

Banerji, Shumeet et al.

Conference Paper

The energy crisis and climate change

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The Global Environment

The Energy Crisis and Climate Change

The Challenges

The future global economy is likely to consume ever more energy, especially due to the rising energy demand of developing countries such as China and India. At the same time, the tremendous risk of climate change associated with the use of fossil fuels makes supplying this energy increasingly difficult.

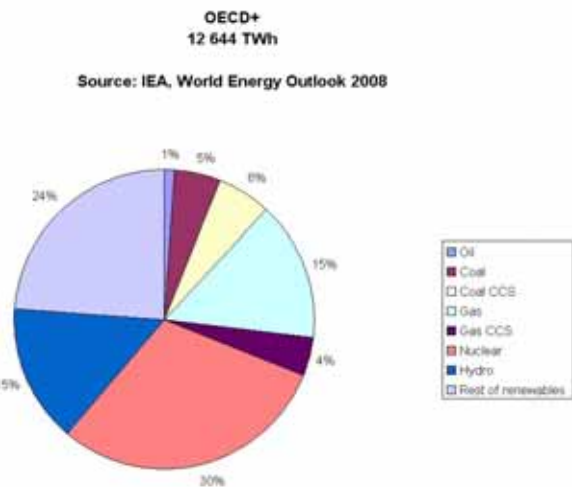


According to IEA projections, a larger size of the world population and the world economy would result in an increase of the world's primary energy demand by 45% by 2030 without any climate policy (Here and in the following, data are based on the IEA World Energy Outlook 2008). However, significant welfare consequences of climate change require us to take strong policy on carbon dioxide emissions, possibly to stabilize the atmospheric carbon dioxide concentrations as low as at 450ppm in the long-run. This necessitates us to limit the total use of energy to some degree. (In IEA's projection, the world primary energy use is 15% less with a 450ppm stabilization target in the year 2030 than in the case without climate policy).

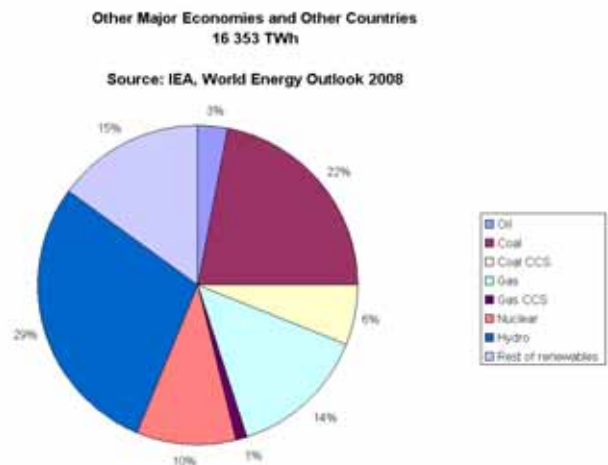
Still, we need to dramatically expand the use of clean, renewable energy sources, while continuing the exploitation of conventional energy sources to a substantial degree. Regionally, the challenge will be more acute in the developing world. The IEA estimates that China and India alone will account for half the energy demand increase in the next quarter century. As for other regions, the population in Africa will increase by more than 60% from now to 2030 and could become an important factor for the global energy demand. The remaining large income gaps between the developing and developed economies would justify the former's increasing energy use to achieve better standards of living.

The problem can hardly be solved by single local solutions; rather, it requires an interconnected global portfolio of energy sources that matches regional characteristics and that can satisfy the global energy demand as efficient and carbon-free as possible. While many developing regions are abundant in potential energy sources such as coal, solar power, wind and water, state-of-the-art energy technologies are mainly developed in the industrialized countries, at least so far.

Electricity generation by fuel and by regional grouping in the 450 Policy Scenario, 2030



Electricity generation by fuel and by regional grouping in the 450 Policy Scenario, 2030





As the development of these technologies moves forward, it is important to know what future energy markets will look like. What are the future business strategies for international investment in the energy sector? In how far does the current financial crisis prevent or enhance domestic and international investment in energy saving technologies? What will be the dominant energy sources in different regions? In which fields of technology and locations will political action be necessary? Will action be taken by a global institution or on a regional level? In which form and time frame? Herein, an important step is the introduction of a CO₂ emission price (tax or cap and trade system). In addition, the development, diffusion and application of new energy solutions may be fostered through all channels of international cooperation. The main actors would be multinational companies and investors. For example, they might invest in large-scale solar energy projects in African deserts, in large-scale offshore wind parks in Europe, or in CCS-equipped power plants in China. Policy makers should set a sound legal framework to give the right incentives to business initiatives, possibly via specifying energy efficiency standards on products. Where an efficient allocation fails, scientific advisors should identify policy strategies to promote international private investment and (international) technology diffusion, for example via sorting out institutional barriers in implementing energy saving technologies. They should also provide guidance on effective public investment in R&D and foreign aid. Given the increasing demand for energy in developing countries, a particular focus should fall on efforts to transfer technologies to these countries.

Proposed Solutions

Shumeet Banerji

CEO, Booz & Company

The energy shift and its impact on global climate change

The unprecedented volatility in energy prices of the last few years, and the policy imperative to reduce greenhouse gas emissions, have produced deep uncertainty about the future of energy, and especially about the future of fossil fuels. A broad shift toward lower-carbon alternatives is now well under way, but on its current path, is happening too slowly to achieve the reductions in emissions that scientists consider essential to slow the pace of global warming.

Energy prices will continue to be volatile, due to the inherent lags in bringing new capacity on line in a time of sharp shifts in demand, as well as to concerns about long-term energy availability and security and the impact of climate change legislation on the costs of using different fuels. The pressure to shift away from coal, despite its low cost and abundant supplies, will continue. Natural gas, on the other hand, will be favored due to its relatively low greenhouse gas emissions (roughly half that of coal) and sharply rising estimates of potential reserves. Slowing the growth in energy demand will require a significant focus on energy conservation. Many low cost opportunities are available, such as improvements in insulation, better maintenance of heating systems, and smart thermostats (see www.businessfuture.com; for more: Spiegel, Eric, and Neil McArthur, with Rob Norton, *Energy shift: Game-changing options for fueling the future*, Booz & Company and McGraw-Hill, 2009).

While much of the popular debate about controlling emissions centers around transportation solutions, most of the reductions in the short to intermediate term will need to come from the power generation sector. Both sectors face significant uncertainties.



Transportation

The long-term trend in transportation will be towards alternative power trains, and, thus, five key themes are likely to drive the shape and pace of change.

- Conventional diesel will likely gain share both in Europe and other regions like the US.
- Biofuels will increase in production volume but overall market penetration will be slow outside of specific nations and regions, such as Brazil and the Midwestern US.
- Conventional hybrids will likely gain market share in the short term, particularly among environmentally conscious consumers.
- Long term options are likely to focus on all-electric and hydrogen vehicles, although both face significant uncertainty – hydrogen more-so than electric.

Power generation

The mix of fuels used to generate the electricity will have to change significantly. Producers will have to make decisions surrounding which fuel to “bet on” for future electricity generation.

Coal is currently not a feasible option for investment in most developed countries, due to the high costs of carbon capture and sequestration (CCS) using today’s technology. While this may change, CCS is not expected to have a major impact over the next decade or more.

Natural gas will play a key role. Estimates of reserves have risen significantly in the last few years, particularly in North America, due to the expansion of unconventional sources. Increasing gas supplies, in the form of liquefied natural gas, which is a globally traded commodity, will likely set the price for CO₂ in the US as a cap and trade system is implemented.

Nuclear energy will emerge as an economic alternative if greenhouse gas restrictions are implemented and natural gas prices remain high, despite concerns related to safety and security. Its viability, however, will depend on government backing and commitment.

Renewables are potentially important suppliers of world energy in the long term, but remain cost-uncompetitive in the current environment. Their future role will thus be determined by the extent of governmental support and technology improvements, especially for solar.

Policy

Policy responses to lower greenhouse gas emissions have been modest to date. Most national and regional goals established in earlier years for reducing greenhouse gas emissions have not been met, and recent developments have been discouraging. The energy legislation currently under consideration in the ., for example, seems likely to result in a compromise with modest goals for emissions reductions. On the international front, the greenhouse-gas reductions agreed at the G8 summit in July represented a retreat from goals that many nations had set in earlier years. Moreover, the fact that China and India – two nations where energy use and greenhouse gas emissions are growing rapidly – opted out of the agreement suggests that its effect will be limited.

As the shift to lower carbon fuels unfolds over the next several years, two possible scenarios seem possible: one is a “scramble” scenario where companies and countries rush to secure energy resources, fearing that energy security is a zero-sum game, and efforts to contain global warming falter. The other is a “blueprint” scenario, in which challenges surrounding energy security, supply and environment are anticipated and tackled through global policy agreement and increased public-private coalitions. The latter scenario would result in a much more stable and predictable business and regulatory climate.

To speed the shift towards less carbon-intensive energy sources and to create conditions in which private sector companies can plan effectively for the future, policymakers should pursue three overarching goals:



National and international authorities must resolve uncertainties around carbon pricing and a common global set of regulations and targets are needed, at least among the major economies, or the backsliding will continue.

The concept of energy security must be raised to a global level (not at national levels) or the world will sub-optimize its efforts to abate greenhouse gases.

Governments should focus on technologies with the most promise of delivering large-scale, low-carbon energy, rather than allowing politics to drive investment to low-priority or high-cost areas, as is often the case today.

Lord Browne of Madingley

Managing Director and Managing Partner (Europe), Riverstone Holdings

The term “energy crisis” is used quite loosely so it pays to be clear about what’s under discussion. Broadly speaking the term poses three distinct questions:

Will we run out of energy?

We rely on coal, oil and gas (the fossil fuels) for over 80% of our current energy needs – a situation which shows little sign of changing over the medium-term without drastic policy changes. On top of this energy demand is expected to grow by almost half over the next two decades. Understandably this is causing some fear that our energy resources are starting to run out, with devastating consequences for the global economy and global quality of life.

The potential for crisis if we run out of energy is very real but there is still time before that occurs. In the past two decades proven gas reserves have increased by 70% and proven oil reserves by 40%. At expected rates of demand growth we have enough for thirty years supply. Moreover, better technology means that new oil and gas fields are being discovered all the time while enhanced recovery techniques are opening up a potentially huge array of unconventional sources, including tar sands, shale gas and ultra-deepwater. Ultimately, the near-unlimited supply potential of renewable energy sources should ensure that the world does not fall short of its energy needs.

How secure is our access to energy?

The security of global energy supplies continues to be problematic. Today, oil and gas reserves are in the hands of a small group of nations, several of which are considered political unstable or have testy relationships with large consuming countries. Eighty per cent of the world’s proven oil reserves are located in just three regions: Africa; Russia and the Caspian Basin; and the Persian Gulf. And more than half of the world’s remaining proven gas reserves exist in just three countries: Russia, Iran, and Qatar.

Concerns over energy security prompt policymakers to seek independence from foreign sources of energy. In Europe, new coal-fired power stations are back on the political agenda, partly because Russia is no longer seen as a reliable supplier of gas. In the US, home-grown biofuels have been promoted by successive administrations as an alternative to Middle Eastern oil imports, despite being more expensive. These reactions are a natural consequence. The more governments can extract themselves from the dependence on foreign energy resources, the more secure they feel.

How does climate change affect the energy we use?

Emissions of carbon dioxide into the Earth’s atmosphere – primarily as a result of burning fossil fuels for energy – are thought to be the cause of rising global temperatures. The scientific evidence to support this assertion has become increasingly compelling in recent years, suggesting a need for urgent and concerted action by all nations to prevent ecological degradation on a massive scale.



For the first time in history we face an energy crisis not because we might run out of energy, but because we are using it in the wrong way. Up to now the energy industry was judged by two metrics: its contribution to energy security and the cost of energy delivered to the consumer. To this we must now add a third: its success in reducing the emission of greenhouse gases, chiefly carbon dioxide, into the atmosphere.

Fortunately, finding solutions to these differing energy crises demands a broadly similar response:

Solution 1

Reduce growing energy demand through improved energy efficiency and conservation.

The first step to reducing global emissions is to arrest the growth in energy demand with an aim to eventually setting it on a downward trend. The key for continued economic progress is to learn how to create more wealth with less energy. This has additional benefits in improving energy security, preserving precious natural resources and saving money for businesses and the ordinary consumer.

However, unlocking the potential savings from improved energy efficiency will be very difficult without government coordination to change consumer behaviour. This will involve stricter product regulations as well as public education programmes to encourage people to think differently about energy. Governments should also address the issue of financing, providing cheap loans to households and small businesses with which they can carry out the necessary improvement works.

Solution 2

Research, develop and deploy a broad range of energy sources, both domestic and international, to work with properly functioning global markets to help meet future energy demands.

We need to look at both the short-term and long-term. In the short-term we can push existing technologies to help reduce carbon emissions. Fortunately we already have many technologies at our disposal: from wind, wave, solar and biomass for heat and power, to liquid biofuels, biogas and electric motors for transport. In the long-term, evolutionary technologies need to be further developed and research into revolutionary ones pursued.

A crucially important technology will be carbon capture and storage (CCS) which allows for the continued use of fossil fuels in the future energy mix. Coal is widely used to generate electricity in many of the world's largest economies (especially the USA, China and India) and without CCS technology there is little chance that their energy demands can be met whilst at the same time reducing greenhouse gas emissions.

Solution 3

The so-called "developed countries" along with large developing countries such as China, India, Russia and Brazil, should agree and adopt a common position on climate change, focused on reducing greenhouse gas emissions through an effective cross-border market and technology transfer mechanism.

Put simply, we cannot hope to avoid the dangerous consequences of climate change unless global emissions are halved from current levels by 2050. At current rates of population growth and with current technologies this will be impossible without a global agreement to limit and disperse the negative consequences. Developed countries must shoulder the initial burden with an agreement for immediate emissions cuts. In return, the largest developing countries must agree to cut their own emissions in the future, but only after having achieved some recognisable level of economic development.

All countries must agree to, and participate in, a carbon market framework with the aim of reducing emissions where it is most efficient and least costly. Whatever its design, the carbon



market must create and defend a long-term price for carbon which is stable enough for businesses to factor it in to their forward planning. Where the flow of finance through the carbon market is insufficient to make the necessary reductions in emissions, additional funds should be made available. These should be used to allow non-OECD countries to develop alternative energy sources and help their citizens adapt to global warming. The OECD nations should seek to create a US-\$100 billion fund for this purpose.

Michael Huebler

Kiel Institute for the World Economy

Thomas Lontzek

Kiel Institute for the World Economy

Daiju Narita

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A solution for the future global energy problem should be based on the hard reality that global energy demand is likely to be expanded substantially in the short- to medium-term future due to population and economic growth. Only a mix of different means, rather than a single formula, would solve the problem, and the solutions should reflect regional conditions.

Renewable energies

Renewable energies are a key element in this solution portfolio. Wind power is already being installed at a growing rate globally and has a large potential in places such as China, India and the US, as well as in Europe. Together, the use of wind power could be expanded tenfold by 2030 with an increasing share of offshore instalments. Wind power may become the second most important renewable energy for electricity generation after hydropower. Tidal and geothermal power would play a role in some countries, such as China, Russia, the US, and a part of Europe. The use of hydropower, including the one from large-scale dams, should be doubled by 2030. Installations in non-OECD Asia would be important given its increasing energy needs. Concentrating solar thermal power is an opportunity for sunny developing countries near the equator. While concentrating solar thermal power has been tested in Europe, Australia and the USA so far, projects in China, Iran, Jordan and Malta are planned. The role of solar photovoltaics would still be small but could have some importance in remote sunny regions, particularly for specific purposes such as air-conditioning. Renewable heating (solar, geothermal, biomass) could be harnessed in a large scale at low costs in China.

Non-renewable energies

Nuclear energy capacities could be doubled by 2030. Also, we would need to continue using coal power generation by a large scale, allowing non-OECD countries to keep the size of production at least at the current level. In parallel, coal power generation should be downsized in the developed regions, and remaining facilities should be scrapped even before the end of lifetime and be rebuilt with CCS equipment.

Energy infrastructure

Based on this energy portfolio, the solution for the energy problem at second depends on energy transport and storage solutions such as hydrogen. They would be a crucial step towards a globally connected energy system matching energy supply and demand over space and time.

Such a shift of energy infrastructure requires a great amount of investment, a majority of which should take place in developing countries (The IEA estimates the amount of investment should



be US-\$1.2 trillion globally by 2030, which is on an annual basis (around US-\$50 billion) about half the size of world's total official foreign aid (approximately US-\$100 billion)). Pricing schemes of emissions, such as tax, cap-and-trade systems, or a combination of these, are basic instruments to achieve this goal. Herein, the current financial crisis offers an opportunity to direct private and public investment into energy efficiency improvements, for instance within stimulus packages. Given the increasing demand for energy in developing countries, a particular focus should fall on efforts to transfer technologies to these countries, as the infrastructure built in these countries now will help define the energy mix in these countries for the next 30–40 years. In particular, mechanisms allowing flexibility on cross-region burden sharing such as CDM should be strengthened. As a supplement, additional public financing schemes, such as the World Bank technology fund, can play an important role. When applied in countries with weak legal institutions, they would reduce business risks of energy-related foreign direct investment, which is likely to lead to a faster transfer of energy-efficient technologies. At the same time, the enforcement of intellectual property rights may be relaxed internationally to promote the diffusion of emission-saving technologies. Finally, substantial public R&D would also be needed since some promising energy technologies are still in infancy.

Gerhard Koenig

Member of the Board of Executive Directors, Wintershall Holding AG

Climate protection without blinkers: an intelligent mix of fossil and renewable energies

Energy research must **abstain from pigeonholing** energies as fundamentally good or bad, **from** saying “renewable energies are automatically good and fossil energies are bad”. That is a dead-end street in which we cannot afford to linger. We need a candid review of climate and energy policy – without blinkers and illusions.

Real sustainability requires a balance between economic and ecological considerations, not an ecological fantasy world. In order to reconcile the interests of climate protection, supply security and market competition, we need an intelligent mix of renewable and fossil energies – and a global strategy which can be adapted to the specific energy landscape of the different regions. Fossil fuels are not part of the problem; they are part of the solution. For renewable energies can only secure the global energy supply and protect the climate in combination with fossil fuels.

In its 2008 World Energy Outlook the International Energy Agency (IEA) projected an increase in global primary energy consumption by a third by 2030 – even assuming very favorable climate policy conditions. According to its projections, fossil fuels will cover three quarters of energy requirements, and global natural gas consumption will increase significantly, owing primarily to economic growth in China and India. But Europe needs more gas too: according to our calculations, we could be facing a supply gap of over 100 billion cubic meters of gas as soon as 2020. Without investing in a reliable link to new gas reserves, supply security for Europe is unimaginable.

In order to reduce CO₂ emissions and at the same time ensure the global energy supply, there are, in my opinion, **five key areas of action**:

- increasing energy efficiency,
- expanding the use of renewable energies,
- substituting high CO₂ fuels with low CO₂ fossil fuels,
- an energy-efficient combination of fossil and renewable energies and
- developing the climate-friendly generation of energy from fossil fuels.



Improving **energy efficiency** is absolutely essential for climate policy. Studies show that the insulation of buildings offers the greatest potential to save energy. Vehicles with enhanced energy efficiency are another area, as are natural gas condensing boilers in the home. The latter reach efficiency rates of up to 98% by using the heat that is usually discharged to the atmosphere. In the power plant sector, highly-efficient CCGT plants, i.e., combined cycle gas turbine power plants, show the way forward. Together with combined heat and power they reach efficiency levels of up to 90%.

It is certainly helpful for the state to take action to steer things in the right direction in order to increase energy efficiency – and to promote innovation with targeted measures. International institutions such as the World Bank also play an important role in supporting the transfer of energy-efficient technologies from OECD countries to the emerging and developing countries. A scenario developed by the IEA shows just how important this transfer is. According to the IEA, if global climate policy doesn't change radically, global CO₂ emissions will increase by 45% by 2030. 97% of these additional emissions would be caused in non-OECD countries – around three-quarters of them by China, India and the Middle East alone!

It is hoped that **renewable energies** will play an important role in meeting the world's future demand for energy. But they have to be commercially viable too in order to be truly sustainable and fit for the future. Saying yes to climate protection does not necessarily mean saying yes to costly subsidies for energy carriers that are not economical. Furthermore, the social impact has to be taken into account. A high ecological and social price was paid for many hydro-electric power stations. And the production of biogas can hit developing countries hard if food prices are forced up.

Since renewable energies will only cover about 25% of global energy demand in 2030 – even according to optimistic forecasts – and they can only ensure supply together with fossil energy sources, we should focus on the **fossil energy source that has the best ecological balance sheet**. And that just happens to be natural gas. Gas has the highest level of hydrogen and the lowest amount of carbon out of all the fossil fuels. As such it emits much less CO₂ when used as fuel. In addition, natural gas contains no aromatics and much less sulfur. It is mostly dust-free.

The gas used in Germany releases 25% fewer greenhouse gases during combustion than oil, 30% less than hard coal and 35% less than brown coal. This has been confirmed by the German Institute for International and Security Affairs (Stiftung fuer Wissenschaft und Politik), which advocated “More natural gas for climate protection” in a recent study. It also outlines the advantages of natural gas engines in road traffic. The institute estimates that natural gas vehicles, assuming further efficiency improvements, even emit 15% less CO₂ than diesel engines. If a quarter of the cars in Europe were to convert to natural gas, 39 Mt of CO₂ could be saved. Hence, natural gas can play a key role in the transition to a more renewables-oriented energy sector.

Combining renewable and fossil energies directly also offers great opportunities. For example, the combination of solar installations with modern condensing boiler technology – an energy mix which is used in Germany, for instance, for heating water. The solar technology heats the water by harnessing solar irradiation, and natural gas steps in when the weather is bad. For while solar energy can cover up to 70 to 100 percent of the warm water requirements of a one-family house in summer in Germany, it can only provide 20 percent in winter. Modern natural gas technology can be used in the same way as a back-up for wind energy.

“Fossil, but new and different” – research: herein lies the fifth key area of action for achieving an ecologically sound energy supply. Innovative solutions based on fossil energy carriers can serve climate protection worldwide.

Let me give you one example. Together with the Leibniz Institute of Marine Sciences in Kiel, we are researching how gas hydrates that lie under the seabed can be harnessed for clean combustible methane gas. Time is short for this project, as many scientists fear that because



of climate change large methane ice deposits could be released into the atmosphere unburned – which would be extremely harmful to the climate. Another project, entitled “SUGAR,” is focusing on the storage of CO₂. While normal CCS (Carbon Capture and Storage) projects merely aim to store the CO₂ in former gas reservoirs, with SUGAR it is injected into the submarine methane gas deposits in order to force out the gas hydrates. This way large quantities of climate-friendly energy can be gained and the CO₂ can also be stored securely since CO₂ hydrates are much more stable in terms of temperature and pressure than methane hydrates.

Further **investments** are needed in all the fields mentioned: either for expanding the infrastructure, for public or private-sector research or for modernizing the world in which we live and work in an energy-efficient way. However, current calculations by the IEA show that global investments in the supply of oil and gas have decreased by 21% compared to 2008. Yet the financial crisis also offers opportunities – for example when state-funded economic stimulus programs serve to improve energy efficiency. But overall what we need in Europe is not billions of additional taxpayers’ money, but the political will to pave the way for the energy sector to strengthen the economy through its own investments. This requires decisions that create reliable transit routes, investment certainty and more competition.

The non-OECD countries already overtook the OECD countries in terms of energy consumption in 2005 – and the hunger for energy in **China, India and the Middle East** continues to climb rapidly. Thus, in order to ensure climate protection and energy security, the emerging and developing countries need to get actively involved. But the OECD countries also have a special responsibility. They have to foster the transfer of technology and the increase in energy efficiency in other countries and support a political framework that allows private-sector companies to make the investments in the first place.

But in the long term energy solutions have to be worthwhile for all countries – and above all: they have to be financially viable.

Richard A. Muller

Professor of Physics, Faculty Senior Scientist, Lawrence Berkeley Laboratory, University of California, Berkeley

Cheap clean

Expensive technology, even if it yields clean energy, cannot solve the challenge of global warming. Any solution, to be viable, must be low enough in cost that the world can afford to implement it widely. Indeed, it is likely that the only technologies that are sustainable are those that are beyond cheap – those that are profitable.

The reason for this conclusion is a key fact that underlies the IPCC projections of global warming: the predicted rise in temperature is tightly linked to the end of poverty in the developing world.

Economic progress in the developing world has been amazing and exciting. Growth of the GDP of China and India has set a pace of 6% to 12% per year, an improvement that is cheered by every caring person. But that growth has been accompanied by a matching increase in energy use. The correlation is not accidental; wealth is tightly linked to energy. To find the GDP of any country, take the yearly total energy use per capita in kilowatt-hours (all energy, not just electricity) and divide by 3. That gives the GDP per capita in US-\$, within a factor of two, for virtually all the countries in the world.

True, the developed world has been responsible for most of the observed 0.5 C global warming so far. But that is changing. China already releases more greenhouse gas each year than the US. In fact, the preponderance of the expected future warming will arise from the economic rise of the developing world. Expensive technologies that can be used by wealthy



nations to reduce emissions are not a viable option for the poorer nations, until they too are wealthy – but by then, it will likely be too late.

There is no blame in this. The developing world has the right to the same standard of living as the developed world. A leader of a developing nation may very likely be more concerned about poverty, poor nutrition and health, inadequate education and lack of opportunity, than about a few degrees temperature rise.

It is not good enough for the developed world to "set an example" if the approach is too expensive for the developing world to afford.

Not only must we reduce greenhouse emissions, we must do that in a sustainable way, a way that will continue to work during economic downturns. The one clear way to achieve that goal is to emphasize reductions which are profitable. Sustainability and profitability are inextricably linked.

Using these observations for guidance, the possible solutions are as follows:

- Improve energy efficiency. Developing nations are extremely inefficient in their energy use. This was true for the United States in the 19th and 20th centuries, and is true of China and India now. The carbon dioxide of these nations per GDP is 3 to 5 times greater than in the US. We need to help the developing world achieve higher efficiency on a quicker time schedule.
- Improve energy conservation. As verified by the McKinsey study, using conservation to reduce carbon emissions can be profitable with remarkably short pay-back times. Heating and air conditioning can be reduced by using better insulation and IR reflecting roofs. Cooking and lighting can use much less fuel. These measures are readily adaptable in the developing world, and can yield virtually immediate economic benefits.
- Search for clean tech solutions that are cheaper than the dirty ones. The biggest challenge: provide energy cheaper than we can get from coal. In my estimation, some of the technologies that offer this possibility are wind, thin-film solar, and small-scale nuclear. Not likely in my opinion: geothermal (in most of the world); large-scale solar thermal; wave or tidal power.
- Develop technology that addresses not only clean energy, but also energy security. Energy security is highly valued in many countries, so technology that addresses this need can find a market even if it is not as cheap as, say, imported natural gas. The technologies are very location specific, and could include biofuels, wind, and solar.
- Develop carbon capture and sequestration as a back-up in case coal remains the cheapest form of energy. The technology must be such that it can be used in the developing world, perhaps subsidized by the wealthier nations.
- Electric autos in the developing world, where expectations of long driving range are not yet part of their culture. The emphasis must be on cheap batteries, since replacement costs are the greatest expense.
- In exchange for carbon reductions among the developed nations, the poorer nations must agree to allow foreign technology be used to help them reduce their own emissions. This could be everything from advanced wind turbines, better solar cells, small nuclear plants, to carbon sequestration technology. Many developing nations want to create their own technology, and may put up barriers to use of foreign methods. But if this happens, the cheap tech may never be developed. The huge markets in the developing world are the best inspiration for the huge investments that will be needed to make clean cheap.

Some people advocate cap and trade as a solution. But the real value of cap and trade is reached only if it inspires the development of inexpensive clean energy technologies. Unless clean becomes cheap, it will not be adopted by the developing world, and without that, atmospheric carbon dioxide increases are inevitable.



Expensive clean won't work. Cheap clean is essential. To be sustainable, clean technology must be profitable. The best bets: energy efficiency and conservation.

Sanjit Bunker Roy

Founder, Barefoot College

The Barefoot College

The Barefoot College is the ONLY fully Solar Electrified College based in a village in India. 45 kws of solar panels and 5 Battery banks of 136 deep cycle batteries have been installed by semi-literate barefoot solar engineers. The solar components (invertors, charge controllers, battery boxes, stands) are all fabricated in the College itself. Provides power to run 30 computers, e-mail, 500 tube lights, 70 fans, photocopying machine, VCRs, camcorders, pathology Lab, dining hall, a 40,000 book Library, dentist chair, film editing machine, slide projectors, and battery chargers.

As of December 2008 in India 289 illiterate (213 men and 76 women) barefoot solar engineers have solar electrified 599 villages generating a total of 550 kwp electricity per day reaching 11,900 families in 14 States of India: installed 8,700 solar units in individual houses fabricated 4,100 solar lanterns for 549 night schools benefiting 10,700 families with a population of nearly 100,000 people. The barefoot solar engineers have installed 16 solar power plants of 2.5 kws each: women have fabricated 40 parabolic solar cookers: 71 solar water heaters have been fabricated and installed in the Himalayas: trained rural communities to establish 23 rural electronic workshops.

As a result the College has prevented 1.86 million tons of carbon emissions from polluting the atmosphere. Illiterate women are fabricating parabolic solar cookers water heaters.

500 kws is being generated in one day from all the solar installations all over India.

What is the barefoot approach?

A technology just dumped on rural villages from the urban areas by solar engineers has no chance of being successful. The village community has to be sensitised to manage, control and finally own the technology. Poor village communities can run solar units on their own if they are trained to fabricate the solar equipment at the village level as well as repair and maintain it. Illiterate rural women have demonstrated this is possible.

Before any non-electrified village is solar electrified anywhere in the world a Village Energy and Environment Committee (VEEC) has to be formed and the VEEC has to take two major decisions.

- How much each family is prepared to pay for the Fixed Solar Unit or Solar Lantern per month.
- Who the VEEC will select from among the poorest of the poor family in the village to be trained as a Barefoot Solar Engineer.

This approach was first tried, tested and widely applied in India in the 1990s.

Once the barefoot approach had produced a significant impact in India in the remotest villages all along the Himalayas it was decided to go global and see if it could be replicated all over the world.

GLOBAL

For the first time in the history of the Least Developed Countries (LDCs) in the UNDP Human Development Report it was decided to identify ONLY illiterate and semi-literate middle aged



village women who had never left their villages in their lives to be trained as barefoot solar engineers. This has proved to be remarkably successful.

Afghanistan

In 2005 a total of 150 individual houses were solar electrified by 10 semi-literate men and women who had never left their village. In the history of Afghanistan this is the first time 3 semi-literate women had solar electrified their own villages.

The 5 villages were electrified in the most backward regions of the country.

Today in 2008 with Norwegian funding the barefoot approach has been replicated in 100 villages saving over 500,000 litres of kerosene. 21 more women have been trained.

Never had any politician or engineer or bureaucrat believed it could have been possible but in June 2008: 35 very poor semi-literate women had completed the solar electrification of 504 houses in 48 villages all over the country.

Lessons learnt

So what are the universal lessons we have learnt from training poor illiterate rural women as solar engineers from 3 continents and 17 countries around the globe?

Lesson 1

Any middle aged illiterate woman from any part of the world who has never left her village can be trained in 6 months in India to be a competent and confident solar engineer.

Lesson 2

Prepare the community first by involving them in taking major decisions on behalf of the whole community and only then bring in the technology in the village. This will reduce the dependency on urban skills from outside. It will also give a sense of ownership.

Lesson 3

Keep all urban based paper qualified solar engineers away from the inaccessible non-electrified village because their top down approach is doomed to fail. They have neither the vision nor the courage nor the faith to select and train illiterate women as engineers. They also do not have the communication tools to speak as equal to poor communities.

Lesson 4

What makes the barefoot approach fundamentally different is that NO certificates, diplomas or degrees are issued after training to the women. The certification is done by the community they serve. The issuing of certificates is one major reason why migration takes place from the villages to the cities.

Lesson 5

To reach the very poor only a partnership model will work. Where providing the hardware is the responsibility of governments/donors and the repair and maintenance is the responsibility of the poor rural communities.

The "barefoot" approach has worked in 3 continents, 17 countries and over 100 villages across the globe. Between 2005–2008 the total amount spent has been close to US-\$ 2 million. Less than what is being wasted on ONE Millennium Village in one country in Africa.

There is no question. The demystified decentralized approach is the only long-term solution to tackling the energy crisis and climate change in the inaccessible villages around the world.



Rainer Seele

Chairman, WINGAS GmbH & Co. KG, Member of the Board, Wintershall Holding AG

Climate protection without blinkers: an intelligent mix of fossil and renewable energies

Energy research must *abstain from pigeonholing* energies as fundamentally good or bad, from saying “renewable energies are automatically good and fossil energies are bad.” That is a dead-end street in which we cannot afford to linger. We need a candid review of climate and energy policy – without blinkers and illusions.

Real sustainability requires a balance between economic and ecological considerations, not an ecological fantasy world. In order to reconcile the interests of climate protection, supply security and market competition, we need an intelligent mix of renewable and fossil energies – and a global strategy which can be adapted to the specific energy landscape of the different regions. Fossil fuels are not part of the problem; they are part of the solution. For renewable energies can only secure the global energy supply and protect the climate in combination with fossil fuels.

In its 2008 World Energy Outlook the International Energy Agency (IEA) projected an increase in global primary energy consumption by a third by 2030 – even assuming very favorable climate policy conditions. According to its projections, fossil fuels will cover three quarters of energy requirements, and global natural gas consumption will increase significantly, owing primarily to economic growth in China and India. But Europe needs more gas too: according to our calculations, we could be facing a supply gap of over 100 billion cubic meters of gas as soon as 2020. Without investing in a reliable link to new gas reserves, supply security for Europe is unimaginable.

In order to reduce CO₂ emissions and at the same time ensure the global energy supply, there are, in my opinion, *five key areas of action*:

- increasing energy efficiency,
- expanding the use of renewable energies,
- substituting high CO₂ fuels with low CO₂ fossil fuels,
- an energy-efficient combination of fossil and renewable energies and
- developing the climate-friendly generation of energy from fossil fuels.

Improving *energy efficiency* is absolutely essential for climate policy. Studies show that the insulation of buildings offers the greatest potential to save energy. Vehicles with enhanced energy efficiency are another area, as are natural gas condensing boilers in the home. The latter reach efficiency rates of up to 98% by using the heat that is usually discharged to the atmosphere. In the power plant sector, highly-efficient CCGT plants, i.e., combined cycle gas turbine power plants, show the way forward. Together with combined heat and power they reach efficiency levels of up to 90%.

It is certainly helpful for the state to take action to steer things in the right direction in order to increase energy efficiency – and to promote innovation with targeted measures. International institutions such as the World Bank also play an important role in supporting the transfer of energy-efficient technologies from OECD countries to the emerging and developing countries. A scenario developed by the IEA shows just how important this transfer is. According to the IEA, if global climate policy doesn't change radically, global CO₂ emissions will increase by 45% by 2030. 97% of these additional emissions would be caused in non-OECD countries – around three-quarters of them by China, India and the Middle East alone!

It is hoped that *renewable energies* will play an important role in meeting the world's future demand for energy. But they have to be commercially viable too in order to be truly sustainable and fit for the future. Saying yes to climate protection does not necessarily mean



saying yes to costly subsidies for energy carriers that are not economical. Furthermore, the social impact has to be taken into account. A high ecological and social price was paid for many hydroelectric power stations. And the production of biogas can hit developing countries hard if food prices are forced up.

Since renewable energies will only cover about 25 percent of global energy demand in 2030 – even according to optimistic forecasts – and they can only ensure supply together with fossil energy sources, we should focus on the *fossil energy source that has the best ecological balance sheet*. And that just happens to be natural gas. Gas has the highest level of hydrogen and the lowest amount of carbon out of all the fossil fuels. As such it emits much less CO₂ when used as fuel. In addition, natural gas contains no aromatics and much less sulfur. It is mostly dust-free.

The gas used in Germany releases 25% fewer greenhouse gases during combustion than oil, 30% less than hard coal and 35% less than brown coal. This has been confirmed by the German Institute for International and Security Affairs (Stiftung fuer Wissenschaft und Politik), which advocated “More natural gas for climate protection” in a recent study. It also outlines the advantages of natural gas engines in road traffic. The institute estimates that natural gas vehicles, assuming further efficiency improvements, even emit 15% less CO₂ than diesel engines. If a quarter of the cars in Europe were to convert to natural gas, 39 Mt of CO₂ could be saved. Hence, natural gas can play a key role in the transition to a more renewables-oriented energy sector.

Combining renewable and fossil energies directly also offers great opportunities. For example, the combination of solar installations with modern condensing boiler technology – an energy mix which is used in Germany, for instance, for heating water. The solar technology heats the water by harnessing solar irradiation, and natural gas steps in when the weather is bad. For while solar energy can cover up to 70 to 100% of the warm water requirements of a one-family house in summer in Germany, it can only provide 20 percent in winter. Modern natural gas technology can be used in the same way as a back-up for wind energy.

“Fossil, but new and different” – research: herein lies the fifth key area of action for achieving an ecologically sound energy supply. Innovative solutions based on fossil energy carriers can serve climate protection worldwide.

Let me give you one example. Together with the Leibniz Institute of Marine Sciences in Kiel, we are researching how gas hydrates that lie under the seabed can be harnessed for clean combustible methane gas. Time is short for this project, as many scientists fear that because of climate change large methane ice deposits could be released into the atmosphere unburned – which would be extremely harmful to the climate. Another project, entitled “SUGAR”, is focusing on the storage of CO₂. While normal CCS (Carbon Capture and Storage) projects merely aim to store the CO₂ in former gas reservoirs, with SUGAR it is injected into the submarine methane gas deposits in order to force out the gas hydrates. This way large quantities of climate-friendly energy can be gained and the CO₂ can also be stored securely since CO₂ hydrates are much more stable in terms of temperature and pressure than methane hydrates.

Further *investments* are needed in all the fields mentioned: either for expanding the infrastructure, for public or private-sector research or for modernizing the world in which we live and work in an energy-efficient way. However, current calculations by the IEA show that global investments in the supply of oil and gas have decreased by 21% compared to 2008. Yet the financial crisis also offers opportunities – for example when state-funded economic stimulus programs serve to improve energy efficiency. But overall what we need in Europe is not billions of additional taxpayers’ money, but the political will to pave the way for the energy sector to strengthen the economy through its own investments. This requires decisions that create reliable transit routes, investment certainty and more competition.



The non-OECD countries already overtook the OECD countries in terms of energy consumption in 2005 – and the hunger for energy in *China, India and the Middle East* continues to climb rapidly. Thus, in order to ensure climate protection and energy security, the emerging and developing countries need to get actively involved. But the OECD countries also have a special responsibility. They have to foster the transfer of technology and the increase in energy efficiency in other countries and support a political framework that allows private-sector companies to make the investments in the first place.

But in the long term energy solutions have to be worthwhile for all countries – and above all: they have to be financially viable.