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Resource Efficiency

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Editorial

Think big for a resource efficient future

Humanity is demanding ever greater economic productivity at a time when natural resources, the input that feeds this productivity, are dwindling. To reduce pressure on key assets, such as water, minerals, fuel and land, we must use less of them, and we need to increase the efficiency and productivity of resources that we do use, to achieve more output per input. Put simply, we must do more with less. This thematic issue reports on research which helps guide the way to a more resource efficient society.

Developing this society will require large-scale and widespread changes to how the economy functions. However, scientific, economic and social research can play an important role in reaching this goal, by determining current levels of consumption, measuring levels of efficiency, and developing new, more efficient technologies and processes. Furthermore, it can analyse different policy options and help us understand their impact on behaviour and perceptions of resource use.

This issue begins with an overview of overconsumption. **'Report outlines global patterns of resource consumption'** explores the severity and global distribution of resource exploitation. Between 1980 and 2005, the worldwide extraction of resources increased by almost 50 per cent, from 40 billion tonnes to 58 billion tonnes. The article reports a further expected increase in annual resource extraction to 100 billion tonnes by 2030.

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Visioning a future where resources are sustainably consumed is an important exercise. **'Choosing the path towards a sustainable future'** describes the qualities of a future society which does not drive overconsumption in the way our current society does. It suggests that we need to measure social progress in terms of quality of life, social cohesion and environmental protection, not by ever increasing incomes. **'Socio-economic transformation needed to reduce resource extraction'** calls for a new type of industrial revolution to counteract the damaging effects of the last industrial revolution, which led to rapid increases in resource use over the last 150 years.

A number of studies have provided practical guidance reducing resource depletion and increasing resource productivity. For example, the study described in **'Seven steps to improving resource productivity and dematerialisation'** suggests ways in which businesses can balance commercial and environmental concerns. An important step is to define the 'material footprint' of a product or process to better understand how to improve its resource efficiency. **'Resource scarcity threat and eco-innovation demand EU policy response'** suggests EU policy interventions to increase resource efficiency. For example, the Eco-Design Directive could be reformed to include material intensity as well as energy use. **'International cooperation needed to prevent depletion of resources'** calls for coordinated efforts between OECD and non-OECD nations to promote efficient use of resources in order to protect the environment and key industries.

Measuring resource use and efficiency is essential to understanding the physical basis of the global economic system and driving progress towards an efficient world. However, **'Material Productivity as consumption indicator needs careful interpretation'** suggests that Material Productivity (MP) may not be appropriate as an international indicator of environmental progress as it favours high-income countries even though they tend to have the highest level of resource use. Alternative indicators are required. **'Total cost accounting helps reduce resource use in manufacturing'** provides a way of measuring resource sustainability for industry. Taking electronic transformers as a case study, this approach demonstrates that copper is a more sustainable choice of metal. One limited resource that is receiving deserved attention is phosphorus. Phosphorus fertilisers are essential to modern agriculture and food security, but their source, phosphate rocks, are being depleted.

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'More efficient use of phosphorus needed' highlights concerns about this precious resource and proposes measures for increasing its efficiency.

Energy is also a clear example of an area where we need to be much more efficient. Technological efficiencies go some way to realising this goal, but social research, described in **'Behavioural change essential to lowering energy use in the home'**, explains that technological change alone is not enough. Lifestyle changes are also needed to reduce our use of finite fossil fuels and minimise greenhouse gas emissions.

There are some concerns that using fewer resources will have detrimental effects on employment levels. However, research has suggested that this is not necessarily the case if the bigger picture is considered. Although efficiency increases may cause a drop in employment for sectors that source and produce basic materials, there may be increased employment in sectors that increase the efficient use of materials, such as recycling industries, leading to overall increases in employment. The study's results are outlined in **'Potential for efficient use of materials to boost employment levels'**.

Much research points to a need for an economic transformation to increase resource efficiency. While this is a major challenge, it is an achievable goal; a tenfold increase in resource productivity is possible. We just have to think big. However, thinking big does not mean thinking hastily. Carefully considered, step-by-step changes are essential for a shift to a sustainable future. For example, cycles of capital stock renewal can be accelerated slowly, and we can prevent investment in wasteful installations and infrastructures. Active price policy (making energy prices rise more or less in parallel with documented energy productivity gains) could be the most elegant and least bureaucratic instrument for spurring energy and resource efficiency.

Policy thus needs to be long-term and consistent and, while national policies can still be effective, given the global nature of resource consumption, internationally harmonised policy will make the task of reaching a resource efficient future a smoother operation. Research that elucidates the complexity of resource use, such as that highlighted in this issue, will help shape long-term, future policies.

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Report outlines global patterns of resource consumption

People are using more of the Earth's natural resources than ever before, seriously harming the environment and placing the well-being of future generations at risk. A recent report finds that Europe is particularly reliant on imported resources and proposes actions to help societies move towards a more sustainable way of using resources.

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"Most resources are extracted from developing nations, where working conditions are often poor and environmental deterioration is remarkable."

Ecosystems across the world supply humankind with natural resources, including water, energy, land, food and raw materials for housing and industries. But growing populations and greater economic prosperity in many parts of the world has led to dramatic increases in the consumption of resources: between 1980 and 2005, the worldwide extraction of resources increased by almost 50 per cent, (from 40 billion tonnes to 58 billion tonnes) and is projected to increase to 100 billion tonnes by 2030.

The report argues that richer nations, such as in Europe, will have to substantially decrease their use of resources, to allow people in poorer countries better access to resources to improve their quality of life. Most resources are extracted from developing nations, where working conditions are often poor and environmental deterioration is remarkable. For example, in 2005, nearly half (48 per cent) of global resources were extracted from Asia, which is home to over half of the world's population.

Global demand for raw materials and products has significantly driven international trade over the last 50 years. Of all the major regions in the world, Europe has the highest net imports of natural resources, equivalent to almost 3 tonnes for every person in Europe each year.

Consumption patterns vary widely across the world. On average, a North American consumes 90 kg of resources per day, Europeans consume 45 kg each a day, in Asia, each person consumes 14 kg a day and Africans consume 10 kg a day each.

Improvements in the efficient use of resources have occurred, but economic growth has outstripped these gains and resource extraction and use continue to rise globally. It is not possible for natural resources to continue to be used at the same rate as in the past. Many non-renewable resources, such as oil, are estimated to be close to their peak levels of extraction and shortages are driving up prices.

Short-term measures to achieve this goal include: encouraging businesses to be more innovative in resource use, in response to higher prices for resources; making resource efficiency standards part of public procurement in Europe, encouraging a change in lifestyle and consumption and increasing recycling rates.

In the longer-term, new ways of growing the economy using fewer resources must be found. The report suggests society should re-focus on non-material aspects of well-being, such as relationships and more leisure time, rather than on material possessions, as is the case in many societies today.

Source: SERI, GLOBAL 2000, Friends of the Earth Europe. 2009. Overconsumption? Our use of the world's natural resources. Vienna/Brussels. The report can be accessed at: www.foeeurope.org/publications/2009/Overconsumption_Sep09.pdf

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Choosing the path towards a sustainable future

The high consumption lifestyles that currently drive much of society are not sustainable, so recent research has explored how society could develop more sustainably over the next century. Resource depletion, climate change, water scarcity, environmental pollution, and alleviating poverty are some of the urgent issues that have to be addressed.

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"If global progress is measured, not by GDP, but by the "quality of development", there would be a shift towards a form of development that is citizen-enhanced, culturally diverse and ecologically committed."

This study developed four different scenarios to see what the world could be like in 2100. The researchers developed the scenarios by focusing on key drivers that move the world closer to or further away from sustainability on a global scale. Factors promoting sustainability are those that de-materialise lifestyles, protect natural resources, promote social stability and resilience, reduce poverty and hunger, mitigate greenhouse gas emissions and preserve habitats.

Of all the four scenarios, the study suggests that the scenario called the 'Great Transition' is the most desirable option. Under this scenario, society measures progress by the quality of life, social cohesion and protection of the environment, not by ever increasing incomes.

Lower birth rates, especially in developing countries, that result from better education and reduced poverty, would see the global population falling by the end of the 21st century, and incomes converge between wealthy and poor regions, as poverty is significantly reduced. Quality of life, such as a shorter working week and more leisure time, is valued over a highly consumerist lifestyle. A smaller population, with less demand on the environment would help protect nature, reduce water demand and increase water security.

There would be improved energy efficiency and savings in a less material-intensive world, less travel and less meat consumption. In addition, energy would come almost entirely from renewable sources. These changes, coupled with conservation of forests and soils, would ensure that global carbon dioxide emissions fall significantly, keeping average global temperature changes below 2ºC.

The other three scenarios analysed present different outcomes. Under the 'Market Forces' scenario, the world economy is driven by free trade and deregulation, and success is measured by increases in GDP. Growing populations, particularly in developing countries where poverty and fertility rates remain high, and persistent poverty would place severe pressure on the environment and human well-being, community cohesion and there would be little improvement in environmental protection.

Under the 'Policy Reform' scenario, only strong leadership and international efforts guide the Market Forces world towards sustainability targets, but the necessary political determination is not yet apparent. Under the 'Fortress World' scenario, there is no attempt made at sustainable development as protectionist elites try to preserve their wealth and increasing numbers of people would be driven into poverty.

If global progress is measured, not by GDP, but by the "quality of development", such as under the Great Transition scenario, there would be a shift towards a form of development that is citizen-enhanced, culturally diverse and ecologically committed. This study argues that this is the best path for increasing people's well-being, promoting equity, and reducing pressures on the environment for a sustainable future.

Source: Raskin, P.D., Electris, C. and Richard A. Rosen, R.A. (2010) The Century Ahead: Searching for Sustainability. *Sustainability.* 2: 2626-2651. This article is free to view at: www.mdpi.com/2071-1050/2/8/2626/

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Socio-economic transformation needed to reduce resource extraction

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A new report has estimated that if business continues as usual, global resource extraction and associated CO_2 emissions could triple by 2050. It concludes a coordinated change across policies is needed with targets for resource extraction, environmental impact and efficiency of supply.

"The worldwide transformation from a predominantly agricultural society to an industrial regime has rapidly increased our use of resources, such as fossil fuels, metals and timber, especially in the second half of the 20th century."

The worldwide transformation from a predominantly agricultural society to an industrial regime has rapidly increased our use of resources, such as fossil fuels, metals and timber, especially in the second half of the 20th century. Newly industrialised and developing countries are playing an increasing role.

The study constructed three scenarios of resource extraction for the year 2050. In the *business-as-usual scenario*, industrial countries maintain the same rate of resource use per capita whilst developing countries catch up. Under this scenario, annual global resource extraction could triple, as would average per capita emissions to 3.2 tons CO_2 per capita, compared to the year 2000.

Under a *moderate contraction and convergence scenario*, industrial countries reduce their rate of resource use by a factor of two, while developing countries catch up to these reduced rates. Compared to 2000, this could produce an increase in annual resource extraction of 40 per cent and an increase in average per capita emissions of nearly 50 per cent (1.6. tons CO_2 per capita).

Under a *tough contraction and convergence scenario*, the consumption levels of resources in 2050 are the same as levels in 2000. It requires industrial countries to reduce their rate of resource use by a factor of 3 to 5 and developing countries by 10-20 per cent. This could decrease per capita emissions of CO_2 by 40 per cent.

These results suggest a need for policy intervention. The study identified four types of policies:

1. Policy targets to ration extraction rates. These need to be negotiated on a global level and adjusted depending on whether the resource can be substituted by acceptable alternatives.
2. Targets on the environmental impact of resource use. IPCC targets, for example, have implications for reductions in the use of fossil fuels, types of biomass use and animal livestock numbers, if severe climate change is to be avoided, and no functioning carbon storage technology is available.
3. Targets on the supply of services to people, in the sense of providing maximum benefit to people at the expense of minimum resources. These would base targets on resource use per capita.
4. Policy targets on economic productivity, i.e. providing maximum income with as few resources as possible. These face problems in deciding at which point in a product's life cycle to measure productivity.

The report suggests that different types of target cannot be set independently and should be applied in a coordinated manner. This could trigger a socio-economic transformation on the same scale as the industrial revolution it seeks to address.

Source: Fischer-Kowalski, M., Krausmann, F., Steinberger, J.K. & Ayres, R.U. (2010) *Towards a low carbon society: Setting targets for a reduction of global resource use*. Social Ecology Working Paper 115, Vienna 2010. Downloadable from: www.uni-klu.ac.at/socec/downloads/WP115_web.pdf

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Seven steps to improving resource productivity and dematerialisation

It is estimated that 90 per cent of natural materials, whether they are ingredients, energy or services, is wasted during the making, delivering and use of goods. A new report has proposed seven practical steps to 'dematerialise' goods by a factor of ten, which could help achieve a balance between commerce and the environment.

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"To evenly distribute consumption among the world's population, it is estimated that natural resource use in industrialised countries should be reduced to one tenth of its present level (the 'factor 10 goal')."

To evenly distribute consumption among the world's population, it is estimated that natural resource use in industrialised countries should be reduced to one tenth of its present level (the "factor 10 goal"). Environmental initiatives tend to focus on output by reducing pollution, effluent and emissions. To make a greater impact, 'dematerialisation', or reductions in material input are also needed.

The study, conducted under the EU Living Lab project[1], introduces the concept of a 'material footprint'. For a product, this is the total input of natural resources required from cradle to point of sale. For a service, it is the material input to deliver this service. To measure this material flow, it proposed the use of MIPS (Material Input Per unit Service or output) where material input is measured in kilograms and the service (output) in a unit appropriate to the service. For example, a car's service would be measured per kilometre travelled, but for a washing machine it would be measured per kilogram of clothes washed.

The report proposed seven steps to increase resource productivity in goods and services.

1. Form a resource efficiency team. The team should involve employees from different departments, such as R&D, maintenance and production. It should be overseen by a co-ordinator to ensure progress towards resource efficiency.
2. Choose a product and define the service it provides. This involves comparing different products and selecting the most suitable for change. Comparisons can be made on qualities such as share in total production or market penetration.
3. Identify the product chain. This involves drawing a diagram of all the processes that are part of the life cycle, from cradle to grave.
4. Assess the current status of the product. The current performance of the product in different stages of its life cycle should be assessed for this, i.e. raw material extraction, production, use and recycling/disposal.
5. Estimate the MIPS of the product. This requires data on the different material inputs into the product or service chain. It allows the identification of the most resource-intensive aspects of the life cycle or "hot spots".
6. Optimise the product and implement eco-innovation. All options for increasing efficiency should be evaluated, and the best chosen.
7. Re-design the product. The product itself can be re-designed, or its service or way of using it could change.

1. LIVING LAB is supported by the European Commission under the Seventh Framework Programme. See: www.livinglabproject.org

Source: Lettenmeier, M., Rohn, H., Liedtke, C. & Schmidt-Bleek, F. (2009) *Resource productivity in 7 steps: How to develop eco-innovative products and services and improve their material footprint.* Wuppertal Institute for Climate, Environment and Energy. Downloadable from: http://factor10.de/__oneclick_uploads/2010/02/7steps_internetversion_final2.pdf.

Resource scarcity threat and eco-innovation demand EU policy response

A new report reviews EU industrial and energy policy development, addressing growing resource scarcity and the urgent need to reduce global resource consumption. Proposed policy interventions include reform of the Eco-design Directive and regional funding mechanisms.

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"Extraction of mineral and biomass resources in the EU has grown by 3 per cent in 25 years, compared with global growth of 48 per cent, but only because the European economy is increasingly dependent on imports."

Extraction of mineral and biomass resources in the EU has grown by 3 per cent in 25 years, compared with global growth of 48 per cent, but only because the European economy is increasingly dependent on imports – it outsources more of its extraction than any other part of the world.

The report, written to support the work of the European Parliament's ITRE Committee[1], recommends speeding up eco-innovation in the EU. This should encompass strategies for 'greening the EU budget': cutting unsustainable spending, and investing the savings in eco-innovation. It identifies two barriers to eco-innovation driving economic resource-efficiency, which the EU must actively address: 1.) policy gaps in the areas of entrepreneurship, pre-commercialisation and mass-market development and 2.) emotional and psychological barriers to uptake of eco-innovation by society.

Tools in the first case include market-based incentives, such as a new minimum tax directive on construction minerals, and reform of existing policies, such as the Eco-design Directive[2], which may be extended from energy use to material intensity and innovation, or CIP[3], which favours recycling technologies over new resource-efficient technologies. Additionally, the energy performance of buildings directive[4] is insufficiently implemented. Industry engagement is considered essential for leadership on social change, creating products and communicating demand via service-oriented business models.

Global economic growth has seen rapidly increasing demand and prices for resources and increasing competition may soon lead to conflict. For instance, many reserves have already passed their peak production, including critical rare-earth elements vital for emerging high-tech and environmental industries, such as the photovoltaics sector, which could damage the innovation and economy of the EU. China has already attempted to restrict exports of such elements.

Analysis of resource use is a developing science, but the report outlines three areas of strategic importance and considerable technological interaction: housing, mobility and food. Selected eco-innovations examined include deep, 'green' renovation of housing, electric cars, and community-supported agriculture. Proposals include reducing large-scale infrastructure projects and favouring local development schemes, via reform of regional funding mechanisms; similarly, redirecting CAP funds toward locally-adapted sustainable production strategies.

With European Investment Bank support, integrated rural development and decentralised infrastructure for power and water treatment could promote local eco-innovation, supported by a network of European resource efficiency agencies. Following the gaps identified above, the study also proposes to establish three new initiatives: 1.) A European Trust Funds for Eco-Entrepreneurship to support system innovation driven by new companies; 2.) A Technology Platform for Resource-light industries, to develop new markets for European manufacturing industries; and 3.) A Programme to foster energy and resource efficiency in the building sector.

1. http://www.europarl.europa.eu/committees/itre_home_en.htm
2. http://ec.europa.eu/energy/efficiency/ecodesign/eco_design_en.htm
3. Competitiveness & Innovation framework Programme: http://ec.europa.eu/cip/
4. http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

Source: Bleischwitz, R., Giljum, S., Kuhndt, M. et al. (2009). Eco-innovation – putting the EU on the path to a resource and energy efficient economy. Study and briefing notes. Policy Department, European Parliament.

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International cooperation needed to prevent depletion of resources

Without ambitious new policies, population growth and economic development will push natural resources to their limits by 2030, according to an OECD report. The report calls for action to promote efficient use of resources in order to protect the environment and key industries, and supports cooperation between OECD and non-OECD nations to help achieve this.

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"'Resources' are not just energy and raw materials, such as metals, but also other resources under stress, including water, biodiversity, land and ecosystems."

'Resource efficiency' is a basic business concept. Simply, it means being able to produce more with fewer resources, thus reducing costs and increasing profits. Therefore, the case for improving resource efficiency is economic as well as environmental. The European Commission is currently putting together a roadmap to facilitate the move towards a resource efficient economy. This is scheduled for publication in mid-2011[1].

Both the European Commission and the OECD report recognise that 'resources' are not just energy and raw materials, such as metals, but also other resources under stress, including water, biodiversity, land and ecosystems. The report highlights pressure on these crucial resources and predicts how this pressure will increase by 2030 unless political action is taken. For example, almost 3 billion people already live in areas of severe water stress. This number could increase to more than 3.9 billion without steps to improve water efficiency.

According to the report, unsustainable subsidies and underpricing of natural resources contribute to resource depletion across several sectors. It blames environmentally harmful production-linked subsidies for wasteful and environmentally damaging practices in agriculture. The report suggests that these subsidies should be scrapped, and that new pricing strategies for irrigation water should be introduced to encourage more environmentally responsible use of water. "Getting the prices right", it says, helps to green the economy, whilst keeping the cost of environmental policies low.

The report also highlights a "worrying outlook" for the fisheries industry. Without political action, over-exploitation of fish stocks will not just affect biodiversity, but also those employed in fisheries. Strategies suggested for limiting resource depletion in this industry include regulating catch levels, fishing methods and fishing seasons or zones.

As in other industries, the report recommends further efforts to strengthen international cooperation in order to reduce pressure on fish stocks. The report places a heavy emphasis on OECD countries – including the EU – working together with rapidly developing non-OECD countries, such as Brazil, Russia, India, Indonesia, China and South Africa. Because the greatest growth in income and population will occur in these countries, the report authors believe they should be key partners in addressing global environmental challenges.

The report also notes that political action cannot be limited to environmental ministers. All relevant ministries, including finance, economy and trade, need to take action on environment concerns. Key policy actions include support for basic R&D and business incentives for eco-innovation.

A separate OECD report[2] has also provided recommendations for increasing eco-innovation in industry, which could further encourage resource efficiency. It positions eco-innovation as a key driver of industry efforts to realise 'green growth' in the post-Kyoto era.

Source: OECD. (*2008*). *OECD* Environmental Outlook to 2030. Downloadable from: www.oecd.org/environment/outlookto2030

1. See: http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/10/715&format=HTML&aged=0&language=EN&guiLanguage=en
2. OECD. (2010). Eco-Innovation in Industry: Enabling Green Growth. See: www.oecd.org/document/34/0,3746,en_2649_34173_44416162_1_1_1_1,00.html

Material Productivity as consumption indicator needs careful interpretation

Analyses of global material consumption patterns have suggested that the main indicator of sustainable consumption used at policy level in Europe and the OECD provides only part of the picture. 'Material Productivity' (MP), a commonly used indicator, favours high-income countries, even though these tend to have the highest level of resource use, according to researchers.

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"With global resource scarcity no longer a remote prospect, analysis of material flow indicators is required to understand the physical underpinnings of the global economic system."

Economic development and environmental change are currently driven by global material extraction. 47-59 billion tonnes of resources are estimated to be extracted around the world per year, and this figure is rapidly rising. This trend has raised significant concerns about resource availability, leading to calls for decoupling economic growth from material extraction and consumption.

MP is used to measure how much an economy is decoupled from its physical, material basis, or its 'dematerialisation'. A country's MP is defined as GDP per unit material consumed. Higher MP supposedly implies greater sustainability. Studies have shown that MPs in industrialised countries are gradually increasing as their economies grow at a faster rate than their material consumption, and that global MP has been increasing for over a century.

However, the study suggests the indicator is too simplistic and appears to be linked to income, a result which implies that the physical basis of national economies need fundamentally restructuring to achieve dematerialisation.

The study analysed global flow and consumption of materials, focusing on four broad resource categories – biomass (over 33 per cent of total resources extracted), construction materials (also over 33 per cent), fossil fuels (21 per cent) and industrial ores (10 per cent). These were investigated in relation to population, GDP, land area and climate zones. The analysis used domestic material consumption (DMC) as an indicator of consumption, calculated as Domestic Extraction (DE), minus exports and plus imports.

Higher population clearly led directly to higher consumption, although in all categories, material use is distributed unevenly across populations. For example, the lowest 10 per cent of biomass consumers use only 4.8 per cent of global resources, whilst the upper 10 per cent of consumers use 27 per cent of resources.

Fossil fuel and ore consumption appeared to be more closely linked to GDP than population size, i.e. consumption is dominated by rich nations, the top 10 per cent consuming more than 40 per cent of these resources. The lowest 10 per cent consume less than 0.5 per cent. The analysis highlights the potential pitfalls of increasing use of biomass as biofuels, which could strengthen the link between biomass consumption and economic strength, and further increase global inequality.

Trade was found to be linked to economic activity – import levels reflect GDP, although this relationship is less apparent for exports, particularly for ores and fossil fuels. Large, sparsely inhabited areas of land often indicate production of biomass and industrial ores, leading to large domestic extraction figures. However, these materials are frequently processed before export, in much smaller quantities, to rich trading nations, which disguises the inequity in resource consumption.

With global resource scarcity no longer a remote prospect, analysis of material flow indicators is required to understand the physical underpinnings of the global economic system.

Source: Steinberger, J.K., Krausmann, F., & Eisenmenger, N. (2010) Global patterns of material use: a socioeconomic and geophysical analysis. *Ecological Economics*. 69: 1148-1158.

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Total cost accounting helps reduce resource use in manufacturing

One way of measuring the sustainability of a product over its entire life cycle is to use a 'total cost accounting' approach. A recent study has applied this method to show that copper would be a more sustainable choice of metal to use in transformers than aluminium, primarily because of the high value of recycled copper compared with the price of recycled aluminium.

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"The method assesses all factors that might affect the life cycle of the product, including the intended function of the product over time, the impact of the life cycle production on the environment, and the economic aspects."

With natural, abiotic ('non-living') resources, such as metals and water, around the world being depleted, product manufacture must become sustainable in the longer term. This implies that a range of materials for products or components should be assessed to see which contribute most to the sustainability of a product.

This study demonstrated the total cost accounting approach to measuring the sustainability of a product over the entire product life cycle. The method assesses all factors that might affect the life cycle of the product, including the intended function of the product over time, the impact of the life cycle production on the environment, and the economic aspects, such as the cost-effectiveness of the product and profitability to the business.

In a case study, the total accounting approach was used to decide whether the design of electrical transformers would be more sustainable if the metal windings coiled around the transformer were made from copper or from aluminium.

For both types of metal, the repeated recycling of the metal windings was essential to making the transformers more sustainable. Copper and aluminium metal is lost during the manufacturing processes, as well as during the use of the transformer and end-of-life processing and recycling of the metals, so it is necessary to add virgin metal to the scrap metal recovered for recycling. However, the study suggests it should be possible to retain 87 per cent of copper and 97 per cent of aluminium in the product life cycle.

Using available environmental and other cost data, the total cost (including life-time labour, materials, energy and waste costs) for copper and aluminium metals were compared. Given the higher, and sharply increasing, prices paid for scrap copper metal compared with aluminium scrap, copper would be a better alternative to aluminium in electrical windings for transformers. The cost recovery in the end-of-life use phase outweighs the costs associated with material and energy use during product processing and use. When the end-of-life phase is not considered, the lower production costs for aluminium would favour the use of this metal over copper.

Source: Carlsson, B. (2010) Total Cost as Suitable Indicator in Realization of More Sustainable Product Life Cycles Regarding Utilization of Natural Abiotic Resources. *Journal of Sustainable Development*. 3: 36-59.

More efficient use of phosphorus needed

Phosphorus resources are not threatened in the short-term, but could decline by up to 50 per cent by 2100, according to researchers. Although the predictions are uncertain, they support the need to reduce phosphorus fertiliser use through greater material efficiency measures, such as recycling and better agricultural management.

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"Over time, the rise in phosphorus use is expected to slow. Nevertheless, in 2100 the use of phosphorus is estimated to be between 65 and 115 million tonnes of phosphorus oxide."

Phosphorus fertilisers are essential for global food production and come from non-renewable sources, i.e. phosphate rocks, which are being depleted. The use of phosphorus fertilisers also leads to water pollution, which further supports the need for their sustainable use.

The study provides a systematic assessment of the risks of phosphorus depletion using a model that accounted for four different scenarios of economic and agricultural growth and data on phosphorus resources and consumption, sourced mainly from the US Geological Survey (USGS) and the International Fertilizer Industry Association (IFA).

In all scenarios, phosphorus use was expected to increase, but the amount varied according to the scenario. The amount of phosphorus oxide extracted from phosphate rock, ranged between 49 million and 78 million tonnes in 2030 compared to 44.5 million tonnes in 2000. Over time, a stabilising global population, higher efficiency rates of fertiliser application and improved management practices are expected to slow the rise in phosphorus use. Nevertheless, in 2100 the use of phosphorus is estimated to be between 65 and 115 million tonnes of phosphorus oxide.

In all scenarios, the main use of phosphorus is in fertilisers, with the greatest increase in use in developing countries. Another factor is the increasing amount of meat in diets, which requires more animal feed and therefore more fertiliser to produce the feed. In the short-term, this should not cause extensive depletion of reserves, but by the end of the century, depletion could be between 10 and 65 per cent of the current amount of phosphorus depending on estimations of phosphorus resources. If agriculture continues to rely on large amounts of phosphorus fertilisers, depletion could be in the order of 50 per cent.

Major reductions in the use of phosphorus fertiliser can be achieved through several efficiency measures. Using animal manure as a fertiliser and recycling phosphorus content from human and/or animal excreta will reduce demand. Further reductions can be gained by minimising waste and the erosion of phosphorus-containing soil. Reducing meat consumption could also have an impact, as could using alternatives to phosphates in detergents. Increasing efficiency in phosphorus fertiliser application will also need to be accompanied by greater efficiency in extracting phosphorus reserves to bring noticeable improvements in phosphorus availability.

Source: van Vuuren, D.P., Bouwman, A.F. & Beusen, A.H.W. (2010) Phosphorus demand for the 1970-2100 period: A scenario analysis of resource depletion. *Global Environmental Change*. 20:428-439.

Behavioural change essential to lowering energy use in the home

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Themes: Resource efficiency, sustainable consumption and production.

A recent study suggests relying on technical efficiency improvements in the home to reduce energy consumption is unlikely to produce significant energy savings unless householders also adopt lifestyles with lower consumption habits.

"Surprisingly, residential energy consumption increased, rather than decreased, under some measures of technical energy improvements. For example, well-insulated homes consumed on average 2254 kWh more electricity per year than homes with no insulation."

Lifestyles in developed countries have improved dramatically over the last century, leading to high levels of material consumption. Much of the energy for this development has come from burning fossil fuels. Although using alternative sources of energy will reduce the emissions of greenhouse gases, a reduction in the overall consumption of energy is also needed for a sustainable future. Energy efficient buildings and equipment will contribute to these efforts, but behavioural change could have the greatest impact.

In this study, energy use in households was examined from two perspectives: 1.) technical improvements designed to reduce energy consumption, and 2.) lifestyle and behavioural choices of householders that affect energy consumption. The impact of both approaches on energy conservation was compared.

Technical improvements included the installation of various forms of home insulation, using energy-efficient dishwashers and washing machines, and controlling central heating and air conditioning by thermostats, which reduces energy use. Lifestyle factors that were considered included the size of the home (number of bedrooms and coverage in square feet), the type of home and the installation of luxury appliances, such as hot tubs.

Overall, there was evidence that technological improvements, such as the use of energy-saving washing machines, reduced domestic energy use. However, there was also a strong relationship between lifestyle and energy consumption. The results suggest that families living in detached houses, for example, used 1198 kilowatt hours (kWh) more electricity per year than families living in apartment buildings consisting of two or more units. (In 2005, the annual average electricity consumption of a detached house was 12949 kWh.)

Surprisingly, residential energy consumption increased, rather than decreased, under some measures of technical energy improvements. For example, well-insulated homes consumed on average 2254 kWh more electricity per year than homes with no insulation. (In 2005, the annual average electricity consumption of a well-insulated house was 11835 kWh).

One explanation for this result is that energy savings through technological means can have unintended consequences on peoples' behaviour. For instance, although there may be initial savings for householders on their energy bills, these savings could be spent to enhance home comforts which consume further energy, such as, turning the heating up higher in cold weather, using more air conditioning in hot weather or buying more home appliances and gadgets. This could be evidence of the rebound effect, where the more efficient use of energy eventually leads to greater consumption in the long term.

It appears that technological efficiencies are not enough to compensate for high-consumption lifestyles. Changing lifestyles is thus an important step to increasing resource efficiency and reducing greenhouse gas emissions.

Source: Adua, L. (2010) To cool a sweltering earth: Does energy efficiency improvement offset the climate impacts of lifestyle? *Energy Policy*. 38: 5719–5732.

Potential for efficient use of materials to boost employment levels

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Themes: Sustainable consumption and production, Sustainable development and policy analysis

A new study has estimated the future employment impacts of five innovations that use materials more efficiently. The results indicate there could be small overall increases in employment levels in all cases, however, this may require substantial structural changes in different economic sectors.

"If more plastics are recycled, employment will drop primarily in the plastic production and waste incineration sectors, but this will be counterbalanced by increases in employment in companies that recycle plastics or transport them to recycling plants."

The post-Lisbon goals have highlighted the importance of analysing the economic impacts of policies that encourage environmental innovations. The research analysed five cases of increasing efficiency of material use in Germany and the effects on employment up until the year 2020.

Efficiency increases may cause a drop in employment for sectors that source and produce basic materials, as better efficiency requires less material. However, there may be increased employment in sectors that increase the efficient use of materials, such as companies involved in recycling or producing resource-efficient technologies. The analysis combined modelling results with technological forecasts, expert interviews and scenario analyses to estimate impacts of material efficiency on the economy.

The five case studies were: the sustainable production and use of paper, recycling plastics, prolonging the life span of cars, car sharing and the production of bio-based products, such as oil and textiles made from natural ingredients, including soybeans, flax and jute.

In all case studies, there was a fall in employment in basic material sectors. For example, the sustainable production and use of paper applies various strategies, such as recycling, printing on demand and substituting paper use by increased email communication. Assuming a 10 per cent reduction of paper use, this would have a combined decrease in employment of 40,000 in sectors that produce pulp and paper and in transport sectors. However, there will be an accompanying increase of around 60,000 in employment in sectors, such as collecting paper for recycling, printing on demand and communications technology. This could potentially lead to an overall increase in employment of 27,000 if the development of these 'new' sectors were achievable within Germany.

Similarly, if more plastics are recycled, employment will drop primarily in the plastic production and waste incineration sectors, but this will be counterbalanced by increases in employment in companies that recycle plastics or transport them to recycling plants. The study estimated an overall increase in employment of 2000. Both prolonging the life span of cars and car sharing led to decreases in employment in the car manufacture sector, but possible gains in other sectors, such as car repair and maintenance and industries to organise car-sharing. The estimated increases in total employment from these innovations were 13,000-16,000 each.

Lastly a rise in the use of bio-based products is likely to reduce employment in industries that make equivalent products from traditional materials, such as the petrochemical industry. However, employment in agriculture and new process technology could see positive effects leading to an estimated total increase in employment of about 1000.

Overall, service-orientated sectors tend to benefit. Service sectors tend to be labour intensive and domestically based to a greater degree, which results in small increases in total employment. However, in all case studies there is an assumption that the frameworks are in place to support these shifts of employment to different sectors. In addition, the research tends to assume that gains would occur within Germany, when in reality, services such as recycling, could occur abroad.

Source: Walz, R. (2010). Employment and structural impacts of material efficiency strategies: results from five case studies. *Journal of Cleaner Production*. Doi: 10.1016/j.jclepro.2010.06.023.

A selection of articles on Resource Efficiency from the *Science for Environment Policy* news alert.

Reducing the environmental impact of building materials (10/3/11)

A recent study has compared the environmental impact of a range of building materials. Energy consumption, carbon dioxide emissions and water demand can all be reduced by switching to renewable sources of energy, improving technologies and promoting eco-friendly alternative materials.

Diversification may help water supply problems (6/1/11)

Increases in population and urbanisation are challenging current systems of water supply. A new study has assessed existing examples of alternative supply systems, such as wastewater reclamation, rainfall collection and desalination of seawater. It suggests that adopting several types of system may provide a better and more flexible solution.

Macro-economic models need to widen their perspective (18/11/10)

The recent recession has prompted the adoption of 'return to growth' policies but the tools used to assess growth often have a narrow economic focus. A new report has assessed current macro-economic models and suggests they need to incorporate the impact that environmental factors can have on the economy, and vice versa, and recommends they should consider limits on resource and material consumption.

Public acceptance crucial to success of water recycling systems (18/11/10)

A new study has analysed public perceptions of greywater re-use systems in Barcelona, which are being increasingly employed to save water during times of shortage. Several factors, including perceived health risks, system reliability and maintenance costs, appear to influence public acceptance of the technologies

Managing electricity demand could maximise wind power benefits (15/7/10)

Controlling energy demand instead of supply could help solve the problems of variability associated with wind power, according to new research. In the case of Portugal, it was estimated that measures to reduce electricity demand could reduce the peak consumption by 17.4 per cent in 2020.

Clear identity needed for industrial recycling networks (17/6/10)

Recycling waste products between companies in industrial recycling networks can bring environmental and competitive benefits. A recent study on whether such networks can be used to advance sustainable development more broadly suggests companies first need a clear, shared network identity before other types of sustainability-oriented cooperation can take place.

To view any of these articles in full, please visit: http://ec.europa.eu/environment/integration/research/newsalert/index_en.htm, and search according to article publication date.

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