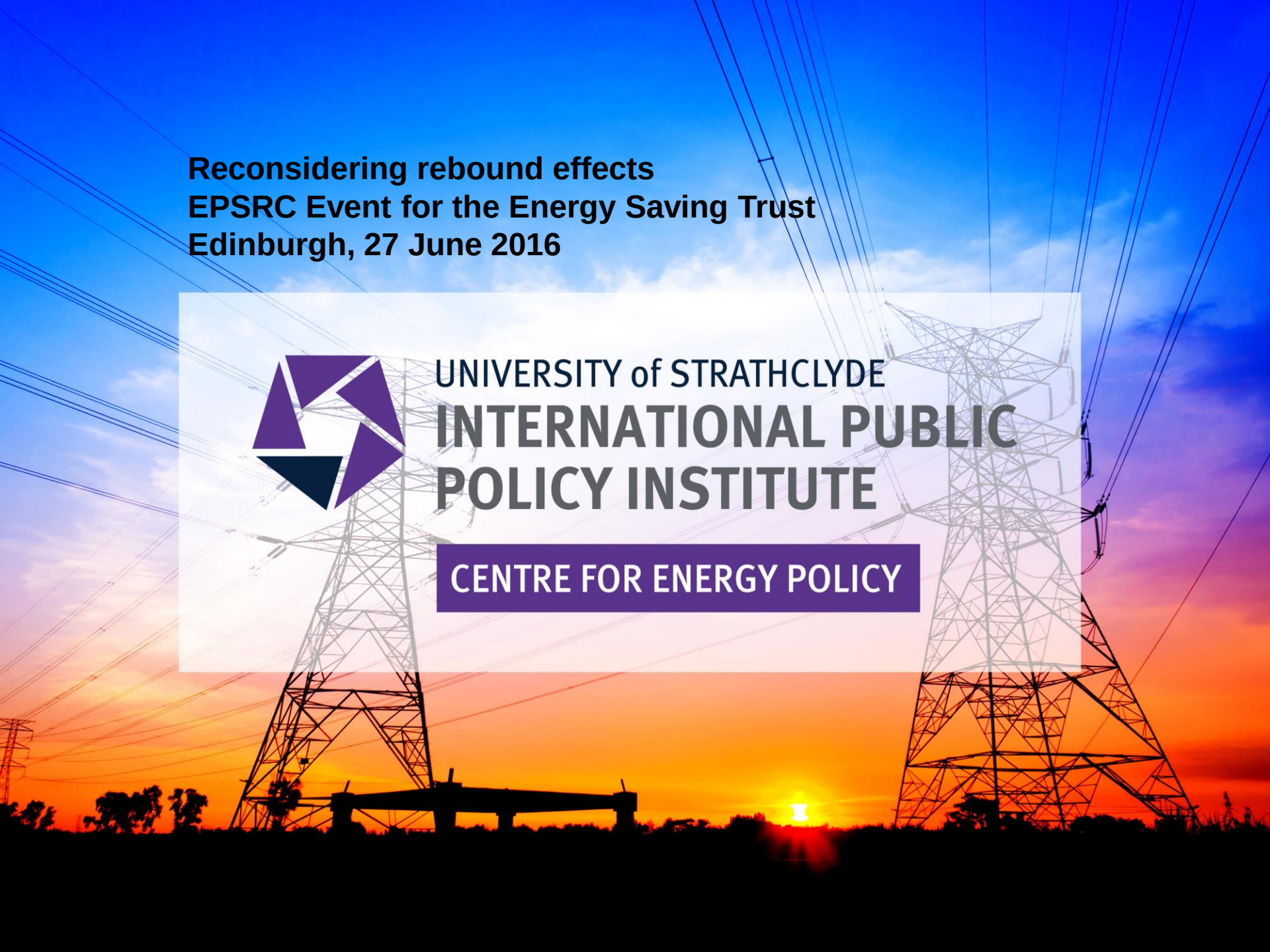
Reconsidering rebound effects
EPSRC Event for the Energy Saving Trust
Edinburgh, 27 June 2016



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Our project

EPSRC EUED project 'Energy saving innovations and economy-wide rebound effects'

Project web-page:
http://cied.ac.uk/research/impacts/energysavinginnovations

Project partners: EUED CIED centre at Sussex and Fraser of Allander Institute (Strathclyde); external collaborators on different WP (Dublin, Sassari, Zaragoza)

Research Councils UK Energy For a Low Carbon Future

University of Strathclyde Business School

FRASER OF ALLANDER INSTITUTE

Centre on Innovation and Energy Demand

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1. INTRODUCTION

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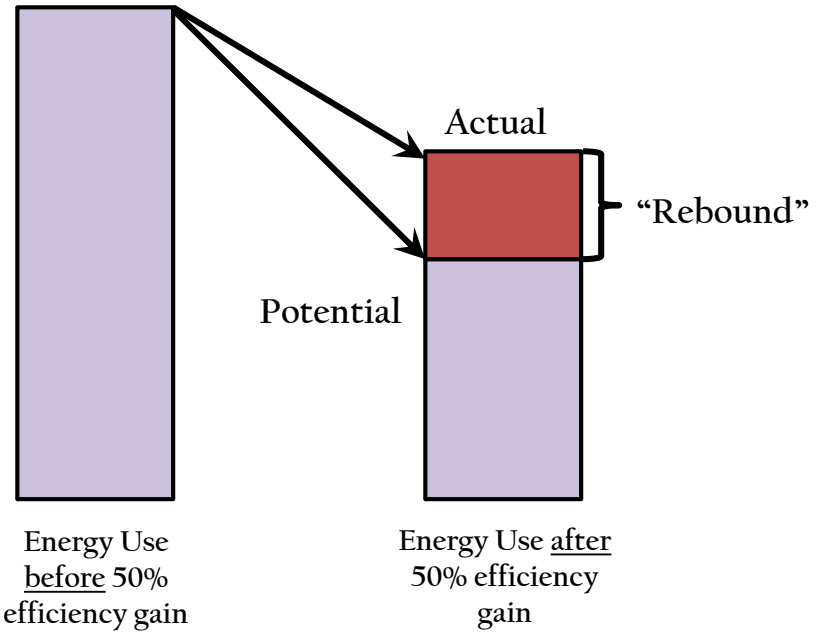
What is rebound?



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What is rebound?

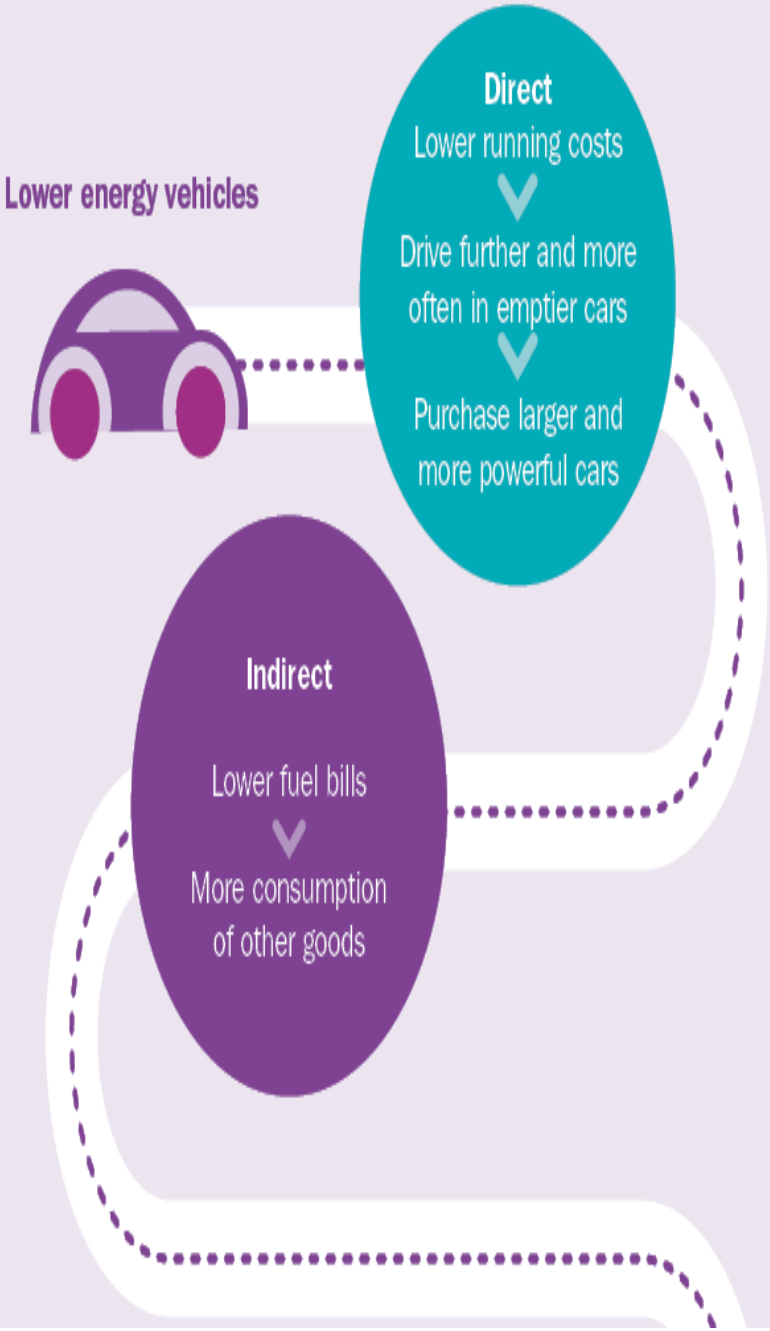
- Rebound triggered by fact that reduced physical energy requirement reduces price of delivering energy service
- Most obvious is ‘direct rebound’ – e.g. costs £X less to run heating at 20 degrees for 1 hour, we may heat the house for longer and/or higher temperature
- But will trigger series of economic responses
- Zero rebound would imply no economic response whatsoever

Direct

Cost-effective efficiency improvements make energy services cheaper, thereby encouraging increased consumption of those services.

Indirect

Cost savings from energy efficiency improvements may be spent on other goods and services whose provision involves energy use and emissions at different stages of their international supply chains. For example, savings on gasoline bills may be used to purchase laptops made in Asia and shipped to the UK.

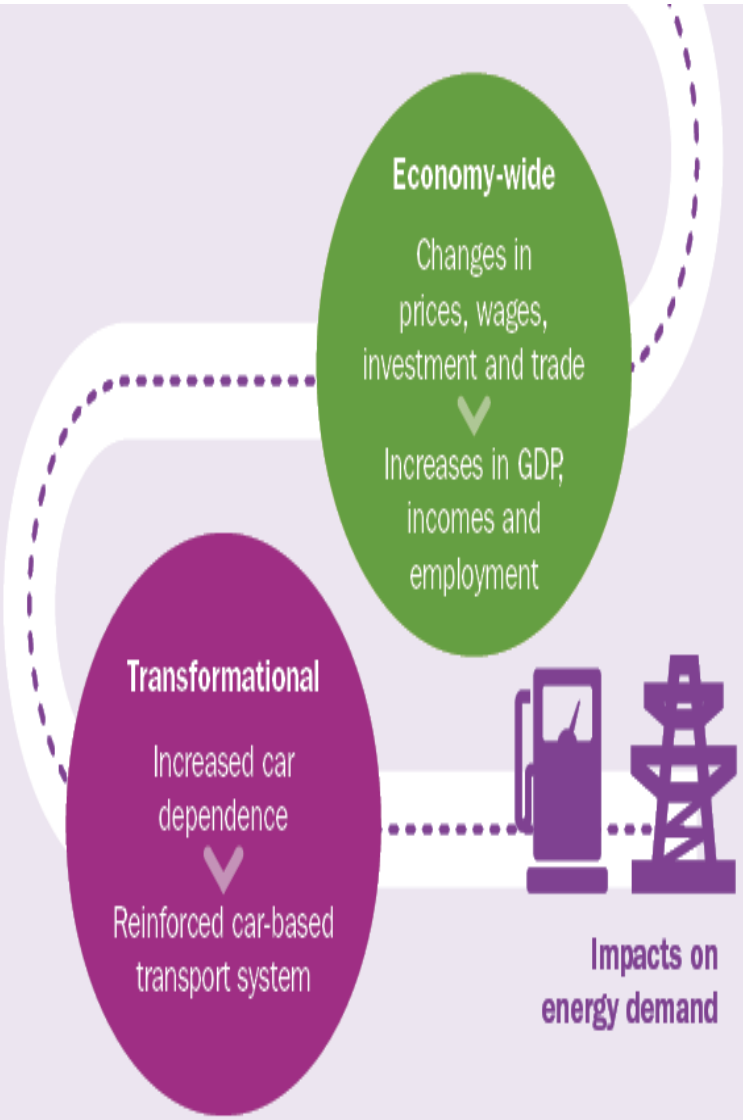


Economy-wide

Shifts in consumption patterns may trigger multiple changes in prices, investments and incomes in both domestic and international markets. Energy efficiency improvements by firms may lower output prices, boost productivity and competiveness, encourage economic expansion and thereby increase energy consumption.

Transformational

In some cases, efficiency improvements may help open up markets for new technologies and systems, triggering entirely new energy-using applications, products and industries.



Impacts of low-energy innovations are uncertain and often unexpected.

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Calculating rebound

$$R = \left(1 - \frac{AES}{PES}\right) x100$$

- Ratio of **actual energy savings** to **potential energy savings** following an **energy efficiency** improvement
- AES depends on focus – direct, indirect or economy-wide
- PES generally stated in terms of potential **engineering or technical savings**
- Increase efficiency by 10%, require 10% less physical energy input to produce same level of production output or consumption utility
- But debate over PES…..
- Here, if PES is say 100 terajoules and AES is 70 terajoules, we have R=30%

WP2 – Developing the model database and extending to international supply chains

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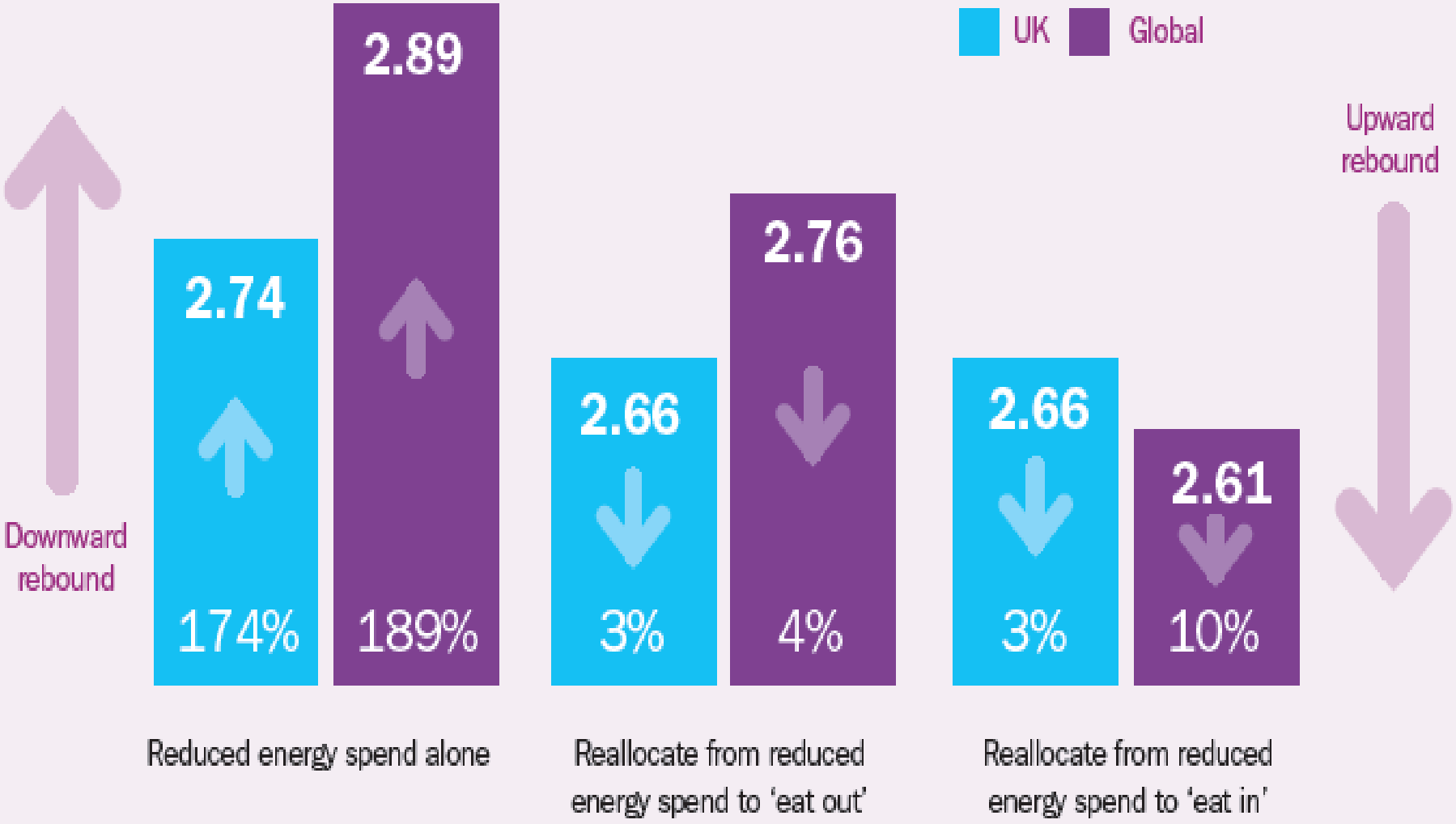
Rebound re-stated as energy/carbon savings multiplier

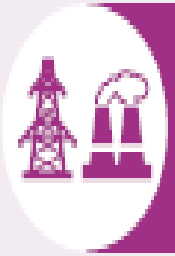
- WIOD input-output database
- Focus on quantity adjustments in energy supply chains underlying ***negative rebound*** effects
- Use of multiplier analysis to consider UK and international energy use and carbon impacts of different spending allocations
- WIOD permits ***full 'carbon footprint'*** analysis with impacts broken down by industries within countries

- Policy brief – focus on ***restating rebound*** in terms of initial ***energy/carbon savings multiplier*** that is then eroded (but not wiped out) by positive rebound effects

CARBON SAVING MULTIPLIERS FROM REALLOCATION OF SPENDING FOR A 'HEAT OR EAT' EXAMPLE – REDUCTION IN SUPPLY CHAIN CO_2 PER KT REDUCTION BY HOUSEHOLDS



OUTPUT MULTIPLIERS (IMPACTS PER £1M SPEND)

	Energy	CO_2
 UK Electricity, Gas and Water Supply	+59.676tj	+2.96kt
 UK Hotels and Restaurants	+4.45tj	+0.22kt
 Global Food and Drink	+9.88tj	+0.49kt

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We can identify a more useful tool to help people consider the energy/carbon impacts of different types of spending

2. PROPOSITION 1

Introduction

Proposition 1 : Input-output multiplier analysis an alternative tool to rebound measures

Multiplier analysis measures the economy-wide impacts of changes in final demand for the output of specific production sectors.

➢ **Why input-output multiplier analysis?**

- Simple tool
- Policy tool (e.g. employment multipliers)
- Flexible framework or tool (e.g. Inter-country or Regional analysis)

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Applying multiplier analysis to consider different re-spending options

➢ Scottish Example

- ❖ What are the Carbon Savings Multipliers for Scotland?
- ❖ What are the GHG multiplier impacts in Scotland for different 'Eat', 'light', 'Heat' and 'Travel' domestic spending options?

➢ Data

- ❑ Scottish Input-Output (IO) Tables 2012
- ❑ UK Average Sectoral GHG Intensities

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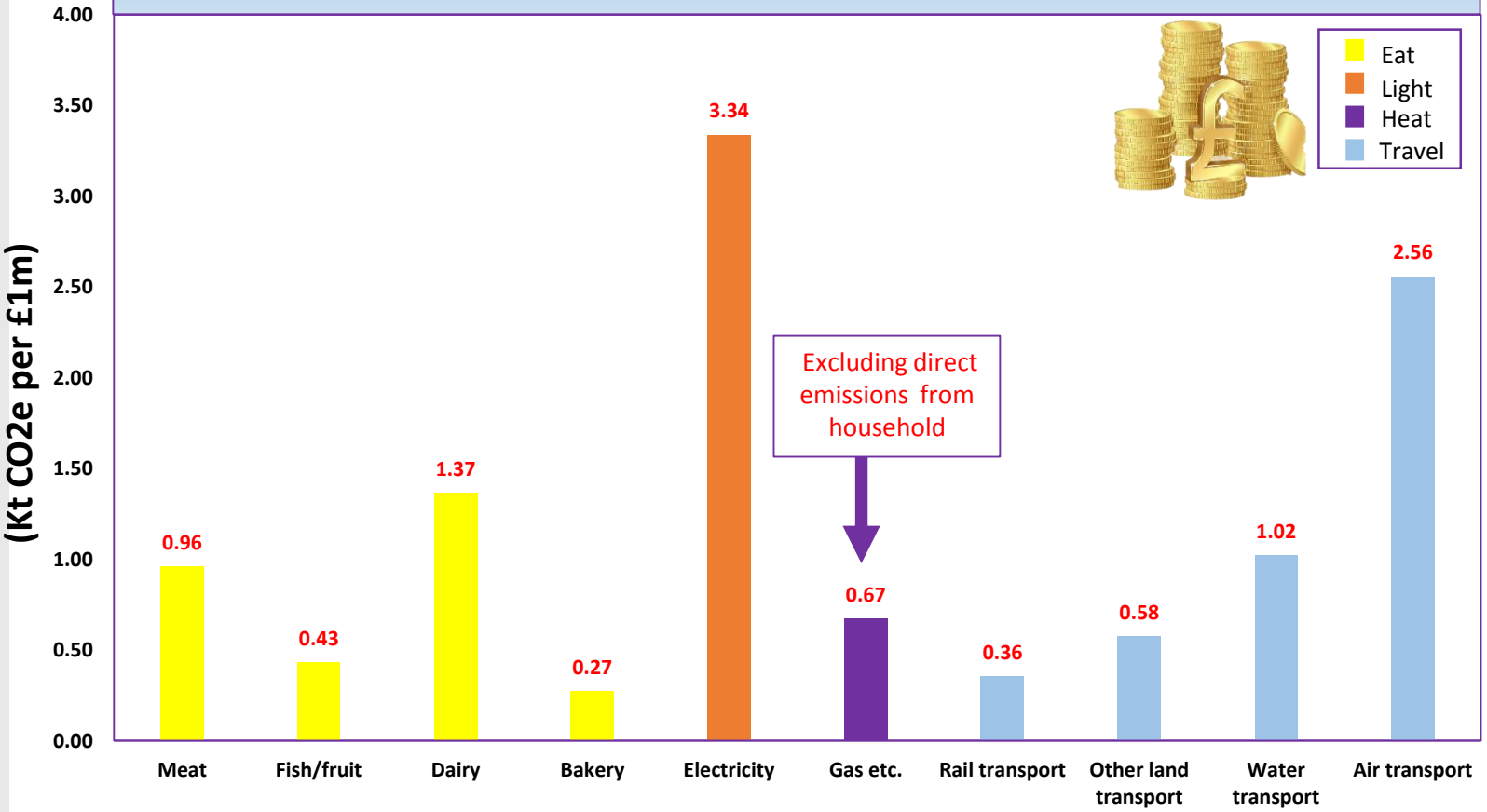
GHG Multipliers impacts in Scotland (Kt CO2e per £1m) for 'Eat', 'Light', 'Heat' and 'Travel domestic spending options



Challenge in applying input-output multiplier analysis

- **Data: Appropriate physical data is usually unavailable or difficult to obtain**

'Scotland is in an excellent position with regard to economic input-output accounting data, however a key challenge/problem is a lack of region-specific data on sectoral GHG

Further Applications:

- How GHG is distributed within Scotland's supply chain.
- Use Scottish data to replace the electricity GHG intensities to see how the multipliers change.
- Replicate similar scenarios as in the inter-country case.

Advantages of input-output multiplier analysis

- Useful tool for examining the interdependences within an economy and the interactions between the economy and the environment.
- Flexible framework or tool (e.g. Inter-country or Regional, other pollutants, waste and resource uses)
- Alternatives tool/method to Rebound measures.
- Framework to construct a regional Computable General Equilibrium (CGE) model.
- Support existing economic and environmental policies or inform new policy decisions. (Answer key questions and 'What if' scenarios)

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Conclusion

Development of an IO-based tool?

- Kenechi working over summer on basis for developing an IO-based tool aimed at public education of carbon impacts of different types of spending
- Simon Messenger (London EST office) sent link to the Home Energy Check tool as an example of what could ultimately be developed
- From initial high level check to more detail for keener user
- Provide user with clear answers and EST with more granular date
- By time of London EST workshop at end July, Kenechi will have considered basics to potentially allow development of a similar type of tool
- Thoughts? (Now or over the next month)

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Focus on how economy-wide rebound is linked to a range of wider economic benefits

3. OUR PROJECT

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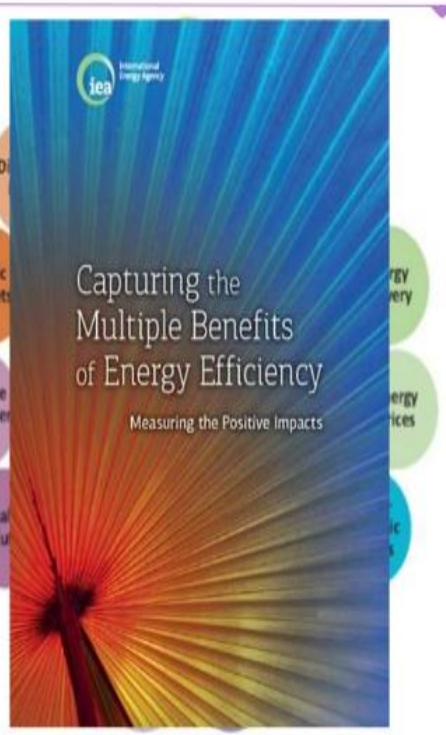
EE has multiple benefits

DATABUILD



IEA (2014), *Capturing the Multiple Benefits of Energy Efficiency*, OECD/IEA, Paris.

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Multiple benefits

- Primary aim – cost effective energy efficiency improvements to deliver energy savings/reduced energy use at sectoral and economy-wide levels

- Issue of ‘rebound’ effects triggered by decrease in price of energy service
  - E.g. more efficient boiler example
  - May not be a ‘bad thing’ if homes under-heated
  - Real income boost, reduced spend on energy - fuel poverty implications

- Trigger for a stimulus to the wider economy

European Commission

Science for Environment Policy

SfEP Logo.jpg

Household energy efficiency could help boost the economy

Improving the energy efficiency of homes could have positive economy-wide impacts, recent UK research suggests. It would allow householders to spend the money they save on energy on other products and services. Although this additional demand and the associated production in non-energy sectors would partly offset the energy saved in the home, this 'rebound effect' does not completely outweigh the household energy savings.

June 2015
Thematic Issue 49

Exploring the Links between Energy Efficiency and Resource Efficiency

This study explored the links between increased energy efficiency of UK households and the wider UK economy using 'general equilibrium' modelling. In particular, researchers investigated a potential 5% improvement in energy efficiency, which they assumed would occur as a result of technological improvements (e.g. more efficient appliances) that allow a household to continue operating at the same capacity, but using less energy.

Financial savings from this lower energy use will probably mean that householders use their appliances more than before, creating 'direct rebound effects'. This study also considered 'indirect rebound effects'. These occur because the cost savings allow householders to spend more money on goods and services other than energy. The energy used by other sectors that provide these goods and services can reduce the overall benefits of the initial improvement in household efficiency. To understand these rebound effects, the researchers assessed the energy usage of 21 economic sectors. These included four energy sectors (1. coal; 2. refined oil (and also nuclear fuel that goes to the electricity generation sector - analysed together with oil, as these two sectors were integrated in the study's source of data); 3. gas; 4. electricity) and 17 other sectors, including food, textiles/clothing and finance.

The model's results suggest that the 5% improvement would have positive effects on the national economy, because increased real income and spending on non-energy sectors has a

Source: Lecca, P., McGregor, P. G., Swales, J. K., & Turner, K. (2014). The added value from a general equilibrium analysis of increased efficiency in household energy use. *Ecological Economics*. 100, 51–62. Doi:10.1016/j.ecolecon.2014.01.008.

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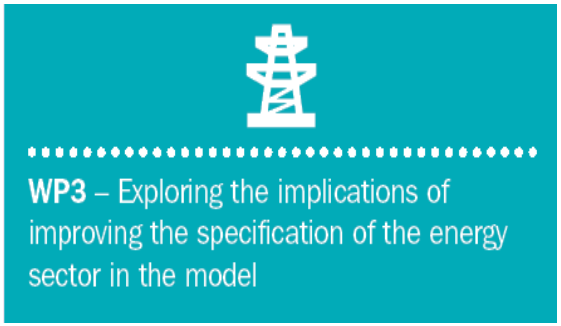
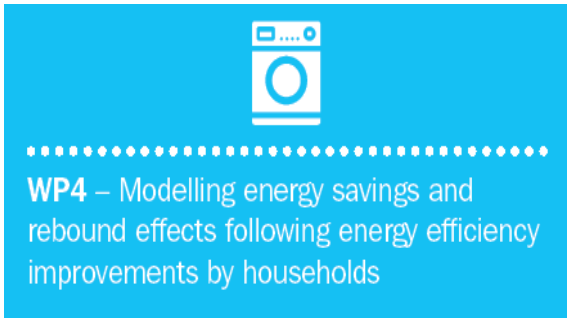
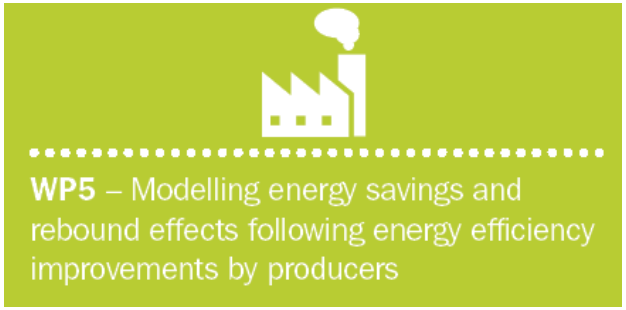
Multiple benefits

- Where efficiency increases in energy use on production side of economy – productivity-led expansion
- Where efficiency increase in household energy use – demand-led expansion

- Working with multi-sector economy CGE model
- Similar to HMRC model used by DECC, AMOS model used by Scottish Government
- Investigating a range of factors impacting nature of expansion and rebound effects







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Rebound may actually help reduce fuel poverty

4. PROPOSITION 2

Is rebound necessarily bad?

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Macroeconomic Benefits

Studies show that the presence of rebound is associated with a series of macroeconomic benefits. These include stimulus to important components of GDP such as investment, consumption and trade, and to key labour market indicators (unemployment, employment and real wage level).

Impact on households

Rebound is associated with changes in patterns in consumption. Households reallocate their spending taking into account for savings from the more cost-effective use of energy, changes in prices of commodities and income variations.

Can we reduce fuel poverty by increasing energy efficiency?

- *"A household is in* **fuel poverty** *if it would be required to spend more than 10% of its income (including Housing Benefit or Income Support for Mortgage Interest) on all modelled household fuel use"* (The Scottish Government 2012).
- In this study we analyse the general equilibrium impacts of introducing an illustrative 10% efficiency improvement household's energy use across five households income bands.
- We focus on two particular energy use by simulating a 10% energy efficiency increase in a) electricity consumption*, b) refined oil fuels used in private transport.
- We use a regional dynamic CGE model for Scotland specifically designed to the effect to disturbances in the energy sector.

* *We have investigated also the case of gas, and electricity and gas as composite good*

The Structure of Consumption

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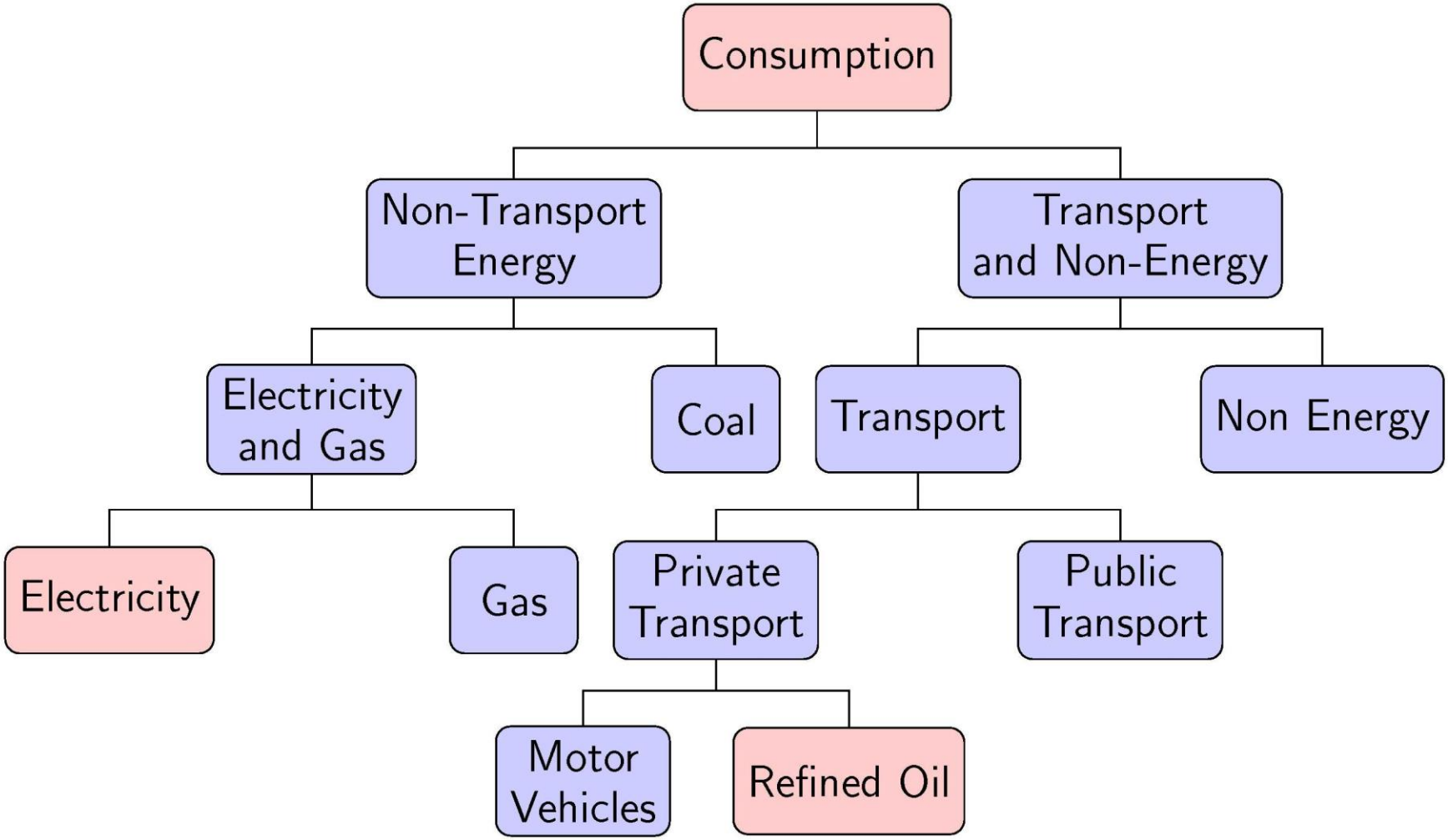
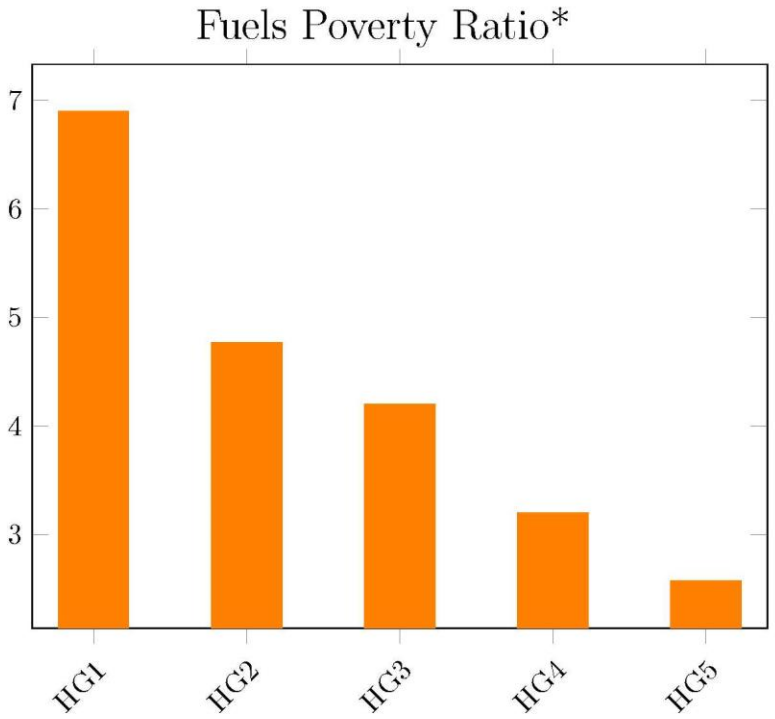


Disaggregating the household sector in the Scottish SAM

Table 1: Income group disaggregation in the 2010 Scottish SAM

HG1	HG2	HG3	HG4	HG5
up to £32.0K	£32.1K - £41.0K	£41.1K - £52.0K	£52.1K - £69.0K	£69.1K and over



*calculated as total energy consumption/household income

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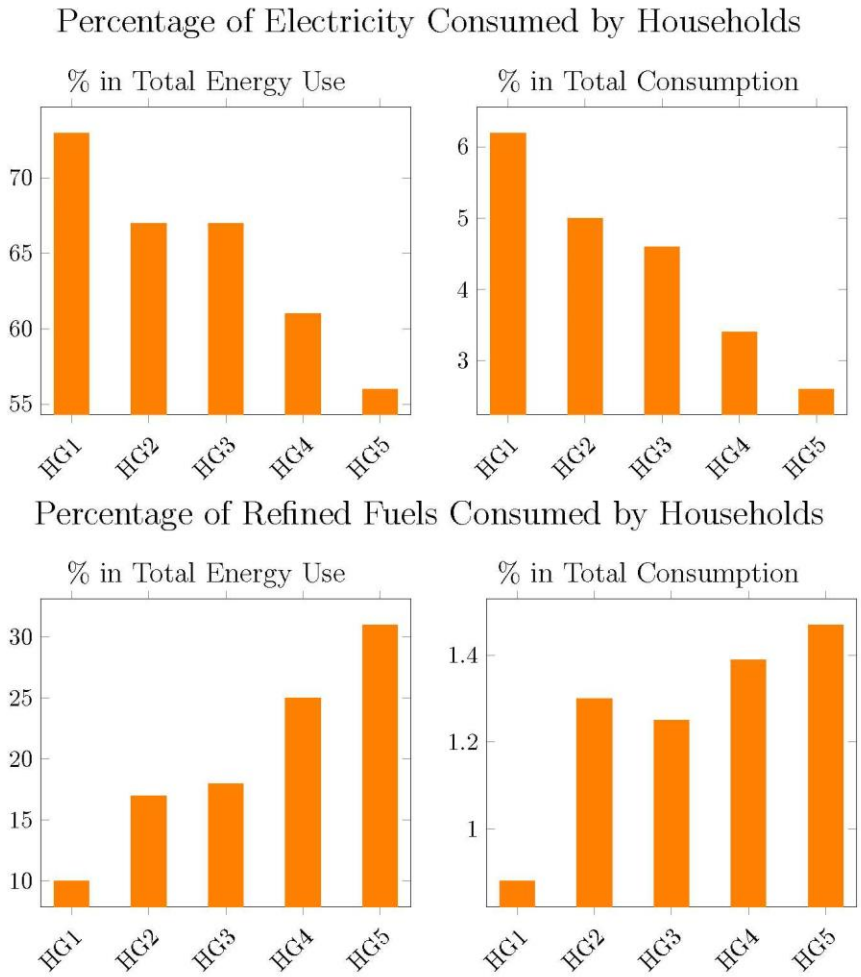
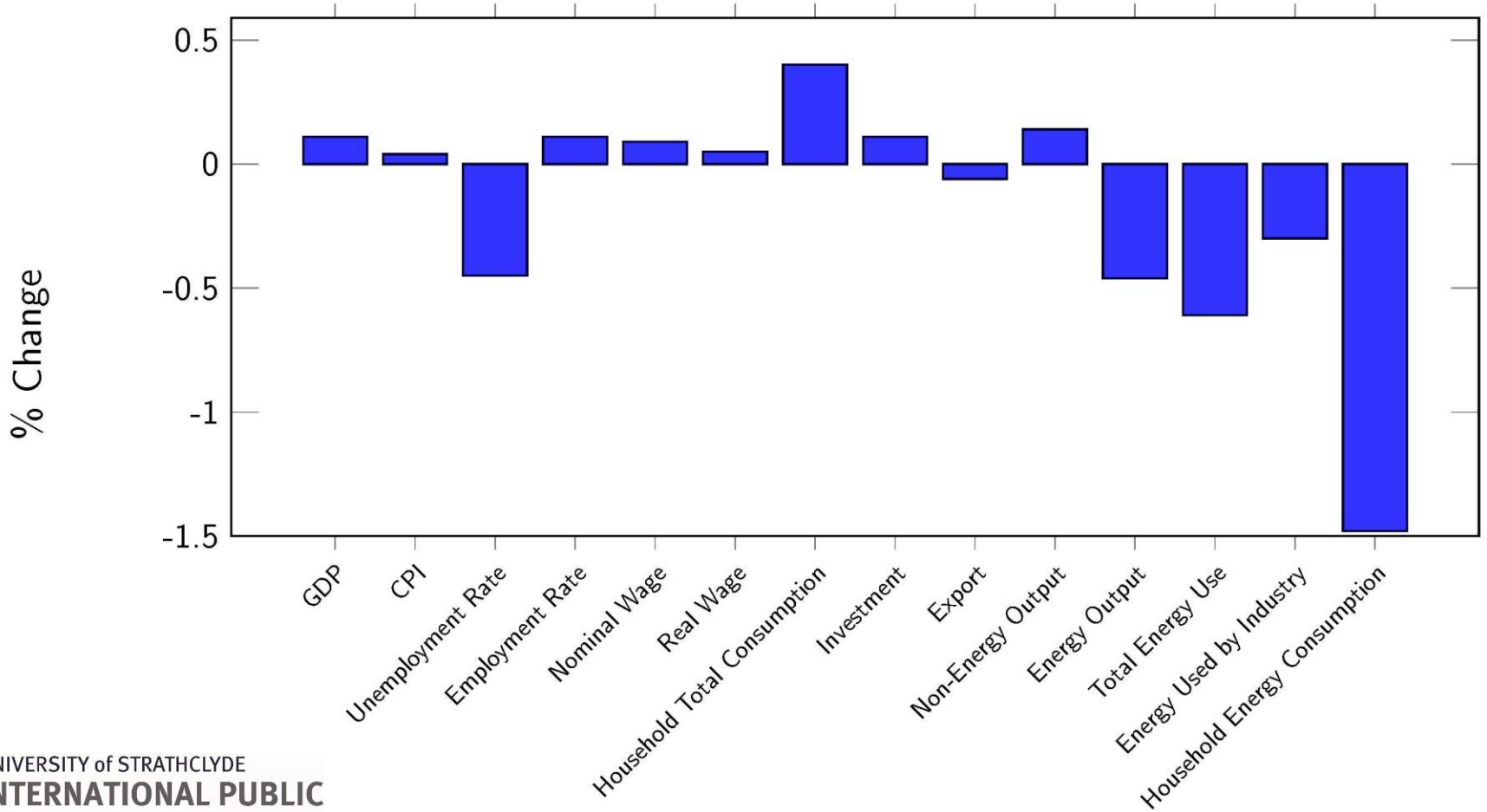
Patterns in energy consumption



Macroeconomic impacts of an illustrative 5% increase in household's energy efficiency



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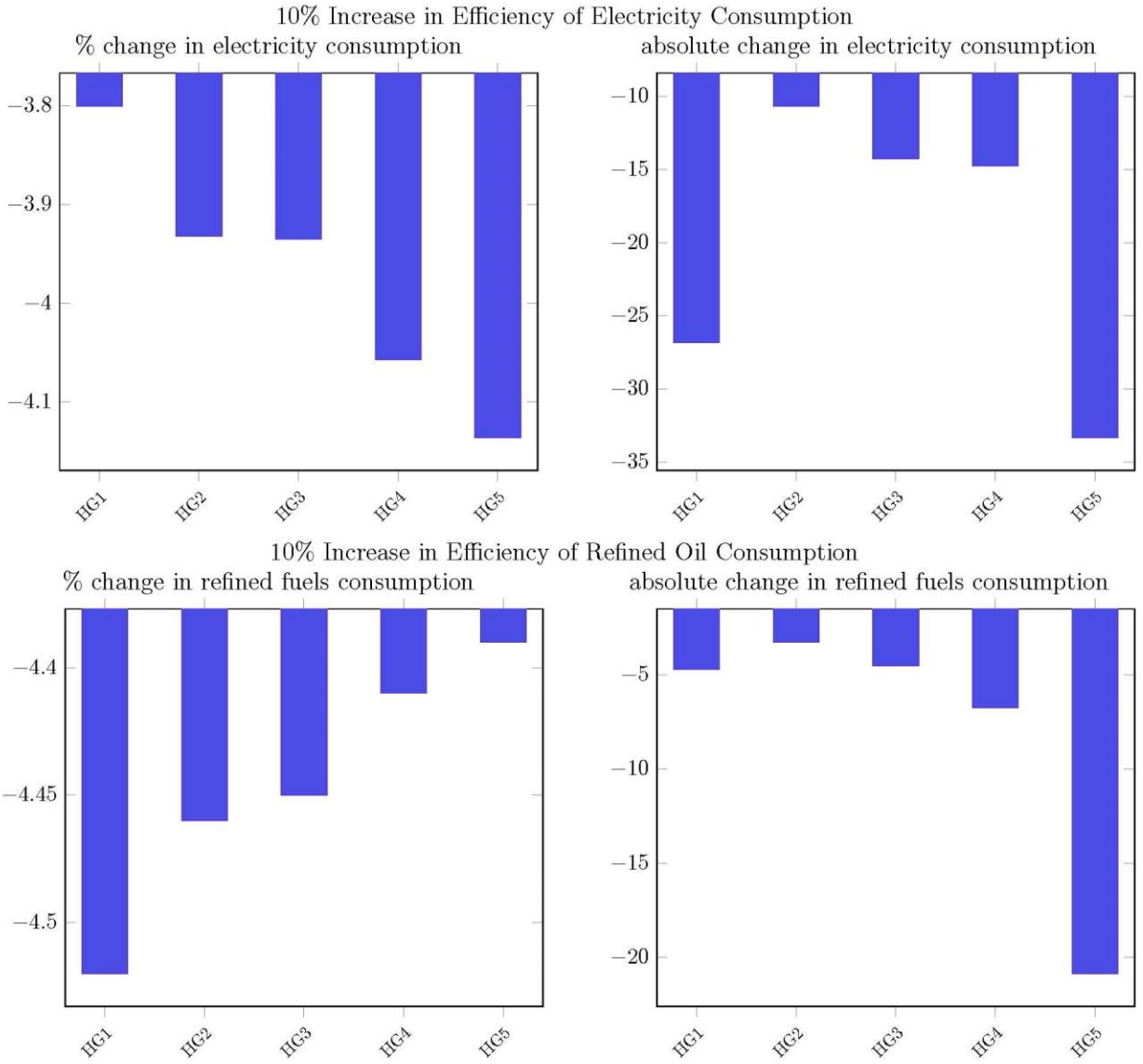
Impacts of increasing energy efficiency



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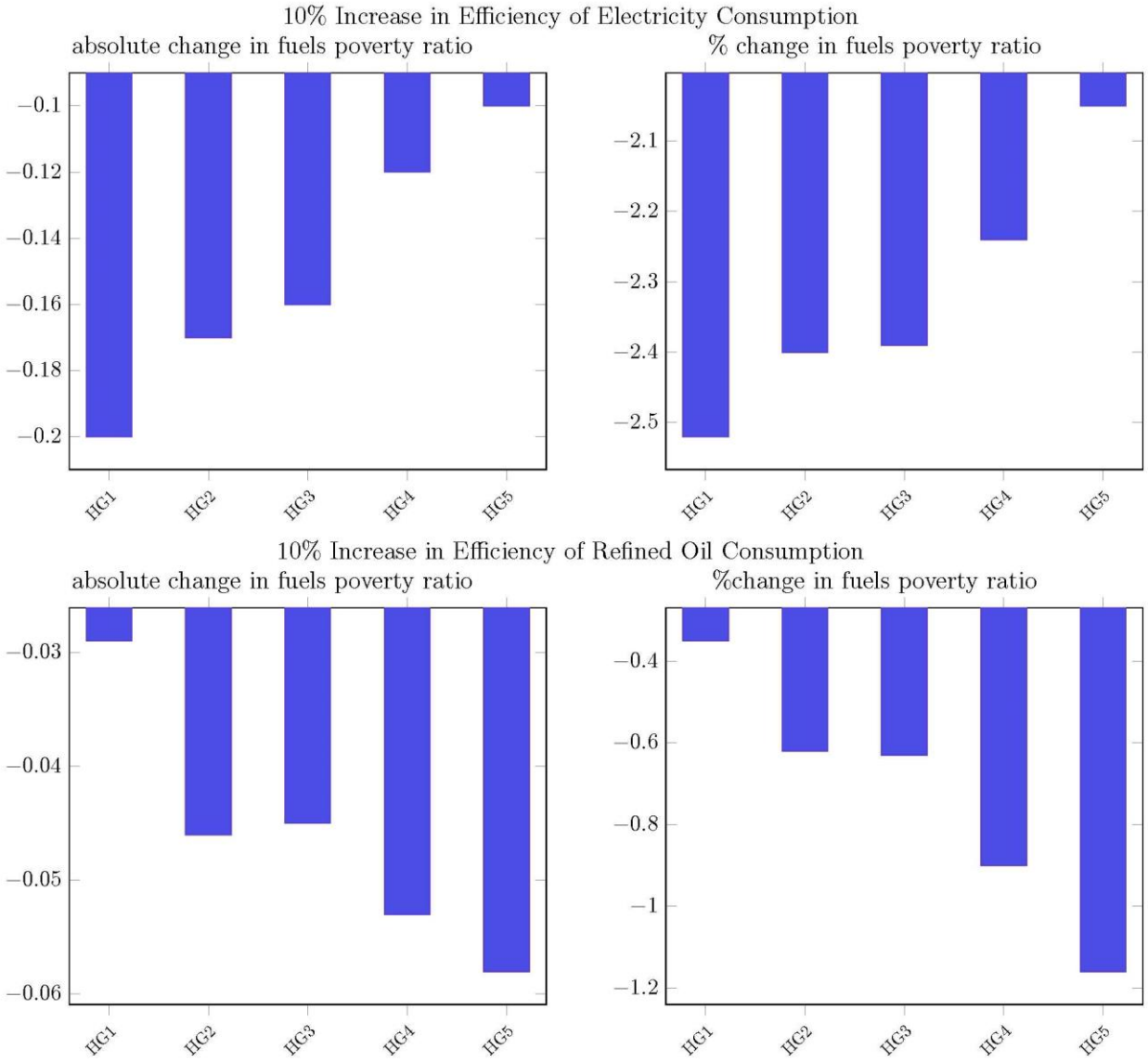
How does the fuel poverty ratio changes?



Comparing rebound effects

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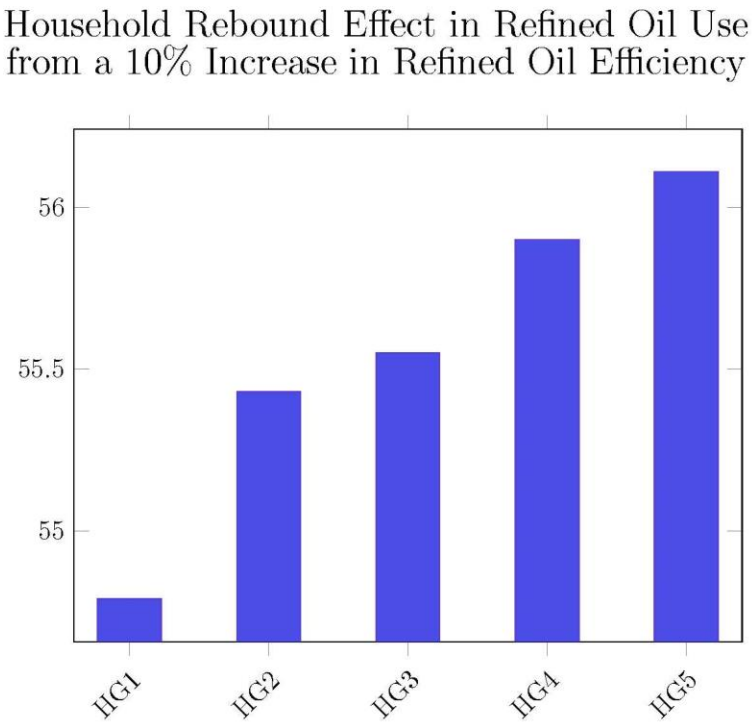

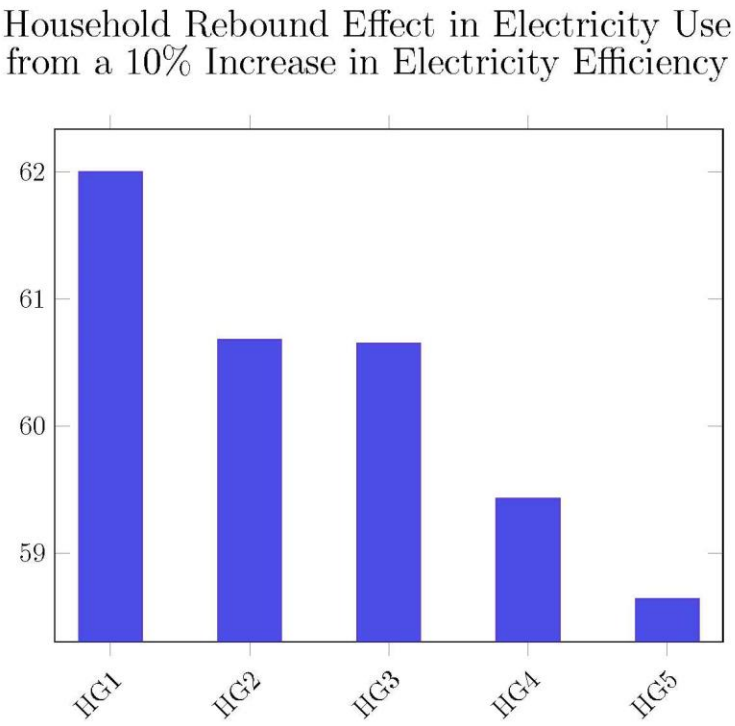

Conclusion

- Income groups consuming a certain energy good more intensively tend to rebound more in the use of the same good.
- The disaggregated household rebound effect varies across different income groups depending on which energy use is improved in efficiency.
- The rebound effect can help to reduce fuel poverty.
- Improving efficiency in electricity is more effective in terms of fuels poverty reduction.
- Improving energy efficiency in household energy use reduces energy demand, improves equality and reduces gas emissions.

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Can we reduce rebound without sacrificing economic benefits of increased efficiency?

5. PROPOSITION 3

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Our research question

- **Can we decouple economy-wide rebound and economic expansion?**

- Economy-wide rebound driven by same processes as economic expansion
- Does this make rebound a necessary ‘evil’?
- **Can we reduce rebound without sacrificing macroeconomic benefits of increased energy efficiency?**
- Focus of energy efficiency often simply on the most energy intensive activities
- **What if we increase energy efficiency in something that is a competitor for a relatively energy-intensive activity?**

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Remember..
multiple benefits

- Economic expansion following an energy efficiency improvement

- Key:
- Change in ***what*** is consumed
- And ***level*** of consumption – incomes boosted by falling energy costs and increased economic activity

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Public vs. private transport

- Experiment with UK CGE model: increase energy efficiency in UK ‘Road and Rail’ public (and freight) transport sector

- Delivers expected benefits of a productivity led expansion – positive impact on GDP, aggregate investment, employment, exports, household income and consumption

- However, expansion accompanied by rebound in energy use across economy

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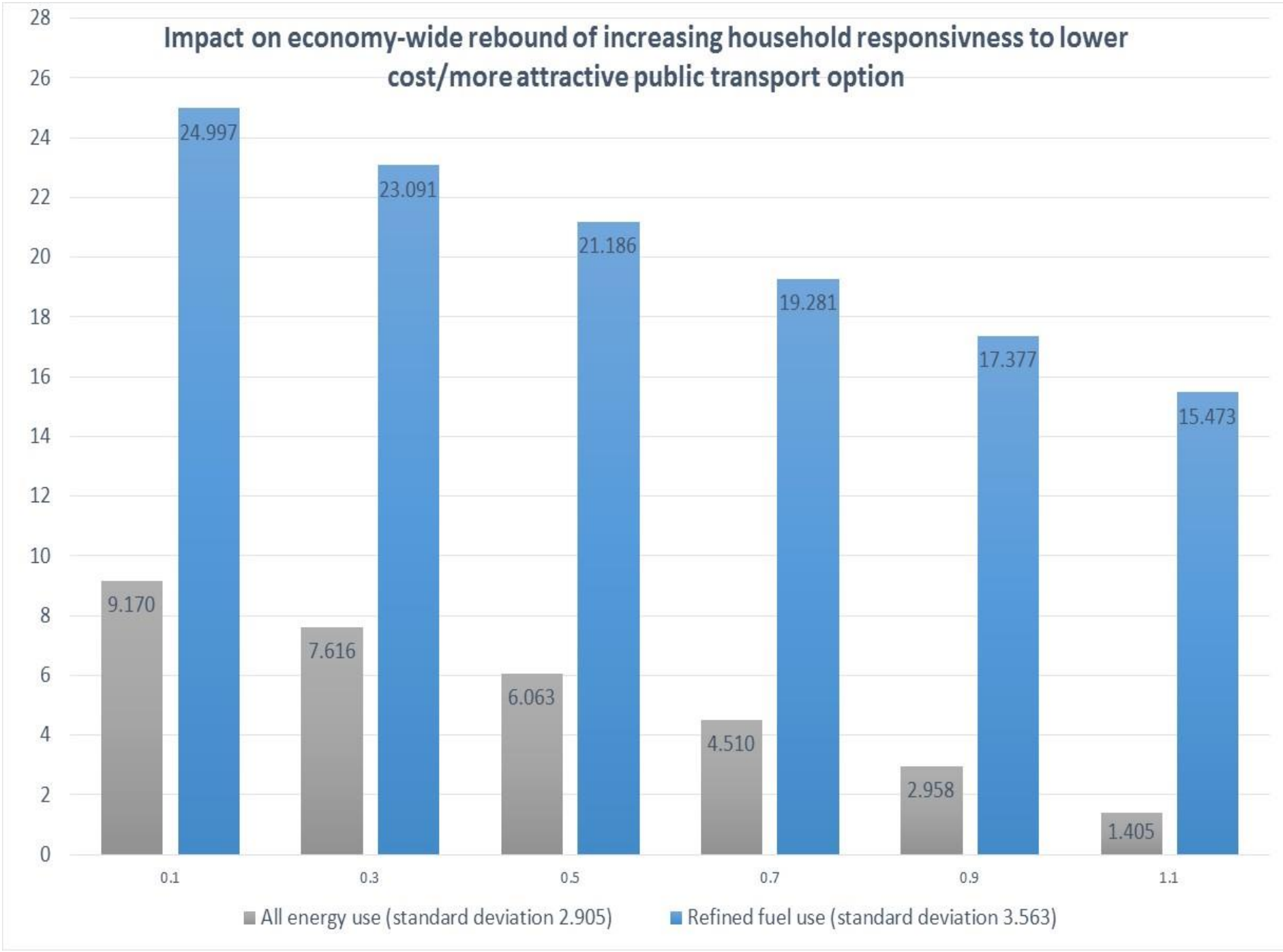
Public vs. private transport

- Focus in model on household choice between public vs. private options in delivering transport service
- The more households respond to change in relative price of public over private options that may result from energy cost savings
- Or cost savings could be used to improve attractiveness of public option in another way


Impact on economy-wide rebound of increasing household responsivness to lower cost/more attractive public transport option
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
24.997
23.091
21.186
19.281
17.377
15.473
9.170
7.616
6.063
4.510
2.958
1.405
0.1
0.3
0.5
0.7
0.9
1.1
All energy use (standard deviation 2.905)
Refined fuel use (standard deviation 3.563)

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Key result

- As we make households more willing to substitute in favour of public option
- Economy-wide rebound reduced while retaining macroeconomic benefits

- Key – ***composition*** of household transport activity
- Dematerialisation agenda – focus on efficiency of delivery (and use) of energy (using) ***service*** options to deliver low carbon expansion

- Could the same argument apply to delivery of heating services?
- Gas vs. low carbon electricity?

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More general conclusion

- Counter argument to 'limits to growth'
- Focus on *the composition* rather than level of economic activity
- Focus on *demand for service* rather than demand for fuel itself
- Technologies with low energy/carbon properties *relative to other means of delivering service*….
- …can deliver wider social benefits through economic expansion with *lower and less damaging rebound effects*

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Current work (Spanish case study)

- Need to renewables production to become more efficient and competitive in reduced/no subsidy environment
- Initial work considering scenarios where
- (a) households become more efficient in electricity use
- (b) renewable electricity generation becomes more efficient and competitive
- Greater economic expansion, slightly larger rebound
- But change in composition of electricity production – ***backfire*** in renewables

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6. The way forward for policy relevant research?

- Focus on delivery and uptake of low energy/carbon services
- Linking energy efficiency with policy on more competitive renewables
- Understanding energy supply responses
- How do we use research findings and tools to impact both decision makers in policy and industry, and household user behaviour?

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Thank you for listening!

karen.turner@strath.ac.uk

http://cied.ac.uk/research/impacts/energysavinginnovations

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