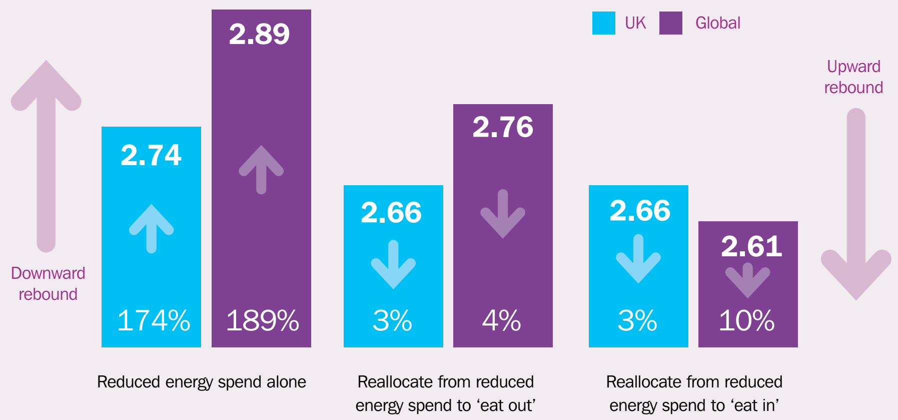
Multiplier analysis of re-spending rebound effects

Policy Briefing 02

January 2016

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



Rebound effects occur when potential energy savings from an energy efficiency improvement are eroded as a result of a range of economic responses to changes in costs of energy services, incomes and prices throughout the economy.

This briefing focuses on a particular type of rebound effect, which results from re-spending decisions as households realise savings due to reduced energy requirements. Measuring rebound from re-spending involves identifying changes in emissions-relevant energy use embodied in the supply chains of different goods/services that households may switch consumption between as their energy requirements are reduced

In assessing re-spending options, we consider a carbon saving multiplier (CSM). This measures the change in embodied supply chain emissions per kilotonne (kt) directly saved by UK households. A key aim of policy will then be to limit the erosion of this multiplier value. Our central finding is that upward rebound effects in supply chains supporting re-spending decisions erode carbon saving multiplier effects of reduced energy spending. There may also be important effects in terms of increased emissions overseas (carbon leakage) because non-energy supply chains tend to be more international than energy supply chains.

Who will this briefing be of interest to?

This briefing note uses a simple example to consider how multiplier tools may be used to consider and rank different re-spending options in terms of impacts on emissions-relevant energy use in different sectors of the economy. It will be of interest to both policy analysts and decision makers who need to identify key headline information in considering the wider impacts of energy efficiency and other policy options aimed at reducing household energy use.

Summary of key findings:

Unless the re-spend choice involves more energy spend (direct rebound), or has a supply chain with more embodied CO_2 than the reduced energy spend, the CSM will remain positive (net downward rebound). Taking a simple example, the graph opposite summarises negative and positive indirect rebound effects of reallocating UK household spending from energy to 'eat out' and 'eat in' options using a CSM:

- The first two bars for 'reduced energy spend alone' show that for every 1kt of CO_2 directly reduced in UK household energy use, **another 1.74kt is saved** in the UK energy supply chain (blue bar). **This rises to 1.89kt** when we look at the global supply chain (purple bar). **These are downward rebound effects (additional energy and CO_2 savings)**.
- However, re-spend decisions involve increased energy use and CO_2 generation in other sectors. This erodes energy and carbon savings due to **upward rebound effects**.
- The resulting erosion of the CSM through positive rebound in UK CO_2 generation (blue bars) is almost identical for the 'eat out' and 'eat in' options. **The UK CSM falls by 3% from 2.74 to 2.66 in both cases**.
- The purple bars in Graph 1 again focus on the impacts of considering CO_2 embodied in imports. **In the 'eat out' scenario the global CSM is reduced by 4%, from 2.89 to 2.76**.
- In the 'eat in' scenario, the erosion is even greater, with the **global CSM reducing by 10% from 2.76 to 2.61**. That the purple bar is smaller than the blue bar reflects in this case that we have 'carbon leakage' from the UK to other countries due to a greater reliance on imports and global supply chains.
- Similar analysis could be conducted for other scenarios involving spending reallocations.

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How do we use multiplier tools to measure energy and CO_2 savings from re-spending decisions?

Multiplier analysis (using input-output tables) is a policy tool that is commonly used to consider the economy-wide impacts of changes in final demands for the outputs of specific production sectors. This includes use of, for example, employment multipliers to consider how many jobs are impacted (directly and indirectly) in the supply chains of stimulated or depressed sectors. Similarly, energy and associated CO_2 emissions embodied in supply chains serving, for example, household final demands may be measured using relevant energy and CO_2 multipliers.

Where an energy efficiency improvement delivers reduced requirements for energy spending, we can apply the value of this to the energy-output and output-CO_2 multipliers (see below) of the relevant energy supply sector(s) to consider how energy use throughout the energy supply chain is impacted. We then apply the corresponding positive value to the multiplier(s) of the sector(s) producing the output where spending is reallocated. The latter allows us to identify where in the economy rebound pressures occur that act to offset potential energy savings from the efficiency improvement.

High level multiplier assessment for a case of UK household energy efficiency

Here, we demonstrate using a global inter-country input-output model *. We consider the simple illustrative example of reallocation of UK household spending following an efficiency improvement that reduces required spending on the outputs of a combined Electricity, Gas and Water Supply (EGWS) sector by 10%. The input-output data tell us that the direct effect of this is that UK households reduce their spending in this sector by £3,532m, use 152,591 terajoules (tj) less energy and generate 6,172 kilotonnes (kt) less CO_2 (entirely related to household gas use).

The table below shows the key type of information required to make a high level assessment of different spending options for a simple 'heat or eat' example. Here, reduced spending on energy can be reallocated to 'eat out' or 'eat in' options.

From the information in the table it is clear that reduced spending on UK EGWS has a larger global energy and CO_2 multiplier effect than either of our two 'heat or eat' options where spending could be reallocated. So we know that global emissions relevant energy use and CO_2 will fall.

However, more detailed examination of the results of applying multipliers to the spending reallocation allows us to consider the type of industries where energy use and emissions rise or fall, and whether impacts are felt at home or abroad.

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**

Key findings:

- Reallocation of spending to the 'eat out' option of UK Hotels and Restaurants has the smallest upward re-spending rebound effect and greatest reduction in global emissions relevant energy use and CO_2 generation.
- Greater upward rebound effects from re-spending will be reflected in greater erosion of the CO_2 (and energy) savings multiplier from the energy savings.
- Where reallocation of spending involves increased imports and/or reliance on overseas supply chains, it is important to decompose multiplier results to identify whether a net decrease in global energy use and emissions actually involves a net increase in emissions overseas.

Downward multiplier effects in energy supply chain activity

1 – MORE ENERGY EFFICIENT UK HOUSEHOLDS REDUCE SPENDING ON UK 'ELECTRICITY, GAS AND WATER SUPPLY' (EGWS) BY 10%

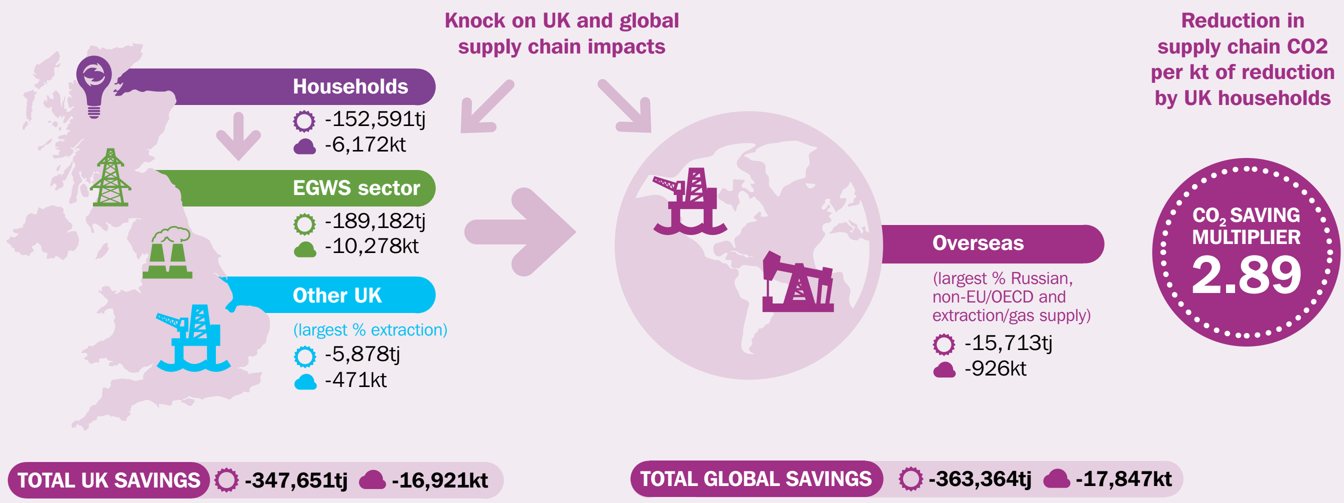

Figure 1 shows that most of the reduced energy use and CO_2 generation resulting from the £3,532m reduction in UK household energy spend occurs within the UK, and mainly within the EGWS sector itself. We are also able to report another key indicator by dividing the reduction in total global CO_2 generation (17,847kt) by the direct reduction in UK household emissions (6,172kt). **This gives us a CO_2 savings multiplier (CSM) of 2.89**, which tells us that, **for every 1kt reduction in direct household emissions, there is a total reduction of 2.89kt in global CO_2 emissions. In assessing re-spending options, a key aim will be to limit the erosion of this multiplier value.** (NB. the savings multiplier can be calculated for energy use or CO_2 and for different elements of the initial and overall savings using the results reported in the figures above and below). We consider potential sources of erosion below.

Upward rebound effects from re-spending scenario 1 (eating out)

2A – RE-SPEND SCENARIO 1: UK HOUSEHOLDS SWITCH SPENDING TO UK 'HOTELS AND RESTAURANTS' (HR)

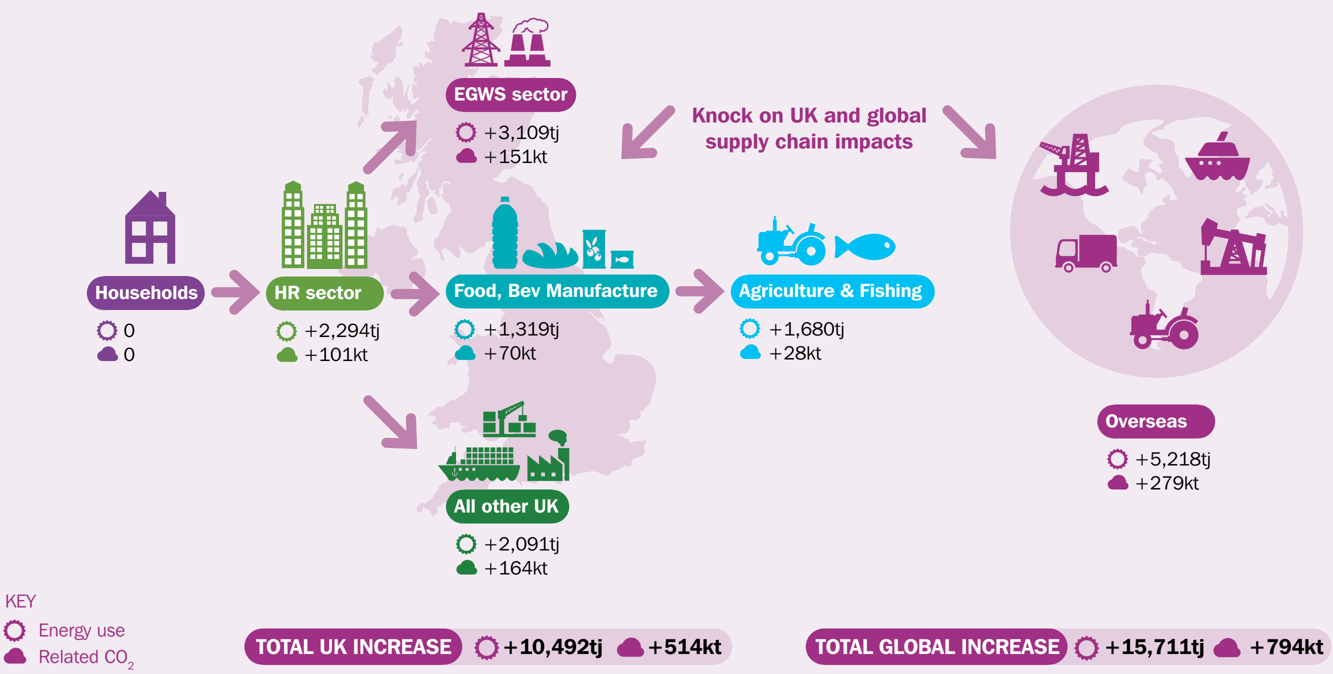

Figure 2A shows that the biggest upward impacts on energy use and CO_2 emissions from reallocating spending to the UK Hotels and Restaurant sector occur in the UK EGWS sector, followed by the domestic Food and Beverage Manufacture and Agriculture and Fishing sectors. However, around a third of the global impacts occur overseas.

2B – NET IMPACTS ON ENERGY USE AND RELATED CO_2 FROM EGWS TO HOTELS AND RESTAURANTS REALLOCATION

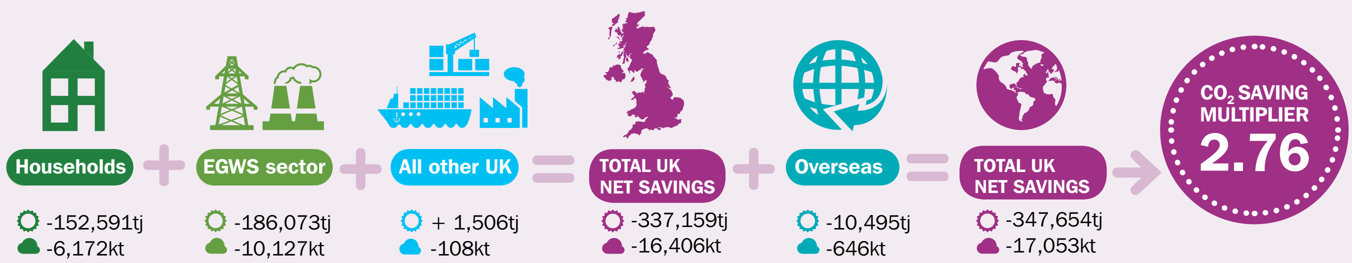

Figure 2B confirms that there is a net downward impact on global energy use and CO_2 emissions from this re-spending option. There is actually a net increase in energy use in UK industries outside of EGWS. However, that the corresponding CO_2 result is negative reflects the lower CO_2-intensity of this energy use. **Overall the CO_2 savings multiplier is eroded from 2.89 to 2.76.**

KEY
Energy use
Related CO_2

Upward rebound effects from re-spending scenario 2 (eating in)

However, the picture is somewhat different if UK households choose to reallocate their spending on outputs of the global Food and Beverage sector. This may involve spending more on better quality food, rather than simply consuming more. Assuming that this re-spend scenario involves an unchanged pattern of domestic and imported expenditure on food and beverages, it involves more than half of the £3,532m being spent on imports. The UK Food and Beverage sector itself is relatively import-intensive (though slightly less so than Hotels and Restaurants). So we expect overseas supply chain impacts of the 'eating in' case to be larger than in the 'eating out' case above (where most UK household spending is on the domestic HR sector).

3A – RE-SPEND SCENARIO 2: UK SWITCH SPENDING TO GLOBAL FOOD, BEVERAGE MANUFACTURE

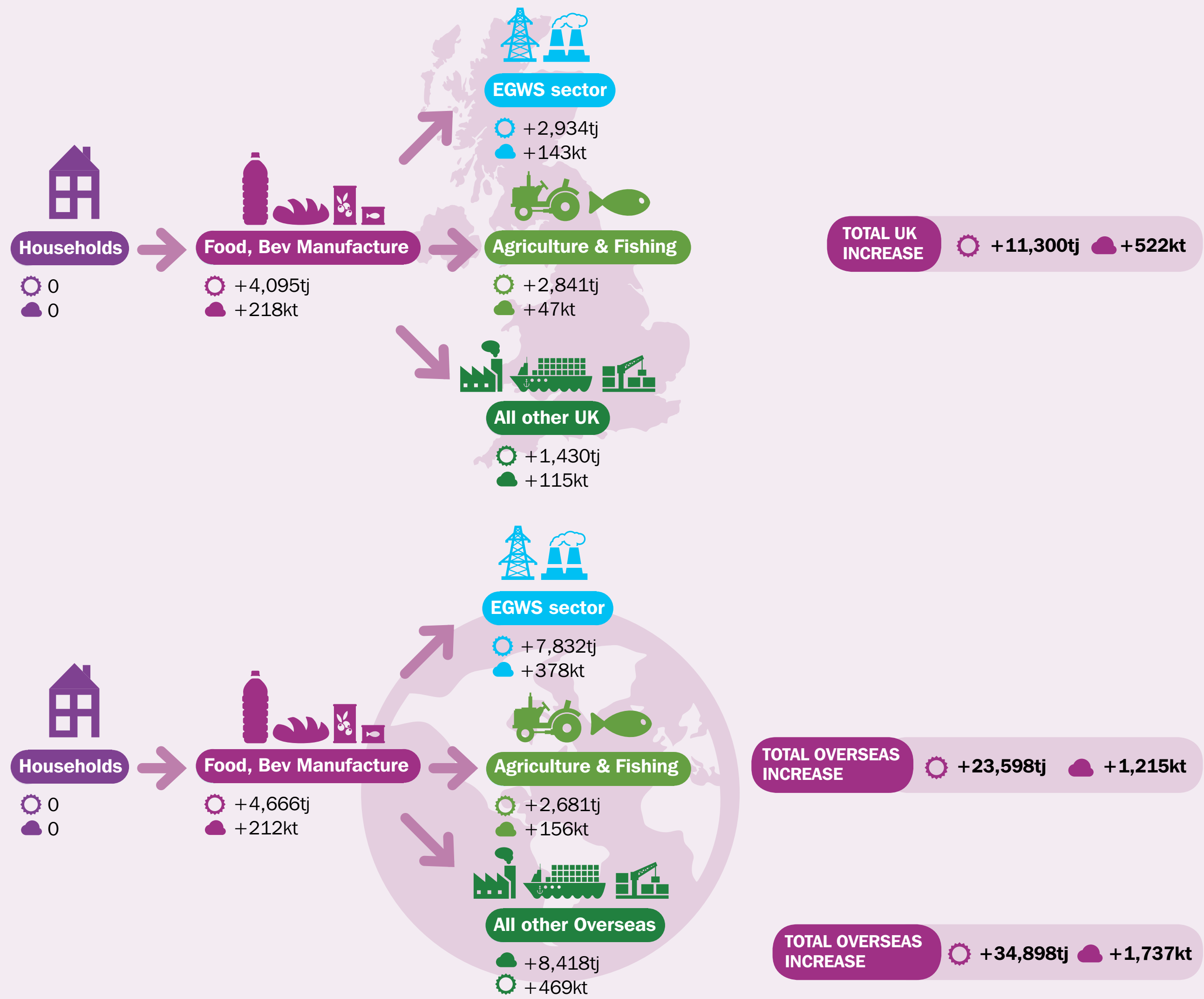

Figure 3A summarises the composition of the 34,898tj and 1,737kt increases in global energy use and CO_2 emissions for the 'eat in' scenario. As in the 'eat out' example above, the main industrial sources of these impacts are EGWS, Food and Beverage, and the Agriculture and Fishing sectors. However, the key result is that around 70% of both increases impact overseas (a much higher share than the value of the reallocation of spending).

KEY
Energy use
Related CO_2

Upward rebound effects from re-spending scenario 2 (eating in)

3B – NET IMPACTS ON ENERGY USE AND RELATED CO_2 FROM EGWS TO GLOBAL FBT REALLOCATION

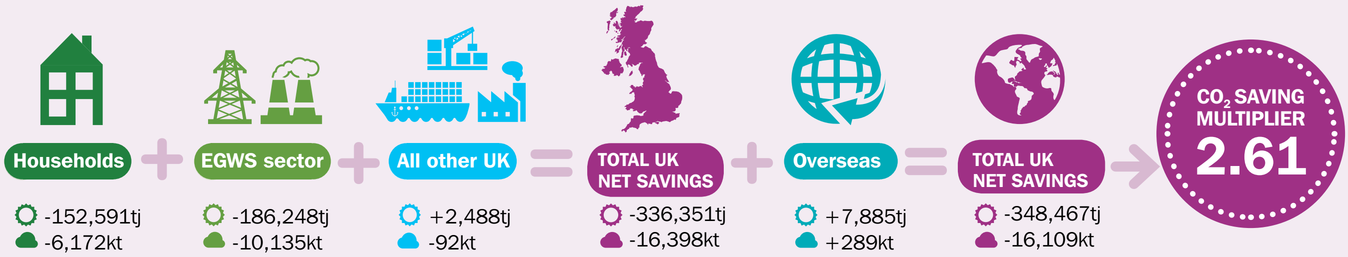

Figure 3B shows that there is a net increase in overseas energy use and CO_2 generation when we set the upward multiplier (and rebound) results of the FBT reallocation against the downward ones of the reduction in EGWS spend. This means that upward rebound effects in overseas energy use and CO_2 emissions causes a displacement, or CO_2 leakage in the reduced UK household 'carbon footprint'. **Overall the CO_2 savings multiplier is eroded from 2.89 to 2.61**. The imports content is crucial. If we focus attention on CO_2 emissions in the UK only, the 'eat out' and 'eat in' scenarios actually erode the CO_2 savings multiplier by the same amount, to 2.66. However, the impact on overseas emissions works in the opposite direction in the two cases.

Further information and reading:

*This study uses the data reported in the most recent year of the EU FP7 World Input-Output Database Project for which both economic data and satellite accounts on emissions relevant energy use and CO_2 emissions are available. The data may be downloaded at **http://www.wiod.org/new_site/home.htm**.

For full details see: Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015) An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production, Review of International Economics, 23, 575–605.

Other suggested background reading:

Figus, G., Turner, K., Lecca, P., McGregor, P. and Swales, Kim (2015) *Increased Household Energy Efficiency : Can it Boost the UK Economy?', Policy Brief, University of Strathclyde International Public Policy Institute (download at http://strathprints.strath.ac.uk/53551/)*. Also see summary at **http://ec.europa.eu/environment/integration/research/newsalert/pdf/household_energy_efficiency_could_help_boost_economy_49si7_en.pdf**

Turner, K. (2013,) 'Rebound effects from increased energy efficiency: a time to pause and reflect', The Energy Journal, 34(4), 25-42 (Contact karen.turner@strath.ac.uk)

Sorrell, S. (2007) 'The rebound effect: An assessment of the evidence for economy wide energy savings from improved energy efficiency', UK Energy Research Centre, London

A version of the full academic paper that the findings here are drawn from will shortly be available for download at **http://www.strath.ac.uk/ippi/ourpolicypapers/**.

See other work by the authors at **http://www.strath.ac.uk/staff/turnerkarenprof/**.

About the project:

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