Overraskende endringer i husholdningenes energiforbruk

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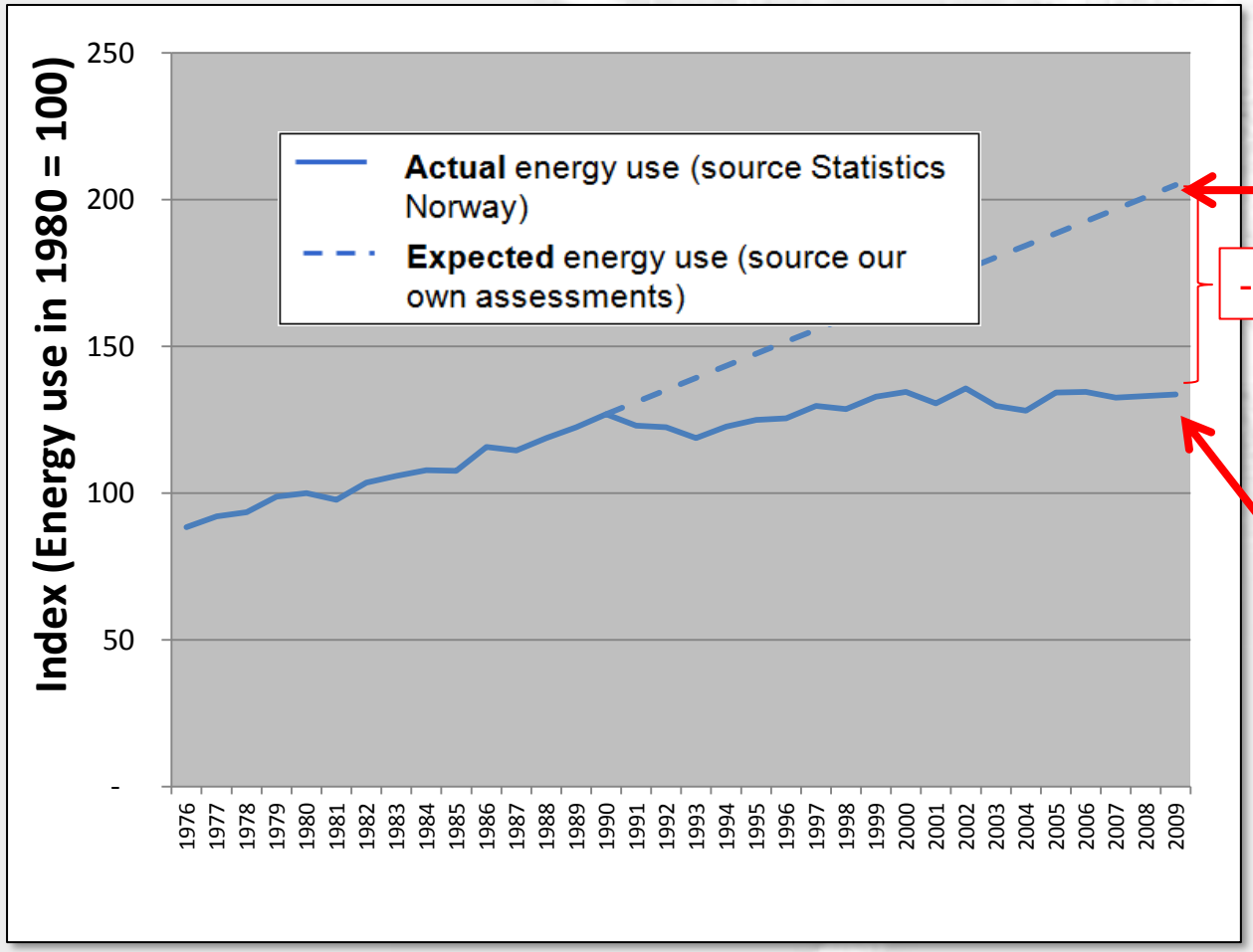
Outline

- The case
- An energy and climate policy context
- Methodological approach
- Results
- Some final reflections on the way ahead

The case



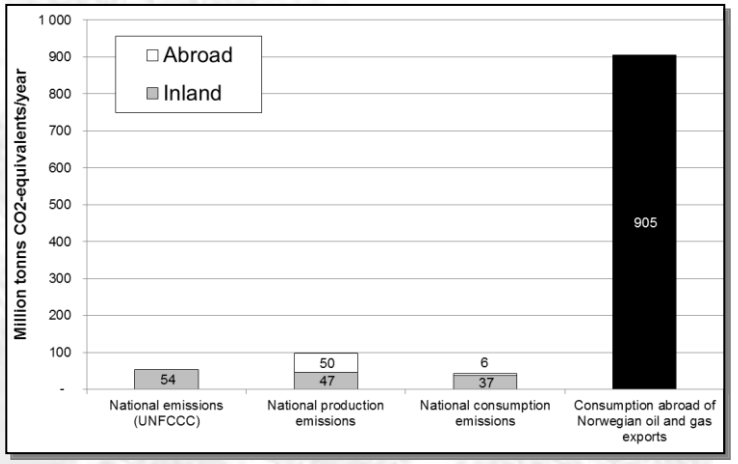
Assessments made by the Norwegian Water Resources and Energy Directorate (NVE) in **1990** (and **1998**) concluded that household energy-use would continue to increase at the same rate as from 1976 to1990

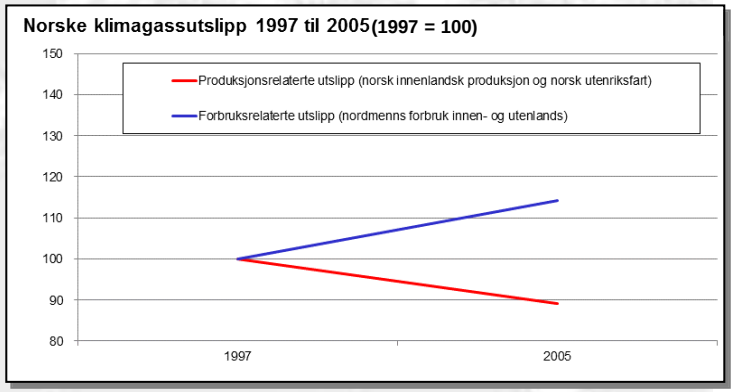
In **2011** NVE commissioned a study to explain why this had happened (19 % lower energy-use in 2009 than what was expected)

The energy and climate policy context

- **Norwegian energy policy**
  - Increasingly borrowing political credibility from climate policy
  - Strong focus on introducing CCS technologies in Norwegian oil- and gas production
  - Also focus on increasing the capacity of producing renewable energy

- **Norwegian climate policy**
  - Strong disputes on how much of the mitigation efforts should be done abroad and inland
  - GHG emissions relating to Norwegian inland production have fallen whereas emissions embedded in Norwegian private consumption are increasing





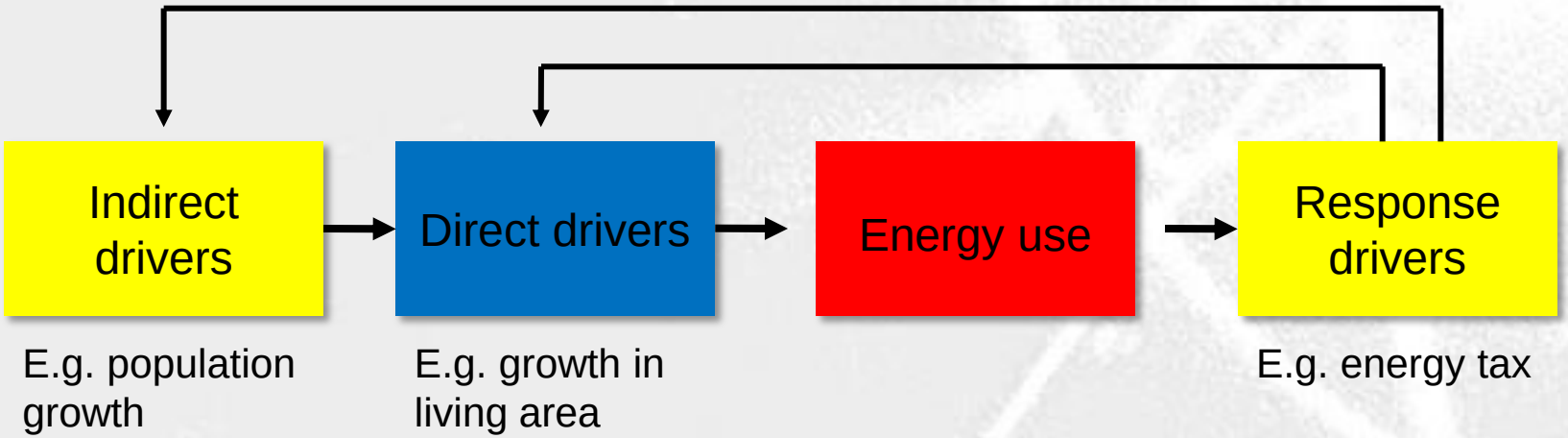
Still – some policies have been implemented on reducing energy-use and GHG emissions in Norwegian households

- Information from Enova
- Energy-labelling of electric appliances
- Time limited (2002/03) economic support for installing air-to-air heat pumps
- Tax on oil
- Tax on electricity
- Step-by-step increasingly more stringent building regulations

Methods applied

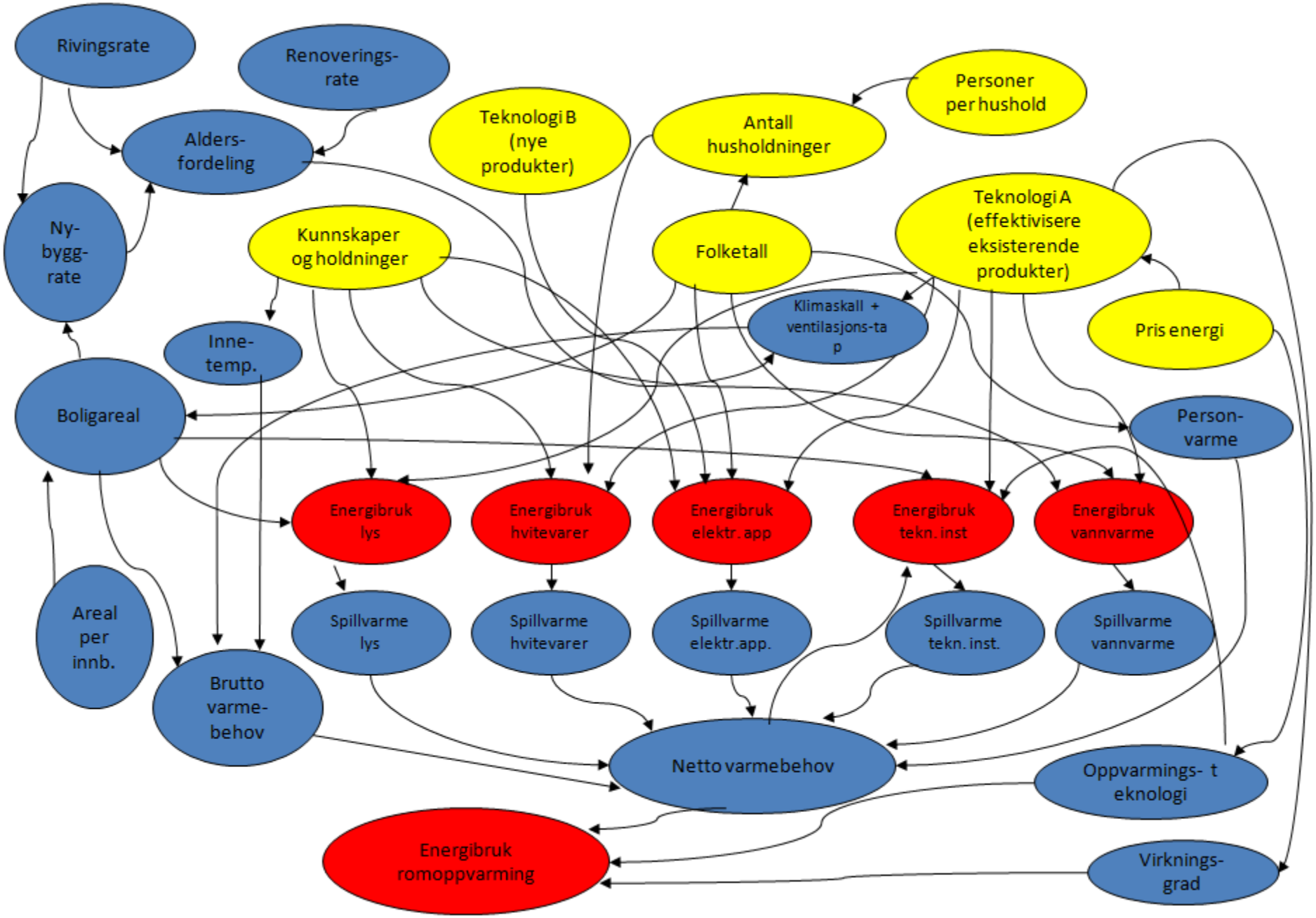
- **Literature review**
  - Going through existing Norwegian energy consumption statistics (NVE, SSB) and relevant “single” studies on energy consumption (10 studies identified)
  - Supplemented by going through relevant statistics and studies from Sweden (6 studies identified) and Denmark (5 studies identified)
- **Model development**
  1. Established a causal model
  2. Established a calculation model
  3. Create a proxy historical dataset by means of interpolation
  4. Create a scenario model

1) The general causal model

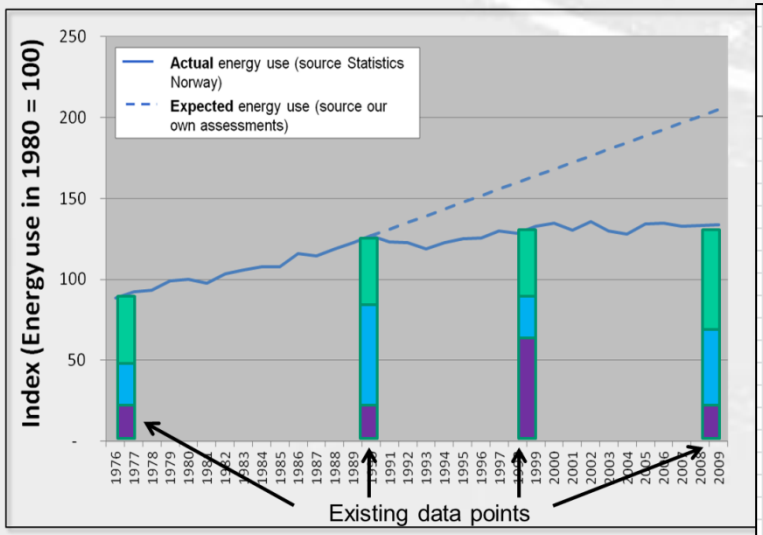


1) The specific casual model

Indirect drivers	Direct drivers	Response drivers
• Changes in environmental conditions (mainly outdoor temperature) • Demographic changes • Economic considerations • Technological development • Changes as to knowledge, attitude and preference	• Living area • The distribution of dwellings and living area according to types of building • The condition of the building envelope • Indoor temperature • Water heating specific energy consumption • Energy consumption relating to lighting and electrical equipment • Choice of heating system • Heat pumps	• Information • Taxation • Regulations • Economic support


Rivingsrate
Renoverings-rate
Alders-fordeling
Ny-bygg-rate
Teknologi B (nye produkter)
Antall husholdninger
Personer per hushold
Kunnskaper og holdninger
Folketall
Teknologi A (effektivisere eksisterende produkter)
Klimaskall + ventilasjons-tap
Pris energi
Inne-temp.
Boligareal
Person-varme
Energibruk lys
Energibruk hvitevarer
Energibruk elektr. app
Energibruk tekn. inst
Energibruk vannvarme
Areal per innb.
Spillvarme lys
Spillvarme hvitevarer
Spillvarme elektr.app.
Spillvarme tekn. inst.
Spillvarme vannvarme
Brutto varme-behov
Netto varmebehov
Oppvarmings- teknologi
Energibruk romoppvarming
Virknings-grad

3) The proxy interpolated historical dataset

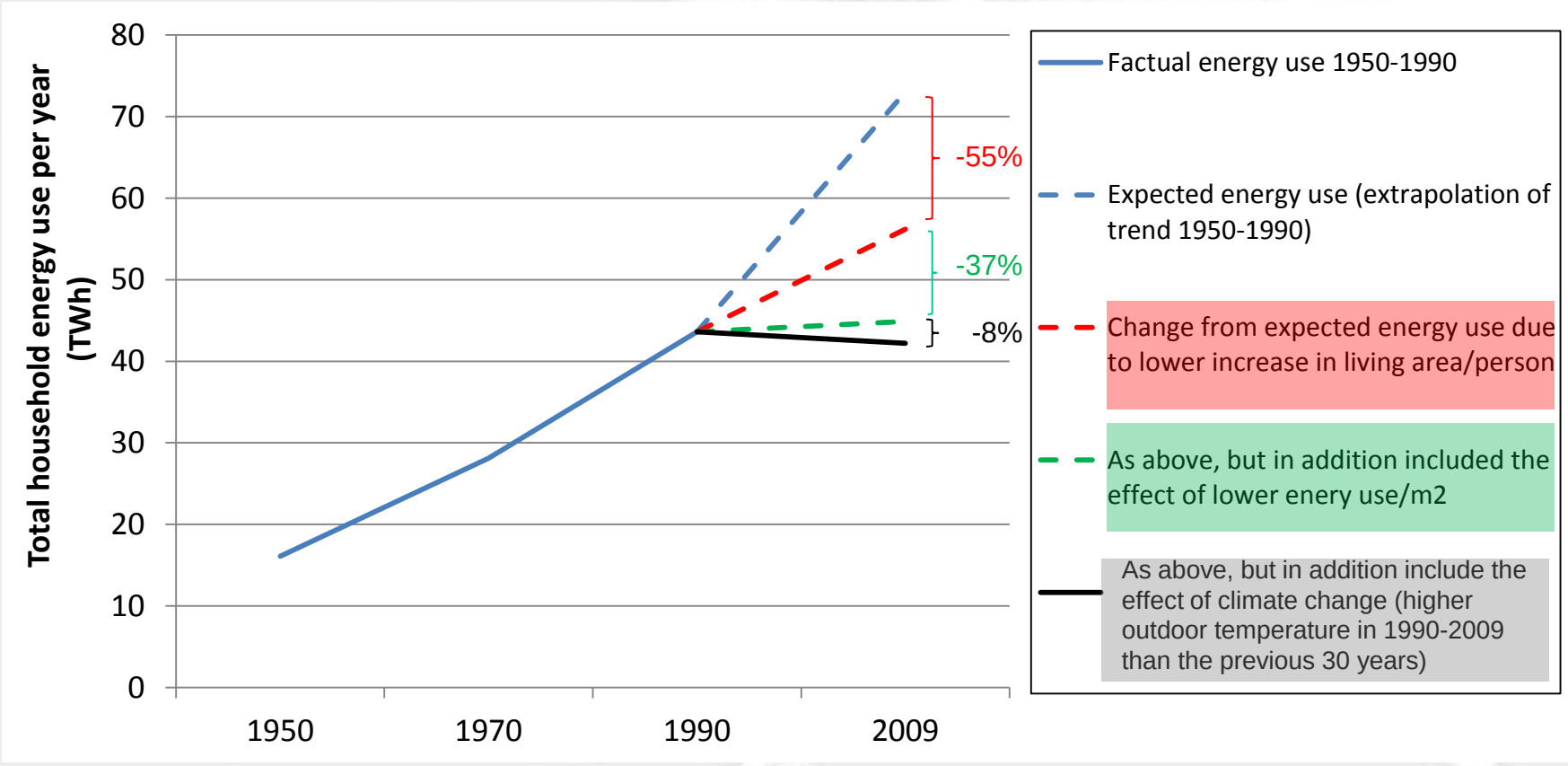


				Spesifikk energibruk kWh pr m2 pr år				Energibruk pr husholdning		
Årstall	Energibruk hus-holdninger TWh	Energibruk pr bolig kWh pr år	Energibruk kWh/m2 pr år	Enebolig, inkl. våningshus	Rekkehus, 2- og 4-mannsbolig	Leiligheter i blokk, nærings-bygg	Felles-funksjoner blokker kWh/m2 pr år	Enebolig, inkl. våningshus	Rekkehus, 2- og 4-mannsbolig	Leiligheter i blokk, nærings-bygg
1970	27,2	20 988	229	236	221	207	14,2	25 938	17 708	11 802
1971	28,0	21 225	229	236	222	207	14,4	26 083	18 100	11 922
1972	28,7	21 466	230	237	222	208	14,7	26 232	18 503	12 045
1973	29,5	21 709	231	238	223	208	14,9	26 385	18 918	12 171
1974	30,4	21 955	232	239	224	209	15,1	26 541	19 343	12 299
1975	31,2	22 204	233	240	225	210	15,3	26 702	19 780	12 430
1976	32,1	22 456	234	241	226	211	15,5	26 866	20 230	12 563
1977	33,0	22 710	235	242	227	212	15,7	27 034	20 691	12 700
1978	33,9	22 967	236	244	229	214	16,0	27 207	21 166	12 839
1979	34,8	23 228	238	245	230	215	16,2	27 383	21 654	12 982
1980	35,8	23 491	240	247	232	216	16,4	27 563	22 155	13 127
1981	36,5	23 645	236	243	228	213	16,7	27 856	22 025	13 202
1982	37,2	23 801	233	240	225	210	16,9	28 153	21 895	13 277
1983	38,0	23 958	230	237	222	207	17,2	28 452	21 767	13 354
1984	38,7	24 115	227	234	219	205	17,4	28 755	21 640	13 430
1985	39,5	24 274	225	231	217	203	17,7	29 062	21 513	13 508
1986	40,3	24 434	222	229	215	201	17,9	29 372	21 387	13 585
1987	41,1	24 594	220	227	213	199	18,2	29 686	21 263	13 664
1988	41,9	24 756	218	225	211	197	18,5	30 003	21 139	13 743
1989	42,7	24 919	217	223	210	196	18,7	30 324	21 016	13 822
1990	43,6	25 083	215	222	208	194	19,0	30 649	20 894	13 902
1991	43,7	24 855	213	219	206	192	19,3	30 487	20 729	13 652
1992	43,7	24 629	211	217	204	190	19,6	30 327	20 565	13 409
1993	43,8	24 405	208	215	201	188	19,8	30 168	20 403	13 174
1994	43,8	24 183	206	212	199	186	20,1	30 011	20 242	12 947
1995	43,9	23 963	204	210	197	184	20,4	29 855	20 083	12 727
1996	43,9	23 745	202	208	195	182	20,7	29 701	19 925	12 514
1997	44,0	23 529	200	206	193	180	21,0	29 549	19 768	12 307
1998	44,0	23 315	198	204	191	178	21,3	29 398	19 613	12 106
1999	44,1	23 103	196	202	189	177	21,6	29 249	19 459	11 911
2000	44,1	22 893	194	200	187	175	22,0	29 101	19 306	11 722
2001	44,2	22 685	192	198	185	173	22,3	28 954	19 155	11 539
2002	44,3	22 440	189	195	183	171	22,6	28 667	19 039	11 449
2003	44,4	22 197	187	193	181	169	22,9	28 383	18 923	11 363
2004	44,5	21 958	185	190	178	167	23,3	28 103	18 809	11 280
2005	44,5	21 720	182	188	176	165	23,6	27 827	18 695	11 199
2006	44,6	21 486	180	186	174	163	23,9	27 553	18 582	11 121
2007	44,7	21 253	178	184	172	161	24,3	27 284	18 470	11 045
2008	44,8	21 024	176	181	170	159	24,6	27 017	18 359	10 972
2009	44,9	20 797	174	179	168	157	25,0	26 754	18 248	10 901

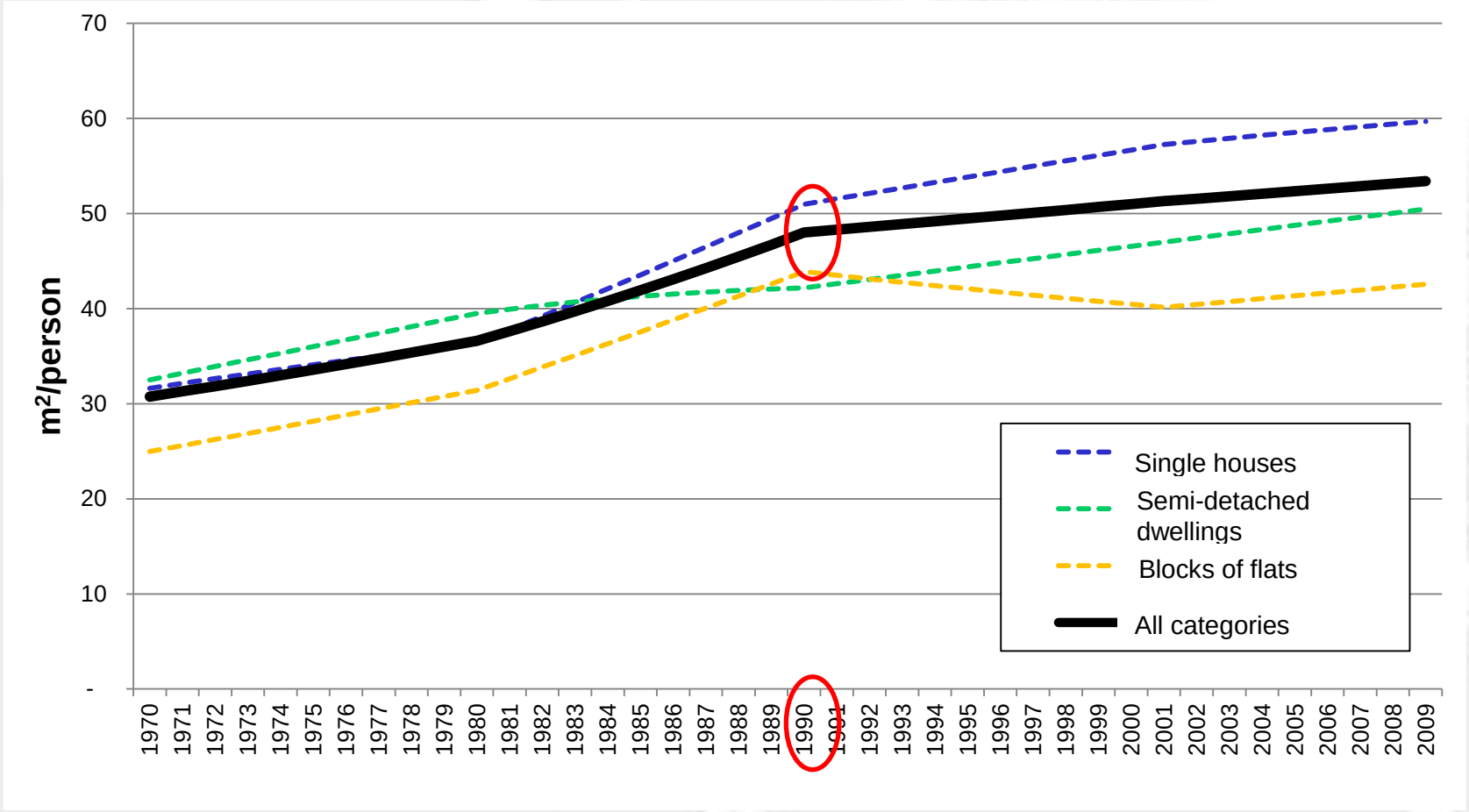
3) The scenario model

				Trinn 1	
	Formål	Verdi 2009		Til år	Årlig vekst
Areal	Areal pr person	53,8	Lineær	2 030	0,5 %
	Rivingsrate	0,1 %	Lineær	2 030	0,0 %
Boliger	Person pr hushold	2,2	Eksponen	2 030	-0,2 %
Lys	kWh pr m2	8,0			
	Teknologi A	1,00	Eksponen	2 013	-15,0 %
	Spillvarmefaktor	60,0 %	Lineær	2 030	0,0 %
Hvitevarer	kWh pr m2	13,1			
	Teknologi A	1,00	Lineær	2 030	-1,5 %
	Teknologi B	1,00	Lineær	2 030	0,5 %
	Spillvarmefaktor	50,0 %	Eksponen	2 015	-5,0 %
Elektronikk	kWh pr m2	10,9			
	Teknologi A	1,00	Lineær	2 020	-3,0 %
	Teknologi B	1,00	Lineær	2 030	2,5 %
	Spillvarmefaktor	60,0 %	Lineær	2 015	-5,0 %
Vannoppvarming	kWh pr m2	25,1			
	Teknologi A	1,00	Eksponen	2 030	-0,5 %
Beredertap	kWh pr m2	6,7			
	Teknologi A	1,00	Eksponen	2 030	-1,5 %
Teknisk drift	kWh pr m2	14,5			
	Teknologi A	1,00	Eksponen	2 030	0,0 %
Fordeling areal	Enebolig, % areal	65,8 %	Lineær	2 030	0,0 %
	Rekkehus, % areal	18,7 %	Lineær	2 030	0,0 %
	Blokker, % areal	15,5 %	Lineær	2 030	0,0 %
Fordeling boliger	Enebolig, % boliger	52,7 %	Lineær	2 030	-3,0 %
	Rekkehus, % boliger	20,6 %	Eksponen	2 030	0,0 %
	Blokker, % boliger	26,7 %	Eksponen	2 030	3,0 %

Main categories of factors that can explain the levelling out of household energy use



Changes in living area per capita



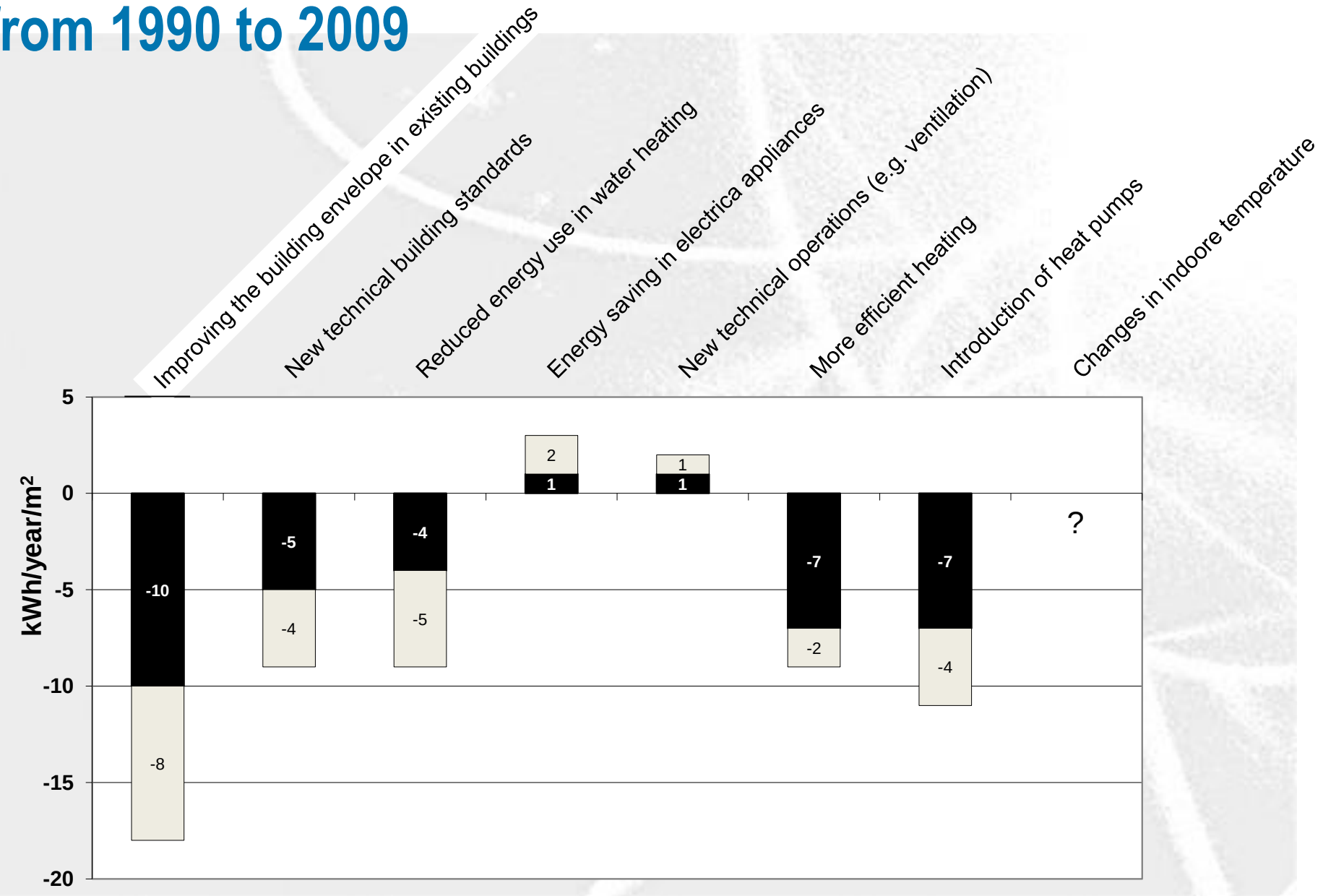
Reasons for a lower increase in living area per capita from 1990 to 2009

- **Increase in real-estate prices (especially in major cities) and real interest rates (for the whole of Norway)**
  - In 2009 we inhabited an area per capita that was 2/3 larger than in 1973, but had to pay 7 times more for it (in constant currency)
- **Changes in peoples preferences**
  - People find it less important to have a large home
- **The growth in non-western immigration**
  - Use 1/3 less living area per capita than the rest of the population

Ca 90%

Ca 10%

Direct drivers for changes in energy-use per m² from 1990 to 2009



Indirect and policy drivers of changes in energy-use per m^2

Most important

Individual behaviour

Energy use for certain categories of electrical equipment may see differences by a factor of 20 among otherwise equal households, and there may be differences in energy use for heating by a factor of 3 (1)

Marked prices on energy

Increased oil price compared to that of electricity → (irreversible) shift from oil to electric heating starting in the 1970s

Increase in prices on both oil and electricity after 2000 stimulated to do other energy saving physical alterations

(1): See e.g. http://groentregnskab.albertslund.dk/boliger/mit-boligomraade

Least important

Technological improvements

Today: 50 % have water saving shower heads and 80 % have: refrigerators and freezers of energy efficiency class A and higher

Policy measures

Tax: little importance because not used much

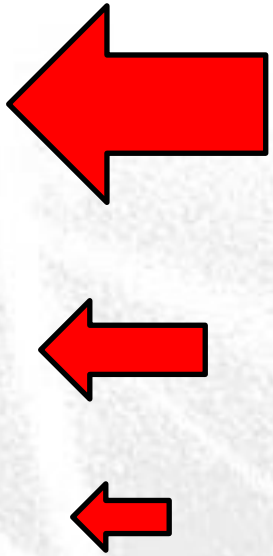
Economic support: little importance, but with exemption for the support to install air-to-air heat pumps

New building requirements can only explain 10-15 % of the reduction in specific energy use for all residences since 1990

Modes of change

Focus in policy discourse

- **Change energy-efficiency in consumption**
  - E.g. change to a car with less fuel consumption per km
- **Change patterns of consumption**
  - E.g. change from private car to public transportation
- **Change volume of consumption**
  - E.g. reduce your total transport work measured in person kilometres



How do these categories apply to the case of energy-use in Norwegian households?

Modes of change in household energy-use

Share of contribution in the total reduction in energy-use from 1990 to 2009 (- 19% relative to expected trend)

Type of change		Effect
Change energy efficiency in consumption	Improvements of building envelope in existing houses	-13%
	Introduction of air-to-air heat pumps	-8 %
	New technical building standards	-7 %
	Reduced energy use in water heating	-6 %
	Energy use for technical operations (ventilation and lifts)	+1 %
	SUM	**-33 %**
Change patterns of consumption	Change from oil to electric heating	-6 %
	SUM	**-6 %**
Change volume of consumption	Reduced increase in living area per person due to: • increase in real-estate prices • changes in peoples preferences • non-western immigration	-55%
	Changes in indoor temperature	
	SUM	**-55 %**
Net effect of efficiency gains and growth in volume of consumption	Appliances and lighting, efficiency gains	**-7% (?)**
	Appliances and lighting, growth in volume	**+10% (?)**
	SUM	**+2%**

Summing up the observed changes in household energy-use from 1990 to 2009

- **Unexpected nature of change**
  - Changes in volume of consumption more important than that of increasing energy-efficiency
- **Unexpected drivers of change**
  - Most of the observed change is due to unexpected effects of drivers other than environmental-motivated policy-measures
- **Unexpected location of change**
  - Most of the total energy reduction due to reduced energy-use per m^2 took place in "existing" buildings (improving building envelopes) and not in new buildings due to tougher building regulations.
- **Unexpected rebound effect**
  - Increase in number of electrical appliances outweigh efficiency gains

Future research within CenSES

- **Supplementary empirical study**
  - Any sign of trend shift 2009-2013 compared to that of 1990-2009?
- **How have NVE applied the scenario model?**
- **Own scenario analysis**
  - Business as usual, - 0%, -20 %, -50 % by 2040
  - Five scenario paths: Information, economic support, tax, technological improvements, land-use planning regulations
  - Existing versus new buildings
- **Discussion**
  - Is it probable that emerging new policy initiatives will manage to result in any substantial decrease in the total household energy-use?

Relevant literature

Aall, C. (2013): Why has the level of household energy consumption stopped increasing in Norway -– and how to make it can we bring about a decrease? In: Hansson, L., Holmberg, U., Brembeck, H. (Eds.). (2013). Making Sense of Consumption. Göteborg: University of Gothenburg. ISBN 978-91-974642-6-0

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Thank you for your attention!

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