



Introducing the Resources and Energy Analysis Programme (REAP)

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INTRODUCTION

In most countries environmental impacts tend to be dealt with at source, often through the regulation of production activities; the discharge of pollution into soils, rivers and the air is monitored and controlled and there is a long history of regulating polluting industries and conserving natural areas.

Another way of addressing environmental impacts is to account for the environmental consequences throughout the supply chain of what people in a country buy and use. The environmental pressures associated with household consumption activities are both local and global in nature. On a local level, patterns of consumption may result in impacts on air and water quality, biodiversity and land use. At the same time, many of the goods and services a person buys are sourced from outside of a country. The global pressures that consumption places on the environment are often hidden but can take the form of rapid resource use, climate change, water, air and soil pollution and consequential biodiversity loss.

This form of accounting for environmental pressures is commonly described as the consumption approach (or consumption-based accounting). This approach transcends territorial boundaries and takes into account the environmental pressures associated with products produced in other countries by a nation's consumption. At the same time it excludes the impacts of goods and services manufactured domestically but exported to and consumed in other countries.

In 2008 the UK Government Department for Environment, Food and Rural Affairs (Defra), published a report prepared by the Stockholm Environment Institute (SEI) and the University of Sydney, which used a consumption approach to look at greenhouse gas emissions (consumer emissions). The report showed that total UK consumer emissions were consistently and increasingly higher than emissions emitted in the UK by industry (producer emissions). In 2004, UK consumer emissions stood at around 730Mt CO₂, 20 per cent higher than producer emissions.

Today, government structures and policies in the UK are still orientated towards the impacts associated with production activities. Producer emissions are reported under United Nations Framework Convention on Climate Change (UNFCCC) requirements, and are used as a measure of the UK Government's success in mitigating climate change. But there is a clear move to try and understand impacts of consumption and production together. The Resources and Energy Analysis Programme, REAP for short, has played an important role in bringing evidence on the impacts associated with consumption to policy makers at all levels of government in the UK.

THE REAP MODEL

REAP is an input-output-based software tool that calculates the environmental pressures associated with consumption activities. It contains baseline data on the greenhouse gases, air pollutants and ecological footprints for every local authority area, government region and nation in the UK. One of REAP's most important functions is the scenario editor. This can be used to explore the environmental pressures associated with changes in population, consumption patterns and production technology over time.

At the heart of REAP is an environmentally extended input-output model which combines tables from national economic accounts with data from environmental accounts. REAP is a two-region input-output model that distinguishes between products produced in the UK and products imported from the 'rest of the world'. Its economic input-output tables describe the flow of goods and services between the UK and 'rest of the world' for 178 individual sectors over a year. The sectors cover a range from agricultural and manufacturing industries to transport, recreational, health and financial services. They are classified using the Standard Industrial Classification (SIC) System.

Environmental data from the supply chain of a product can be assigned to the point of consumption using the economic relationships depicted in the input-output table. REAP uses UK Environmental



Figure 1: REAP Interface

Accounts together with International Energy Agency and global databases (GTAP¹, EDGAR²), to distinguish between the environmental impact of industrial sectors in the UK and the rest of the world. By modelling the combination of industries needed to produce different products, the impact per pound (£) spent of 356 product groups and over 50 distinct consumption categories can be calculated.

To provide a consistent set of results at the national, regional and local level, REAP combines physical data on energy and fuel use with monetary data on household and government expenditure. Using this approach, REAP can account for the full supply chain impacts associated with the food people eat, the clothes they buy, the way they travel as well as how they heat and light their homes. This allows the user to look at the impacts of individual consumption activities in the context of lifestyles as a whole.

CREATING REAP SCENARIOS

Scenarios are stories of the future: they can be used to test ideas, challenge assumptions and compare policies. Scenarios created in REAP are quantifiable but entirely user-defined. In REAP, the user can alter over 200 variables and explore their effect on the environmental indicators.

The variables that can be altered in REAP broadly fit with the way debates on human interaction with the environment are conceptualised. In 1971 Ehrlich³ explained how the Environmental Impacts (I) of a given population can be influenced by three major determinants: Population (P), Affluence (A) and Technology (T). Population refers to population size, Affluence to wealth or income and Technol-

1 The Global Trade Analysis Project. <https://www.gtap.agecon.purdue.edu/>

2 <http://www.sec.gov/edgar/aboutedgar.htm>

3 The IPAT equation is generally credited to the ecologist Paul Ehrlich who looked at the sources of environmental impact in the 1970s.

ogy to industrial efficiency. The resulting formula is commonly referred to as IPAT and forms the basis of many debates on human interaction with the environment:

$$\text{Environmental Impact} = \text{Population} * \text{Affluence} * \text{Technology}$$

This formula is the basis for the REAP scenario editor. Environmental pressures are determined by the size of the population, the level of consumption activities and the efficiency with which goods and services are produced. More precisely, the user can change the following variables:

Population

- The user can change the population and number of households over time.

Consumption

- Expressed as total household demand for domestically produced or imported goods and services. The scenario editor is set up so the user can alter per-capita expenditure on food, consumables, durables and services. Expenditure is split so that it is possible to change expenditure on imports and domestic products and services.
- Household consumption basket. Changing household expenditure can also be used to alter patterns of expenditure. This means that scenarios can be created that alter the average diet or represent a shift from products to services. This has the advantage of allowing the user to measure the effect of reallocating money saved in one area to spending on another. In some cases, this can lead to an increase in consumer emissions, this is known as the rebound effect.
- Household energy use. This component of the scenario editor uses kWh data, to show the average fossil fuel and electricity used by a household. The user can change the total amount and mix of energy consumption over time.
- Resident travel behaviour. The user can change the average distance (km) travelled by residents a year for seven modes of transport. For each mode of transport it is also possible to change average occupancy and efficiency (i.e. g CO₂ / passenger km).

Technology

- Energy mix. REAP shows a baseline energy mix for each industrial sector. The user can alter the energy mix of the entire global economy or for specific industrial sectors. Through the input-output model this changes the environmental pressure associated with products which the sectors supply.
- Industrial energy demand. The user can define how total energy use by sector will change over time within the scenario. This can be used to explore the extent to which improvements in the energy efficiency of industrial sectors offsets the impact of increasing levels of consumption.

For each scenario variable the user has two decisions to make. Firstly, it is necessary to define the extent to which the variable will change. This could be a percentage increase in renewable energy or an increase in the average distance travelled by plane. Secondly, it is necessary to set the time over which the change occurs. REAP allows the user to set a positive or negative growth rate for up to 50 years, implement a change by a defined year or specify a value for a variable for every single year.

The coefficients in REAP calculate the environmental consequences of changes to each variable but it is the user that must decide the extent to which the variable changes in the first place. This provides the scenario editor with maximum flexibility but places a requirement on the user to translate policy ideas into quantifiable changes in the production or consumption side of the economy.

Scenarios are constructed based on a combination of data sources, value judgments, local knowledge and assumptions. Data on the impact of loft insulation on energy consumption may be combined

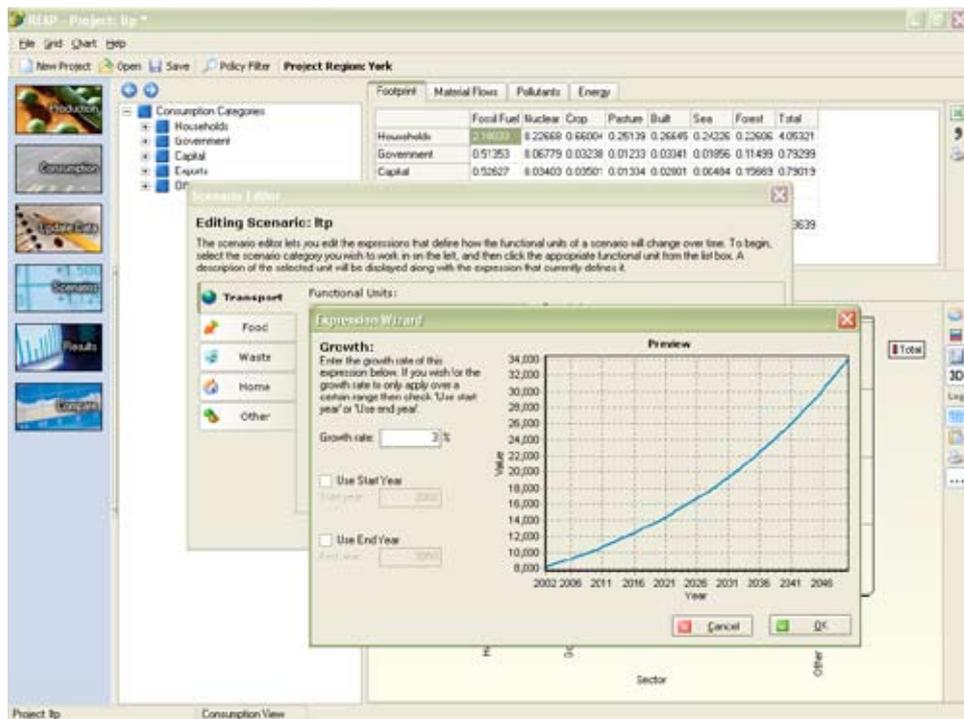


Figure 2: REAP Scenario editor

with local plans that set out the number of homes that will be insulated in a year and local data on existing energy use levels. In many cases the data will include some generalisations as it will not be possible to take into account every variation that may occur. What is important is that the scenario developed matches the application. Simple scenarios can be constructed in a matter of minutes; those which could be used to inform policy development may require a week of background work.

Commonly, the REAP user sets a target for a cut in environmental impact by a certain year. Alternative scenarios can then be developed that change population, consumption and technology levels over time and show different ways the target could be met. Often, the changes required to meet the target require action that falls outside the direct control of any one organisation. The scenarios generated by REAP can be used to encourage discussion and collaboration between policy areas and across organisations.

The development of scenarios can also encourage users to take a more strategic perspective on policy decisions. Sometimes there is a temptation to focus on ‘totem policies’ that appear practical to implement and which people think will make a difference. But these only represent part of the picture and may be complimented or contradicted by other trends and policy decisions. REAP scenarios can be used to compare policies targeted at individual activities or set them in the context of the production and consumption system as a whole. As such they form part of the decision making process and, when used appropriately, have many applications to policy.

THE REAP FAMILY

REAP belongs to a family of models created by Stockholm Environment Institute (SEI), to convert the input-output approach into evidence that supports sustainable development. The REAP tool was

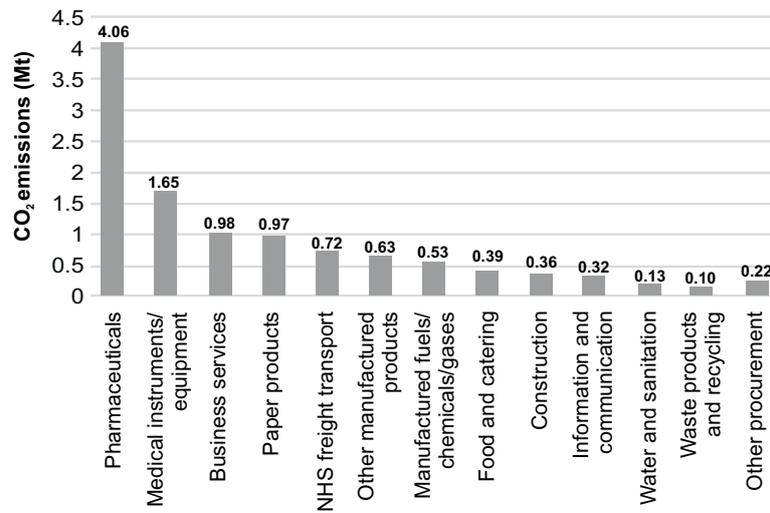


Figure 3: NHS Procurement Emissions

launched in 2006 as part of the Ecological Budget UK project funded by Biffaward⁴. Since then the input-output based methodology behind REAP has been used by SEI to create a family of models all promoting sustainable development.

Whereas REAP takes a complete view of the economy and associated environmental impacts, a number of follow-up models look at different sectors of the economy in more detail. A specific focus has been on government spending with tools developed to look at the impact of the UK education sector and the National Health Service (NHS) in particular.

The REAP tools designed for education and the NHS use the same basic structure as REAP. They each hold baseline data on global greenhouse gases throughout the supply chain associated with educational or NHS activities. They also contain scenario editors which include pre-determined scenarios as well as flexible user defined variables that can be changed over time.

Using input-output tables to account for the emissions associated with the supply chain, is an important component of the education and NHS tools. The NHS is the largest public sector employer in Europe and 60 per cent of its emissions are associated with the manufacture and transportation of NHS purchased goods and services. Exploring how these emissions could be reduced through scenarios supported the development of an NHS carbon reduction strategy for England that covered all areas of the organisation's activity, not just its direct energy use and travel.

Another approach taken by SEI is to use the efficiency factors generated by the input-output tables behind REAP to create calculators that can be used to focus on different applications. REAP efficiency factors describe the consumer emissions per pound (£) spent on different consumption categories. Online footprint calculators use the REAP efficiency factors to calculate individual footprints and a community tool has been developed to support local groups who want to measure their own ecological or carbon footprint. Since its launch on the internet in 2007, a WWF calculator, developed with SEI data has been used 250,000 times⁵. Using these tools, results can be broken down by activity, and compared with those of other groups or individuals. Ways of reducing the footprint can be discussed within the context of local issues and wider decisions a community needs to make.

4 <http://www.massbalance.org/>

5 WWF Footprint Calculator <http://footprint.wwf.org.uk/>



Figure 4: WWF Calculator

The same approach was taken to develop REAP Tourism, a software tool designed in collaboration with South West Tourism to calculate the environmental footprint of visitors to any area in the UK. Using this tool the full supply chain emissions of visitors can be calculated by combining visitor numbers with data on visitor expenditure, accommodation choices and recreational behavior for any user-defined area or time period. This means that a user can identify areas of visitor behaviour with a high environmental impact and demonstrate the impact of attracting different types of visitor to an area.

APPLICATIONS AND FUTURE DEVELOPMENT

SEI's mission is to bridge the gap between science and policy. REAP and its associated tools are used to support this mission through the provision of data, policy analysis and capacity building workshops.

Footprint data generated at a national and sub-national level by REAP is published annually online by SEI and is used in a range of government publications and reports including the State of the Countryside Report, Environment Statistics in your Pocket, and regional State of the Environment reports. In the first year data was provided for all 433 local authorities in the UK, it was accessed by users 3,500 times⁶.

Since its UK launch in February 2006 REAP has been used in a wide variety of policy applications and on over 100 projects. The scenario application in REAP has been used to evaluate regional strategies, create footprint reduction roadmaps, and assess sector specific policies on food, transport and housing.

6 The reports can be accessed from <http://www.resource-accounting.org.uk/>

Often REAP projects are undertaken by SEI but REAP is also provided to 20 local authority partners, and through the Sustainable Consumption and Production Network (SCP-NET⁷), to all Regional Assemblies, Regional Observatories, Government Offices and Regional Development Agencies in England.

SEI have delivered REAP based workshops to around 500 policy makers over the last three years, these have been used to support collaboration on climate change across different policy areas and different local authorities as described in the case study below.

Looking to the future, REAP is now being developed at a national level for all members of the EU-27 through the One Planet Economy Network⁸. Versions of REAP containing sub-national data are also being developed for Sweden and the Basque Country in Spain.

CASE STUDY: CREATING HOUSING SCENARIOS IN THE TEES VALLEY

The Environment Agency for England and Wales approached SEI to help provide an environmental perspective to regeneration issues in the Tees Valley in the North East of England. The area is split between five local authorities.

It was agreed that over two days staff from the Environment Agency, a number of regional agencies and each of the Tees Valley local authorities would use REAP to test out a range of alternative futures for housing and transport in the Tees Valley. The results demonstrate how REAP can be used in workshops to inform policy development on a range of issues.

Housing in Tees Valley has a low Carbon Footprint relative to the rest of the UK but the generation of electricity for households and fuel use in the home still account for almost a third of consumer emissions.

To create a housing ‘Business as Usual’ scenario for Tees Valley, SEI took figures from existing plans and targets in the Tees Valley and the North East and entered them into REAP. The results suggested that there may be a 1.8 per cent increase in carbon dioxide emissions associated with the consumption of household fuel and electricity over the next 20 years. Because of projected population decline this worked out as a 5.5 per cent increase per person over the same period.

Provided with the ‘Business as Usual’ results, workshop participants were asked to create alternative scenarios for housing in the Tees Valley. Split into four groups they first had to agree an approach; they could set out to develop policies which they thought would be politically acceptable, would meet the aspirations of the public, would be in line to meet a 60 per cent reduction in carbon dioxide emissions by 2050 or manage a combination of the three.

The workshop participants then chose and agreed the effectiveness of a range of policy interventions. These included housing market renewal through demolition and refurbishment, different rates and energy performance standards for new build and changes to the renewable energy mix. The resulting scenarios are summarised in figure 5.

The alternative scenarios created by workshop participants showed that there were opportunities for introducing further practical measures to reduce the carbon footprint associated with housing by at least 10 per cent over the next 20 years. These scenarios were created before a number of high profile government measures were introduced for housing in the UK.

They also indicated that it was possible to bring about significant reductions in the carbon footprint associated with housing without changing demolition rates or reducing build projections for the Tees Valley. Different groups introduced energy saving measures at different rates and at different levels of penetration but the most effective scenarios combined measures to increase renewable energy, roll out

7 <http://www.scpnet.org.uk/>

8 Website under construction – should be available during 2010.

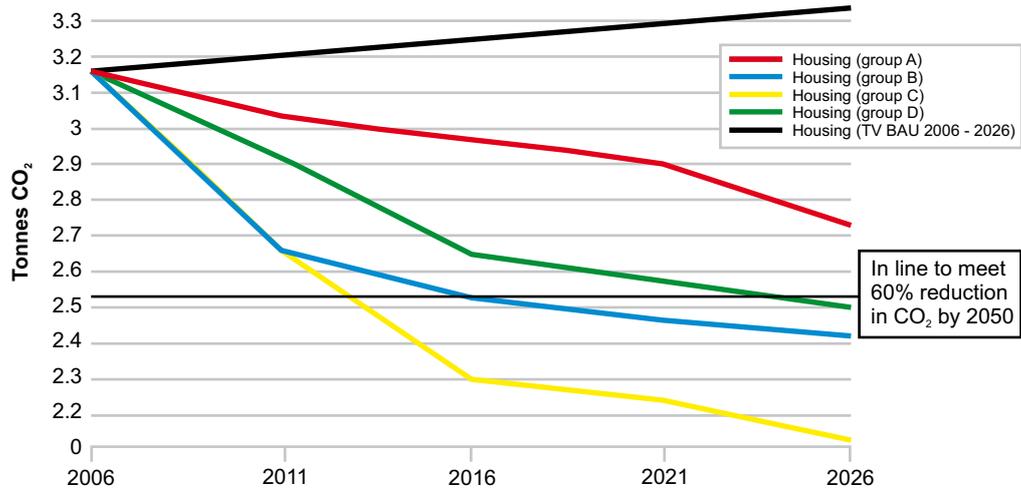


Figure 5: Summary of group scenarios for housing. Annual and overall change shown in per capita figures. Tees Valley 2006-2026

energy efficiency measures in existing homes and improve the energy performance requirements of new homes. The process of using REAP allowed workshop attendees to put numbers to their policies and quantify the extent to which improvements are possible based on different levels of intervention. Because the results were generated and presented back within the workshop environment, this also allowed participants to share and challenge each other's ideas and assumptions. The process used in the Tees Valley has since been repeated by SEI with groups of policy makers all over the UK.

FURTHER READING

Selected journal articles

- Minx, J. *et al.* (2009) Input-output analysis and carbon footprinting: An overview of regional and corporate applications. *Economic Systems Research*, 21(forthcoming December 2009)
- Nye M. and Rydin, Y. (2008) The contribution of ecological footprinting to planning policy development: using REAP to evaluate policies for sustainable housing construction. *Environment and Planning B: Planning and Design*. 35 (2) , 227-247 <http://dx.doi.org/10.1068/b3379>
- Wiedmann, T. (2009) A review of recent multi-region input-output models used for consumption-based emission and resource accounting. *Ecological Economics*, 69(2), 211-222. <http://dx.doi.org/10.1016/j.ecolecon.2009.08.026>

Selected reports

- Assessing the environmental impacts of economic growth on the Environment*. Final Report to the North East Regional Information Partnership. <http://www.nerip.com/library/view.aspx?id=1048>
- Development of an Embedded Carbon Emissions Indicator*. Final Report to the Department for Environment, Food and Rural Affairs. <http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14606>
- Ecological Budget UK* <http://www.ecologicalbudget.org.uk/>
- NHS Carbon Reduction Strategy for England* http://www.sdu.nhs.uk/page.php?area_id=2
- Reducing South East England's Ecological Footprint – A Route Map*. South East England Regional Assembly. http://www.southeast-ra.gov.uk/best_practice.html
- The Right Climate for Change – Using the carbon footprint to reduce CO₂ emissions, a guide for local authorities*. WWF-UK http://assets.wwf.org.uk/downloads/wwf_uktherighttimeweb.pdf

SEI project reports

- Ashford's Footprint – Now and in the Future*
- Carbon Footprint of Housing in the Leeds City Region*
- The Tees Valley Footprint*
- Wales' Ecological Footprint – Scenarios to 2020*.
- All at <http://www.resource-accounting.org.uk/reports>

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The Stockholm Environment Institute

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