Reflective mirrors in a solar farm.

Mapping the future:

Why bidding farewell to fossil fuels is in our interests – and how it can be done

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Developing efficient, sustainable energy systems based on renewable energy and smart grid technology is not only an environmental necessity: it is a social and economic imperative. We rely on fossil fuels for more than 85 per cent of all energy we use and pay a high price for our dependency, on all fronts. An overhaul of the way we produce, transport, store, and consume energy is underway and an improved energy world is emerging, slowly. Intelligent policies based on concise roadmaps will get us there faster.

People around the world are already suffering from the impacts of climate change. Rising sea levels, melting glaciers, storms, droughts, and floods – these natural processes, artificially intensified by global warming, will affect agriculture, fishing, transportation, and tourism to an ever greater degree. Changing ecosystems and landscapes, biodiversity losses, the surge of tropical diseases, and food and water shortages will lead to economic and welfare losses on an unprecedented scale should climate change remain largely unabated as it is today.

The cost of fossil fuels is unjustifiable

Even if we take climate change, which has been called this century's greatest challenge, off the table for a moment, transitioning our energy systems is a socio-economic imperative. For a host of reasons, our reliance on fossil fuels comes at an unjustifiably high cost to our economies. First, the burning of coal and petroleum pollutes our air and water. China, for example, estimates that addressing its pollution and pollution-related health problems swallows up to 10 per cent of its total annual GDP. Imagine if the country could put these huge resources into addressing pressing social needs!

Second, fossil-based energy systems force many nations to rely heavily on fuel imports. Despite enormous potential for renewable energy, many countries rely on imports for most of their fuel and electricity supply – some for 90 per cent or more. As a consequence, fuel prices in these countries are higher than elsewhere, creating a heavy economic burden. The volatility of the energy market is another grave problem. An increase of US$10 in the world crude oil price translates into a 1.5 per cent decrease in GDP in many Pacific small-island states, with dire social consequences.

Third, let us look at energy subsidies. The view still persists that renewables can survive only with the helping hand of governments that fiscally favour them over conventional sources. But the opposite is the case. Almost 20 years after governments decided at the highest level that human interference with the climate system had to be prevented, and despite the heavy burdens that fossil fuel production places on our societies, public subsidies for these fuels are about 12 times those for renewable energy. And this staggering figure does not even include the indirect costs – essentially, additional subsidies – that we all have to shoulder: health problems, pollution control, and the impacts of climate change.

Low-carbon growth is a necessity

There are good reasons to project that those countries that can produce energy cleanly and use it most efficiently will dominate the global economy in this century. Three striking examples of countries that are already committed to accelerating green energy production illustrate the benefits of early action. In Germany, 340,000 jobs have been created in the renewable energy industry alone; South Korea aspires to be Asia's clean technology tiger and projects the value of its energy exports to reach US$36.2 billion in 2015. Denmark has decoupled economic growth from its energy consumption, expanding its economy by more than a third over the last 20 years while cutting total energy use. In addition, Denmark more than doubled the share of renewables in its energy mix, already at a high level.

There is little evidence that such green ambitions have hurt these three countries, economically or otherwise. In fact, they seem to have weathered the recent economic crisis better than others. Moreover, they are better prepared for the next inevitable surge in fuel prices when the economy takes off again.

For many countries, a low-carbon development path is not a luxury but a necessity. In China – the world's largest producer and consumer of coal, and since last year a net importer – and India, more than 70 per cent of electricity is powered by coal, the dirtiest of all energy sources. Both countries could run out of domestic coal as early as the next 40 years. With regard to oil, China is already dependent on imports for more than half of its supply, and India for almost three-quarters. And even if both countries make their ambitious nuclear plans a reality, the power provided by these new reactors – at relatively high costs – can cover only a small margin of the energy needs of both nations. In India, almost half of households still lack access to the grid. So what other energy sources remain? What will our future energy system look like?

An unrecognisable renewables future

With the enormous untapped potential of renewable energy and energy efficiency improvements, the world's energy system – from generation to end-use in every sector – could be all but unrecognisable by mid-century. First, renewable energy sources and efficiency will be closely integrated. Our calculations have shown that if renewables and energy efficiency improvements are employed in concert, half of the world's energy needs can be supplied by renewables as early as 20 years from now. By 2050, their integration could lead whole countries to what smaller communities have already achieved today: to be entirely based on renewables, with local pollutants and greenhouse gas (GHG) emissions at or close to zero.

Electricity grids, today powered almost exclusively by large coal, natural gas, nuclear, and hydropower plants, will be increasingly the domain of modular solar, wind,

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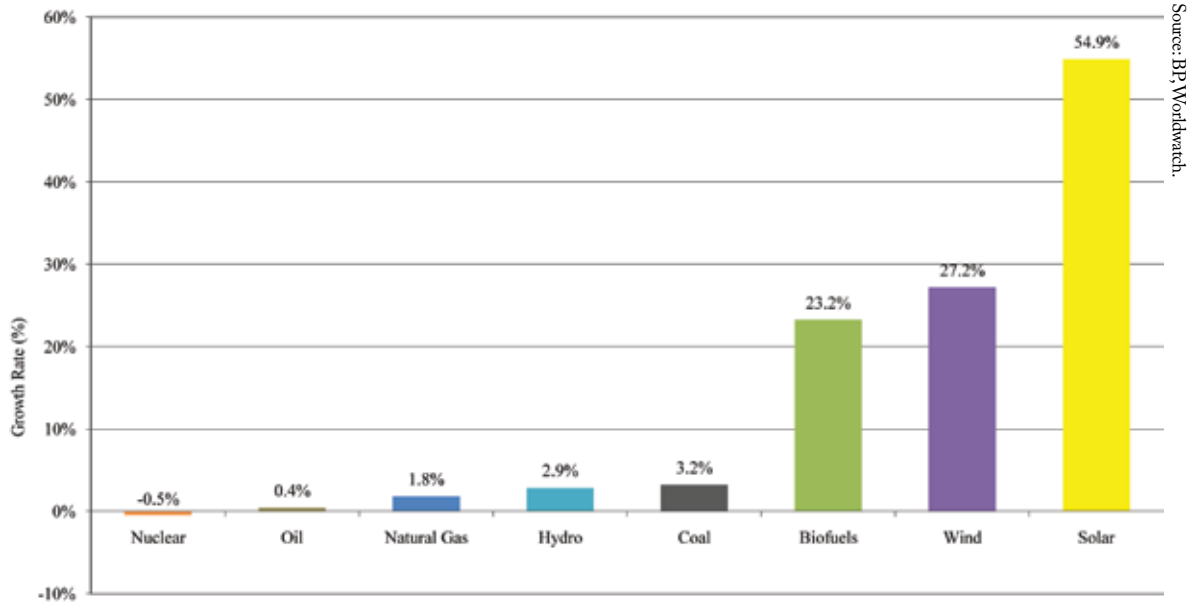
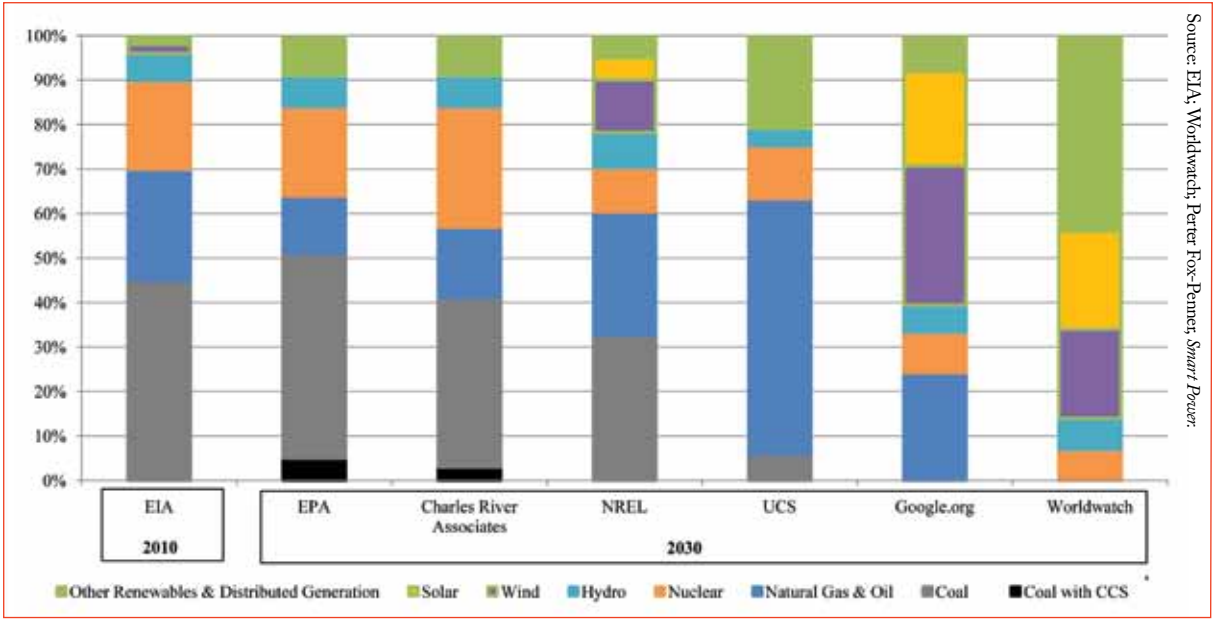
Average annual global growth rate in energy consumption by source, 2004-2009.



Nuclear, Oil, Natural Gas, Hydro, and Coal numbers reflect primary energy use. Biofuels use volumetric production as a proxy, and Wind and Solar use cumulative installed capacity as a proxy.

United States 2010 electricity generation mix compared with sample scenarios for 2030.



Source: EIA; Worldwatch; Perter Fox-Penner, *Smart Power.*

biomass, small hydro, and other renewable facilities. The 1.5 billion people worldwide currently without access to electricity, often in rural areas far from the existing grid, will be provided with access to power not by extension of the existing grid but through decentralised generation that takes advantage of local resources, whether they are sunlight, wind, water, agricultural and industrial waste, or any combination of the above. Biofuels from algae, grasses, and crop wastes will help lessen the demand for oil.

The sun always shines – somewhere

The intermittent nature of wind and solar energy, a major stumbling block for their integration into large grids, can be mitigated by further expansion, their integration with natural gas and innovative storage technologies, as well as the design of smart grids. Variability decreases dramatically when multiple wind and solar sites in larger regions are aggregated, and this decentralisation of alternative power generation will make production far more predictable.

Natural gas will see an increase in use because it is the least GHG-intensive fossil fuel and can be fed into the grid with much greater flexibility than power from other energy sources, including nuclear. Since coal power plants can be retrofitted relatively easily for natural gas, gas has an important role to play as a natural ally of renewables and a bridge to a 100 per cent renewables world.

It will also be essential to pair energy production with practical storage technologies, including hydropower, which can be tapped easily during production lows. The growth of electric cars will not only lower the demand for oil but also add versatility to the electric grid, as these vehicles can be charged when consumption rates are lowest and then feed power back into the grid when needed. A changing energy generation mix and structure will require significant changes to transmission and distribution networks but these changes will bring their own benefits.

So-called 'smart grids' will help consumers save money by informing them about electricity rates in real-time and allowing them to run appliances when rates are lowest. This will benefit utilities by flattening the peaks in energy demand that come at midday. High Temperature Superconducting transmission lines currently in development can carry 10 times the power of a conventional copper cable on a single line and will dramatically lower power losses. All of this will result in utilities needing fewer peak power plants and increase the efficiency of the entire system.

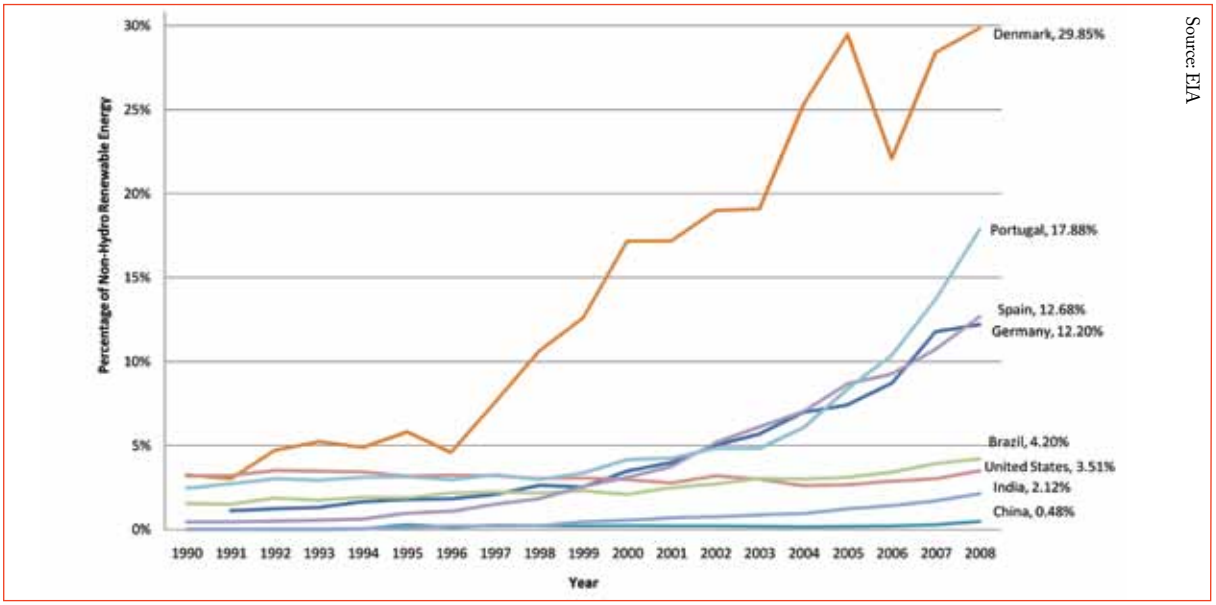
The way in which we use energy will also be transformed with more efficient appliances and the development of inventions that are only now on the horizon. The 'straddling bus' that rides over cars to combine the benefits of light rail and bus transit, or roof tiles that change colour to reflect heat in summer and absorb it in winter, for example, could be commercialised, each helping reduce our need for traditional power generation.

A patchwork of policies for a patchwork of technologies

A climate-friendly world based on sustainable energy technologies is technically feasible and socio-economically preferable. But, despite the recent successes of renewables, the mix of technologies that will power our world and reduce our energy needs in the coming decades will not be deployed automatically – at least, not fast enough. These technologies will have to arise out of a patchwork of policies at all political levels, from the local to the global.

Many countries remain unconvinced that moving to a low-carbon economy is in their interest or worth the required upfront investment. Often, necessary information and expertise is lacking. Finding the right way requires roadmaps that assess the solutions that are physically available, economically viable and politically feasible. Detailed energy resource mapping, technological,

Non-hydro renewable energy as a share of total electricity generation.



Source: EIA

economic and social assessments, as well as a review of existing policies and practices are important stages to arrive at a comprehensive picture of the environment for investment. The final product of this analysis should be energy policy roadmaps that provide specific steps forward to a low-carbon economy that is in the interest of its citizens. These roadmaps will strengthen government, civil society and industry capacity and help officials coordinate and optimise ongoing low-carbon development activities while increasing investor confidence in new projects.

There are numerous policy options that governments can deploy to increase the competitiveness of sustainable technologies, reduce investment risk, and address vested interests that favour the status quo. Countries at the forefront of low-carbon development around the world have experimented with various policy measures and created a rich toolkit ranging from regulatory approaches to market-based mechanisms. Roadmaps play a crucial role by identifying which of these policies are best for the specific circumstances in a given country or region.

A lack of political will

Worldwide, energy efficiency standards provide incentives for companies to reduce their own carbon emissions and those of their products. 'Passports' for buildings in Germany, for example, encourage infrastructure upgrades and sustainable consumer behaviour. Weatherisation or home insulation programmes help low-income families improve their home's energy efficiency. In 80 countries, provinces, or municipalities – from China to the Dominican Republic to Uganda – feed-in tariffs stimulate renewable power generation by guaranteeing producers of renewable energy a specified price for every megawatt-hour of power fed into the grid. And there is an abundance of market mechanisms at hand to boost clean energy technologies, from the European Emission Trading Scheme initiated in 2005, to the 'bottom tax' that Denmark has used since the early 1990s to create a minimum on fossil fuel prices, which increases over time.

The technologies are available, the policies have been developed and the economics have been proven. We can map our energy future and say goodbye to our unsustainable use of fossil fuels. What we need now is the political will to create an energy system that is in the interest of the people, wherever they live.

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