GREEN ENERGY CHOICES

THE BENEFITS, RISKS AND TRADE-OFFS OF LOW-CARBON TECHNOLOGIES FOR ELECTRICITY PRODUCTION

Rising energy demand and efforts to combat climate change require a significant increase in low-carbon electricity generation. Yet, concern has been raised that rapid investment in some novel technologies could cause a new set of environmental problems. The report of the International Resource Panel (IRP) Green Energy Choices: The Benefits, Risks and Trade-Offs of Low-Carbon Technologies for Electricity Production aims to support policy-makers in making informed decision about energy technologies, infrastructures and optimal mix. Compared to coal, electricity generated by hydro, wind, solar and geothermal power can bring substantial reductions in emissions, not only of greenhouse gases (by more than 90%) but also of pollutants harmful to human health and ecosystems (by 60-90%). The capture and storage of CO2 from fossil fuel power plants will reduce greenhouse gas emissions by 70%, but increase the pollution damaging human health and ecosystems by 5-80%.

Global demand for energy is expected to double by 2050, requiring an estimated investment of 2.5 trillion USD a year over the next twenty years in new energy installations and energy conservation initiatives. Production of electricity, a major energy carrier, is currently responsible for 25 per cent of anthropogenic greenhouse gas (GHG) emissions, as well as other negative impacts on the environment and on human health. Fortunately, technologies with lower carbon emissions have become available and started to penetrate the market.

There is a risk that the massive deployment of low-carbon energy technologies, while effective in reducing GHG emissions, could lead to new environmental and social impacts, such as toxic metal pollution, habitat destruction, or resource depletion. Given the scale of the investments and infrastructure development required, it will be important to strategically plan the appropriate energy mix of each country or region, in order to avoid “lock-ins” of resource intensive technologies and infrastructure that will be difficult to change.

Building an optimal energy system equipped with low carbon technologies should consider maximizing energy output, mitigating GHG emissions and at the same time addressing a range of environment and resource problems.

The IRP’s report *Green Energy Choices: The Benefits, Risks and Trade-Offs of Low-Carbon Technologies for Electricity Production* represents the first in-depth international comparative assessment of mainstream renewable and non-renewable power generation technologies, not only analysing their GHG mitigation potential, but also other benefits, risks and trade-offs, which include:

- environmental impacts: ecotoxicity, eutrophication and acidification, etc.
- human health impacts: particulates, toxicity, smog.
- resource use implications: iron, copper, aluminium, cement, energy, water and land.

The report provides a comprehensive comparison of 9 electricity generation technologies including coal and gas with and without CO_2 capture and storage (CCS), photovoltaic solar power, concentrated solar power, hydropower, geothermal, and wind power. It takes a whole life-cycle perspective, from the production of equipment and facilities to the extraction and use of fuel, from the operation of power plants to their dismantling.

The assessment analyses and benchmarks the environmental impacts of the technologies per unit of power produced. It also assesses global environmental, health and resource implications of implementing the IEA’s Blue Map (or 2°C) mitigation scenario in comparison to a *business as usual* scenario. The scenario envisions replacing fossil fuels for power generation with renewables on a large enough scale to keep global warming to 2 degrees.

MAIN FINDINGS OF THE REPORT

- From the life cycle perspective, the GHG emissions of electricity produced from renewable sources are less than 6% of those generated by coal or 10% by natural gas.
- Human health impacts from renewable energy electricity production are only 10-30% of those from the state-of-the-art fossil fuel power.
- Damage to the environment from renewable energy technologies is 3 to 10 times lower than from fossil fuel based power systems.
- Natural-gas combined cycle plants, wind power, and roof-mounted solar power systems have low land use requirements, while coal fired power plants and ground-mounted solar power require larger areas of land.
- Site-specific environmental impacts, such as the ecological impacts of coalmines, hydropower dams and wind turbine installations, vary greatly, depending on the significance of the species and habitats affected and may be mitigated or offset by proper site selection and planning.
- Coal- or gas-fired systems with carbon capture and storage (CCS) are a promising way to reduce greenhouse emissions, but will exacerbate various environmental pollution impacts by 5-80%.

SCENARIOS FOR THE FUTURE GLOBAL ENERGY MIX

- Under the *business as usual* scenario for energy production, GHG emissions would double; so would the human health impacts; the impacts on ecosystems and land use would increase substantially.
- Under the 2°C scenario, greenhouse gas emissions from power generation decline by a factor of five while electricity generation doubles; human health impacts stabilize or decline moderately; environmental pollution, ecosystem impacts and land use stabilize or decline moderately.
- Building the worldwide low-carbon power systems, as envisaged in the 2°C scenario will require an increased use of steel, cement and copper in comparison with the BAU scenario. However, the amount of cement required is small relative to current levels of world production. The iron and copper required until 2050 represent 1-2 years' worth of current global production, which is significant but manageable.
- Renewable energy technologies rely on several functionally important metals, such as silver, indium, tellurium, and rare earth elements. The demand for these materials will be significant, especially given competing uses, associated with the 2°C scenario. Potential possible solutions to resource supply constraints include materials efficiency, material recycling, material substitution and alternative technologies, as well as new sources. The literature reviewed does not agree on the severity of potential supply constraints of critical materials.
- The use of variable renewables, such as wind and solar, poses challenges to balancing generation and demand in an electricity grid. It often requires fossil fuels to offset the fluctuations in supply, causing additional emissions. Variability can be addressed through larger, more versatile grids, demand-side management and energy storage.

OPPORTUNITIES TO REDUCE IMPACTS

- Methane emissions from hydropower facilities are an important concern. Yet, the emissions are unevenly distributed, with few power plants responsible for a large share of emissions. Avoiding large reservoirs that produce relatively little energy and reducing the influx of biomass and nutrients can largely address these concerns.
- Some wind power plants have been in the focus because of collisions of birds and bats with rotating blades. Such collisions can be avoided, in part through avoiding habitats for such birds and bats and in part through the slowdown of wind turbines when birds are detected.
- 80% of the pollution associated with photovoltaics and wind power is caused by the production of the conversion devices. Increasing power production through good siting and avoiding downtimes reduces the impact per unit of energy delivered. Producing materials with clean energy reduces production-related emissions.
- Coal mining, transport and storage is responsible for 70% or more of the freshwater pollution resulting from coal power and a substantial share of associated emission of particulate matter. Pollution varies widely depending on geological factors and operational measures. Sourcing fuels only from low-polluting sites and putting in place appropriate mitigation measures can substantially reduce the environmental impacts of fossil fuel power.

APPROPRIATE ENVIRONMENTAL "DUE DILIGENCE" FOR INVESTMENTS IN ELECTRICITY PRODUCTION TECHNOLOGIES IS NEEDED

The key to sound energy decisions lies in selecting the right mix of technologies according to local or regional circumstances and putting in place safeguard procedures to mitigate and monitor potential impacts. This demands careful assessment of various impacts of different alternatives, so as to avoid the unintended negative consequences, and to achieve the most desirable mix of environmental, social and economic benefits.

Life cycle assessment is of central importance to making the right energy choices. Sound criteria are essential to distinguish between different actions and technology choices in terms of their ultimate sustainability. These criteria will help ensure that overall sustainability goals are met and that the actions taken are in line with global targets, such as the 2°C degree target under the UN Framework Convention on Climate Change and species protection targets under the Convention on Biological Diversity.

Green Energy Choices lays the foundation for developing such sustainability criteria, and so making good decisions about the energy sources that will influence the human future and that of life on Earth, in an era of growing pressure over scarce resources.

The International Resource Panel was established in 2007 to provide independent, coherent and authoritative scientific assessments of the sustainable use of natural resources and the environmental impacts of resource use over the full life cycle.

By providing up-to-date information and the best science available, the International Resource Panel contributes to a better understanding of how to decouple human development and economic growth from environmental degradation. The information contained in the International Resource Panel's reports is intended to be policy-relevant and support policy framing, policy and programme planning, and enable evaluation and monitoring of policy effectiveness.

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