Sustainable Energy

Indicators and Opportunities;
from One Big World and 3 Small Islands

University of Otago
Energy Management Programme

Robert Tromop
Manager Monitoring and Research

- Economies and trade groups are setting targets for energy intensity improvements.
- Monitoring of energy trends internationally and domestically shows valuable energy intensity and efficiency improvements are occurring. But it is early days.
- Many challenges remain – particularly in addressing population driven energy growth and personal consumption.
- If the world is to realise the potential of sustainable energy we need to start thinking beyond the technological approaches currently utilised around the world and start looking for new paradigms.
- What might it take to develop significant improvement?

We’ll cover;

A. International changes and drivers
B. New Zealand’s progress
C. What is energy efficiency?
D. Challenges

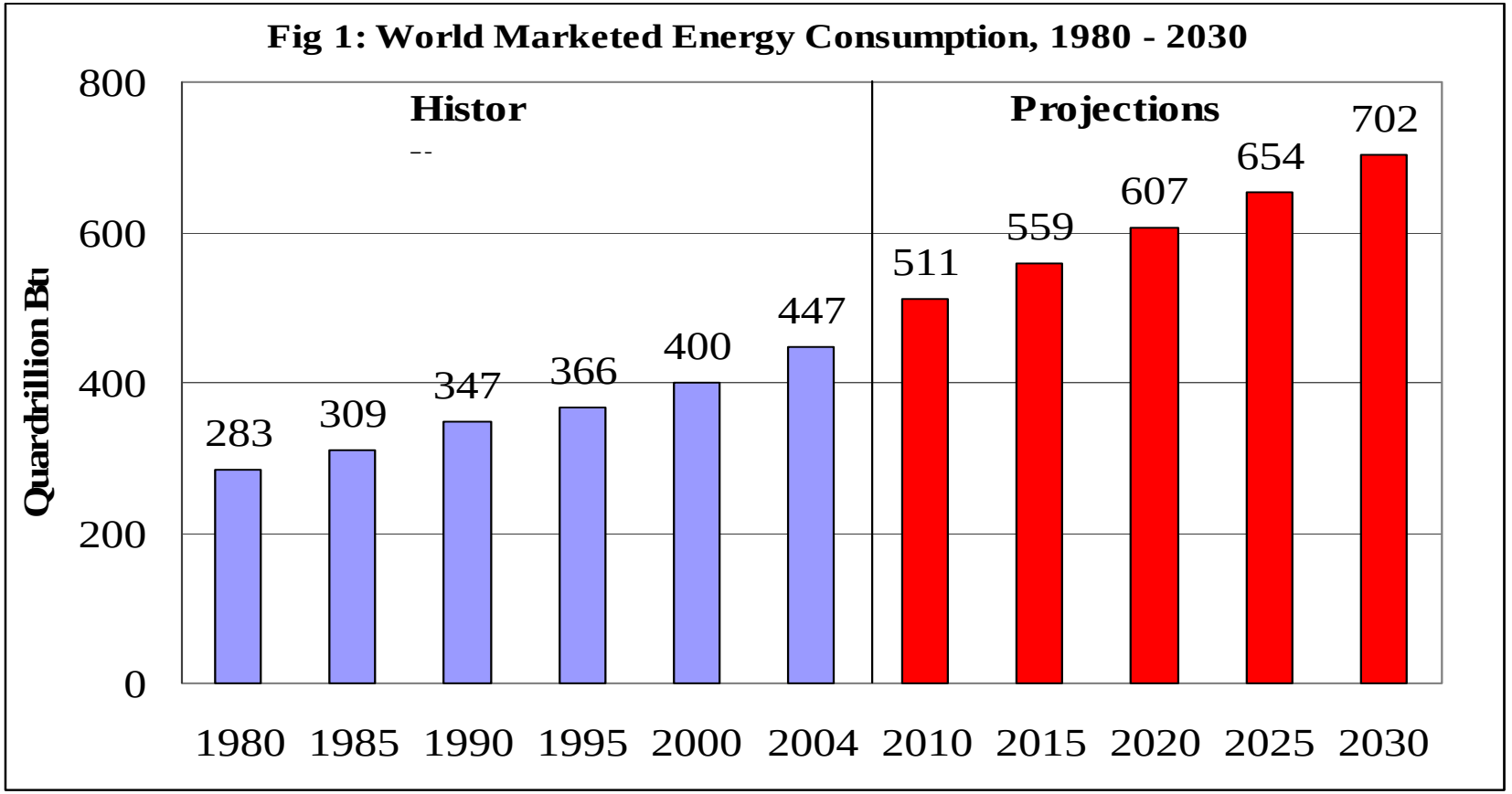
Energy Indicators: Capacity Development and Application in APEC Economies

A report to APEC Energy Working Group, EWG35, summarising the work and findings of EWG Project; EWG 03/07 ‘Application of Energy Indicators in APEC Economies.

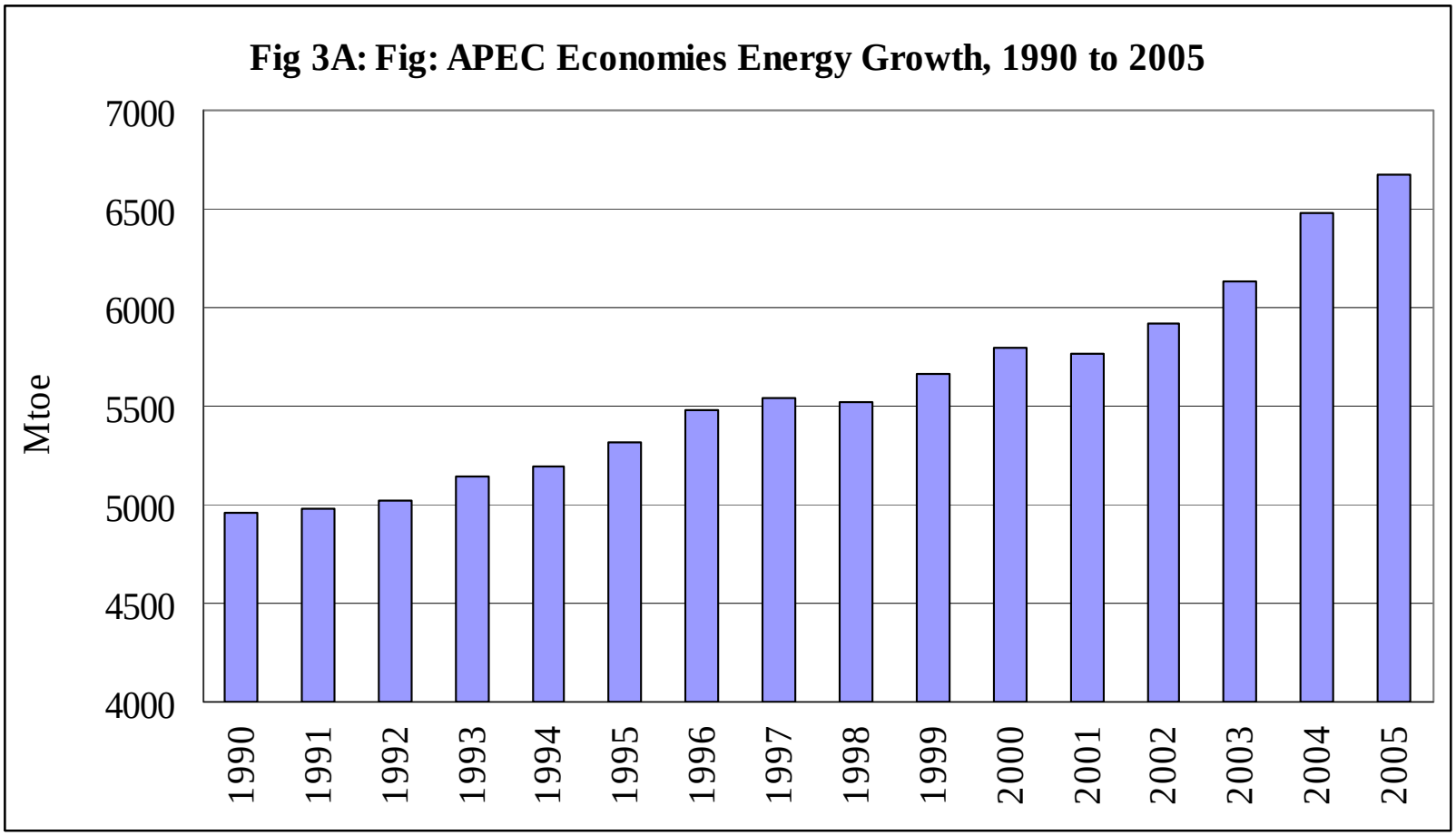
Shigeru Kimura EGEDA

Robert Tromop EGEE&C

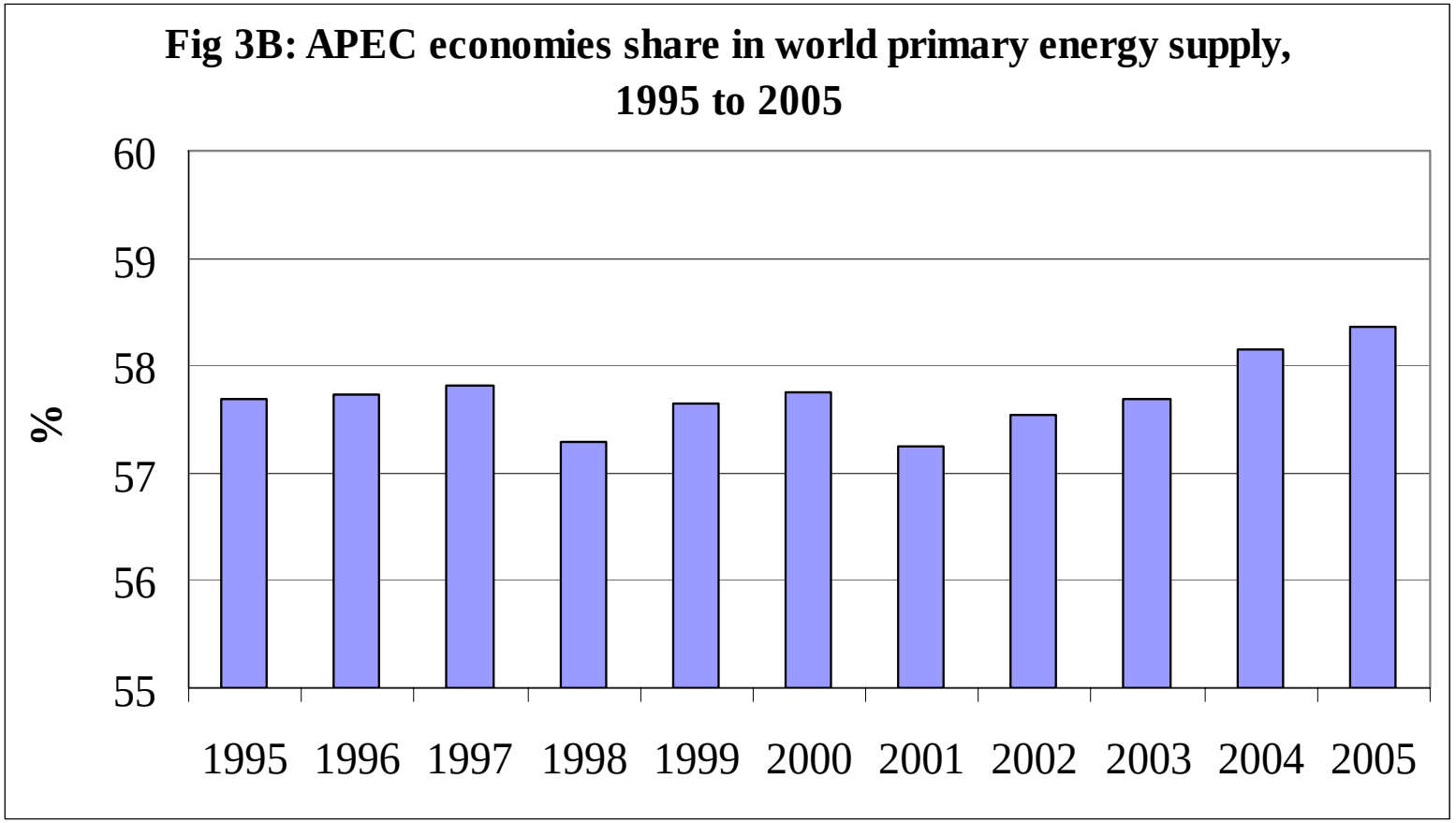
Is global energy consumption increasing?



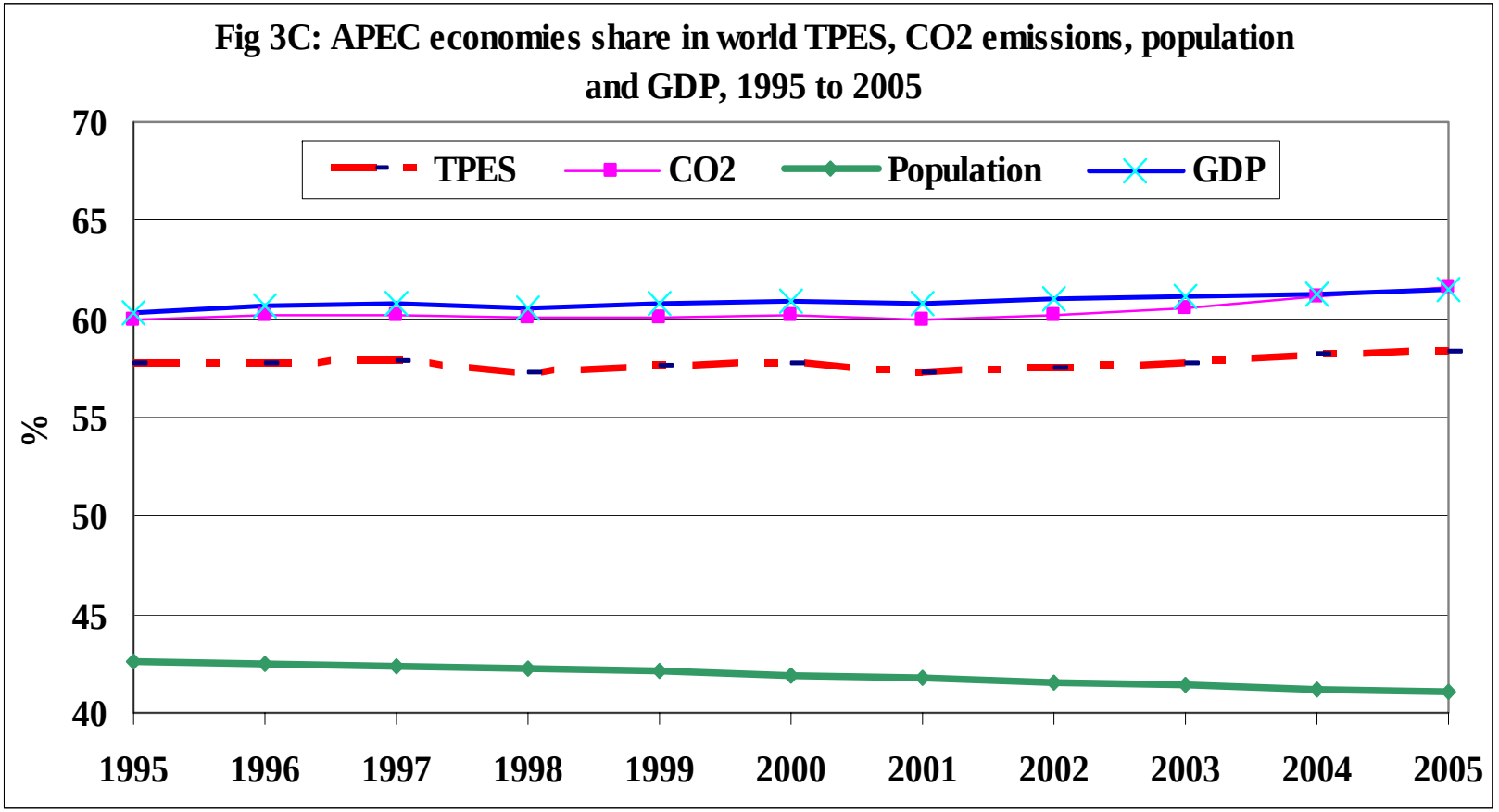
Is APEC energy primary energy supply requirement increasing?



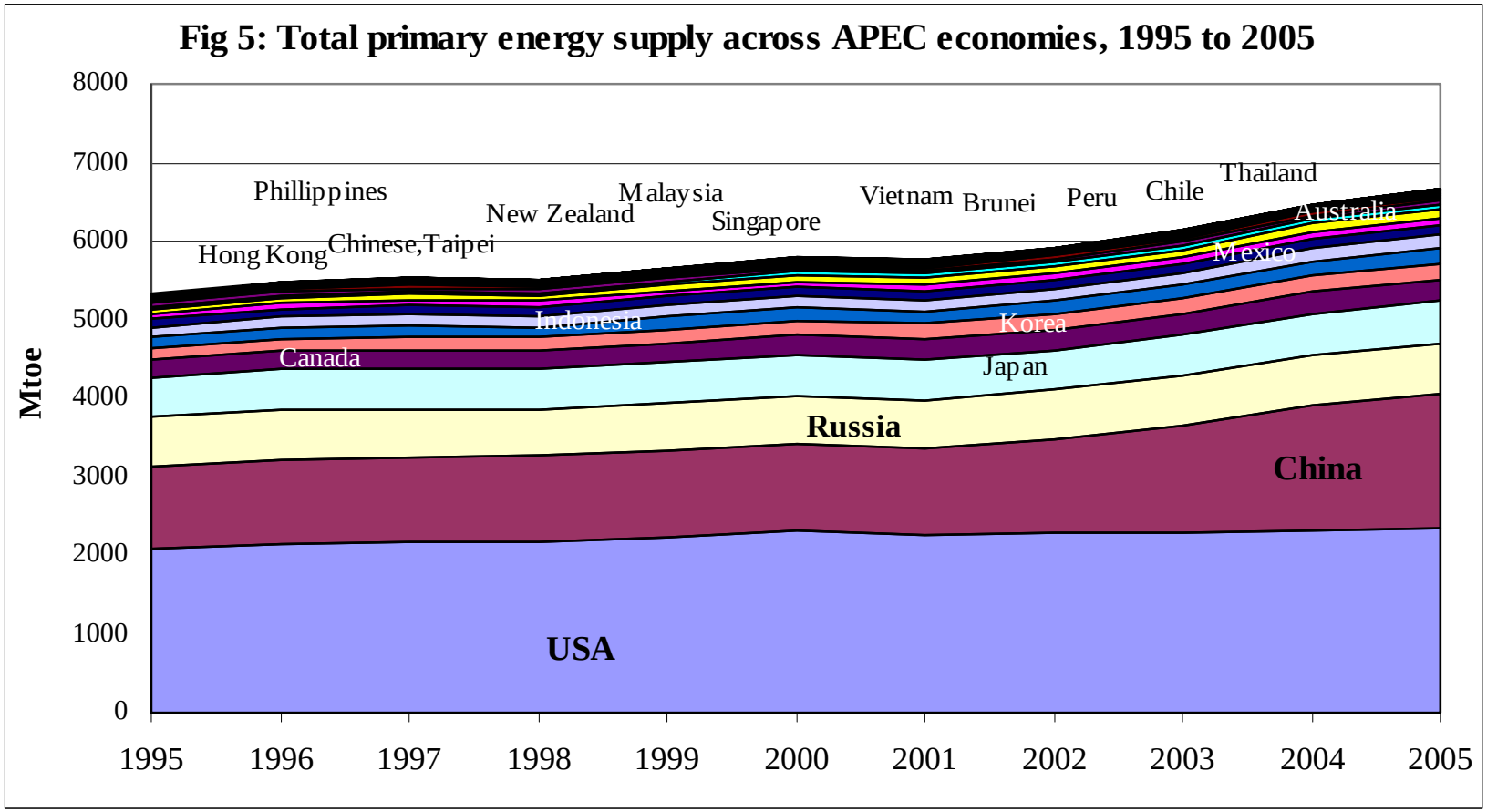
How significant is APEC primary energy supply internationally?



What factors drive primary energy supply growth?



How does the demand for energy from APEC economies' contribute to APEC's total energy demand?



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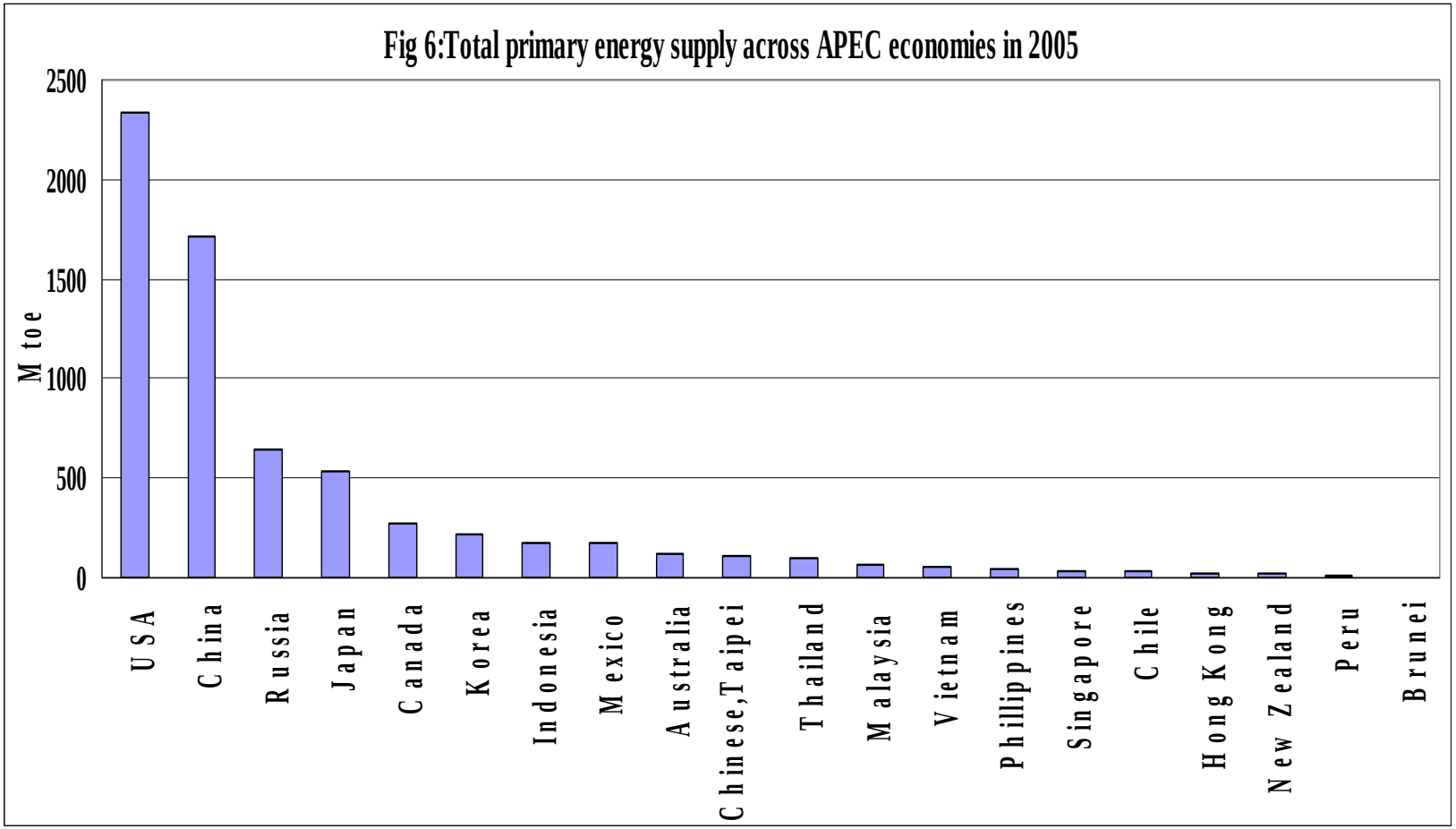
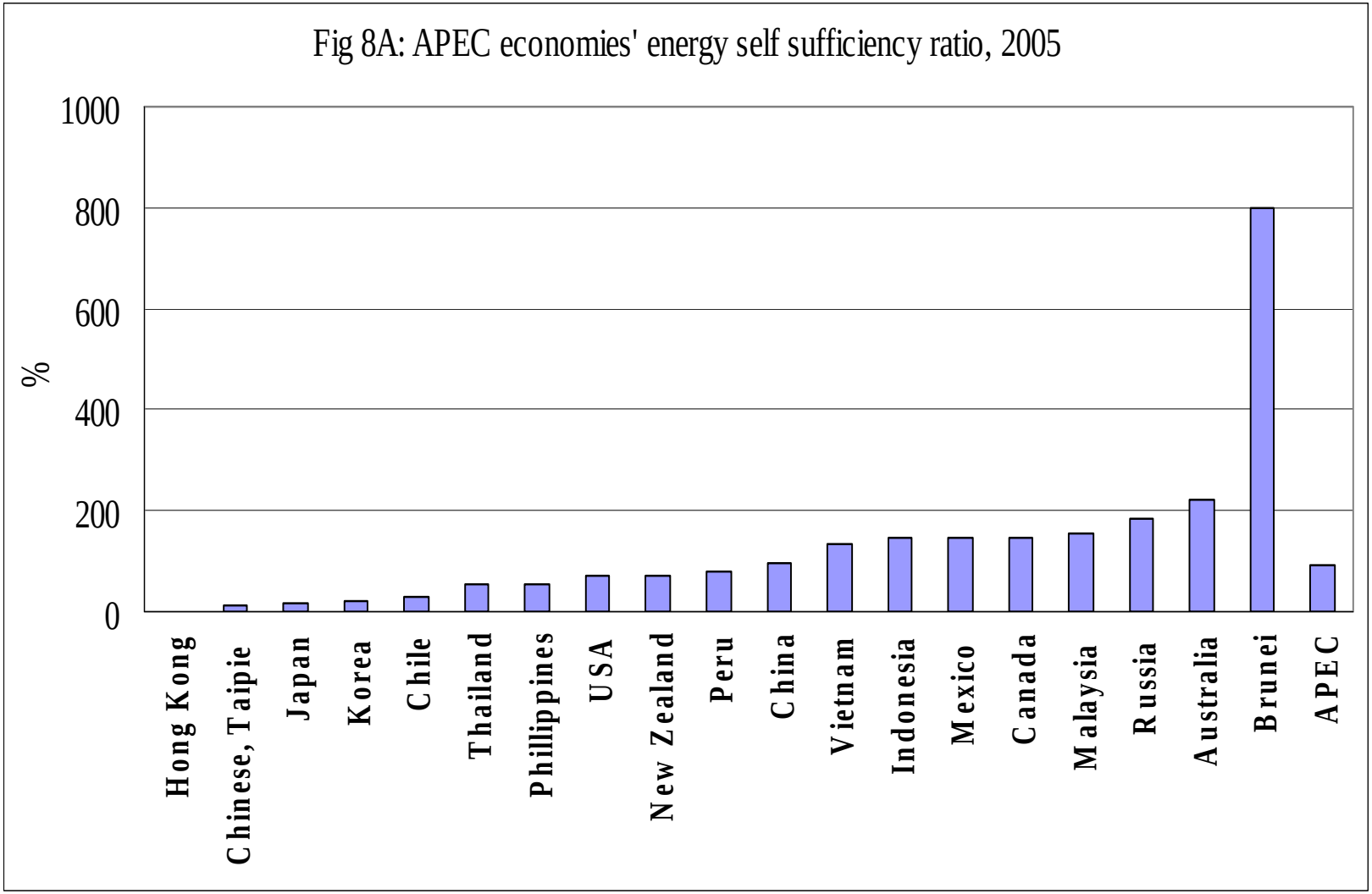
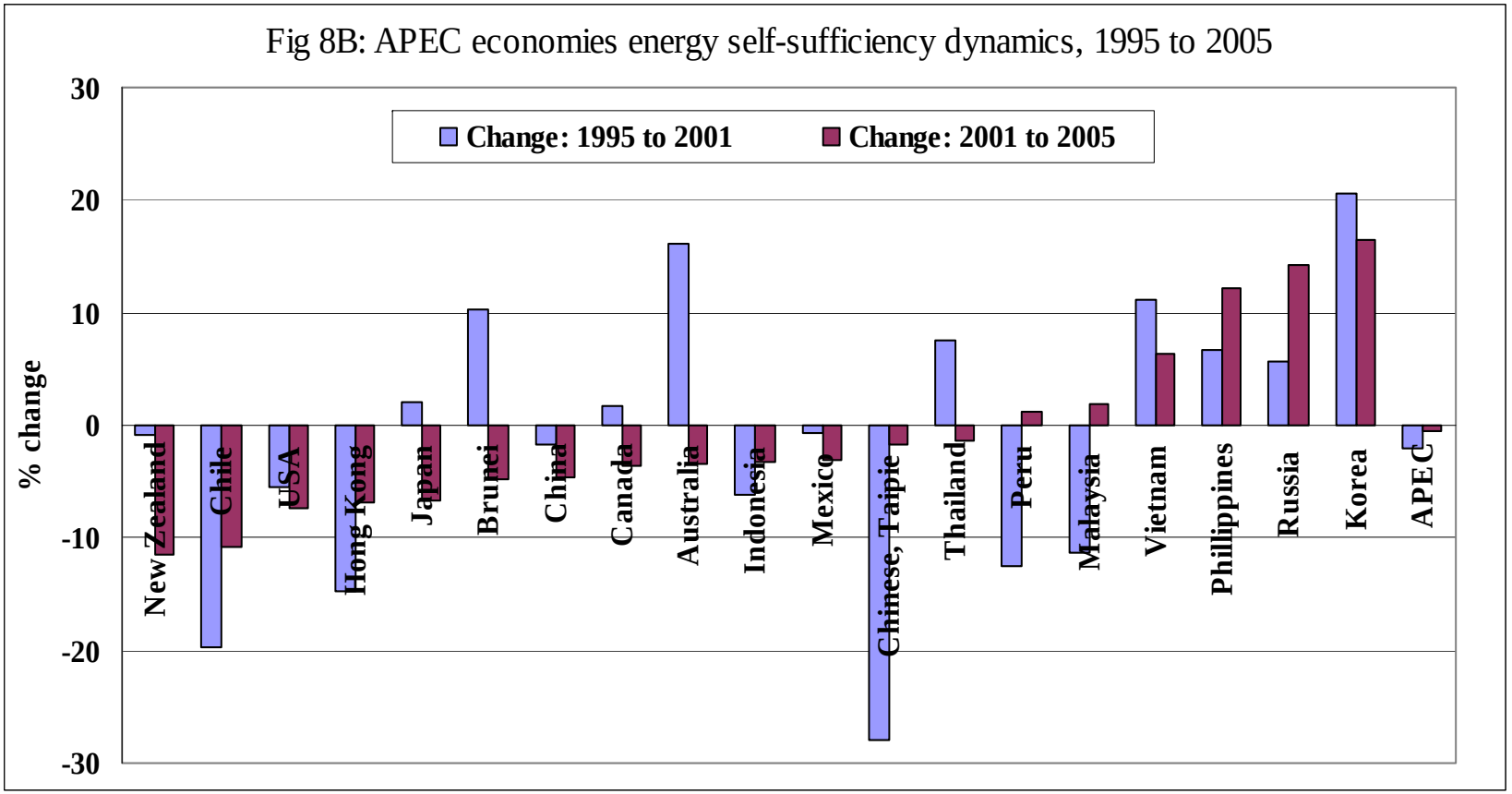


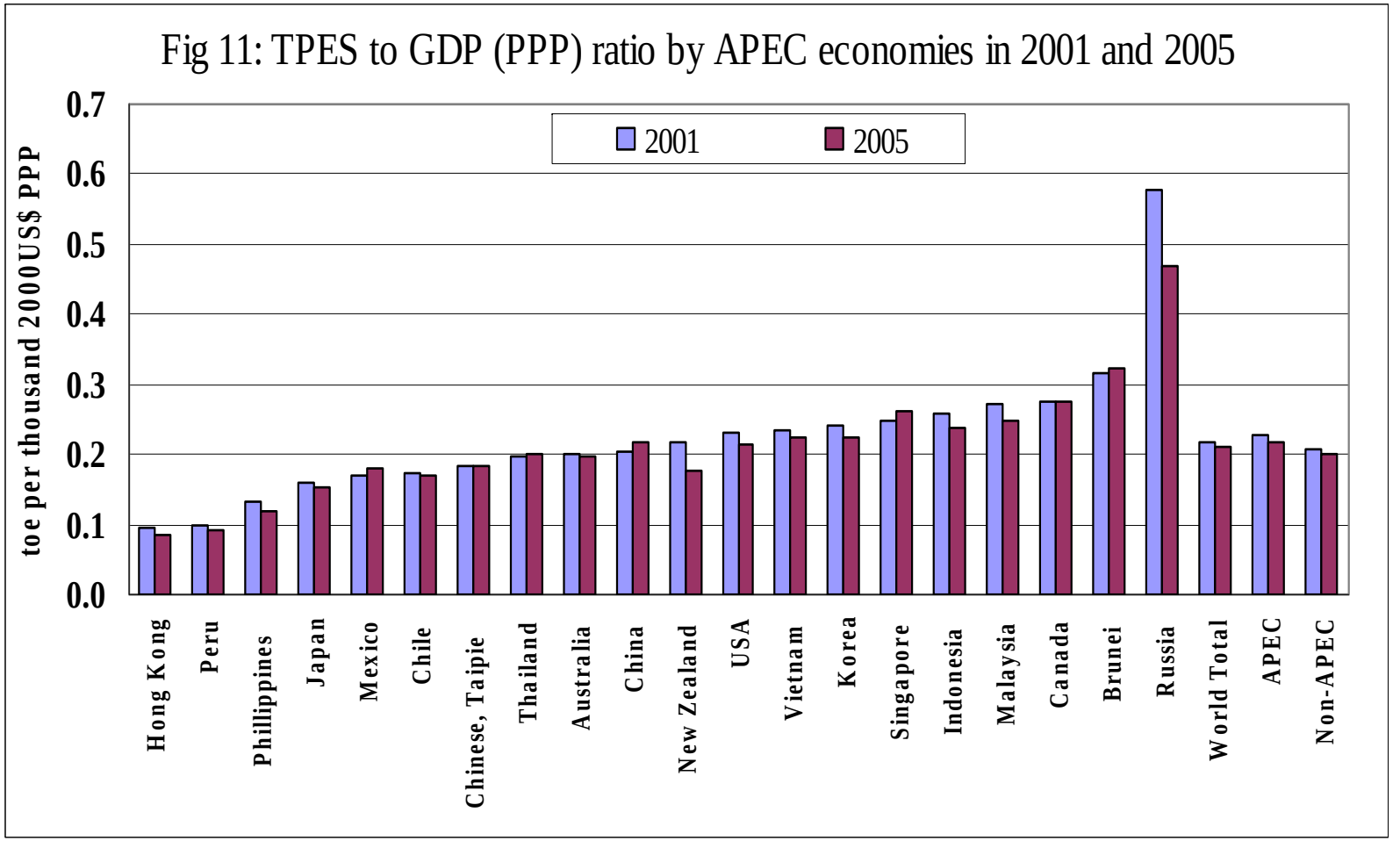
APEC economies self sufficiency



Have APEC economies become more or less self sufficient with that growth?



How has the value (GDP_{ppp}) that APEC economies derive from energy changed?



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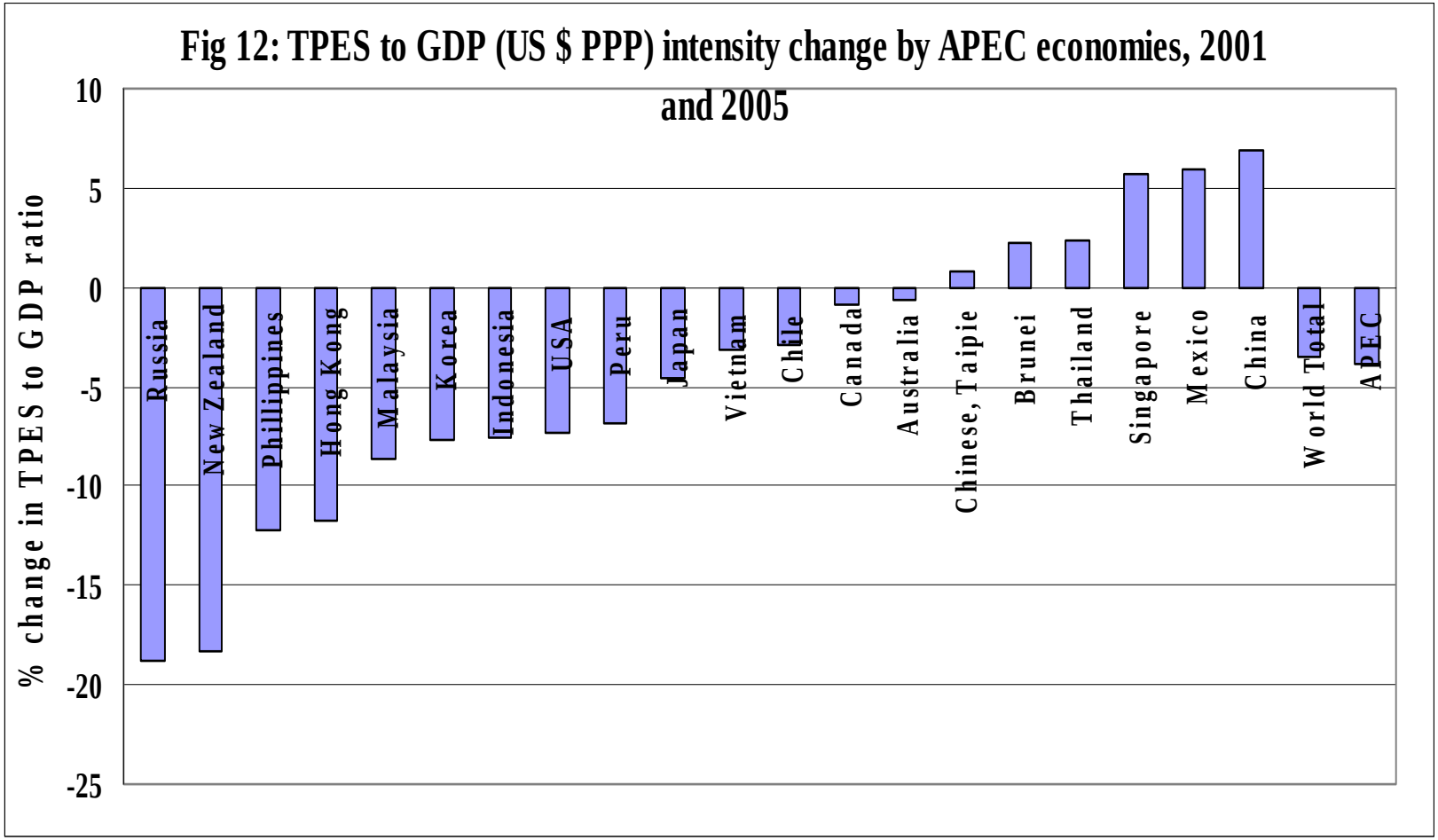
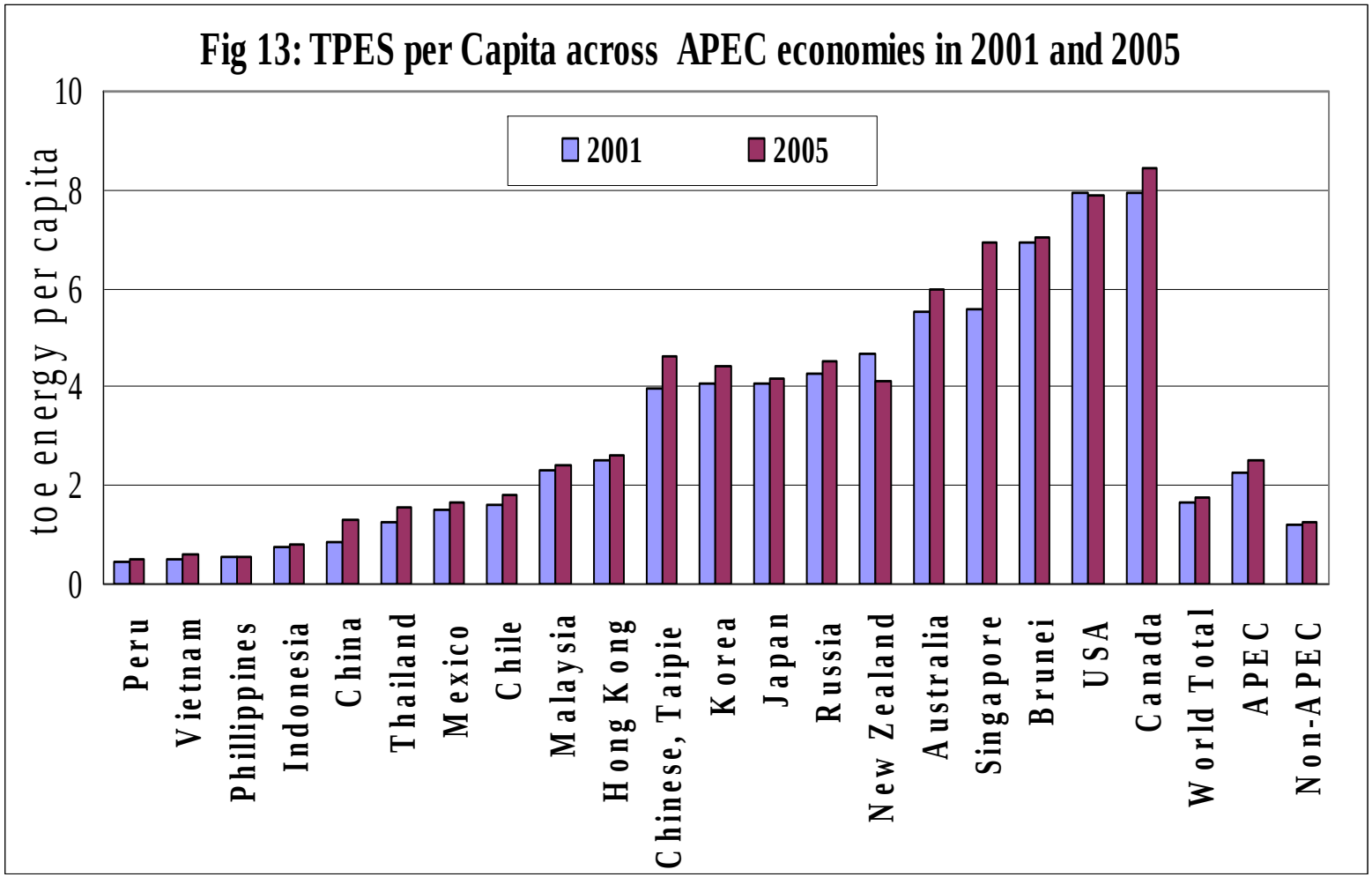
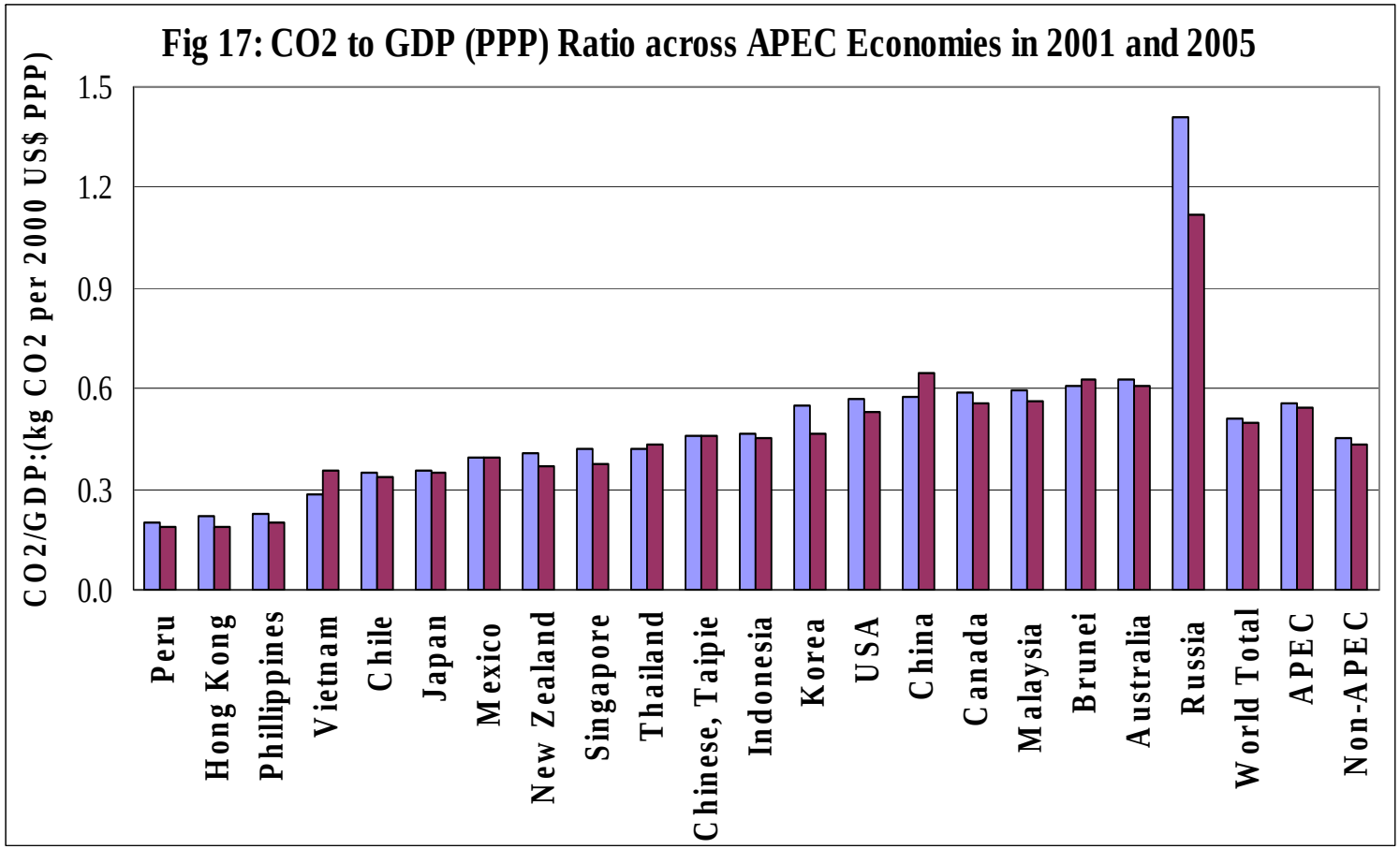


How has energy-population intensity changed?



Have APEC economies CO_2 emission intensities (tCO_2/GDP_{ppp}) improved?



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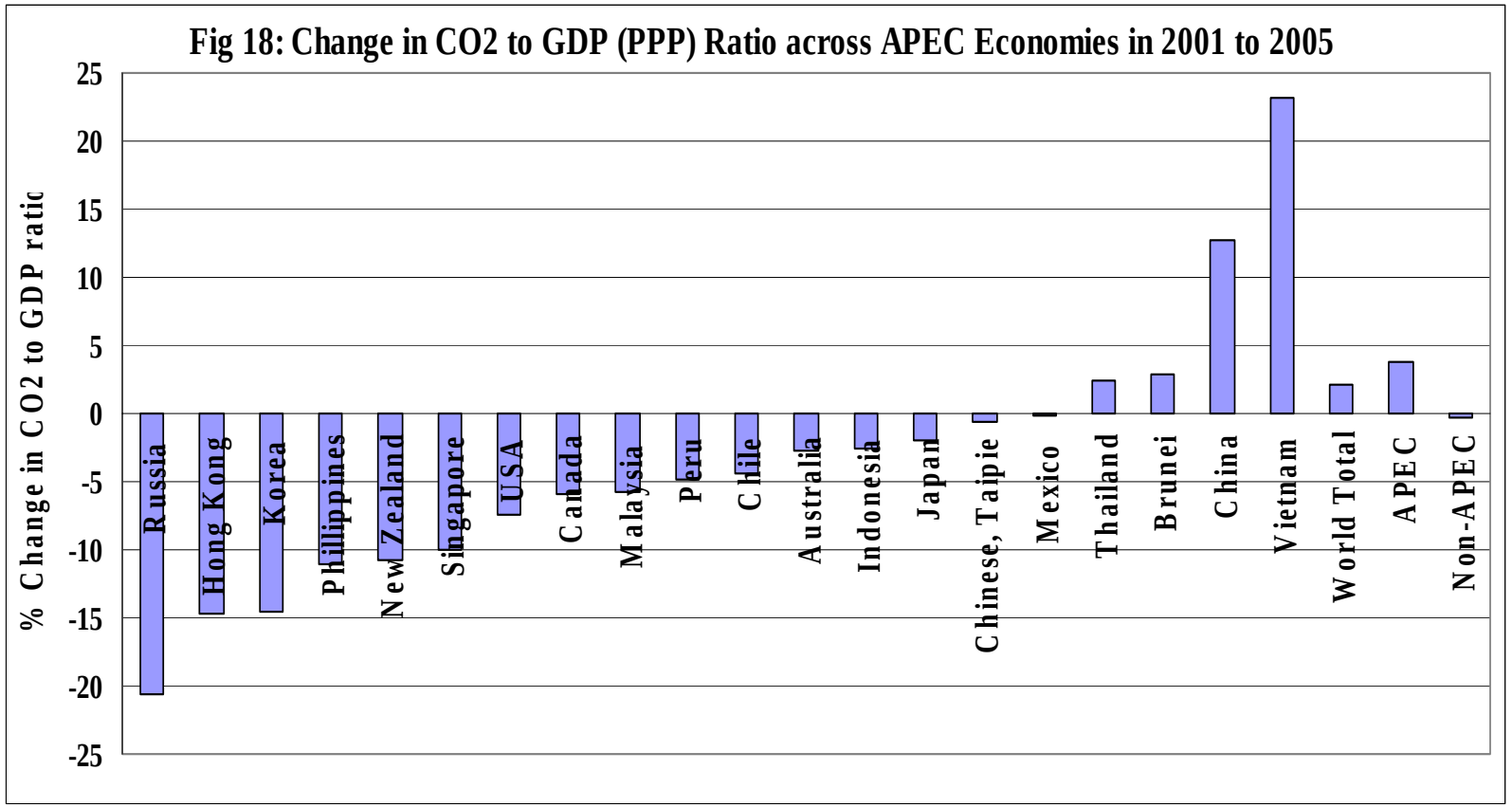


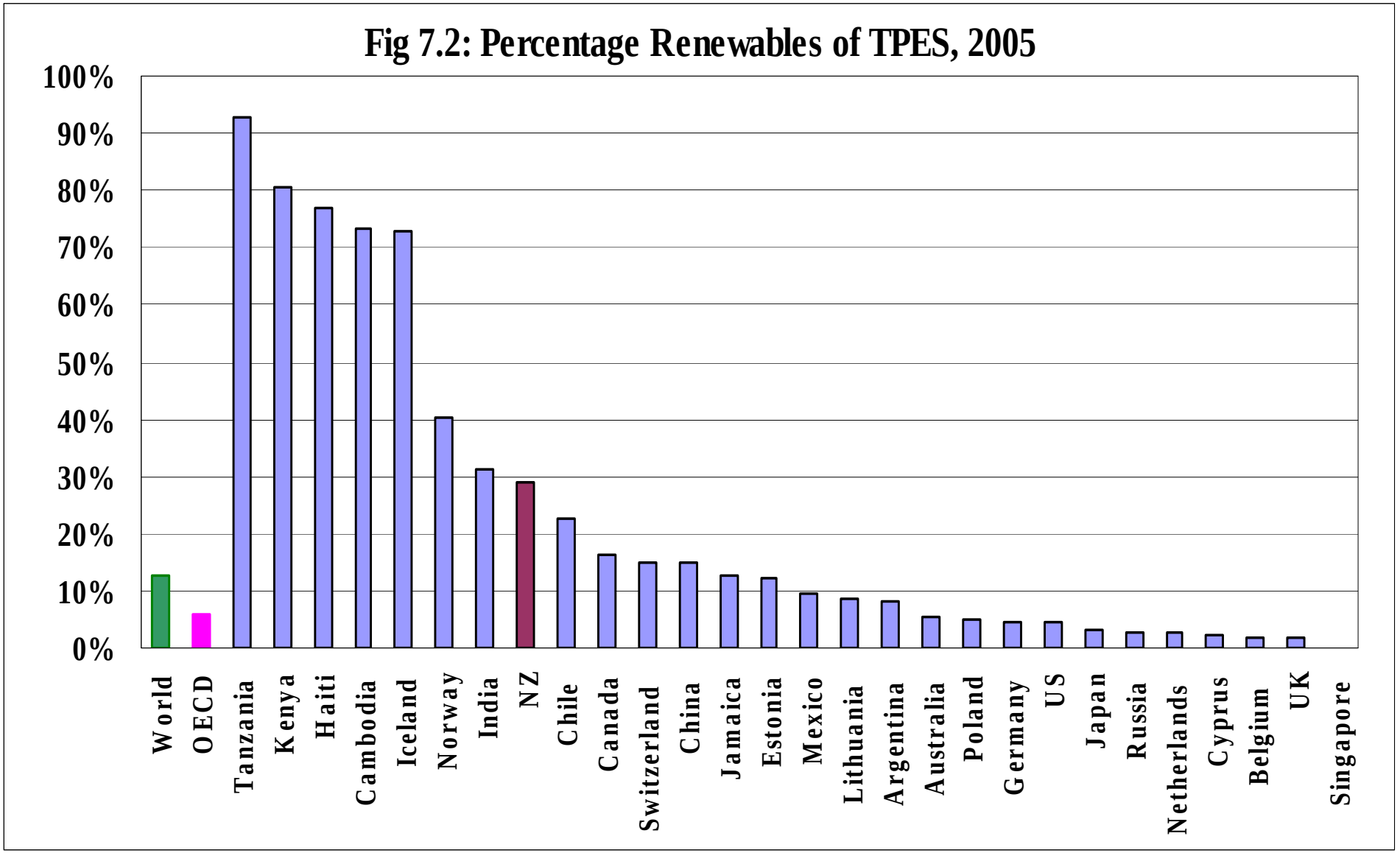


Fig 7.2: Percentage Renewables of TPES, 2005
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
World
OECD
Tanzania
Kenya
Haiti
Cambodia
Iceland
Norway
India
NZ
Chile
Canada
Switzerland
China
Jamaica
Estonia
Mexico
Lithuania
Argentina
Australia
Poland
Germany
US
Japan
Russia
Netherlands
Cyprus
Belgium
UK
Singapore

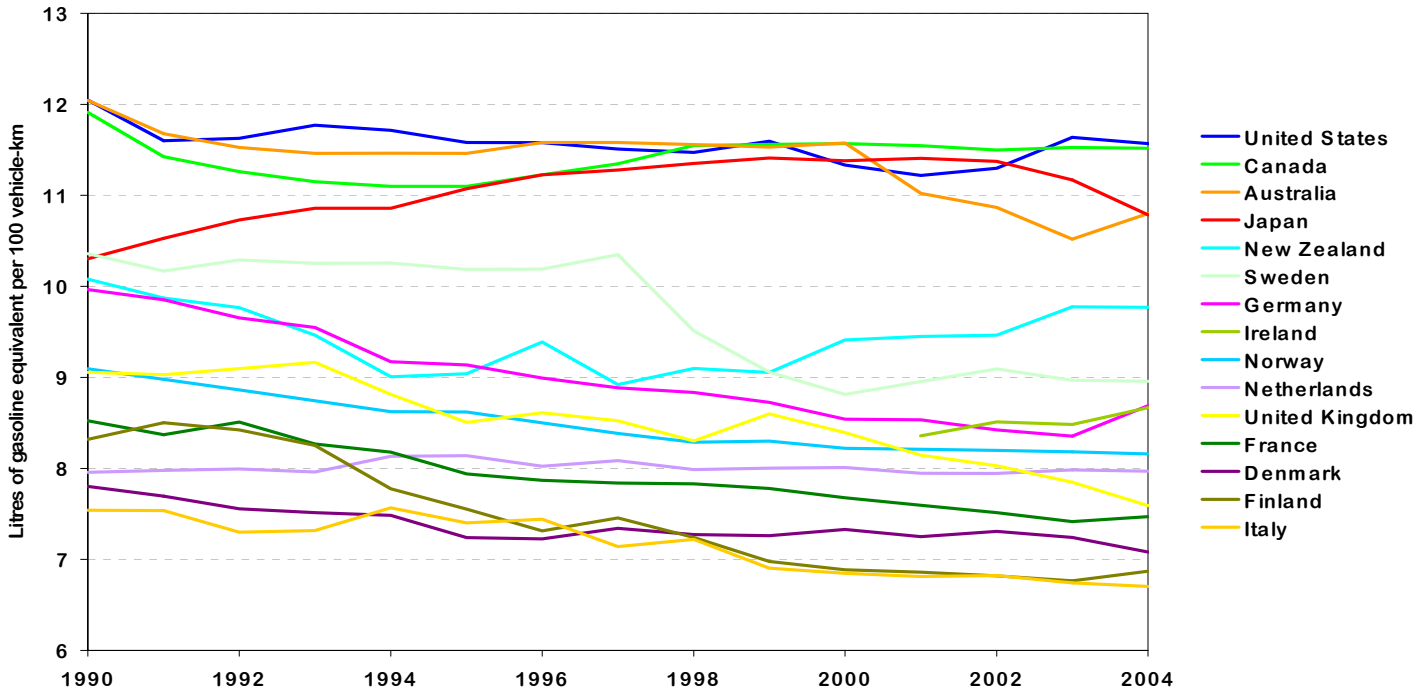
Has the fuel efficiency of our existing fleet of cars improved?

Energy Use in the New Millennium

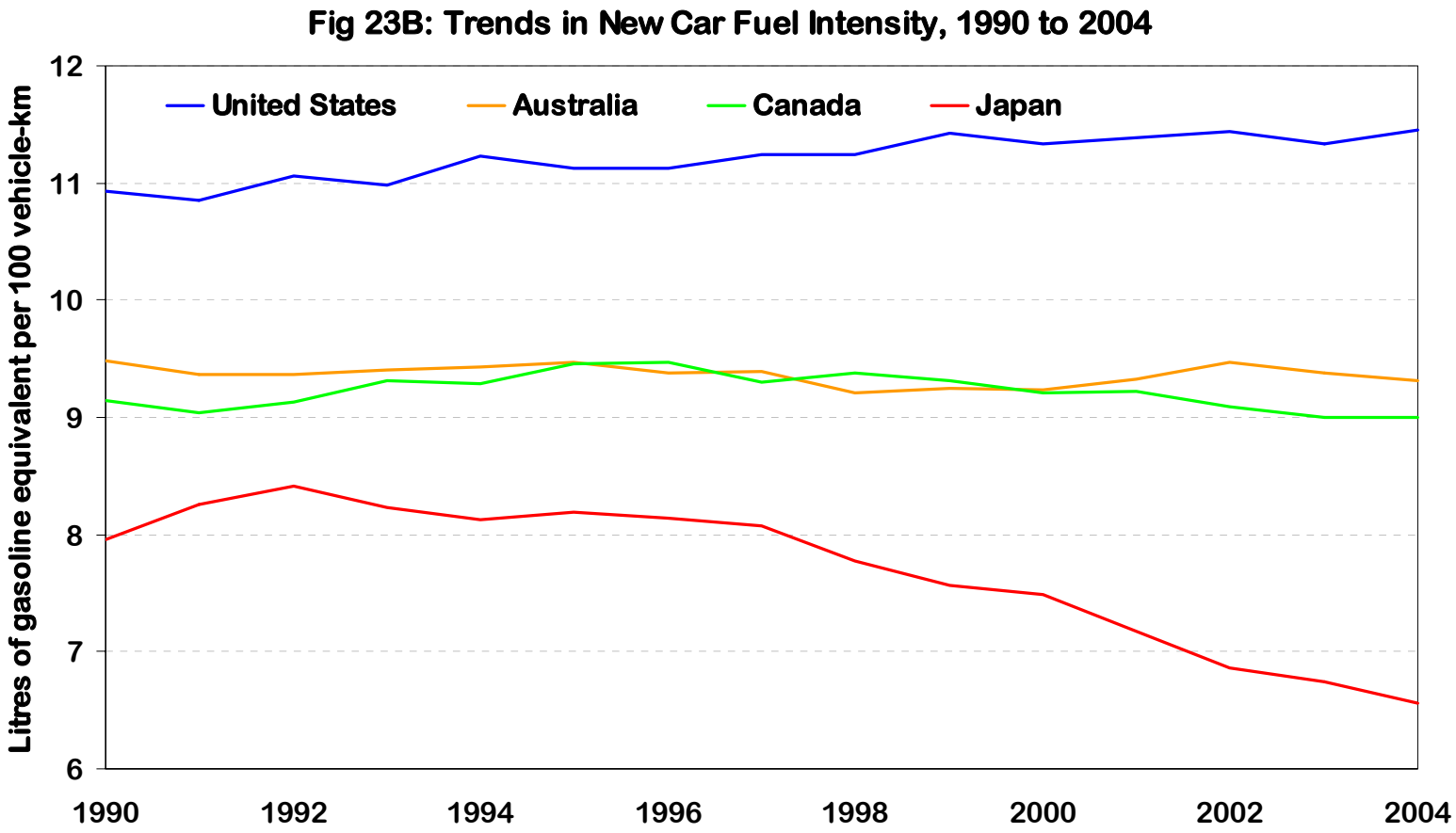
Trends in IEA Countries

ENERGY INDICATORS

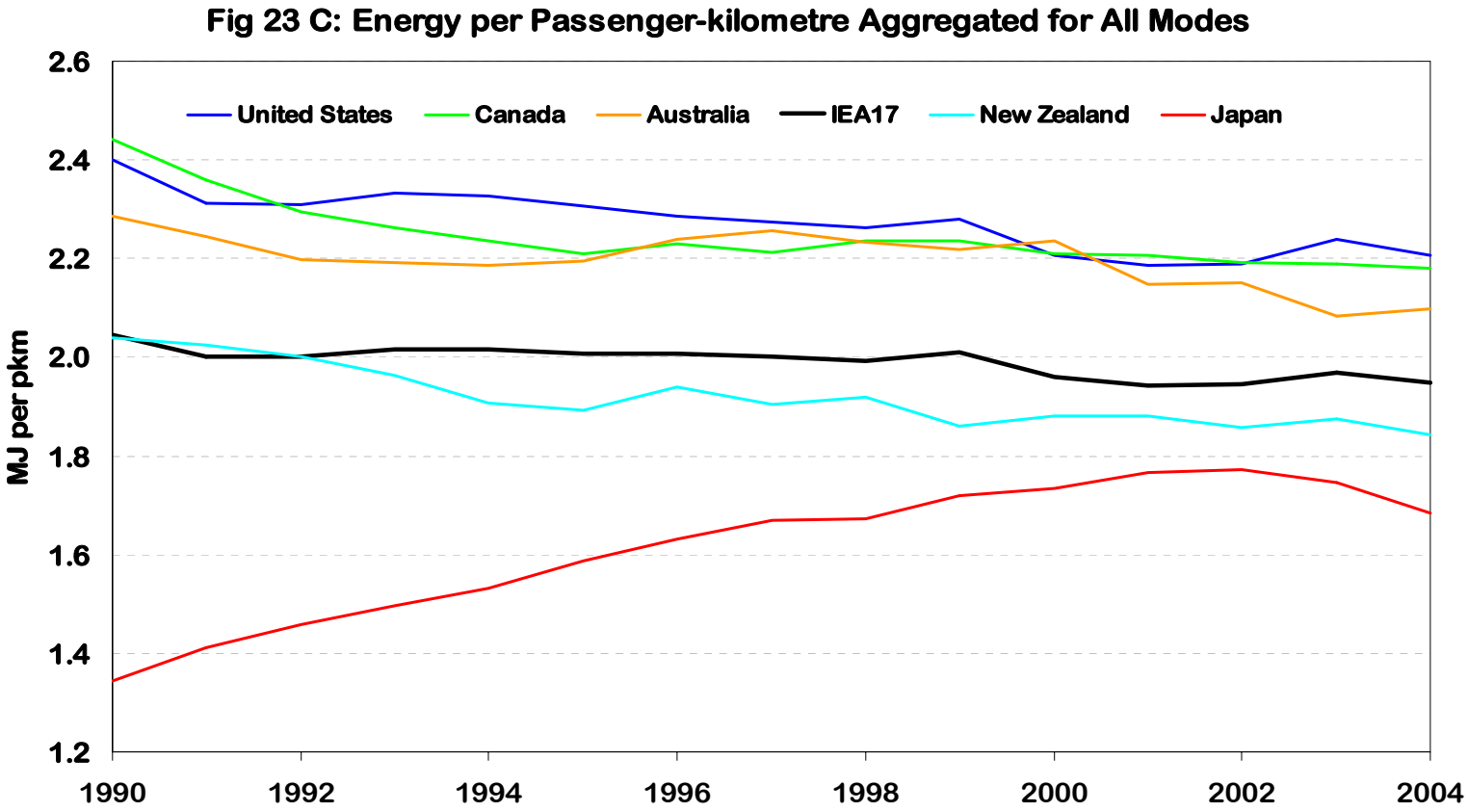
Average Fuel Intensity of the Car Stock



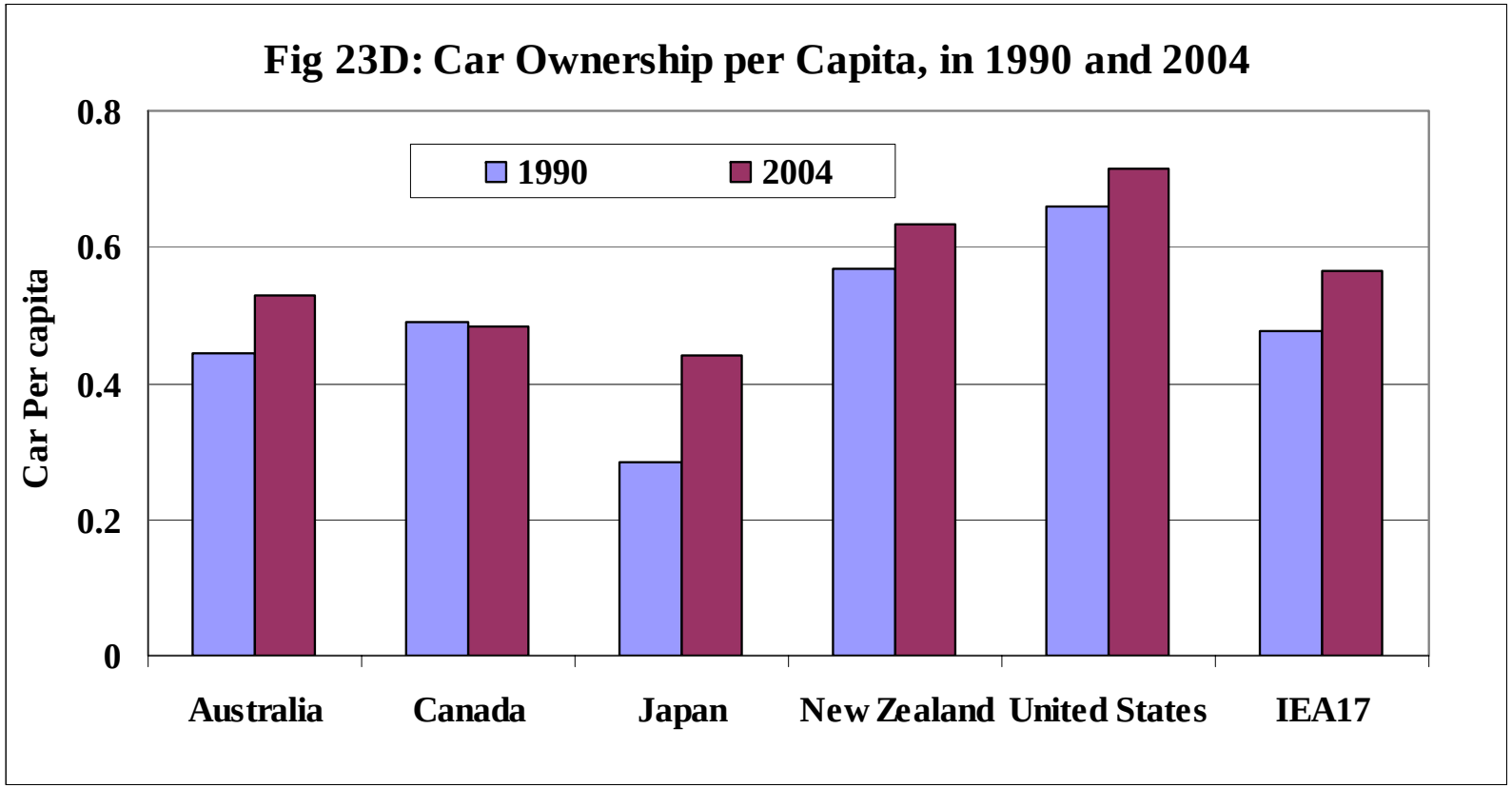
Are our news cars any more efficient?



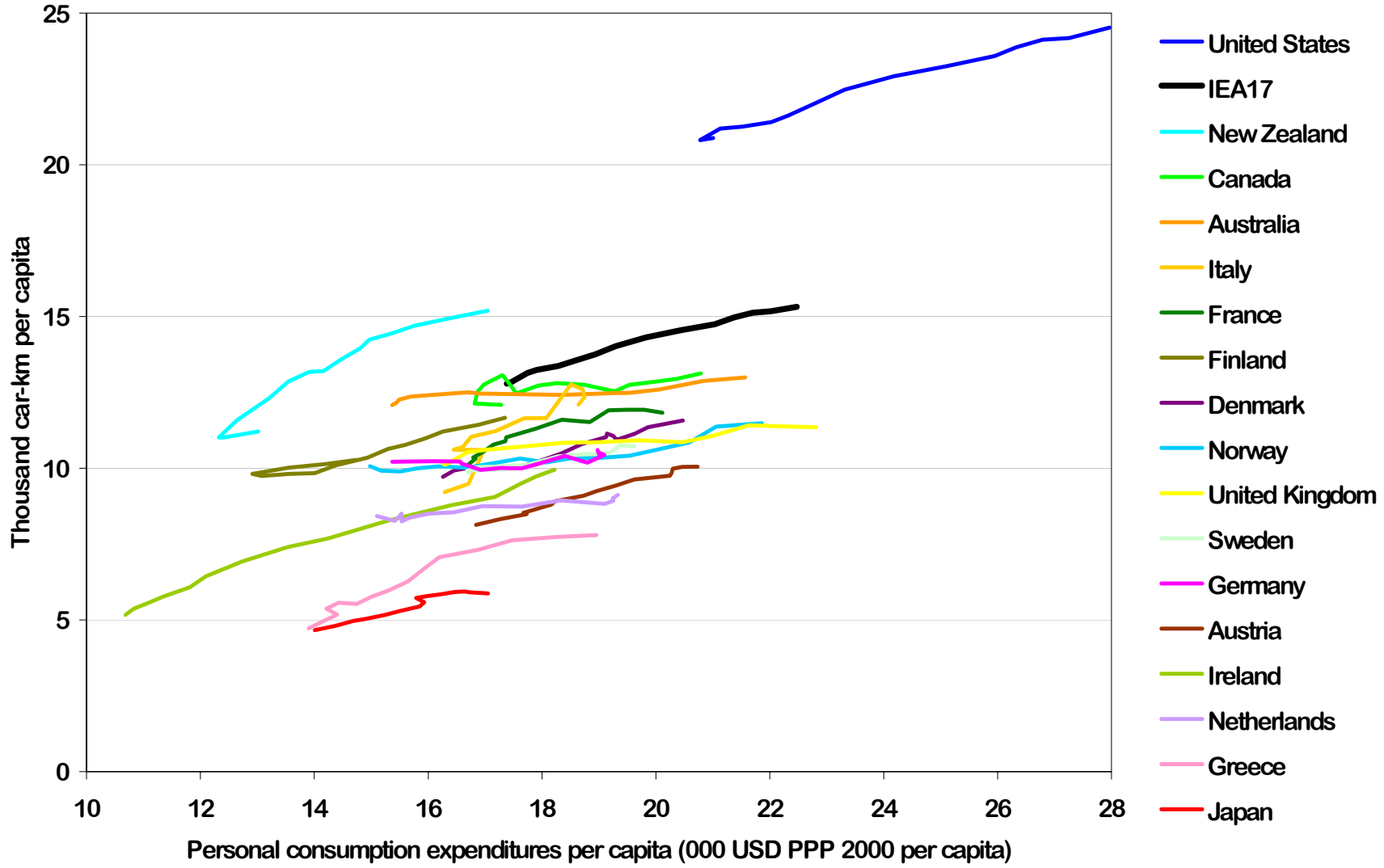
How efficient is our passenger transport system?



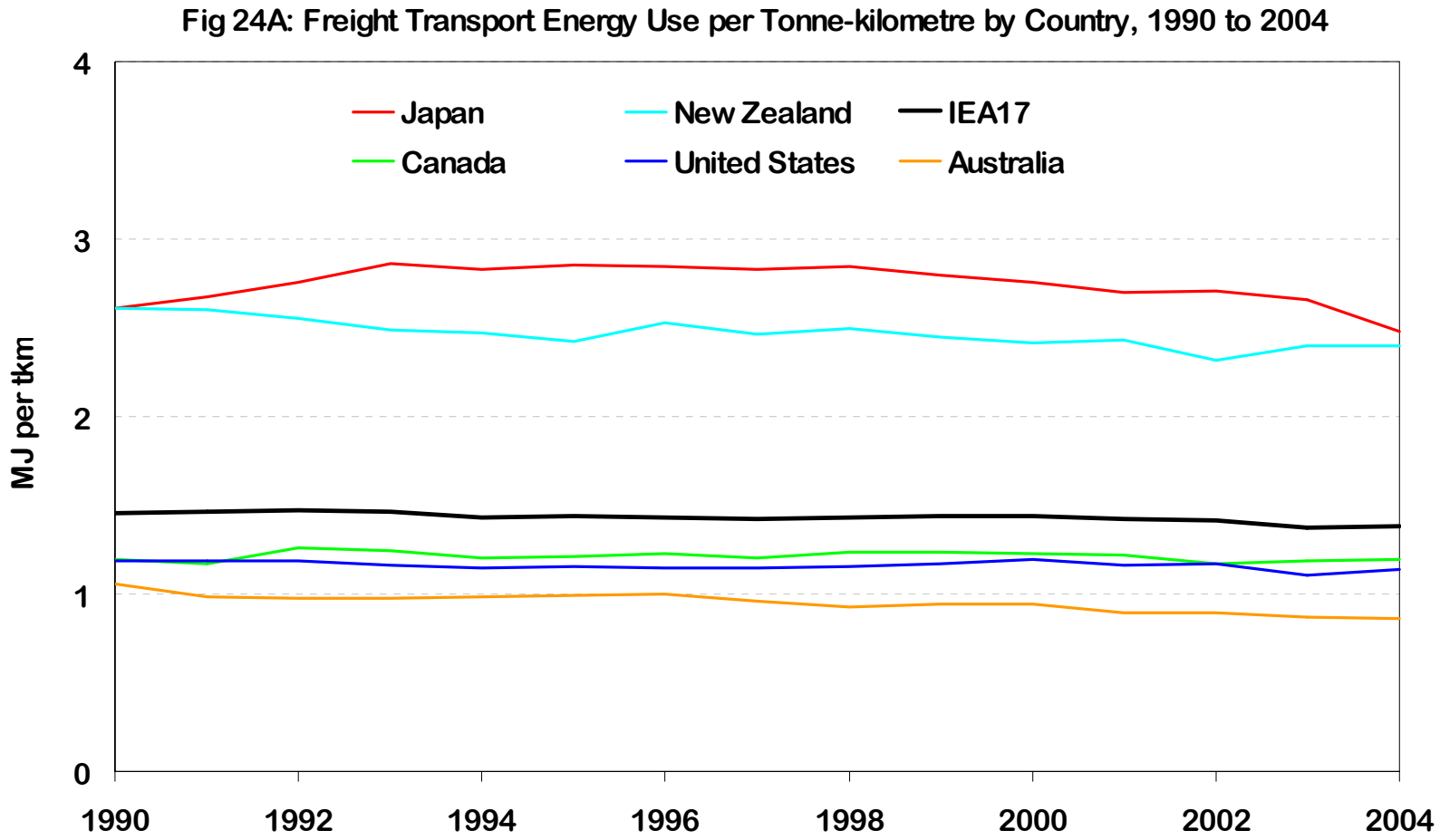
How intensive is our car ownership?



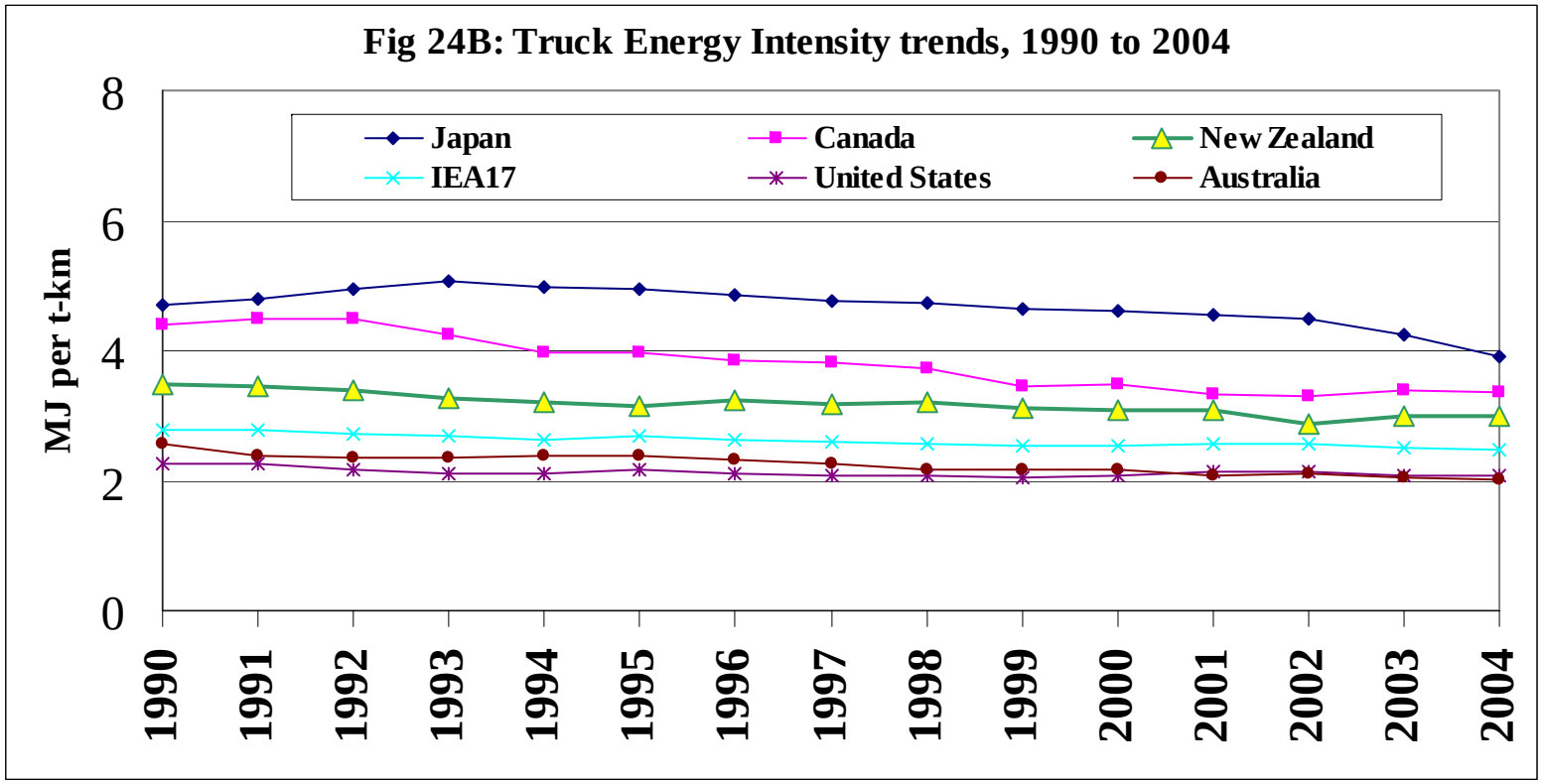
Can we afford it?



How energy intensive are our freight systems?

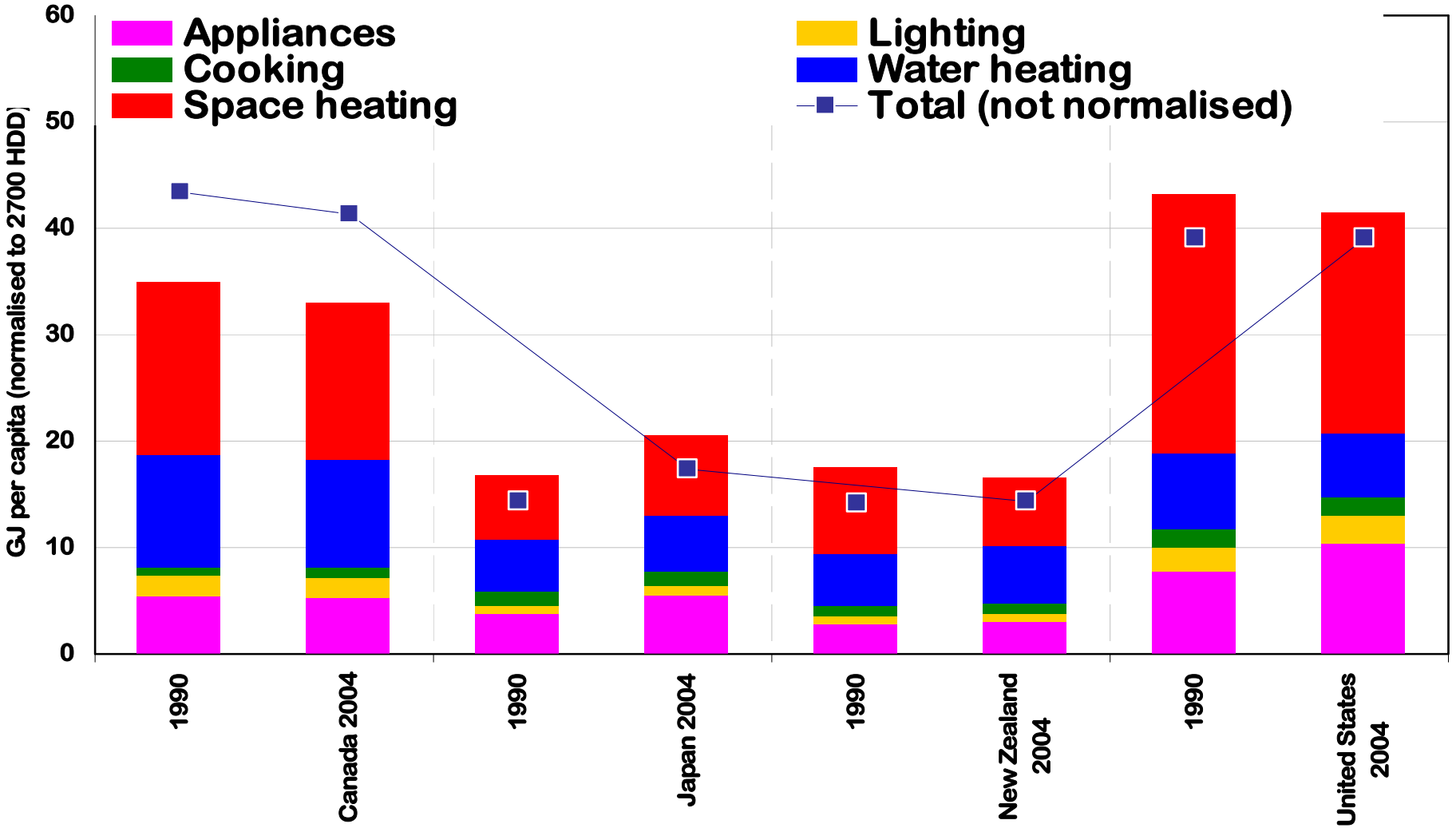


How efficient are our trucks?



How much energy is used in households and how is it used?

Fig 25: Household Energy Use Per Capita in Selected Countries, 1990 and 2004



Energy Efficiency and Renewable Energy Review: Year Five Report to 2006

EE&C Act 2000 [Clause 21 (1) (f)] mandates EECA to monitor and review three aspects of energy use:

- Energy efficiency
- Energy conservation, and
- Use of renewable sources of energy

Energy efficiency is one a number of factors that impact energy use.

Divisia decomposition used to separate out various driving factors

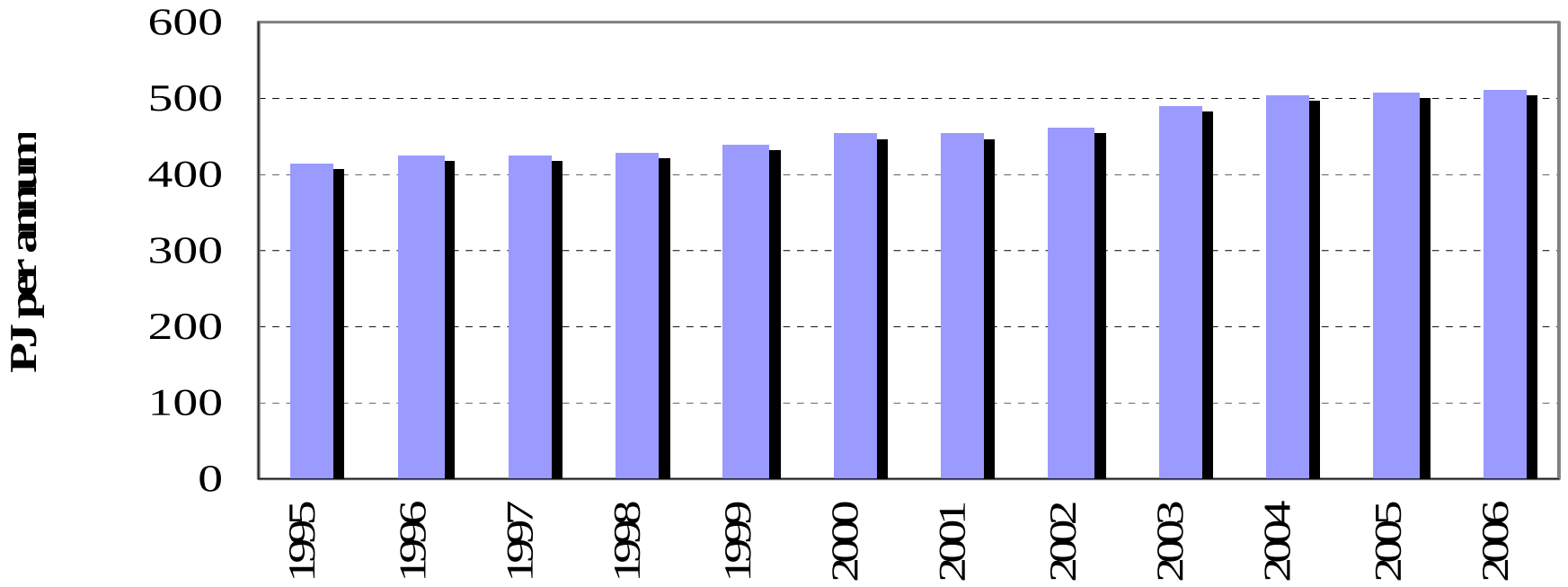
Energy consumption can rise while energy efficiency improves

In the analysis; energy efficiency = energy efficiency + energy conservation. We cannot separate these (yet).

Energy Efficiency and Renewable Energy Review: Year Five Report to 2006

- Measure energy efficiency
  - 5 Sector Level (not programme level)
  - Split across electricity, oil and other fuels
- Renewable energy
  - Consumer energy level (‘involves’ primary energy)
  - Split across sources
  - Split across energy use form
  - Hydro is normalised for inflow variations

Fig 2.1: Economy Wide Energy Use Trend 1996 – 2006



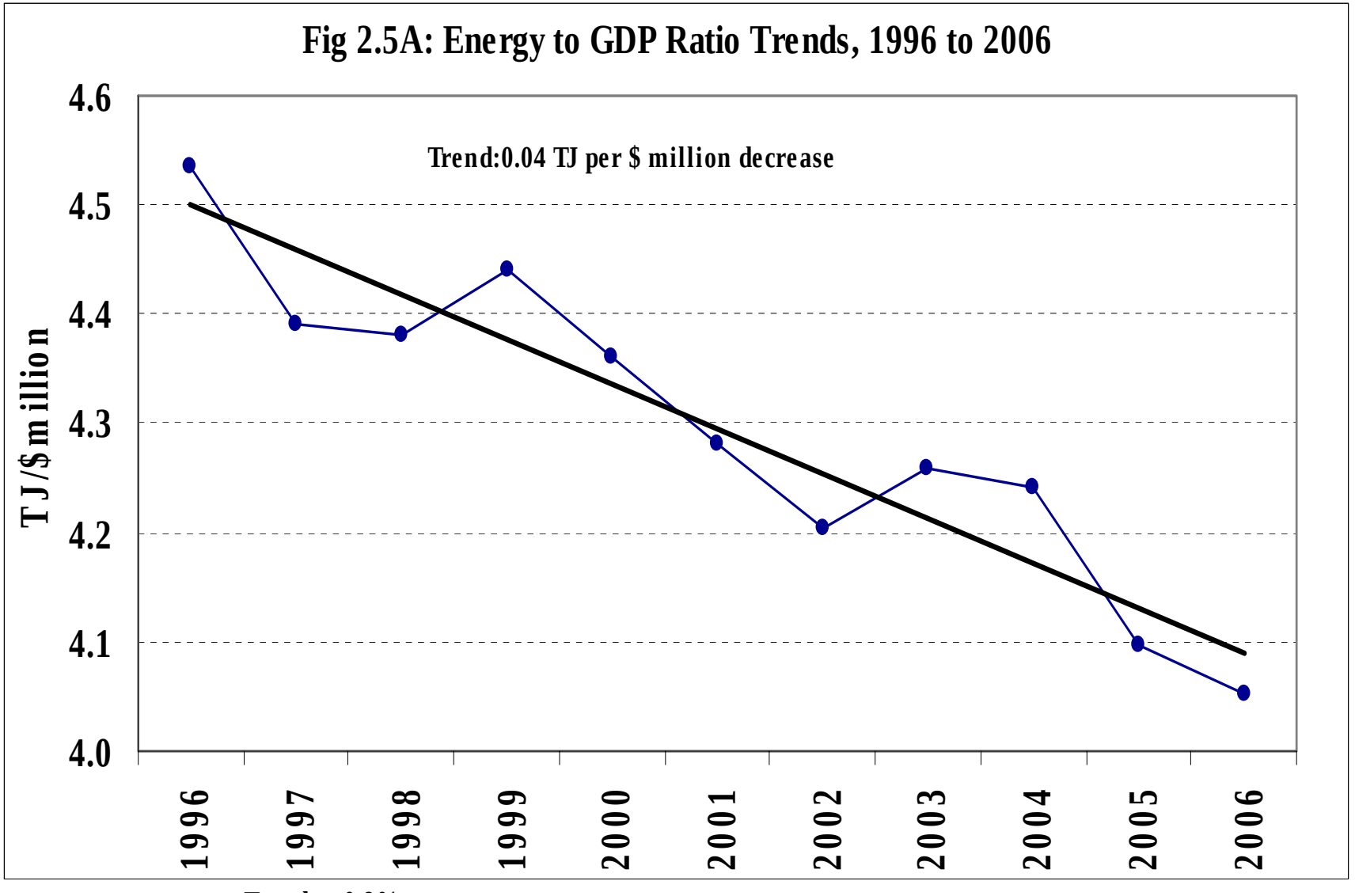
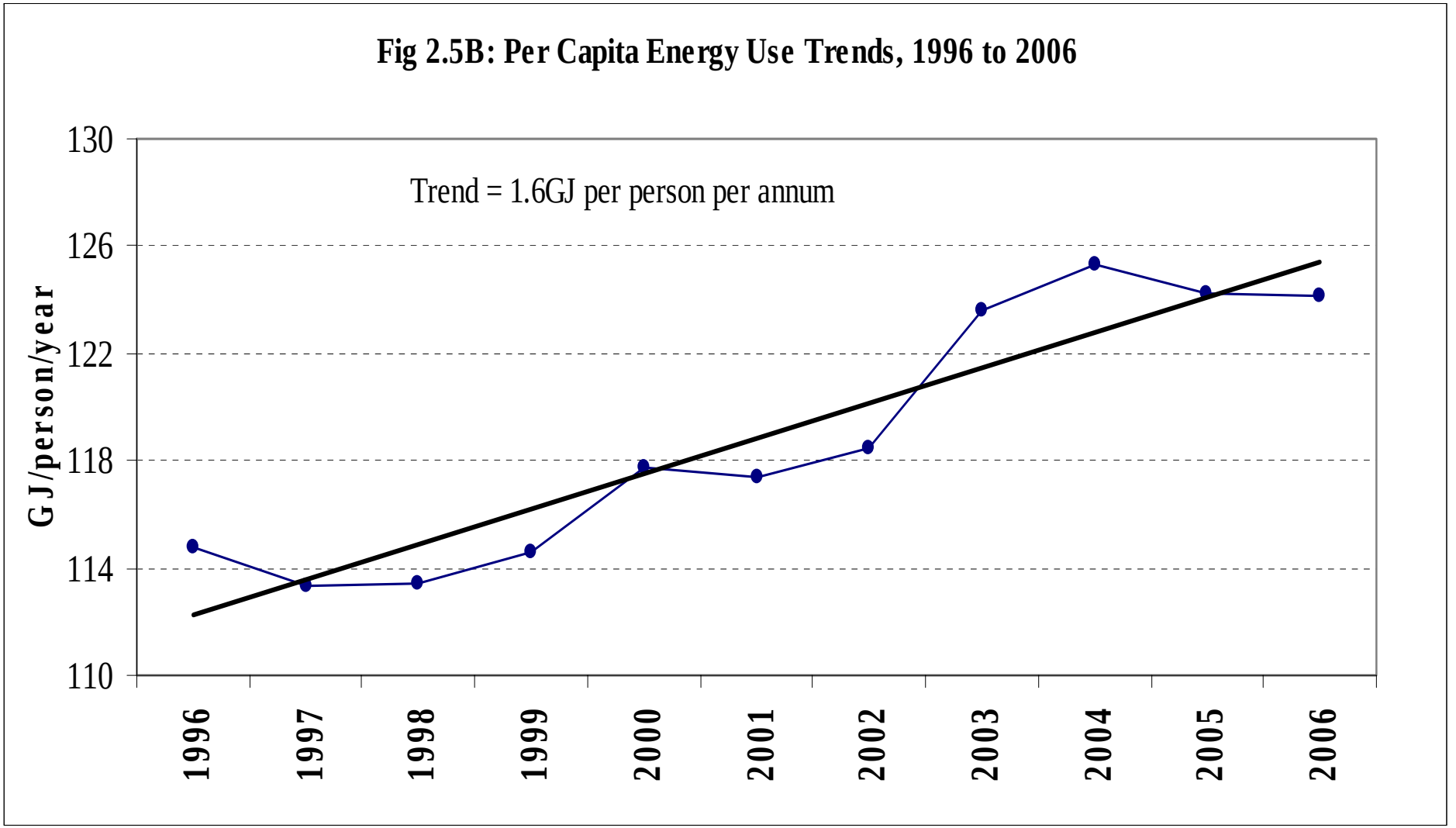
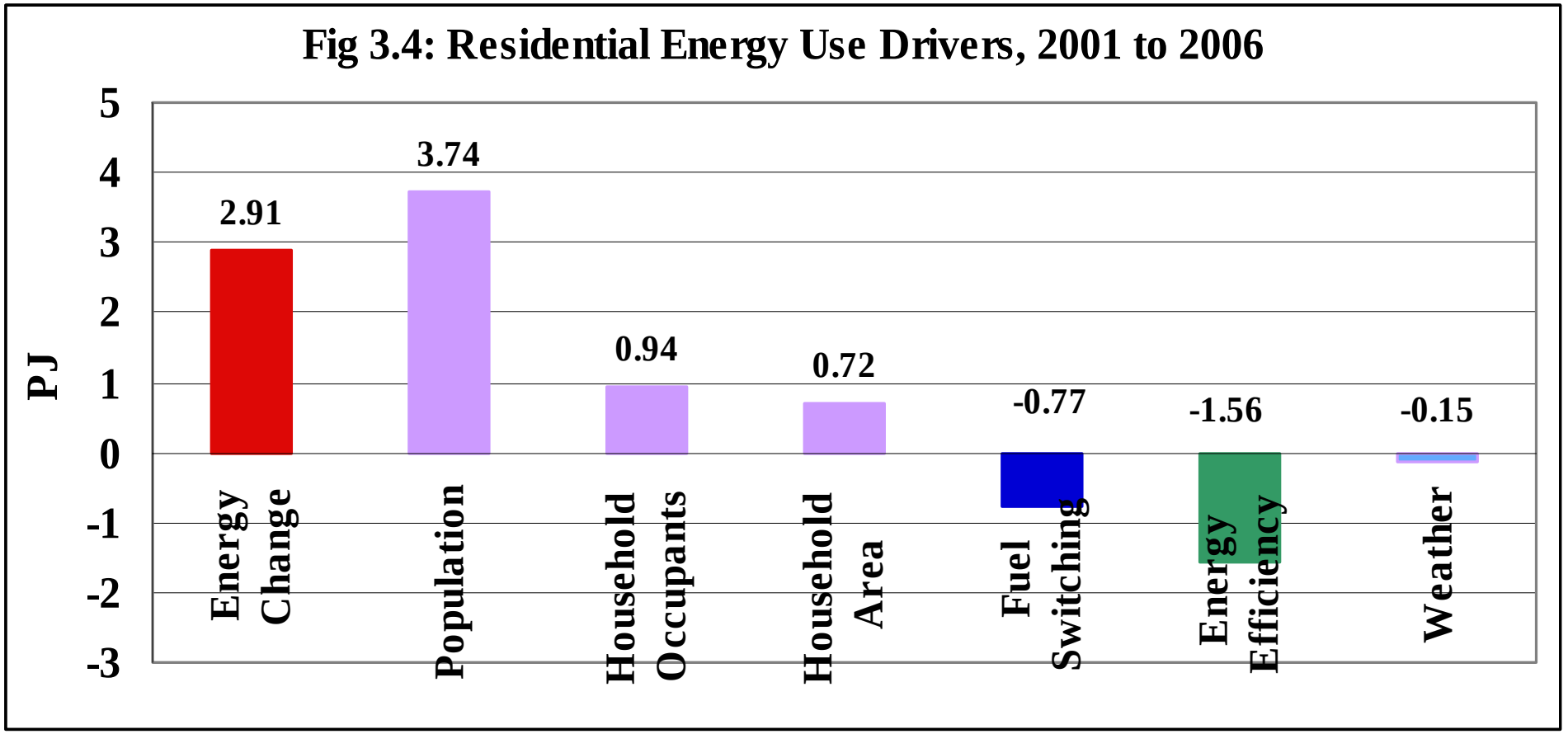


Fig 2.5A: Energy to GDP Ratio Trends, 1996 to 2006
Trend:0.04 TJ per $ million decrease
TJ/$million
4.6
4.5
4.4
4.3
4.2
4.1
4.0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

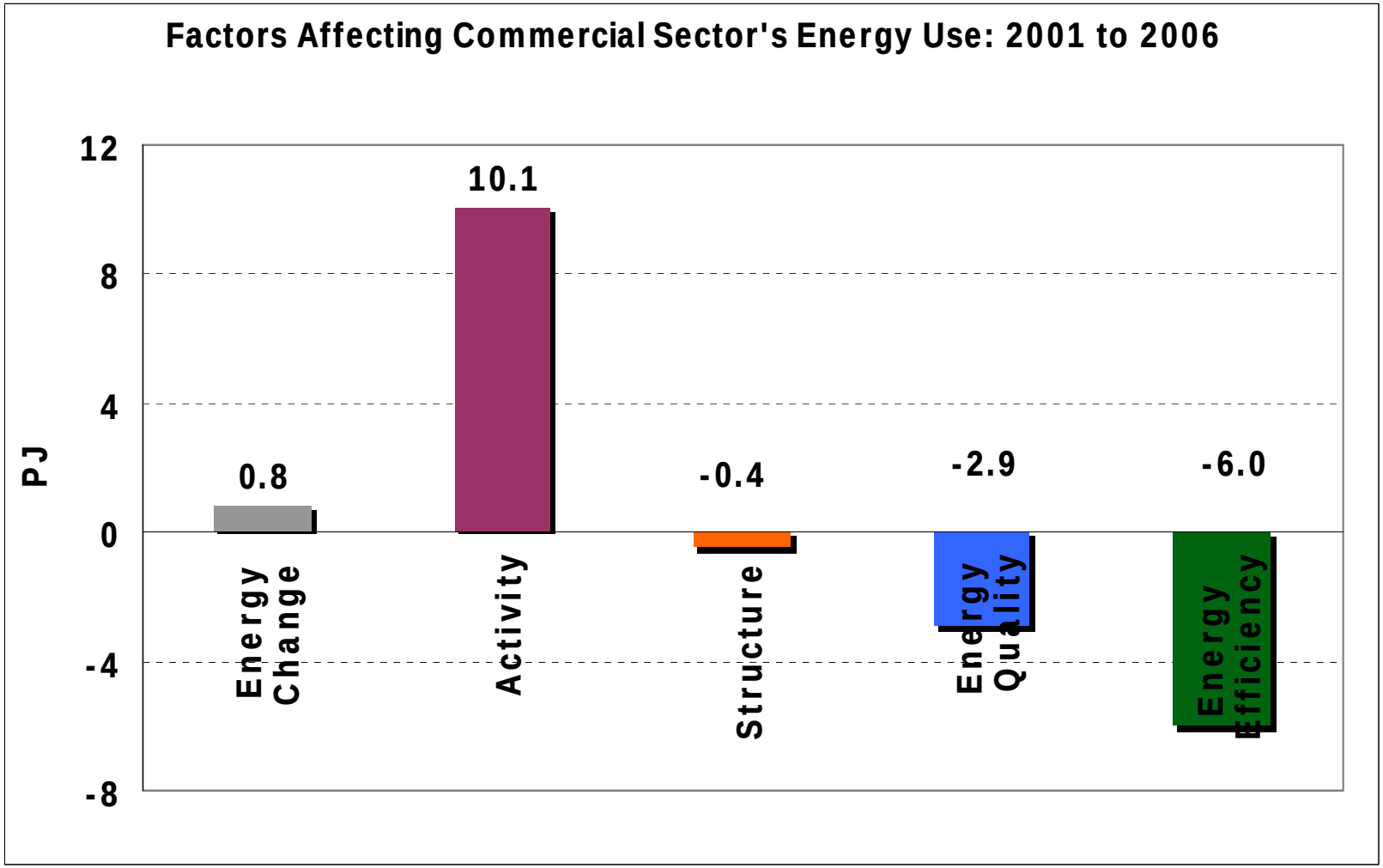
Fig 2.5B: Per Capita Energy Use Trends, 1996 to 2006



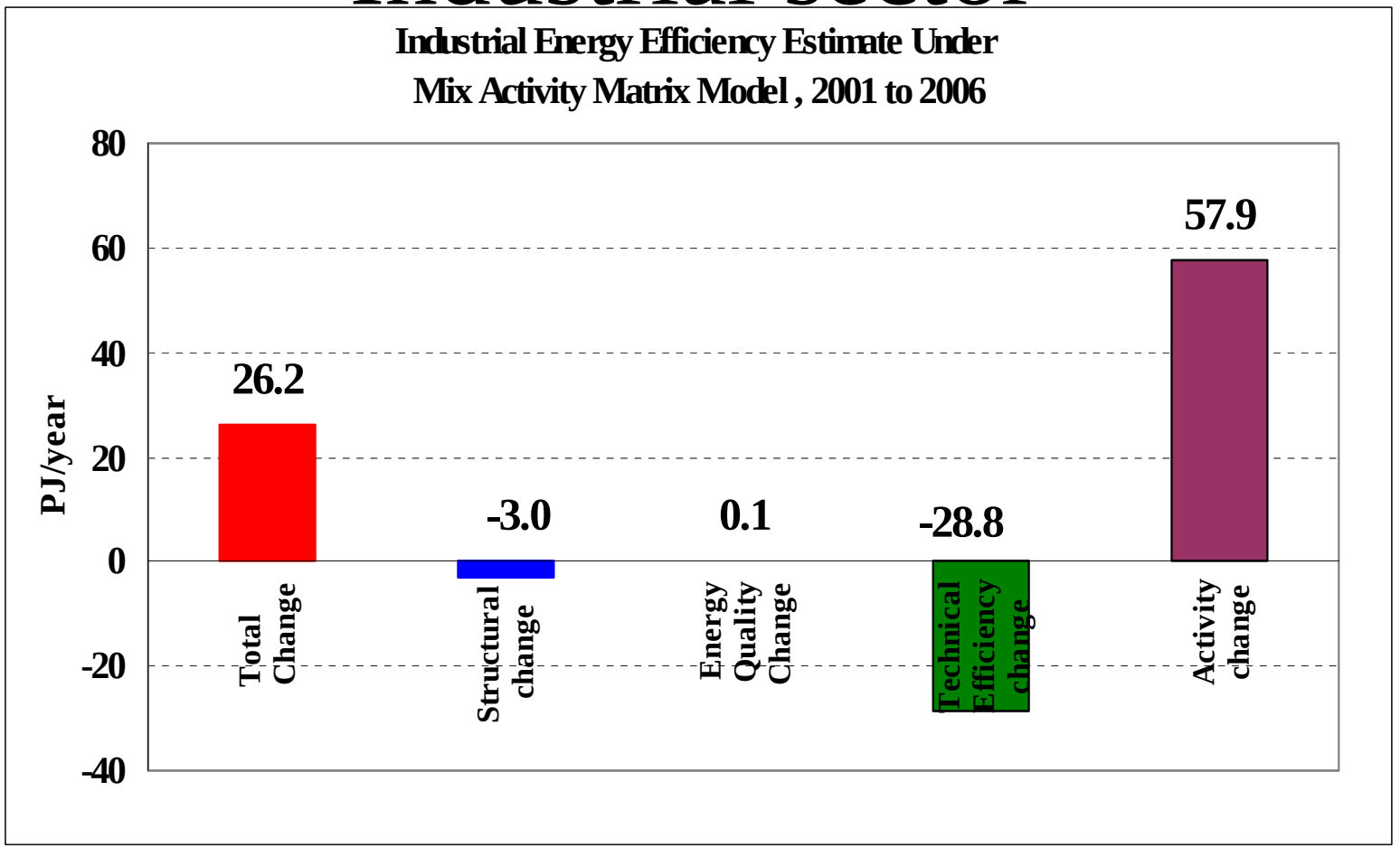
Residential Sector



Commercial Sector



Industrial sector



Sources of industrial energy change by activity change matrix (PJ), 2001 to 2006

Source	Activity Matrix			
	GDP	TWI	PPP	Mix*
Structural change	-3.0	-3.0	-3.0	-3.0
Energy Quality Change	0.1	0.1	0.1	0.1
Energy Efficiency Change	9.0	-51.1	10.1	-28.8
Activity change	20.0	80.1	19.0	57.9
Total	26.2	26.2	26.2	26.2

* = output of wood, pulp and paper, meat, other foods, and basic metals represented by TWI

GDP: all sectors represented by value added, except where physical output is available

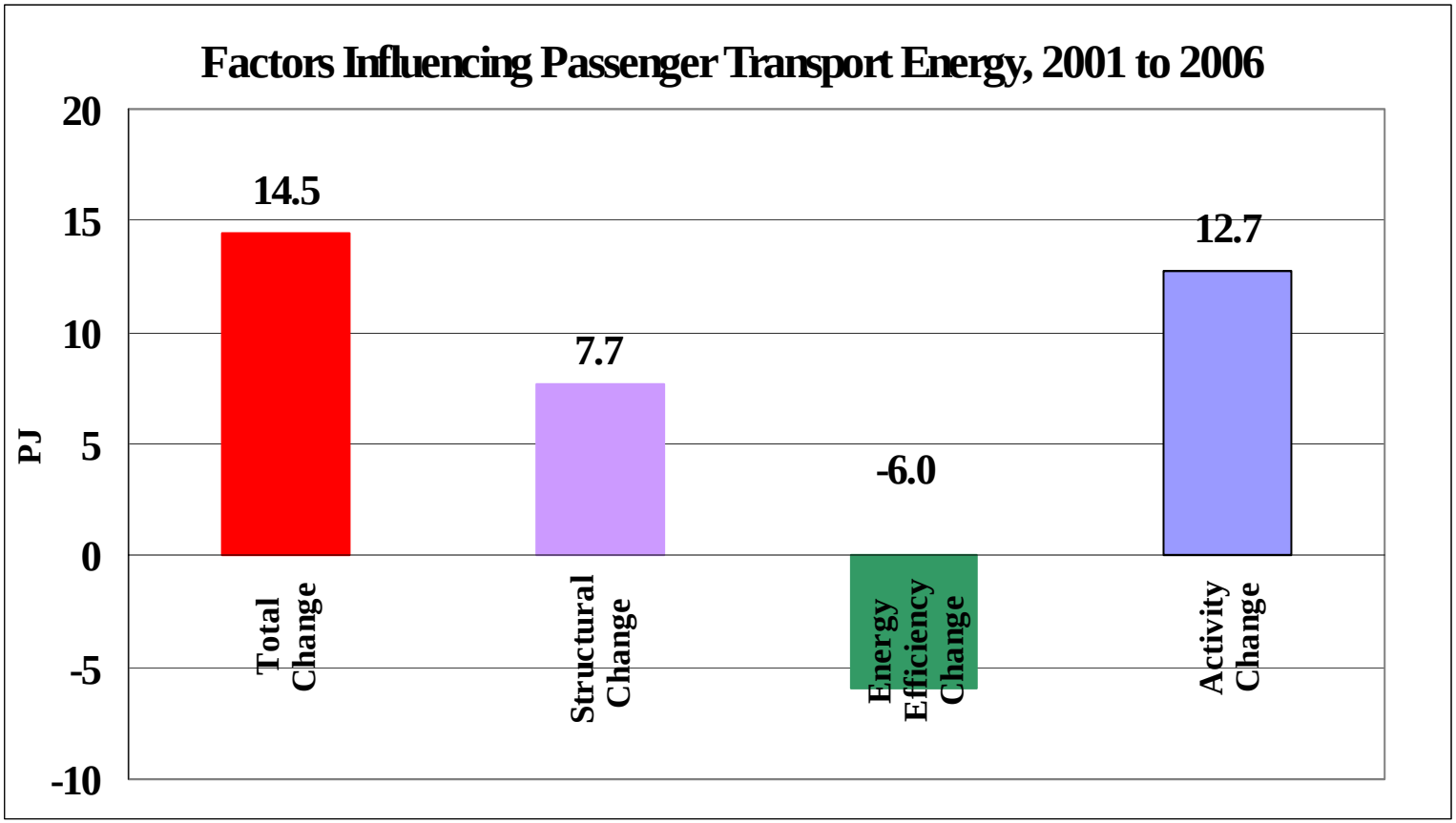
TWI: all sectors represented by value added weighted by Trade Weighted index

PPP = all sectors represented by value added at Purchasing Parity

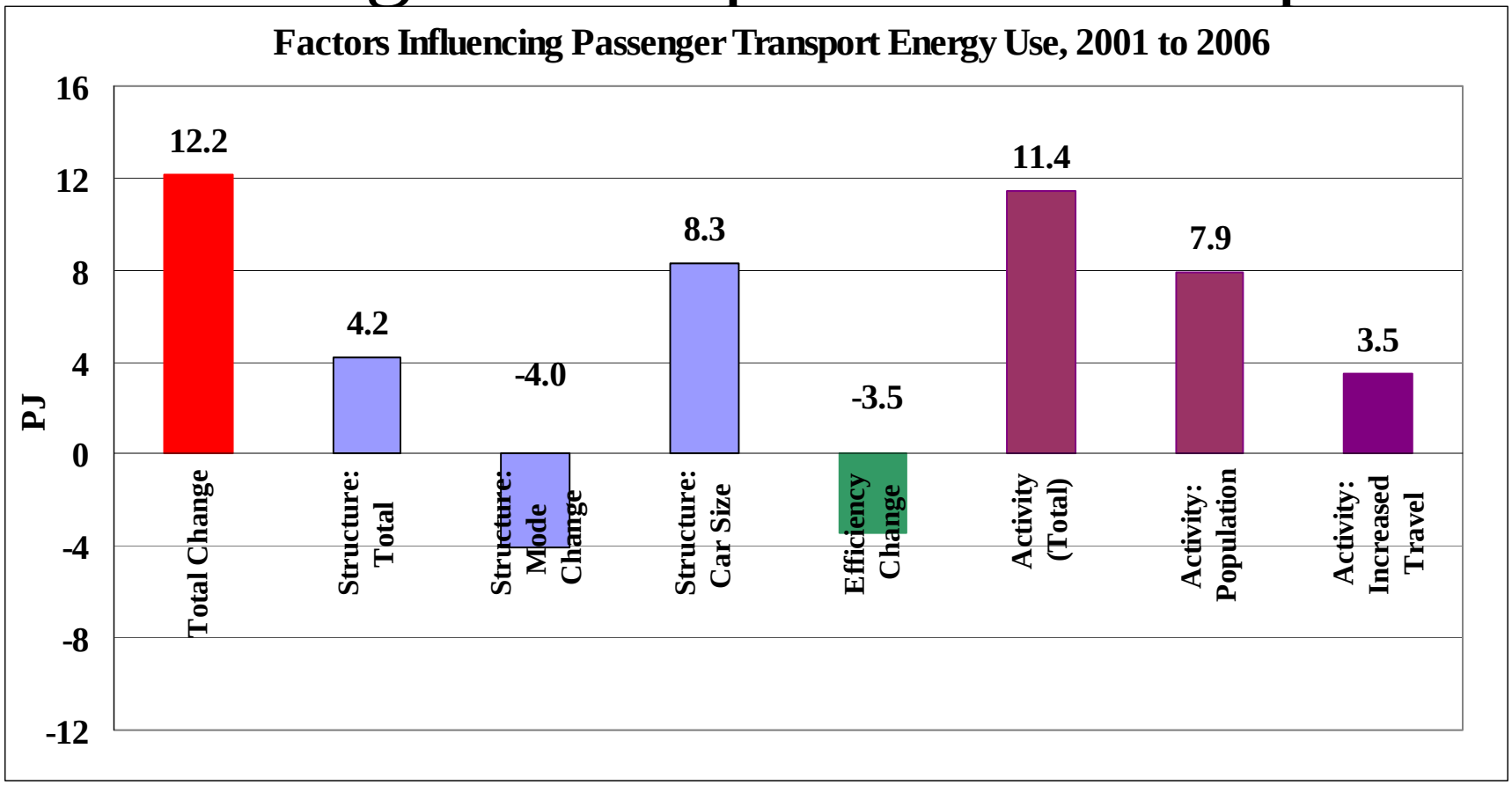
Mix: wood, pulp and paper, meat, other foods, and basic metals represented by TWI, others by price adjusted value adde

Conceptual definition of energy efficiency in modern exporting heterogeneous economy is critical to the answer you will get

Passenger Transport



Passenger Transport: Further Split



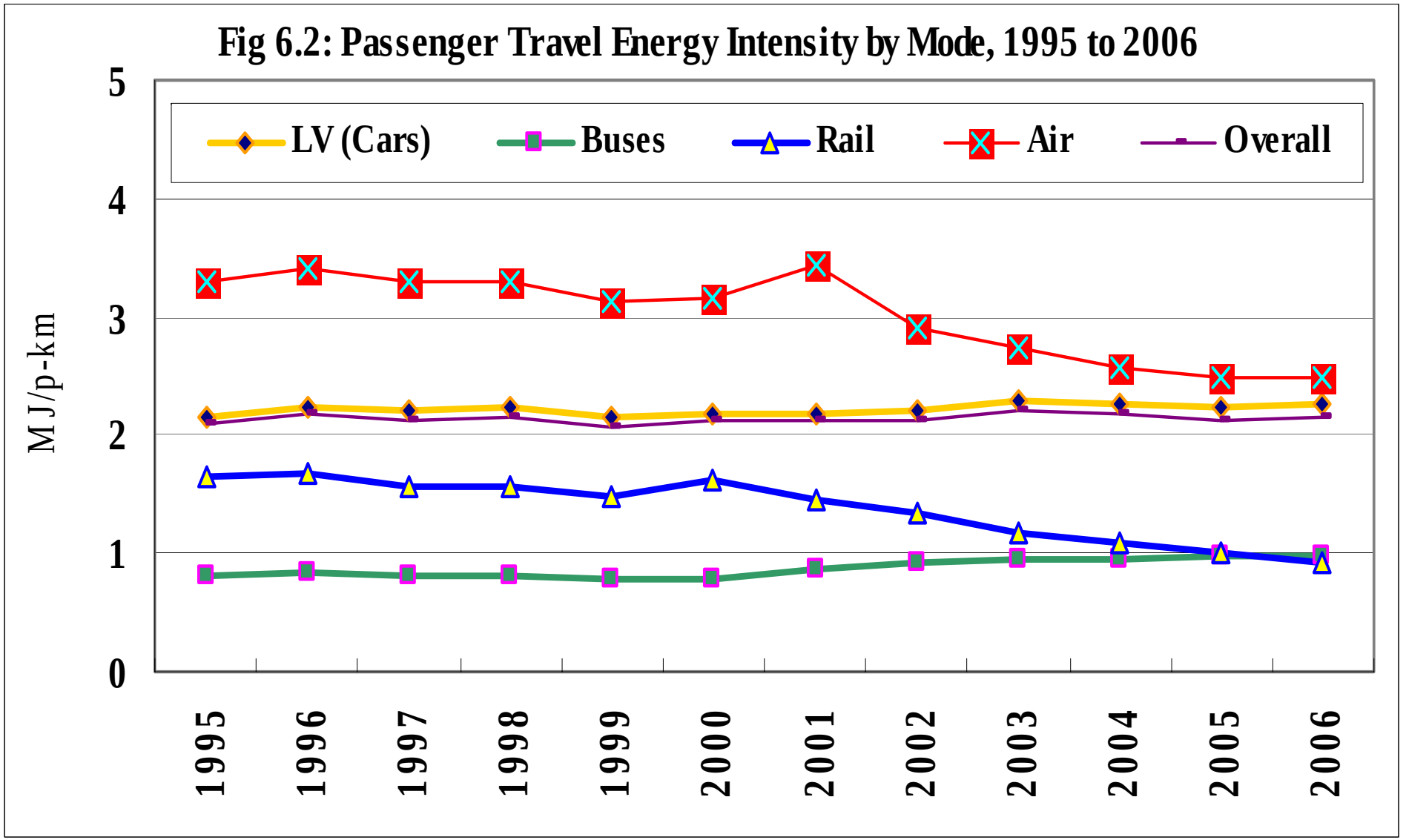
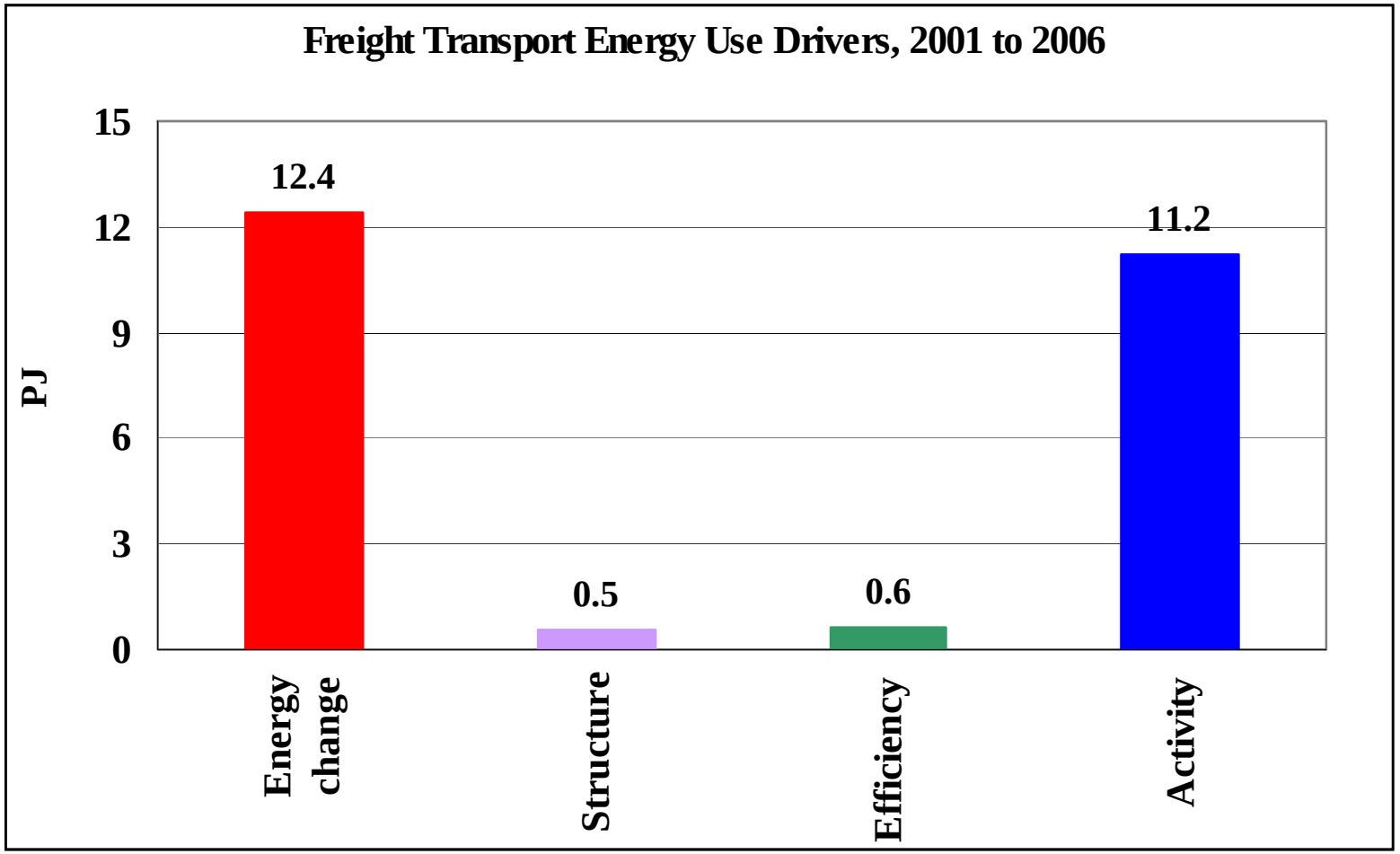


Fig 6.2: Passenger Travel Energy Intensity by Mode, 1995 to 2006
LV (Cars)
Buses
Rail
Air
Overall
MJ/p-km
5
4
3
2
1
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

Freight Transport



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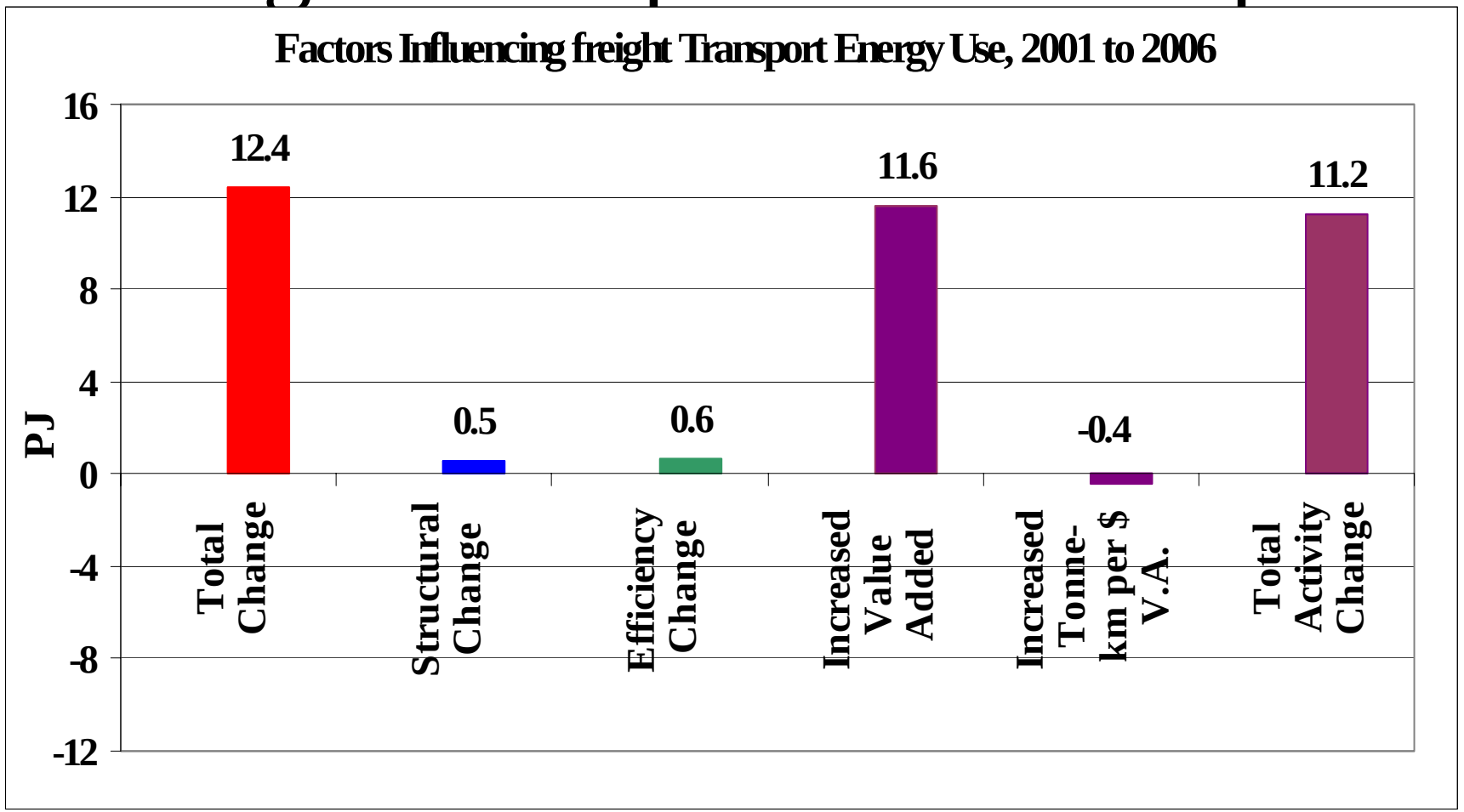
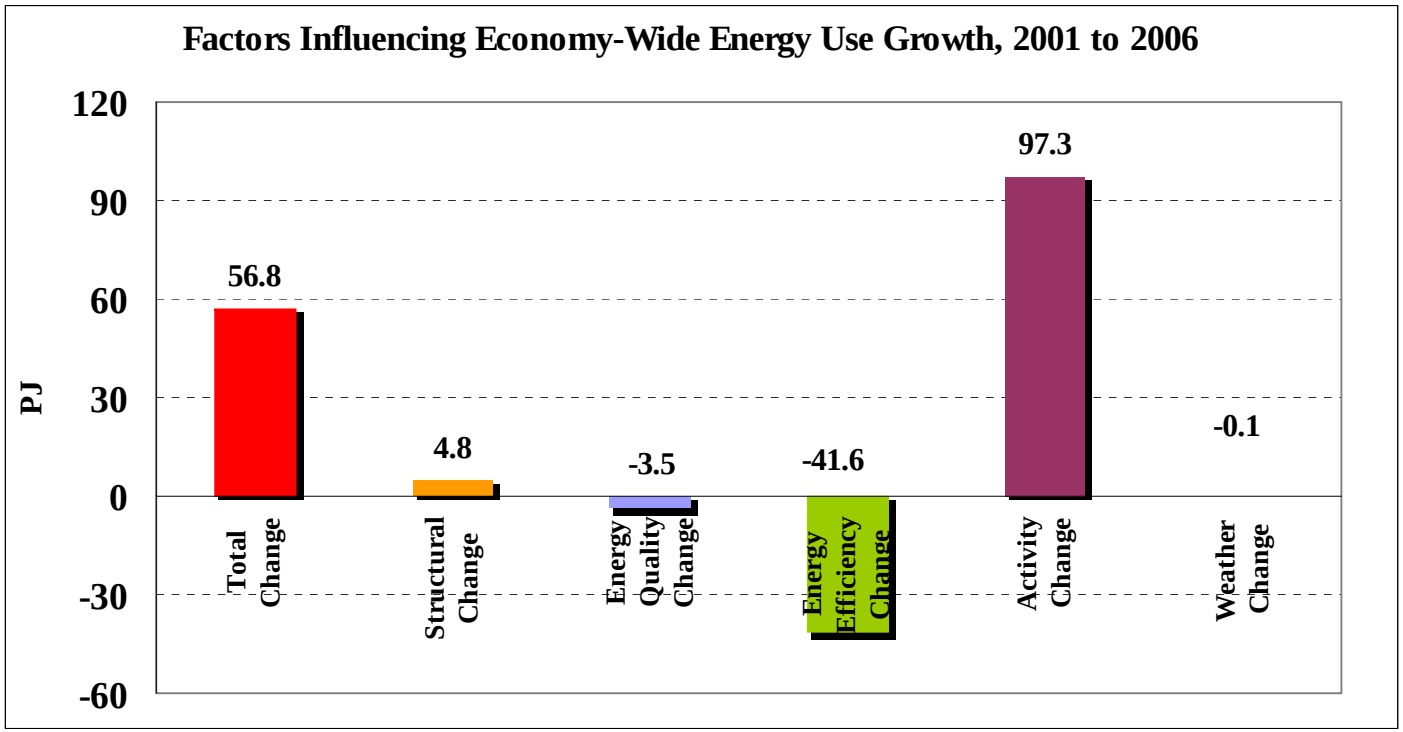


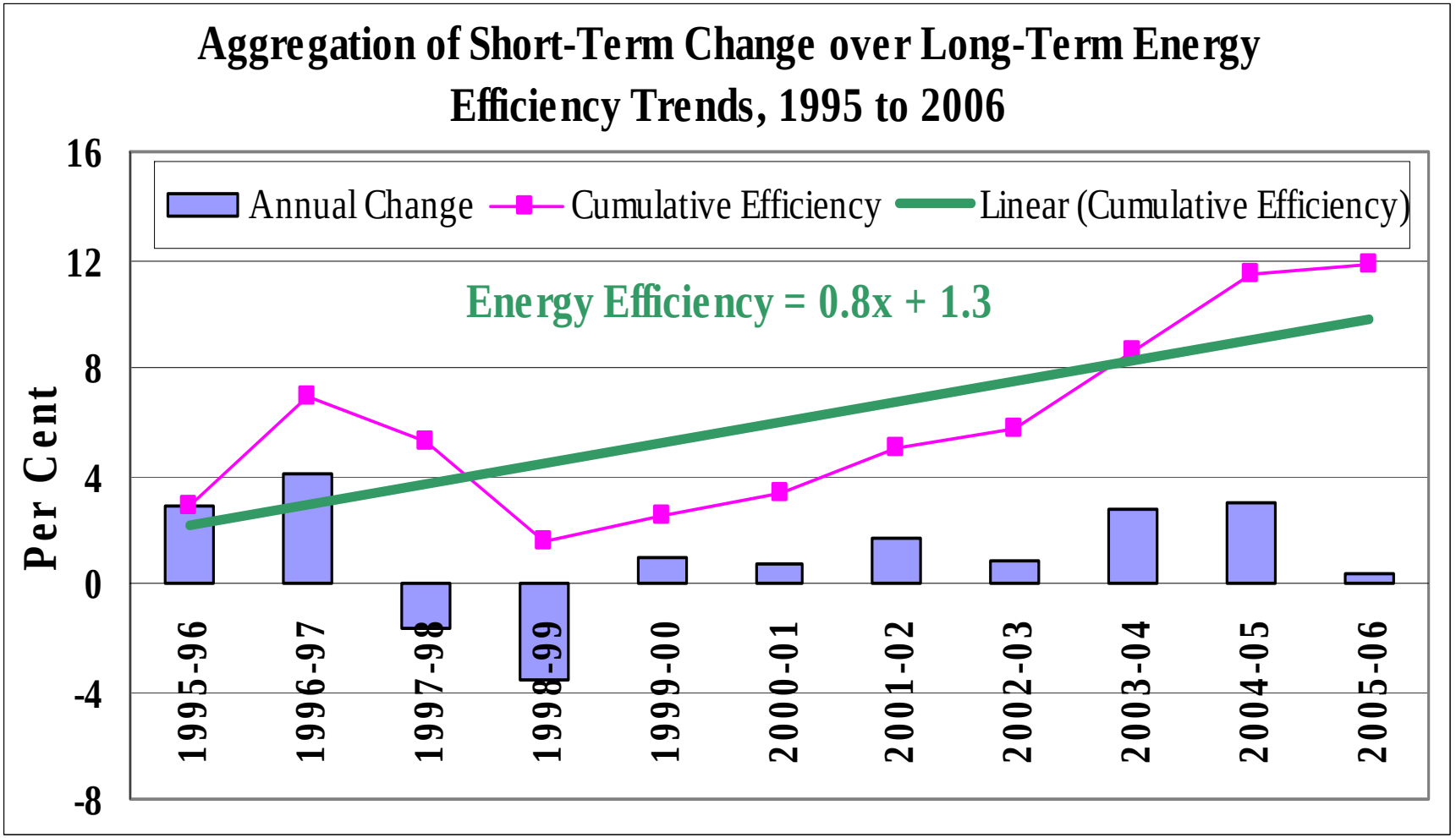
Economy-Wide Progress: 2001 and 2006

Sector Level Energy Efficiency Performance:. 2001-2006

	Energy Use (PJ)			Energy Use Drivers (PJ)					Energy Efficiency Uptake (%)		
PJ	2001	2006	Total Change	Structural Change	Quality Change	Efficiency	Activity Change	Weather Change	Total	Average pa	**Growth /pa**
Industrial	160.3	186.6	26.2	-3.0	0.1	**-28.8**	57.9	-	17.96	3.59	**3.36**
Commercial	48.4	49.2	0.8	-0.4	-2.9	**-6.0**	10.1	-	12.28	2.46	**2.34**
Passenger Transport	132.4	146.9	14.5	7.7	0.0	**-6.0**	12.7	-	4.50	0.90	**0.88**
Freight Transport	53.5	65.9	12.4	0.5	0.0	0.6	11.2	-	-1.17	-0.23	**-0.24**
Residential	59.0	61.9	2.9	0.0	-0.8	**-1.6**	5.4	-0.1	2.65	0.53	**0.52**
Economy Wide	**453.8**	**510.5**	**56.8**	**4.8**	**-3.5**	**-41.6**	**97.3**	**-0.1**	9.18	1.84	**1.77**

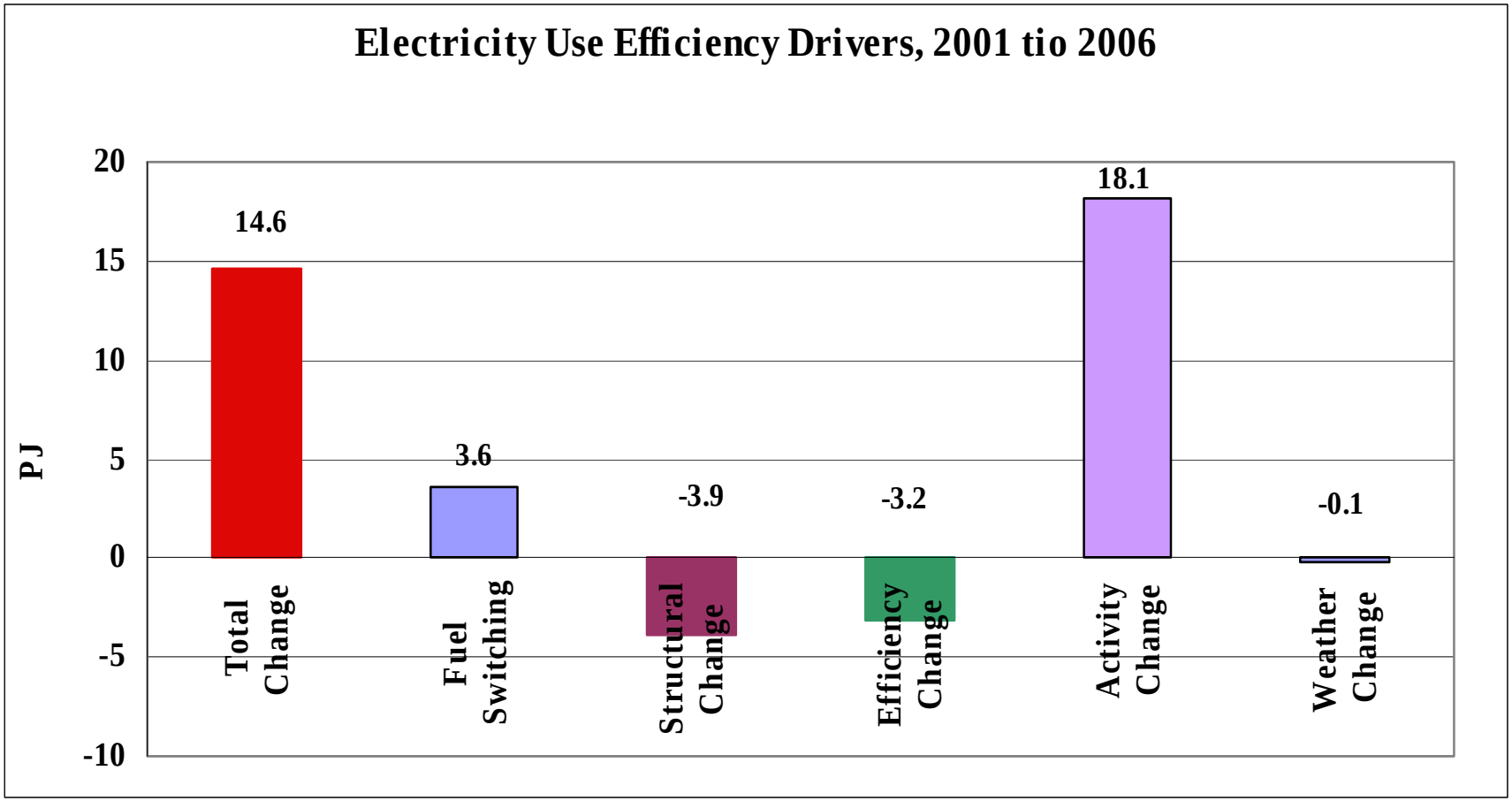
Economy-Wide Energy Efficiency Progress: 2001 and 2006

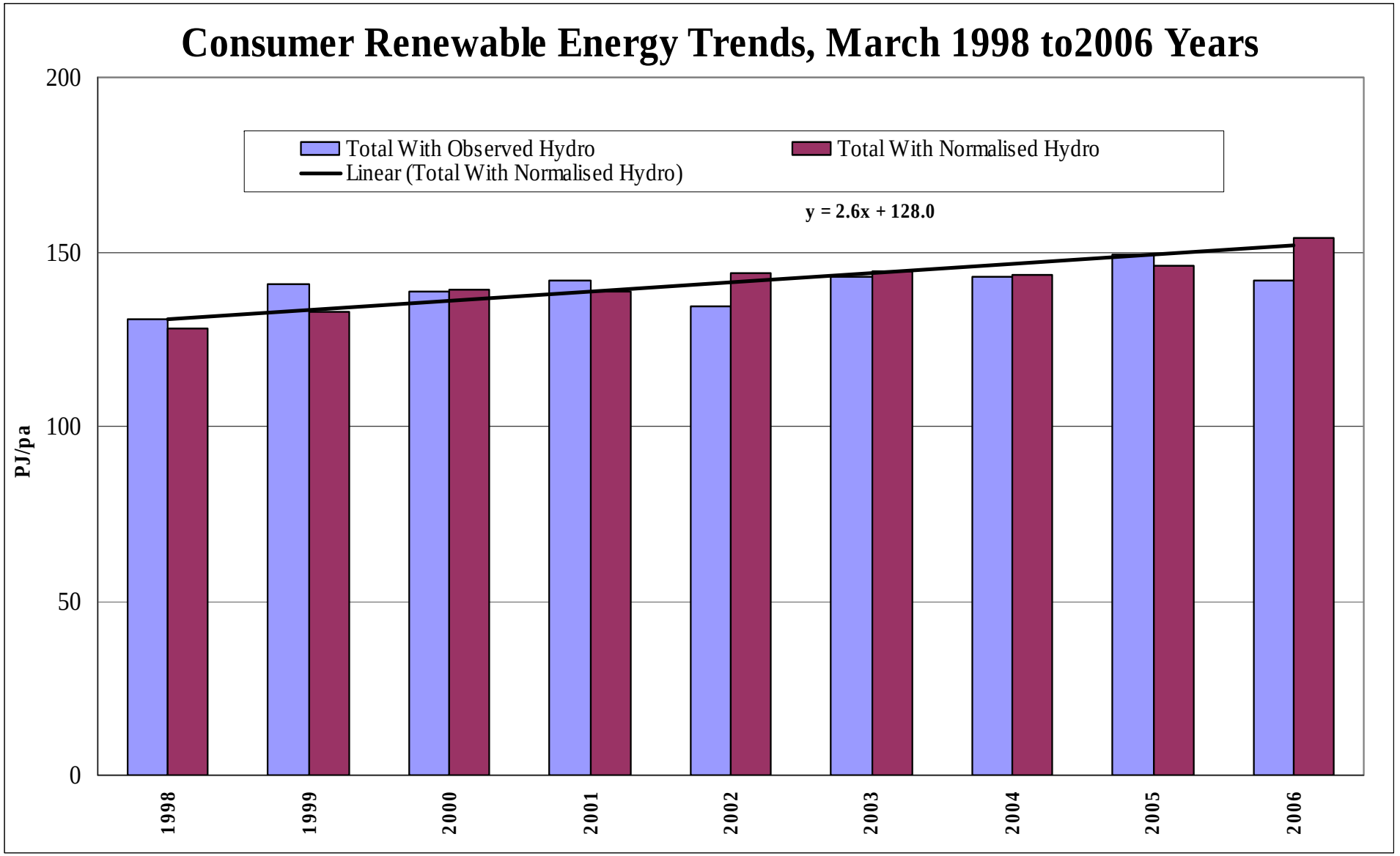



Aggregation of Short-Term Change over Long-Term Energy Efficiency Trends, 1995 to 2006
Annual Change
Cumulative Efficiency
Linear (Cumulative Efficiency)
Energy Efficiency = 0.8x + 1.3
Per Cent
16
12
8
4
0
-4
-8
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06

Economy-Wide Progress: 2001 and 2006

Electricity End-Use Efficiency




Consumer Renewable Energy Trends, March 1998 to2006 Years
200
150
100
50
0
PJ/pa
Total With Observed Hydro
Total With Normalised Hydro
Linear (Total With Normalised Hydro)
y = 2.6x + 128.0
1998
1999
2000
2001
2002
2003
2004
2005
2006

Consumer Renewable Energy Sources

Consumer renewable energy performance by source to March 2006 year

	Hydro Observed	Hydro Normalised	Geothermal	Biogas	Wood	Wind	Solar	Total With Observed Hydro	Total With Normalised Hydro
1998	75.2	72.3	25.3	1.7	28.4	0.1	0.18	130.9	128.0
1999	80.0	72.1	27.4	1.7	31.3	0.1	0.18	140.8	132.8
2000	76.2	77.0	28.3	1.5	32.0	0.2	0.18	138.4	139.2
2001	79.9	76.8	23.4	1.5	36.3	0.5	0.19	141.8	138.7
2002	73.4	82.4	22.7	1.6	36.3	0.5	0.19	134.6	143.7
2003	81.9	83.5	20.1	1.7	38.4	0.6	0.20	142.8	144.5
2004	81.0	81.8	18.8	1.9	40.2	0.6	0.22	142.6	143.4
2005	86.8	83.5	19.0	1.4	40.3	1.7	0.25	149.4	146.1
2006	72.6	84.4	21.1	2.7	43.2	2.2	0.24	142.0	153.8
2001 to 2006 (PJ) Change	-7.3	7.6	-2.4	1.2	6.9	1.7	0.05	0.2	15.1
2001 to 2006 (%) Change	-9.1	9.9	-10.0	84.1	18.9	322.2	28.6	0.1	10.9

Limits of Energy Balance Analysis for Energy Efficiency Indicators

"From Macro to Micro Energy Indicators"

Data and Methodology Training Session

How and why to get the big picture right

IEA

28 April 2006

Robert Tromop

Manager Monitoring and Technical

Introduction

- NZ’s methodology
- What are we trying to do?
- What we know we don’t know
- Methodological limits - Can indices adequately explain comfort, activity, structure or productivity?
- Energy services way of thinking
- Where to from here

NZ methodology – a Suite of Indicators

- Compare energy use change in PJ
- Compare energy intensity indicators at homogeneous service levels
- Isolate change components by Divisia decomposition
- Integrate with micro indicators.

Energy Efficiency

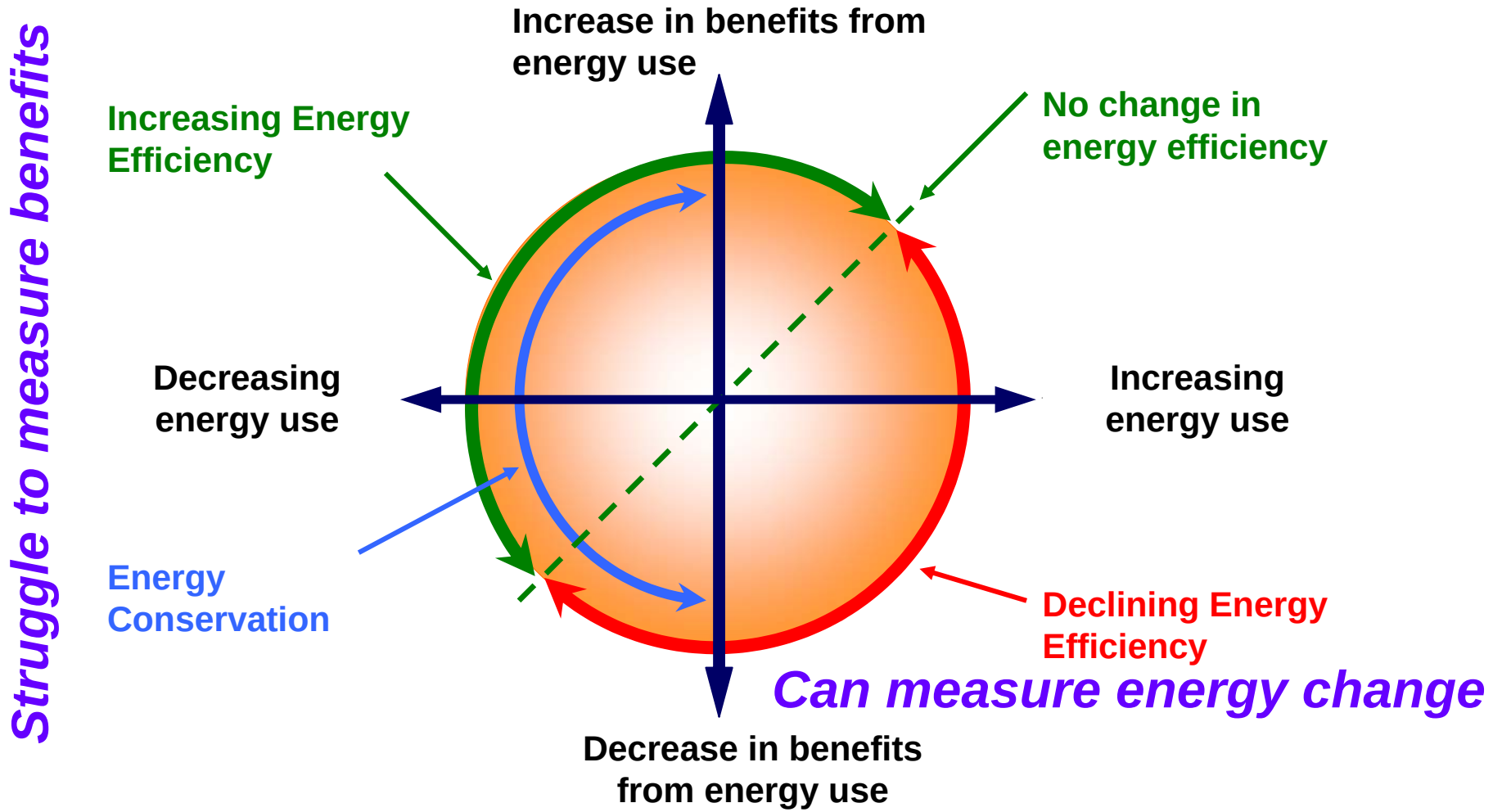
- Politicians want it…
- Experts argue about it…
- Stakeholders doubt it …
- Ordinary folk just don’t get it at all…

- Our key challenges are about defining and communicating what we analyse

What is Energy Efficiency?

- Energy Intensity is not Energy Efficiency
- but intensity indicators are used to define EE
- Physical output indicators ignore wealth effects
- but may be the best indicator for sectoral EE given reasonable sectoral homogeneity
- Macroeconomic EE is very difficult:
- modern economies are very heterogeneous
- output/benefit definition and measurement is very difficult

What is Energy Efficiency



Its like trying to measure God!

No one can see EE, but its everywhere

Everyone has their own sense of what EE is,

- but most people can’t explain exactly what it is

Plenty of agnostics and athiests

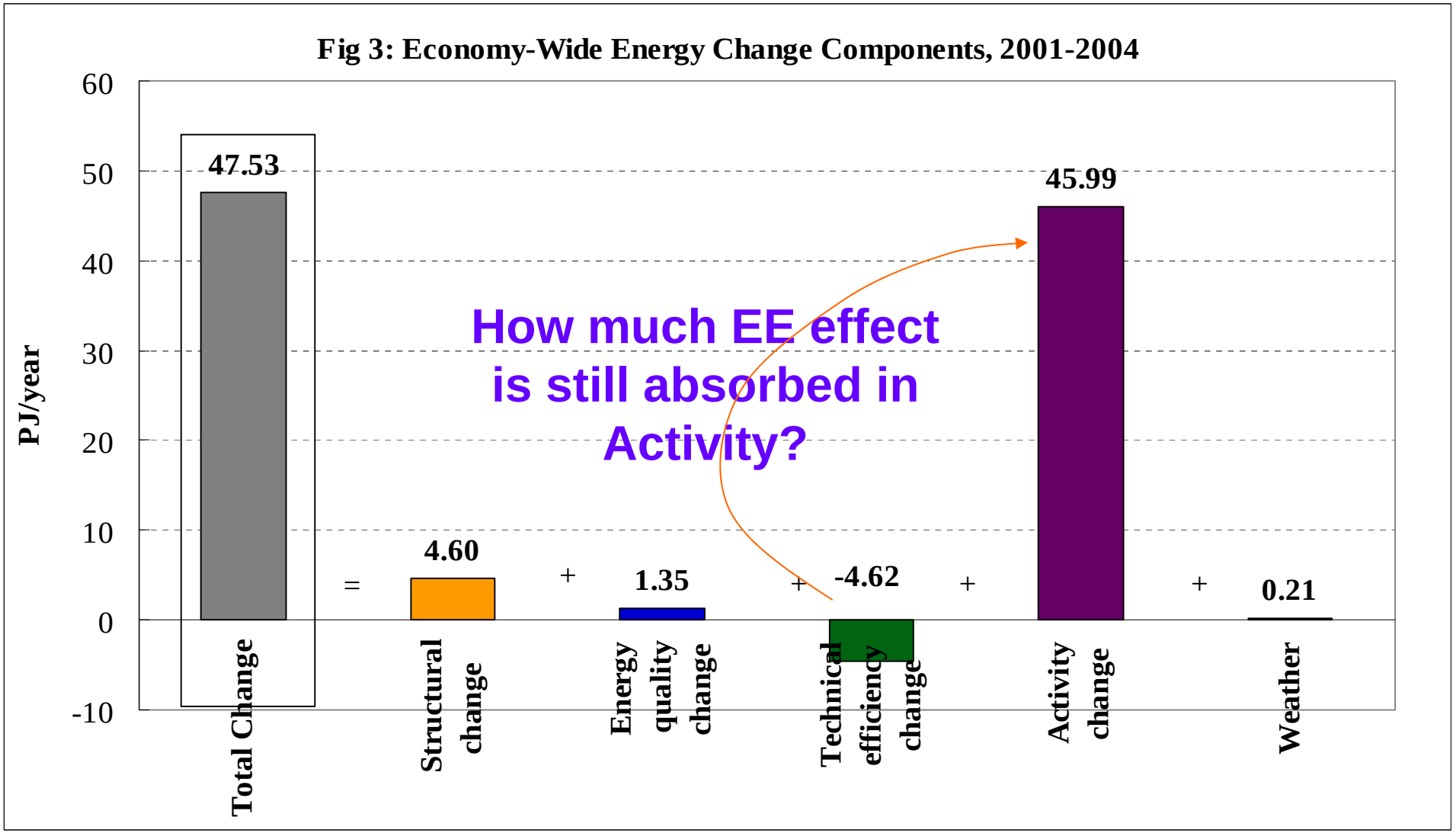
Many claim to have ‘seen‘ it or what it does

- but who can measure it?

Its like trying to weigh frogs!

- Easy to understand at a micro level – engineering definitions work well – can't define macro level?
- (micro; can dissect a frog – macro; live frog)
- Energy data problematic, but measures of outputs or benefits worse – measures for comfort? mobility?
- Takeback & rebound means that EE interventions give more service and minimal demand reduction
- Should we account for under-heated homes? sub-optimal production?

Decomposition



Energy Services Required- Spaceheating NZ homes

All figures PJ.	2001	2017
Required end-use heat energy for 18C	43	
Supplied consumer heat energy	20	
Heat energy projected with growth to 1.82m homes and no change to housing stock energy (frozen efficiency)		57
Heat energy projected with all pre-1978 housing stock upgraded & new stock 50% of NZBC 2000 energy needs		45
Heat energy projected with all pre-1978 housing stock upgraded & new stock 50% of NZBC 2000 energy needs and 1 million heat pumps.		35

Takeback &Rebound

- Takeback - potential savings applied to improved service resulting in reduced energy savings
- Rebound – new consumption from savings
- 5 yr NZ insulation/health study; $1200 insulation retrofit provides $2300NPV. 70% of value is health/productivity improvements, 30% energy savings.
- Benchmarks for takeback and rebound? Is this normal?
- Relationship between takeback and sub-optimal service? – less developed counties, full takeback?

Energy Services

Table 3: Appliance proliferation in New Zealand households

Appliance	Total		% Change	Per 1000 people		Household	
	2001	2004		2001	2004	2001	2004
Oven	2,698,000	2,891,700	7%	709	731	1.88	1.93
Washing Machine	1,392,400	1,451,500	4%	366	367	0.97	0.97
Dryer	916,000	910,800	-1%	241	230	0.64	0.61
Refrigerator	2,306,800	2,402,700	4%	606	607	1.61	1.61
Dishwasher	564,600	657,600	16%	148	166	0.39	0.44
Television	1,410,000	1,466,600	4%	371	371	0.98	0.98
Computer	675,300	928,900	38%	178	235	0.47	0.62
Heater	4794400	5017800	5%	1260	1268	3.35	3.36

Time to have a cup of tea and rethink some fundamentals

Energy is a derived demand

- Energy only purchased for service benefits

  (No one purchases energy for the sheer pleasure of paying utility bills).

- Benefits sought are ultimately welfare benefits (production driven by welfare)
- We are all trying to maximise welfare

A service perspective

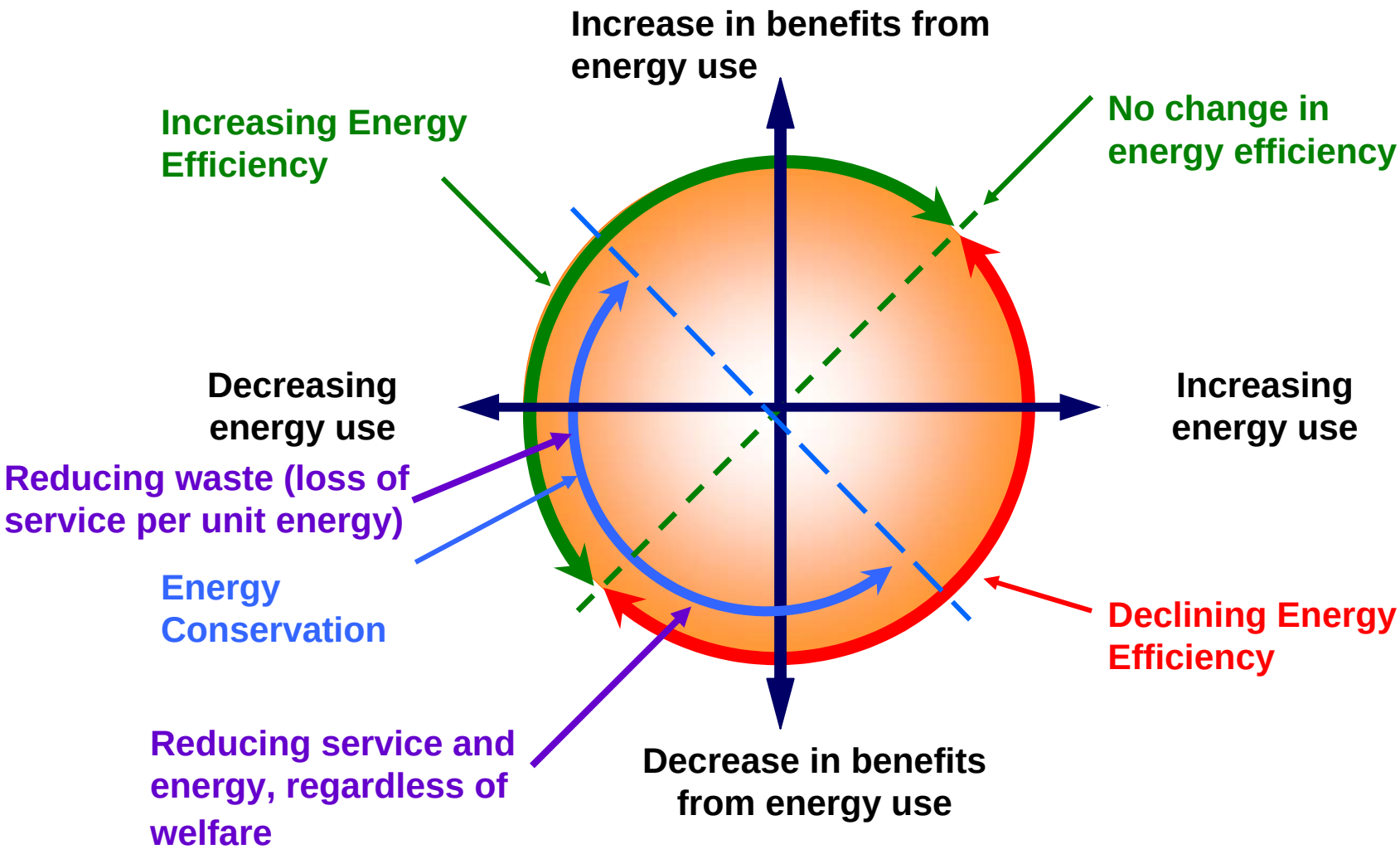
- All energy consumption delivers either welfare services or technical and behavioural losses.
- Takeback is not regressive (bad) it’s a simply a quite natural (but poorly framed) allocation of theoretical ‘savings’ across different services
- Users inherently maximise welfare by balancing the range of service value from an efficiency improvement
- (they take welfare gains from EE until the marginal value of their welfare service mix is equal to the value of reduced energy demand)

What might this all mean?

Should we expect all energy reductions from energy efficiency to be either directly or indirectly applied to increased welfare?

- seems likely for a developed economy like NZ?
- essential for any developing economy

What is Energy Conservation?



But we want to reduce energy demand

- To minimise; costs to society, perverse impacts, delay resource depletion…
- Could be quite a different objective from EE & EC? (demand is derived)
- Drivers for demand reduction need ‘authority’ - the capacity to alter a system regardless of system endogenous features
- E.g. price, regulation, VA’s, taxes, treaties…

Values

Values drive attitudes,

Attitudes drive behaviours,

Behaviours drive change.

- Preference for democracy
- Citizens not consumers
- Attitudes informed by knowledge
- Acceptance of knowledge driven by values

- Economies and trade groups are setting targets for energy intensity improvements.
- Monitoring of energy trends internationally and domestically shows valuable energy intensity and efficiency improvements are occurring. But it is early days.
- Many challenges remain – particularly in addressing population driven energy growth and personal consumption.
- If the world is to realise the potential of sustainable energy we need to start thinking beyond the technological approaches currently utilised around the world and start looking for new paradigms.
- What might it take to develop significant improvement?