



Environment Center  
Charles University  
in Prague

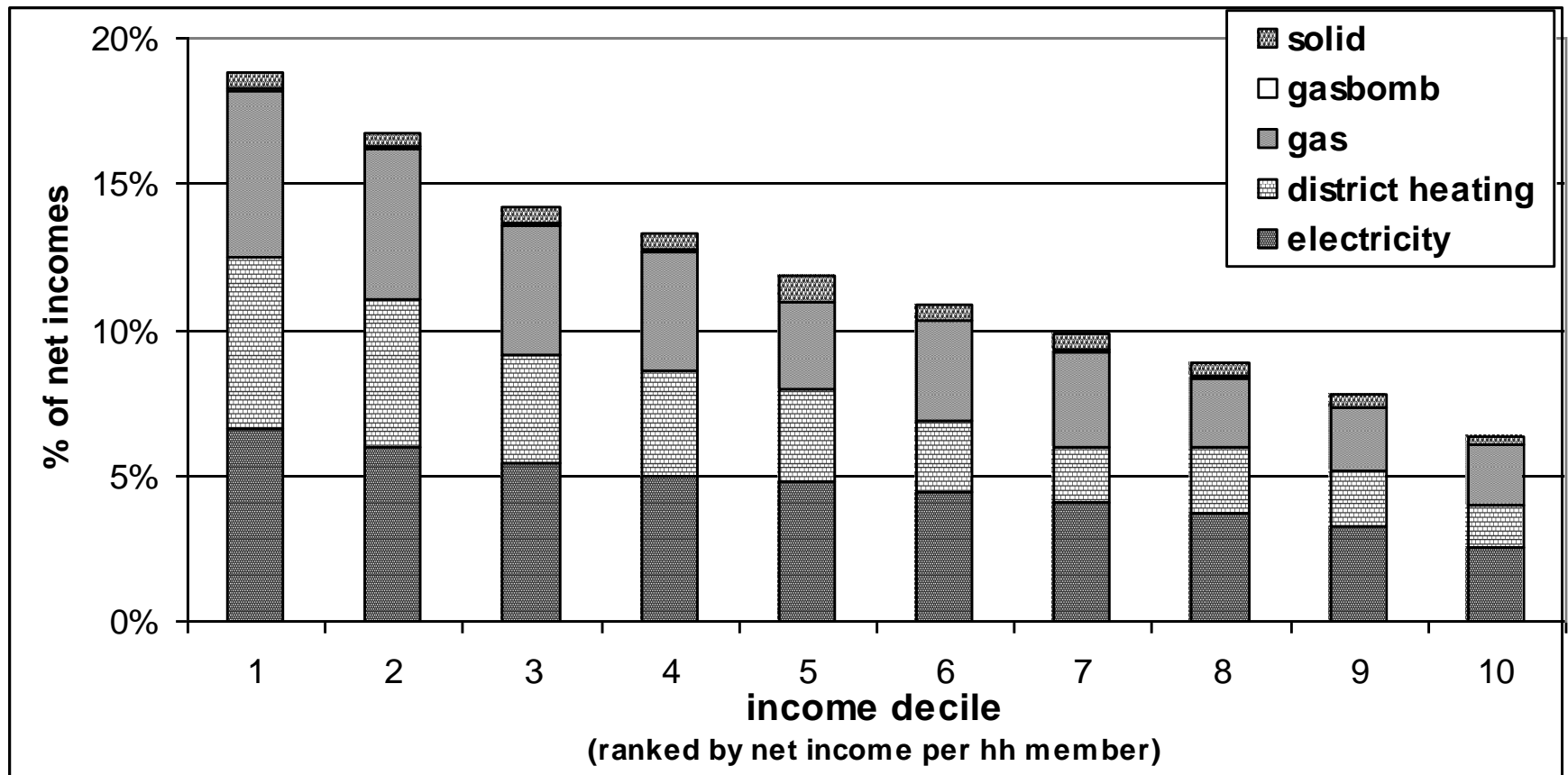
# **Residential Energy Efficiency And Energy Consumption: Economic, Environmental And Social Aspects**

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INSTREAM Workshop: Energy and Resource Efficiency –  
Modelling, Analysis, Indicators,  
Prague, 5th April 2011

# Motivation

**Indicator on residential energy consumption / expenditures vs. on residential energy savings**



# Energy consumption and energy savings

Nobody demands energy (and fuels) *per se*

- energy demand is a derived demand
- energy is combined with durable goods to produce service

Two means of achieving residential energy savings

- consequence of lower **demand for energy services**, or
- thanks to the installation of **energy-efficient durables**

Determinants of energy consumption

- **stock** of appliances
- **quality** of appliances (i.e. efficiency-rating)
- **frequency and duration** of their use

# Contents

- 1. To summarize result from the survey on residential energy efficiency**
  - determinants of energy-savings in households
  - energy-saving durables and curtailments
- 2. Determinants of motor fuel use by Czech households**
  - consumption of propellants and passenger car fleet
- 3. Note on distributional aspects**
- 4. Some policy recommendations**

# Energy-saving behaviour data

Lack of data on household behaviour

- **Household Budget Surveys** (expenditures, durables, but nothing about frequency of use and durable's attributes, no direct info about use)
- **EU-SILC** (expenditures, any information about durables and their use)
- **ENERGO** (durables, kWh/GJ, but no info about frequency of use, no financial data)

**OECD Project on “Household Behaviour and Environmental Policy”** (2006-2009)

- Coordinating body: OECD Environment Directorate's WP NEP
- Population: adult population of 10 countries (AUS, CAN, **CZE**, FRA, IT, KOR, MEX, NL, NOR, SWE)
- Data: household survey (N=cca 1000 in each country), 2008
- Areas:
  - waste handling, personal transportation, organic food, water use
  - **residential energy**
- further information: <http://www.oecd.org/dataoecd/20/11/42186861.pdf>

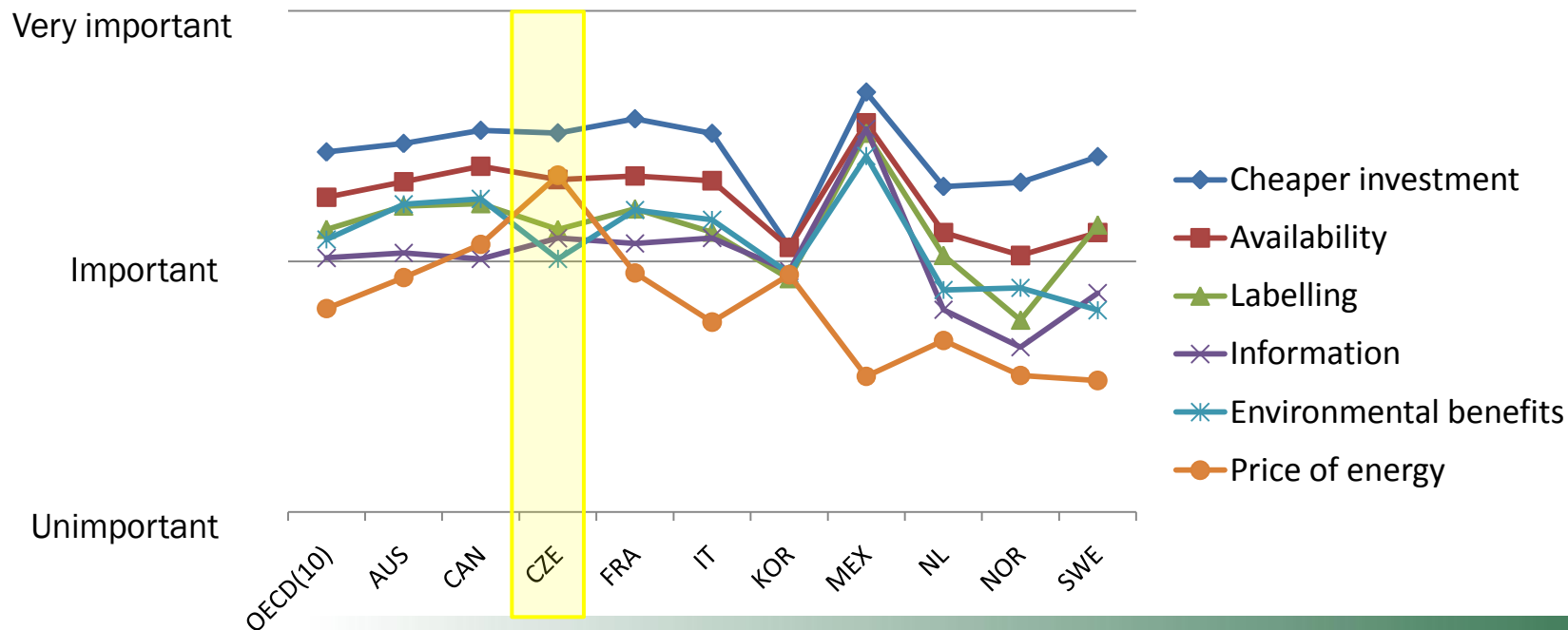
# OECD sub-task: residential energy efficiency

1. Household penetration with:
  - appliances
  - **efficient appliances**
  - **other energy-saving measures (thermal insulation)**
2. **Energy-saving activities (curtailments)**
3. **Stated motivation for energy-saving**
4. **Knowledge of efficiency labels**
5. Willingness-to-pay for green electricity

# Stated motivation to energy conservation

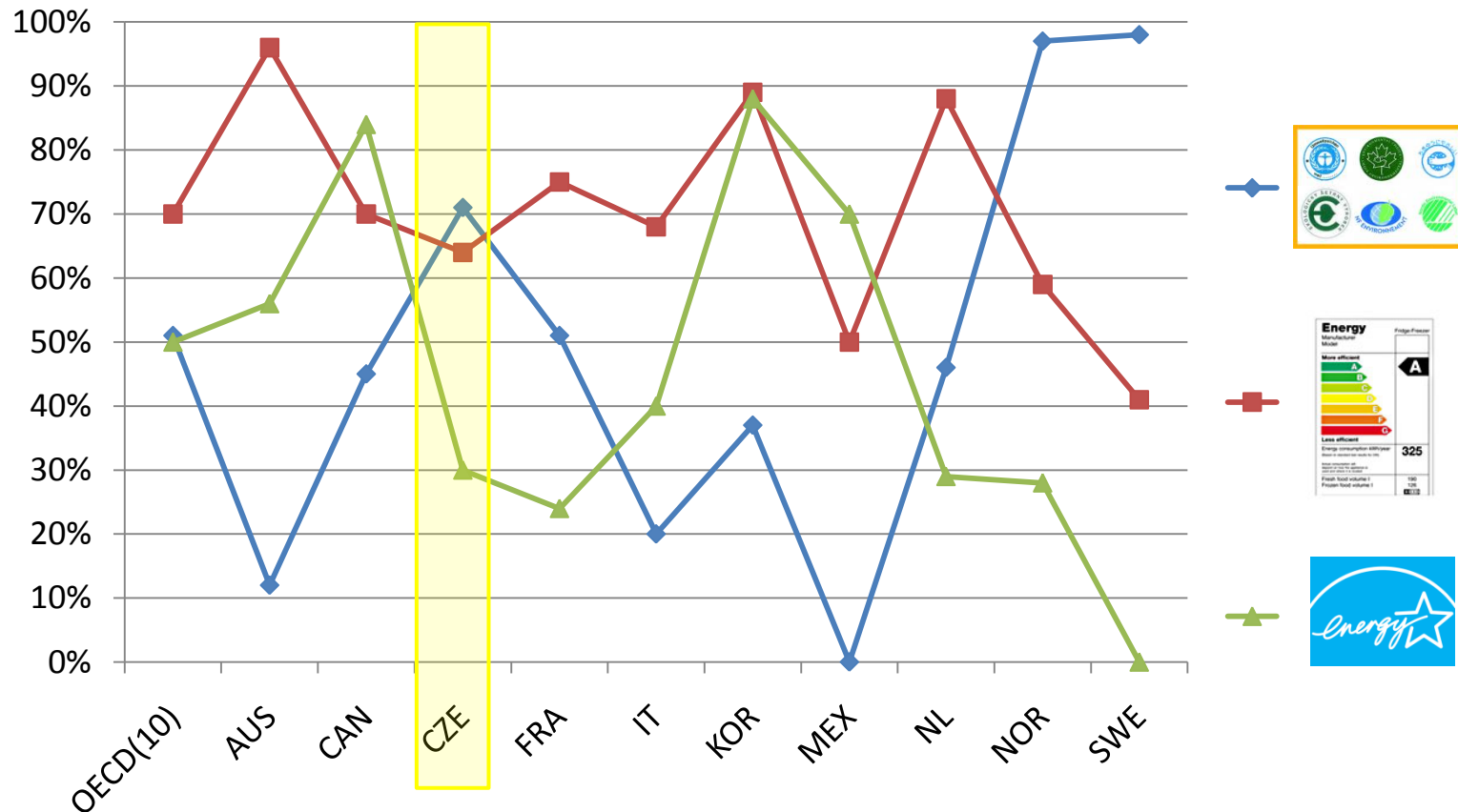
How important are following factors for you in reducing your energy consumption?

1. Less expensive to invest in energy-efficient equipment
2. Greater availability of energy-efficient products
3. Easier identification of energy efficiency labels
4. More practical information on energy conservation measures
5. Belief that the environmental benefits are significant
6. Higher energy prices



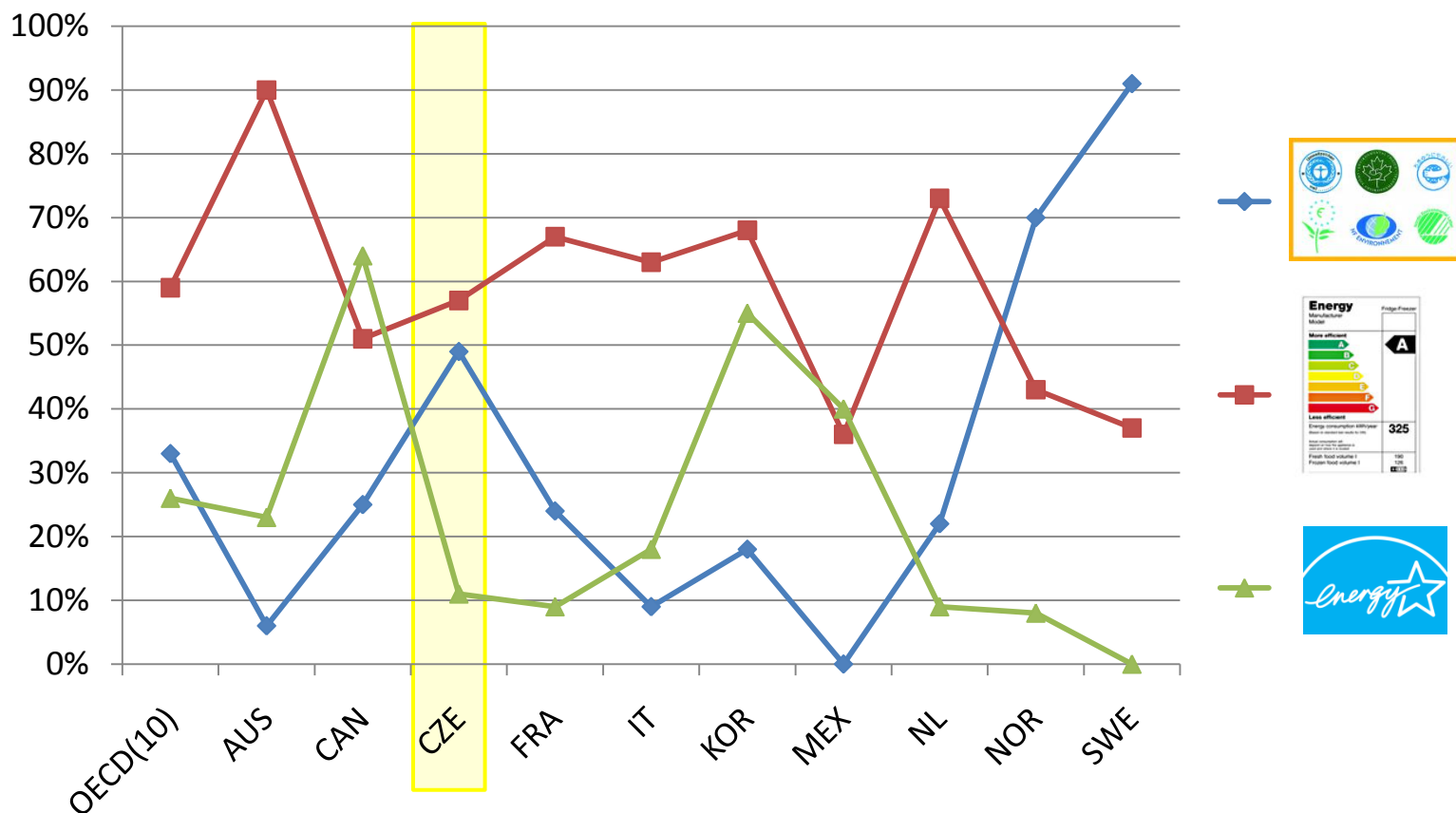
# Knowledge of efficiency labels

Among the following logos/ labels, please select the ones you are familiar with.



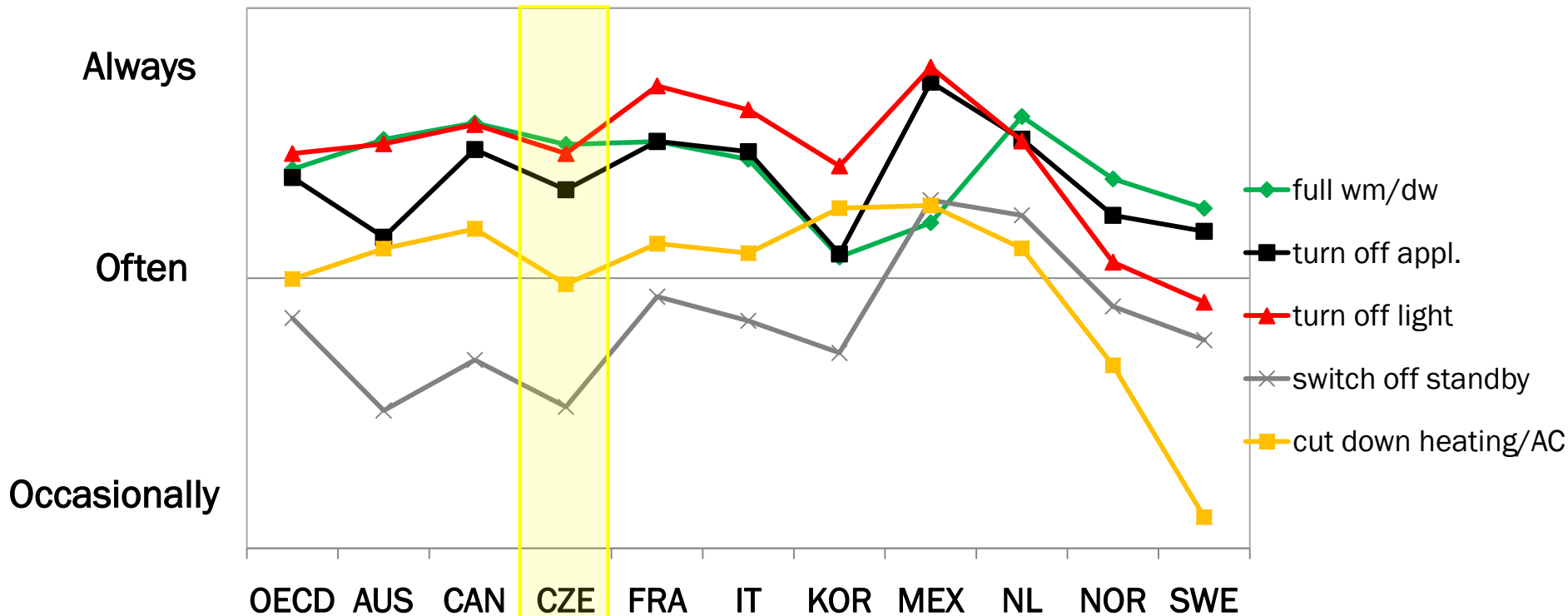
# Stated effects of efficiency labels

Among the following logos/ labels, select the ones you take into account in your purchasing decisions.



# Energy-saving activities

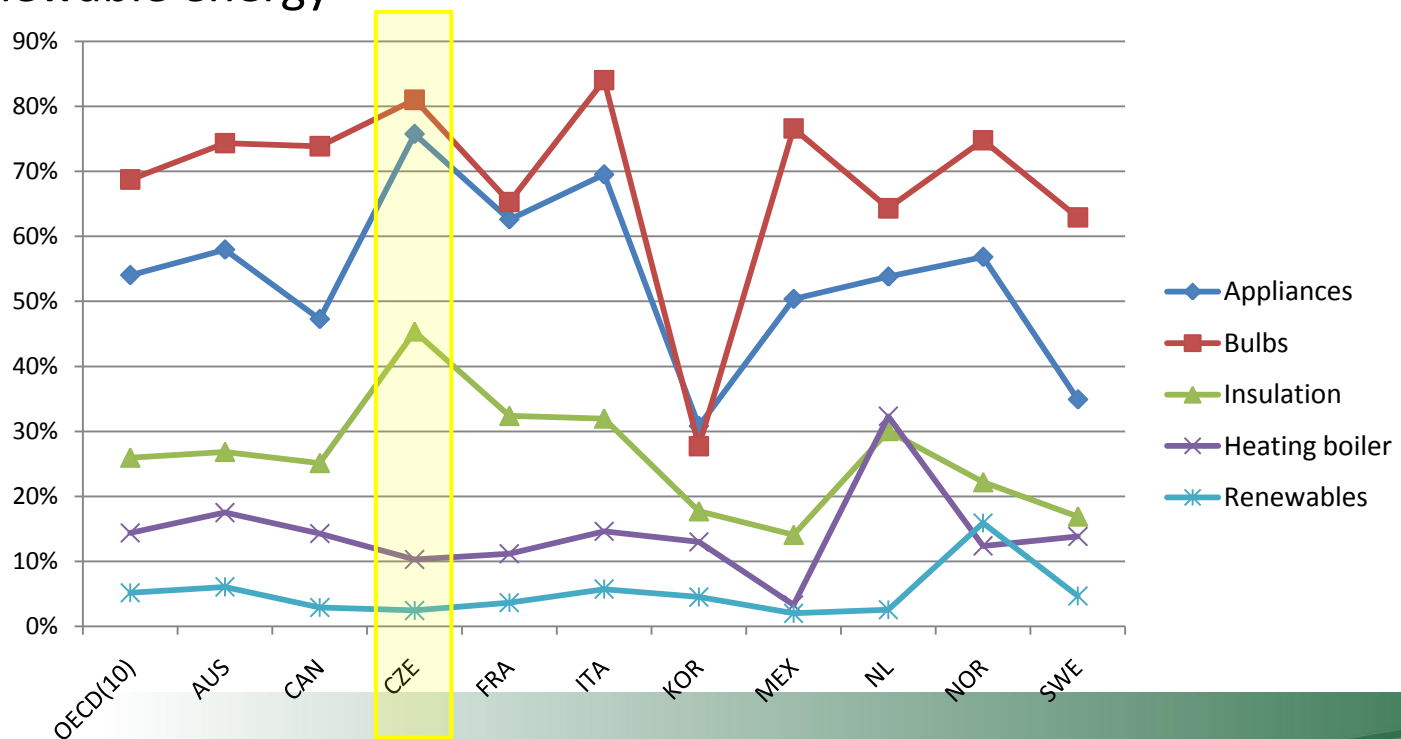
1. waiting until **washing machine/ dishwasher** is full loaded
2. turning off **appliances** not used
3. turning off **light** when leaving a room
4. switching off **stand-by mode**
5. cutting down on **heating/AC**



# Efficiency investments

Has your household installed any of the following items over the past ten years in your current primary residence?

1. Low-energy light bulbs
2. Energy-efficiency-rated appliances
3. Thermal insulation
4. Efficient heating boiler
5. Renewable energy



# Curtailments and efficiency investments

Do those people who purchase efficient appliances also save energy by performing certain energy saving activities?

Theory gives no definitive answer to this question:

- **YES:** common motivation factors (energy concern, environmental concern)
- **NO:** various types of behaviors are subject to different external constraints and to specific motivation factors; having more energy efficient durable may increase demand for energy (rebound effect)

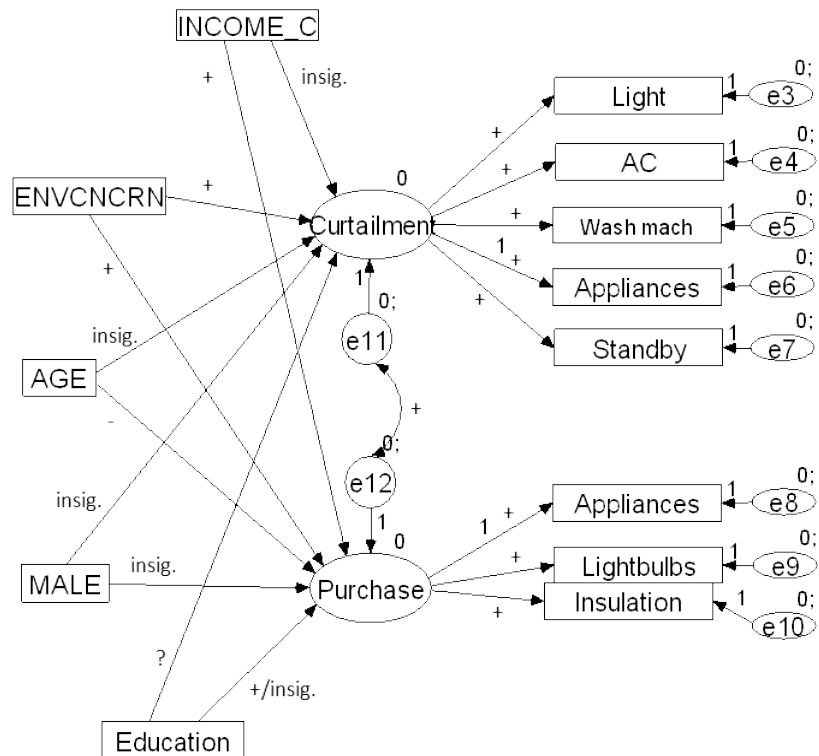
Empirical evidence on the direct rebound effect (e.g. Dimitropoulos and Sorrell 2007)

- Space heating: 1.4% to 60% (but with low confidence)
- Electric appliances: low to moderate, may decline with income
- In general, there are very few empirical studies

# Curtailments and efficiency investments

**Method:** structural equation modeling

- relationships between latent variables (curtailments, investments, enviro concern)
- background variables
- controls for spurious correlations (direct and indirect effects)
- compares models across countries (measurement and factorial invariance)



# Curtailments and efficiency investments

## Results:

1. **background variables** have weak and often inconsistent effect across the 10 countries

2. **environmental concern** has positive effect on curtailments and investments

3. positive effect of **saving retrofits on saving activities** but, when controlling for environmental concern, the **correlation between curtailments and investments disappears**

			OECD(10)		CZE	
			Beta	Sig.	Beta	Sig.
Curtailment	<---	Income	-0,11	***	-0,03	0,62
Purchase	<---	Income	0,116	***	0,113	0,07
Curtailment	<---	Env. cncr.	0,254	***	0,107	0,02
Purchase	<---	Env. cncr.	0,088	***	0,028	0,61
Curtailment	<---	Male	-0,06	***	-0,01	0,90
Purchase	<---	Male	0,007	0,61	0,035	0,53
Curtailment	<---	Education	0,006	0,63	-0,04	0,47
Purchase	<---	Education	-0,08	***	-0,01	0,83
Curtailment	<---	Age	0,141	***	0,141	0,00
Purchase	<---	Age	0,164	***	0,188	0,00
Chi (df=49)			1688		124,3	
NFI			0,887		0,828	
CFI			0,89		0,881	
RMSEA			0,057		0,047	

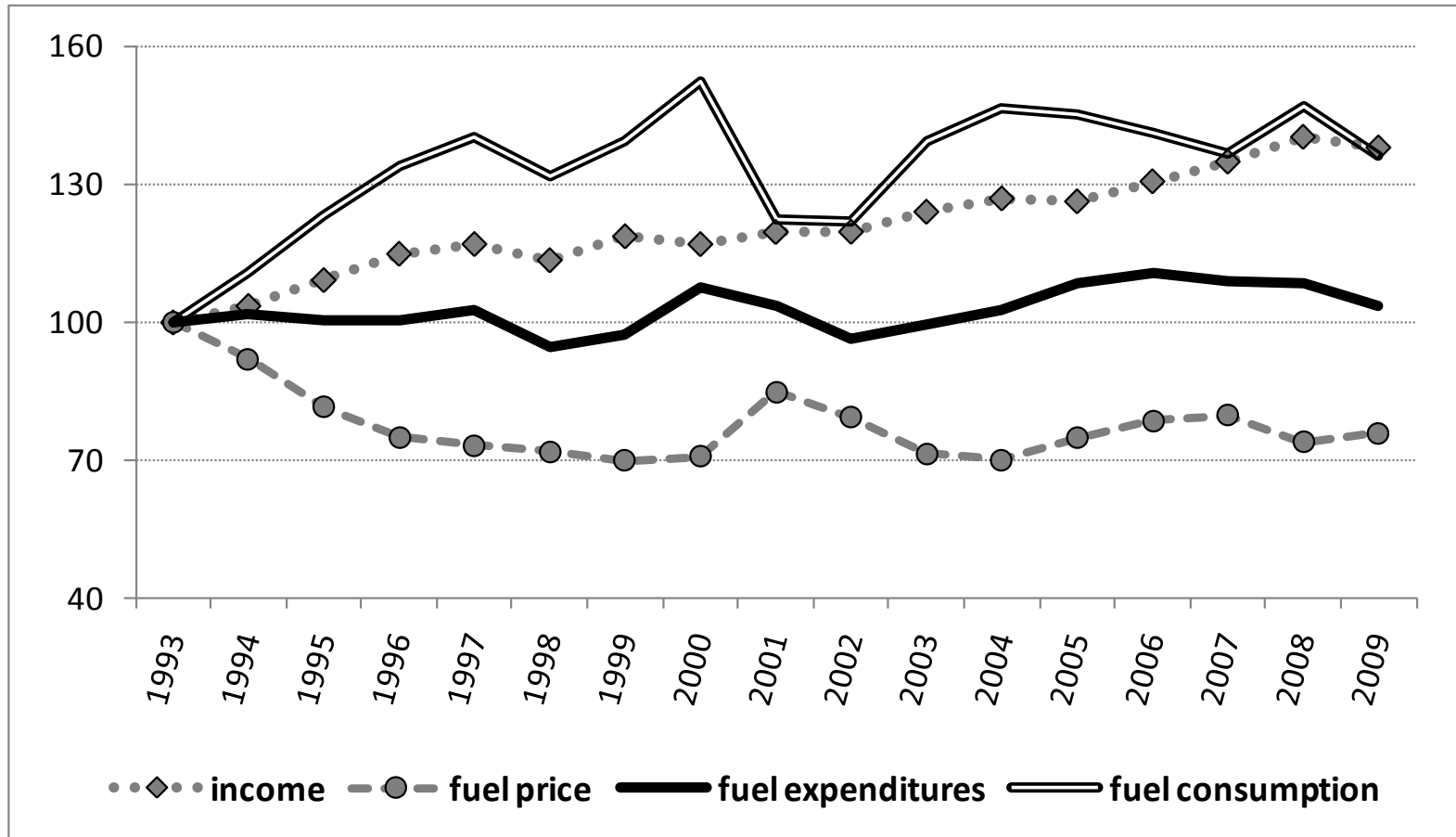
Note: \*\*\*<0.001

# Fuel expenditures in Czech Republic

	Only households with own car (N=29,398)			
	consumption [l per year]	fuel expenses [CZK(2005) a year]	fuel expenses [% of net incomes]	fuel expenses [% of total expenditures]
1993	386	13 583	5.88	6.10
1994	428	13 840	5.93	6.10
1995	476	13 666	5.51	5.79
1996	517	13 647	5.26	5.51
1997	540	13 935	5.28	5.45
1998	508	12 866	4.95	5.20
1999	537	13 209	4.95	5.16
2000	588	14 641	5.59	5.89
2001	471	14 075	5.25	5.65
2002	470	13 110	4.85	5.24
2003	538	13 510	4.85	5.21
2004	566	13 956	4.87	5.34
2005	559	14 750	5.23	5.81
2006	544	15 029	5.12	5.68
2007	527	14 795	4.82	5.47
2008	567	14 756	4.73	5.42
2009	525	14 044	4.55	5.15

On average, real fuel expenditures, consumption and budget share are quite stable over time → Why?

# Driver of fuel consumption & expenditures



Note: Figures are based on the averages for each variable (only households with a car), 1993 level set to 100

# Why environmental burden from passenger transport has been increasing? → car ownership

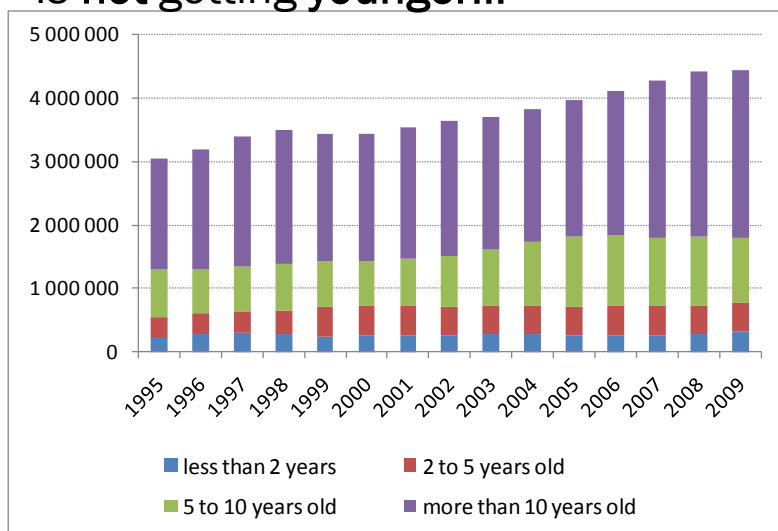
How many households have at least one car?

	own car (EU-SILC)	own car (HBS)			business-cars (HBS)		
	ownership	ownership	average age	median age	possibility to use	average age	median age
<b>1993</b>		53.0%	10.36	9			
<b>1994</b>		51.0%	10.81	10			
<b>1995</b>		51.5%	11.24	10			
<b>1996</b>		53.4%	11.26	10			
<b>1997</b>		55.6%	11.34	11			
<b>1998</b>		56.0%	11.44	11			
<b>1999</b>		58.1%	11.01	10	2.9%	4.87	3
<b>2000</b>		58.6%	11.04	10	3.0%	4.94	3
<b>2001</b>		60.9%	11.36	11	3.4%	5.32	4
<b>2002</b>		60.6%	11.52	11	3.3%	5.83	5
<b>2003</b>		61.6%	11.62	11	3.1%	6.58	5
<b>2004</b>		63.1%	10.95	9	4.4%	7.06	6
<b>2005</b>	59.4%	62.3%	11.37	10	3.9%	7.63	7
<b>2006</b>	61.0%	61.7%	11.62	10	3.9%	7.19	7
<b>2007</b>	62.9%	61.2%	11.37	10	4.2%	7.47	7
<b>2008</b>	64.3%	60.8%	11.07	10	4.5%	6.64	6
<b>2009</b>	65.6%	62.1%	10.62	10	4.2%	6.80	6

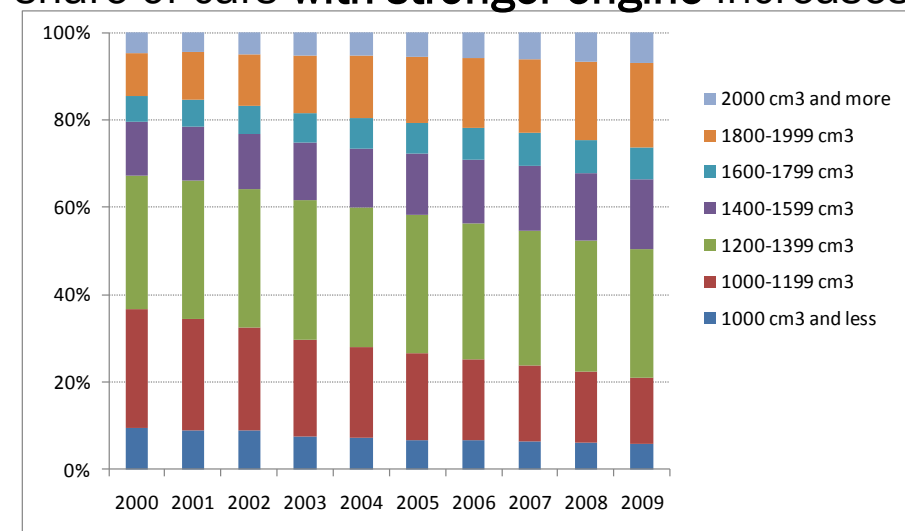
Source: HBS and EU-SILC; Scasny (2011)

# Passenger vehicle fleet

Is not getting younger...

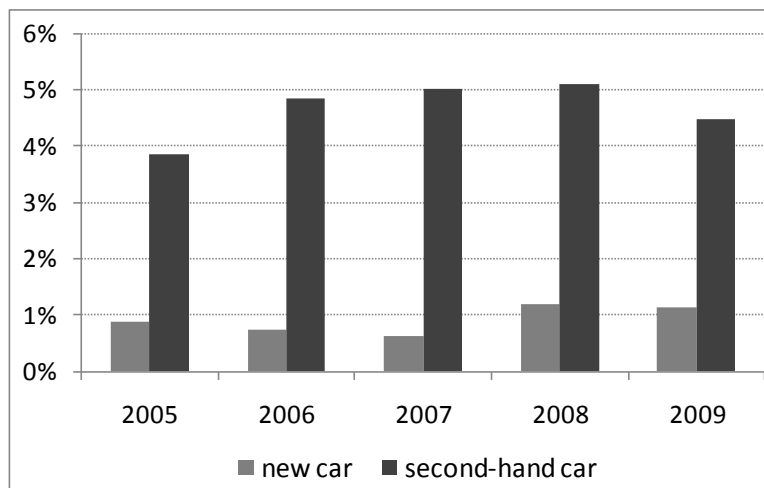


share of cars with stronger engine increases...



Source: Based on vehicle register; Yearbook on Transport (Min-Tran & CDV, various years)

Most are the second-hand cars...



more hholds equipped with more cars...

	share of hholds with 1 car	hholds with 1 car	hholds with 2 cars
<b>1993</b>	95.6%	50.6%	2.3%
<b>1997</b>	93.5%	52.0%	3.6%
<b>2001</b>	91.1%	55.5%	5.4%
<b>2005</b>	89.1%	55.5%	6.8%
<b>2009</b>	88.1%	54.7%	7.4%

Source: Based on HBS by Czech Statistical Office (computed by author)

# Which household is more likely to own a car?

Table: Probability to own a car, logit model (HBS data)

Variable name	Variable description	Coeff. estimate	Marginal effect	t stat	p-value
<b>Intercept</b>		-3.6956		-21.59	<.0001
<b>adult</b>	<i>continuous: number of adults in the family</i>	1.5132	0.2398	45.36	<.0001
<b>singleM</b>	<i>dummy: =1 if single male</i>	-1.4318	-0.2127	-13.74	<.0001
<b>singleF</b>	<i>dummy: =1 if single female</i>	1.2651	0.1880	24.79	<.0001
<b>retired</b>	<i>dummy: =1 if household of retired</i>	-0.2926	-0.0435	-8.18	<.0001
<b>child5</b>	<i>count; number of children younger than 5</i>	0.1198	0.0178	3.99	<.0001
<b>child69</b>	<i>count; number of children of age 6 to 9</i>	0.0958	0.0142	2.94	0.0032
<b>child1014</b>	<i>count; number of children of age 10 to 14</i>	0.0259	0.0038	0.94	0.3482
<b>child15plus</b>	<i>count; number of children older than 15</i>	0.0083	0.0012	0.33	0.7439
<b>income</b>	<i>continuous; net annual household income in 1000 CZK</i>	0.0067	0.0010	36.98	<.0001
<b>fuelprice(-1)</b>	<i>continuous; lagged real(2005) price of liter propelant</i>	-0.0188	-0.0028	-3.16	0.0016
<b>city500</b>	<i>dummy; residence with less than 500 inhabitants</i>	1.3701	0.2036	23.4	<.0001
<b>city2000</b>	<i>dummy; residence with 500 to 2,000 inhabitants</i>	0.8652	0.1285	21.17	<.0001
<b>city5000</b>	<i>dummy; residence with 2,000 to 5,000 inhabitants</i>	0.6974	0.1036	14.46	<.0001
<b>city10k</b>	<i>dummy; residence with 5,000 to 10,000 inhabitants</i>	0.5010	0.0744	8.93	<.0001
<b>city50k</b>	<i>dummy; residence with 10,000 to 50,000 inhabitants</i>	0.5259	0.0781	15.18	<.0001
<b>city100k</b>	<i>dummy; residence with 50,000 to 100,000 inhabitants</i>	0.2760	0.0410	7.05	<.0001
<b>N. obs.</b>		43 674			
<b>LogLik</b>		-21 183			
<b>McFadden's LRI</b>		0.2625			
<b>Adjusted Estrella</b>		0.3294			
<b>AIC</b>		42 400			

# Distributional aspects

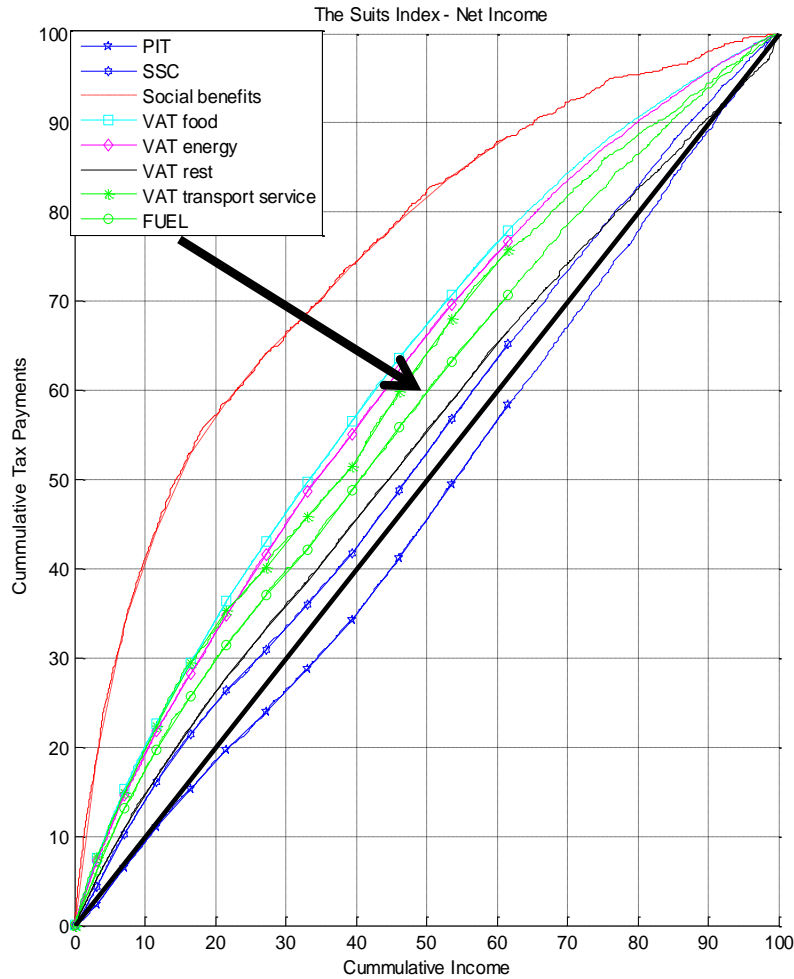
	car ownership,				fuel expenditures as % of income*			
	1993	1998	2003	2008	1993	1998	2003	2008
whole sample	0.53	0.56	0.62	0.61	5.35	4.45	4.41	4.22
decile 1	0.50	0.56	0.59	0.50	5.28	4.60	4.60	5.33
decile 2	0.38	0.45	0.57	0.51	5.08	4.34	5.16	4.38
decile 3	0.42	0.55	0.55	0.60	5.36	4.21	4.68	4.00
decile 4	0.44	0.48	0.57	0.57	5.49	4.62	4.37	4.36
decile 5	0.52	0.50	0.56	0.54	5.37	4.50	4.01	4.16
decile 6	0.54	0.60	0.60	0.65	5.58	4.63	4.46	3.93
decile 7	0.58	0.53	0.67	0.65	5.19	4.15	4.61	3.89
decile 8	0.61	0.64	0.69	0.67	5.31	4.92	4.29	4.55
decile 9	0.67	0.66	0.68	0.68	5.51	4.56	4.28	4.06
decile 10	0.65	0.62	0.68	0.70	5.25	3.96	3.79	3.81

	1995		2005	
	car-owner	fuel expenses as % of incomes*	car-owner	fuel expenses as % of incomes*
farmer_small	0.79	0.06	0.82	0.06
farmer_large	0.74	0.05	0.82	0.06
retired_small	0.34	0.05	0.48	0.05
retired_medium	0.28	0.05	0.44	0.05
retired_large	0.28	0.04	0.35	0.04
EA1_small	0.25	0.07	0.43	0.07
EA1+_small	0.62	0.07	0.82	0.07
EA2_small	0.69	0.07	0.84	0.07
EA2+_small	0.74	0.05	0.95	0.07
EA1_large	0.22	0.07	0.35	0.05
EA1+_large	0.46	0.05	0.65	0.05
EA2_large	0.68	0.05	0.83	0.05
EA2+_large	0.72	0.05	0.84	0.05

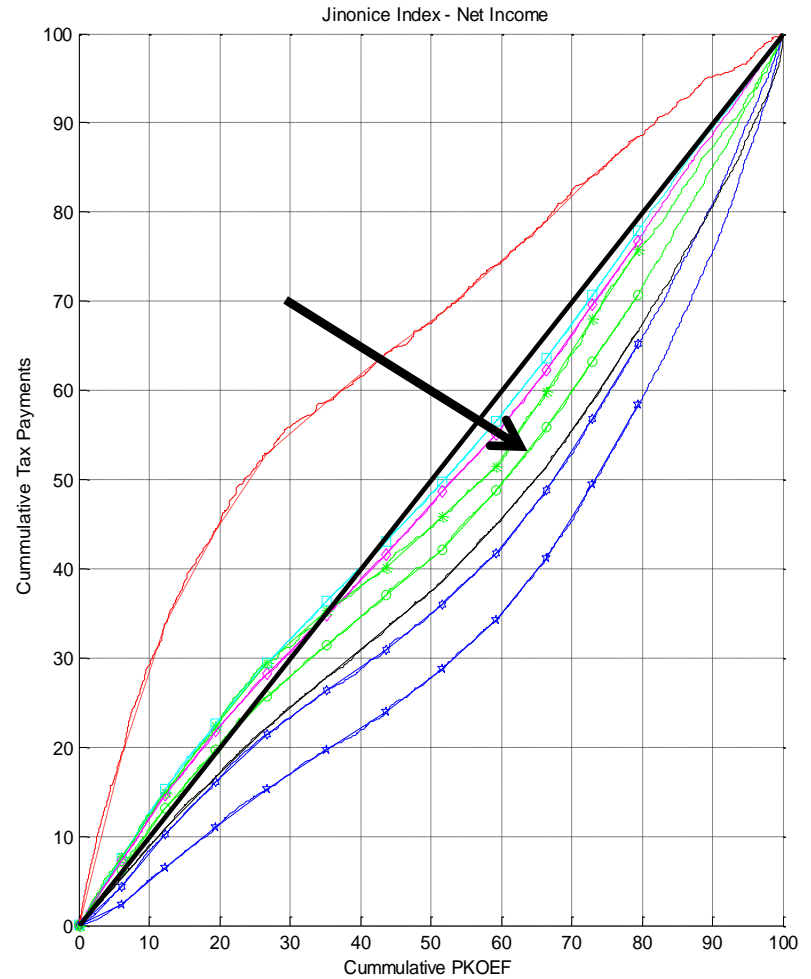
Note: \* Households with zero expenditures on fuel are excluded.

# Who is paying the fuel tax (and buying fuel)?

## Indicator measurement (Suits and Jinonice Index)

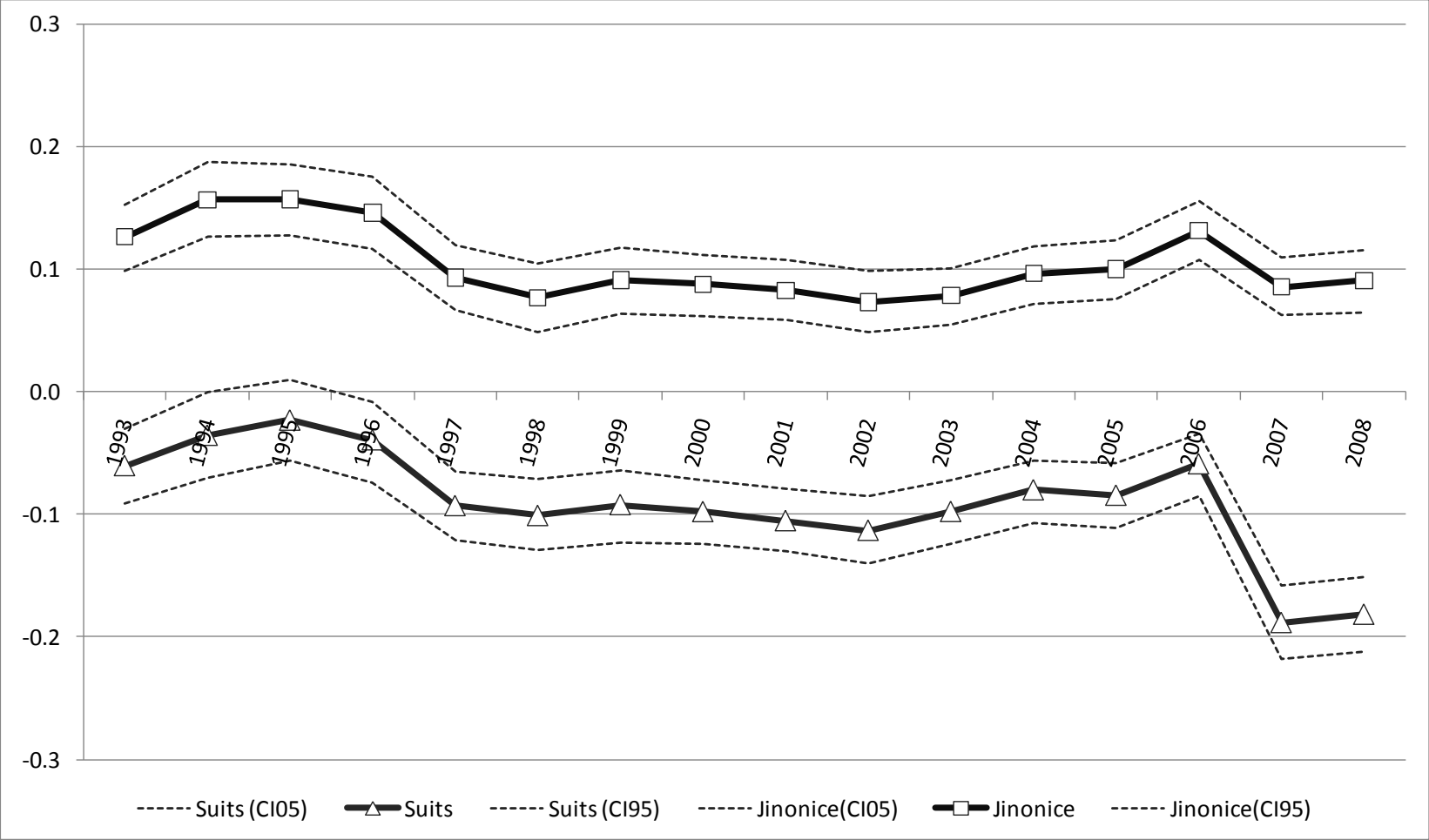


Diagonal in the Suits == flat-tax



Diagonal in the Jinonice == lump-sum tax

# Fuel Tax progresivity measurement (Suits & Jinonice Index)



# Some policy recommendations

Understand determinants of consumer demand for energy service

- target **the stand-by mode, cutting down heater, richer**
- **price** matters

Understand consumer's preferences for the stock of durable and its attributes

- target **tenant**, enhance demand for **efficient-durable** (e.g. car)
- familiarity with **labels**, but less often taken into account in purchases
- **richer** invest in efficient durable more, but also buys more appliances → does the efficient durable replaces the old one or increases the stock?
- **lower capital cost** –followed by **availability and easier identification** of efficient durable – is the most important motivating factors to reduce energy
- positive effect of **saving retrofits on saving activities**, but, when controlling for environmental concern, the correlation disappears → focus on rebound effect
- **environmental concern** matters as **environmental attitudes** do (for instance, EA affects negatively the number of durables but positively their first choice → target the first purchases

People are just different → examine the distribution of consumption, payments or policy impact

**Thank you for your attention**

# Distributional impact assessment

Policy affect different segments (households) differently because of

- differences in demand responsiveness → elasticities
- differences in consumer patterns (e.g. before-policy expenditures)

Incidence of tax-policy on households predicted by the DASMODO micro-simulation model

- What would be the effect on certain household segment if the price of fuel was 35 Kč per l (compared to 28.4 Kč in BAU-2008)
- Effect on consumption, expenditures, welfare, paid taxes etc.
- policy with revenue recycling via PIT cut from 15% to 14.22% in order to keep revenue-neutrality

<b>in CZK per year and household</b>	expenses on public transport	fuel expenses	fuel tax	fuel use (l)	paid labor taxes	Welfare	additional revenues from fuel taxation	net change in public revenues	DWL
<i>decile 1</i>	37	890	1 344	-36.7	-1 271	-604	1 198	168	435
<i>decile 2</i>	30	857	1 272	-33.6	-1 248	-506	1 132	121	385
<i>decile 3</i>	21	706	1 057	-28.4	-989	-475	941	140	335
<i>decile 4</i>	14	734	1 078	-27.8	-848	-625	958	271	353
<i>decile 5</i>	24	736	1 075	-27.3	-968	-494	954	170	324
<i>decile 6</i>	19	816	1 183	-29.7	-1 109	-495	1 050	152	343
<i>decile 7</i>	50	991	1 453	-37.4	-1 631	-355	1 289	-32	388
<i>decile 8</i>	64	1 053	1 551	-40.3	-1 958	-167	1 375	-211	378
<i>decile 9</i>	78	1 223	1 798	-46.5	-2 283	-181	1 594	-255	436
<i>decile 10</i>	102	1 359	2 005	-52.3	-2 838	87	1 776	-523	435
<i>farmer_small</i>	95	1 229	1 781	-44.7	-1 844	-570	1 575	81	489
<i>farmer_large</i>	34	2 873	3 035	-13.1	-1 882	-1 127	2 572	1 047	80
<i>retired_small</i>	4	607	837	-18.6	-30	-1 063	740	716	347
<i>retired_medium</i>	22	313	600	-23.2	-29	-928	548	524	404
<i>retired_large</i>	-20	354	488	-10.8	-29	-607	434	410	197
<i>EA1_small</i>	53	624	1 000	-30.4	-1 046	-405	894	47	358
<i>EA1+_small</i>	8	1 178	1 793	-49.7	-1 323	-1 192	1 604	532	660
<i>EA2_small</i>	-81	1 480	2 249	-62.1	-2 501	-651	2 021	-4	655
<i>EA2+_small</i>	24	1 908	2 785	-70.9	-2 589	-1 205	2 478	381	825
<i>EA1_large</i>	49	936	1 394	-37.1	-1 610	-317	1 239	-65	382
<i>EA1+_large</i>	22	726	1 218	-39.7	-1 512	-299	1 099	-125	424
<i>EA2_large</i>	98	1 367	1 974	-49.0	-2 698	32	1 743	-442	411
<i>EA2+_large</i>	92	1 586	2 239	-52.7	-2 930	-43	1 974	-399	442
Entire population bln. CZK or mil. litres	0.18	3.93	5.80	-151.2	-6.36	-1.60	5.15	0.00	1.60

# Green vs. brown electricity ?

- no quantitative information on renewable energy demand
- ***“Does your household take special measures to buy renewable energy from your electricity provider?”***
  - 16% Yes 4%, 43%
  - 67% No 43%, 85%
  - 17% Don't know 8%, 27%
- ***“What is the maximum percentage increase on your annual bill you are WTP to use only renewable energy? Please assume that your energy consumption remains constant.”***
  - WTP=0 20%, 64%
  - mean 4.9% to 8.9%
  - median 3.4% to 6.2%

Source: Read more in Kriström (2009)