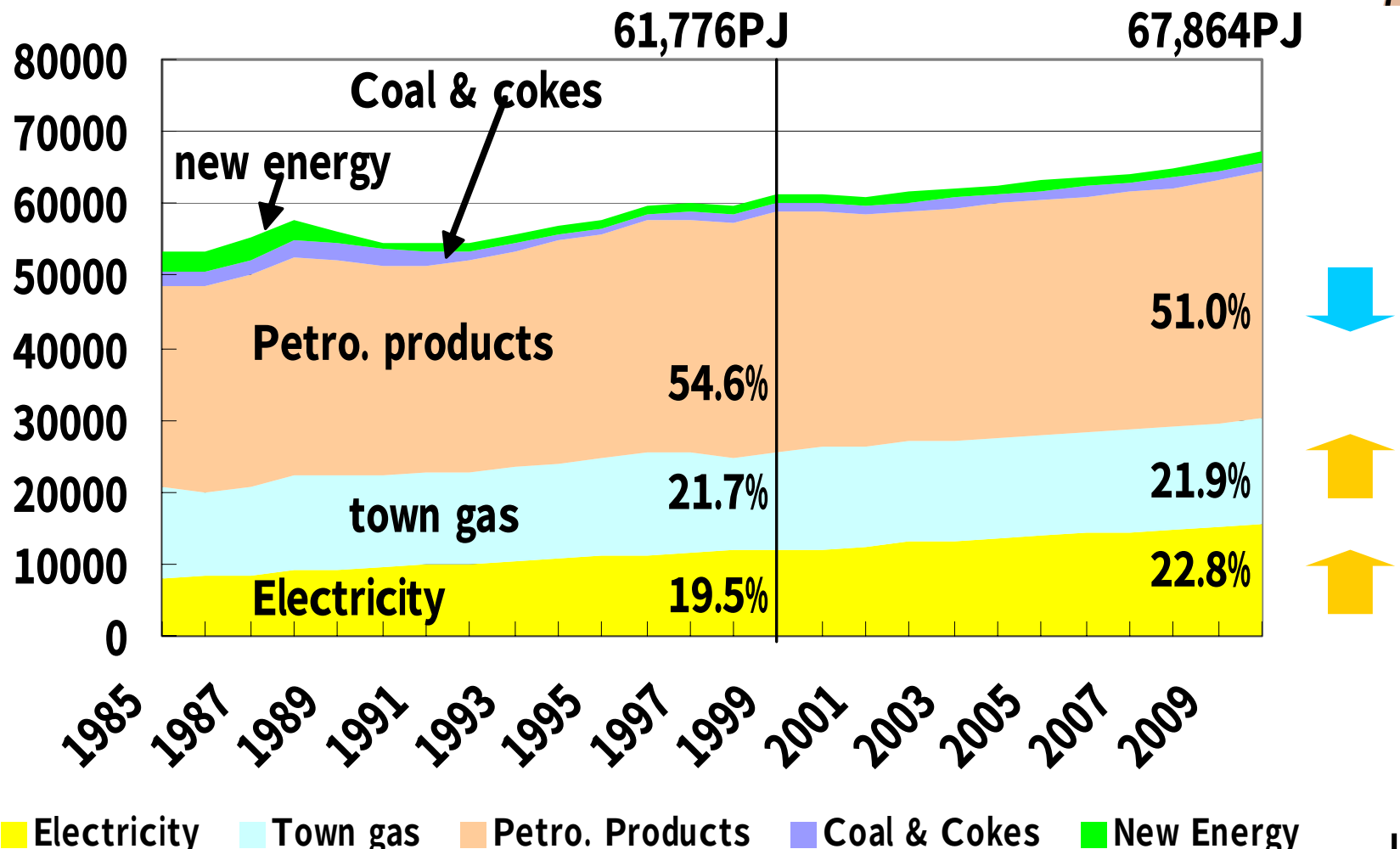




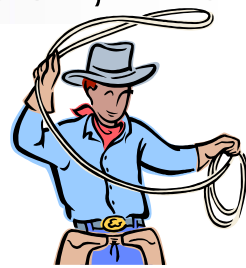
Unit: PJ

Final Energy Consumption by Energy

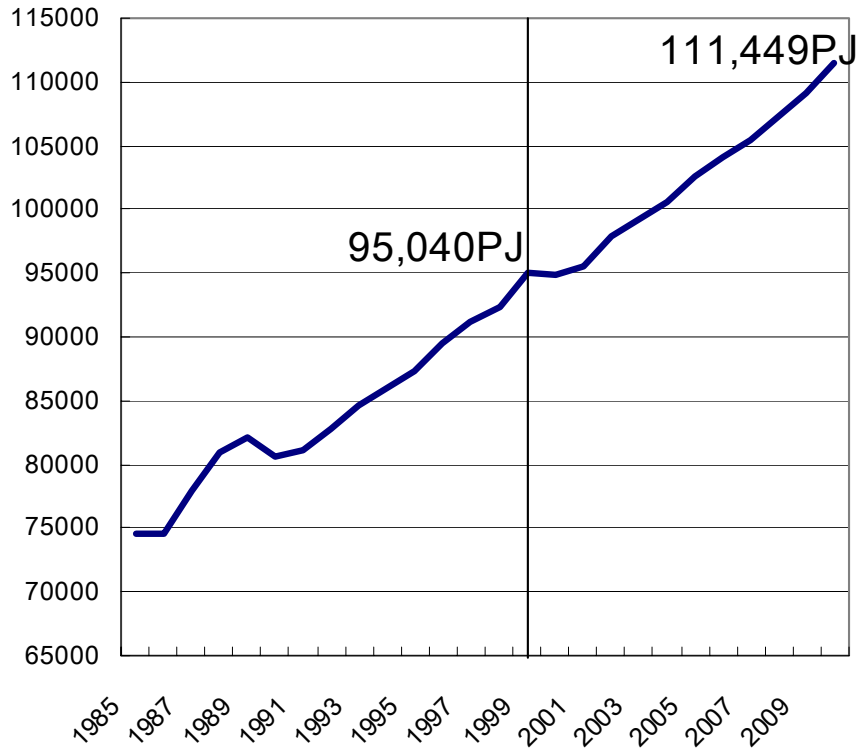


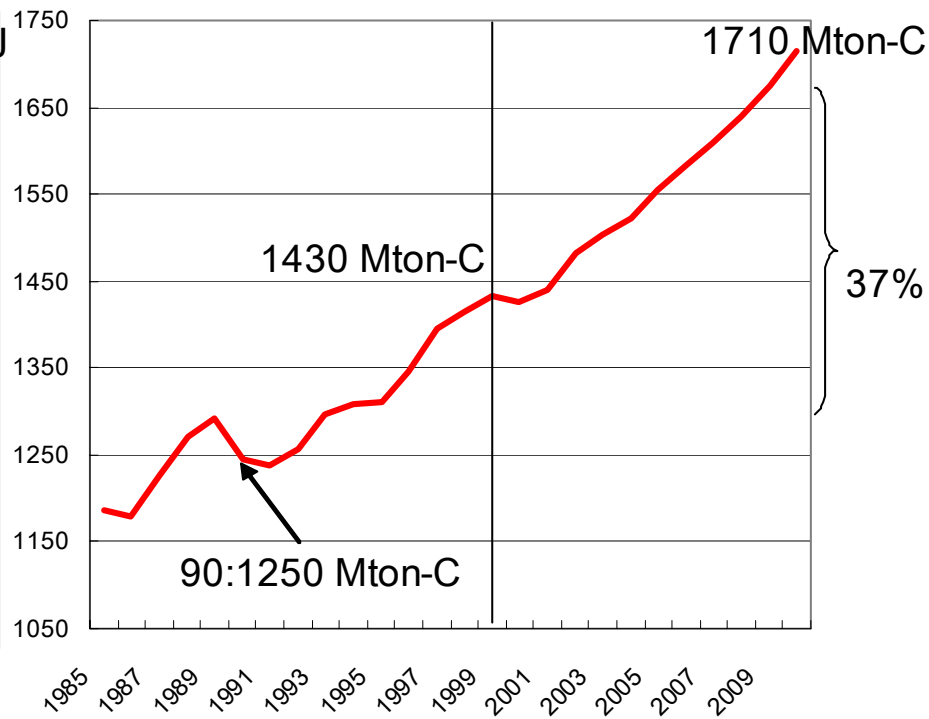


Unit: PJ



Primary energy supply & CO2





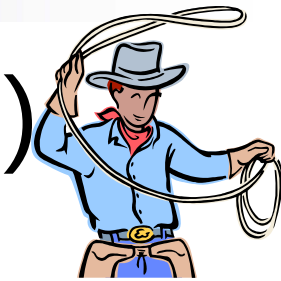
Primary energy demand:

1999: 95,040 PJ→2010: 111,449 PJ

CO2 Emission

1999: 1430 Mton-C

→2010: 1710 Mton-C (37% ↑ from 90)



Comparison with gov. outlook (1) Final energy demand

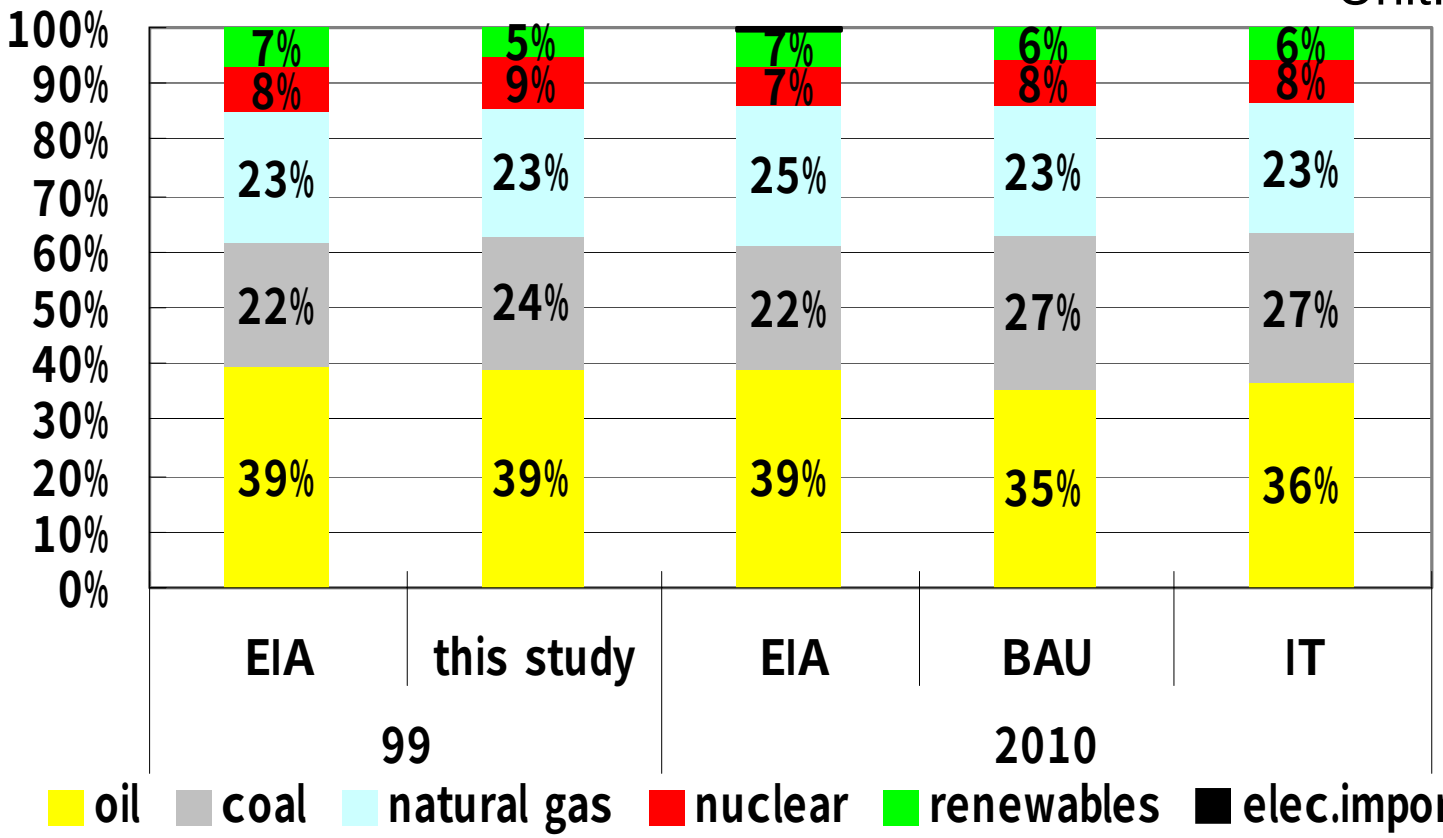
Unit: %/year

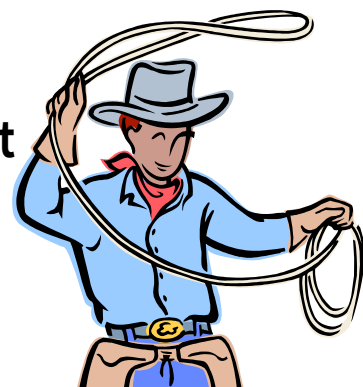
	Growth rate 2010/1999	
	EIA	this study
Industry	1.1	0.9
Residential	1.4	0.5
Commercial	2.3	-1.5
Transportation	2.2	1.5

※ Our study shows lower growth rate for “Residential”, “Commercial”, and “Transportation” sectors. Big difference in commercial growth rate is because we consider influence of IT investment in the estimation of commercial floorspace.

Comparison with gov. outlook (2)
Primary Energy Supply

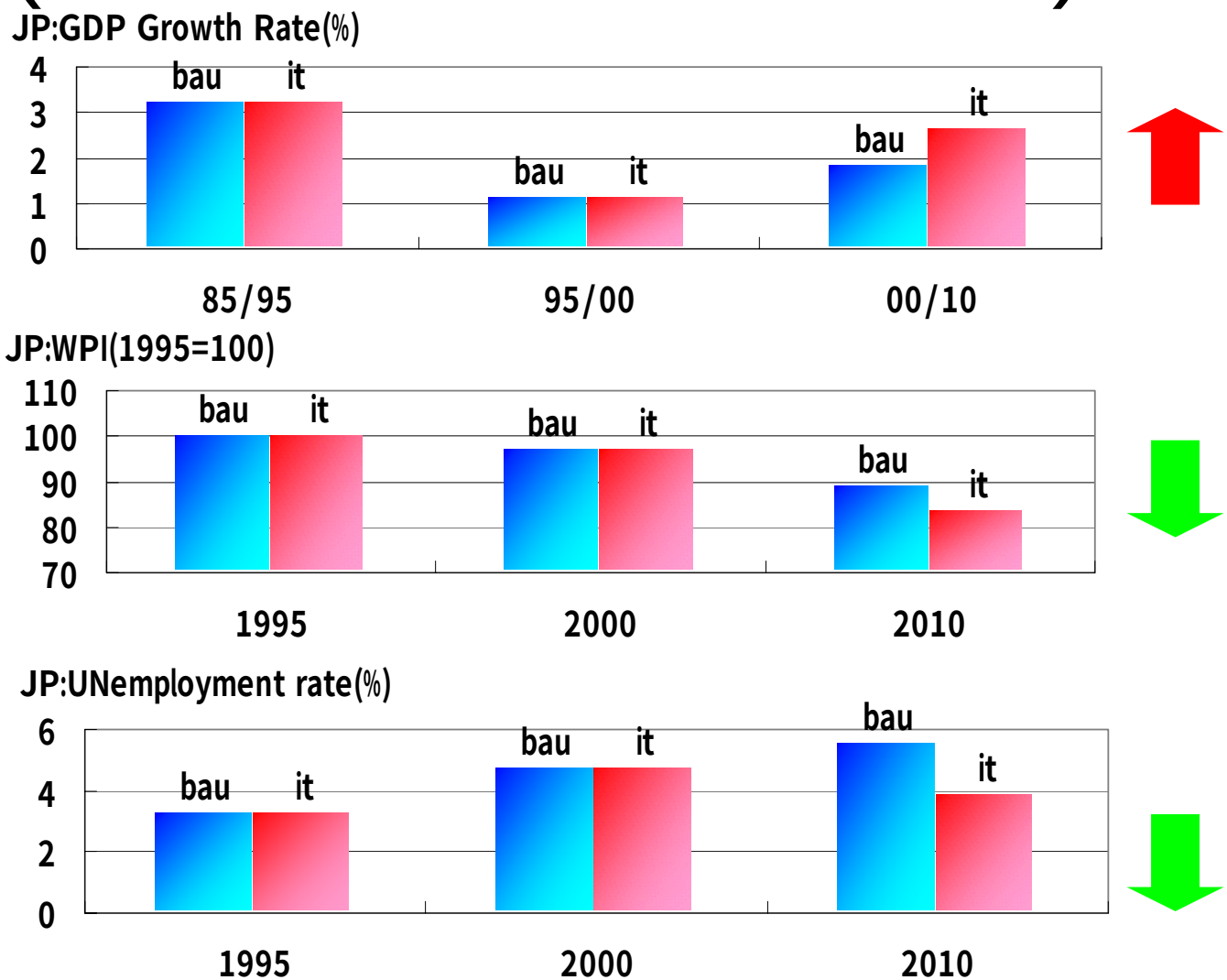
Unit: quadrillion Btu





- IEA2002: higher share of oil & natural gas
- This study: higher share of coal

Impact of IT investment (6→12%/y) (Macro economic model)



Consistent result with U.S. Department of Commerce (June 2000)

Impact of IT investment (Input-Output model)

- IT impact on, final demand converter & import coefficient.

	Increase (trillion yen)
Output total	69 (6%↑)
Business services	22.6
Electronics & communication	14.8
Finance, insurance & real estate	6.3
Communication & broadcasting	3.3
Transportation equipment	-3.2

IT sector 26.6%→28.9%

Transportation equipment decrease because of shifting production overseas.

Impact of IT investment
Input to energy model (from Macro & IO model)

- Industry structure will shift out from heavy industries.

	2010		
	BAU	IT	IT-BAU
Crude Steel	92 mil.ton	90 mil.ton	-1.9 mil.ton
Ethylene	8.5 mil.ton	8.1 mil.ton	-0.4 mil.ton
Cement	73 mil.ton	63 mil.ton	-10 mil.ton
Paper	20 mil.ton	18 mil.ton	-1.4 mil.ton

- Transportation demand grow at higher speed.
- Commercial floorspace will decrease by 7%
  (because the equation includes direct influence from IT investment.)

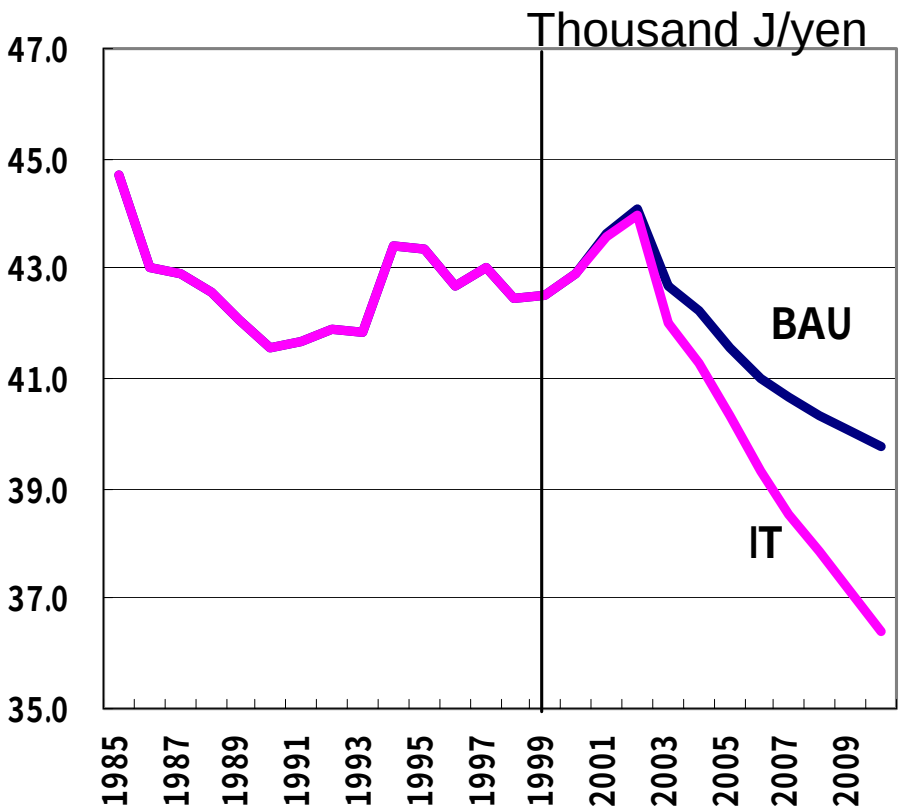
Impact of IT investment (Energy model)

Substitution effect

Income effect

	2010		
	BAU	IT	IT-BAU
Final Demand (PJ)	17,460	17,277	-183
Industry	8,048	8,001	-47
Residential	2,544	2,617	73
Commercial	2,164	1,931	-238
Transporation	4,375	4,397	22
Primary energy supply	25,237	24,912	-325
CO2 Emission (Mton-C)	374.9	369.2	-5.7

Impact of IT investment (Energy model)



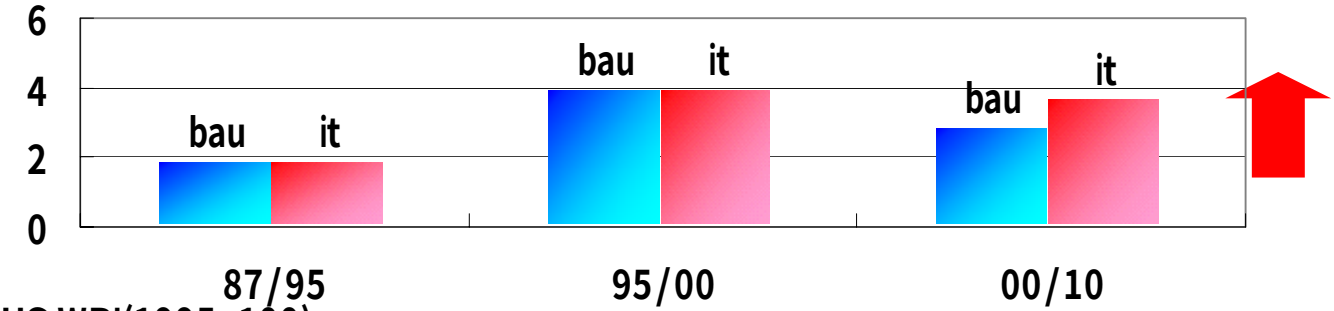
Elasticity	99/85	10/99	
		BAU	IT
TPE	0.88	**0.57**	**0.35**
CO2	0.50	**0.75**	**0.46**

TPE/GDP

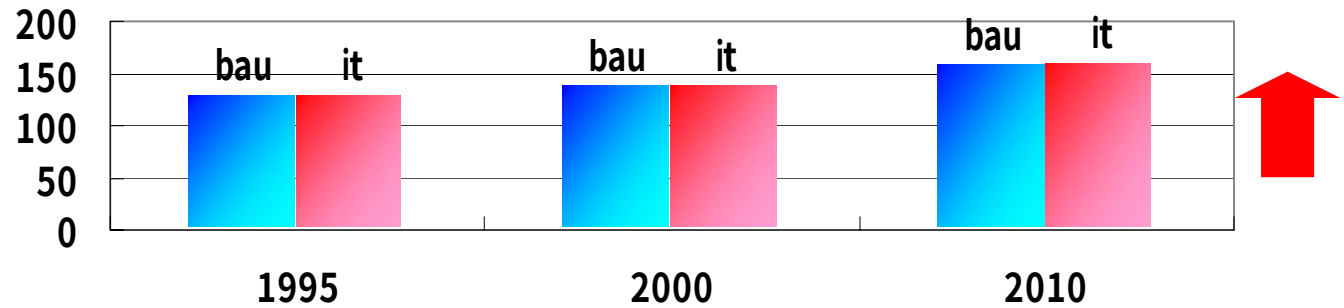
※BAU: 7% ↓, IT: 14%↓

Impact of IT investment (10→12%/y) (Macro economic model)

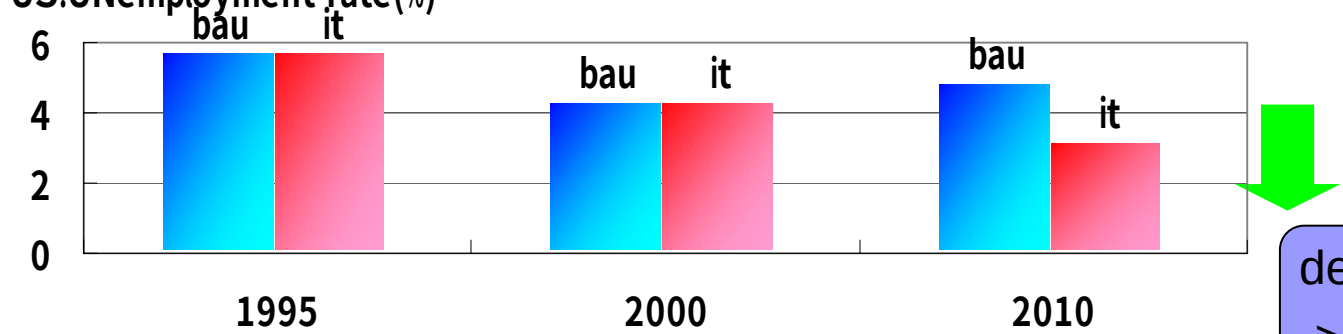
US:GDP Growth Rate(%)



US:WPI(1995=100)



US:UNemployment rate(%)



demand increase (+)
> efficiency increase (-)

Impact of IT investment
Input to energy model (estimated in the model)

	2010		
	BAU	IT	IT-BAU
Crude Steel	119 mil.ton	126 mil.ton	6.4 mil.ton
Pulp	64 mil.ton	66 mil.ton	1.7 mil.ton
Motor vehicle stock	254 mil.	262 mil.	7.8 mil.
Commercial floorspace	61 bil.ft^2	58 bil.ft^2	-2.9 bil.ft^2

- Industry production, transportation demand are larger in IT case.
- Commercial floorspace will decrease by 5%
  (because the equation includes direct influence from IT investment.)

Impact of IT investment (Energy model)

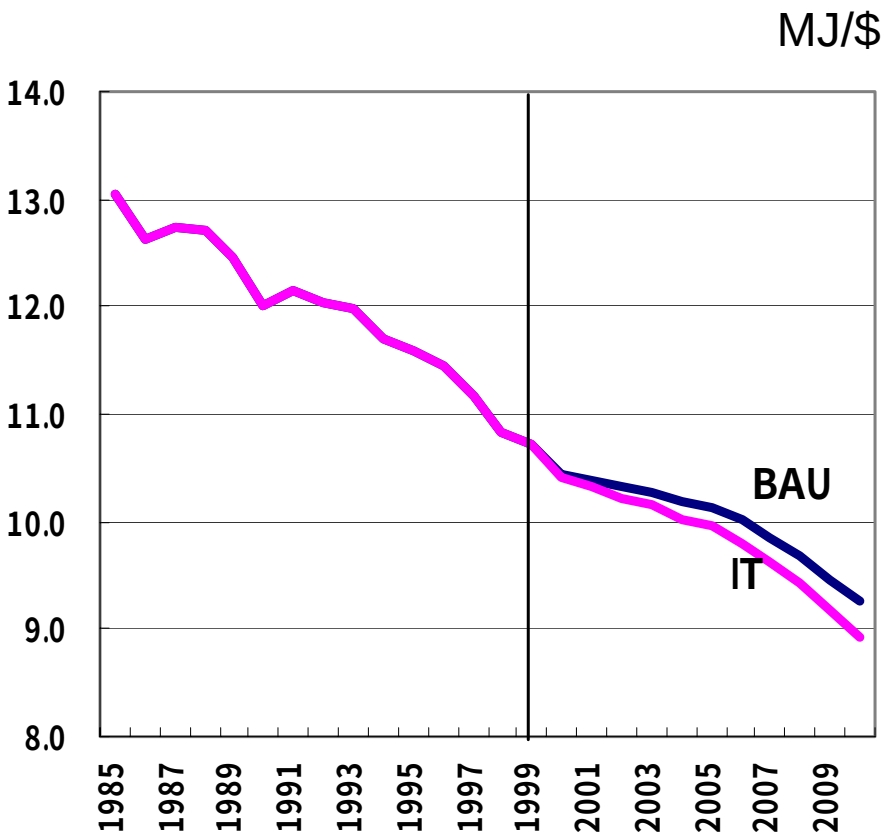
Substitution effect

Income effect

	2010		
	BAU	IT	IT-BAU
Final Demand (PJ)	67,864	70,594	2,730
Industry	17,207	19,080	1,873
Residential	11,257	11,376	119
Commercial	6,507	6,195	-312
Transporation	29,770	30,718	948
Primary energy supply	111,449	116,033	4,584
CO2 Emission (Mton-C)	1715.5	1792.6	77.1

USA

Impact of IT investment (Energy model)



TPE/GDP

※BAU: 12% ↓, IT: 14%↓

Elasticity	00/85	10/00	
		BAU	IT
TPE	0.51	**0.57**	**0.56**
CO2	0.39	**0.66**	**0.64**

Reason for energy intensity decline in U.S. (1995～1999)

- Was it because of warm winter***??

	E/GDP(MJ/$)	Heating degree day
70-99 average	10.1	4,518
95-99 average	7.4	4,381
difference	*-27%*	*-3%*

Lower heating degree day explains only 0.19*(-3%)=-0.57% of E/GDP decline.

LOG(UTLFD/UGDP) = +1.18621 +**.193421** LOG(UHDD) -.025487 TIME

(1.42) (1.96) (-43.97)

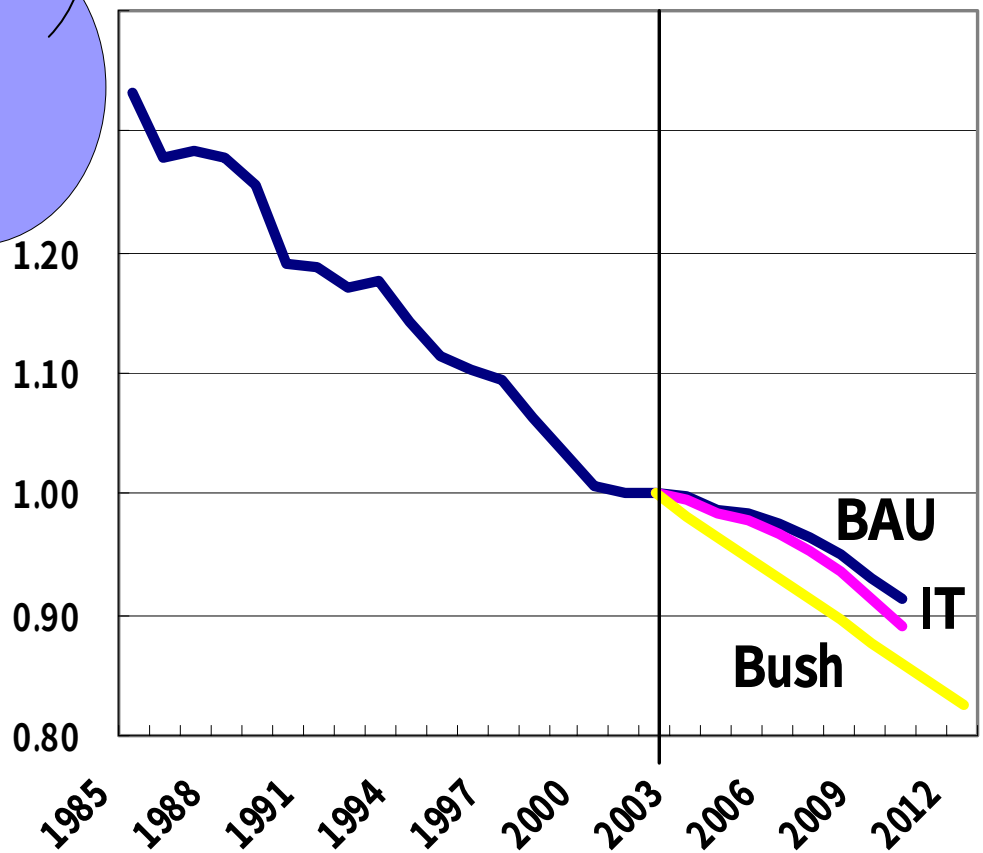
R^2= 0.9878 S.E.= 0.025 D.W.= 0.481

President Bush's Commitment

My administration is committed to cutting our nation's GHG intensity by 18 percent over the next 10 years.

©Department of Defence

Our Study	BAU:	-10%(2000-2010)
	IT:	-13%
President Bush		-18%(2002-2012)



Summary of IT impact (Economy)

	Japan	USA
Economic growth rate	↑	
Unemployment	↓	
WPI	↓	↑

Economic growth (↑) > productivity growth (↓)

※95-99 deflation in US was because of productivity growth.

Summary of IT impact (Energy demand)

Laitner (2000.3)
"2～3% decrease of CO2 emission" :
Income effect was excluded.

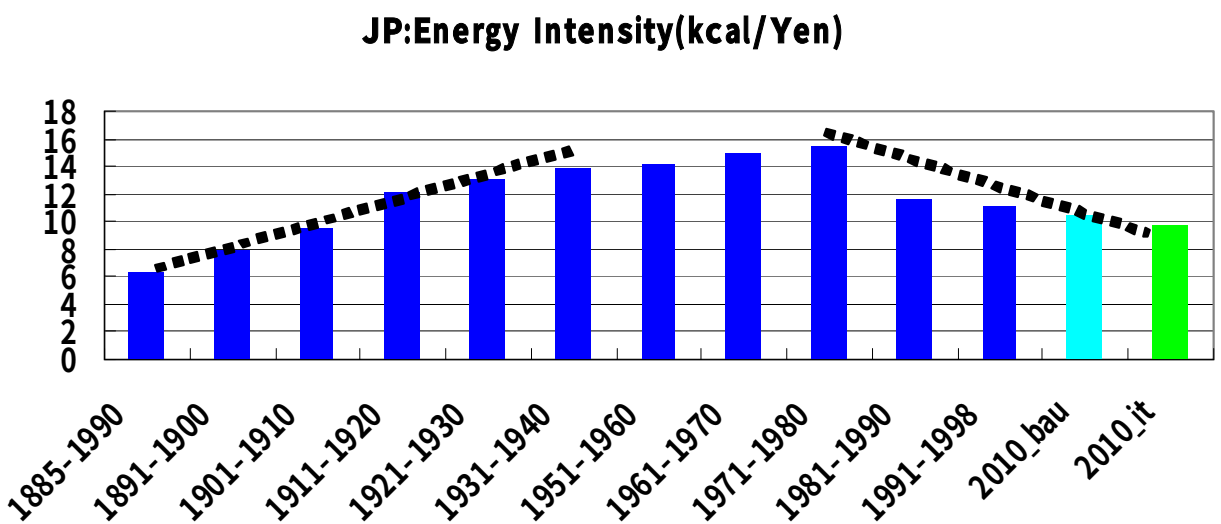
- Substitution effect
  - Industrial structure shift from "massive and heavy" to the IT industries (electronics & communication etc.).
- Income effect
  - Household purchase more electrical appliances and motor vihicles.

Final energy demand	Japan ↓	USA ↑
Industry		Already de-massed**
Residential		
Commercial	Decreased floorspace	Decreased floorspace
Transportation		

Summary of IT impact (Energy/GDP)

- Inverted U curve was seen (Schmalensee et. Al, Judson et. Al.) in both country's Energy/GDP.
- De-materialization and inverted U curve (Bernardini & Galli)
  - Change in demand structure (goods to services)
  - Efficiency growth in use of goods (car efficiency rise)
  - Substitution between goods (iron to plastics)

Impact from IT



Summary of IT impact (Did it decreased Energy/GDP??)

- **Warm winter** effect was not enough (explained only **-0.57%** out of **-27%**) to explain rapid decrease in the **U.S.** from 1995 to 1999.

- Effect of **IT impact** is the prime suspect of the rapid decline.

Next challenge to be done

- Include direct effects of IT investment to energy conservation.
  - Effect of SOHO increase to transportation demand,
  - Effect of introducing network control system to the household appliances (increase efficiency), etc.