Climate change and the energy crisis

Alleviating climate change

Robert Goodland and Simon Counsell

Abstract. Addressing climate change will require dramatic policy shifts in the fields of energy, livestock production and forest management. The following paper summarises where we are now and what we need to do, with an emphasis on how multilateral organisations like The World Bank can help to address the challenges ahead.

Forty-six nations and 2.6 billion people are now at risk of being overwhelmed by armed conflict and war related to climate change. A further fifty-six countries face political destabilisation, affecting another 1.2 billion individuals.[1] Climate change is today's biggest threat to international security and will intensify North-South tensions.[2] The world has to end growth in greenhouse gas (GHG) emissions within seven years (by 2015) and reduce emissions by about 80 percent by 2050. At least two-thirds of energy demand over the next twenty-five years will come from developing countries. The world must reduce annual carbon emissions from today's 8 billion tons down to about 2 billion tons to balance the assimilation capacity of the world's carbon sinks (such as oceans, forests, and other biomass).

Climate change is today's biggest threat to international security and will intensify North-South tensions.

The Energy Sector

The energy industry calculates that several thousand billion tons of coal remain in the ground - 150 years' worth at current extraction rates. It is therefore clear that most of the remaining coal has to stay in the ground if we are to avoid climate catastrophe. Three-quarters of coal reserves are in five nations: the United States, Russia, China,

Thus the fate of human civilisation probably hinges on the coal decisions of six nations and on preventing extensive forest fires in three others.

India, and Australia. Canada should be added to the list of critical nations because of the scale of its Athabasca tar sands and boreal peat deposits. Thus the fate of human civilisation probably hinges on the coal decisions of six nations and on preventing extensive forest fires in three others (Brazil, Indonesia, and Congo).

The polluters, the historic emitters of GHG, must pay developing countries to leave coal and oil in the ground, leave their forests intact, and plant trees. In 2007 the World Bank proposed a new fund (the Forest Carbon Partnership Facility, FCPF) that might in principle serve to do that. At the time of writing, however, the details had still not been worked out, and Bank staff have so far refused to rule out that industrial logging in tropical forests will be eligible for FCPF funds. The International GHG Treaty should ban all subsidies to fossil fuels immediately and insist on full-cost pricing for all energy production. The $250Bn in subsidies currently allocated to fossil fuels and nuclear energy should be switched to renewable energy.

Over-reliance on efficiency and carbon trading is a monumental error.

Lighting accounts for 20 percent of global energy use. Over the past decades voluntary switching from 5 percent efficient incandescent light bulbs to 15 percent efficient fluorescents has not worked; incandescents must be banned outright. More efficient and with much longer lives? than compact fluorescents, LEDs (Light Emitting Diodes) are already available. The even newer Ceravision lamp has no electrodes, is 50 percent efficient, and does not wear out. Pricing, codes, and policies are all needed to accelerate uptake of efficient technologies.

Picture 1. (*Courtesy Nigel Dudley, Equilibrium Research*)

Energy efficiency

Over-reliance on efficiency and carbon trading is a monumental error. Neither reduces the causes of climate change or the amount of GHG emitted. The term "carbon trading" conflates "cap-give-away quotas-and trade" with "cap-auction-trade." In both cases the cap is to the good, but giving away the rights to historical polluters means blessing the existing theft of the commons and letting scarcity rents go to private corporations rather than capturing them for public revenue. Trading at the national level, and maybe at a regulated international level, may be useful. Carbon emitters have to pay a higher price more commensurate with their pollution, and trading opens up a source of funds to transfer to the poor. A global carbon tax might do all this better.[3] A policy of sustainability first, leading to efficiency second, should be the first design principle for energy and climate policy.

The entire world demand for electricity could be met from 254 x 254 km of Sahara desert.

Ecological tax reform is a big part of the solution: a stiff severance tax on carbon levied at the wellhead and mine mouth, accompanied by equalizing tariffs on carbon-intensive imports and rebating the revenues by abolishing regressive taxes on low incomes. Such a policy would reduce carbon use, spur the development of less carbon-intensive technologies, and redistribute income progressively. Higher input price (on fossil fuels or carbon content) induces efficiency at all subsequent stages of the production process, and limiting depletion ultimately limits pollution.[4]

The transition to renewable energy should be accelerated as urgently as possible. Although most (such as geothermal) is site-specific, the potential is limitless. For example it has been calculated that wind energy in the Dakotas could supply adequate electricity to the whole USA. The entire world demand for electricity could be met from 254 x 254 km of Sahara desert. Desertic nations should be financially encouraged to export solar electricity and eventually hydrogen from water. Offshore wind, wave, current, and tidal power could become the backbone of the UK's electricity.[5]

No reliance should be placed on "clean coal" because it does not yet exist.

Coal

There is increasing support for banning all new coal-fired power plants that do not have provisions for CO_2 capture and sequestration. Since wind-generated electricity is already economic relative to coal with sequestration, there is no reason to allow the building of new power plants that would emit large amounts of CO_2 for decades.[6] Care must be taken to ensure that all former coal industry employees are retrained for sustainable jobs or fully compensated. Boosting efficiency by retrofitting existing coal power plants should be accelerated, as should phase-out of the dirtiest coal plants.

Clean Coal

No reliance should be placed on "clean coal" because it does not yet exist. It could become available after 2020, too late for the climate crisis. In any event, if clean coal is achieved, it will be about 25 percent more expensive and nearly impossible to monitor. Carbon capture and sequestration (CCS) technology is being experimented with, but on 30 January 2008, the US government cancelled its first pilot CCS project (FutureGen in Matoon, Illinois) after five years of costly delays. No replacement plans have been announced.

The era of cheap oil is already over; exploration for new deposits should be discouraged.

The intense focus of institutions such as The World Bank on coal efficiency and clean coal prevents developing countries from leap-frogging past the dirty energy phase of development, a mistake industrial countries are paying for dearly. China looks set to surpass the United States to become the world's largest energy consumer after 2010. China opens more than two new 600MW coal-fired power plants a week;[7] not one is capable of being readily retrofitted with future carbon sequestration technology. Each new coal plant emits about 15,000 metric tons of CO_2 per day. Coal accounts for more than 80 percent of China's carbon emissions.

Carbon sequestration

There is scope for carbon sequestration by reducing deforestation, planting trees and managing land on a global scale. However, extreme caution is needed to ensure that such plantation schemes do not undermine the rights or livelihoods of poor people living in what are sometimes viewed as "degraded" forest environments, but which actually comprise occupied subsistence farmland. In addition, micro-algae have been demonstrated to sequester more than 80 percent of daytime CO_2 emissions from power plants and can be used to produce up to 10,000 gallons of liquid fuel per acre per year.[8]

Oil

It seems likely that the world cannot afford to burn its remaining oil. The era of cheap oil is already over; exploration for new deposits should be discouraged. Canadian tar sands should be left in place and re-vegetated.

Natural Gas

Natural gas is 'cleaner' than coal: It contains 70 percent less carbon per unit of energy than coal. As the transition to renewables will be wrenching, natural gas will have a role as a bridging fuel. But gas leaks are inevitable, it (methane) is 21 times more climate forcing than CO_2, and liquefaction, transport and regasification emit substantial quantities of GHG, so the gains are limited and temporary.

As the transition to renewables will be wrenching, natural gas will have a role as a bridging fuel.

Nuclear Energy

Nuclear energy is not a panacea. Full environmental and social costing, including the risk of terrorism and accidents and the diversion of radioactive materials to weaponry, must be mandated. The industry must pay for permanent storage of nuclear wastes. All waste storage and insurance against accidents must be the responsibility of the nuclear industry from now on. All subsidies to the nuclear industry must cease and preferably be reallocated to renewable forms of energy.

Hydroprojects

Reservoirs are the largest single source of anthropogenic methane emissions, contributing around a quarter of these emissions, or more than 4 percent of global GHG emissions. The recommendations of the World Commission on Dams[9] should be followed. In particular, hydroelectric projects likely to emit substantial amounts of GHG should be banned. Carbon emissions from any dam should be subject to the proposed global carbon tax.

Hydrogen fuel cells to promote the "hydrogen economy" may prove to be among the best bets for temporary subsidies.

Hydrogen

Generating hydrogen from fully renewable energy systems (such as solar and wind) by electrolyzing water (even sea water) seems hopeful. This is one of the main technologies for research. Hydrogen fuel cells to promote the "hydrogen economy" may prove to be among the best bets for temporary subsidies.

Caveat on Carbon Trading

The *International Carbon Procurement Vehicles Investor's Guide* (2007)[10] notes that more than 50 carbon funds exist and nearly €6 billion of capital has already been invested in them. They offer investors a diverse menu of opportunities for participating in the carbon market. However, analysts argue that conclude that the carbon trading approach to the problem of rapid climate change is fraught at present and ineffective.[11]

Box 1. Contraction and Convergence

Contraction and Convergence (C&C) is a global framework for reducing GHG emissions to a safe level. C&C was designed by the Global Commons Institute for the Intergovernmental Panel on Climate Change and the UN Framework Convention on Climate Change.[12] Longtime industrialised countries, which have produced the bulk of greenhouse gases, bear a much larger burden in preventing climate change; therefore they will have to play a leadership role, both regarding drastic emissions reduction and development of low- or no-carbon technologies to provide room to poor developing countries for economic development within the boundaries of a global carbon regime.

C&C is based on the science of limits and the principle of carbon justice, striving for convergence to equal-per-capita emissions rights, assisted by a medium-term, multistage approach accounting for differentiated national capacities. "Contraction" means global emissions are reduced in total over time so the concentration of greenhouse gas in the atmosphere stabilises at a level low enough and soon enough to prevent dangerous rates of climate change from taking hold. "Convergence" means that subject to this global limit, initial entitlements to emit carbon are distributed to all the countries or regions of the world with an agreed process of convergence to equalise per capita emissions entitlements across the planet.

During contraction and convergence, entitlements are assumed to be tradable and hence must be capped, with quotas initially distributed to the government, which then auctions them to users who are allowed to re-sell them. C&C also could work using the carbon tax rather than cap and auction-and-trade.

Caveat on Cap-and-Trade Schemes

Cap-and-trade schemes do not reduce GHG emissions; they merely allocate emissions costs, depending on where the cap is set. Clearly the cap could and should be set well below current usage. Cap-and-trade history shows that allowances are perversely handed out to major carbon emitters, who can use them or sell them at market rates. A growing consensus warns that carbon trading, and in particular the idea of offsetting carbon emissions, may be hurting, not helping, efforts to ensure a safe climate future. Cap-and-trade proponents argue that trading the right to emit CO_2 allows firms and nations to decide whether they should spend money on cutting pollution or on buying the right to pollute by paying someone else to cut back.

Most of the carbon credits being sold to industrialised countries come from polluting projects. Projects should be net reducers of carbon to have a credit to sell. Burning methane from coal mines or waste dumps for energy does little to wean the world from fossil fuels, but do such activities result in reduction of GHG? The forestry and carbon sink projects proposed for inclusion in the Clean Development Mechanism are a way for industrialised countries, responsible for 75 percent of greenhouse gas emissions, to obtain access to cheap ways of buying emission rights without committing themselves to reducing their emissions. At least they have to pay more to emit, and what they pay goes to a country that has not used its quota. GHG emission reductions must become the overriding priority and are achieved by a low cap, not by trading. Almost all such reductions must come from the polluters, namely the industrial nations.

Climate Geo-engineering

Schemes to increase the earth's albedo to reflect more sunlight back into space would need thorough environmental assessments well beforehand. For a life form that lives on solar radiation to block more of it from the earth to permit more rapid consumption of nonrenewable energy seems perverse. The hope that iron fertilisation of oceans will boost C-sink capacity seems risky. None of these ideas seems at all attractive to date and may postpone reductions in GHG emissions.

Box 2. Sector Solutions to Reduce Climate Risks

Transportation: Pedestrianism (including moving walkways) and non-motorised transport (such as bicycles) must become the priority. Transportation will become almost entirely electricity-driven. Mopeds and other electric and fuel-cell vehicles should become common and feasible through urban planning. Mass transit (electric) systems should become the norm; modal shifts to inter- and intra-city (electric) rail, and water transport should be encouraged. New highways are problematic. Air transport is likely to decline until renewable low- or zero-carbon fuels (such as solar hydrogen) become available.

Buildings: Changes include rehabilitation of existing building stock, insulation, solar windows with high insulation (which reflect heat in the hot season and absorb heat in the cold season), new lighting technology (compact fluorescents, LED bulbs), efficiency standards for water heating, refrigeration and other appliances, rooftop and parking-lot solar systems.

Industry: The most energy-intensive industries should be phased down. Combined heat and power systems will become commonplace. Industry must facilitate recyclability of its products. Industry should progress toward closed-loop manufacturing in which there is no waste. Wastes and waste disposal should be taxed to provide incentives for industry to recycle.

Urban and Municipal Authorities: Telecommuting should become the norm; working from home would reduce congestion and transport costs. Urban design should prioritise pedestrianism and facilitate bicycles. Other developments include solar-roofed parking lots, district heating systems, combined heat and power, efficient street lighting, efficient water pumping, waterless composting sanitation (with no new water-based sewage systems), recycling of water, collection of rain, composting of all organics.

Agricultural: Innovations include efficient solar and wind irrigation pumps, solar and wind-powered desalination, rainwater harvesting, water conservation, trickle irrigation, irrigation of food crops only, with none for fodder or livestock. There may be a role for the lowest-impact irrigation reservoirs.

Agrifuels produce more GHG than the fossil fuel they displace. If all costs are internalised, agrifuels will become uneconomic.[13] Diversion of crops to fuel reduces food availability, the prices of which are therefore soaring worldwide. In addition, 9,000 liters of water are needed to produce about one liter of agrifuel. There may be some benefit in the future from cellulosic and algal fuels, but they are still experimental. Livestock contribute more to GHG emissions than any other form of agriculture, and forests are often burned or destroyed to make room for ranches. Livestock constitute the least efficient form of producing human food and consume more water than any other product.

Livestock

The agriculture sector is generally agreed to account for one-quarter of GHG emissions, of which deforestation and livestock are the main elements. One journal estimated that 23

Picture 2. (*Courtesy Nigel Dudley, Equilibrium Research*)

percent of global carbon emissions derive merely from keeping livestock alive.[14] The FAO[15] provided a lower but still startlingly high estimate of 18 percent of GHGs attributable to the raising, processing, and transportation of livestock and their products. A 2006 Sierra Club report[16] estimated that the proportion of GHGs attributable to livestock may be 40 percent or higher.

However, the Food and Agricultural Organisation projects a doubling of livestock numbers in the next few decades. Reducing livestock consumption should be a key aim of greenhouse reduction policies.[17]

Commendably the World Bank published a Livestock Strategy in 2001, stating that the Bank would "avoid funding large-scale commercial, grain-fed feedlot systems and industrial milk, pork, and poultry production except to improve the public good areas of environment and food safety." Since then the International Bank for Reconciliation and Development (IBRD) and International Development Agency (IDA) branches of the Bank Group have not funded a single large-scale livestock project. However the International Finance Corporation (IFC) has stated that it need not abide by the World Bank's livestock strategy, and since the strategy appeared in 2001, IFC has invested US$732M to promote twenty-two livestock production projects, dwarfing and undermining IBRD/IDA's comparatively modest financing to reduce deforestation and GHG emissions. Almost all of IFC's projects involve precisely the type of livestock system that the World Bank's livestock strategy seeks to avoid: large integrated producers rather than small mixed farmers.

Agrifuels produce more GHG than the fossil fuel they displace. If all costs are internalised, agrifuels will become uneconomic.

The agriculture sector is generally agreed to account for one-quarter of GHG emissions, of which deforestation and livestock are the main elements.

Better results for the food industry—including producers (especially family farmers)— and consumers, nutrition, public health, and the environment, have clearly been seen when financial resources have been provided, both to producers to provide and market healthy products and to public health groups to conduct public-awareness campaigns.

Scarce agricultural development resources are more economically allocated to promoting increased accessibility by the poor to healthful foods, because such foods provide lower risks and impacts for the environment and public health, are more efficient in resource use, and are more equitable to poor farmers. Since most meat and dairy products are now available in soy-based versions, this alternative would not require lowering nutritional standards; on the contrary, it would improve them.[18]

Forest Policy

More than 35 million acres of tropical forests are destroyed annually (particularly in developing countries), releasing more than 1.5 billion metric tons of CO_2, methane, and NOx into the atmosphere every year. Climate change is intensifying drought and the risk of forest fires. In some years, like the 1997-1998 El Niño year when fires released some 2 billion tons of carbon from peat swamps alone in Indonesia, emissions are more than twice that.

Serious technical challenges remain to the inclusion of forest carbon issues in any binding agreement on climate, not least because monitoring of carbon balances and flux from forests is practically difficult and poorly developed.

The omission of avoided deforestation from the Kyoto treaty resulted from concerns about the environmental effectiveness of the process, particularly since it would be difficult to enforce agreements by developing nations. Some environmentalists fear nations might sign up to secure one area, shifting deforestation elsewhere but bringing no net gain. Serious technical challenges remain to the inclusion of forest carbon issues in any binding agreement on climate, not least because monitoring of carbon balances and flux from forests is practically difficult and poorly developed.[19]

The World Bank reports that deforestation accounts for about 20 percent of global carbon emissions, mainly from fires set to clear land. In 2007 the Bank established a US$250m Forest Carbon Partnership Facility (FCPF), which aims to establish pilot activities to enable tropical countries to prepare for the inclusion of "avoided deforestation" in a post-Kyoto agreement in 2012. At the time of writing the FCPF had received the backing of the G8 and sign-off from the board, although many important details of the initiative are still under development. The Bank's BioCarbon Fund finances projects that sequester or conserve greenhouse gases in forest, agro, and other ecosystems. BioCarbon Fund projects have to fulfill criteria to ensure that the fund meets its own targets in the areas of climate and environment, poverty alleviation, project management and learning, and portfolio balance. Each BioCarbon Fund project is expected to deliver between 400,000 and 800,000 tons of CO_2 equivalents (CO_2e) over a period of ten to fifteen years. In return a typical project will receive about US$2-3 million in payments (US$3-4 per ton CO_2.[20] It is still too soon to judge the extent to which this can reduce atmospheric GHG.

However, the Bank's own policies sometimes seem to be at odds. The US$80m Amazon Region Protected Areas Project expands Brazil's protected areas system in the Amazon region as a first phase alone. But this is undermined by IFC's Bertin cattle-ranching projects in the Amazon forest region. The issue of the IFC undercutting other Bank policy calls for more explanation as they are theoretically governed by the same board. Similar IBRD projects finance forest conservation in Mexico (US$45M), Costa Rica (US$32M), and Peru (US$23M). Such initiatives need to be monitored, revised, and

Photo 3. (*Courtesy Nigel Dudley, Equilibrium Research*)

ramped up. In 2007 the Bank's former chief economist and vice president, Lord Nicholas Stern, urged the Bank to desist from financing deforestation as the biggest and most immediate contribution it could make to reducing GHG emissions. However, the Bank has a long track record of funding industrialisation of natural forest areas in the tropics and, more recently, in the former communist countries.[21]

Outright conversion or fragmentation of natural forests for any purpose, such as oil palm plantations, cattle ranching, soy, logging, and mangrove shrimp ponds should cease immediately.

More than 2.5 million acres of Indonesian rainforests are cleared for oil palm plantations, and 3.5 million acres of Amazonian rainforest are cleared every year, primarily for enormous soy fields and cattle ranching.[22] IFC finances oil palm, soy, and cattle ranching in tropical rainforest regions and shrimp cultivation in mangrove forests. For IFC, destruction of tropical rainforest in general is insufficient reason for an Environmental Assessment (EA) Category "A." For example, IFC's US$80 million finance of Indonesia's Wilmar Oil Palm Project in 2006 is EA Category "C." IFC justifies this by writing, "It is anticipated that this project will have minimal or no direct, adverse social or environmental impacts." IFC omits emissions of greenhouse gas, risks to indigenous peoples, and loss of biodiversity.[23]

Outright conversion or fragmentation of natural forests for any purpose, such as oil palm plantations, cattle ranching, soy, logging, and mangrove shrimp ponds should cease immediately. Conservation of forests, prevention of forest burning, remote-sensing detection of logging and fires, and enforcement of laws should be emphasised. The In addition, the G8/ World Bank BioCarbon Fund should increase by orders of magnitude from today's few million dollars to several billion dollars within a very few years, especially in the Congo and Central Africa, Indonesia, Malaysia, Papua New Guinea, Cambodia, Laos, and the Amazon forest nations.

The risks are that incorporating forests into the carbon market would simply guarantee their passing into the hands of big private interests.

The Forest Carbon Partnership Facility should not directly or indirectly fund any activities connected to industrial forestry in any natural or semi-natural forests. It also should not necessarily focus on preparation of avoided-deforestation programs for entry into future forest carbon markets. Instead it should explore and support investigation of the most cost-effective means of protecting forests, particularly through changes to land-tenure and resource-access regimes. It should support the development of Fund-based forest carbon-financing mechanisms instead of only trading mechanisms. The risks are first that incorporating forests into the carbon market would simply guarantee their passing into the hands of big private interests. Second, such funds could trigger further displacement, conflict, and violence to Indigenous Peoples. As forests themselves increase in value, they might perversely be declared off limits' to communities that live in them or depend on them for their livelihoods.

Assist developing countries to plan for and implement a prompt and orderly transition to renewable energy and GHG reduction.

Key Recommendations

The following recommendations are offered to help alleviate climate risks. These roughly ranked recommendations strongly support and are generally consistent with those offered by seven major recent international studies.[24] IEA concludes, "Vigorous, immediate, and collective policy action by all governments is essential to move the world onto a more sustainable energy path."

"Prevention first by reducing GHG emissions; adaptation second"

1. ***Forest Conservation:*** Switch from current financing of industrial logging and forest destruction to support strengthening of tenure rights of forest-based communities, community-based forest management, and more conservation, reforestation, and afforestation for carbon sequestration. This is the most cost-effective GHG measure, according to Lord Nicholas Stern.

2. ***Comply with World Bank Group (WBG) Livestock and Nutrition Rules:*** Instruct IFC to follow all WBG policies and strategies, especially: (a) the Livestock Strategy (no more financing for industrial livestock production), and (b) the Nutrition Strategy, which does not recommend meat consumption. This would be the second most cost-effective method, according to FAO.

3. ***Renewable Energy:*** Switch from current massive financing of fossil fuels rapidly toward renewable energy (solar, wind, wave, tidal, micro-hydro) with conservation and energy efficiency, and especially decentralised systems for the poor. Eliminate all subsidies for fossil fuels. Assist developing countries to plan for and implement a prompt and orderly transition to renewable energy and GHG reduction.
   - **Get the Price Right:** Promote all nations' adoption of clear price signals, such as a global carbon tax to be used as each

nation sees fit. The C-tax must be revenue neutral for the poor.

- ▷ **Contraction and Convergence:** Finance, advise on and otherwise encourage contraction and convergence to reduce GHG emissions. Persuade borrowing member nations to adopt that principle. Support a physical limit (hard cap) that declines to zero before the threshold 2°C rise in temperature occurs.
- ▷ **International Agreements**: Vigorously support the process for the comprehensive post-Kyoto international agreement under the auspices of UN FCCC.
- ▷ **Stringent Energy Standards:** Accelerate improvement of end-use standards commensurate with evolving science for vehicles, lighting, building codes, electric motors, and appliances.
- ▷ **GHG Sources and Sinks:** Monitor GHG emissions and carbon-sink capacities, including oceanic (marine acidification). Implement agreements on deforestation and livestock.

4. ***Prioritise Poverty Reduction:*** Reinvigorate meeting the Millennium Development Goals as the WBG's top priority to reduce poverty and to assist the poor in becoming more resilient to withstand climate impacts. Ramp up direct funding for poverty reduction, job creation, nutrition, education, and health. Move away from indirect and inefficient trickle-down economics.

- ▷ **Adaptation to climate change:** Assist developing countries to adapt to climate change, starting with vulnerability assessments of small island nation states such as the Maldives and deltaic countries such as Bangladesh.

Acknowledgments
We offer sincere thanks for the contributions to this paper from Herman Daly, especially his 2008 paper on the monumental blunder of pursuing efficiency in coal-powered electricity generation before sustainability. Aubrey Meyer kindly helped us with 'Contraction and Convergence'.

Robert Goodland is former chief ecologist at The World Bank. Simon Counsell is director of The Rainforest Foundation in London

Notes

1 Smith 2007.
2 Campbell *et al.* 2007.
3 Daly 2007a.
4 Daly 2007b.
5 Helweg-Larsen and Bull 2007.
6 Wheeler 2008.
7 Martinot and Junfeng 2007.
8 Makhijani 2007.
9 World Commission on Dams 2000.
10 *International Carbon Procurement Vehicles Investor's Guide* 2007.
11 Lohmann *et al.* 2006, Leach 2008.
12 www.gci.org.uk/briefings/ICE.pdf
13 Smolker *et al.* 2007, Searchinger 2008.
14 Calverd 2005.
15 FAO 2006.
16 Sierra Club 2006.
17 Goodland 1998.
18 Chopra *et al.* 2007.
19 Counsell *et al.* 2007.
20 Bosquet 2006.
21 Stern 2007.
22 Bickel 2003, Caruso 2005, Chomitz *et al.* 2007, Dros 2004, Kaimowitz *et al.* 2004, Lilley 2004.
23 Greenpeace 2007.
24 Helweg-Larsen and Bull 2007, GLCA 2007, InterAcademy Council 2007, Makhijani 2008, Practical Action 2007, Wheeler 2008.

References

Barnard, N.D., A. Nicholson, A. and J.L Howard, The medical costs attributable to meat consumption. *Preventive Medicine* 24: 646-655, 1995.

Bickel, U. and J.M. Dros,The Impacts of soybean cultivation on Brazilian ecosystems: Three case studies, WWF Forest Conversion Initiative, WWF, Gland, Switzerland, 2003.

Bosquet, B., The BioCarbon Fund: Using the global market to restore ecosystems: New opportunity for public-private partnerships, The World Bank, Washington DC., 2006.

Calverd, A., A radical approach to Kyoto, *Physics World* p.56. 2005. *Security Implications of Global Climate Change.*

Campbell, K., J. Gulledge, J. McNeill, J. Podesta, P. Ogden, L. Fuerth, R.J. Woolsey, A. Lennon, J. Smith, R. Weitz and D. Mix, *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change*, The Center for Strategic and International Studies (CSIS) & The Center for a New American Security, Washington DC., 2007.

Caruso, E., Roads of deforestation in Brazil: how soya and cattle are destroying the Amazon with the help of the IFC. In: *Broken promises how World Bank Group policies and practice failed to protect forests and forest peoples' rights*, World Rainforest Movement, the Rainforest Foundation, CDM Watch, Global Witness, Sinks Watch, Forest Peoples Programme, Environmental Defense, WRM, Down-to-Earth, 55 p. 2005.

Chomitz, K.M., P. Buys, G. De Luca, T.S. Thomas and S. Wertz-Kanounnikoff, *At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests*, World Bank, Washington, D.C., 2007.

Chopra, M., S. Galbraith and I.Darnton-Hill, A global response to a global problem: the epidemic of over nutrition, *Bulletin of the World Health Organisation* 80 (12): 952-958, 2007.

Cline, W.R., *Global warming and agriculture: end of century estimates by country*. Center for Global Development: Peterson Institute for International Economics, Washington, DC., 2007.

Counsell, S., C. Long and S. Wilson (Eds.), *Concessions to Poverty; The environmental, social and economic impacts of industrial logging concessions in Africa's rainforests*, Rainforest Foundation UK and Forests Monitor, Cambridge, UK, 2007.

Daly, H.E., Ecological economics and sustainable development, Edward Elgar, Cheltenham, 2007a.

Daly, H.E., Climate Policy: from "know how" to "do now". American Meteorological Society, Washington D.C., 2007b.

Dros, J.M., Managing the soy boom: *Two scenarios of soy production expansion in South America*, AIDEnvironment, 2004.

German Advisory Council on Global Change, 2007. Climate change as a security risk. Berlin, WBGU, 15 p. www.wbgu.de.

GLCA (Global Leadership for Climate Action), *Framework for a post-2012 agreement on climate change*, United Nations Foundation Washington D.C., 2007.

Goodland, R., The case against consumption of grain-fed meat (Ch. 6: 95-115) in D. Crocker, and T. Linden (eds.), *The Ethics of Consumption*, Rowman and Littlefield, Lanham MD, 1998.

Greenpeace, *How the oil palm industry is cooking the climate*, Greenpeace International, Amsterdam, 2007.

Helweg-Larsen T. and J. Bull, *Zero Carbon Britain*. Centre for Alternative Technology, Machynlleth, Powys, Wales, 2007.

Kaimowitz, D., B. Mertens, S. Wunder and P. Pacheco, *Hamburger Connection Fuels Amazon Destruction*, Center for International Forestry Research, Bogor, 2004.

Leach, P., *Carbon sunk? The potential impacts of avoided deforestation credits on emissions trading mechanisms,* The Rainforest Foundation, London, 2008.

Lilley, S., *Paving the Amazon with soy: World Bank bows to audit of Maggi loan*. CorpWatch, USA, 2004.

Lohmann, L., N. Hällström, R. Österbergh and O. Nordberg, *Carbon trading: a critical conversation on climate change, privatisation and power.* Development Dialogue, No. 48, Dag Hammarskjöld Foundation, Uppsala, Sweden, 2006.

Makhijani, Arjun., *Carbon-free and nuclear-free: A roadmap for US energy policy.* Rdr Books, Berkeley, 2008.

Martinot, E. and L. Junfeng, Powering China's development: the role of renewable energy, Worldwatch Institute, Washington D.C., 2007.

Practical Action, *Energy to reduce poverty: the urgency for G8 action on climate justice: Stop climate injustice*, Intermediate Technology Development Group, Rugby UK, 2007.

Searchinger T., R. Heimlich R.A. Houghton, F. Dong A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes and T. Yu, Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change, *Science* 319 (5867):1238-1240, 2008.

Sierra Club, http://www.wellfedworld.org/worldbank.htm, 2006.

Smolker, R., B. Tokar, A. Petermann and E. Hernandez, *The real cost of agrofuels: Food, forest and the climate*, Global Forest Coalition.org, 2007.

Stern, N., *The economics of climate change*: The Stern review on the economics of climate change [for the UK Treasury], Norwich UK, 2007.

Wheeler, D., The World Bank can lead the way to zero-emissions power, Carma.org & CGD.org., 2008.

World Commission on Dams, *Dams and development: A new framework for decision-making*, Earthscan, London, 2000.

Nuclear power, global warming and uranium supplies

David Fleming

Abstract. The world's endowment of uranium ore is now so depleted that shortages of uranium— and the lack of realistic alternatives— could lead to interruptions in supply from the middle years of the decade 2010-2019, and will be expected to deepen thereafter. Every stage in the nuclear process, except fission, produces carbon dioxide. As the richest ores are used up, emissions will rise.

Greenhouse gases

Every stage in the life-cycle of nuclear fission uses energy, and most of this energy is derived from fossil fuels. Nuclear power is therefore a substantial source of greenhouse gases. The delivery of electricity into the grid from nuclear power produces, at present, roughly one third as much carbon dioxide as the delivery of the same quantity of electricity from natural gas....[1]

... or, rather, it *would* do so, if the full energy cost of producing electricity from uranium were counted in— including the energy cost of all the waste-disposal commitments. Unfortunately (in part because of the need to allow high-level waste to cool off) that is not the case. Nuclear waste-disposal is being postponed until a later date. This means that the carbon emissions associated with nuclear energy look rather good at the moment: at about 60 grams per kWh they are approximately 16 per cent of the emissions produced by gas-powered electricity generation.[2] The catch is that this figure roughly doubles when the energy-cost of waste-disposal is taken into account, and it grows relentlessly as the industry is forced to turn to lower-grade ores. What lies ahead is the prospect of the remaining ores being of such poor quality that the gas and other fossil fuels used in the nuclear life-cycle would produce less carbon dioxide per kilowatt-hour if they were used directly as fuels to generate electricity.[3]

Carbon dioxide is not the only greenhouse gas released by the nuclear industry. The conversion of one tonne of uranium into an enriched form requires the addition of about half a tonne of fluorine, producing uranium hexafluoride gas (hex) to be used in the centrifuge process. At the end of the process, only the enriched fraction of the gas is actually used in the reactor: the remainder, depleted hex, is left as waste. Not all of this gas can by any means be prevented from escaping into the atmosphere, and most of it will eventually do so unless it is packed into secure containers and finally buried in deep repositories.[4] Hex is a halogenated compound (HC), one of several that are used at various stages of the cycle. HCs are potent greenhouse gases. The global warming potential of freon-114, for instance, is nearly 10,000 times greater than that of the same mass of carbon dioxide.[5] There is no published data on releases of HCs from nuclear energy. A reliable study of all releases of greenhouse gases from the nuclear fuel cycle, and their effect on the atmosphere, were commissioned and published without delay.

The gas and other fossil fuels used in the nuclear life-cycle would produce less carbon dioxide per kilowatt-hour if they were used directly as fuels to generate electricity.

Ore quality

Both the quantity of greenhouse gases

released by nuclear energy per kilowatt hour and the net energy return of the nuclear industry are determined primarily by the quality (grade) of uranium ore being used. The lower the grade of ore, the more energy is needed to mine and mill it and to deal with the larger quantity of tailings. The limit, in theory, is reached with an ore grade of about 0.01 percent for soft rocks such as sandstone, and 0.02 percent for hard rocks such as granite. If grades lower than those limits were to be used, more carbon dioxide per kilowatt hour would be produced by the nuclear cycle than by the same amount of energy produced from gas. The energy return on energy invested (EREI) would be less than the energy return you would get if you generated the electricity directly in a gas turbine.[6]

But these are only "theoretical" limits, because in practice the turning-point to a negative energy return may be substantially sooner. There are five key reasons why ore which is theoretically rich enough to give a positive EREI may in fact not be rich enough to justify exploitation: to yield a *practical* return on energy investment (PREI): increasingly deep deposits; problems with water; difficulties in raising investments for what may be a long payback; local geological conditions; and the relatively small energy contribution from the ore

Where, then, does the practical turning point lie, below which the ore quality is too poor to be useful? We know that this varies with local conditions; but for a worldwide average above which uranium ore can still provide a positive PREI, a suggested guideline is *no lower than 0.1 percent.*[7]

Uranium supply

So— how much uranium ore with a positive PREI do we have left? The "Red Book" is the most authoritative source on the quantity and quality of the remaining uranium ore, and of future prospects for production. It is prepared by the OECD Nuclear Energy Agency (NEA) in partnership with the International Atomic Energy Agency (IAEA), and the 2005 edition was published in June 2006.[8] In its discussion of the availability of usable uranium ore, it suggests that there is 70 years' supply at the current price.[9] It adds, however, that, when "prognosticated and speculative" resources are added in, there is enough to maintain current output for a further 270 years.[10] The figure of 70 years is not dissimilar to that of independent analysts Storm van Leeuwen and Smith, who suggest 60 years.[11] However, the NEA/IAEA expects its prognosticated and speculative reserves to last 270 years. Prognosticated and speculative reserves, if they exist, will be deep below the surface, requiring very large investments of time, capital and energy before they can be exploited. Those speculative resources— which the NEA hopes will one day becomes usable reserves— will need to be remarkably rich, relative to the vast deposits of very low-grade and useless ore of which we are already aware.

There is a widely-shared recognition that there will be a severe shortage of uranium around 2013.

Furthermore, both the NEA and the Storm van Leeuwen and Smith estimates contain assumptions which tend to exaggerate the time remaining before depletion. First, both estimates are "reserves-to-production ratios", which gives the misleading impression that production can continue at a constant rate before coming to an abrupt stop. In fact, it is well understood that production of a resource in its latter years takes its time to decline towards zero; it is in the years *closely following the peak* that the trouble starts. Secondly, the growth in demand for uranium which the nuclear industry seems to expect would, in any case, foreshorten the whole sequence a likely cut-off point on the assumption of increasing demand is probably closer to 35 years. Thirdly, both estimates are of the TREI limits, not the much earlier turning-point to negative PREI. These three factors bring forward the period during which deep deficits in uranium supply can be expected, to the decade 2011-2020.

Supply crunch

And, indeed, there is a widely-shared recognition that there will be a severe shortage of uranium around 2013. This is frankly acknowledged by the NEA itself, and set in context by the First Uranium Corporation.[12]

At present, about 65,000 tonnes of natural uranium are consumed each year in nuclear reactors worldwide.[13] The number of reactors in existence in 2013 will be the product of (1) retirements of old reactors and (2) start-ups of new ones. There is no basis for a reliable estimate of what that net number will be, so we will assume that there is no change from the present.

About 40,000 tonnes of this total demand of 65,000 tonnes are supplied from uranium mines, which leave the remaining 25,000 tonnes to be supplied from other sources.[14] 10,000 tonnes comes from "military uranium"— that is, from the highly-enriched uranium salvaged from nuclear weapons, chiefly from the arsenal which the Soviet Union built up during the Cold War, and which is now being dismantled with the help of subsidies from the United States. The remaining 15,000 tonnes comes from a range of "secondary supplies", consisting of inventories of uranium fuel that have been built up in the past, together with recycled mine tailings and some mixed-oxide fuel (MOX), a mixture of recycled plutonium and depleted uranium.[15] The expectation is that neither of these crucial supplements have much longer to last. Military uranium is being depleted rapidly Russia is getting towards to the end of her supply of obsolete nuclear warheads. There is no chance of the contract being renewed beyond 2013.[16]

Secondary supplies are also in decline. The inventories are approaching exhaustion, and this has been one of the drivers of the recent sharp rise in the price of uranium.[17] The amount of uranium derived from tailings has been falling, and it has been calculated that the scale of the task of increasing production of uranium-235 now would require arrays of continuously-operating gas centrifuge plants running into the millions.[18] The supply of MOX fuel, derived from a reprocessing which is already at its practical limits, is not expected to increase.

2013, the year in which the contract for military uranium expires, can be taken to be a crucial date for uranium prospects. Unless the production of mined uranium can be increased by some 22,000 tonnes per annum, there will be a 35 per cent deficit in uranium supply. So, the question is whether the production of mined uranium can rise to compensate.

Box 1. Dealing with waste

The nuclear industry also has a major problem with the disposal of its own waste products; itself a massively energy intensive process. Unless it starts directing almost the whole of its net energy output to clearing up its own waste in the very near future, the nuclear industry will never produce the energy needed to do so. The planet will be left with leaking, burning and flooding high level waste-dumps in perpetuity. It would be helpful if this task were done before rising sea levels reach the coastal nuclear reactors and the waste dumps in their back gardens.

Can uranium production increase to fill the gap?

Although several of the medium-sised producers have in recent years roughly maintained their output, or slightly increased it— notably Kazakhstan, Namibia, Niger and Russia— the world's two largest producers— Canada and Australia— both show some evidence of being in recent decline, with uranium production falling by (respectively), 15 and 20 percent in 2005-2006.[19]

In both cases, hopes for expanding production have been pinned on major new projects— the new Cigar Lake mine in Canada, and the expansion of Olympic Dam in Australia. Cigar Lake is designed to produce nearly 7,000 tonnes per annum, and it was due to start in 2007. However, in October 2006, it flooded; the probable way of containing the water in the sandstone above the workings is by refrigeration, which will require large inputs of energy even before work can begin. It is now uncertain whether, even after long past and future delays, Cigar Lake will ever be a substantial source of uranium.[20]

Far from expanding in order to sustain the flow of energy following the oil peak, the nuclear industry could indeed begin to falter during the decade 2010-2019

The contribution of Olympic Dam is in some ways even more dubious. At present, it is an underground mine well past its maturity, and the management, BHP Billiton, is considering whether to move to an adjacent ore body with an open pit mine on a massive scale. The problem is that the uranium ore is very low-grade— only 0.06 percent and less, with an average of 0.029 percent, so that it would be uneconomic in money terms if it were not for the copper, gold and silver which the rock also contains. But that itself is a mixed blessing because it means that the copper is contaminated with small quantities of uranium, which has to be removed in a smelter constructed in the Australian desert, adding even greater energy-costs to the final energy yield.[21]

Lovelock's argument is persuasive. But there are three grounds on which it is open to criticism.

On this evidence is seems probable that, far from expanding in order to sustain the flow of energy following the oil peak, the nuclear industry could indeed begin to falter during the decade 2010-2019, with some nuclear reactors being closed down for lack of fuel, and some of the reactors now in the planning stage and under construction remaining unused indefinitely. In the light of this, a judgment has to be made as to whether hopes of a revival of uranium supply are a sufficiently realistic foundation on which to base expectations that the nuclear industry has a long term future as a major energy provider

Alternative uranium sources

Finally, we should consider James Lovelock's robust dismissal of the idea that the growth of nuclear power is likely to be constrained by depletion of its raw material. This is how he deals with it:

"Another flawed idea now circulating is that the world supply of uranium is so small that its use for energy would last only a few years. It is true that if the whole world chose to use uranium as its sole fuel, supplies of easily-mined uranium would soon be exhausted. But there is a superabundance of low-grade uranium ore: most granite, for example, contains enough uranium to make its fuel capacity five times that of an equal mass of coal. India is already preparing to use its abundant supplies of thorium, an alternative fuel, in place of uranium."[22]

Lovelock urges that we have a readily-available stock of fuel in the plutonium that has been accumulated from the reactors that are shortly to be decommissioned. And he might have added that other candidates as sources of nuclear fuel are seawater and phosphates. So, if we put the supposed alternatives to uranium ore in order, this is what we have: (1) granite; (2) fast-breeder reactors using (a) plutonium and (b) thorium; (3) seawater; and (4) phosphates.

Lovelock's argument is persuasive. But there are three grounds on which it is open to criticism.

1. The nuclear fuel cycle

Uranium depletion is not a "flawed idea"; it is a reality that is just a little way ahead. Uranium ore is in increasingly short supply. Sources from granite or seawater are too inefficient to make practical sense. Phosphates might be possible but world production is already struggling to keep up with agricultural requirements. Fast breeder reactors have failed to live up to their promise and widely abandoned; it is highly unlikely that they can be developed quickly enough to address the immediate problems of global warming

The nuclear energy industry is small, providing a mere 2.5 per cent of the world's final energy demand.

2. Alternative energy strategies

Lovelock may underestimate the potential of the fourfold strategy which can be described as "Lean Energy":

1. Energy efficiency: to achieve the decisive improvements in the efficiency of energy-services made possible by the conservation and energy-saving technologies.
2. The proximity principle: to develop the potential for local provision of energy, goods and services. Deep reductions in travel and transport can be expected to come about rapidly and brutally as the oil market breaks down.
3. Renewable energy: to design and build renewable energy systems to match the needs and resources of the particular place and site.
4. Tradable Energy Quotas (TEQs): to define a secure energy budget for the whole economy, involving every energy-user in the common purpose of achieving deep reductions in energy demand.[23]

It cannot be expected that this strategy will fill the energy gap completely, or neatly, or in time, but nor is Lovelock suggesting that nuclear energy could do so. Even if there were neither a uranium-supply problem to restrain the use of nuclear energy, nor a waste-problem, and even if it were the overriding priority for governments around the world, nuclear energy would still fall far short of filling the gap. There are good reasons to believe that Lean Energy could do better. It would start to get results immediately. Per unit of energy-services produced, it would be about ten times cheaper.

3. The oil peak

Lovelock does not give enough weight to the significance of the oil peak. As this weighs in, it will establish conditions in which there is no choice but to conserve energy, whether the urgency of climate change is recognised or not.

Conclusion

The priority for the nuclear industry now should be to use the electricity generated by nuclear power to clean up its own pollution and to phase itself out before events force it to close down abruptly. Contrary to what you might think, given the huge scale of its problems and its supposed status as a fall-back position which could solve our energy problems the nuclear energy industry is small, providing a mere 2.5 per cent of the world's final energy demand.[24] Nuclear power is not a solution to the energy famine brought on by the decline of oil and gas. Nor is it a means of reducing emissions of greenhouse gases. It cannot provide energy solutions, however much we may want it to do so.

David Fleming (fleming@theleaneconomyconnection.net) is director of the Lean Economy Connection and a researcher and writer on energy and the environment, based in London. He is a former chair of the Soil Association.

Notes

1 Storm van Leeuwen and Smith 2006.
2 Storm van Leeuwen 2006a.
3 Oxford Research Group 2006a and 2006b.
4 Storm van Leeuwen 2006c.
5 Nuclear Fuel Energy Balance Calculator 2007.
6 SLS; Storm van Leeuwen 2006b.
7 Note that Rio Tinto (2005) announced a "cut-off grade" of 0.08 per cent for its existing stocks of ore at its Ranger mine in Namibia.
8 NEA/IAEA 2006.
9 Nuclear Energy Agency 2006; The World Nuclear Association 2007b.
10 Nuclear Energy Agency 2006.
11 Oxford Research Group 2006a.
12 Nuclear Energy Agency 2006; First Uranium Corporation 2007.
13 World Nuclear Association 2007b.
14 World Nuclear Association 2007c.
15 Dzhakishev 2004.
16 Bunn 2003.
17 Collell 2005; Zittel and Schindler 2006.
18 Busby 2007a.
19 World Nuclear Association 2007c.
20 Zittel and Schindler 2006.
21 Australia Uranium Association 2007; BHP Billiton 2007; Busby 2007b.
22 Lovelock 2006.
23 Fleming 2007; Womack and Jones 2003.
24 IEA 2007; Boyle 2004.

References

Australia Uranium Association, "Australia's Uranium Mines", www.uic.com.au/emine.htm., 2007.

BHP Billiton, Annual Report, 2007.

Boyle, G., *Renewable Energy*, Oxford, 2004.

Bunn, M., "Reducing Excess Stockpiles", Nuclear Threat Initiative (NTI), www.nti.org/e_research/cnwm/reducing/heudeal.asp, 2003.

Busby, J., "A Little Makes a Lot?" http://www.sandersresearch.com/index.php?option=com_content&task=view&id=1300&Itemid=105. (http://tinyurl.com/35gunk), 2007a.

Busby, J., "An Even Bigger Hole", http://sandersresearch.com/index.php?option=com_content&task=view&id=1323&Itemid=103 (http://tinyurl.com/35pefj), 2007b.

Collell, M. C., "The Nuclear Mirage and the World Energy Situation", Real Instituto Elcano, http://www.realinstitutoelcano.org/analisis/925.asp, 2005.

Dzhakishev, M., "Uranium Production in Kazakhstan as a Potential Source for Covering the World Uranium Shortage", World Nuclear Association, at http://www.world-nuclear.org/sym/2004/dzhakishev.htm, 2004.

First Uranium Corporation, *Annual Information Form* at http://www.firsturanium.com/downloads/2007_annual_information_form.pdf (http://tinyurl.com/28xmy8), 2007.

Fleming, D, *Energy and the Common Purpose: Descending the Energy Staircase with Tradable Energy Quotas (TEQs)*, third edition, London: The Lean Economy Connection, 2007.

International Energy Agency, *Key World Energy Statistics*, http://www.iea.org/textbase/nppdf/free/2007/key_stats_2007.pdf (http://tinyurl.com/2vqztn), 2007.

Lovelock, J., *The Revenge of Gaia*, Penguin, London, 2006.

NEA/IAEA, Nuclear Energy Association / International Agency, *Uranium 2005: Resources, Production and Demand*, (the "Red Book"), OECD, Paris, 2006.

Nuclear Fuel Energy Balance Calculator,at http://www.wise-uranium.org/nfce.html, 2007.

Oxford Research Group, Storm van Leeuwen, "Energy Security and Uranium Reserves", Factsheet 4, http://tinyurl.com/2ntqkt, 2006a.

Oxford Research Group, Storm van Leeuwen, http://tinyurl.com/3atnrd, 2006b.

Rio Tinto, "Increase in Ranger Mine's Reserves and Resources", (press release), http://www.riotinto.com/documents/Media/PR444g, 2005.

Storm van Leeuwen, J.W. and P. Smith, Nuclear Power: The Energy Balance", at http://www.stormsmith.nl/, 2006.

Storm van Leeuwen, J.W., "Greenhouse Gases from Nuclear", Appendix B, in Evidence to the IPCC Working Group III, Fourth Assessment Report Draft for Expert Review, 2006b.

Womack, J. and D. Jones, *Lean Thinking*, second edition, Simon & Schuster, London, 2003.

World Nuclear Association, "World Nuclear Power Reactors and Uranium Requirements, http://www.world-nuclear.org/info/reactors.html, 2007a.

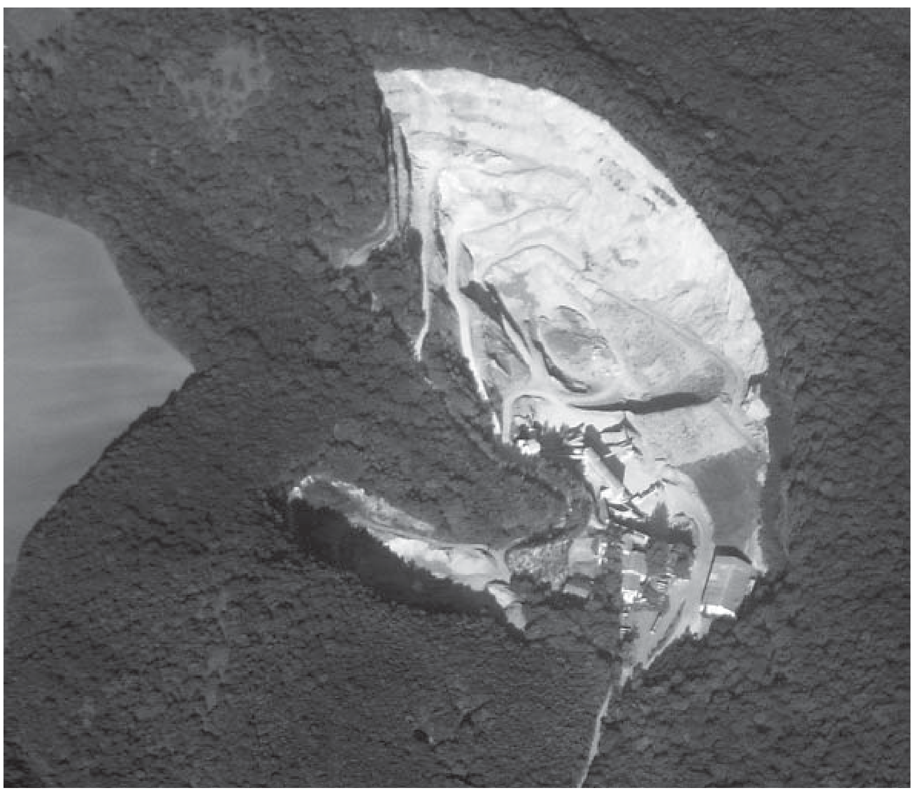
World Nuclear Association, "Uranium Production Figures (1998-2006), www.world-nuclear.org./info/uprod.html, 2007b.

Zittel, W. and J. Schindler, *Uranium Resources and Nuclear Energy*, Energy Watch Group, http://www.energyshortage.com/uran/docs2006/REO-Uranium_5-12-2006.pdf (http://tinyurl.com/2uggkd), 2006.

The differences between biotic and mineral resources and their implications for the conservation-climate debate

Rolf Steppacher and Pascal van Griethuysen

Résumé. Toute tentative de relier les enjeux de la conservation à la question climatique devrait partir d'une distinction préalable entre les ressources biotiques et les ressources minérales sur la base de leurs caractéristiques écologiques et économiques. Les ressources biotiques peuvent être utilisées de manière soutenable mais ne peuvent alimenter un processus de croissance économique exponentielle. Les ressources minérales (et en particulier les combustibles fossiles) permettent d'alimenter une croissance économique exponentielle, mais seulement pendant une période historiquement limitée et au prix de graves conséquences écologiques.



Picture 1. Resource use in France (*Courtesy Nigel Dudley, Equilibrium Research*)

Introduction

When jointly addressing issues such as natural resources, conservation or climate change, economic questions are prevalent. The manner in which these questions are formulated, presented and organised, depends on the preconceptions of economic theory, its cultural, philosophical and methodological foundations. This is the case with natural resources: while conventional economics tries to approach natural resources through their monetary counterpart,[1] ecological economics stresses the need to make the biogeochemical characteristics of these resources explicit. This allows distinguishing between the ecological and economic potential of resources, beginning with their differing capacity to meet social objectives such as economic growth and ecological sustainability. Given their radically different ecological and economic characteristics, erroneous conclusions tend to be drawn as the wide variety of natural processes is simplified down to an undifferentiated notion of natural resources. This article aims to help avoiding such erroneous approaches in the conservation-climate debate.

Distinguishing ecological characteristics of different kinds of natural resources

The main lesson of ecological economics concerns the biogeochemical nature of the economic process. It reminds us of the fact that economic processes are subject to the laws of thermodynamics, particularly the law of entropy[2]. In accordance with this law, economic activities (production, consumption, distribution) require high quality energy-matter resources (low entropy), that are qualitatively degraded in the economic transformation process. With production and services inevitably go together low quality energy-matter waste and dissipated energy-matter (high entropy).[3]

Such a perspective allows economic analysis to consider the biogeochemical preconditions and limitations of economic activities such as the unavoidable degradation of natural resources, the limited capacity of natural resources for renewal, and the fact that this limited capacity only relates to certain resources (so-called renewable resources). Proposing a classification that is valid both for economic and ecological analysis, Georgescu-Roegen and modern ecological economics define four analytical categories in order to take account of the potentials and limitations of natural resources: funds, services, stocks and flows[4]. *Ecological funds,* built up and maintained by solar radiation are able to renew themselves and provide both *ecological and economic services,* as long as the conditions necessary for their renewal are met.[5] *Stocks* constitute limited reservoirs of organised matter and mineralised energy resulting from biogeochemical processes on a geological and not a historical time scale, but from which it is possible to extract an energy-matter *flow*[6]. This flow can thus only be exploited for a relatively short period of human history, leaving stocks depleted and the environment degraded by its dissipated energy-matter.[7]

Distinguishing unequal economic potentials of different natural resources[8]

Natural resources can also be distinguished according to their economic potentials, starting with their capacity to respond to the imperative of economic growth. The growth potential of living or *biotic resources* is naturally limited[9] and therefore cannot fuel exponential economic growth.[10] However, the limited capacity of biotic resources to supply economic growth[11] is compensated by the different quality of being renewable. The lesson is: limited growth yet possible sustainability.

The case of non-renewable *mineral resources* is quite different. Since the time of thermo-industrial revolution mineral resources are capable of inducing a process of exponential growth: the stocked energy-matter can be used to develop machines and motors that allow an even quicker exploitation of the stocks. The process is therefore circular and cumulative. However, as the process quickens, stocks get irreversibly depleted at an increasing pace while the natural assimilation capacities are altered by the ever increasing of entropic degradation. Fuelled by a limited stock of mineral resources and taking place in a limited natural environment, such exponential economic growth is thus inexorably *limited to a given historical period*. The lesson is: exponential growth yet no sustainability. Table 1 illustrates the radically different potentials of biotic and mineral resources.

Table 1. Biotic and mineral resources: radically different potentials

		Potential	
		sustainable use	**exponential growth**
Resources	biotic	yes	no
	mineral	no	yes

To distinguish between services of funds and flows of stocks makes us aware also that different natural resources have specific *temporal characteristics*. Given that biotic resources depend on ecological reproductive cycles, the availability of their services is subject to the natural calendar. Therefore, they do not allow for the continuous use of economic production funds (land, labour and equipment) *i.e.* exploit them to their full capacity.[12] That is why economic activities in agrarian economies are diversified and organised in accordance with the cyclical rhythms of nature. On the other hand, the flow of mineral resources from stocks allows an industrial organisation of production *in line*, which makes it possible to use economic production funds at their *full capacity.*[13] This characteristic reduces costs and makes specialisation possible, which along with the continuity of economic activity, is an essential element of industrial production.[14]

Given their radically different ecological and economic characteristics, erroneous perceptions, illusions, economic myths and biased conclusions may occur when the wide variety of natural processes are simplified down to the undifferentiated notion of natural resources.

Given their radically different ecological and economic characteristics, erroneous perceptions, illusions, economic myths and biased conclusions may occur when the wide variety of natural processes are simplified down to the undifferentiated notion of natural resources. This is the case, for instance, when attempts are made to maintain the illusion that it is possible to fuel an exponential growth process through the sustainable exploitation of biotic resources, or that the substitution of non-renewable by renewable resources would be as feasible as the inverse case. In fact, given the limited growth potential of living resources, only an exploitation of the services of these resources at a rate beyond the capacity for renewal of the funds providing them (fields, forests, lakes, seas) is able to fuel an albeit short time exponential growth process.[15]

Given the limited growth potential of living resources, only an exploitation of the services of these resources at a rate beyond the capacity for renewal of the funds providing them (fields, forests, lakes, seas) is able to fuel an albeit short time exponential growth process.

Given the institutionalised growth dependency of western civilisation[16] it is not surprising therefore that nearly all technological progress over the last 150 years has been based on the substitution from renewable to non-renewable resources, in industry, agriculture and services alike. In such a context, an undifferentiated concept of natural resources is highly problematical also due to the fact that the per capita consumption of mineral resources is very unequally distributed. It hides the economic privilege that goes with a high per capita consumption of mineral resources as well as the particular difficulties that are inherent in the use of biotic and other renewable resources, particularly in combination with high population growth.

Conservation of living resources and exploitation of mineral resources

Bearing in mind the radical economic and ecological differences between mineral and biotic natural resources as conditions to be considered in respect to any reasoned decision of resource utilisation, it is equally important to insist on the close links that further exist between the exploitation of mineral resources (required for the growth of the global industrial structure) and any effort in favour of the conservation of biotic resources. Given the two basic types of biotic and mineral natural resources, any realistic conservation strategy of living resources (flora and fauna) needs to consider two complementary phenomena: overexploitation and disruption.

1. Overexploitation is a complex notion due to the fact that an ecological fund consists of a constellation of biotic resources (*e.g.* a forest) providing multifunctional economic and ecological services. Overexploitation often means harvesting *economic* services (wood or minor forest products) at a rate beyond their sustainable yield. Such economic overexploitation may reduce the capacity of the fund to provide *ecological* services, and may lead to the weakening of the ecosystem's resilience and capacity for renewal.
2. Disruption of the multifunctional serviceability of ecological funds may also be a indirect result of *mineral* resources consumption, particularly the use of fossil fuels which affect ecological funds at both local and global scale. Local waste rejection, local pollution beyond the assimilation capacity of specific local ecosystems and global CO_2 emissions beyond the assimilation capacity of the Biosphere are often as dangerous as local direct overexploitation. Climate change mainly due to excessive per capita consumption of fossil fuels in industrial societies may reduce biodiversity as much or more than local ecosystem destruction by societies not privileged to the same availability of mineral resources.

Both direct overexploitation and indirect disruption reinforce each other in a circular and cumulative causation path, and this causal interdependence is the main reason why conservation cannot only concern itself with contexts characterised by local overexploitation of biotic resources, but needs to consider environmental degradation induced by the exploitation of mineral resources as well.

Making the ecological sustainability imperative explicit

The distinction made by Georgescu-Roegen between stocks and flows, funds and services, sheds light on the notions of conservation and sustainability and their practical applications. According to this analysis, the preservationist approach to conservation corresponds to applying to biotic resources the mineral resources rationale, *i.e.* specified in terms of stocks

Picture 2. Quarry in a forest reserve in Senegal (*Courtesy Nigel Dudley, Equilibrium Research*)

and flows, where only the non-use will allow the maintenance of existing stocks. The contemporary approach to conservation— which focuses on the preservation of the regenerative capacities of natural ecosystems and the sustainable use of living resources—[17] corresponds to applying to biotic resources an approach that is adapted to their specific characteristics, *i.e.* specified in terms of environmental funds and multifunctional services. The new concept is thus a progress. At least the days are gone when scientists and politicians from industrial countries, living mainly from mineral resources (and therefore more easily able to protect their own biotic resources), directed people living mainly from biotic resources *not* to use their *only* available resources.

However, the progress is only partial. "Modern" conservation projects are often unable to provide enough employment to compensate for the loss of activities imposed by the project. In addition, biotic resources alone cannot provide the necessary economic services to growing populations. Moreover, such projects address neither the unequal per capita consumption of mineral resources nor its global ecological consequences that both remain unresolved. Understanding the economic and ecological differences between the two categories of natural resources and their reciprocal interaction is therefore no more than a preliminary requisite for any future conservation strategy.

The terminology developed by Georgescu-Roegen allows us to address these issues by making it possible to *formulate ecological sustainability imperatives* in a concise and coherent manner. According to this approach, three imperatives must be guaranteed simultaneously in order to ensure that the natural environment has the capacity to sustain human activities:[18]

1. The *preservation of the renewal capacity of multifunctional ecological funds* (forests, lakes, oceans, atmosphere, the Biosphere). This is the essence of conservation.
2. *A sustainable exploitation of economic services provided by the funds of biotic resources,* meaning that they do not endanger the reproduction of economic *and* ecological services of the same funds. This is the *sustainable use* defined in *Caring for the Earth,*[19] an understanding of natural resource use familiar to most traditional societies including the eighteenth century forestry science under the concept of *sustained yield.*[20]
3. *A more or less sustainable management of ecological stocks* (minerals, fossil energy

The goals of conservation and sustainable use of biotic resources have little hope of being reached unless complementary and priority actions are specifically aimed at reducing the consumption of mineral resources in countries with high per capita consumption.

sources), *i.e.* in such a manner that the flows extracted from the stocks and rejected in degraded form to the environment do not exceed the assimilation capacity of the global natural environment. This imperative can logically not be dissociated from conservation.

The issue of *climate change* illustrates how interdependent these three imperatives are. Induced by industrial development, human-induced climate alterations are not due to the over-exploitation of the "climatic services" but rather to anthropic disturbances in biogeochemical cycles caused by intensive exploitation of mineralised energy stocks.[21] Social and environmental repercussions induced by this perturbation, uncertain as they may be, endanger the capacity for renewal of many ecological funds and threaten the survival of many species. In such a context, the goals of conservation and sustainable use of biotic resources have little hope of being reached unless complementary and priority actions are specifically aimed at reducing the consumption of mineral resources in countries with high per capita consumption. This interaction is recognised by the conservation community, who points out that "*[a]ddressing the problem of climate change is central to efforts to conserve the integrity and diversity of nature and to ensure that natural resources are used equitably and sustainably".*[22]

Theoretical attempts to assign quantifiable monetary values to biological and cultural diversity.

How to satisfy the needs of poor populations through the sustainable use of biotic resources?

In an effort to conciliate ecological sustainability and social equity, recent approaches to conservation advocate for the granting and reinforcing of resources rights to local populations.[23] Apart from different institutional issues that cannot be addressed here,[24] such approaches should not overlook the essential fact that a sustainable use of biotic resources alone can be quite insufficient to cover basic needs of a growing population, even at a low level of *per capita* consumption.

Development options within the limits of biotic resources are often disappointing from even essential economic and social point of views: Strategies of external aid (material and/or financial), more commercial exploitation of biotic resources, valuing traditional knowledge, tourist exploitation of "traditional" ways of life or whatever else are in reality often far more limited in economic returns than assumed. At the same time experience shows that they may create problems in terms of cultural identity, loss of autonomy and of distribution of economic return. Theoretical attempts to assign quantifiable monetary values to biological and cultural diversity (often in an effort to convince political decision-makers of the value of protecting nature) come up with virtual values and are therefore purely fictive. They can neither be invested in the formation of productive capital nor be used as payment for import or debt service.

come up with virtual values and are therefore purely fictive. They can neither be invested in the formation of productive capital nor be used as payment for import or debt service.

Following industrial countries' development path of focussing on mineral resources is an alternative that allows, for some time, an autonomous process of economic growth and the satisfaction of the basic needs of poor populations. But such a path depends not only on the possibility to get access to mineral resources for the most impoverished; it also requires that they be granted the right to emit into the environment the inevitable wastes generated by a process of economic growth based on mineral resources. The political and institutional requirements and implications of this alternative on a global scale are considerable. In order not to overstretch global ecological limits, any increase in consumption of mineral resources by poor populations would have to be compensated by a drastic reduction of this consumption by the wealthiest.[25] The state of international negotiations on energy and climate illustrates how far away we are from such a world development.

Differentiating clearly between ecological and economic qualities (potentials and limits) of stocks and flows of mineral resources, and funds and multifunctional services of biotic resources is an imperative in order to understand the multiple double-binds and path dependencies of our actual conservation and sustainability crisis. Not to consider these differences does not only lead to erroneous perceptions or biased conclusions, it also means implicitly pursuing the economic interests of societies with the highest per capita consumption of mineral resources and actively ignoring those of less privileged societies.

Rolf Steppacher (Rolf.Steppacher@graduateinstitute.ch) and **Pascal van Griethuysen** (Pascal.vangriethuysen@graduateinstitute.ch) are senior lecturers at the Graduate Institute of International and Development Studies in Geneva, Switzerland.

Notes

1 The development of methods to define monetary counterparts to environmental goods and services is an essential element of environmental economics. The best known are the contingent valuation method, the hedonic price method and the travel cost method (Baumol & Oates, 1975; Turner *et al.*, 1994).

2 The first law of thermodynamics, the law of conservation of energy, establishes that the quantity of energy-matter in an isolated system (with no exchange of energy-matter with its environment) remains constant; the second law, the law of qualitative degradation of energy or *entropy law*, states that the quality of energy-matter in all isolated systems is irreparably degraded over time. Open systems, such as economies, which exchange energy and matter with their environment, depend for the maintenance on a throughput of energy-matter that degrades in the process and leaves the environment qualitatively degraded (Georgescu-Roegen, 1971).

3 Georgescu-Roegen 1971.

4 Georgescu-Roegen 1966, 1971.

5 Ecosystems such as forests and lakes but also the global ecosystem, which constitutes the Biosphere, thus enter into the category of ecological funds.

6 Fossil fuel reserves stored in the lithosphere are the typical example of ecological stocks.

7 See Georgescu-Roegen (1971:209ss) for a more detailed analysis.

8 This section is based on Steppacher & Griethuysen 2002.

9 Beyond a certain development threshold, every biotic resource stops growing, unless it has an abnormal growth pattern (of a cancerous nature), the outcome of which is most often fatal.

10 Affecting some of the limiting factors (fertilising, irrigation) is often possible, but biotic production remains subject to overall limits.

11 Such a growth potential reflects progress in know-how and techniques.

12 Georgescu-Roegen 1965.

13 Georgescu-Roegen 1965.

14 For more details see Bieri, Moser & Steppacher 1999 and Steppacher & Griethuysen 2002.

15 This situation, which corresponds to the application of the stock rationale to ecological funds, is characteristic of debtor economies trying to pay for imports or debt service by exporting agricultural resources. Advocating for a rigidly preservationist approach to conservation (where no exploitation of biotic resources is allowed), a perspective that has until recently been common among conservationists (Fisher *et al.*, 2005), is another example of an erroneous application of a stock rationale to ecological funds.

16 See Bieri, Moser & Steppacher 1999, Steppacher & Griethuysen 2002 and Steppacher 2007.

17 IUCN/WWF/UNEP 1980, IUCN/UNEP/WWF 1991.

18 Based on a different terminology and enumeration of facts, these imperatives correspond to the three priority conditions identified in the World Conservation Strategy: maintenance of essential ecological processes, preservation of genetic diversity, sustainable use of species and ecosystems (IUCN/WWF/UNEP, 1980).

19 *Caring for the Earth* defines sustainable use as "*use of an organism, ecosystem or other renewable resource at a rate within its capacity for renewal.*" (IUCN/UNEP/WWF, 1991:211).

20 See Prodan 1977.

21 As already recognised in the first report of the Intergovernmental Panel on Climate Change (IPCC, 1990).

22 UICN 1999:11.

23 See particularly Borrini-Feyerabend, Kothari & Oviedo 2004, Borrini-Feyerabend, Pimbert, Farvar, Kothari & Renard 2004, Fisher *et al.* 2005.

24 Some of those issues are dealt with in Griethuysen 2006.

25 Bund & Misereor 1996.

References

Baumol W.J. and W.E. Oates (1975), *The Theory of Environmental Policy* (Cambridge: Cambridge University Press).

Bieri Hans, Moser Peter & Steppacher Rolf (1999), *Die Landwirtschaft als Chance einer zukunftsfähigen Schweiz,* SVIL-Schrift Nr. 135 (Zürich: Schweizerische Vereinigung Industrie und Landwirtschaft).

Borrini-Feyerabend G., A. Kothari and G. Oviedo (2004), *Indigenous and Local Communities and Local Areas : Towards Equity and Enhanced Conservation* (Gland and Cambridge : IUCN).

Borrini-Feyerabend G., M. Pimbert, M.T. Farvar, A. Kothari and Y. Renard (2004), *Sharing Power—Learning-by-Doing in Co-Management of Natural Resources throughout the World* (Teheran : IIED and IUCN/CEESP/CMWG, Cenesta).

Bund & Misereor, Hrsg. (1996), *Zukunftsfähiges Deutschland, Ein Beitrag zu einer global nachhaltigen Entwicklung* (Basel : Studie des Wuppertal Instituts für Klima, Umwelt, Energie).

Fisher R.J, S. Maginnis, W.J. Jackson, E. Barrow and S. Jeanrenaud (2005), *Poverty and Conservation : Lanscapes, People and Power* (Gland & Cambridge : IUCN).

Georgescu-Roegen N. (1965), Process in Farming Versus Process in Manufacturing: A Problem of Balanced Development, in Georgescu-Roegen (1976), *Energy and Economic Myths*, 71-102.

Georgescu-Roegen N. (1966), *Analytical Economics : Issues and Problems* (Cambridge, MA : Harvard University Press).

Georgescu-Roegen N. (1971), *The Entropy Law and the Economic Process* (Cambridge, MA; London : Harvard University Press).

Georgescu-Roegen N. (1976), *Energy and Economic Myths : Institutional and Analytical Economic Essays* (New York : Pergamon).

Griethuysen P. van (2006), ` A Critical Evolutionary Economics Perspective Of Socially Responsible Conservation ´, in Oviedo G. and van Griethuysen P. eds. 2006, *Poverty, Equity and Rights in conservation— Technical paper and case studies*, IUCN, Gland, Switzerland, IUED, Geneva, Switzerland, 5-46.

IPCC-Intergovernmental Panel on Climate Change (1990), *Aspects scientifiques du changement climatique*, Rapport rédigé pour le GIEC par le Groupe de travail I, Groupe d'experts intergouvernemental sur l'évolution du climat (Genève : OMM-PNUE, IPCC).

IUCN/UNEP/WWF (1980), *World Conservation Strategy: Living Resource Conservation for Sustainable Development* (Gland, Switzerland: UICN/PNUE/WWF).

IUCN/UNEP/WWF (1991), *Caring for the Earth. A Strategy for Sustainable Living* (Gland, Switzerland: IUCN/PNUE/WWF).

IUCN (1999), *Report of the Eleventh Global Biodiversity Forum: Exploring Synergy Between the UN Framework Convention on Climate Change and the Convention on Biological Diversity* (Gland, Cambridge : UICN).

Kapp K.W. (1976), ` The Open-System Character of the Economy and its Implications ´, in Dopfer (ed.) (1976), *Economics in the Future* (London; Basingstoke: Macmillan), 90-105.

Oviedo G. & van Griethuysen P. eds. (2006), *Poverty, Equity and Rights in conservation— Technical paper and case studies*, IUCN, Gland, Switzerland, IUED, Geneva, Switzerland, 5-46.

Prodan M.M. (1977), ` Sustained Yield as a Basic Principle to Economic Action ´, in Steppacher R., Zogg-Walz B. & Hatzfeldt H. (eds.) (1977), *Economics in Institutional Perspective* (Lexington : D.C Heath and Company), 101-13.

Steppacher R., Zogg-Walz B. & H. Hatzfeld (eds.) (1977), *Economics in Institutional Perspective* (Massachusetts : Lexington).

Steppacher R. & P. van Griethuysen (2002), ` Propriété et ressources minérales : la combinaison spécifique de la croissance économique occidentale ´, *Proceedings*, Interdisciplinary Workshop on the Institutional Foundations of World Trade, Institut Universitaire d'Etudes du Développement, Genève, Juin, (Genève : IUED) 1-12.

Steppacher R. (2007), ` Property, Mineral Resources and « Sustainable Development » ´, in O. Steiger (ed.) (2007), *Property Economics. Property Rights, Creditor's Money and the Foundations of the Economy* (Marburg : Metropolis) 323-354.

Turner R.K., Pearce D., Bateman I. (1994), *Environmental Economics - An Elementary Introduction* (New York *et al.* : Harvester Wheatsheaf).

Back to the energy crisis— the need for a coherent policy towards energy systems

Nigel Dudley

Abstract. The modern environmental movement has been highly influenced by concerns about energy supplies and the need for a coherent energy policy. However, consensus amongst NGOs has recently disappeared and it is possible to find mainstream environmental groups opposed to *every* realistic energy source. This creates strategic dangers and weakens the environmental position in future debates about energy supply. The article argues for the development of a strategy and an NGO agreement.

Picture 1. The Severn Estuary between England and Wales, UK (*Courtesy Nigel Dudley, Equilibrium Research*)

Introduction

Thirty-five years ago, a perceived "energy crisis" was one of the driving forces behind the modern environmental movement. Friends of the Earth and Greenpeace were both established in 1973, after a sudden oil price rise and growing concern about the expansion of nuclear power. For several years there were attempts to develop a coherent policy towards energy supply, based around opposition to nuclear power, promotion of renewable sources and energy conservation and, until evidence emerged about the seriousness of the greenhouse effect, support for coal.[1] While there were certainly voices raised in opposition,[2] the mass of opinion within the NGO sector, and within virtually all environmental organisations, was aligned and provided a powerful lobby.

The immediate energy crisis did not materialise, in part because of the existence of far larger stocks of oil than had previously been recognised.[3] However, the problem of declining fossil fuel sources has been deferred rather than eliminated. Indeed to some extent the situation today is more serious, because knowledge about the greenhouse effect has increased arguments against fossil fuel use and a mixture of safety concerns and poor economic performance has led to a significant downturn in the world's nuclear industry. The peak oil theory has gained widespread credence.[4] However it has also generated some opposition[5] and there are few signs that governments are taking a likely energy shortage very seriously; recent falls in oil prices will continue to foster a sense of complacency.

Unfortunately, just at the time when the need for a coherent NGO response to energy policy is probably greater than at any time for the last 30 years, there has also been a virtual collapse of the consensus once shared amongst environmental groups about future energy scenarios.

Today it is possible to find mainstream environmental organisations opposed to virtually all energy sources, including almost all renewable sources. Table 1 provides a brief summary and some examples. Any energy proposal is likely to have environmental groups opposing it; and these are not just front groups set up by the traditional energy industries (although these certainly exist)[6] but mainstream and genuine environmental organisations. This situation seriously weakens any chance of environmental NGOs making a coherent case for a particular energy strategy.

Table 1. Opposition to energy sources from NGOs: some examples

Energy source	Opposition from environmental NGOs
Nuclear power	Virtually all green organisations, many groups established purely to oppose nuclear power. Conversely some well established conservation organisations have now explicitly expressed guarded support for nuclear power either because of concerns about the alternatives or because it is seen as a viable option for reducing global warming[7]
Oil	Campaign against oil run by Greenpeace,[8] also NGOs such as Oilwatch and Rainforest Action Network.
Gas	Greenpeace is campaigning against expansion of gas drilling in the North Sea; there are also local opposition campaigns in many other parts of the world.
Coal	Coal burning has been seriously criticised because of the greenhouse effect and acid rain by, for example, WWF, Friends of the Earth and the Swedish NGO Secretariat on Acid Rain.[9]
Wind power	Opposition is increasing. For example several long-established UK groups oppose onshore wind farms, including the Campaign for the Protection of Rural Wales and the Ramblers Association and there is also local opposition to offshore wind installation.[10]
Hydro-power	Many NGOs oppose large HEP systems including the International Rivers Network. Support for HEP by the Swedish Society for Nature Conservation almost caused a permanent organisational split. Even small-scale hydropower schemes are frequently opposed by nature conservation bodies.
Tidal power	Friends of the Earth[11] is one of a number of organisations that oppose the construction of a tidal barrage in the UK's Severn Estuary, which has the world's second highest tidal reach.
Solar	Several building conservation bodies in Europe oppose solar panels on the roofs of houses for aesthetic reasons.
Biomass	The World Rainforest Movement is one of many groups that campaign against any large-scale tree plantations.[12] Opposition to biofuels has increased dramatically in the last 5 years as land has been set aside from food growing to produce liquid fuels.

At present there seems to be little opposition to solar cells being placed in desert areas or to passive solar heating or to fuel cells. But no-one is suggesting that these alone will solve the energy shortfall or address the problems of global warming.

Biomass for energy

The issue of biofuels has become central to the debate and needs to be considered in slightly more detail. Wood is already the major energy source for almost half the world's population, where it is usually burnt in open fires and simple stoves. However, biomass from woody and other plants could provide significant amounts of energy for the richer countries as well, especially if it is converted into gaseous or liquid fuels, as outlined in Table 2 overleaf. Direct conversion of biomass to energy has for many years been seen as a long-term alternative to fossil fuel production. It is argued that biomass energy would be roughly carbon-neutral in terms of the release of greenhouse gases, because carbon would be quickly recaptured again in the next crop, and that tree plantations would be renewable over the long term.

biomass from woody and other plants could provide significant amounts of energy for the richer countries as well, especially if it is converted into gaseous or liquid fuels

Table 2. Biomass for energy

Method	Notes
Combustion	Efficiency depends on type of biomass used, water content and methods of combustion. Energy efficiencies range from 18.6-20.9 MJ/kg dry weight for **wood chips** to *e.g.* 9.5 MJ/kg for **sugar cane bagasse**. Open fires are amongst the least efficient forms of combustion.
Pyrolysis	Heating biomass in the near-absence of oxygen. Used in the production of **charcoal**, which has the advantage of being light and clean, but is wasteful of energy in conversion.
Gasification	Heating biomass at a higher temperature than in pyrolysis, with limited oxygen, creating a **producer gas** mixture. Can be followed by: condensation to produce **methanol**; production of **methane**; further conversion to **ammonia**, or for electricity generation.
Hydrogasification	Conversion of biomass to **methane** or **ethane** by reduction with hydrogen at high temperatures and pressure.
Anaerobic digestion	Breakdown of wet biomass (often manures) in the absence of oxygen by anaerobic bacteria, releasing **methane** gas as a by-product. Not usually from wood.
Fermentation	Fermentation of biomass to alcohol in the absence of oxygen, achieved by use of yeasts. The most common end product is **ethanol**. Again not from wood.
Reduction	Reduction of aqueous biomass to produce a range of fuel oils.

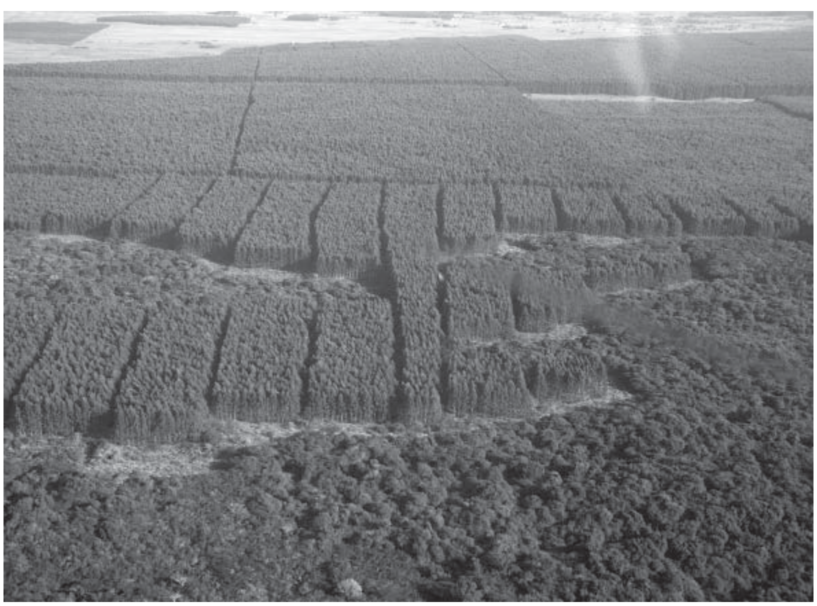
However, there are serious implications for land-use and forest management:

- Very large land areas would be required to supply even a small proportion of the energy requirements of an industrialised country;
- The most efficient type of biomass production for energy is from short-term rotations, so that large areas of forest or agricultural land could be turned over to intensive production of this type;

- ▷ Exotic or genetically manipulated trees, chosen for maximum biomass gain in a given period, would become widespread;
- ▷ Such plantations would require substantial inputs in terms of fertilisers, pesticides and herbicides to maintain such high levels of production.

At the moment, the global environmental movement (if such a thing exists) is in serious danger of arguing against every form of energy and therefore, by tacit implication, excluding itself from the debate.

Such changes could undermine many of the gains made in terms of forest management. We might see, for example, governments arguing that such energy plantations were agricultural crops rather than forests and thus exempt from any controls or guidelines that have developed over forest management. If future energy supplies were seen to be in serious question, such arguments would become compelling. The impacts of biofuels have already been exhaustively assessed by activist groups.[13]



Picture 2. Eucalypt plantations in South Africa (*Courtesy Marc Hockings*)

But what are the alternatives?

At the moment, the global environmental movement (if such a thing exists) is in serious danger of arguing against every form of energy and therefore, by tacit implication, excluding itself from the debate.

The nuclear industry has been quite successful in claiming itself as the environmentally acceptable alternative to coal and oil and the potential saviour in terms of climate change. Large-scale biomass use would fit the aspirations of the transnational companies that currently control the world's energy supply and is already being presented as a clean and renewable resource.

There are very few totally "clean" supplies, so that support for one over another will be a matter of careful judgement and some trade-offs.

Opposition to everything is pointless and self-defeating. As fuel prices increase, the pressure to exploit alternatives— such as coal shales, Arctic oil reserves, nuclear technology and large-scale biomass plantations— will grow. The conservation movement has regularly failed to halt such developments and there is little reason to think that the situation will change. There is an urgent need for research, debate and policy development that could lead to a consensus about future energy supplies, at least in the beginning amongst NGOs.

This will not be easy. There are very few totally "clean" supplies, so that support for one over another will be a matter of careful judgement and some trade-offs.

The overall impacts of most will depend to a large extent on how they are applied, on what social and environmental safeguards can and will be attached, whether these will actually be applied and on the aspirations of the majority. What might seem an impossible compromise to environmental and social activist groups may not elicit the same response from other people. Sacrificing the Amazon rainforest for cheap fuel would be a done deal for many of today's drivers. The energy industry will be able to draw on powerful and apocalyptic images to make its case. If NGOs are going to oppose the worst excesses of the energy industry with any hope of success we will need to speak with one voice and be clear about the sacrifices as well as the potential gains.

IUCN could play an important facilitating role in this process. It will not be easy, because positions are in many cases already entrenched and time is short. But the current state of chaos will simply lead to lack of effective opposition against any energy supply, however damaging this might be.

Nigel Dudley (equilibrium@compuserve.com) is a member of WCPA and CEESP and works mainly on issues related to protected areas and forest conservation. At one time he lived and worked at the Centre for Alternative Technology in Wales, researching the practical application of renewable energy systems.

Notes

1 Lovins 1973; Commoner 1976; Todd and Alty 1976; Leach 1979; Olivier *et al.* 1983.
2 Beckmann 1979.
3 Odell 1970.
4 Leggett 2005.
5 Clarke 2007.
6 Rowell 1996.
7 Ramblers Association 2007.
8 Greenpeace 1993, and many other documents.
9 Lundberg 2003 and many other documents.
10 Ramblers Association 2007.
11 Friends of the Earth Cymru 2007.
12 Carrere 1999.
13 Smolkar *et al.* 2008.

References

Beckmann, P., *The Health Hazards of Not Going Nuclear*, The Golem Press, 1976.

Carrere, R., *Plantations Campaign: Ten replies to ten lies*, World Rainforest Movement, Montevideo, 1999.

Clarke, D, *The Battle for Barrels: Peal oil myths and world oil futures*, Profile Books, London.

Commoner, B., *The Poverty of Power*; Knopf, New York, 1976.

Friends of the Earth Cymru, *The Severn Barrage*, Friends of the Earth Cymru, Cardiff, Wales, 2007 Greenpeace, *Energy Without Oil: The technical and economic feasibility of phasing out global oil use*, Greenpeace International, Amsterdam, 1993.

Leach, G., *A Low Energy Strategy for the UK*, International Institute for Environment and Development, London, 1979.

Leggett, J., *Half Gone: Oil. Gas, hot air and the global energy crisis*, Portobello Books, London.

Lovins, A., *Soft Energy Paths*, Penguin Books, Middlesex, 1973.

Lundberg, F., *To Phase Out Coal*, Swedish NGO Secretariat on Acid Rain, Goteborg, 2003.

Odell, P.R., *Oil and World Power*, Penguin Books, Middlesex UK, 1970.

Olivier, D. *et al*, *Energy Efficient Futures*, Earth Resources Research, London, 1983.

Ramblers Association, *Walk*, Spring 2007, London, 2007.

Rowell, A., *Green Backlash: Global subversion of the environmental movement*, Routledge, London, 1996.

Smolker, R., B. Tokar, A. Petermann, E. Hernandes and J Thomas, The Real Cost of Agrofuels: Impacts on food, forests, people and the climate, Global Forest Coalition, 2008.

Todd, R. and C. Alty [editors], *An Alternative Energy Strategy for the United Kingdom*, Centre for Alternative Technology, Machynlleth, Wales, 1976.

Energy— a great deal of hot air and little sense

Roger Crofts

Abstract. Countries need to make rational choices about future energy supply. Scotland is a country that has recently gained greater autonomy from the UK and is in a stronger position to decide its own energy policies. A recent study by the Royal Society of Edinburgh looked at some of the myths and realities relating to energy policy and sought input from the public, explicitly including school students, to build a picture of what the Scottish public was looking for in terms of energy supply and where there was and was not a degree of consensus about future steps. The following paper summarises the results.

Energy is one of the great debating subjects of the decade. And it is likely to remain so for some time. But are we really making progress in resolving some of the critical issues, or are we really just on an increasingly polarised course between different interests who are implacably opposed to entering into dialogue? I fear so if the situation in the small country of Scotland is anything to go by. Nuclear generation for electricity is a 'no no' and renewables especially wind are the saviour according to the so-called environmental groups. Industrialists, economists and industry experts talk about security of supply and worry about price escalation and the instability of governments in major energy supply countries. And the consumer is increasingly concerned that the lights may go out, that prices will rise and they will not be able to afford well heated houses and the normal range of consumer goods requiring energy to operate them. As a result, politicians have a field day by trying to drive the agenda in a direction which suits them. All of this is most unsatisfactory and is damaging to society, to the economy and to the environment. So what is the solution? There is not a simple answer to this vitally important question.

Three key aspects of energy: what a nation should achieve, what are the objective realities and the unsupported myths, and how to stimulate reasoned debate to provoke the necessary action.

It was for this reason that a number of experts on various aspects of energy, along with economists and environmental specialists, formed a committee under the aegis of the Royal Society of Edinburgh (Scotland's national academy of science, technology, humanities and the arts) to inquire into energy issues for Scotland. The reports from the study and from a subsequent round of public debates are available on the Society's web site www.royalsoced.org.uk.[1]

I shall focus on three key aspects of energy: what a nation should achieve, what are the objective realities and the unsupported myths, and how to stimulate reasoned debate to provoke the necessary action.

Energy strategy

What most of the debates seem to ignore is the need for an overall energy policy with a clearly defined set of aims and objectives and means of measuring their achievement. This is not an arid exercise as until all stakeholders have a common view of why we need energy and the consequences of potential shortage of supplies, of over consumption, of price inelasticity, of the social, economic and environmental effects

Scotland should think in a global context and act locally using natural resources at its disposal to provide social, economic and environmental benefits.

of different approaches, then little or no progress can be made. It is very obvious to those like myself who have worked on energy, economic development and environment that a range of objectives needs to be satisfied through the types and rates of energy we consume as a society. Energy is needed to sustain existing economic activity and to stimulate new activity. Energy is needed for human survival and should have an aim of reducing poverty (and specially fuel poverty) and seeking to attain greater social harmony and the removal of social disparities. And energy must be obtained from sources and used in ways which will have the least damage to environmental systems and processes on land, in the air and at sea. These are not mutually exclusive and should not be traded one against the other.

In our Scottish study, we concluded that "Scotland should think in a global context and act locally using natural resources at its disposal to provide social, economic and environmental benefits". Following from this statement, guided by the Brundtland commission's enduring statements of almost two decades ago; we determined that the strategic aim should be "a secure, competitive, socially equitable and low carbon emission supply of energy". Our interpretation of these elements was as follows:

- ▷ 'Secure': means having sufficiency of supply from a diversity of fuel types and geographical sources using a variety of technologies, encouraging new technological development to marketability and having the appropriate government framework and instruments.
- ▷ 'Competitive': means that the cost of energy will not result in Scotland being uncompetitive in world markets and will also be competitive in the use of technology and innovation.
- ▷ 'Socially equitable': means that all sectors of society should have access to energy at a price which they can afford, implying that some economically and socially poorer sections of society will be aided to rise out of 'fuel poverty'.
- ▷ 'Low carbon emissions': mean that throughout their lifecycle, technologies should produce the lowest possible levels of greenhouse gas emissions, bearing in mind that there are no technologies or energy sources that have no emissions during their lifecycle.

It is pointless having clear goals and aims without defining a clear set of objectives. In the light of our comprehensive aim we determined the following four objectives:

1. To encourage energy efficiency to benefit economic development;
2. To ensure that energy availability contributes to improvements in social benefits;
3. To minimise environmental effects globally and locally; and
4. To capitalise on natural energy resources in economically viable and environmentally sensitive way.

The debate is about the energy sources for future electricity generation, whereas heating and transport are by far the largest energy consumers compared with electricity production.

Myths and realities

The second step in formulating energy policy to achieve multiple benefits is to assess the factual material about supply and demand, consumption and the use of different energy sources and technologies as a basis for informing debate on realities and challenging many strongly held views and opinions which frequently have no factual basis. This is important for a number of reasons. In Scotland, and in the UK as a whole, for example most of the debate is about the energy sources for future electricity generation, whereas heating and transport are by far the largest energy consumers compared with electricity production. Analysis of energy flow statistics also reveals that a great deal of energy is lost at varying stages: in production of especially at large generating stations, and in energy loss from domestic premises. Hence energy savings and energy efficiency measures are widely regarded as the most crucial first step in dealing with the imbalance between supply and demand, and also helping to deal with the high costs of energy by reducing consumption. Public attitudes towards energy consumption and especially savings are increasingly important in post industrialised countries. Only with very large increases in energy costs that are sustained over long periods of time is there likely to be a reduction in use of energy especially in domestic households.

Energy use is highly variable during the day due to social habits and economic activity, and also through the year due to the obvious seasonality factors of the weather. These variations have to be taken into account in developing reliable and robust energy supply schemes and ensuring that there is an adequate stockpile of energy resources.

It is also important to gather objective information on the source of energy raw materials used, including the type of energy material, and its geographical provenance, and on the technology used, including its reliability to transform it into consumable energy.

Picture 1. Scotland already derives much of its electricity supply from hydro sources (*Courtesy Nigel Dudley, Equilibrium Research*)

There are also, at least in the part of the world where I live, many **energy myths**. On the supply side those who are convinced that we have passed the point of 'peak oil' but ignore the as yet undiscovered hydrocarbon reserves on the ocean shelves, ignore the new technologies which result in a greater proportion of the resource being extracted and significantly ignore human ingenuity in finding energy sources that previous generations had missed. Those who continue to claim that there is no link between emissions to the atmosphere of greenhouse gases from the use of fossil fuels and climate change are ignoring virtually all of the scientific evidence. Indeed, those who claim that the conclusions of the scientists within the Intergovernmental Panel on Climate Change are gagged and neutered by governments seem to live in some cloud cuckoo land of their own making. Others consider that renewable resources are infinite. This is true as we can reasonably assume, for example, that solar energy resources and tidal energy resources will last until such time as the relationship between the earth and the other planets is fundamentally different. I know of no geological predictions that these relationships will change in even hundreds of millions of years. However, we cannot assume that exploitation of these renewable resources is entirely environmentally benign. Tidal barrages have a significant effect on terrestrial and near shore hydrology and biodiversity. Wave devices for example will affect society's perception of the coastal environment, and potentially have an effect on inshore fisheries. Onshore wind devises can have a very significant effect on landscape and society's perception of its attractiveness, as well as on the diurnal migration pattern of certain bird species. Hydro-electric power significantly changes the hydrological and sedimentation system and can result in high risk to communities downstream. And all technologies, whether relying on non-renewable or renewable energy resources consume energy in their construction and emplacement and in their decommissioning.

In our present situation, it is difficult to see how supplies of electricity to meet the variable daily and seasonal demands can be met without use of large scale generating stations.

In the UK, there has been an assumption that the market has the solution to satisfy society's energy needs. There is patently not true as, for example, there remains an imbalance between the profits of the privatised industry and the escalating costs which the consumer has to pay.

In our Scottish study, it also became clear that there were a number of other widely held beliefs on energy. For example, it is stated frequently that renewable sources can meet the energy gap once the large scale coal, gas and nuclear powered generating stations are closed. Yet this views fails to recognise the variability of the supply sources over which we have little control, that we had as yet not cracked the means of long term storage of energy (except though pumped storage schemes), and that the means of gathering electricity from a wide range of episodic sources and delivering supply to consumers at some distance from the generation point is technologically possible in theory, but in practice is very difficult to achieve with the present grid transmission system. Also on electricity, there is a widely held view that wind generated electricity can replace nuclear generated electricity. This is nonsense. Nuclear generation provides base load electricity supply, *i.e.* what we need every day of the year, whereas wind can only provide episodically the top up. In our present situation, it is difficult to see how supplies of electricity to meet the variable daily and seasonal demands can be met without use of large scale generating stations. The problem then is to find the most environmentally benign technologies. Although there are many on the drawing board, such as clean coal and carbon sequestration technologies, they are still a long way off full scale commercial operation.

Finally in relation to energy myths, we have to realise that consumer behaviour is an important factor. Will consumers change their behaviour and reduce their energy consumption? There is no clear evidence of this occurring and economists consider that prices will have to be sustained at a very high level for a long time for them to have real impact on consumption. In a curious way, opinion surveys suggest that people are prepared to pay more for energy, but the level of complaint about rising prices seems to be contrary to this expectation. The fact of the matter is that in countries like the UK energy prices have been low for many years and the recent price escalation was to be expected at some stage.

From the analysis of energy data there are what I would call a number of **energy truths**. Although many of these are disputed by some commentators, there is a high degree of scientific consensus about their veracity. So for the sake of stimulating debate we must be sure that we have the factual basis behind statements. Those we have used in these circumstances in Scotland are as follows. There is substantive evidence to link global climate change with the increase in the emission of greenhouse gases in the atmosphere arising from human activities in recent centuries. Despite technological advancement, as identified above, fossil fuel supplies in are decline. Estimates of the time scale of the decline vary. The best evidence we gathered in our Inquiry suggested that oil supplies can last for at least another 30 to 40 years, gas 70 years and coal 250 years at present rates of consumption. Nevertheless, as recent experience has shown, prices are volatile and security of supply uncertain due to a range of geopolitical factors which make predications difficult. And at the same time in the UK and in many other post industrial countries, consumption is rising; and, in addition, in industrialising countries the rise is at a very high rate. At the same time, many post industrialised countries, and most certainly the UK, have a poor record is energy savings and energy efficiency.

Stimulating debate

Given the vital importance of energy to our societal well being and economic progress and the impact that its exploitation and use has on the environment, there is a need to stimulate debate on energy futures. In Scotland, we determined at the end of the formal energy inquiry that stimulating debate within civil society was a necessary next step.[2] This was unusual for the Royal Society of Edinburgh, especially as it tends to hold most of its events in Edinburgh. We agreed to hold a series of debates around Scotland. We chose the main population centres to host evening public discussion forums. In total over six locations we had 455 participants. In addition, we decided that the views of the younger generation were essential and would likely give a different perspective. We engaged with 407 students in the 15 to 17 age range in 14 schools around Scotland.

Given the vital importance of energy to our societal well being and economic progress and the impact that its exploitation and use has on the environment, there is a need to stimulate debate on energy futures.

In order to stimulate debate we identified in opening presentations a range of issues. We sought to steer the debates in to the wider energy issues rather than focus on the specificities of the electricity debate (nuclear versus renewables, onshore wind versus offshore sources). But such was the strength of opinion and knowledge that, inevitably, these were the most debated topics and the ones on which there was no consensus.

From all of these sessions we identified areas of general consensus and areas of continuing debate, identified issues which varied by location and specifically recorded the perspectives of the younger generation. The points of general consensus arising from the public sessions were as follows:

1. Recognition of the link between emissions from fossil fuels and global climate change.
2. Agreement that renewable sources of energy are a key contributor to energy supply needs because of their low greenhouse gas emissions, the abundance of the Scottish resource, and the need to encourage technologies other than onshore wind, for example tidal, wave, solar, biomass, and offshore wind.

3. Recognition of the need for energy savings to preserve supplies and to reduce environmental effects, and especially the need to reduce the waste of energy, coupled with more effective instruments for encouraging energy saving.
4. Recognition of the technological expertise on energy based in Scotland and the need for further support for technological development.
5. A call for new thinking on the way energy is supplied to the consumers, especially through distributed systems and micro approaches.
6. A call for new fuels provided they are economic and environmentally neutral.
7. Recognition of the need for action at political, industry and societal (including personal levels) following proper debate.

There was a lack of consensus on many issues as follows:

1. The key objectives of public policy: greenhouse gas emission reduction, and/or security of supply. Balancing the benefits and costs to the environment was considered to be very difficult.
2. Ethics was a major issue, specifically whether Scotland, as a small country with low emissions in total in global terms, should do anything at all or whether it should be an exemplar to other countries.
3. There was unresolved debate on whether renewable sources bring real economic, social and environmental benefits to Scotland. There are many concerns that one solution was being over promoted, often termed 'the dash for wind', and that other solutions were being given less prominence.
4. Energy price trends are not clear and it is debatable whether the consumer is prepared to pay more. Only consistently much higher prices might change behaviour in favour of greater savings and efficiency, but is this ethically defensible?
5. On alternative sources of supply, there was no consensus on the immediate solutions, such as renewables versus new large generating plant for electricity, and the unresolved arguments about whether supply should be from the source nearest to the consumer or at the most advantageous point of high energy resource. Also the debate on the balance between fossil fuels and renewables is unresolved.
6. The greatest disagreements consistently were on the technologies for electricity generation. The polarities are:
   - ▷ nuclear has to be key part of shorter term solution given the improved technology and costs, and the excellent safety and delivery records of existing civil nuclear reactors, or there should never be any more nuclear powered electricity generating stations in Scotland because of the lack of action on storage of high level radioactive waste and concerns about the military use of fuel;
   - ▷ onshore wind has been given too much prominence compared to other renewable technologies;
   - ▷ there remains large resources of fossil fuels for decades (oil and gas) and for centuries (coal and uranium);
   - ▷ there is no consensus on the need for and effect of transmission lines on the environment and on nearby communities and options for under-grounding or for offshore routes; and
   - ▷ there are doubts about the practically of some new technologies, such as carbon sequestration in clean coal technology.

Picture 2. Scotland (*Courtesy Nigel Dudley, Equilibrium Research*)

In the schools discussions, there was a much greater degree of optimism. There was always a clear view that 'the lights will not go out' within a decade because of human ingenuity and a mixture of existing and new technologies being available. Furthermore, the polarities which existed in the public sessions with regard to technologies for electricity generation were much less evident in the school discussions. There was a strong view that a change in culture was needed to wean society off its dependency on fossil fuels. Alongside this, was an appreciation of the need for energy savings and greater information on what can be done to achieve these savings, and the need for alternative fuels for transport and heating. Most students recognised the link between global climate change and the use of fossil fuels and therefore the need for precautionary action to mitigate climate change. There was a perception amongst the students that their views and opinions were not being sought on energy issues and that meant they could not influence decisions.

It was clear from all of the debates that action was needed and the following specific issues for action were identified:

1. Higher priority and more funding to cleaner fossil fuel technologies and to alternative renewable technologies.
2. Decisions on new base load electricity supply, including decisions on fuel types and final decisions on whether nuclear or not.
3. More effective energy efficiency and energy savings measures and gadgets accessible to the public to stimulate higher levels of performance. Better designed and more affordable energy savings in 'white goods'. Break the circularity of save costs on energy/ buy more energy consuming devises through public education.
4. More financial support from government for bringing energy technologies from the laboratory to full-scale operation.

In order to test the local responses, we organised a conference to conclude our work and invited major figures in the international energy world to participate so that we could call for action with the support of public and industry opinion behind us. The consensus at the conference was that Scotland is no different from other countries and we needed to think in a global context as well as act locally. Claims that there were choices to be made between, for example, central and decentralised systems of electricity supply, between specific technologies or a mix, between supply led approaches or demand management, or concentration on Scotland as a net energy exporter or importer were not accepted. The general consensus emerging was that a mix of solutions, rather than selecting specific winners, was the most sensible course of action. The mix should comprise of old technologies with improved carbon sequestration, new technologies, energy efficiency and energy savings.

Debates could be never ending on polarised issues. To prepare the ground for timely and effective decisions, it was necessary for more objective information to be provided, and for consensus building. The overwhelming priorities for action identified were:

- improvement in the efficient use of energy, and
- reducing the use of fossil fuels in space and water heating and in transport.

There is a wide consensus on the need to constrain the rate of growth of consumption, and to reduce the use of fossil fuels and so reduce the emission of greenhouse gases.

We concluded that to improve the quality of debate and to ensure that the decision-making process is better informed:

- an objective methodology to assess the relative merits of energy technologies, including full lifetime costs was urgently required; and
- bodies independent of government and sectoral interests should be active in stimulating the debate and the identification of decisions needed and the urgency of the situation.

In the wider global and regional debates on energy, I consider that IUCN has a major role to play. It should use its convening power to bring together the various interests, just as it did with the mining industry. I recognise that there are those in IUCN who consider that these discussions and engagements are a step too far, but without them we will not achieve a greater understanding of the different perspectives. If we feel we can stand on the sidelines and shout our views and opinions and be heard then we loose our credibility and fail to use the convening power and knowledge base that exists within the Union.

Conclusion

Energy is a vital matter for societies throughout the world. It is also vital that environmental interests engage with civil society and with the energy industry to indentify the common ground, to determine the areas of divergence and the topics where agreement is unlikely and to consider what action should be taken.

'The Royal Society of Edinburgh is to be congratulated on bringing some sanity to the energy debate that is becoming unhinged from reality'. I hope that others, and especially IUCN, will take up the challenge.

I hope that the model we used in Scotland is of some interest and might be applied by independent bodies in other parts of the world. An editorial in the international scientific journal Nature[3] stated that 'The Royal Society of Edinburgh is to be congratulated on bringing some sanity to the energy debate that is becoming unhinged from reality'. I hope that others, and especially IUCN, will take up the challenge.

Roger Crofts (roger@dodin.idps.co.uk) is World Commission on Protected Areas Regional Vice-Chair for Europe and a member of the Commission on Ecosystem Management. He was Secretary of the Royal Society of Edinburgh Energy Inquiry 2006-2007.

Notes

1 Royal Society of Edinburgh, 2006, 2007.

2 Royal Society of Edinburgh 2007.

3 Anon 2006.

References

Anon, 'Urgent but balanced', *Nature,* issue 7096, 22 June 2006, p. 907.

Royal Society of Edinburgh. *Inquiry into Energy Issues for Scotland: Final Report.* The Royal Society of Edinburgh 2006 *Inquiry into Energy Issues for Scotland: Summary Report.* 2006.

Royal Society of Edinburgh *Energy for Scotland: A Call for Action*, 2007.

Pollution from aircraft

Mark Barrett

Abstract. Aircraft presently release some 2 or 3 per cent of global emissions of carbon dioxide and, together with the effect of other pollutants, contribute a large fraction of global warming that will increase rapidly because of demand growth, unless policies are changed. Aircraft emit a mixture of other pollutants including nitrogen oxides, soot, carbon monoxide and hydrocarbons, and about half of these emissions is injected into the atmosphere at an altitude of 8 to 12 km where they generally have more serious and enduring effects than at ground level— even water has adverse impacts. Nitrogen oxides and water emission bring about global warming and can also cause ozone depletion. Scientific uncertainty about the impacts is great, and will persist. A number of control options are available but reducing aviation demand growth is the only way so far known of creating a marked and immediate reduction.

This article summarises a complex issue; more details may be found in reports such as those by Barrett[1] and the Intergovernmental Panel on Climate Change.[2]

Introduction

The demand for air transport is continuing to grow rapidly, despite rising fuel costs, and the long term growth potential is potentially vast because of the low current per capita demand in poor populous countries. Budget airlines have transformed the sector over the last decade. Pollution emission will grow less rapidly than demand because of technological improvements, but with unchanged policies pollution from aircraft will double in two decades or so. A series of new or augmented policy measures is needed to moderate this increase.

The environmental impact of aircraft

In terms of atmospheric and climatic impacts, air transport has five main effects:

- The emission of carbon dioxide (CO_2) constitutes a small but fast growing contribution to global warming;
- The emission of nitrogen oxides (NO_x) leads to ozone increase near the tropopause and this causes global warming;
- Water emission may lead to increases in high altitude clouds, and these may contribute to global warming;
- The emission of water and NO_x may exacerbate stratospheric ozone loss;
- Other pollutants such as soot and trace chemicals may also have effects either synergistically or separately.

The global fuel burn of aircraft is only approximately known. The coefficients of emission per fuel burn for some pollutants (*e.g.* carbon dioxide and water) are known with accuracy and do not vary significantly with engine type and aircraft operation. The coefficients for others are not precisely known, and do vary with type and operation; for example, the estimate of total NOx emitted by civil aircraft may not be accurate to better than 50 per cent. Accordingly there are uncertainties in total emissions. Furthermore, the effects of pollutants apart from carbon dioxide can vary according to when and where, in terms of altitude, longitude and latitude, they are released in the atmosphere.

Aircraft presently release in excess of 2.5 per cent of the total global emissions of **carbon dioxide** as a result of the burning of fossil fuels. This is equivalent to approximately 12 per cent of the total emissions released by the transport industry according to a report from the Intergovernmental Panel on Climate Change (IPPC);[3] the proportion will have increased since.

Aircraft presently release in excess of 2.5 per cent of the total global emissions of carbon dioxide as a result of the burning of fossil fuels.

Certain anthropogenic pollutants generate or destroy ozone in the atmosphere. Unfortunately the nitrogen oxide from aircraft probably generates ozone where it is not wanted, at low altitudes; and removes where it is wanted, at high altitudes. At low altitudes (less than 15 km or so), extra ozone increases global warming. Its warming impact is thought to be greatest at about 12 kilometres, the altitude at which large commercial jet aircraft typically cruise. Ozone at much greater altitudes decreases global warming.

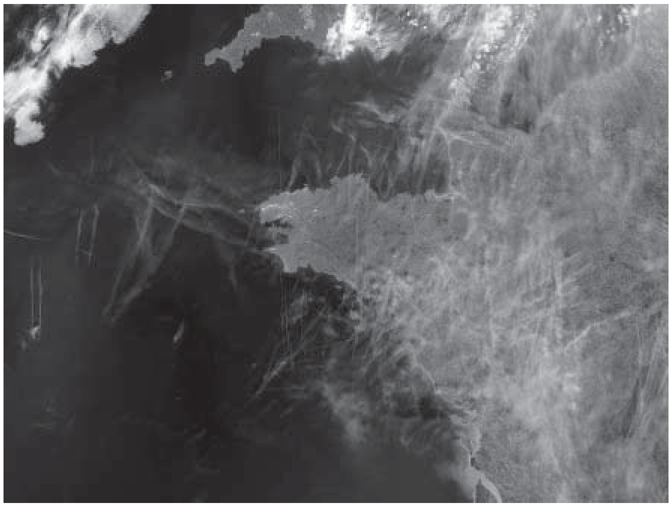
Water vapour has two potential effects. First, through augmenting the formation of high altitude clouds, it can act as a potent global warming agent. Second, extra water vapour at high latitudes may increase the formation of polar stratospheric clouds that are implicated in ozone loss and the formation of the ozone hole.

Aircraft emit a number of other pollutants. This includes carbon monoxide, sulphur dioxide, metals, soot and lubricating oils. Although many of these are emitted in minute quantities which makes insignificant changes to pollution concentrations near ground level, at a high altitude the additions may be significant.

There are considerable uncertainties for pollutants other than carbon dioxide: first, in the amounts and spatial distribution of pollutants from aircraft; and second, in the precise functioning of many atmospheric processes and the impact of pollutants. Many pollutants act synergistically. Their marginal impact depends on the concentrations of other pollutants, and indeed of the pre-existing level of the pollutant being considered. It is therefore not generally possible to assign a particular unique value for the impact of any pollutant. Such is the uncertainty in some of the processes that, for example, some pollutants at certain altitudes are now thought to decrease global warming, rather than increase it.

Nitrogen oxide from aircraft probably generates ozone where it is not wanted, at low altitudes; and removes where it is wanted, at high altitudes.

The UK Royal Commission on Environmental Pollution[4] highlighted the risks of high altitude release of pollutants: "*The impact of aircraft emissions can be very different depending whether they are in the upper troposphere or the lower stratosphere. Both the abundance of trace gases and the dominant chemical composition and associated chemical reaction are very different in the two regions. In particular water vapour content is relatively high in the troposphere and low in the stratosphere whereas ozone levels are much higher in the stratosphere. Stratospheric ozone absorbs radiation from the sun. This leads to a heating profile in the stratosphere that determines its character, and also protects life at the surface from the harmful effects of the UV radiation*."



Picture 1. Airplane condensation trails (contrails) over Brittany, France (© *Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC*)

The Commission noted the rapid increase in air travel and concluded that it had: "*particular concerns about the contribution that aircraft emissions will make to climate change if this growth goes unchecked. The total radiative forcing due to aviation is probably some three times that due to the carbon dioxide emissions alone*."

Controlling pollution from aircraft

Relating to the impact of air pollution from aircraft, there are two basic non exclusive control options:

- The total emissions of pollutants can be limited;
- Emission may be reduced in sensitive zones such that the impacts of pollutants are diminished.

To reduce the environmental impact of aircraft three categories of action are required:

1. Research and monitoring to establish the actual extent of emissions and their effects.
2. Policy options that mitigate environmental impacts need to be devised.
3. Mitigating policies have to be implemented through appropriate legislative and institutional frameworks.

Control options can be put into three categories: demand management; operational change; and technological change. Measures in each of these three categories can be implemented severally. Implementation methods can be divided into intelligence and information, incentive and disincentive, regulation and investment. Table 1 outlines a matrix of basic options and means of implementation with examples of particular measures.

The complex interactions that occur in the aviation industry make it generally difficult to discuss and assess particular control options in isolation from others. Some examples of these interactions and potential dilemmas include:

- Putting more taxes on fuel and aircraft movements makes air travel more expensive thereby suppressing demand. But such taxes may increase load factors which would decrease capital and fuel costs per passenger or tonne or freight, thereby lowering total flight costs and stimulating demand.
- Managing air freight demand can not be best accomplished without at the same time managing passenger demand. Presently two thirds of air freight is carried with passengers. This is at a relatively low marginal economic and environmental cost because of the design of aircraft for mixed passenger and freight transport.
- Provided the same fraction of seats is filled, large aircraft are more efficient and so produce less emission

per passenger kilometre than smaller aircraft ones and so. However it is difficult for large aircraft to meet noise limits, even though the larger the aircraft the fewer the aircraft movements.

Table 1. Some emission control options

Options	Intelligence	Incentive	Regulation	Investment
Operations	flight planning models	fuel and emission taxes	bubble emission limits	global booking system
higher load factor	advanced booking; integrated flight planning	aircraft movement tax	ticket transfer permit	less seat spacing
shorter route	ATC (air traffic control)			
lower altitude	optimum height		zone emission limits	
slower cruise		fuel and emission taxes		
less congestion	better ATC	aircraft movement tax		better ATC
Technology				
engine emission	information to operators and consumers	emission taxes	emission limits per unit thrust	more efficient, low emission engines
aircraft emission	information to operators and consumers	emission taxes	emission limits per seat.km	large aircraft optimised for passenger transport
Demand management	advertising and labelling			
passenger	advertising and labelling	passenger movement or distance tax		better local environment and holiday facilities telecommunications alternative modes
freight	economic information	freight tax		alternative modes
	advertising and labelling			localised production

There is scope for extending technological improvement to airframes and engines, and this might include the introduction of slower more fuel efficient aircraft optimised for passenger transport. Operational changes, especially increasing the load factor of aircraft, could reduce pollution substantially and rapidly by about 20 per cent. However, even if these two categories of measures are applied to a maximum, fuel use and pollution still double in three decades or so under current projections.

In consequence, if aviation is to stabilise or reduce its current emissions of greenhouse gases and other pollutants, demand management will be required. Most air freight is not inherently urgent and much of it could be carried by less polluting surface modes. Business travel could be limited by the increased use of telecommunication. Leisure travellers could be encouraged to visit nearer locations and use less damaging modes where possible. Reducing the demand growth rate by over a half in these ways would, in conjunction with the technological and operational measures, stabilise emissions over the next four decades or so, after which emissions would once again increase.

Most air freight is not inherently urgent and much of it could be carried by less polluting surface modes. Business travel could be limited by the increased use of telecommunication.

All of these measures would be difficult to implement, especially a high degree of demand management. They will however all be required in order to stabilise emissions; to reduce emissions significantly and permanently, heavier constraints on demand or radical technological innovations will be necessary. In a situation of scientific uncertainty, deciding on appropriate policies and timing their implementation, is problematic.

Both the IPCC and the UK Royal Commission recognised the need for demand management, and a study for the UK government[5] noted that: '*even with deployment of the most promising future technologies, if demand is unconstrained by capacity then, in absolute terms, the net effect of the aviation industry on the environment is set to increase*.'

Conclusions

The current contribution of civil aviation to anthropogenic global warming is almost certainly at least 3 per cent, but may be much higher due to the emission of nitrogen oxides and water. There are serious concerns about the specific impacts of aircraft at high altitude especially with respect to their effect on ozone, but the scientific uncertainties remain very great. Global warming and the other environmental impacts of aircraft will increase because of the growth in aviation demand.

About half of air transport is for leisure causing some 50 per cent of total aviation emissions. The prospect is for large long term increases in emissions from aircraft if current policies and strategies are unchanged. With about 5 per cent of the world's people, the USA accounts for some 40 per cent of aircraft pollution and is therefore a key country when constructing control policies, and when considering the consequences if the rest of the world made as many flights. Barrett shows how global warming from aviation may constitute half of total UK global warming by 2050, even with some emission control measures.[6]

About half of air transport is for leisure causing some 50 per cent of total aviation emissions.

Emission limits should be applied to aircraft emissions of greenhouse gases generally. But there are problems suggesting limits for particular gases singly and in combination.

Currently, global anthropogenic CO_2 emission is about 8 billion tonnes of carbon and to avoid unsupportable impacts, reductions of 60 per cent or more over the coming decades are required.[7] With population growth, this would mean an equitable emission allowance of about 0.3 tonnes of carbon per person per year, equivalent to a person making one flight of a few thousand kilometres and doing nothing else that emits carbon. Since most of aviation is for inessential leisure and freight with alternative modes, it should be expected that aviation will have to reduce its emissions substantially to leave scope for essential services such as food production or heating dwellings. In general, however, reducing carbon emissions from aircraft is problematic as the technical options for deep cuts are limited and costly.

The application of firm emission control policies would be effective in reducing emissions substantially below levels projected in business as usual conditions. If all the control measures suggested by Barrett were implemented then aviation emissions would not increase vastly over the current level in the medium term.[8] However, reducing demand growth is the single most important element in such a strategy.

The aviation industry will find it difficult to make global greenhouse emission reductions and will have to make a dramatic response to the challenge, or establish that emissions from aircraft do not have to be reduced pro rata as much as those from other sectors of the global economy.

Recommendations

- A method and convention for calculating and allocating all aircraft emissions to individual countries needs to be developed.
- The prejudice should be for limits to aircraft emissions to be allocated pro rata to other limits of a similar kind (*e.g.* carbon emission). It may be that special derogations might be allotted to aviation in particular regions.
- Aircraft emissions above critical altitudes should be subject to separate international negotiations for their control and limitation in light of their special effects at altitude.

The more important policy issues and measures include:

- It is most critical is that demand management measures are implemented. First, freight should be transferred to low impact surface transport modes having a lower impact. In the short term this should mean the virtual elimination of freight only air transport. Second, measures to reduce both business and leisure air travel such as telecommunication and modal change are required.
- The load factor of aircraft should be sharply increased.
- The possibility of reducing fuel use by lowering speeds should be investigated, as should the avoidance of cruising near the tropopause and in the lower stratosphere.
- The development of aircraft and engine designs aimed at reducing emission should be promoted.

As far as possible, policies to limit the environmental impact of aircraft should be implemented by the aviation industry, both manufacturers and operators. However, the national and international policy framework must be set by governments and international negotiation, and governments must take much responsibility for policy measures such as the management of demand and the development and coordination of transport modes. Governments will have to use a full range of regulatory, planning and taxation options to ensure reductions in fuel use and emissions.

All social and economic sectors of wealthy societies face huge challenges to control greenhouse gas emissions. For aviation, it is particularly difficult given the growth and technical nature of aircraft and aviation fuels. However, governments and the aviation industry need to act urgently in order to develop low impact, sustainable, long distance communication and transport systems. If development is too slow, then the world will suffer worse global warming, and the industry itself will face a rapid and deep crisis because of pressure from emission targets and other, essential sectors.

The aviation industry needs to take a positive rather than a defensive posture. It can first push through technological and operational improvements as fast as possible. This will generally make the industry less vulnerable to fluctuations in fuel prices and environmental taxes or charges, thereby improving the stability of its cost base. As far as the aircraft and aeroengine manufacturing industries go, the recommendations for the rapid introduction of cleaner and more efficient aircraft should be good news because it means more sales. It will mean more costs for operators and consumers, but the impact would be quite gradual and not necessarily very large compared to the total cost of a holiday or business trip. Perhaps most important is for the aviation industry to seek a stable, long term future by diversifying into long distance transport and communication businesses. It can use its great expertise to help develop systems using multiple modes— air, sea and rail— that operate in an integrated fashion with low impact and at minimum cost. In the longer term, it could extend its expertise to address the management of demand; for example to integrate transport planning and systems into international manufacturing and services production systems.

Governments and the aviation industry need to act urgently in order to develop low impact, sustainable, long distance communication and transport systems.

Notes

1 Barrett 1994.
2 IPCC 1999.
3 IPCC 1999.
4 RCEP 2002.
5 Arthur D Little Ltd 2000.
6 Barrett 2007: 74-75.
7 IPCC 2007: 44.
8 Barrett 1994.

References

Arthur D Little Ltd, 2000, *Study into the potential impact of changes in technology or the development of Air Transport in the UK*, DETR Report on Contract No. PPAD 9/91/14, 2000.

Barrett M, 1994, *Pollution Control Strategies for Aircraft*, for WorldWide Fund for Nature International. Download: http://www.bartlett.ucl.ac.uk/markbarrett/Transport/Air/Aviation94.zip

Barrett, 2007, *Low Emission Energy Scenarios for the European Union*, for Swedish Environmental Protection Agency (Naturvårdsverket), ISBN 91-620-5785-5 ISSN 0282-7298. Download: http://www.naturvardsverket.se/Documents/bokhandeln/620-5785-5.htm

Intergovernmental Panel on Climate Change (IPCC), 1999, *Aviation and the Global Atmosphere*, Cambridge University Press. Download: http://www.grida.no/Climate/ipcc/aviation/index.htm

Intergovernmental Panel on Climate Change (IPCC), 2007, *Climate Change 2007: Synthesis Report*. Download: http://www.ipcc.ch/ipccreports/ar4-syr.htm

Royal Commission on Environmental Pollution (RCEP), 2002, *The Environmental Impacts of Civil Aircraft in Flight.* Download: http://www.rcep.org.uk/aviation/av12-txt.pdf.

A proposed contribution to an oil and gas strategy

Sandra Kloff, Emmanuel Obot, Richard Steiner and Clive Wicks

Abstract. The oil and gas industry dominates global energy supply, but is working with finite resources and also often carries high environmental and social costs. Key issues include the move into critical marine areas and the question of oil and gas extraction inside or beside protected areas. Numerous attempts have been made to address these problems, but they continue to be hampered not least by a lack of regulations on critical aspects of exploration and extraction. The paper finishes with a call for a revolution in energy supply, with a major shift to renewable sources (including a shift of subsidies from fossil fuels to renewable energy), reduction in wasteful practices such as gas flaring and elimination of decisions being made about major projects in the absence of Strategic Environmental and Social Assessments.

Background

Currently oil and gas extraction create most of the energy and resources needed to run our society. Unfortunately, they also result in a range of present and future environmental and social costs, both direct and indirect, which need to be balanced against the benefits they bring.

The world is highly dependent on oil— it powers our transport, heats or cools our homes, creates industrial and domestic chemicals and provides the feedstock for many of the materials we use and wear. Transport uses 60 per cent of oil production, mostly to fuel cars and trucks. Oil is a non-renewable resource that we use at a rate of 70 million barrels a day, at present and some estimates are that this will double by 2025. Other estimates, by some of the Industry's own geologists are that by 2025 there will be severe shortages of oil and gas as reservoirs are depleted. Already oil wells in Texas and the North Sea are drying up.

The oil and gas industry impacts on people and the environment in three ways, through climate change, through their operations on land and at sea and finally through positive or negative impacts on the economy, which can have for example also result in adverse social impacts such as corruption, (rent seekers) and civil disturbance.

Unregulated and irresponsible actions by the oil industry destroy habitats and damage biodiversity. "Low-energy habitats" such as mangroves, salt marshes and polar coastal wetlands can be seriously damaged by quite small amounts of oil. Onshore, drilling can harm ecology and open up wilderness areas. Offshore, drilling can damage some of the world's most important marine ecosystems.

Oil and gas industry impacts on people and the environment in three ways, through climate change, through their operations on land and at sea and finally through positive or negative impacts on the economy.

Oil spills at sea have damaged mangrove forests, coral reefs and fisheries, both through major accidents and regular leakage from tankers, loading buoys, drilling rigs and production platforms. Transport of oil is also implicated in ecological damage; for example, there were an estimated 16,000 spills during the construction of the Trans-Alaskan pipeline.[1] Oil tanker accidents such as Exxon Valdez, Erica or Prestige are other well-known examples of ecological disasters that can have long-term effects.

The extractive industries (oil, gas and mining) have often failed to make a contribution to sustainable development or adequately protect the environment**.** The industry is considered by many civil society organisations to have contributed to corruption, pollution, environmental and social problems. Civil disturbance— including wars— are occurring in resource-rich countries, notably in Africa including Nigeria, Angola, Sierra Leone and the Democratic Republic of Congo. Terms like the "curse of oil" and "the paradox of plenty" are in common use.

The top ten oil and gas and the top 25 mining companies together with the 20-30 main hydrocarbon producing nations reap huge financial rewards. However because of corruption and mismanagement a proportion of the resource-rich countries also bear many of the environmental and social costs and remain poor and under developed. Neighbouring nations without hydrocarbon resources also bear many of the costs and reap few of the rewards from the extractive industries.

Extractive Industries Review

In response to this, in 2000 the World Bank Group launched the Extractive Industries Review (EIR) to discuss its future role in these industries with concerned stakeholders. Dr Emil Salim, a distinguished scientist and former Environmental Minister in the Indonesian Government, was asked to chair the review and he presented his report in 2004.[2]

Dr. Salim summarised the EIR in an editorial "World Bank must reform on extractive industries" that appeared on 16 June 2004 in the UK *Financial Times*. He said: *Not only have the oil, gas and mining industries not helped the poorest people in developing countries, they have often made them worse off. Scores of recent academic studies and many of the bank's own studies confirmed our findings that countries which rely primarily on extractive industries tend to have higher levels of poverty, child morbidity and mortality, civil war, corruption and totalitarianism than those with more diversified economies. Does this mean extractive industries can never play a positive role in a nation's economy? No, it simply means that the only evidence of such a positive role we could find took place after a country's democratic governance had developed to such a degree that the poorest could see some of the benefits. Before the fundamental building blocks of good governance— a free press, a functioning judiciary, respect for human rights, free and fair elections and so on— are put in place, the development of these industries only aggravates the situation for the poorest*. (Extracts from editorial)

Climate Change

The Inter-Governmental Panel on Climate Change (IPCC) has highlighted, the escalating threats that climate change poses for the environment and human survival. Climate change must be kept below the critical 2 per cent increase on pre-industrial levels otherwise risk to people and ecosystems will be very serious.

▷ *Human Impacts*

At all levels of warming, a large group of poor, highly vulnerable developing countries are expected to suffer increasing additional food deficits, which is expected to lead to higher levels of food insecurity and hunger in these countries. Some quotations from the UN Framework Convention on Climate Change (see box) illustrate the degree of concern recognised by the global community.

Box 1. Article 2: United Nations Framework Convention on Climate Change (UNFCCC)

Ultimate objective to prevent dangerous anthropogenic **interference with the climate system**... within a time frame sufficient to:

- allow ecosystems to adapt naturally to climate change
- ensure that food production is not threatened
- enable economic development to proceed in a sustainable manner

Food and Article 2

Impacts of a 1^{o}C rise in temperature:

- Around 10 million more people at risk over the century
- Nearly all developed countries benefit
- Many developing countries in the tropics are estimated to experience small but significant crop yield growth declines

1^{o}C to 2^{o}C rise:

- warming triples number of people at risk of hunger in 2080s

Water and Article 2

1.5^{o}C to 2-2.5^{o}C

- Non-linear risk threshold of water shortages or water problems such as flooding
- Numbers at risk rising from close to **600 million** to between **2.4-3.1 billion**
- Mega-cities in India and China will be badly affected

2^{o}C +

- Very high levels of additional risk at all time periods, in the range **662 million** to around **3 billion.**

Eco-Systems and Species Impacts

The impact on ecosystems and species varies but many ecosystems, particularly coral reefs and coastal wetlands are already being affected and more ecosystems and species will be affected as the temperature exceeds 1 per cent above pre industrial levels

Industry Response to Climate Change

Overall the industries' energy scenarios for the 21st Century are not sustainable and will contribute to an environmental and social disaster, which will hit the poorest hardest and increase the gap between the rich and the poor.

BP and Shell took the lead by accepting that climate change is a problem and that biodiversity is fundamental to economic development and human welfare including spiritual, aesthetics, and cultural values. Shell sees "*biodiversity as a real business issue: if not addressed properly it increases our risks and potentially jeopardises our license to grow*". Shell has made a first commitment to stay out of "World Heritage Sites" but this is a long way from the IUCN "Amman declaration" of 2000, which recommended that governments

The industries' energy scenarios for the 21st Century are not sustainable and will contribute to an environmental and social disaster, which will hit the poorest hardest and increase the gap between the rich and the poor.

prevent mining and fossil fuel extraction in all IUCN Category I-IV protected areas.

Shell's energy scenario planning is based on UN population forecasts that the current 6 billion population will rise to between 8.5 and 10 billion by 2050, with 80 per cent of the population living in urban environments. Shell estimate that by 2050 the energy requirement will be 100-200 Giga Joules (GJ) per capita. 100 GJ per capita would be just over twice what it is now and at 200 GJ per capita three times as much. Shell predicts that by 2050 traditional forms of energy (oil, gas and coal) will provide 70 per cent of the requirement while renewables will provide only 30 per cent.

This bleak scenario for climate change is shared by Exxon Mobil the world's largest oil and gas Company. Exxon Mobil appears to go even further in not fully accepting either the principles of the Kyoto or the 2000 Amman Declaration. Exxon claims that oil producers' struggle to keep up with rampant global demand growth will only be won with access to oilfields now off-limits. Exxon Mobil's chief executive Lee Raymond said in a speech to the OPEC International Seminar in Vienna on the 16th Sept 2004 that:[3]

First, the outlook sets before us an enormous task of finding and producing the huge and increasing amounts of energy needed by the people of the world. Inevitably, most of the energy that will be used for many decades will continue to be from fossil fuels: coal, oil and natural gas. For a variety of reasons, we expect demand for fossil fuels to increase in absolute magnitude by about 65 to 85 million oil equivalent barrels per day by 2020.

Just how much is, 65 to 85 million barrels per day? Well, it is in the range of eight times Saudi Arabia's current oil production. Obviously, this is no small chore. Cooperation will be critical in several areas.

There will be a need to ensure that energy-producing companies have access to resources. Today we see a number of access restrictions around the world.

These restrictions exist in energy-importing countries such as the United States, where limitations have been placed on exploring areas where energy resources may be found. But they also exist elsewhere, in energy-exporting countries. The future need for petroleum energy will be such that restrictions— in whatever form and wherever imposed— will jeopardise the provision of adequate energy supplies to world consumers.

Shell predicts that by 2050 traditional forms of energy (oil, gas and coal) will provide 70 per cent of the requirement while renewables will provide only 30 per cent.

With significant heavy oil, tar sands, and other "unconventional" resources, new technology will be critical to making the "unconventional" energy resources of today the "conventional" resources of tomorrow. Making development of these unconventional resources economically attractive will ensure adequate supplies of fossil fuels are available at affordable prices for the next 100 years."

This kind of response is only delaying the end of the oil era not solving long-term energy needs.

It is believed that Raymond is referring particularly to the Arctic Refuge in Alaska. Research by WWF and others has shown that even if all the extractable oil was pumped from under the Arctic Refuge it would only supply about nine months of US demand. It would damage one of the most critical ecosystems on earth, on which the "Gwitchen" people depend for survival. This kind of response is only delaying the end of the oil era not solving long-term energy needs.

In spite of this the US Senate approved, by a two vote majority, the exploration of oil and gas in the Arctic Refuge. Exploitation of Canadian oil shales has recently been stepped up, despite widespread concern about the environmental consequences.

The struggle to keep up with energy demands, particularly from rapidly developing countries like India and China, is driving more and more companies into remote, fragile ecosystems and areas of unique biodiversity where governments often have limited capacity to protect the environment, other economic activities or the people who live there.

Picture 1. The prospect of drought and increasing food shortages are real threats in many developing countries (*Courtesy Sue Stolton, Equilibrium Research*)

Exploration in critical marine areas

Most of the increased oil and gas production in West Africa and other parts of the world will be from offshore wells in sensitive marine environments.

Most of the increased oil and gas production in West Africa and other parts of the world will be from offshore wells in sensitive marine environments, which are critical for human economic survival. There are several reasons for these developments:

- The social and environmental problems that have occurred on land, *e.g.* in Nigeria-the Niger Delta
- Oil reserves on land are starting to dry up, *e.g.* Texas and Gabon
- The technical problems of operating in deep water and rough seas have been largely solved through work in the North Sea, Gulf of Mexico etc
- The lack of laws controlling off shore operations in the marine environment and the ability to negotiate individual agreements with governments, even though the main impact of a spill will be on a neighbouring country not the country in which the spill occurs.
- The ability to convert 25-30 year old single hulled tankers which should have gone to the scrap yards into floating production platforms (so-called FPSOs) for use in countries that do not have strict laws. The USA will not permit them to be used and the maritime certification agency Bureau Veritas[4] has produced a

report advising against the conversion of old single hulled tankers.
- Some civil society organisations claim that there is even a lack of control over what is exported from offshore wells and therefore there is an opportunity for fraud/corruption.

Protected Areas and the oil industry: conflict and attempts at reconciliation

Claims by the industry that they can work in fragile vulnerable environments has not generally been born out in reality, as shown in the World Bank Extractive review and many other reports.

As with other extractive industries oil and gas companies pose many actual and potential threats to protected areas. The wide-ranging methods of extraction, on land and underwater, and the risks of pollution during transport, use and disposal of fossil fuels, mean that a wide range of impacts is possible. These impacts can range from air, land and water pollution to habitat loss and fragmentation, increased settlement and related impacts for instance as a result of roads, pipelines or seismic lines being cut through primary forest or disturbance from drilling camps.

Many governments clearly regard protected areas as suitable for oil and gas production, using arguments about the overall importance of energy supplies.

Many governments clearly regard protected areas as suitable for oil and gas production, using arguments about the overall importance of energy supplies and the possibility that oil and gas extraction can take place in a relatively benign way. On the other hand, others prohibit such activities in protected areas absolutely. Even more common is exploration and exploitation near to protected areas, including within buffer zones. Whether near to or within officially protected areas, there have been increasing pressures on the companies that conduct these extraction activities to operate in a responsible manner, including keeping negative impacts to an absolute minimum and avoid undertaking operations in some specific areas and encouraging positive benefit wherever possible.

Industry and conservation groups have responded through a number of joint ventures to address environmental issues. In 1993, IUCN and the Oil Industry International Exploration and Production Forum (E&P Forum—now the Association of Oil and Gas Producers) jointly published guidelines "*to establish internationally acceptable goals and guidance*" for environmental protection for *Oil and Gas Exploration and Production in Arctic and Sub arctic Onshore Regions.*[5] The guidelines specifically recommended that selection of the drill site should be guided by a number of pointers, including the "*avoidance of protected and conservation areas"* and listed the "*awareness and avoidance of protected areas"* first in a list of general environmental protection measures that should guide activities.

IUCN sought to tackle the issue of extractive industries impacts on protected areas more generally through a recommendation (2.82) at the World Conservation Congress in Amman, Jordan in October 2000. The recommendation calls "*on all IUCN's State members to prohibit by law, all exploration and extraction of mineral resources in protected areas corresponding to IUCN protected area management* *categories I-IV*". And recommended that "*in categories V and VI, exploration and localised extraction would be accepted only where the nature and extent of the proposed activities of the mining project indicates the compatibility of the project with objectives of the protected areas".* Although this recommendation was aimed at Governments, it clearly has implications for many companies. For instance, BP has 49 units operating in or adjacent to national or international protected areas, with five of these units operating within protected areas categorised as IUCN I-IV.[6]

In order to further help countries work, effectively with the Extractive Industries a number of organisations have produced guidelines. WWF produced "*To Dig or Not to Dig*"[7] (see box) with criteria for determining the acceptability of mineral exploration, extraction and transport from ecological and social perspective.

Box 2. To Dig or Not To Dig

WWF suggests in "To Dig or Not To Dig" that mineral activity should not take place in the following places:

- ▷ **Highly protected areas** (IUCN categories I-IV, marine category I-V protected areas, UNESCO World Heritage sites, core areas of UNESCO biosphere reserves, Natura 2000 sites and in European Union countries);
- ▷ **Proposed protected areas within priority conservation areas** selected through Eco-regional planning exercises;
- ▷ **Areas containing the last remaining examples of particular ecosystems or species** even if these lie outside protected areas; and
- ▷ **Places where mineral activities threaten the wellbeing of communities**, particularly including local communities and indigenous people.

The term "mineral activity" is used to denote all levels of activity— prospecting, extraction, processing, transport and decommissioning— which are related to either fossil fuels or minerals, metals or building materials.

The Energy and Biodiversity Initiative aims to develop and promote best practices for integrating biodiversity conservation into oil and gas development and transmission. The first meeting of the Initiative was held in January 2001 and a publication has now been produced[8] under the auspices of nine organisations: BP plc, Conservation International, Chevron Texaco, Fauna & Flora International, Smithsonian Institution, Shell International, The Nature Conservancy (TNC), Statoil and IUCN. The Initiative is a collaborative process to produce outputs with broad dissemination, and important stakeholder groups have and will continue to be consulted throughout the development of these outputs. The principal issues addressed are:

- ▷ The rationale for integrating biodiversity conservation into oil and gas operations
- ▷ Identification and implementation of on-the-ground best technical and management practices
- ▷ Metrics and performance indicators for measuring the positive and negative impact of oil and gas development on biodiversity
- ▷ Criteria for deciding whether to undertake activities in sensitive environments

The International Petroleum Industry Environmental Conservation Association/ International Association of Oil and Gas Producers (IPIECA) was founded in 1974 and provides the oil and gas industry's main channel of communication on environmental issues with the United Nations, particularly the United Nations Environment Programme. IPIECA's focus is on key environmental issues such as oil spill preparedness and response, global climate change and biodiversity; as well as health and social responsibility issues. There are currently over 35 members, drawn from private and state owned companies as well as national, regional and international associations— the membership covers Africa, Latin America, Asia, Europe, Middle East and North America.

In spite of all the efforts of these organisations the reality on the ground is that many areas of high biodiversity including protected areas have been badly affected by the oil and gas industries. The experience of CEESP members helping local NGOs working on oil and gas projects in many parts of the world including West Africa and the Former Soviet territories such as Azerbaijan and Georgia has highlight the problems. One of the fundamental issues is that oil and gas fields are being developed in isolation from or in the absence of National Energy Plans.

The reality on the ground is that many areas of high biodiversity including protected areas have been badly affected by the oil and gas industries.

Another problem is that contrary to OECD, UNEP, UNDP and World Bank Transparency Guidelines, extractive industries are still signing secretive agreements such as Inter Governmental Agreements (IGA's), Host Government Agreements (HGA's), Production Sharing Agreements (PSA's), Contracts of Work, etc, with Government. They have even ordered equipment and approved construction contracts before they have carried out a social study or environmental impact or had their Environmental and Social Impact Assessments (ESIA) approved.

Worse of all the industry are not following International Standards for developing projects, which require decisions to be made on the basis of prior and informed consent.

Worse of all the industry are not following International Standards for developing projects, which require decisions to be made on the basis of prior and informed consent.

A classical example of this is the Baku-Tiblisi-Cheyan pipeline. The decision on the route of the pipeline was made in 2000 before ESIA was even started. HGA and construction agreements were signed in October 2000, the final route was approved in January 2001 but work began on the ESIA only in June of that year. Some NGOs such as WWF Turkey were not even consulted until Dec 2001 after the first ESIA had been carried out.

Lessons learned

Lesson 1: Transparency

All oil and gas companies should respect the UN Convention on Corruption and the Extractive Industries Transparency Initiative and practise total transparency. Companies should inform governments of their standards prior to signing contracts and work with governments to meet the International standards on Transparency.

Lesson 2: National Sustainability

Both Rio and Johannesburg WCSD's proposed that National Sustainability plans should be developed. These should include National Environmental and Energy plans including renewable energy. All oil and gas projects should be developed within a Strategic Environmental Assessment as part of the framework of National Sustainability/Energy Plans. These plans should include the current and future energy needs for the country and the substitution of finite resources with renewables.

Lesson 3: Strategic Environmental Assessment (SEA)

A good model of an SEA has been prepared by the UK Department of Trade and Industry (DTI with support from staff from WWF and many other organisations). A key early step is an SEA scoping exercise to obtain external input to help define:

- The issues and concerns that the SEA should address
- Key information sources and perceived gaps in understanding of the natural environment
- Key information sources and perceived gaps in understanding of the effects of the activities that would result from oil and gas licensing

SEAs are vital for critical marine systems, on which millions of poor people depend for survival. These systems are going to be badly affected unless industry is forced to meet the highest international standards.

Lesson 4: Combined environmental and social studies

Oil and gas companies must complete all environmental and social studies including health impacts at the same time and have them checked by relevant government departments, civil society and an independent agency before giving them to the government for approval. This must be completed before investment decisions are made.

Lesson 5: International Standards

Oil and gas companies should follow the highest international standards both in construction methods and the equipment they use. The use of old (25 plus years) single hulled converted tankers as floating production platforms will cause concern particularly when they are stationed in areas of very high marine biodiversity.

Lesson 6: Treaties

International treaties are needed to control oil and gas operations when the impacts of their operations, including oil spills or discharged process water, may affect a number of countries.

Lack of international legislation for offshore oil and gas operations

Although some general principles exist in both Rio and United Nations Convention on the Law of the Sea (UNCLOS), as shown below, there is a serious lack of detailed international legislation for offshore oil and gas operations. The onus is primarily on states to develop legislation, even though the main impact of pollution may be on neighbouring countries.

There is a serious lack of detailed international legislation for offshore oil and gas operations.

This problem has been highlighted by the Canadian Maritime Environmental Law Association (CMLA): *The present plethora of national legal regimes and the individual contractual negotiations between the major oil companies* *and nation states, often with little or no bargaining power, has resulted in an assemblage of political and economic environments which resembles European medieval fiefdoms.*[9]

Principle 2 of the Rio Declaration provides: *States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.*

UNCLOS states in Article 208 that: *Coastal States shall adopt laws to control marine pollution from offshore units and seabed activities no less effective than in international rules and standards. States shall establish global and regional rules for this purpose*.

A strategy for energy

In recognition of the severe problems arising from the oil and gas industry, and the finite nature of these resources, calls for an Energy Revolution on the scale of the industrial revolution to solve the world's energy and climate change crisis. Key elements of such a "revolution" would be:

Picture 2. West African marine environments could be at risk from increased oil and gas production (*Courtesy Nigel Dudley, Equilibrium Research*)

- By 2050 virtually all energy to come from environmentally-sound renewable, or decarbonised sources. This will also reduce the need for the oil and gas industry to move into areas of high biodiversity and low civil society and government capacity or areas, which are critical for human survival.
- Governments and other key constituencies need to overcome the current unsustainable fossil-based energy system and take clear and decisive steps towards renewable energies and energy efficiency.
- Industry should pay the real cost of their impacts on climate change and other environmental damage; this will also help to ensure that renewable energy sources are competitive and new technologies are developed.
- All direct and indirect subsidies need to be stopped, except those supporting fuel for the poorest people.
- The energy needs for future generations must not be wasted and gas flaring should be stopped; when it occurs it should be subject to financial penalties.
- Countries should be helped to develop National Sustainability Plans including energy plans, which include renewable energy strategies. They should avoid exporting all their fossil fuels before they have developed renewable replacements.
- All extractive industries and all governments should be encouraged to sign the Extractive Industries Transparency Initiative, (EITI) and respect the UN Convention on Corruption.

- Industries should stop signing secretive Host Government Agreements, Production Agreements and Contracts of Work. No contracts should be signed before Strategic Environmental Assessments (SEAs) and Environmental and Social studies (ESIAs) have been carried out. Governments must give prior and informed consent in accordance with OECD Guidelines.
- All poor people should be supplied with renewable low cost energy efficient systems suited to their needs.
- Sums at least the equivalent of the current fossil fuel subsidies need to be invested in research and subsidising the development of renewables and the improvements in energy efficiency.
- The revenue from oil and gas should be used to help countries develop and implement sustainable development plans thereby protecting the environment and helping to eradicate poverty.

Engaging citizens in a legitimate, empowered manner is not just good for companies and concerned and affected stakeholders; it is the heart and soul of ethics and sustainability.

One of the main pillars of achieving environmental and social justice in large-scale projects is to have fully informed stakeholder participation and citizen oversight in projects that are implemented by large industries. Engaging citizens in a legitimate, empowered manner is not just good for companies and concerned and affected stakeholders; it is the heart and soul of ethics and sustainability.

Sandra Kloff, **Emmanuel Obot** and **Richard Steiner** are all members of CEESP's Working Group on Social and Environmental Accountability of the Private Sector (SEAPRISE). **Clive Wicks** (clivewicks@googlemail.com) is co-chair of SEAPRISE, with a particular interest in fossil fuels and mining in Africa. He worked for many years with WWF UK.

Notes

1 Dudley and Stolton 2002.
2 World Bank, 2004.
3 Raymond, 2004.
4 Veritas, 2004.
5 IUCN and E&P Forum, 1993.
6 Bishop *et al.* 2004.
7 Dudley and Stolton 2002.
8 EBI, 2004.
9 Canadian Maritime Law Association, 1996.

References

Bishop, K, N Dudley, A Phillips and S Stolton, *Speaking a Common Language*, University of Cardiff and IUCN, Cardiff and Gland, Switzerland, 2004.

Canadian Maritime Law Association, *Discussion Paper on the Need for an International Legal Regime for Offshore Units etc, Seabed Resources*, 1996 Available on: http://www.wob.nf.ca/News/1998/July98/offshore3.htm

Dudley, N and S Stolton, *To Dig or Not to Dig?*, WWF International, 2002.

EBI (Energy and Biodiversity Initiative), *Integrating Biodiversity Conservation and Oil & Gas Development*, Conservation International, 2004.

IUCN and E&P Forum, Oil and Gas *Exploration in Arctic and Subarctic Onshore Regions: Guidelines for Environmental Protection*, IUCN, Gland Switzerland and Cambridge UK, 1993.

Raymond, L R, Chairman and Chief Executive Officer, Exxon Mobil Corporation
OPEC International Seminar - Vienna, Austria
September 16, 2004

http://www.exxonmobil.com/Corporate/Newsroom/SpchsIntvws/Corp_NR_SpchIntrvw_LRR_160904.asp

Veritas, Press Release, June 18 2004.

World Bank, *Extractive Industries Review*, Washington DC, 2004.