Energy efficiency in existing North American buildings: What's worked, what might work better

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RESNET conference

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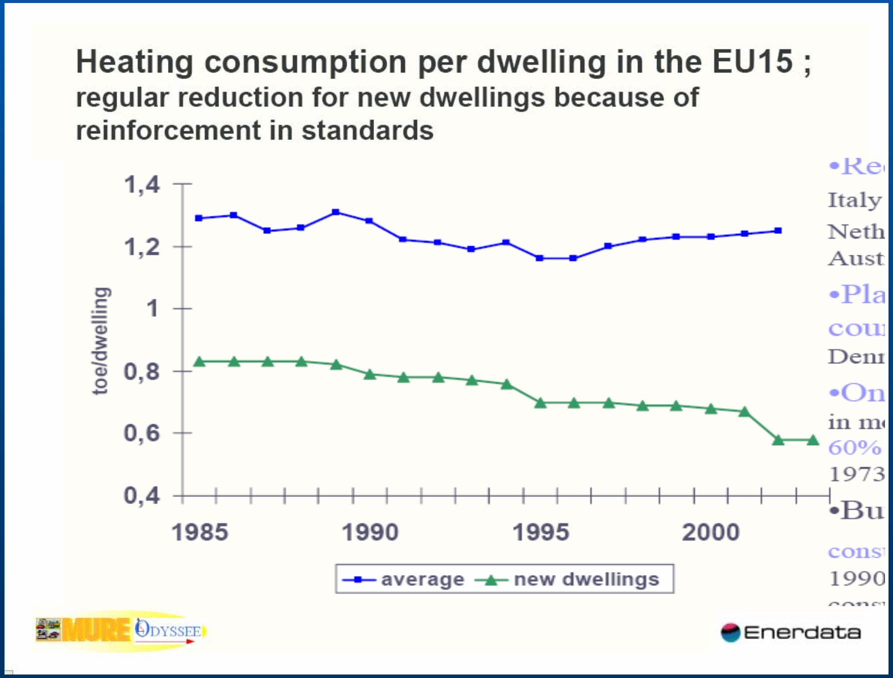
New versus existing buildings

- In OECD less than 1% of buildings new every year
- New buildings use less energy than existing
- Need to separate new and existing buildings to see development in building codes etc.
- Example Mure Odysee:



In existing buildings you even need to split by:

- **year of construction**
- **type of building**

if you want to see the impact of policies !

Project background

- This review will feed into a broader IEA effort on “Policies and Measures to Improve the Energy Efficiency of the Existing Building Stock”
- Complements related work done in IEA-Europe and hopefully other regions to follow
- Will contribute to IEA G8 Plan of Action addressing the buildings sector

Study components

- Assessment of energy performance characteristics of existing building stock
- Assessment of techno-economic savings potentials
- Review of the effectiveness of historic and current policies and programs
- Assessment of remaining policy driven savings potentials
- Recommendations for new policies

Leverages significant other current work in North America

- California Energy Commission effort on "Strategies to Reduce Energy Consumption in Existing Buildings" (AB 549) ongoing project concurrent with IEA work
- Other ongoing efforts in the US and Canada

Broad energy use findings

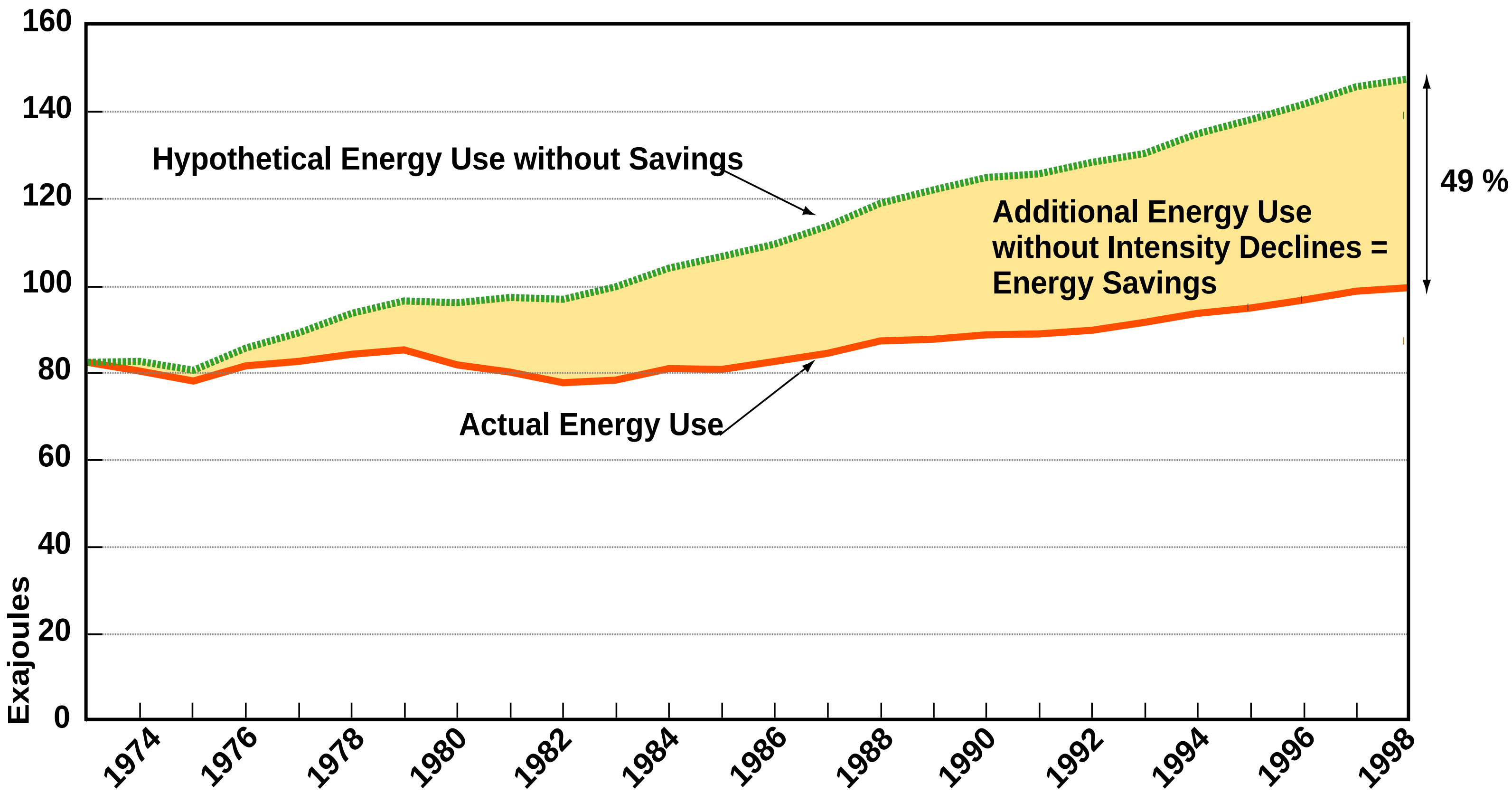
- Buildings are largest energy end-use
- Account for ~ 41% of total US energy use
- 40.3 quadrillion Btu of primary energy in 2002
  - 107 million households = 20.9 quads
  - 4.6 million commercial buildings = 17.4 quads

International building energy trends and North American buildings

Oil
Crises &
Climate
Challenges

30 Years
OF ENERGY USE
IN IEA COUNTRIES

Actual Energy use and Hypothetical Energy Use without Intensity Reductions, IEA-11

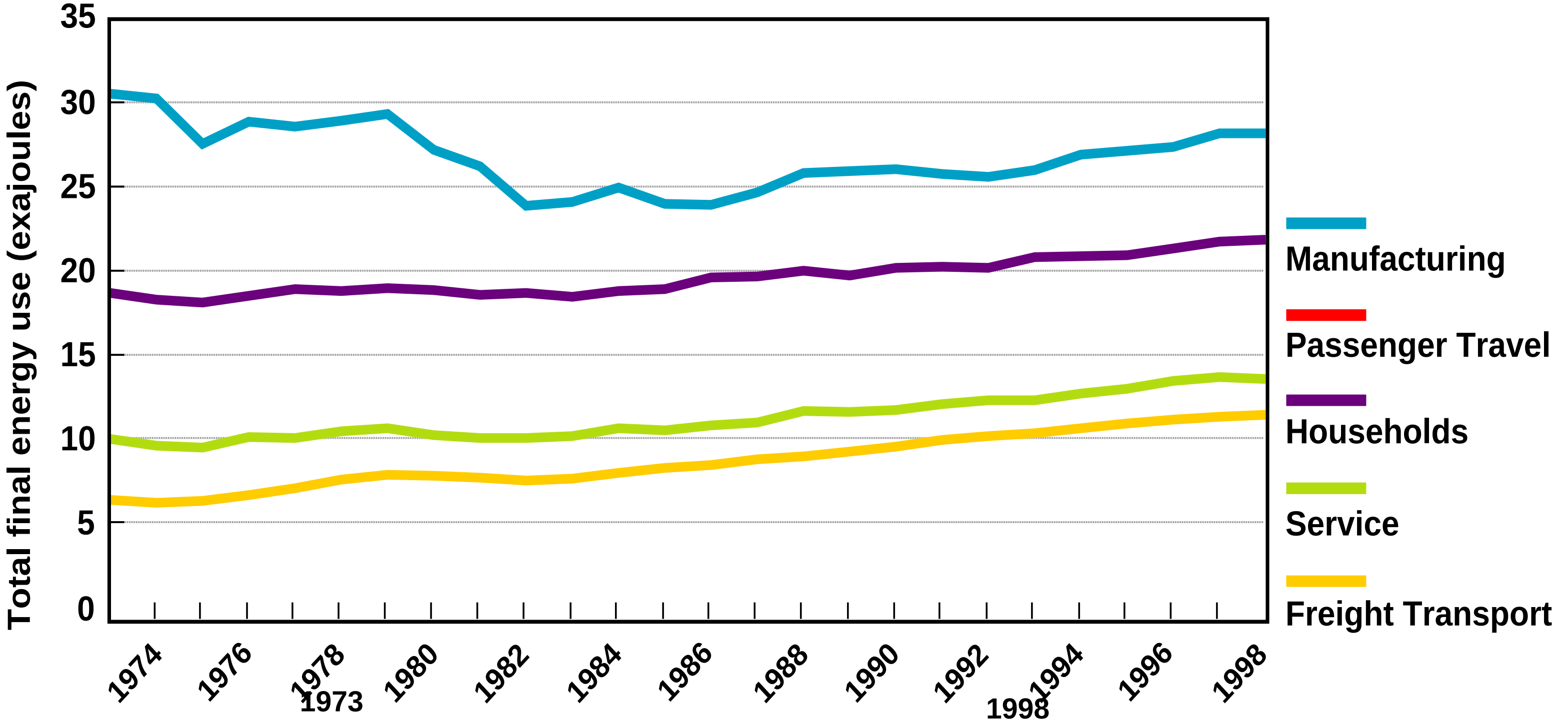


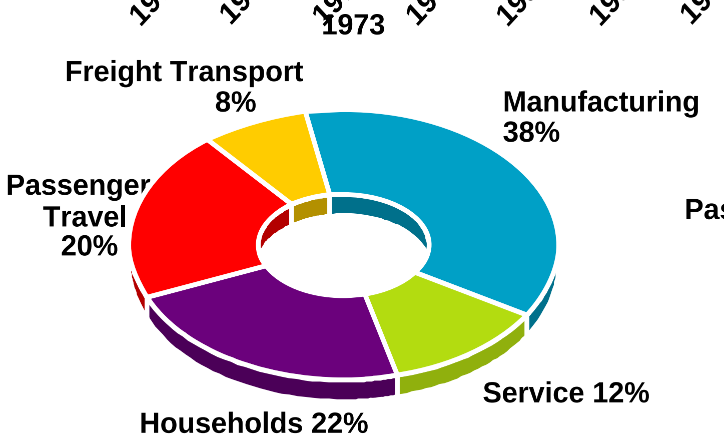
Without 25 years of energy savings, energy consumption would have been almost 50% higher

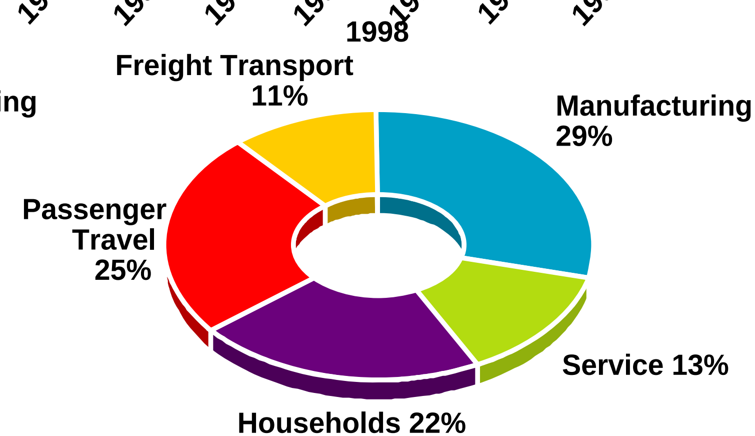
Total Final Energy Consumption by Sector, IEA-11

Oil Crises & Climate Challenges

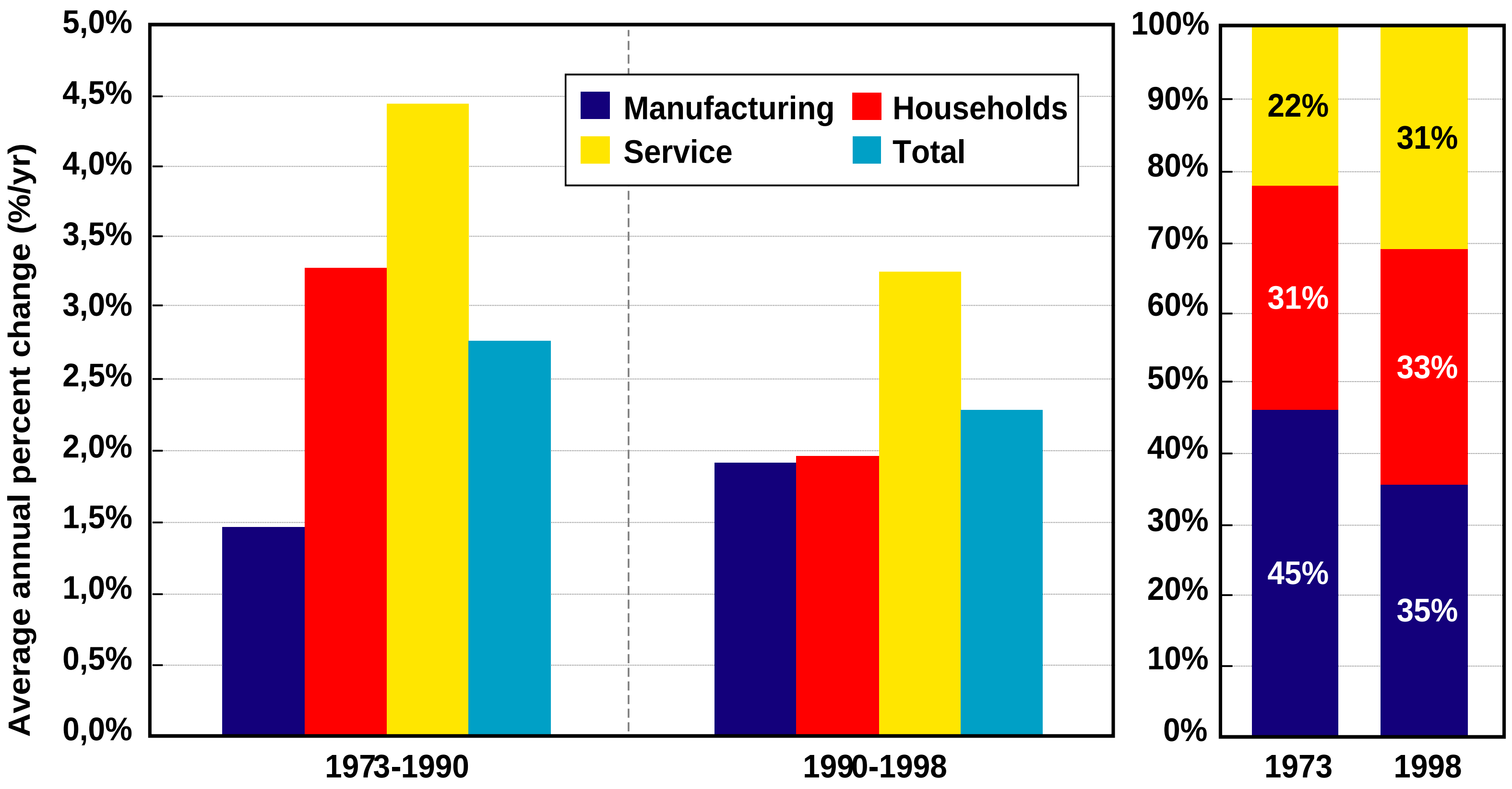
30 Years OF ENERGY USE IN IEA COUNTRIES





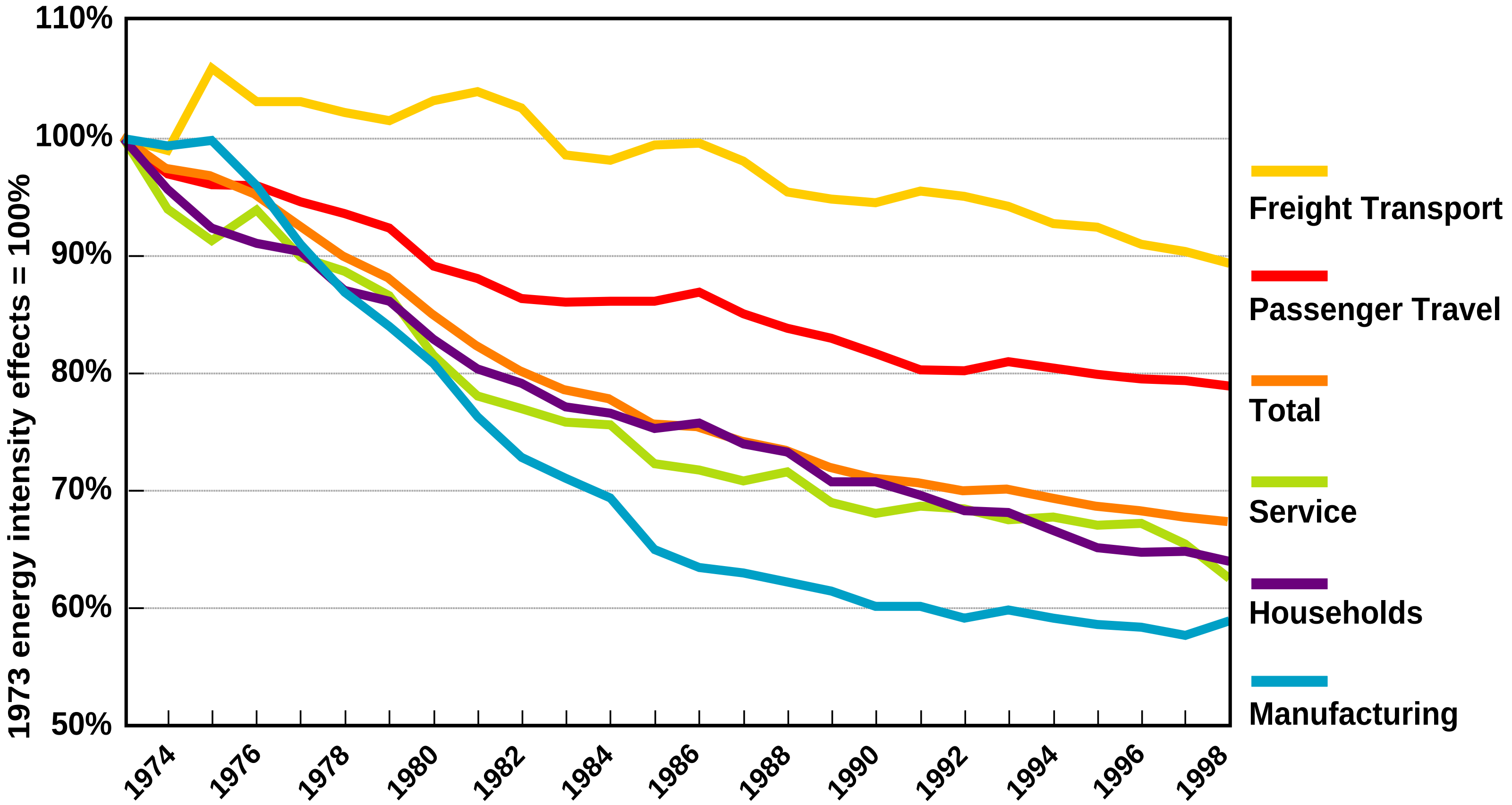


Electricity Demand by Sector, IEA-11



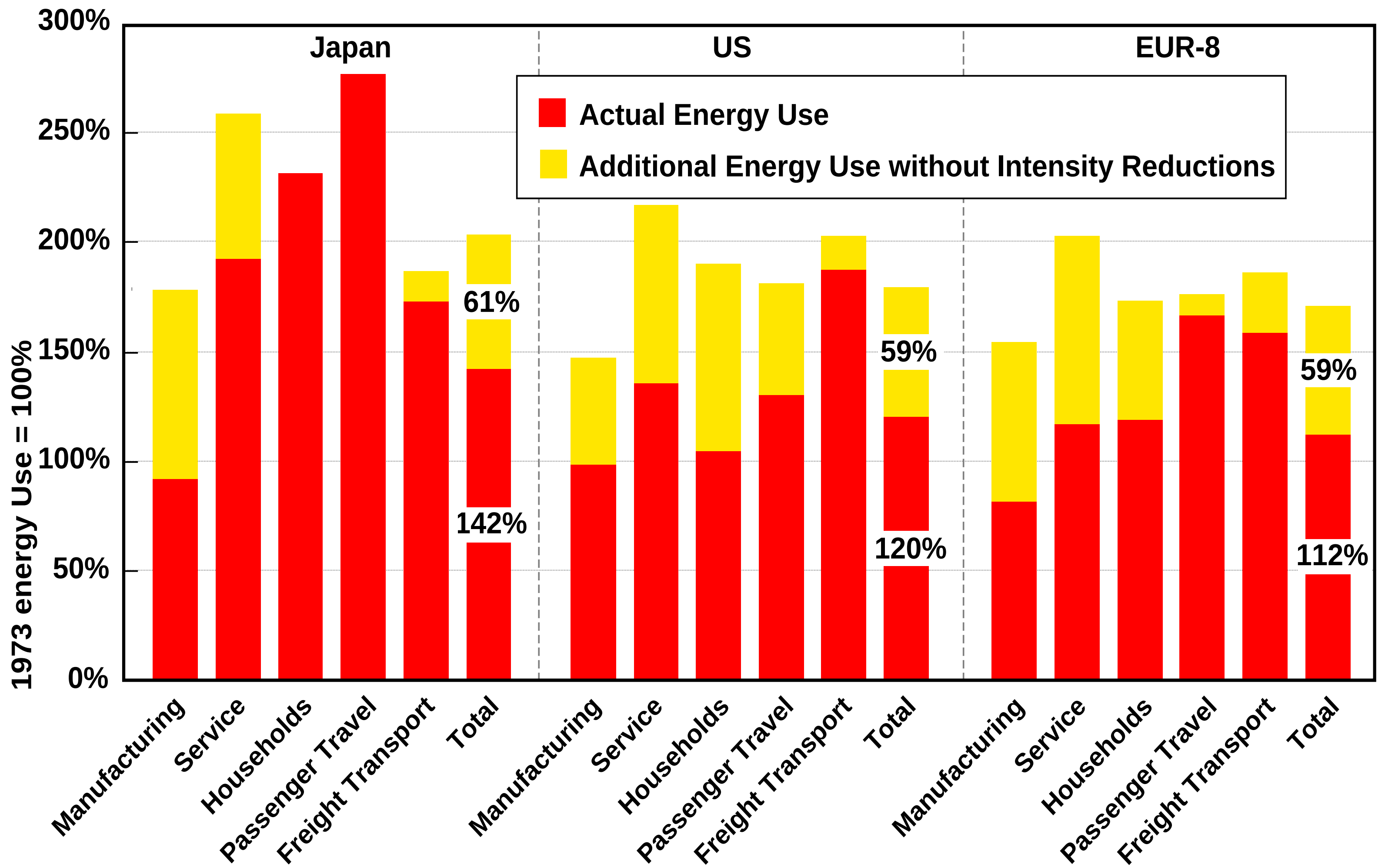
Strong growth in electricity demand in all stationary sectors

Sector Intensities and Total Economy Effect, IEA-11



Energy intensity declines have slowed in all sectors since the late 1980s

Actual Energy Use and Energy Savings



Total energy savings across the three regions are similar, but there are important differences by sector

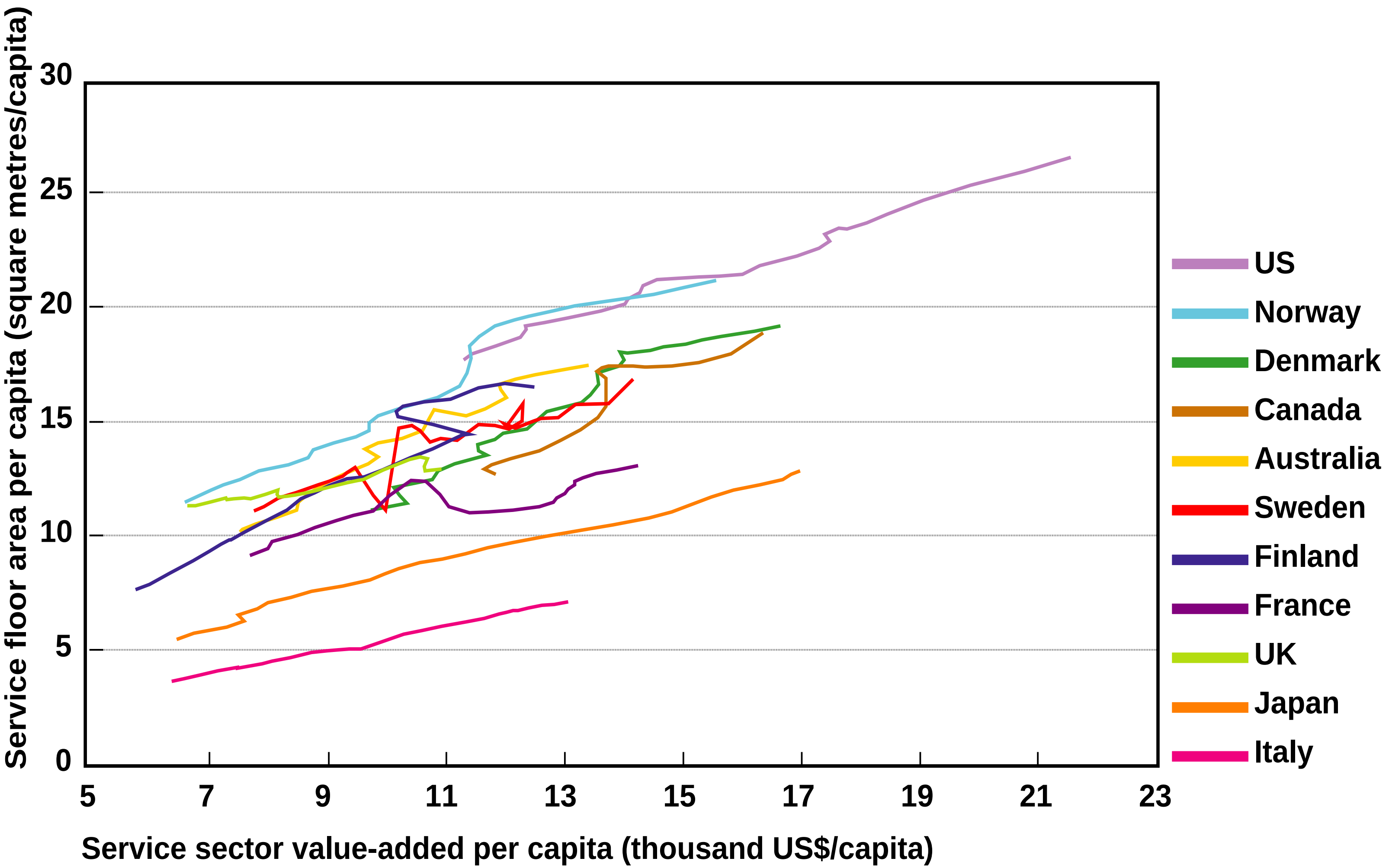
Oil Crises & Climate Challenges

30 Years

OF ENERGY USE IN IEA COUNTRIES

The Tertiary/Service Sector in Context

Service Sector Floor Area per Capita and Value-added per Capita, 1970-1999

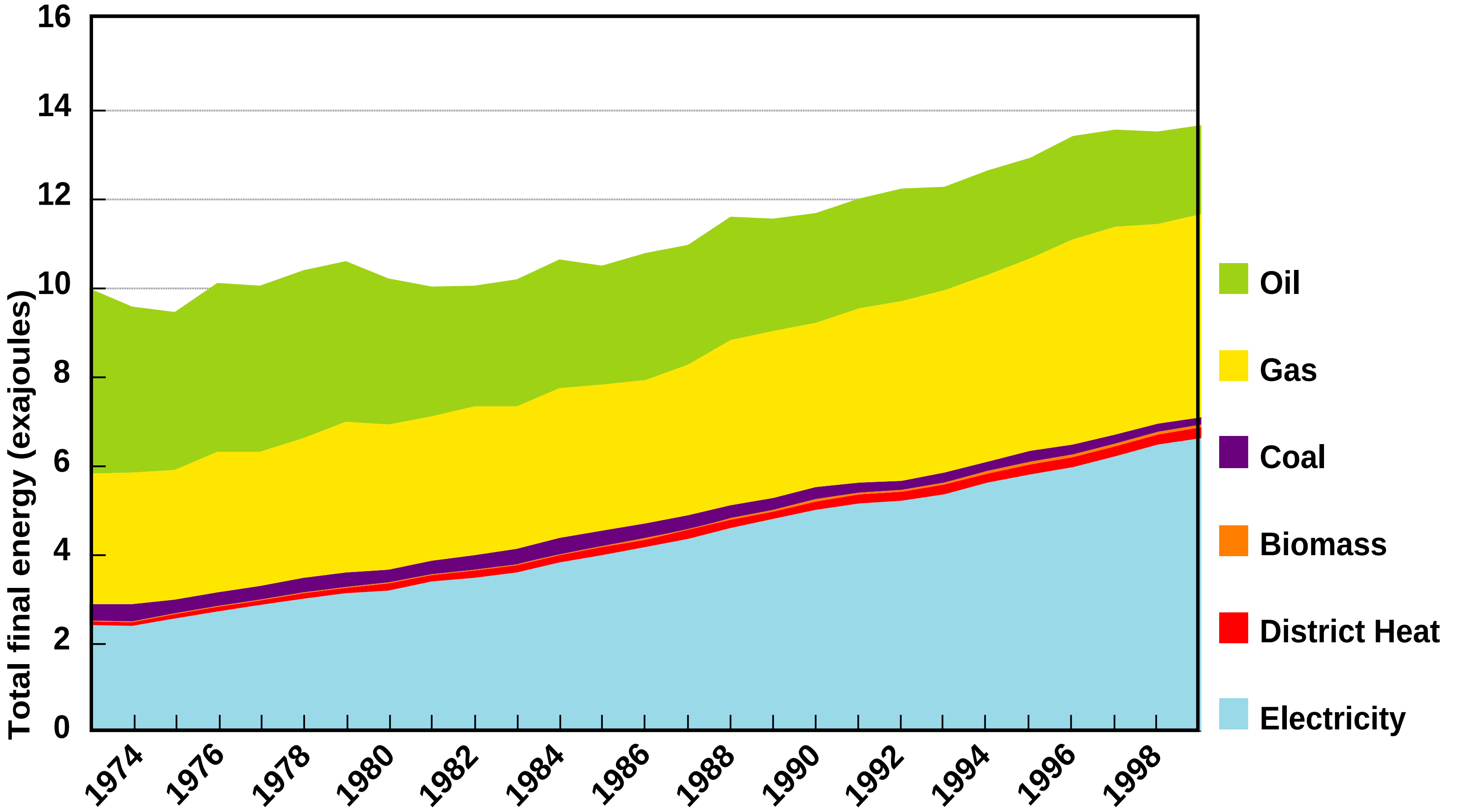


Built area for the service sector is growing with rising economic output

Energy Use in Service Sector by Fuel, IEA-11

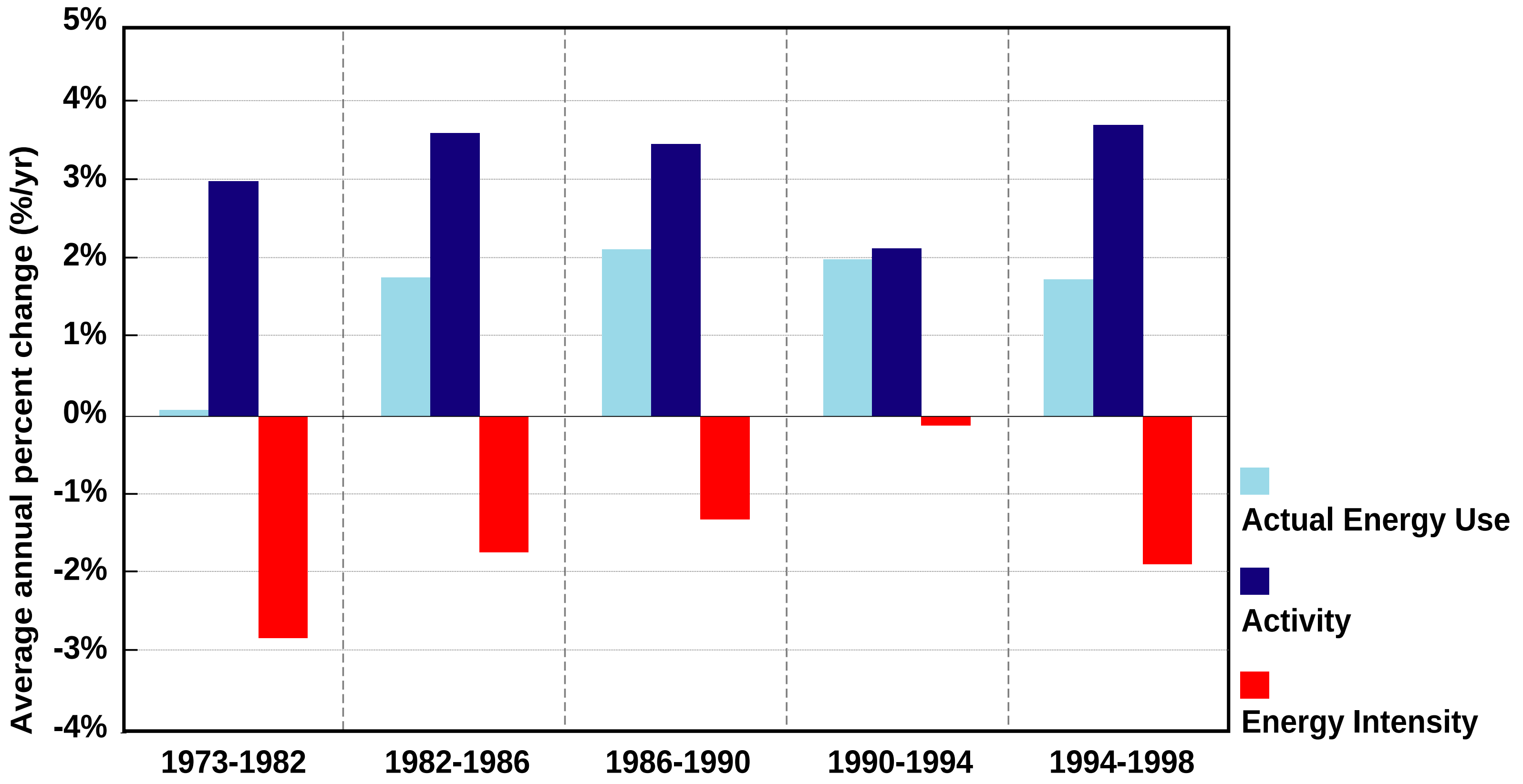
Oil Crises & Climate Challenges

30 Years OF ENERGY USE IN IEA COUNTRIES



Energy demand in the service sector has risen strongly, mainly electricity

Decomposition of Changes in Service Sector Energy Use, IEA-11



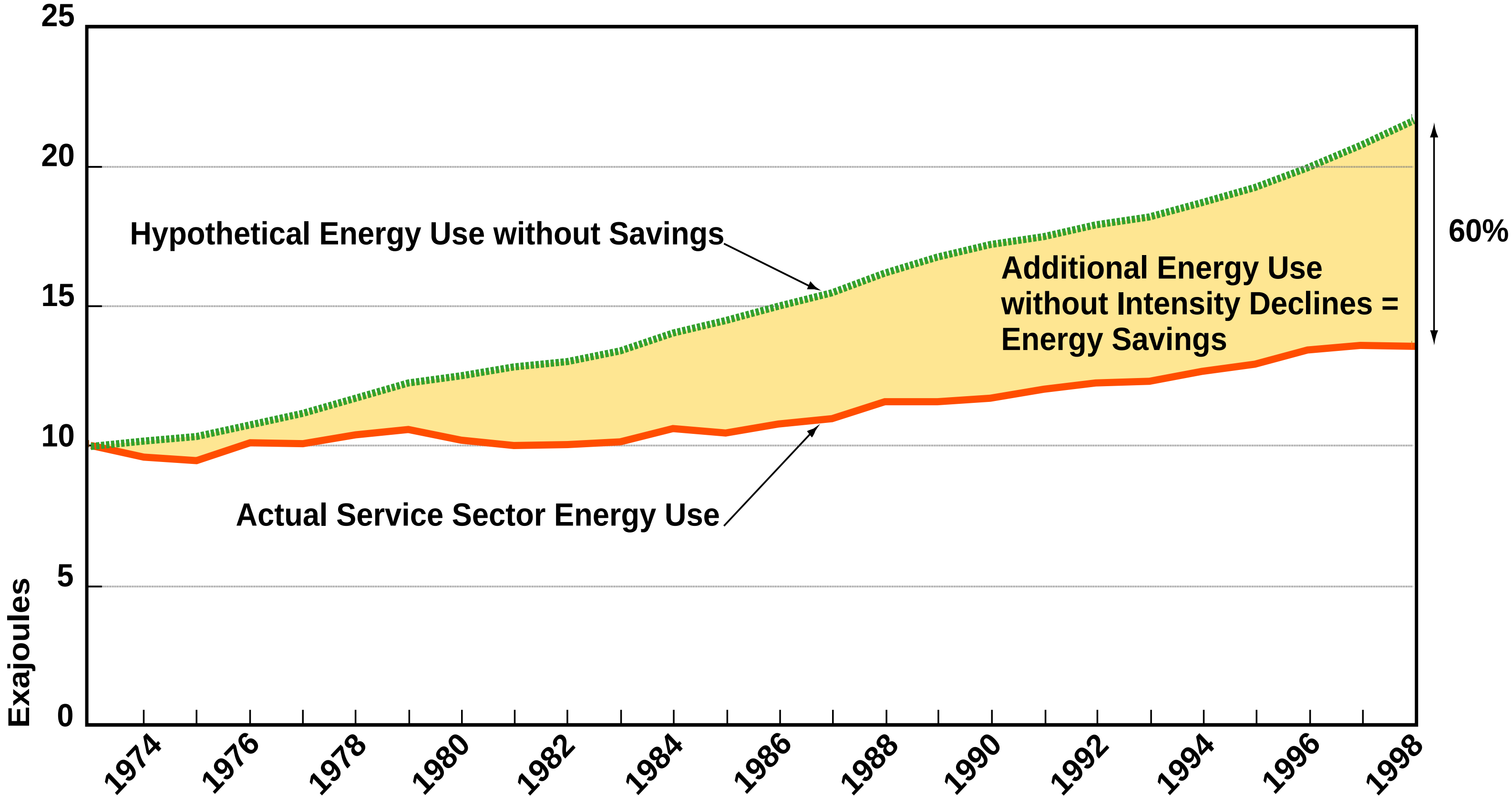
Rates of decline in intensity slowed, then rebounded after 1994

(energy consumption is not very sensitive to changes in activity)

Oil Crises & Climate Challenges

30 Years OF ENERGY USE IN IEA COUNTRIES

Actual Energy Use and Hypothetical Energy Use without Intensity Reductions, IEA-11



Overall, there have been significant energy savings in the service sector

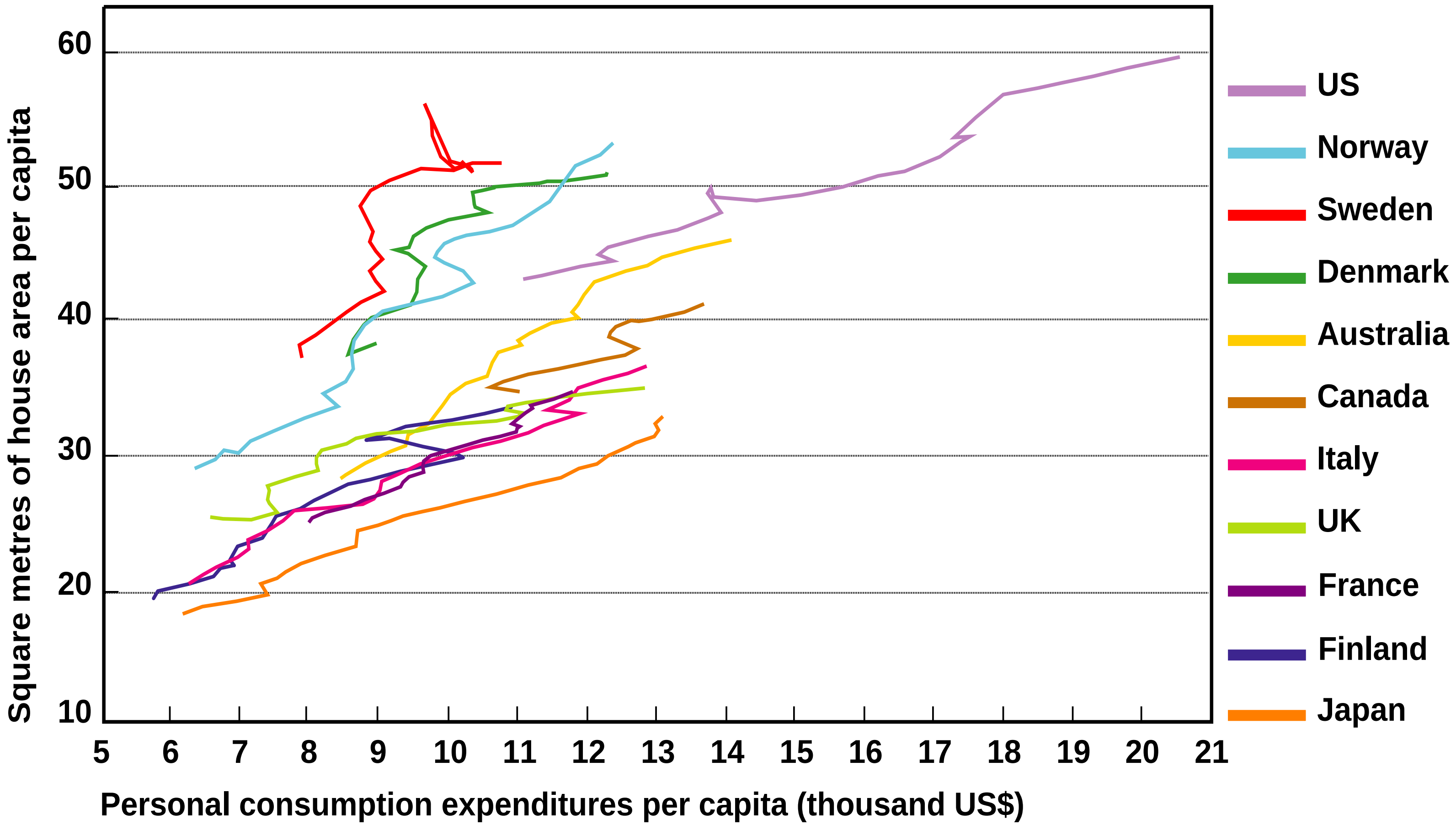
The Residential Sector in Context

House Area per Capita and Personal Consumption Expenditures, 1970-1998

Oil Crises & Climate Challenges

30 Years

OF ENERGY USE IN IEA COUNTRIES

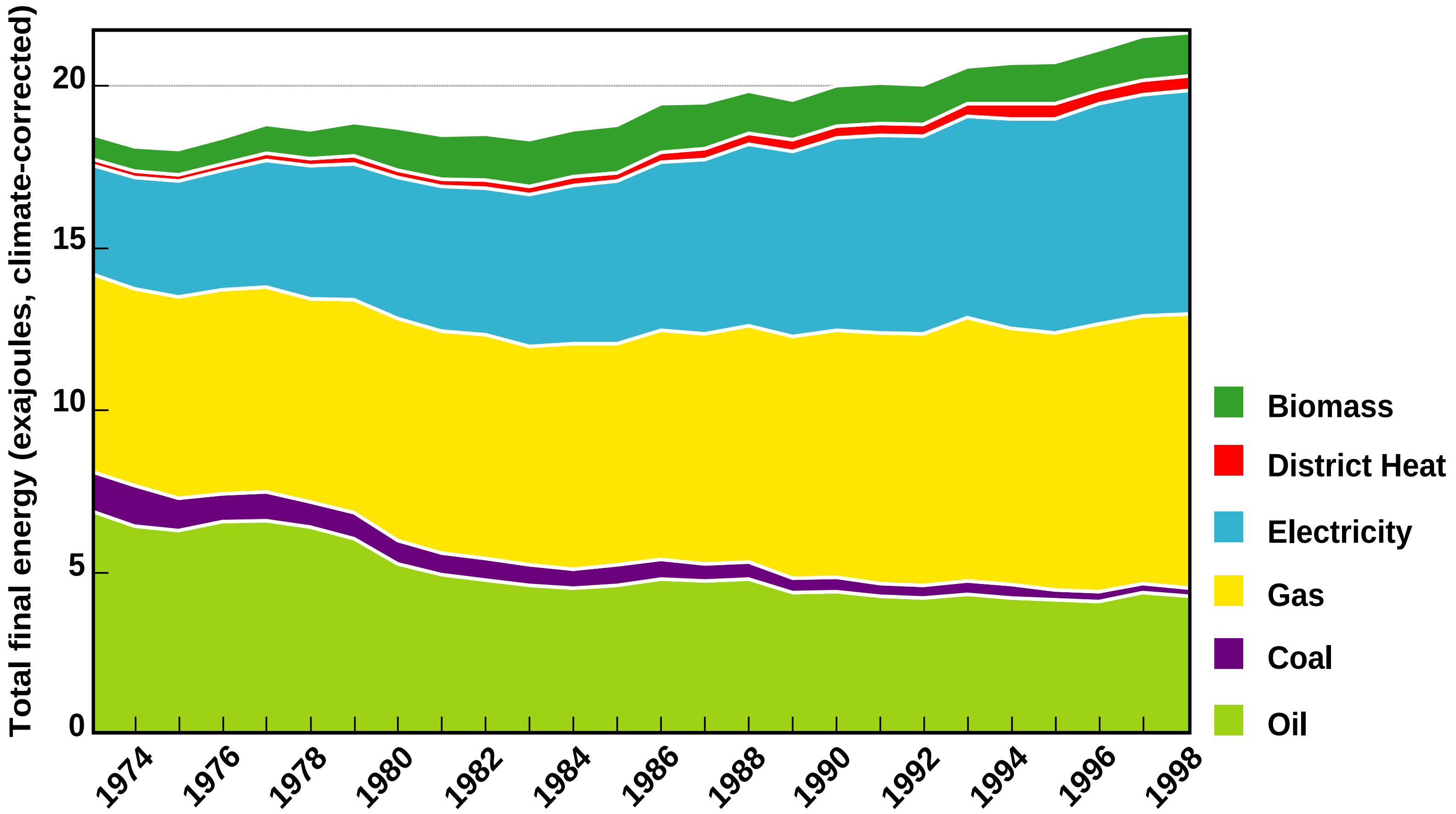


Living space is getting bigger as we get richer

Residential Energy Use by Fuel IEA-11

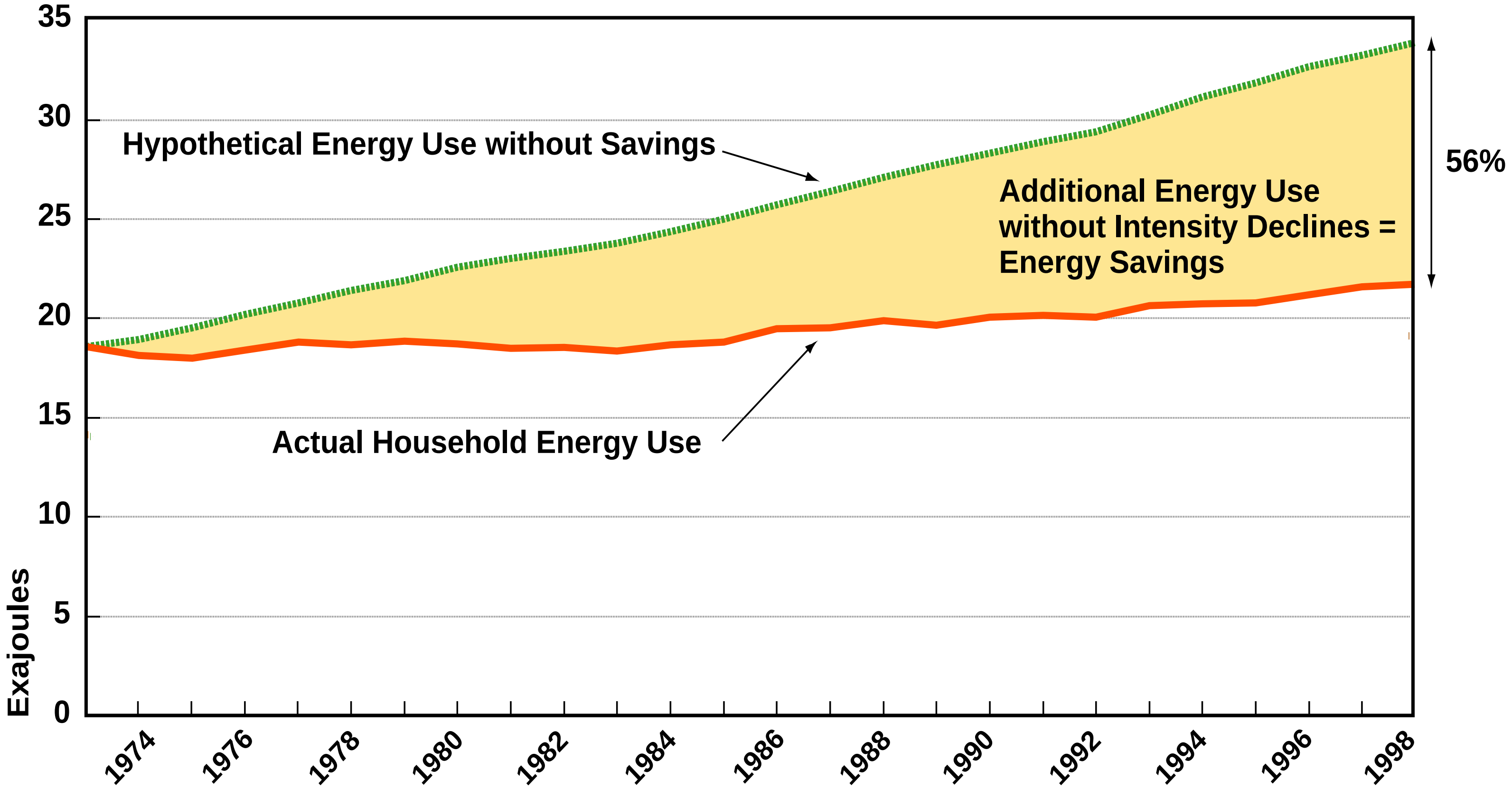
Oil Crises & Climate Challenges

30 Years OF ENERGY USE IN IEA COUNTRIES



Modest growth in energy use with electricity and natural gas in the driver's seat

Actual Energy Use and Hypothetical Energy Use without Intensity Reductions, IEA-11

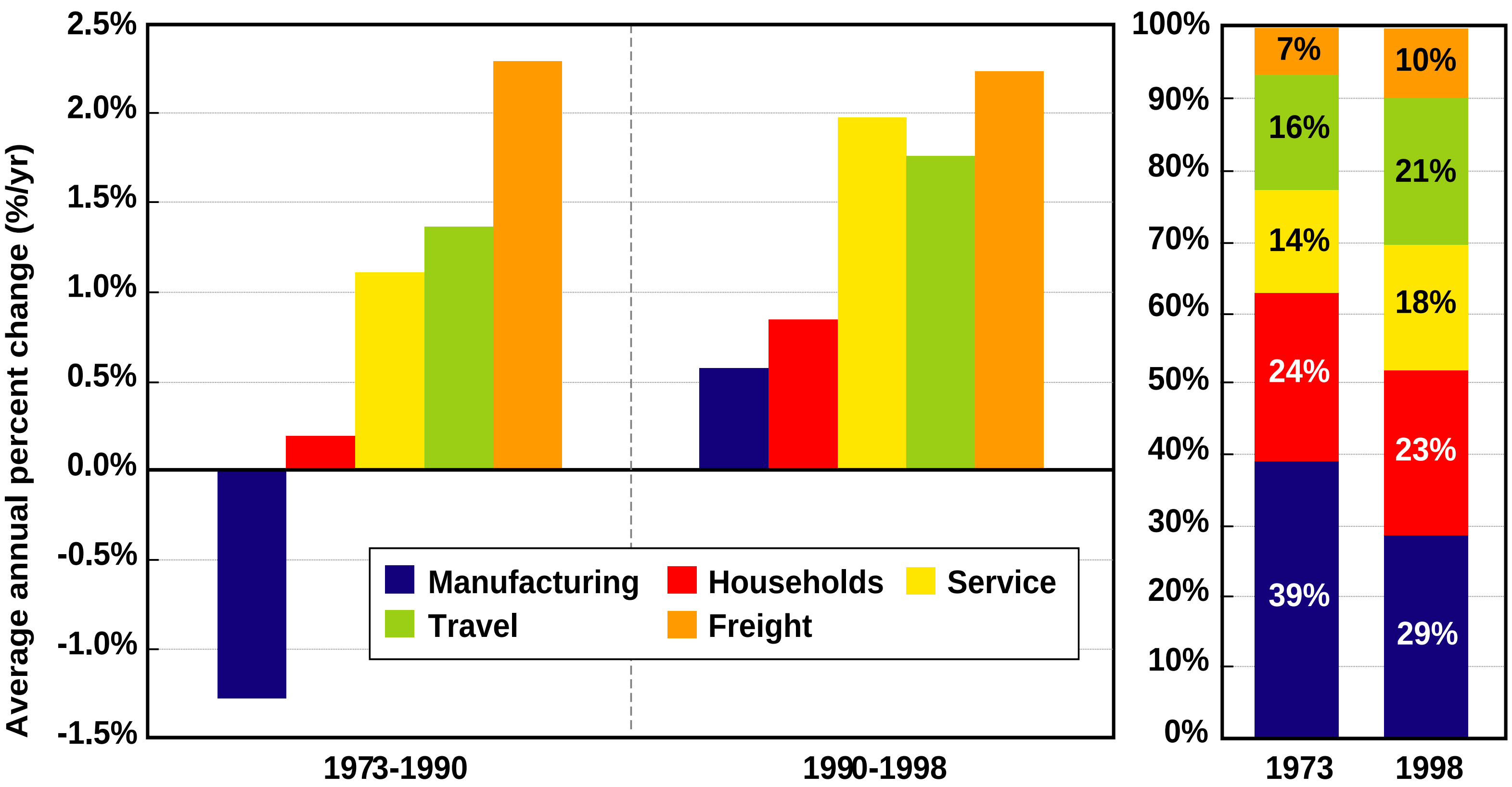


Significant savings of residential demand, but saving rates have slowed

Changes in CO_2 Emissions by Sector and Emission Shares by Sector, IEA-11

Oil Crises & Climate Challenges

30 Years OF ENERGY USE IN IEA COUNTRIES



But, services and freight remain the fastest growing emission sources post-1990

Building energy trends in North American buildings

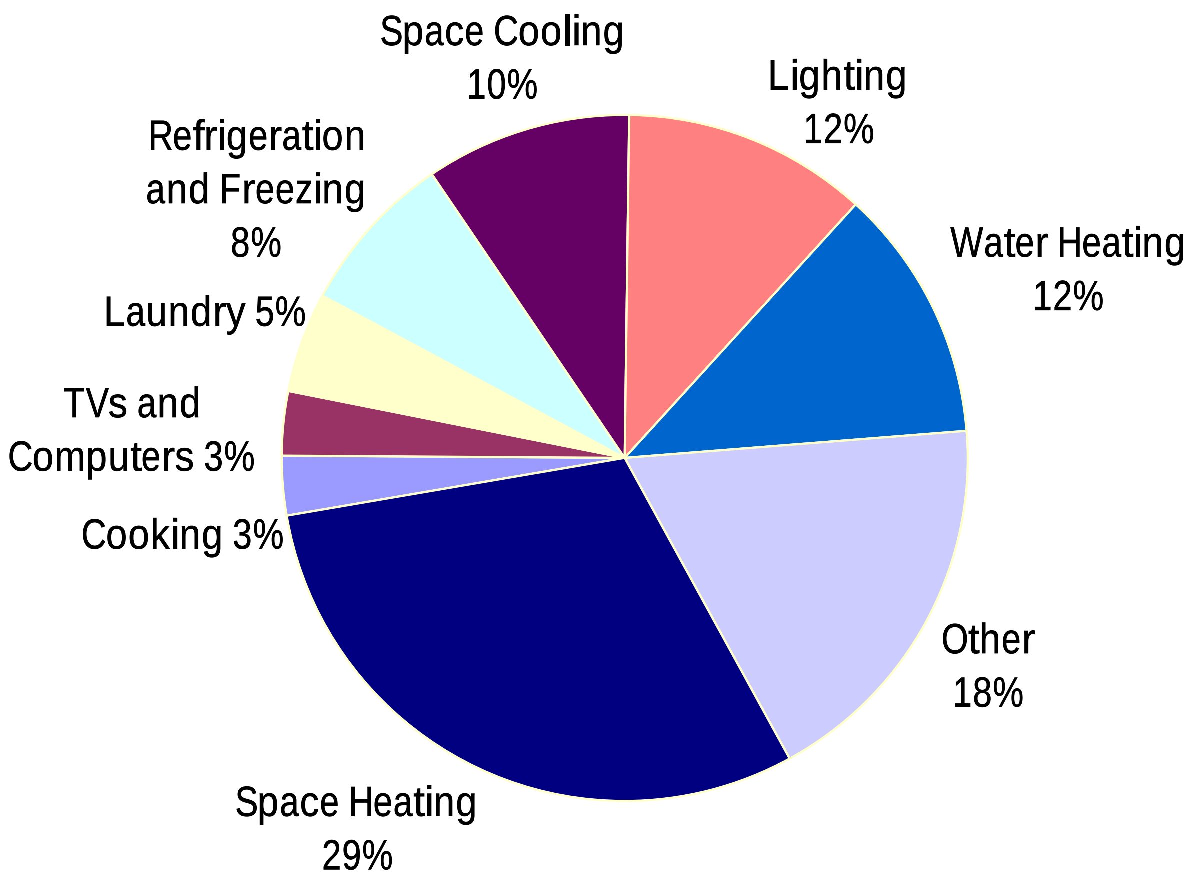
US building energy intensity trends

	Residential			Commercial	
Year	Households (millions)	Avg. House Size (sq.ft)	MMBtu/ household	Floorspace Million sq.ft	MBtu/sq.ft
1980	79.6	1746	199.0	50.9	208.2
1990	94.2	1800	180.8	64.3	207.1
2000	105.7	1963	193.8	68.5	250.2

Trends in energy use

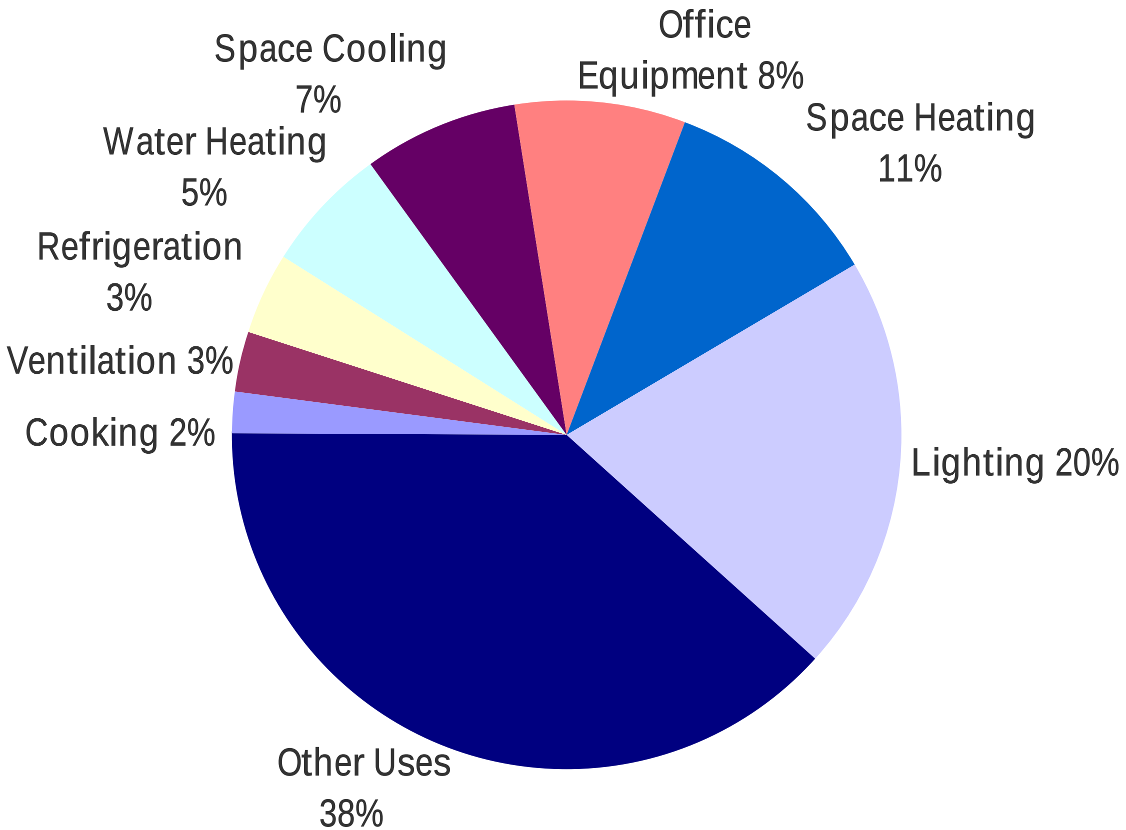
- House size growing; more appliances & electronics
- More efficient equipment and building envelopes, but energy use keeps growing
- In commercial sector, more electronic equipment, which also increases air conditioning loads

Primary energy-use by application: US residential buildings in 2004



Total: 21 Quadrillion Btu

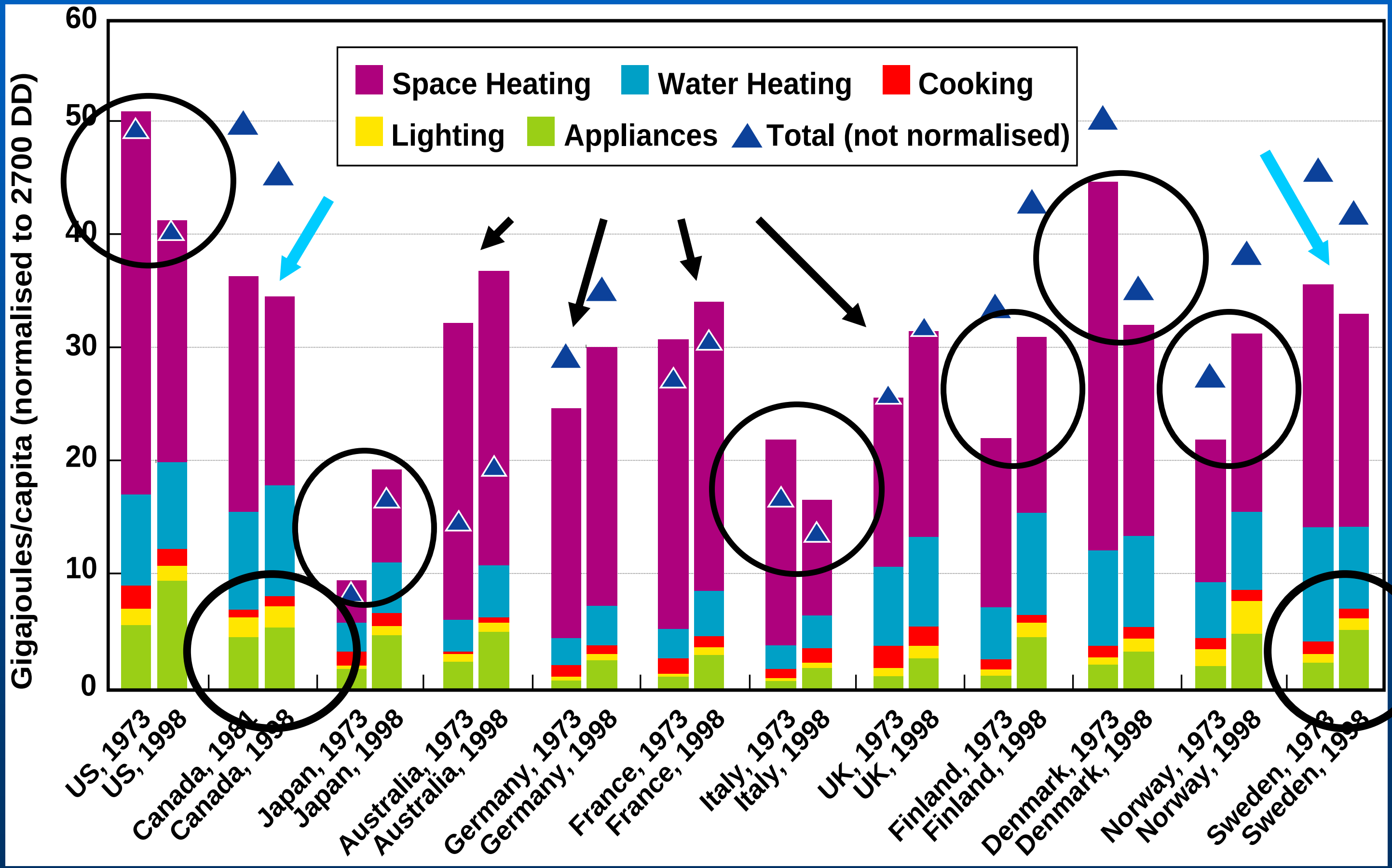
Primary energy-use by application: US commercial buildings in 2004



Total: 17.4 Quadrillion Btu

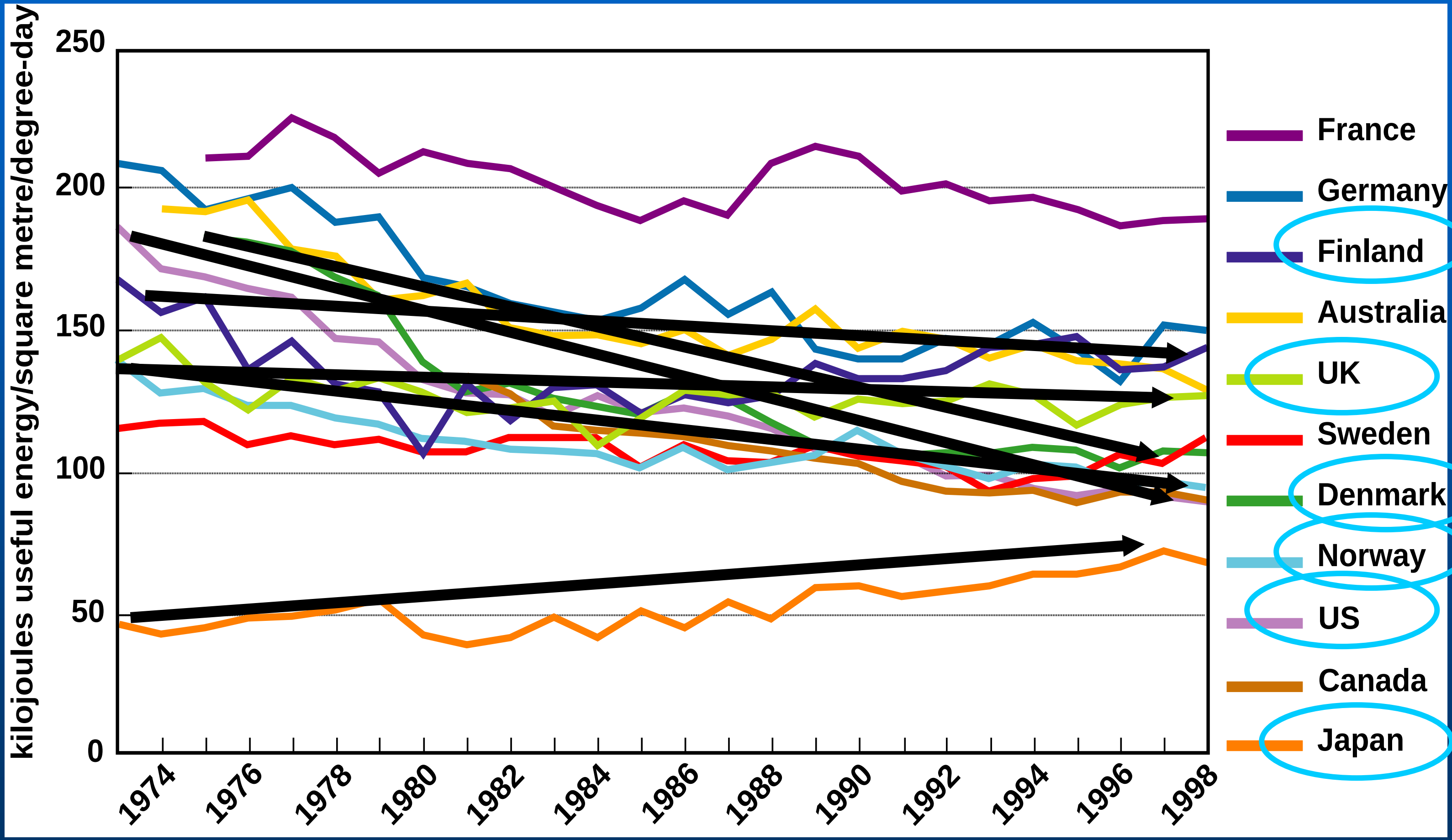
International comparison of per capita residential energy use

Trend ?   Comfort ?   Policy ?

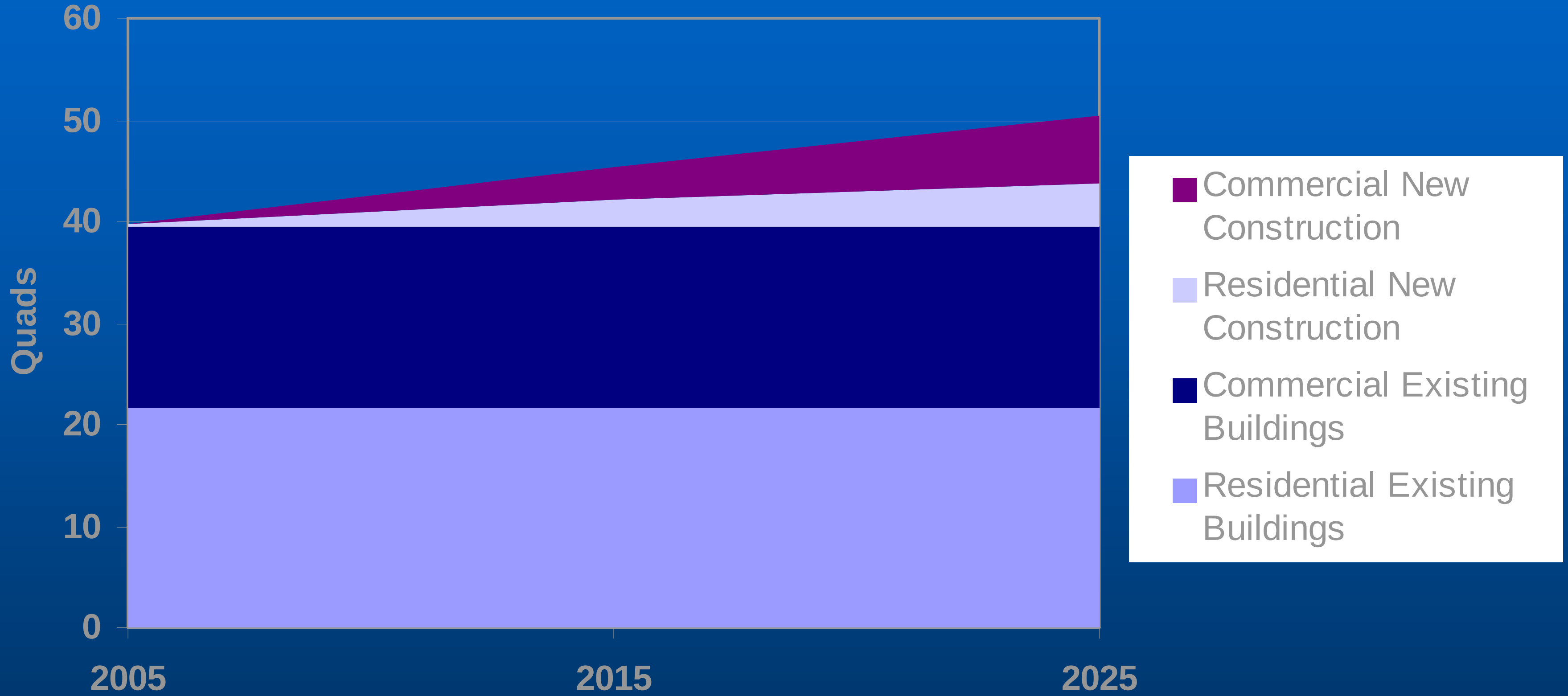


Source 30 years of Energy Use in IEA Countries

International comparison of residential space heating trends



Projected base case primary energy use in US buildings to 2025



4/5ths of building energy in 2025 is in buildings that exist today

Assessment of realizable savings potentials

Options to improve space conditioning efficiency in existing commercial buildings

End Use		% of Total Commercial Energy	Technology Options	Savings Potential
Space Conditioning	Walls	30%	• Improved Insulation	L
	Windows		• Spectrally-specific glass	M
	Roofing		• Light-colored “cool” treatments	L
	Space Heating		• Large buildings: efficient fans and pumps, systems to synergize heating, cooling and lighting • Small buildings: similar to residential options • Small-scale CHP	H
	Space Cooling		• Better compressors, high-efficiency modulating air handler fans • More precise refrigerant valves, variable speed blowers, improved coil designs, better motors • Advanced controls and integrated economizers for rooftop units	M
	Ventilation		• Higher efficiency fans and filters, heat recovery	M

Savings: L (Low) is <15% of end-use energy; M (Medium) is 15–25%; H (High) is >25%

Options to improve other end-use efficiency in existing commercial buildings

End Use	% of Total Commercial Energy	Technology Options	Savings Potential
Lighting	20%	• Compact fluorescent and ceramic metal halide lamps • Scotopic, LED, “Super T8” fluorescent fixtures • Fully integrated daylighting controls • Hybrid solar lighting	H
Office Equipment	15%	• Both standby and active mode power reductions for computers • CPU management	H
Water Heating	5%	• “Point-of-use” systems • Commercial Heat Pump Water Heaters	M

Savings: L (Low) is <15% of end-use energy; M (Medium) is 15–25%; H (High) is >25%

Options to improve space conditioning efficiency in existing residential buildings

End Use		% of Total Residential Energy	Technology Options	Savings Potentia
Space Conditioning	Walls	51%	• Spray-applied cellulose insulation	L
	Windows		• Low-e glazing • Tints • Inert or low-conductance gas fills • Improved weather stripping • Tighter frame design	M
	Roofing		• High-reflectance pigments for standard colored shingles	L
	Space Heating		• High-efficiency condensing gas furnaces advanced furnace fan motors • Reducing duct leakage • Cold climate air-source heat pumps with multiple compressors • Ground-source heat pumps • Boiler controls	H
	Space Cooling		• More precise refrigerant control valve • Improved installation practices • Variable speed blowers • Improved coil design and better motors	H
Water Heating		12%	• Tankless water heaters • High-efficiency condensing natural gas WHs • Heat-pump WH • Solar WH	M

Savings: L (Low) is <15% of end-use energy; M (Medium) is 15–25%; H (High) is >25%

Options to improve other end-use efficiency in existing residential buildings

End Use	% of Total Residential Energy		Technology Options	Savings Potential
Appliances	Refrigerators and Freezers	12%	• High-efficiency fan motors and adaptive defrost control • Major component modification (vacuum panels)	M
	Dishwashers		• ENERGY STAR: improved insulation, better spray arms, filtering systems, pumps and motors • Better standby modes	M
	Laundry Equipment		• Washers with more rinse options, improved sensors, motors and mixing valves resulting in less water used • Dryers with automatic shut-off and electric ignition systems. • Advanced electronic controls	M
Residential Lighting		12%	• Pin-based CFLs • Recessed downlights • Dimming control devices	H
Consumer Electronics		10%	• Improving internal power supplies, more advanced power modes to save standby power • Reducing active mode energy consumption of TVs and monitors	M

Savings: L (Low) is <15% of end-use energy; M (Medium) is 15–25%; H (High) is >25%

The rationale of building energy efficiency policies

Market barriers & failures prevent markets from optimising life-cycle costs

- Principal-agent barriers
- Information/transaction cost barriers
- Externality cost barriers
- Other barriers and economic forces

The market <u>does not</u> fully deliver cost-effective savings autonomously

- Lack of awareness re cost-effective savings potentials
- Missing or partial information on EE performance and lack of common metrics
- Split incentives: Landlord-Tenant issue
- EE often a minor determinant of capital-acquisition decisions
- EE is bundled-in with more important capital decision factors
- All result in emphasis on 1st not Life-cycle costs

Assessment of historic policy impacts

Wide range of policies and programs reviewed

- Federal Policies
- State & Local Policies
- Private Sector Initiatives
- Government Programs

Federal policies

- Appliance and equipment efficiency standards
- Appliance and equipment labeling
- Government purchasing and procurement
- Building codes and standards
- Public sector facility management
- Tax incentives

State and local policies

- Appliance and equipment efficiency standards
- Building codes and standards
- Government purchasing and procurement
- Funding of public benefit programs/activities
- Public sector facility management
- Tax incentives
- Existing building benchmarking

Private sector initiatives

- Resource acquisition programs
- Market transformation initiatives
- Manufacturer-based programs
- Peak load/demand response programs

Government programs

- Energy Star
- Weatherization
- Partnerships for Home Energy Efficiency

Challenges in determining effectiveness

- Attribution: many programs/ policies aim to influence the same end uses and markets
- What would have occurred in absence of policies/programs?
- Inconsistent information available; “a puzzle missing many pieces”

Programmatic effectiveness indicators

- Energy Saved:
  - Magnitude, including savings to date, and remaining potential
  - Persistence/permanence
- Market Transformation Effects
  - Ability to drive innovation
  - Spillover, or “Free-Drivership”
  - Potential for Backsliding

E.g. estimated savings from Federal appliance/equipment standards

Standards (Year Enacted)	Electricity Savings (TWh/yr)			Primary Energy Savings (Quads/yr)			Carbon Reduction (MMT)		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
NAECA (1987)	8.0	40.9	45.2	0.21	0.55	0.61	3.7	10.0	10.1
Ballasts (1988)	18.0	22.8	25.2	0.21	0.27	0.29	4.4	5.0	5.0
NAECA updates (1989-91)	20.0	37.1	41.0	0.23	0.43	0.47	4.8	8.1	8.1
EPAct (1992)	42.0	110.3	121.9	0.59	1.51	1.67	11.8	27.5	27.9
NAECA updates (1997-2001)	0.0	42.0	107.7	0.0	0.5	1.19	0.0	10.4	23.4
EPAct 2005	0.0	14.7	53.0	0.0	0.21	0.65	0.0	3.7	11.5
TOTAL	**88**	**268**	**394**	**1.2**	**3.5**	**4.9**	**25**	**65**	**86**
% of projected U.S. use	**2.5%**	**6.9%**	**9.1%**	**1.3%**	**3.1%**	**4.0%**	**1.7%**	**3.6%**	**4.4%**

Source: Nadel et al 2006

Estimates from existing studies of the effects of energy efficiency programs in 2000

Program	Energy Savings (quads)	Costs (billion $2002)
Appliance Standards	1.2	$2.51
Utility DSM	0.62	$1.78
Energy Star	<0.93	$0.05
DOE Rebuild America	0.01	-
Weatherization Assistance Program	0.09	$0.14
Federal Energy Management Program	<0.07	$0.025
Total (includes some additional programs not aimed toward buildings)	<4.1	

adapted from Gillingham et al, RFF 2004

Effectiveness: federal policies

	Magnitude	Persistence	Savings to Date	Remaining Potential	Drives Innovation	Free Drivership	Backsliding Potential
Equipment Standards	VH	VH	VH	H	M	L	L
Building Codes/ Regulations	H	H	H	H	M	M	M
Government Purchasing/ Procurement	M	M	M	M	M	M	
Tax Incentives	M		L	H	H	M	M

Effectiveness: state and local policies

	Magnitude	Persistence	Savings to Date	Remaining Potential	Drives Innovation	Free Drivership	Backsliding Potential
Building Codes/ Regulations	VH	H	H	M	H	M	L/M
Equipment Standards	H	M	M	M	M	H	L
Funding of Public Benefits Programs	VH	H	H	VH	M	M	M
Government Purchasing/ Procurement	M	M	M	M	M	M	M
Tax Incentives	M	L	M	H	M	H	M

Effectiveness: private sector initiatives

	Magnitude	Persistence	Savings to Date	Remaining Potential	Drives Innovation	Free Drivership	Backsliding Potential
Market Transformation							
--Information/ Education	M	M	M	H	L	M	M
--Training	M	M	M	H	L	M	M
--Mfr/Retailer incentives	L	L	M	M	H	M	M
--Financing Incentives	L	M	L	M	L	L	M
--Performance Contracts	H	M	H	H	L	L	M

Effectiveness: private sector initiatives (cont.)

	Magnitude	Persistence	Savings to Date	Remaining Potential	Drives Innovation	Free Drivership	Backsliding Potential
Product Replacement Incentives							
--Independent Programs	H	M	H	H	M	L	H
--Coordinated Efforts	H	H	H	H	H	H	M
Manufacturer Programs	L	M	L	M	H	M	M
Peak Load/Demand Response	L	L	L	M	M	L	M

Effectiveness: government programs

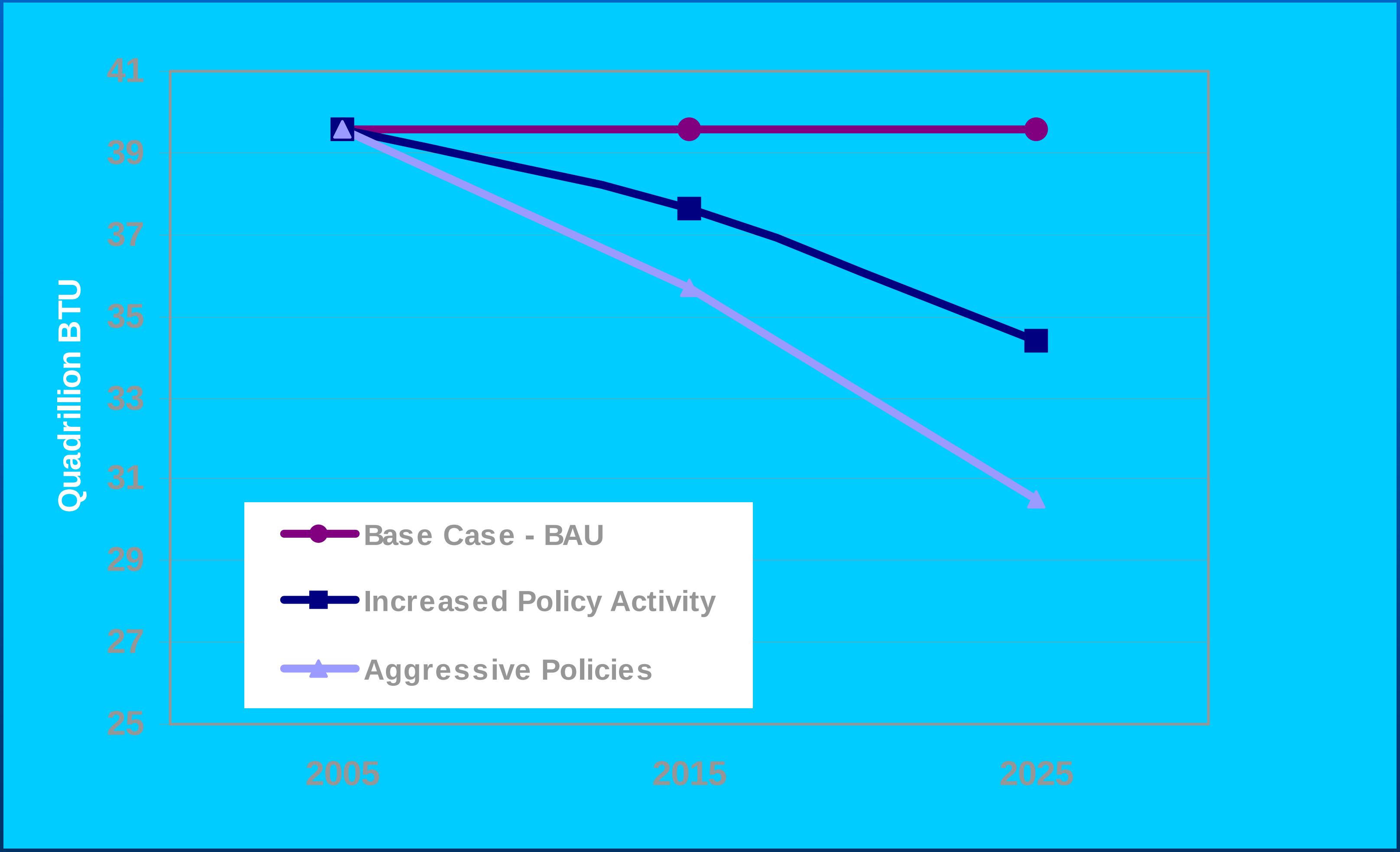
	Magnitude	Persistence	Savings to Date	Remaining Potential	Drives Innovation	Free Drivership	Backsliding Potential
Energy Star	H	M	H	M	M	H	M
Weatherization	H	M	H	H	M	L	M
Partnerships for Home EE	M	M	L	H	M		M

Assessment of impacts of potential new policies

Three policy scenarios considered

- Base Case: no increased policy activity, energy use as forecast in Annual Energy Outlook 2007
- Increased Policy Activity: nationwide adoption of what is happening in leading states/regions; dramatically increased funding toward EE in existing buildings
- Aggressive Policies: substantial push toward rapid implementation of lowest life cycle cost technologies and practices replacing standard equipment in all existing buildings; use/demonstrations of some currently untested policies to push the policy envelope, in line with the most aggressive policies now being pursued at US state level

Projected primary energy-use in existing US buildings to 2025 for three scenarios



Savings of 23% are realizable with strong policies

Projected primary energy-use in existing US buildings for three scenarios (Quads)

	Base Case - BAU			Increased Policy Activity			%Savings in 2025	Aggressive Policies			% Savings in 2025
	2005	2015	2025	2005	2015	2025		2005	2015	2025	
Residential	21.7	21.7	21.7	21.7	20.6	18.7	14%	21.7	19.4	16.4	24%
Commercial	17.9	17.9	17.9	17.9	17.1	15.7	12%	17.9	16.3	14.1	21%
Total	39.6	39.6	39.6	39.6	37.6	34.4	13%	39.6	35.7	30.5	23%

Cost effectiveness of savings

- Cost of conserved energy is $4 - $6.2 per MBtu saved
- Cost of energy supply in 2025 is projected to be $18.2 per MBtu (AEO 2007)
- Net benefit ~ $13 per MBtu avoided
- In 2025 cost to implement savings of 9 Quads = $45 billion but this saves $165 billion in energy costs
- Net annual benefit = US$120 billion

Impacts of electricity savings

- Electricity use in existing buildings in 2025 under the aggressive scenario is projected to be reduced by approximately 20 percent, from 3730 TWh to 2980 TWh
- The 750 TWh of savings avoids the need for about 200 GW of generation capacity
- Avoids generation capital costs of approximately $130 billion at the current average new capacity cost of $650 per kW for new gas fired generation

IPCC 4th assessment report WG3 Findings – mitigation options for residential and commercial buildings

- **Based on assessment of 17 major potentials studies**
  - **Globally, app. 29% of the sectoral baseline emissions can be avoided by 2020 through mitigation measures in the buildings sector cost effectively;**
  - **Additionally at least 6% of baseline emissions can be mitigated if costs up to 100 USD/tCO_2 are considered (underestimate due to lack of high-cost measure assessment)**
  - **These estimates correspond to reductions of ~ 3.6 Gt (economic potential) and 4.3 Gt (technical at up to 100 USD/tCO_2) of CO2eq. in 2020**
  - **Due to the limited number of demand side end-use efficiency options considered by studies, the real potential is likely to be higher**

Courtesy: Vorsatz & Levine 2006

IPCC 4th assessment report Findings

Regions	CO_2 Baseline in 2020	Potential as the share in the total regional baseline CO_2 emissions in cost categories (USD/tCO_2) in 2020 (%)				Potential as the share in the total regional baseline CO_2 emissions in cost categories (USD/tCO_2) in 2020, (Mt CO_2)			
	Mt CO_2	<0	0–20	20–100	Total	<0	0–20	20–100	Total
Total	12487	29%	3%	3%	35%	3603	356	351	4310
Developed countries	4973	27%	3%	2%	32%	1326	159	121	1606
Pacific OECD	*782*	*33%*	*2%*	*1%*	*36%*	*839*	*56*	*19*	*914*
North America OECD	*2512*	*18%*	*4%*	*1%*	*23%*	*140*	*32*	*8*	*180*
Western Europe	*1679*	*21%*	*4%*	*6%*	*31%*	*347*	*71*	*94*	*512*
Transition Economies	749	29%	12%	23%	64%	215	89	175	479
Developing countries	6765	30%	2%	1%	33%	2062	108	55	2225

Courtesy: Vorsatz & Levine 2006

Suggested mix of policies and measures for the North American building stock

Trends expected to drive energy use & programs

- Greater expectations for “Creature Comforts” (AC; consumer electronics)
- Higher/more volatile energy prices
- Climate & environmental concerns
- Demand reduction and enabling technologies
- Greater recognition of efficiency as a resource

Recommended policies address five main areas

1. Improved building energy codes for existing buildings that apply at the time of substantial renovation, sale or change of occupant
2. Market transformation initiatives, including the training of practitioners, to bring energy efficient technologies and practices into the broader marketplace
3. Resource acquisition activities and incentives to cover the initial incremental costs of these higher efficiency technologies and practices in a wide range of applications

Recommended policies address five main areas

4. Regularly updated and ambitious equipment efficiency standards to lock-in the savings from market transformation and resource acquisition efforts and to ensure that these savings are available to all end users
5. Aggressive research, development & deployment (RD&D) of promising energy saving technologies and practices

Energy codes

a) Research efforts to expand coverage of codes and standards to more existing buildings, including time of transfer activities

b) Direct research toward the most effective enforcement mechanisms for codes affecting existing buildings—some work has been done regarding new construction codes, but very little on existing buildings

c) Implement continual, regular updates to codes to lock in changes as new efficiency technologies become standard in the market

Energy codes

d) Improve enforcement of codes to ensure high levels of compliance and allow for more regular upgrades

e) Institute more aggressive advances to get codes equivalent first to Energy Star levels and then to the levels included in the 2006-07 tax incentive levels

Market transformation

a) Identify barriers to greater adoption of energy-efficient technologies and practices and strategies to overcome them

b) Engage in training and capacity building to make all market actors aware of new technologies and practices and to remove existing knowledge and skills gaps

c) Launch coordinated marketing campaigns to educate consumers and others. Where possible this should strengthen existing energy-efficiency messaging and “branding” efforts such as Energy Star in order to maximize consumer uptake and minimize confusion

Market transformation

d) Coordinate with constructors, manufacturers, suppliers and others in the market supply chain to accelerate the deployment and market penetration of the most efficient building technologies and practices

e) Expand implementation of emerging “whole building” approaches, including retrocommissioning, benchmarking, energy performance disclosure and whole-building HVAC initiatives. As these practices have complex market channels comprehensively planned and coordinated market transformation strategies are required

Market transformation

f) Provide appropriate fiscal incentives to increase uptake of the most efficient technologies and refurbishment practices

g) Pursue sector-based approaches targeting energy-efficient refurbishment in specific sectors of the buildings market, such as schools, hospitality, etc

Resource acquisition

a) Implement well-funded, long-term programs to send appropriate market signals that the energy efficiency of buildings is an ongoing, high priority policy area

b) Target programs toward specific technologies that can be easily “acquired” and the savings accurately measured, such as lighting, high efficiency equipment, and residential retrofits where savings are easily calculated and replicable

c) Direct funding toward “hard to reach” sectors such as low income housing and small businesses where progress is otherwise slow due to split incentives, such as the divergent economic interests of landlords and tenants with respect to energy savings investments

Resource acquisition

d) Provide incremental cost incentives for new energy-efficient products and technologies to accelerate their market penetration and technology cost curve evolution to the point where they satisfy cost-effectiveness conditions for market transformation initiatives

e) Coordinate initiatives among different program providers to ensure maximum market effects

f) Expand energy efficiency portfolio standards to drive resource acquisition targets and set appropriate high level goals for implementers to achieve in the most cost-effective manner

Minimum efficiency standards

a) Update existing standards regularly to capture savings in improved products

b) Expand standards to cover new products

c) Establish new standards for installations, testing and system correction at time of equipment replacement

Research, development and deployment

a) Increase funding and support for technology R&D for long range opportunities, as well as for currently available and evolving technologies and practices

b) Undertake ambitious demonstration activities to showcase these technologies and prove their market viability; for example, the refurbishment of public sector or utility buildings, presents an excellent opportunity to exhibit leadership and stimulate market development in energy-efficient building

c) Establish and strengthen state and utility funded emerging technologies programs to support the development and demonstration of promising technologies and practices

Promising Potential Policies: Zero-Energy/Carbon New Buildings & EERS

- The growing interest and technical capacity for designing and constructing zero-energy new buildings could be leveraged to improve the efficiency of existing buildings
- As a condition of service for utilities, new buildings connecting to the utility system would be required to achieve zero-energy performance via onsite energy efficiency and renewable energy generation
- Any remaining energy use in new buildings would be offset by credit purchases in a “white tags” market driven by Energy Efficiency Resource Standard requirements
- Utilities would annually calculate the amount of energy offsets required, and would add increments to their EERS targets accordingly

Promising Potential Policies: Zero-Energy/Carbon New Buildings & EERS

- Utilities would annually calculate the amount of energy offsets required, and would add increments to their EERS targets accordingly
- This would drive new investment in existing buildings to meet the added EERS requirements
- Such policies could also be designed on a zero-carbon basis; the mechanisms would be similar, except that offsets could be obtained from renewable energy and other low-carbon markets
- This approach has not been tested to date, but could be introduced in one of the states that have implemented an EERS

Promising Potential Policies: Time of Transfer Ordinances

A property sale represents an ideal time for implementing efficiency upgrades in existing buildings. Several tools can be used to encourage—or even mandate—efficiency improvements as part of the transaction:

1) Mandatory labeling or HERS rating:

- A mandatory labeling program for existing homes or a requirement that existing homes be given a HERS rating prior to sale would provide buyers a means to compare the energy performance of homes under consideration, thereby making energy use a more salient feature in the home purchase decision
- European and pending Californian experience to be considered

Promising Potential Policies: Time of Transfer Ordinances

2) Mandatory codes:

- Residential and Commercial Energy Conservation Ordinances (RECOs and CECOs) have been implemented by a handful of municipalities as a way to bring the existing building stock closer in line with the energy code requirements for newer buildings.
- Such ordinances require building owners and landlords to implement certain efficiency improvements at the time a property is sold. While their impact to date has been limited, this policy option shows promise if implemented on a wider scale with more stringent requirements and greater enforcement
- Danish experience is relevant

Promising Potential Policies: Time of Transfer Ordinances

2) Mandatory disclosure of EEMs at time of mortgage application

- Just as all U.S. mortgage applicants receive mandatory disclosures on fair housing laws and truth-in-lending information that lays out the full cost of the loan, applicants could receive notice that Energy-Efficient Mortgages (EEMs) are available to finance energy upgrades.
- Many U.S. lenders offer EEMs, but their use has been limited by a general lack of awareness and limited marketing

Promising Potential Policies: Real-time metering & benchmarking

The development and widespread proliferation of metering and communications technologies now allows for real-time metering of building energy use and sharing of energy use data with utilities, government, efficiency programs, and the public at large.

- The ready availability of the data allows for aggregation and benchmarking of individual building performance against that of similar structures.
- The Danish Energy Saving Trust has implemented a web-based tool—Se-elforbrug ("watch electricity consumption")—to present data on electricity consumption in public and private buildings

Promising Potential Policies: Real-time metering & benchmarking

- The website provides hour-by-hour consumption data for each facility as well as analysis reports breaking down average day, evening, and night usage and data on the past three months consumption
- Individual building data can be compared to that of other buildings within the same market sector or to all other participating buildings.
- As of the end of 2006, 780 buildings representing 23 different workplace types were participating in the program
- This program could serve as a useful model for development of national and/or statewide metering and benchmarking programs

http://www.elsparefonden.dk/offentlig-og-erhverv/se-elforbrug/index_html

Type of workplaces - average per workplace

	Count	Type of workplace	Report	Floor area m²	Annual consumption kWh	Annual consumption kWh/person	Annual consumption kWh/m²	Chart
+	31	24-hour care centres		169,471	9,282,621	1,771	53	
+	28	Boarding schools/training centres		150,420	6,055,741	1,848	40	
+	15	Day care institutions		24,651	1,915,954	1,210	69	
+	50	Gymnasier og erhvervsfaglige skoler		426,450	14,976,261	436	35	
+	19	Hospitals		677,024	59,279,632	3,974	88	

http://www.elsparefonden.dk/offentlig-og-erhverv/se-elforbrug/index_html

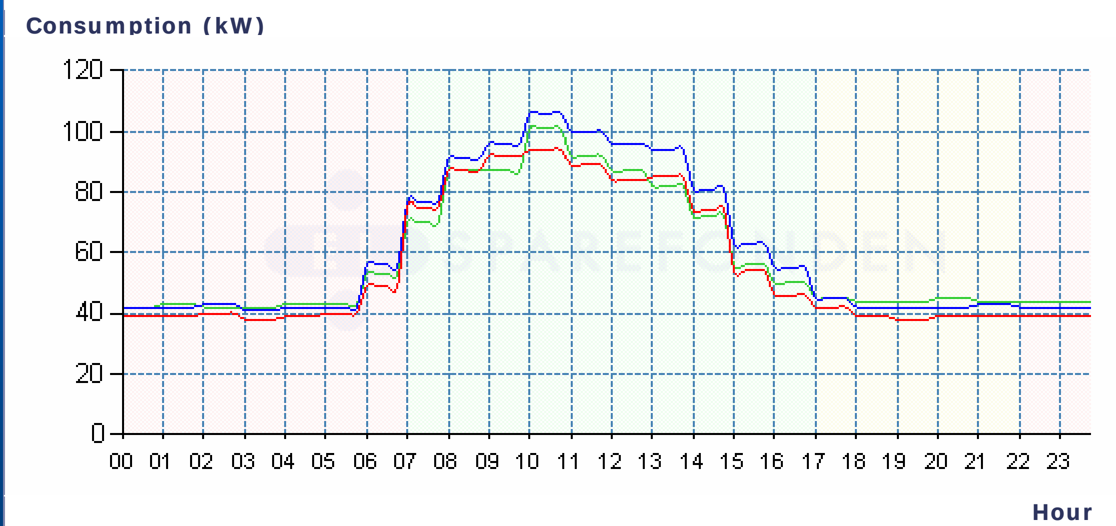
Workplaces - individual information

Count	Workplace	Authority/company	Type of workplace	Report	Floor area m²	Annual consumption kWh	Annual consumption kWh/person	Annual consumption kWh/m²	Chart
1	Aaskov Kommune Rådhuset	Herning Kommune	Office/administration		2,469	96,583	1,486	39	
1	Administrationsbygning	Bornholms Regionskommune	Office/administration		4,100	544,353	5,444	133	
1	AF Århus	Beskæftigelsesministeriet	Office/administration		5,028	89,823	1,283	18	
1	AF Region Ribe	Beskæftigelsesministeriet	Office/administration		4,086	159,835	1,998	39	
1	Af-Randers (af-Region Århus)	Beskæftigelsesministeriet	Office/administration		2,593	82,308	2,058	32	
1	Af-Region Fyn/Af-Odense	Beskæftigelsesministeriet	Office/administration		5,114	178,472	1,475	35	
1	Af-region Roskilde	Beskæftigelsesministeriet	Office/administration		2,144	95,990	1,600	45	
2	Af-region Storkbh./af-vesterbro	Beskæftigelsesministeriet	Office/administration		9,381	184,373	922	20	
1	Af-Region Storkøbenhavn	Beskæftigelsesministeriet	Office/administration		2,200	78,703	984	36	
1	Af-Region Storstrøm/Af-Nykøbing F	Beskæftigelsesministeriet	Office/administration		2,601	121,042	2,017	47	

http://www.elsparefonden.dk/offentlig-og-erhverv/se-elforbrug/index_html

Daily report

Consumption for most recently registered **day** and **4** and **13** weeks ago.

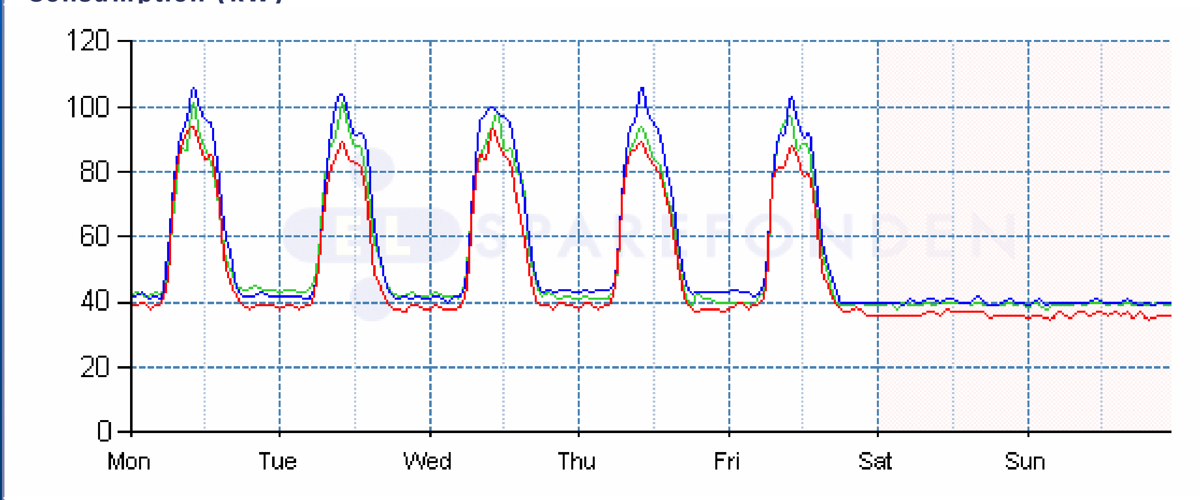


	Consumption data for three days					
	TotalkWh	MinkW	MaxkW	Base%	mo-fr	sa-so
	1,402	42.00	101.00	71 %	X	
	1,465	41.00	106.00	67 %	X	
	1,339	38.00	94.00	68 %	X	

http://www.elsparefonden.dk/offentlig-og-erhverv/se-elforbrug/index_html

Weekly report

Consumption for most recently registered **week** and **4** and **13** weeks ago



Consumption data for three weeks

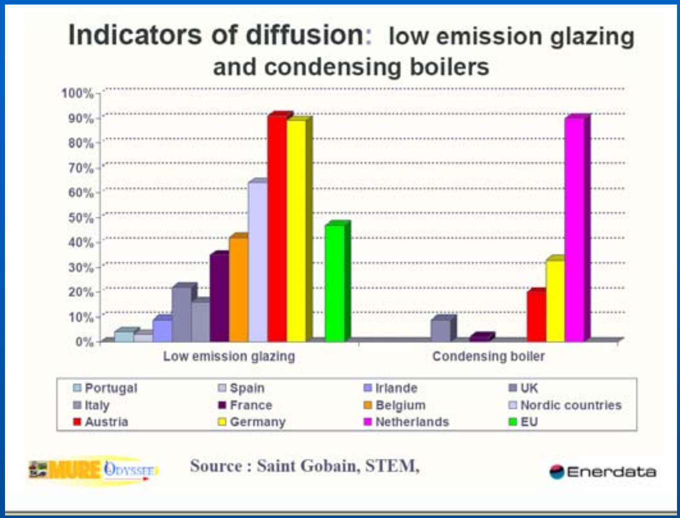
	Total kWh	Min kW	Max kW	Base %	mo-fr	sa-so
	8,872	38.00	101.00	71 %	78 %	21 %
	9,214	39.00	106.00	71 %	79 %	20 %
	8,278	35.00	94.00	71 %	79 %	20 %

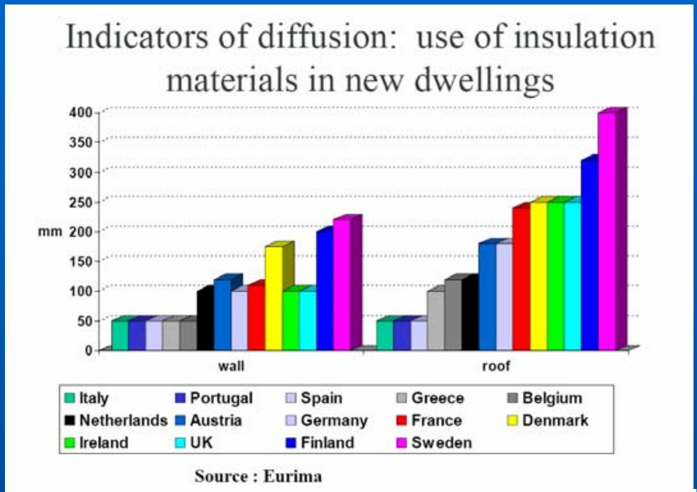
http://www.elsparefonden.dk/offentlig-og-erhverv/se-elforbrug/index_html

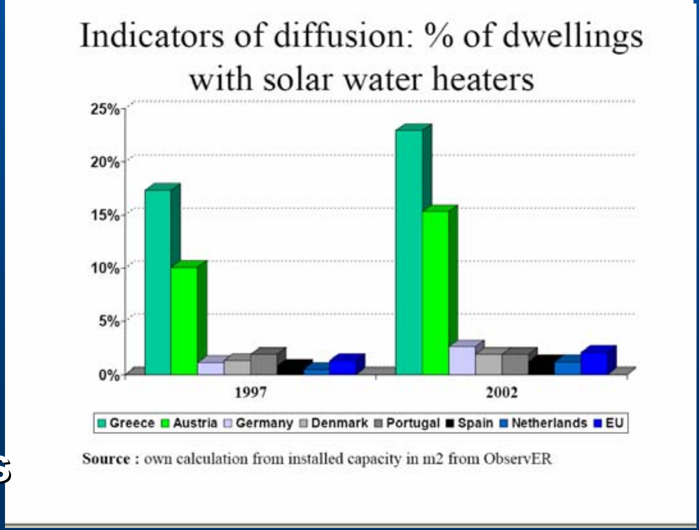
Breakdown

	Power				Energy		
End use	Working hours		Outside working hours		Week		Year
	%	kW	%	kW	kWh	%	kWh
IT/Office eq.	25	24.5	10	3.9	1618	18	74419
Serverrooms	10	9.8	20	7.8	1288	15	59234
Lighting	25	24.5	10	3.9	1618	18	74419
Ventilation	20	19.6	20	7.8	1774	20	81635
Cooling	5	4.9	20	7.8	1044	12	48034
Misc.	15	14.7	20	7.8	1531	17	70435
Sum	100	98	100	39	8872	100	408176

Benchmarking e.g. via technology diffusion indicators







Indicators could show diffusion of efficient products or the number of installed indicators

Some examples taken from the Mure Odysee Database

Other examples could be air-conditioners

Promising Potential Policies: Oil savings programs

Oil use is small compared to electricity and natural gas in the US buildings sector, but it is fairly large in the Northeast and Midwest regions. Energy savings could be achieved through:

End-use efficiency market transformation programs:

- Many of the same types of market transformation programs targeted toward electric and gas appliances and equipment could be used to reduce oil consumption. In particular loans, technical assistance, financial incentives, and education/awareness programs

Fuel switching and retrofits as offsets in carbon cap-and-trade programs:

- Carbon emission reduction policies that focus on the power sector can use non-electricity energy savings as offsets. In the seven-state Regional Greenhouse Gas Initiative, reductions in heating fuel usage in existing buildings are eligible as such offsets

Promising Potential Policies: Oil savings programs

Loan programs for oil dealers:

- Most fuel oil dealers are small businesses, and with the high price of heating oil, their inventory costs going into the heating season are substantial. Members of Congress have considered a federal loan program to help dealers finance their inventories, and it has been suggested that such a program could include conditions requiring dealers to use part of such funds to finance boiler and furnace replacements as well as other efficiency measures

Energy services contracting:

- ESCOs take over the operation of the heating systems and convert boilers to more efficient units, offering the customer lower costs while sharing value of savings through energy performance contracting

Conclusions

- Lots of progress to date; initiatives delivering significant savings, with lasting market effects
- Biggest remaining savings in whole building approaches; high potential, but harder to achieve

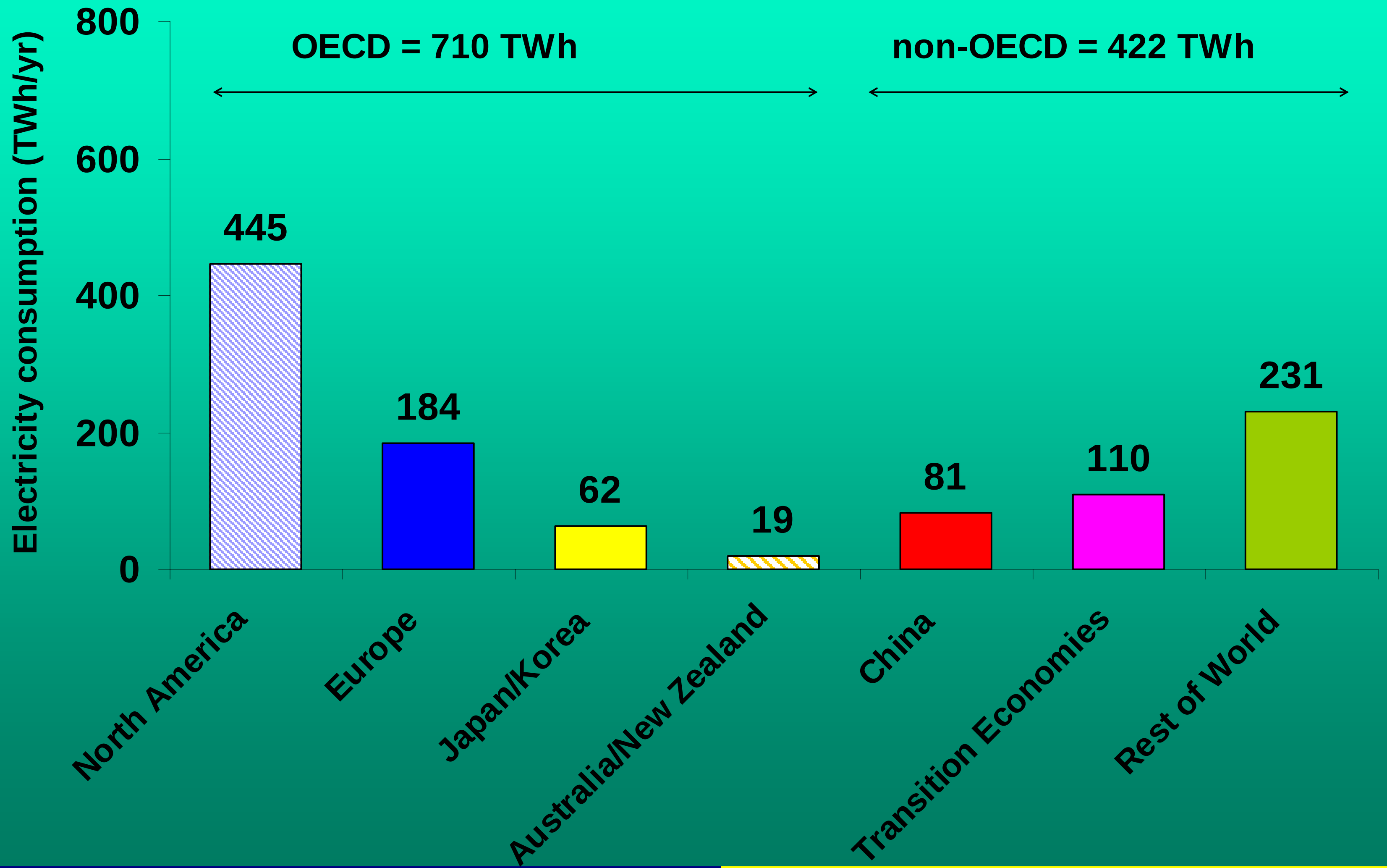
Conclusions (cont.)

- Innovation is pushed by states; both significant funding and aggressive policies
- 20 states account for 87% of energy savings from ratepayer programs; wider adoption either by states or national leadership could deliver big savings

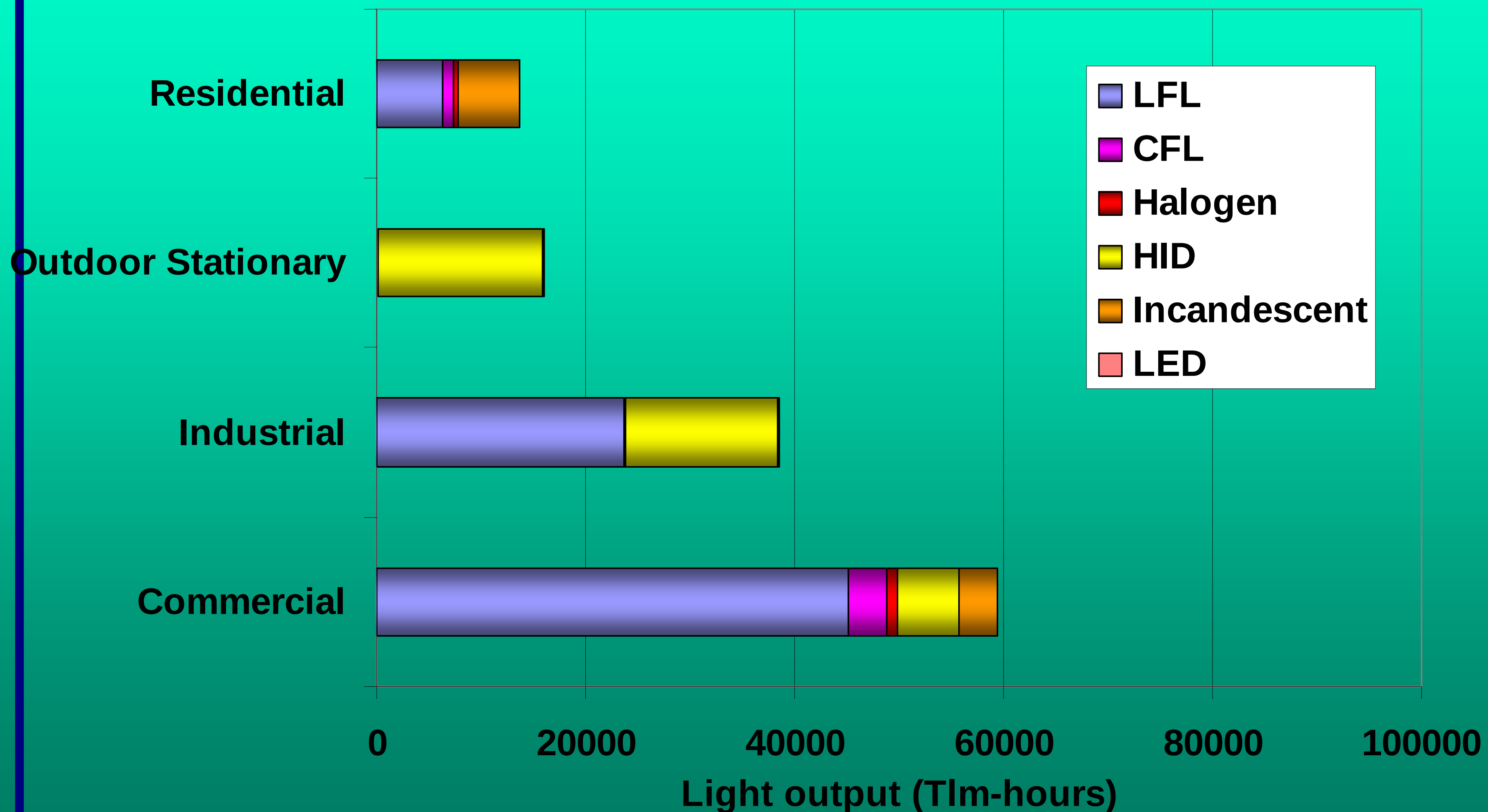
Conclusions (cont.)

- No magic solutions seen moving forward
- Innovative combinations of, and expansions of, initiatives already underway or soon beginning should drive continued improvement
- Stronger implementation of existing measures is important

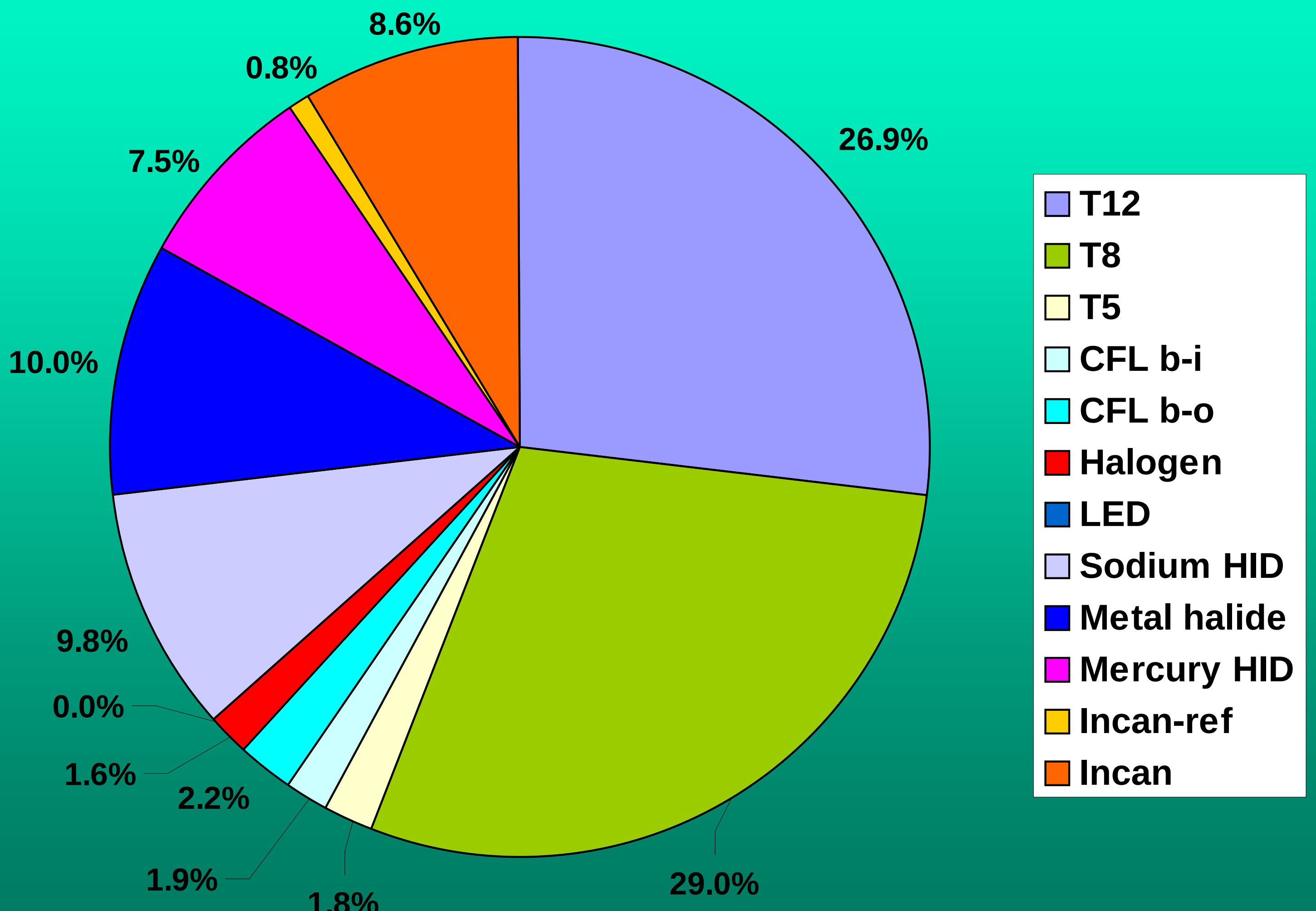
Commercial sector lighting in 2005



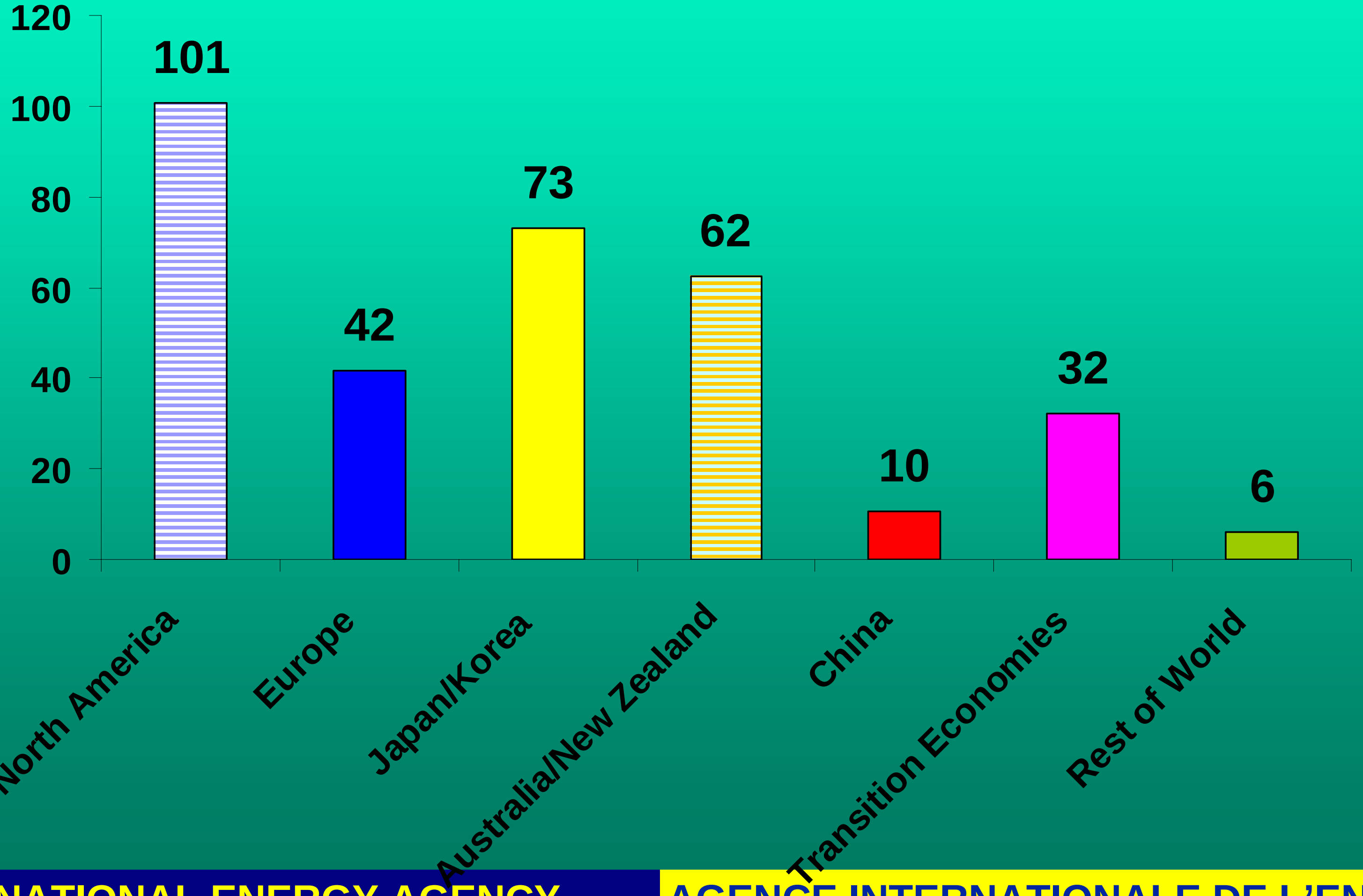
Total delivered light in 2005 (Teralumen hours)



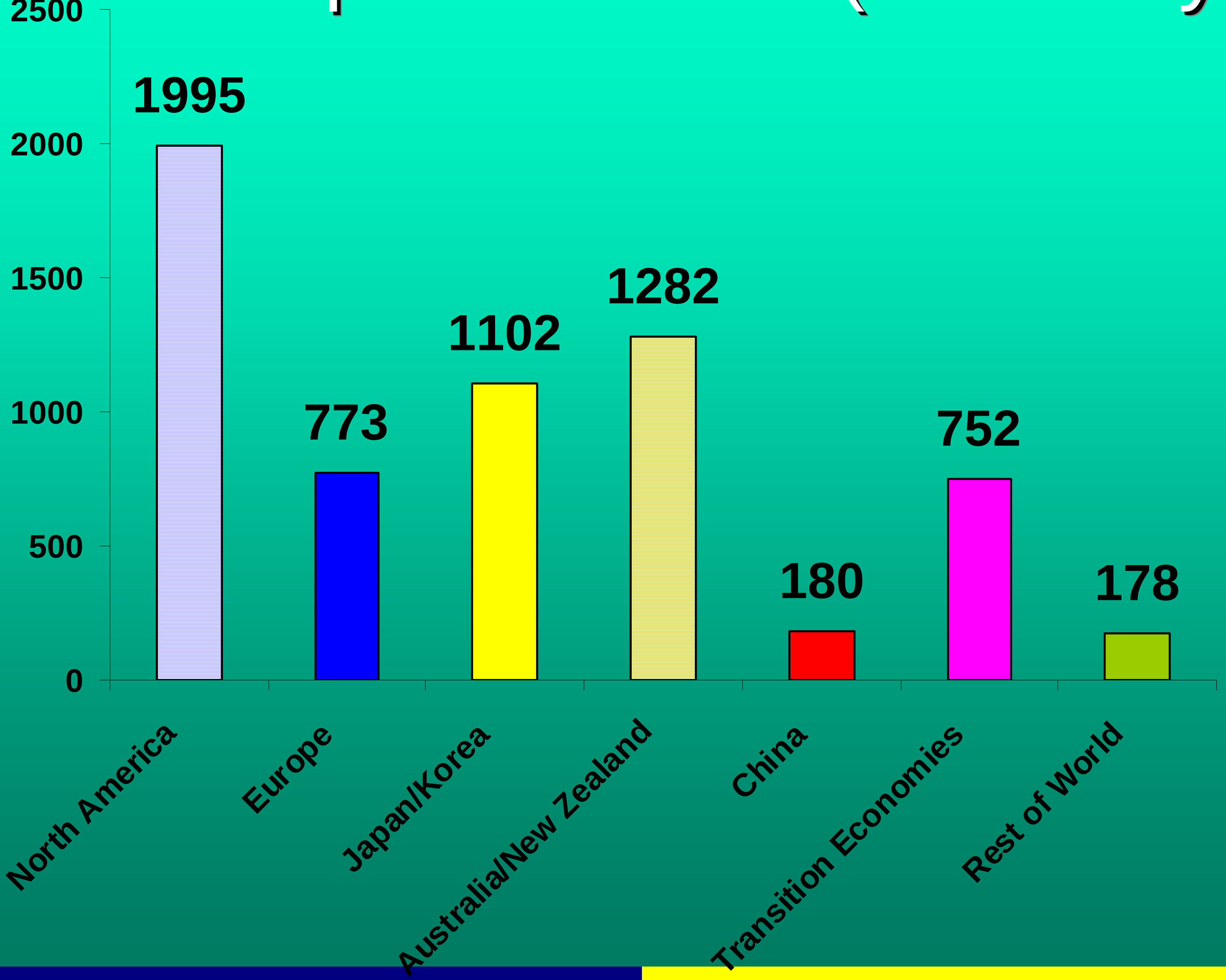
Light output by lamp type in 2005 (global total 113 Peta-lumen hrs)



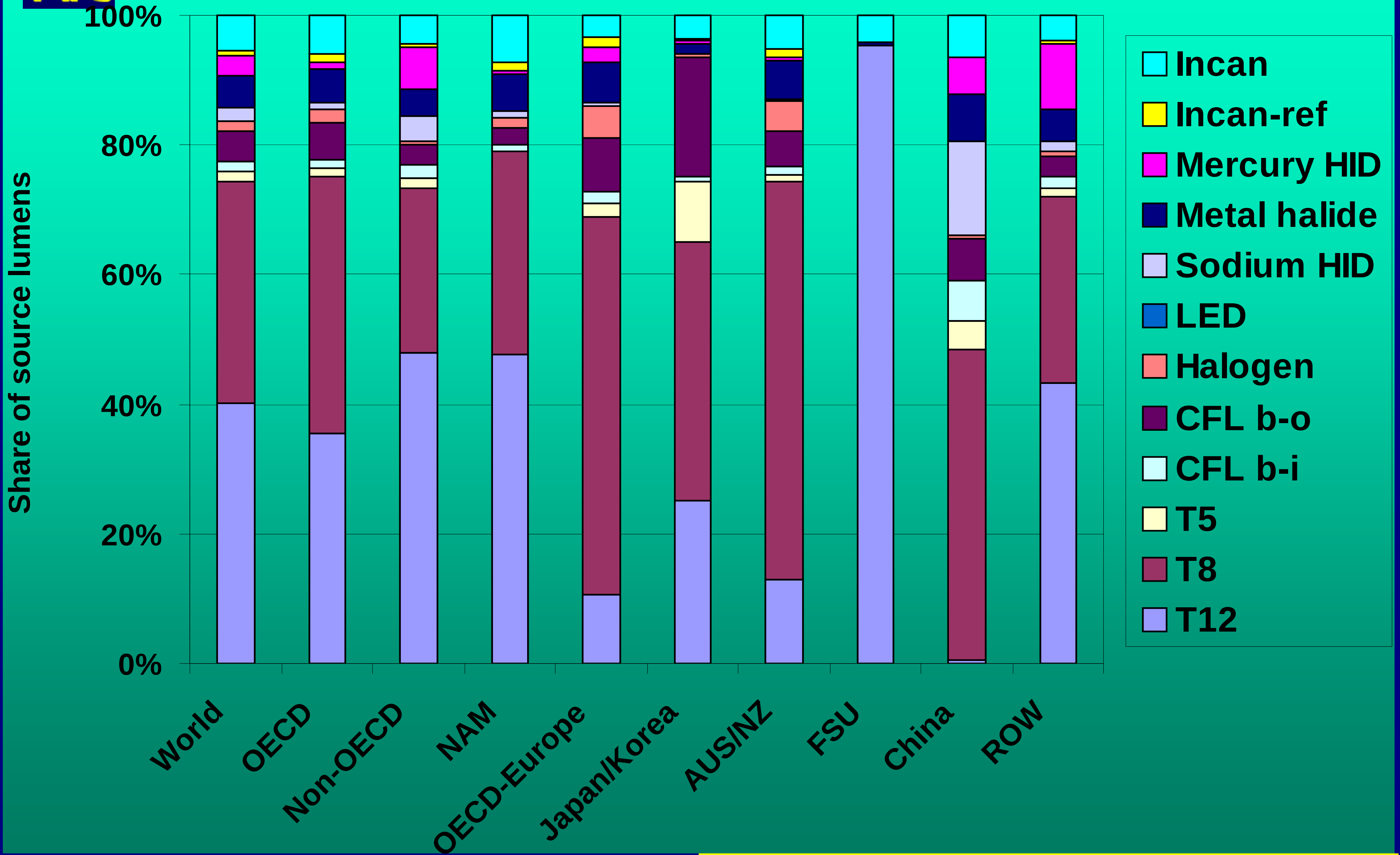
Average per capita electric light consumption (Mega-lumen-hrs per person/year)



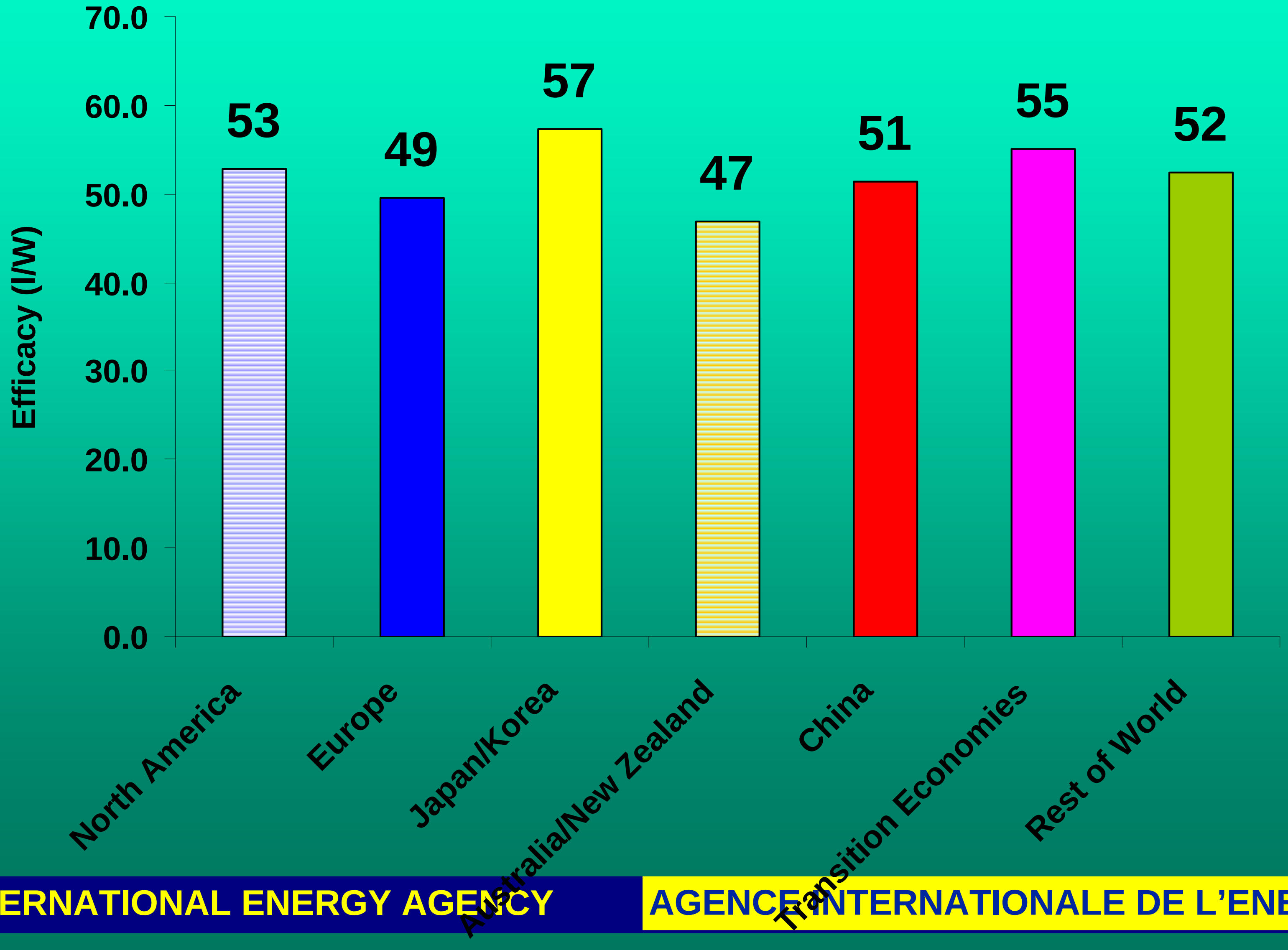
Residential lighting electricity consumption in 2005 (kWh/hh/year)



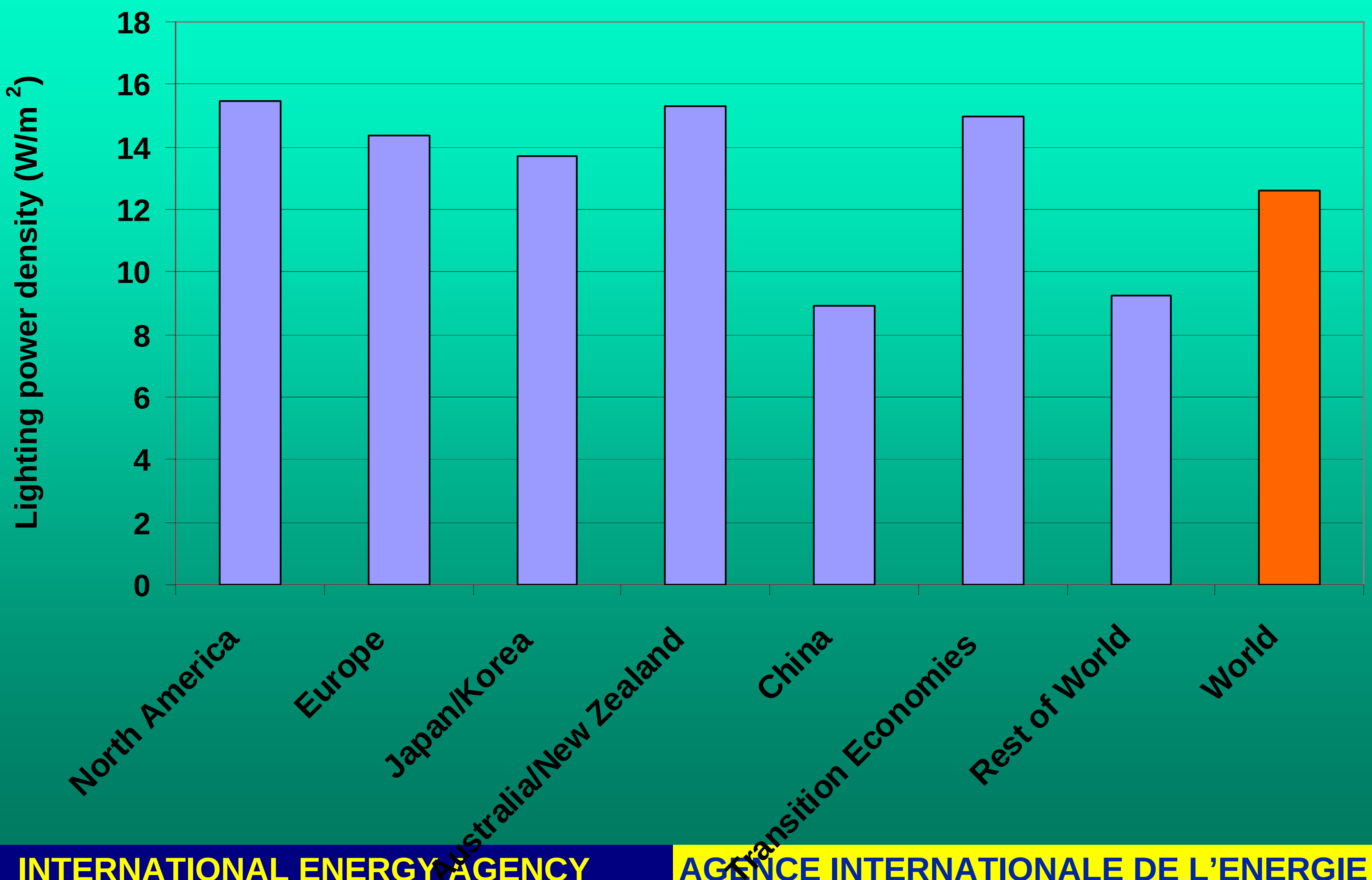
Commercial sector lighting in 2005



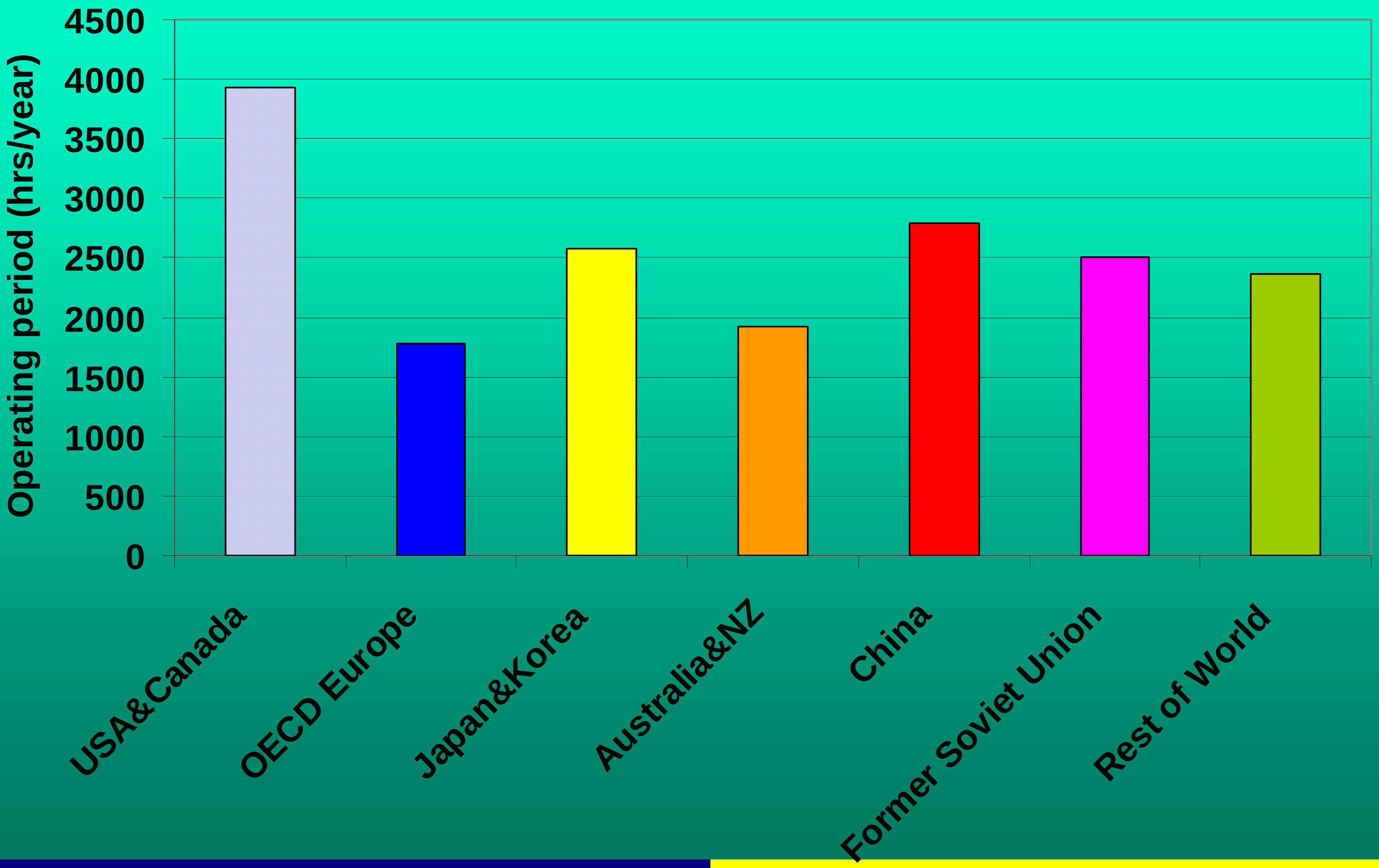
Estimated commercial sector average lighting efficacy in 2005



Commercial sector average lighting power densities in 2005



Commercial sector average lighting annual hours of use in 2005



Commercial sector average lighting energy intensities in 2005