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SYNOPSIS

Climate Change and Peak Oil: The Urgent Need for a Transition to a Non-Carbon-Emitting Society

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The strong environmental effects of greenhouse gas emissions derived from oil use and the negative socioeconomic consequences of future oil scarcity make it urgent that we shift to alternative affordable energy sources. Here we briefly overview the multiple economic, technological, and political pathways that should be implemented immediately to achieve this global energetic transition. We discuss how states could empower their national strategies to improve the efficiency in energy generation, transmission, and consumption and thus progressively reduce carbon emissions. At the international level, we suggest that governments should strongly promote multilateral and bilateral cooperative agreements on energy and climate policies. In addition, we suggest that states should promote the creation of a United Nations international program to facilitate and coordinate a worldwide ordered and nontraumatic transition to low-carbon and energy-efficient economies. Finally, we advocate for a much greater scientific effort to be urgently placed on the interactions between peak oil, climate change, and global society change.

The coming decades will determine whether the human population comes into balance with the capacity of the Earth to support it, or whether the environmental changes brought by the overharvesting of oil and natural resources, climate change, loss of biodiversity, or pollution of air and water—among many other factors driven by human activities—will lead to the end of the improvement in the well-being in developed countries, which have characterized the Modern and the Contemporary Eras. Current indicators are alarming. Declining trends in environmental condition are either continuing unchanged from previous decades or are accelerating beyond our most pessimistic projections (Intergovernmental Panel on Climate Change (IPCC) 2007a, b).

Among these global environmental changes, the most paradigmatic one is the continuous rise of carbon dioxide (CO_2) emissions to the troposphere from fossil fuel burning (Canadell et al. 2007). These unconstrained CO_2 emissions have been the dominant cause of observed anthropogenic global warming, and further increases in emissions and enhanced warming are projected for the following years and decades with corresponding impacts on the Earth and our lives (Intergovernmental Panel on Climate Change (IPCC) 2007a, b).

Most emissions are directly associated with the expansion of the energy and transport sectors, which rely on an increased global demand for low-cost oil and gas resources. However, international assessments of energy resources assert that low-cost fossil fuels, which are sustaining the international expansion of trade, may become limited in the near term (International Energy Agency 2008a). Much of the discussion regarding limited oil availability turns around the concept of "peak oil"—in other words, the point at which global production of conventional petroleum will reach a peak and start to decline, as has already occurred in some countries, such as the USA, which reached its domestic peak oil around 1970 (Hubbert 1949, 1956; Cavallo 2004; Brandt 2007). The global peak oil will easily result in acute economic, social, and environmental problems associated with increases in the price of oil and the desperate demand for alternatives to fill the future widening gap between the demand and the supply of

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conventional petroleum (International Energy Agency 2008a; United Nations 2008a).

The amounts of proven and potential fossil fuel reserves are uncertain and debated, mainly due to information hidden by industry and state (International Energy Agency 2008a; Energy Information Administration 2008). Some authors believe that the energy industry is already close to the maximum amount of oil that can physically be produced at low cost (Campbell and Laherrère 1998; Cavallo 2007). Other authors and institutions disagree and consider that oil reserves and current production could be expanded by increased geographical exploration (Maugeri 2004) or by increased investment in countries making up the Organization of the Petroleum Exporting Countries (OPEC) (Kerr 2008). It is not clear who is more correct, but it is clear that the economic–energetic–environmental problem is already here. Indeed, a recent assessment by the International Energy Agency, a prestigious institution of the Organisation for Economic Co-operation and Development (OECD), warns that oil shortage and increased energy costs could easily be immediate realities after the current financial crisis if massive and strategic investments in the oil industry are not rapidly implemented on a large scale (International Energy Agency 2008a).

An increase in oil prices could strongly affect CO_2 emissions, driving further increases if unconventional additional, dirtier, and more difficult-to-exploit sources of oil are used. Extracting oil from oil shale or tar sands and the technically possible conversion of coal to liquids is expensive, both energetically and environmentally, and drives further increases of CO_2 emissions. In fact, keeping atmospheric CO_2 from exceeding about 450 ppm by 2100 may be feasible only if emissions from these unconventional fossil fuels, coal, and land use are constrained (Kharecha and Hansen 2008). Moreover, we do not need to wait to reach 450 ppm to be worried. The current concentration of CO_2 in the atmosphere has already exceeded the levels that can be considered safe with respect to the Earth's climate (Van Vuuren et al. 2008; Ramathan and Feng 2008).

In sum, both because of the strong environmental effects of greenhouse gas emissions and because of the negative socioeconomic consequences of oil dependence and scarcity, society has an urgent need to shift to alternative affordable energy sources to create and sustain prosperity everywhere and for everybody without altering climate and the environment (United Nations 2008b). The much needed transition to a non-carbon-emitting energy system is the greatest current challenge at the energy–economy–environment intersection. If the climate change and environmental harms or the peak oil problem are not convincing enough, there are, however, many economic advantages of early action that can convince governments, institutions, and companies (Stern 2006; Dietz and Stern 2008). Furthermore, if cheap oil becomes more difficult to obtain due to delays in oil industry investments, political instability, or government control, alternative sources of energy will become economically more stable and competitive.

To stabilize atmospheric CO_2 concentrations at a reasonable level, e.g. at 450–500 ppmv and decrease progressively oil dependency by moving to non-carbon emitting energy sources is not easy at all, but is not a utopia either. It is a feasible goal by promoting several action lines urgently and actively (Hoffert et al. 2002; Paccala and Socolow 2004; Wara 2007).

Since economic constraints often strongly determine societal behavior, governments should study and consider the reduction or suppression of existing environmentally harmful subsidies for oil and gas (OECD 2005) and, beyond that, should place a price on CO_2 emissions by progressively extending and strengthening existing carbon taxes and cap-and-trade programs (Wara 2007). Since it has been recently highlighted that existing emission trading programs may be a grossly inefficient way of cutting emissions, especially in developing countries (Wara 2007; Victor et al. 2005; Prins and Rayner 2007), shifting the focus of political attention to carbon taxes is also recommended (Nordhaus 2007; Metcalf 2009). Carbon taxes are more transparent and are easier to develop and implement than complex cap-and-trade systems; further, they lend predictability to energy prices, thus encouraging preferential investment in low-carbon-emitting options. Moreover, tax revenues may feed back on climate change and energy policies, providing financial support for the deployment of renewable energies, reducing the cost of other government taxes, or even financing international policies to mitigate the increasing negative effects of unstable oil prices and climate change on sustainability and development goals (United Nations 2008a, b; Energy Information Administration 2008; Campbell and Laherrère 1998; Cavallo 2007; Maugeri 2004; Kerr 2008; Kharecha and Hansen 2008; Van Vuuren et al. 2008; Ramathan and Feng 2008). In addition to providing a stable and increasing incentive for emission reductions and the search for alternative energy sources, a gradual increase in the price of CO_2 emissions in the following years may help discourage the conversion of the vast unconventional fossil resources into usable reserves. Even though oil is progressively becoming an already highly priced product—and it will probably become even more expensive after the end of the current financial crisis (International Energy Agency 2008a)—the rise in the price generated by a CO_2 tax will simply represent a recognition of the externality value of CO_2 emissions; and the earlier this value is recognized, the better. In sum, governments should extend the existing carbon taxes and regional cap-and-trade programs and study the viability of their unification in a suitable global framework (Wara 2007).

In order to reduce the use of fossil fuels, energy use efficiency must be globally increased. Governments, private institutions, and the public should largely empower their national, local, and personal strategies to greatly improve the efficiency in energy generation, transmission, and consumption. For example, smart electrical grids with distributed regional and central power generation and technologies to reduce demand and optimize distribution to critical areas during peak periods should be progressively implemented (Coll-Mayor et al. 2006; Ropenus and Skytte 2007; Haines et al. 2007; Marnay 2008). Similarly, improvements in energy efficiency should come from a myriad of bottom-up innovations and practices in several sectors, such as the building or car industries, that should be actively promoted by governmental incentives (Paccala and Socolow 2004). Furthermore, national and local governments should preferentially invest in public transport systems; actively promote more efficient modes of moving goods; and facilitate, whenever possible, the progressive electrification of the private transport sector. Globally, the car industry is already strategically investing in and shifting to plug-in electric cars and hybrid models. If successfully implemented, then the progressive electrification of the car industry sector and the subsequent emergence of millions of battery-powered cars will provide a high capacity and distributed storage system for renewable electricity, thus synergistically complementing the required massive investments in renewable source energies. The electrification of the car industry sector will require the development of networks of electrical charge points, increases in electricity supply, and important investments to produce huge amounts of batteries and required new devices (Armand and Tarascon 2008).

If we reduce our use of fossil fuel, we need alternative sources of energy and improved energy technologies (Potocnik 2007). There is a broadening consensus supporting the necessity of more national plans and incentives to increase the production of renewable electricity at large and local scales, promoting appropriate frameworks with low administrative and regulatory barriers and relatively favorable electric grid access conditions (Belyaev et al. 2005; International Energy Agency 2008b). In relation to new technological advances, promising ongoing research lines include energetically viable biofuel options that do not compete with food production or drive deforestation (Ragauskas et al. 2006; Agrawal et al. 2007; Stephanopoulos 2007; Field et al. 2008), cheaper photovoltaic cells and eolic technologies (Lewis 2007; Bisquert 2008), improved batteries for hybrid and plug-in electric vehicles (Armand and Tarascon 2008), distributed microgrids and smart grids (Coll-Mayor et al. 2006; Marnay 2008), improved coal-gasification technologies to produce electricity and hydrogen while capturing CO_2 (Paccala and Socolow 2004; Shrag 2007), new processes for producing hydrogen from water using solar energy (Service 2007), better means of storing hydrogen (Mao and Mao 2004; Patchkovskii et al. 2005), hydrogen fuel-cell vehicles (Jacobson et al. 2005), and direct removal of carbon from the air (Keith et al. 2006; Pielke 2009). In addition, a range of potential advances to be explored in material sciences, biotechnology, nanotechnology, information technology, and engineering could reduce the energy and resource requirements of product manufacturing and food production (Ragauskas et al. 2006). All of this requires only a 5- to 10-fold increase in the public and private spending for energy research and development—an astonishingly small increase compared with what society spends on energy itself (usually between 5 and 10% of the gross domestic product).

And meanwhile, in our transition to a non-carbon-emitting society, what do we do with our increasing emissions of CO_2 to the atmosphere? We suggest that governments and private institutions should invest and strongly increase efforts in research, development, and experimental implementation of direct carbon removal technologies and geological carbon sequestration strategies (Keith et al. 2006; Pielke 2009; Shrag 2007; Goldberg et al. 2008; Kelemen and Matter 2008), biological carbon sequestration strategies (Paccala and Socolow 2004; Jackson et al. 2005; Gullison et al. 2007; Canadell and Raupach 2008; Kindermann et al. 2008), and sustainable rural development strategies (Kiers et al. 2008; Lobell et al. 2008; Funk et al. 2008).

Leading developed countries are in the best technological, political, and economic position to begin this transition. They have to immediately start the above discussed actions but they must also transfer the necessary technology and help developing countries to ensure a rapid global decline of greenhouse gas emissions in light of the fact that developing countries now account for an important and increasing fraction of fossil fuel emissions (Intergovernmental Panel on Climate Change (IPCC) 2007a, b; International Energy Agency 2008a) and in light of the need for a fair distribution of knowledge and well-being (United Nations 2008b).

Overall, truly honest cooperative dynamics at the international level are required to solve the current energetic–environmental challenge. All nations, especially major developed and developing economies, should decidedly pursue strong leadership and attain diverse multilateral agreements to ensure a nontraumatic, gradual, and ordered global transition to low-carbon economies in all countries. States should harmonize their national policies and interests with global interests in energy transition and climate security, and they should act rapidly, efficiently, and in a coordinated fashion through multilateral or bilateral agreements.

The required international cooperative dynamics will also demand very efficient and executive intergovernmental actors to ensure the effective coordination and timely implementation of international agreements and policies dictated by states. All international institutions should play an active role in this transition (the United Nations system, the Intergovernmental Panel on Climate Change, OECD, G-20/L-20, the World Bank, and the International Monetary Fund). However, we suggest that the United Nations may consider the creation of a multilateral international organization or program to facilitate the global transition to non-carbon renewable energies (United Nations Organization or Programme for the Transition to Renewable Energies and Decarbonization). It should be provided with enough budget, audit, and executive power to successfully facilitate and coordinate the action of states and intergovernmental institutions toward this global transition. This organization should promote diverse multilateral and bilateral cooperative strategic international agreements to effectively secure international energy supplies, to coordinate the urgently required massive investments in energy infrastructure, to develop regulatory agreements to avoid the emergence of speculative dynamics and volatility on oil prices that ultimately damage economic stability and increase the ongoing global food security crisis, and more generally, to allow a worldwide ordered and nontraumatic transition to low-carbon and energy-efficient economies (International Energy Agency 2008a; Wara 2007; Victor et al. 2005). One immediate example of an effective regional multilateral agreement would be the one facilitating the massive gas imports to China and India from Russia and Iran that are needed for a generalized shift from coal- to gas-powered energy plants during the transition. Such cooperative agreements would substantially reduce the amount of emissions produced in these emerging economies (Victor et al. 2005). Similarly, regional multilateral agreements should be attained to harmonize implemented national carbon taxes, to enhance existing cap-and-trade systems, or to transfer carbon sequestration technologies (Nordhaus 2007).

Recent empirical and mathematical studies assert that the emergence of the required multilateral cooperative dynamics would be more feasible only if citizens and policymakers were very well informed about the risks of climate change and the energy crisis (Dreber and Nowak 2008; Milinski et al. 2008). With this aim, we suggest that the role of the scientific community should not be limited to discussing technical and behavioral solutions in specialized and technical debates. Whenever possible, scientists should join the effort of educators, journalists, policymakers, and civil movements to clearly communicate the climate-energy risks to society, and to show the existing multiple pathways that should be immediately implemented. Similarly, to ensure a more precise scientific assessment of the current challenges of the energy crisis, both scientists and specialized institutions such as the International Energy Agency should be provided with high-quality information on oil sources and reserves. OPEC countries, and even private enterprises, should play an important leading role here. Overall, a much greater scientific effort should be urgently placed on the interactions between peak oil, climate change, and global society change. The scale, urgency, and severity of peak oil and climate change mean that no action is too small to matter, too large to contemplate, or too soon to begin. There is not much time left.

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