

**Household Behaviour and Environmental Policy**  
**Residential Energy Efficiency**

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# Energy consumption

- Energy demand is a derived demand
  - energy is combined with durable goods to produce service
- Determinants of energy consumption
  - Stock of appliances
  - Quality of appliances (i.e. efficiency)
  - Frequency and duration of their use



## Research questions

- Counts of electric appliances – as a proxy of electric consumption - and their determinants
- Performance of energy savings through habitual behaviour or installations of energy saving durables
- Factors to reduce energy consumption



## Electric appliances and energy consumption

- Electricity consumption rises with the stock of appliances (Halvorsen and Larsen 2001)
- Almost all efficiency gains during 1990-2005 had been offset by an increase in equipment ownership (Odyssee Project)
- Faster increase since 2000 due to spreading of (WEC 2008)
  - new appliances (ICT's such as PC, IT, TV)
  - new devices (stand-by modes)
  - new end-uses (e.g. AC's)



## Probability of possession of household appliances

	OECD (10)	AUS	CAN	CZE	FRA	IT	KOR	MEX	NL	NOR	SWE
AC-heat											
Wash. mach	0.89	0.90	0.85	<b>0.97</b>	0.89	0.95	<b>0.97</b>	0.85	0.94	0.93	0.62
Dryer	0.29	0.57	<b>0.74</b>	0.03	0.38	0.08	0.10	0.23	0.63	0.05	0.09
Dish Wash	0.47	0.44	0.58	0.28	0.59	0.55	0.20	0.04	0.53	<b>0.82</b>	0.54
Fridge	0.98	<b>0.99</b>	0.98	<b>0.99</b>	0.98	0.95	0.98	<b>0.99</b>	0.98	0.97	0.96
Freezer	0.41	0.43	0.58	0.31	0.54	0.35	0.27	0.03	0.50	<b>0.69</b>	0.42
Oven	0.78	0.94	0.93	0.76	0.88	0.86	0.37	0.34	0.68	<b>0.98</b>	0.96
Microwave	0.85	0.93	<b>0.95</b>	0.88	0.92	0.61	0.87	0.83	0.92	0.80	0.92
Heater	0.39	0.51	0.45	0.45	0.44	0.16	0.31	0.10	0.17	<b>0.80</b>	0.65
AC	0.29	<b>0.67</b>	0.47	0.03	0.09	0.42	0.61	0.28	0.05	0.12	0.07
TV	0.97	<b>0.99</b>	0.98	0.97	0.97	0.91	0.96	<b>0.99</b>	0.98	0.97	0.96
Settop	0.37	0.39	0.18	0.24	0.51	0.53	0.15	0.17	0.32	0.55	<b>0.58</b>
PC	0.96	0.97	<b>0.98</b>	0.96	0.97	0.91	0.96	0.89	<b>0.98</b>	<b>0.98</b>	0.97



# Average number of appliances per household

	OECD (10)	AUS	CAN	CZE	FRA	IT	KOR	MEX	NL	NOR	SWE
Fridge	1.19	<b>1.40</b>	1.24	1.11	1.20	1.10	1.28	1.11	1.22	1.22	1.03
Freezer	0.49	0.50	0.65	0.36	0.61	0.40	0.32	0.03	0.56	<b>0.87</b>	0.53
TV	2.03	<b>2.30</b>	<b>2.26</b>	1.80	1.87	<b>2.23</b>	1.56	<b>2.61</b>	1.88	1.81	1.80
Settop	0.50	0.53	0.31	0.30	0.63	<b>0.71</b>	0.17	0.27	0.37	<b>0.70</b>	<b>0.84</b>
PC	1.62	<b>1.69</b>	<b>1.71</b>	1.42	1.49	1.49	1.41	1.43	1.61	<b>2.16</b>	<b>1.73</b>
AC	0.42	<b>0.99</b>	0.55	0.03	0.13	<b>0.75</b>	<b>0.73</b>	0.55	0.06	0.13	0.08



## Probability of owning an appliance (Logit)

	Fridge	Freezer	TV	Set-top box	PC	AC
<b>Reference country</b> (country dummies omitted)	CZE	NOR	MEX	SWE	NOR	AUS
<b>Age</b>	+	+	+	+	+	+
<b>University</b>	-	-	-			
<b>INCOME_CONT2</b>				+		+
<b>Adults</b>		+		+		
<b>Children</b>	-	+				+
<b>Flatowner</b>		+		+	+	+
<b>Flat_50</b>	-	-	-	-	-	-
<b>Flat150_</b>		+		+		+
<b>Metro</b>	+	-				+
<b>Inhouse_2</b>		-			-	
<b>ENVATTID_INDX</b>	+				+	
<b>ENVCNCRN_INDX</b>	+	+	+		+	
<b>ENVPURCH_INDX</b>	+	+	+		+	



# Number of appliances possessed (Poisson)

	Fridge	Freezer	TV	Set-top box	PC	AC
<b>Reference country</b> (country dummies omitted)	CZE	NOR	MEX	SWE	NOR	AUS
<b>Age</b>	+	+				
<b>University</b>			-	-	+	+
<b>INCOME_CONT2</b>	+		+	+	+	
<b>Adults</b>	+	+	+	+	+	+
<b>Children</b>	+		+	+	+	
<b>Flatowner</b>	+	+	+	+		
<b>Flat_50</b>			-		-	
<b>Flat150_</b>	+	+	+	+	+	+
<b>Metro</b>	-	-			+	
<b>Inhouse_2</b>	-	-	-			
<b>ENVATTID_INDX</b>	-		-	-		-
<b>ENVCNCRN_INDX</b>	-		-		-	+
<b>ENVPURCH_INDX</b>			-			



## Policy implications: possession of household appliances

- Significant differences between the 10 countries (possibly cultural and climatic conditions)
- Effect of the structure of households and situation of dwellings – difficult to influence
- Socio-psychological variables (pro-environmental attitudes, concerns, preference) have mixed effect
  - Positive (presence) and negative (number of appliances)
- Policy should target segments of population with highest probability of owning appliances or with highest number of appliances



# Energy conservation behavior

- Habitual behavior
  - everyday reductions in energy use
  - minimal structural adjustments
  - easily reversible
  - cheap but time consuming
- Purchasing activities
  - technology choices or purchase-related behavior
  - retrofitting of homes to achieve permanent savings
  - involve higher costs at the moment of their purchase



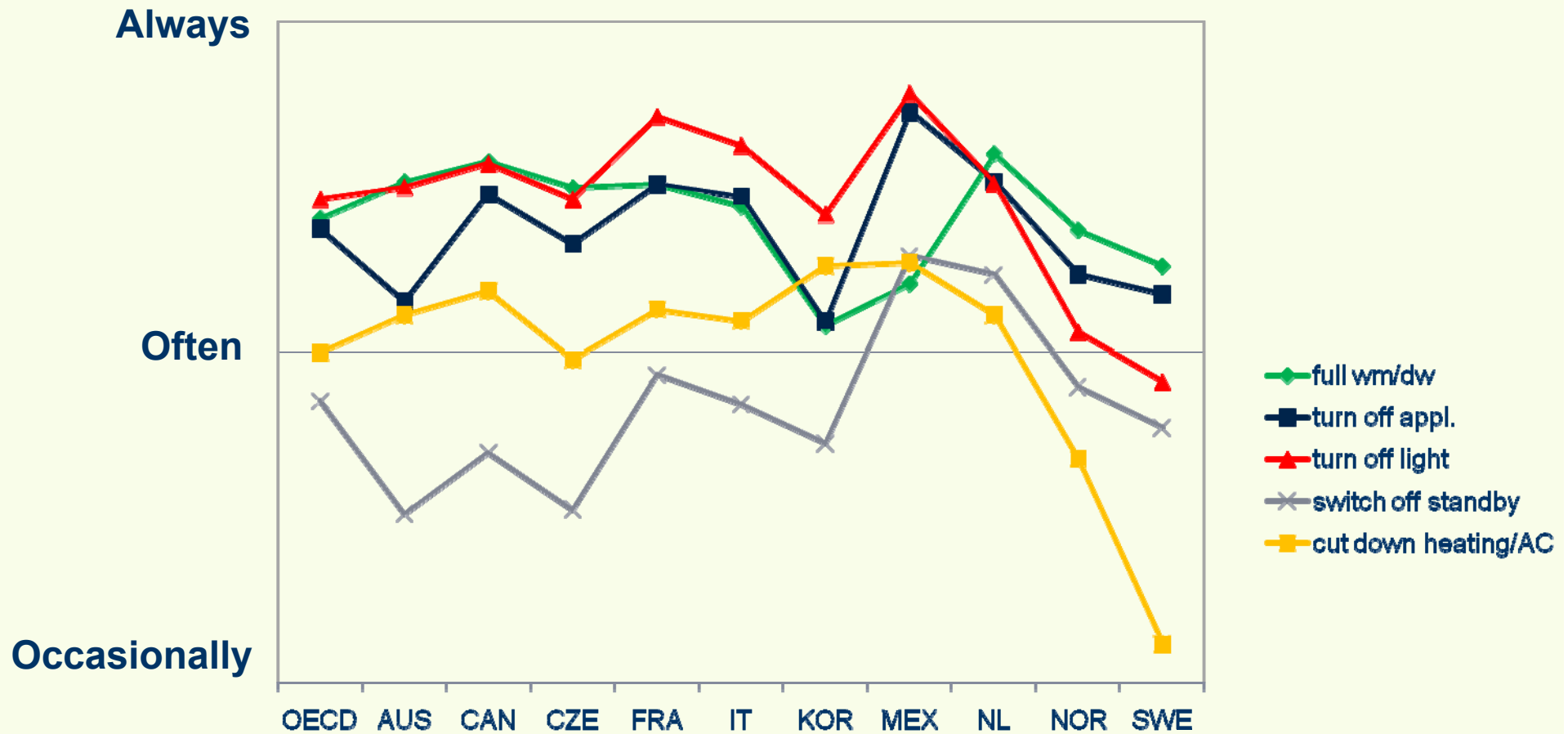
## Energy saving activities: 'habitual behaviour'

How often do you perform following energy-saving activities

- turn off light when leaving a room
- cut down on heating/AC
- wait until washing machine/ dishwasher is full loaded
- turn off appliances not used
- switch off standby mode



# Energy saving activities



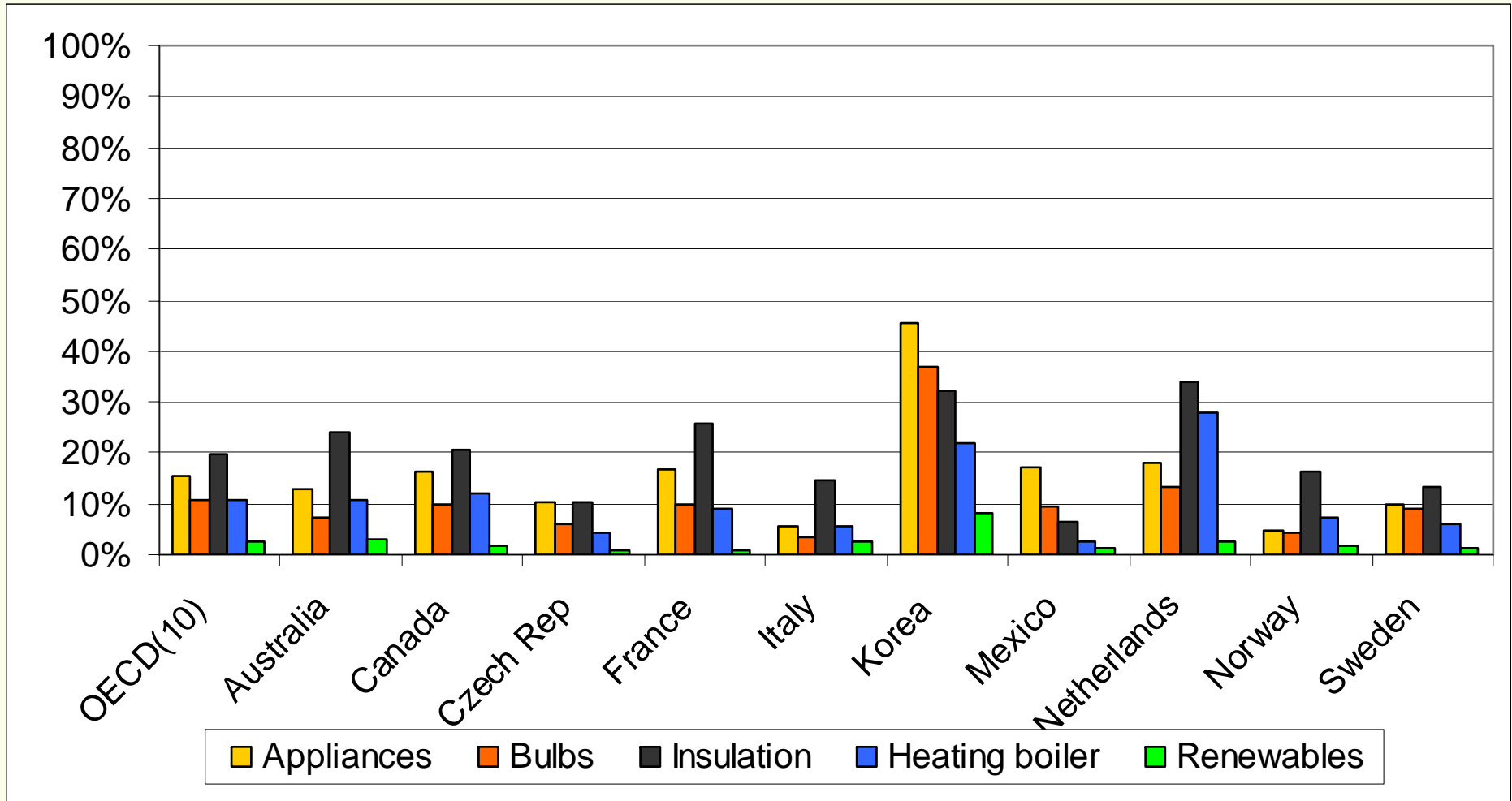


# Determinants of energy saving activities (ordinal logit)

	Turn off lights	Cut down heating/AC	Full load wm/ dw	Turn off appl.	Switch off standby
<b>Reference country</b> (country dummies omitted)	<b>MEX</b>	<b>MEX</b>	<b>MEX</b>	<b>MEX</b>	<b>NLD</b>
<b>Male</b>		-	-	-	-
<b>Age</b>	<b>+/-</b>	<b>+/-</b>	<b>+/-</b>	<b>+/-</b>	
<b>University</b>	-				
<b>Income</b>	-	-	-	-	-
<b>Metro</b>		-	-		-
<b>ENVATTID_IND</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	
<b>ENVCNCRN_IND</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>
<b>ENVPURCH_IND</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>
<b>Payelect</b>	<b>+</b>	<b>+</b>	<b>+</b>		
<b>Payperiod</b>	-		-		<b>+</b>



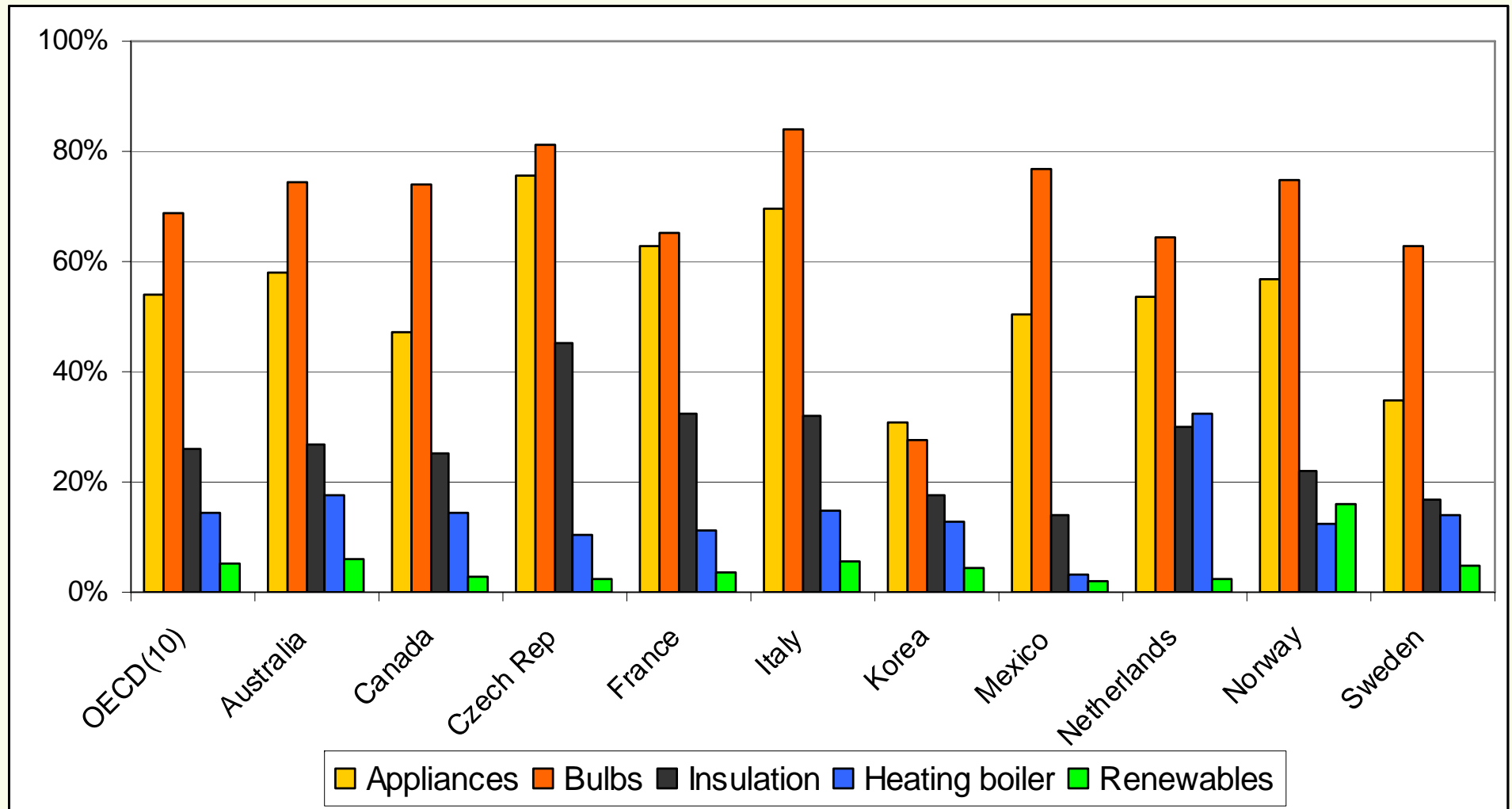
# Energy saving installations the households already equipped with...





# Energy saving installations

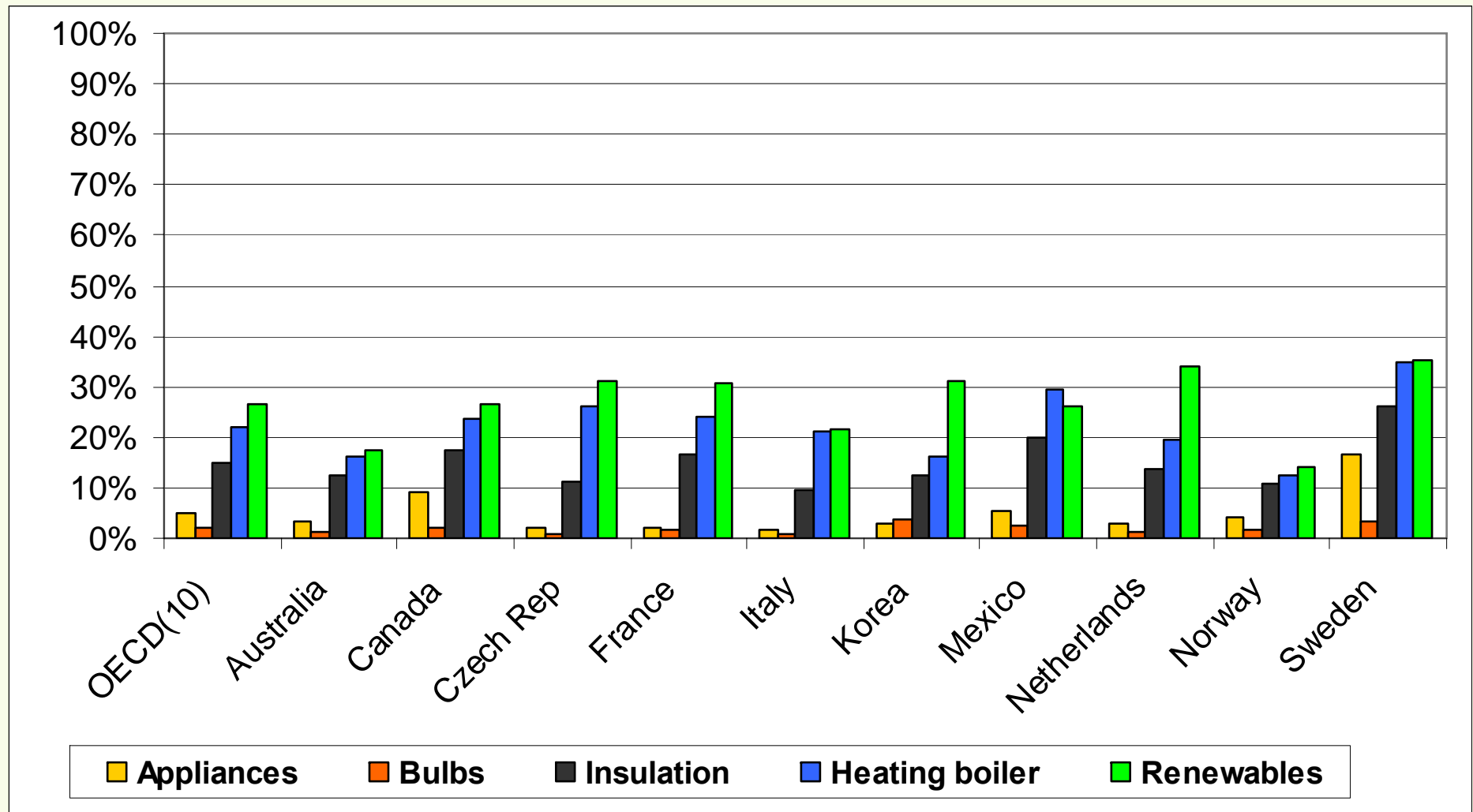
the households which installed efficient durable





# Energy saving installations

the households in that it has not been possible to install saving durables





# Energy saving installations

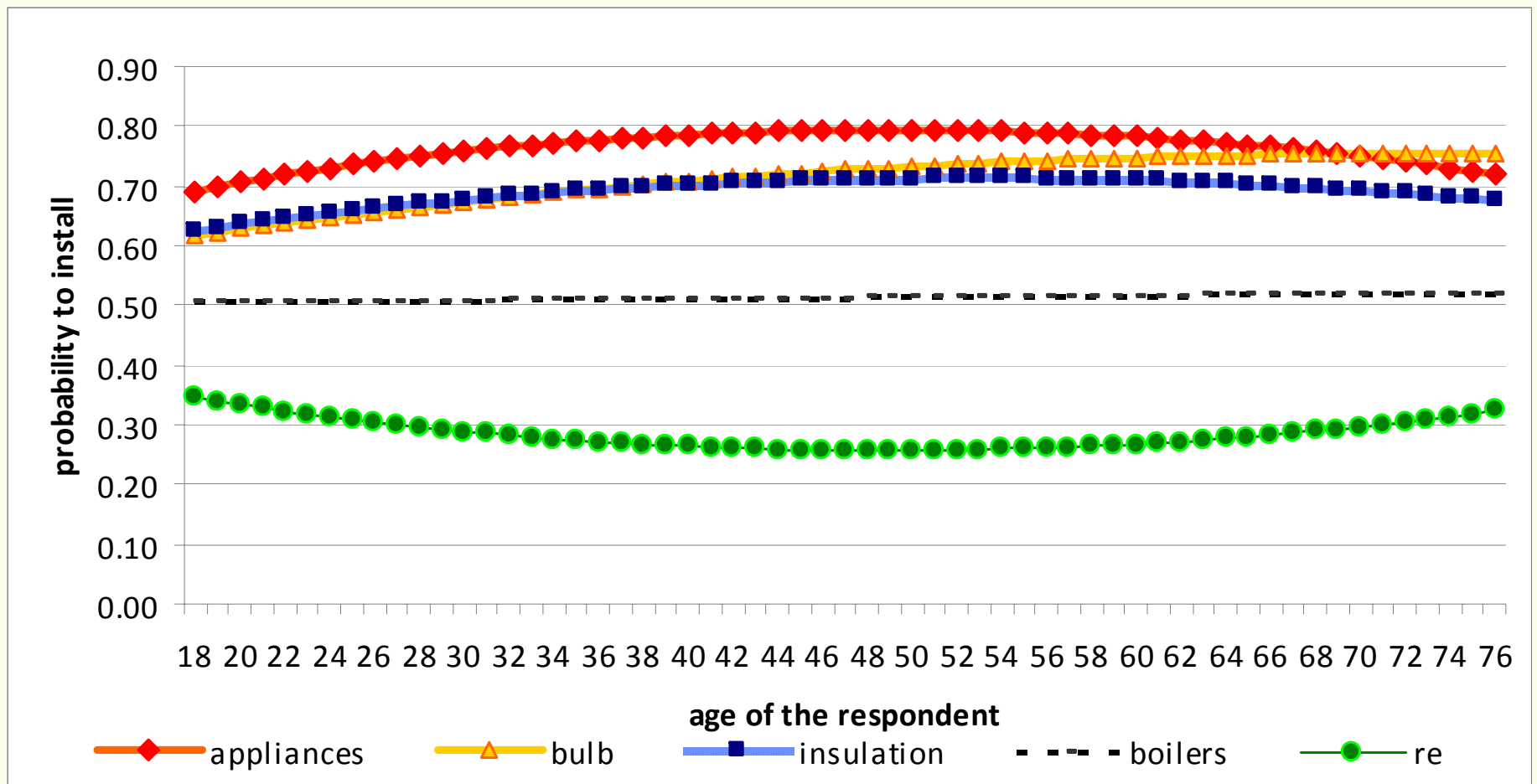
the households which installed saving durable

	Appliances	Bulbs	Thermal Insulation	Heating boiler	Re_energy
Reference country (country dummies omitted)	CZE	ITA	CZE	NL	NOR
Male					+
University			-		
income	+		+	+	
Flat owner	+	+	+	+	+
Inhouse 2years	-	-	-	-	-
Built 5less	+		+	+	+
Rooms	+	+	+		
metro		-	-	-	-
ENV ATTID_IND	+	+		-	-
ENV CNCRN_IND		+	+		
ENV PURCH_IND	+	+	+	+	+



# Energy saving installations

the households which installed saving durable





# Energy saving installations

## the households that installed saving durables

	Appliances	Bulbs	Thermal Insulation	Heating boiler	Re_energy
<b>Knew label</b>	<b>+</b>	<b>+</b>			
<b>Considered label</b>	<b>+</b>	<b>+</b>	<b>+</b>		<b>+</b>
<b>Pay_electricity</b>	<b>+</b>	<b>+</b>			<b>-</b>
<b>Price_varried</b>				<b>+</b>	<b>+</b>
<b>Only electricity</b>	<b>-</b>	<b>-</b>	<b>-</b>		
<b>District_Heating</b>				<b>-</b>	<b>-</b>



# Policy implications determinants of energy-saving behaviour

- Significant differences between reported frequency of energy-saving activities
  - Switching off standby and cutting down heating/ AC are least frequent
  - More expensive saving durables are least frequent
  - Factors that are otherwise significant determinants of habitual behaviour have no effect on switching stand-by mode
  - Flat ownership is always important for saving durable installations
- Policy intervention
  - target specific segments of population
    - younger and elderly, people living in metropolitan areas
    - Habitual behavior: males, wealthier
    - Installations: females, poorer, tenants, living in smaller flats or shorter time
  - Influencing attitudes, concerns, preferences, or knowledge about labels (but general education seems to have no effect)
  - Energy metering is an efficient tool



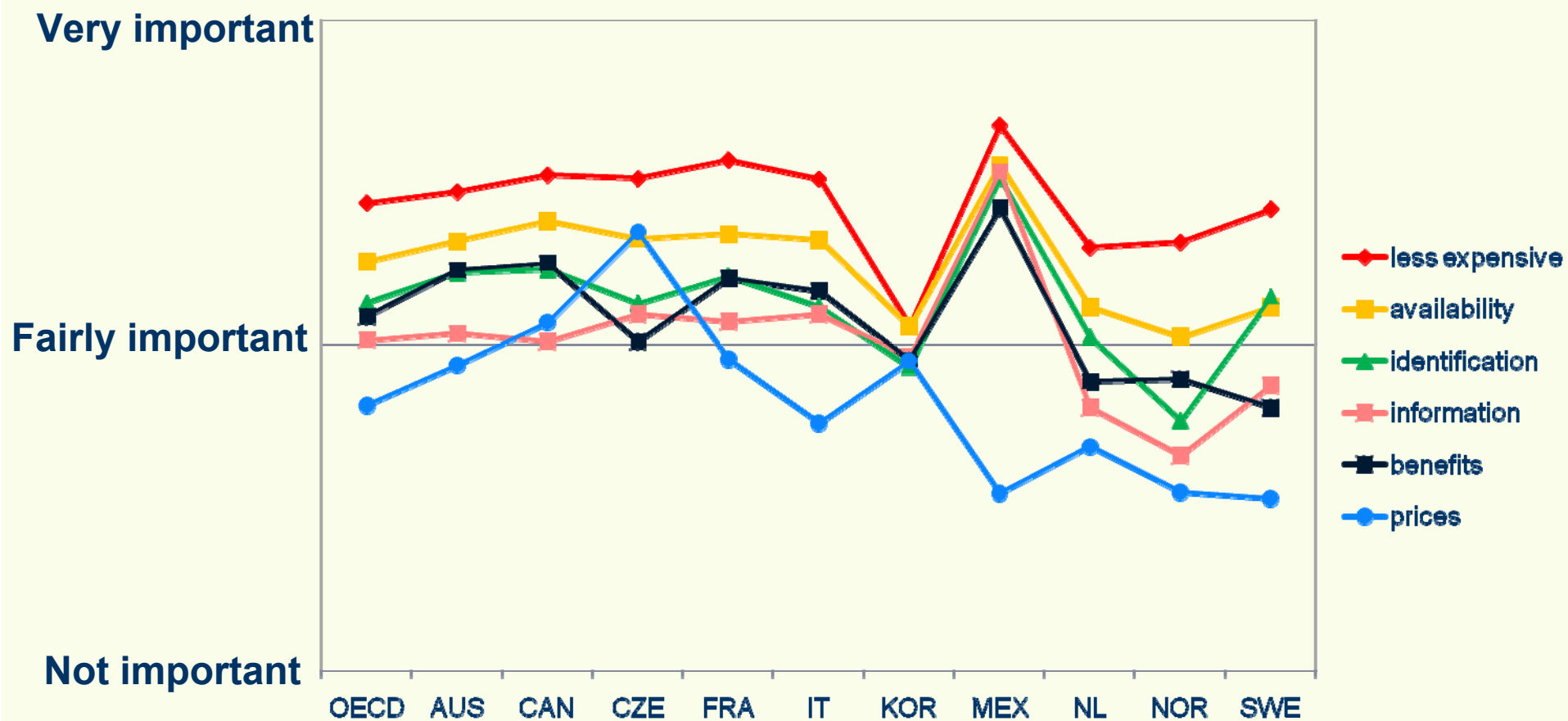
# Factors of energy saving

## Rating of importance of factors of reduction of energy consumption

- More practical information on energy conservation measures
- Higher energy prices
- Beliefs about significance of environmental benefits
- Greater availability of energy-efficient products
- Easier identification of energy efficient labels
- Less expensive to invest in energy-efficient equipment



# Factors of energy saving





## Determinants of importance of energy saving factors

	Info	Prices	Envi Benefit	Availability	Identif Labels	Cheaper Invest
<b>Reference country</b> (country dummies omitted)	<b>MEX</b>	<b>CZE</b>	<b>MEX</b>	<b>MEX</b>	<b>MEX</b>	<b>MEX</b>
<b>female</b>	<b>+</b>	<b>+</b>	<b>+</b>		<b>-</b>	
<b>age</b>	<b>+/-</b>	<b>+/-</b>	<b>+/-</b>	<b>+/-</b>	<b>+/-</b>	<b>+/-</b>
<b>University</b>					<b>-</b>	
<b>Income</b>	<b>-</b>	<b>-</b>		<b>-</b>	<b>-</b>	
<b>metro</b>	<b>+</b>		<b>+</b>	<b>+</b>	<b>+</b>	
<b>ENVATTID_INDX</b>	<b>+</b>		<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>
<b>ENVCNCRN_INDX</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>
<b>ENVPURCH_INDX</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>
<b>payelect</b>	<b>+</b>			<b>+</b>	<b>+</b>	<b>+</b>



## Policy implications: importance of energy-saving factors

- Similar patterns of influence among factors, i.e. synergic effect
- Significant differences between countries (possibly cultural differences in rating of factors – viz Mexico)
- Cheaper energy-saving installations
  - Price of energy rated as the least important
  - Cheaper investments in energy-saving installations rated as the most important
- Target those segments of population that are more sensitive to the factors: aged, females, people in metropolitan areas, people with lower incomes
- Proenvironmental attitudes, concerns, and preferences heighten sensitivity
- Energy metering heightens sensitivity



## Too High 'Implicit' Discount Rates?

- Decision dominated by immediate costs of investment, while savings might be underestimated
  - Possible explanations:
    - imperfectly formed preferences → informing consumer, availability technologies (#2), ability to evaluate consequences
    - uncertainty of future saving
    - home ownership, ...
- In same vein, only 30% of households considered **energy costs** while deciding about housing
  - 47% in CZE, 41% CAN, 37% in KOR and MEX, but 22% in NOR and 19% in NL and AUS
  - More likely by **older and poorer** people with **university education**, and **flat owners**



# Conclusions /1/

- Pricing
  - energy metering
    - positively affects frequency of energy-saving activities
    - Increases importance of other factors of energy-saving
    - Positively affects investments into energy-saving durables
  - energy pricing according to day-time
    - Mostly negative effect on frequency of energy-saving activities
  
- Educational/ information campaigns (influencing attitudes, concerns, and preferences)
  - positively affects frequency of energy-saving activities
  - negatively affects stock of appliances
  - positively affects probability of introducing appliances
  - Increases sensitivity to importance of other factors of energy-saving
  
- Focus on tenant
  - Less likely to perform energy-saving activities as well as install saving durables
  - neither tenant, or owner of the flat do not have incentive to invest in saving durables – to enhance split-incentive mechanism



## Conclusions /2/

- Increase in wealth
  - Increase in stock of appliances
  - Increase in stock of energy-saving durables
  - Lower frequency of energy-saving activities
  - Less sensitive to all energy-saving factors (won't save energy)
  
- Aging of population
  - Increase in stock of appliances
  - Investing more in energy-saving durables
  - More sensitive to energy-saving factors
  - Energy-saving activities more frequent
  
- Educated population
  - Stock of appliances (?)
  - Energy-saving activities (?)
  - Importance of energy-saving factors (?)
  - Investment into energy-saving durables (?)