

Key Findings

The Global Energy Challenge

Since before the Industrial Revolution, societies have relied on increasing supplies of energy to meet their need for goods and services. Major changes in current trends are required if future energy systems are to be affordable, safe, secure, and environmentally sound. There is an urgent need for a sustained and comprehensive strategy to help resolve the following challenges:

- *providing affordable energy services for the well-being of the 7 billion people today and the 9 billion people projected by 2050;*
- *improving living conditions and enhancing economic opportunities, particularly for the 3 billion people who cook with solid fuels today and the 1.4 billion people without access to electricity;*
- *increasing energy security for all nations, regions, and communities;*
- *reducing global energy systems greenhouse gas emissions to limit global warming to less than 2°C above pre-industrial levels;*
- *reducing indoor and outdoor air pollution from fuel combustion and its impacts on human health; and*
- *reducing the adverse effects and ancillary risks associated with some energy systems and to increase prosperity.*

Major transformations in energy systems are required to meet these challenges and to increase prosperity.

The Global Energy Assessment (GEA) assessed a broad range of resources, technologies and policy options and identified a number of 'pathways' through which energy systems could be transformed to simultaneously address all of the above challenges

These are the Key Findings:

1. Energy Systems can be Transformed to Support a Sustainable Future: the GEA analysis demonstrates that a sustainable future requires a transformation from today's energy systems to those with: (i) radical improvements in energy efficiency, especially in end use, and (ii) greater shares of renewable energies and advanced energy systems with carbon capture and storage (CCS) for both fossil fuels and biomass. The analysis ascertained that there are many ways to transform energy systems and many energy portfolio options. Large, early, and sustained investments, combined with supporting policies, are needed to implement and finance change. Many of the investment resources can be found through forward-thinking domestic and local policies and institutional mechanisms that can also support their effective delivery. Some investments are already being made in these options, and should be strengthened and widely applied through new and innovative mechanisms to create a major energy system transformation by 2050.

2. An Effective Transformation Requires Immediate Action: Long infrastructure lifetimes mean that it takes decades to change energy systems; so immediate action is needed to avoid lock-in of invested capital into existing energy systems and associated infrastructure that is not compatible with sustainability goals. For example, by 2050 almost three-quarters of the world population is projected to live in cities. The provision of services and livelihood opportunities to growing urban populations in the years to come presents a major opportunity for transforming energy systems and avoiding lock-in to energy supply and demand patterns that are counterproductive to sustainability goals.

3. Energy Efficiency is an Immediate and Effective Option: Efficiency improvement is proving to be the most cost-effective, near-term option with multiple benefits, such as reducing adverse environmental and health impacts, alleviating poverty, enhancing energy security and flexibility in selecting energy supply options, and creating employment and economic opportunities. Research shows that required improvements in energy efficiency particularly in end-use can be achieved quickly. For example:

- retrofitting buildings can reduce heating and cooling energy requirements by 50–90%;
- new buildings can be designed and built to very high energy performance levels, often using close to zero energy for heating and cooling;
- electrically-powered transportation reduces final energy use by more than a factor of three, as compared to gasoline-powered vehicles;
- a greater integration between spatial planning and travel that emphasizes shorter destinations and enhances opportunities for flexible and diverse choices of travel consolidating a system of collective, motorized, and non-motorized travel options offer major opportunities;
- through a combination of increased energy efficiency and increased use of renewable energy in the industry supply mix, it is possible to produce the increased industrial output needed in 2030 (95% increase over 2005) while maintaining the 2005 level of GHG emissions.

A portfolio of strong, carefully targeted policies is needed to promote energy efficient technologies and address, *inter alia*, direct and indirect costs, benefits, and any rebound effects.

4. Renewable Energies are Abundant, Widely Available, and Increasingly Cost-effective: The share of renewable energy in global primary energy could increase from the current 17% to between 30% to 75%, and in some regions exceed 90%, by 2050. If carefully developed, renewable energies can provide many benefits, including job creation, increased energy security, improved human health, environmental protection, and mitigation of climate change. The major challenges, both technological and economic, are:

- reducing costs through learning and scale-up;
- creating a flexible investment environment that provides the basis for scale-up and diffusion;
- integrating renewable energies into the energy system;
- enhancing research and development to ensure technological advances; and
- assuring the sustainability of the proposed renewable technologies.

While there remain sound economic and technical reasons for more centralized energy supplies, renewable energy technologies are also well-suited for off-grid, distributed energy supplies.

5. Major Changes in Fossil Energy Systems are Essential and Feasible: Transformation toward decarbonized and clean energy systems requires fundamental changes in fossil fuel use, which dominates the current energy landscape. This is feasible with known technologies.

- CO₂ capture and storage (CCS), which is beginning to be used, is key. Expanding CCS will require reducing its costs, supporting scale-up, assuring carbon storage integrity and environmental compatibility, and securing approval of storage sites.
- Growing roles for natural gas, the least carbon-intensive and cleanest fossil fuel, are feasible, including for shale gas, if related environmental issues are properly addressed.
- Co-processing of biomass and coal or natural gas with CCS, using known technologies, is important for co-producing electricity and low-carbon liquid fuels for transportation and for clean cooking. Adding CCS to such coproduction plants is less costly than for plants that make only electricity.

Strong policies, including effective pricing of greenhouse gas emissions, will be needed to fundamentally change the fossil energy system.

6. Universal Access to Modern Energy Carriers and Cleaner Cooking by 2030 is Possible: Universal access to electricity and cleaner cooking fuels and stoves can be achieved by 2030; however, this will require innovative institutions, national and local enabling mechanisms, and targeted policies, including appropriate subsidies and financing. The necessary technologies are available, but resources need to be directed to meet these goals. Universal access is necessary to alleviate poverty, enhance economic prosperity, promote social development, and improve human health and well-being. Enhancing access among poor people, especially poor women, is thus important for increasing their standard of living. Universal access to clean cooking technologies will substantially improve health, prevent millions of premature deaths, and lower household and ambient air pollution levels, as well as the emissions of climate-altering substances.

7. An Integrated Energy System Strategy is Essential: An integrated approach to energy system design for sustainable development is needed – one in which energy policies are coordinated with policies in sectors such as industry, buildings, urbanization, transport, food, health, environment, climate, security, and others, to make them mutually supportive. The use of appropriate policy instruments and institutions can help foster a rapid diffusion and scale-up of advanced technologies in all sectors to simultaneously meet the multiple societal challenges related to energy. The single most important area of action is efficiency improvement in all sectors. This enhances supply side flexibility, allowing the GEA challenges to be met without the need for technologies such as CCS and nuclear.

8. Energy Options for a Sustainable Future bring Substantial Multiple Benefits for Society: Combinations of resources, technologies, and policies that can simultaneously meet global sustainability goals also generate substantial and tangible near-term local and national economic, environmental, and social development benefits. These include, but are not limited to, improved local health and environment conditions, increased employment options, strengthened local economies through new business opportunities, productivity gains, improved social welfare and decreased poverty, more resilient infrastructure, and improved energy security. Synergistic strategies that focus on local and national benefits are more likely to be implemented than measures that are global and long-term in nature. Such an approach emphasizes the local benefits of improved end-use efficiency and increased use of renewable energy, and also helps manage energy-related global challenges. These benefits make the required energy transformations attractive from multiple policy perspectives and at multiple levels of governance.

9. Socio-Cultural Changes as well as Stable Rules and Regulations will be Required: Crucial issues in achieving transformational change toward sustainable future include non-technology drivers such as individual and public awareness, community and societal capacities to adapt to changes, institutions, policies, incentives, strategic spatial planning, social norms, rules and regulations of the marketplace, behavior of market actors, and societies' ability to introduce through the political and institutional systems measures to reflect externalities. Changes in cultures, lifestyles,

and values are also required. Effective strategies will need to be adopted and integrated into the fabric of national socio-cultural, political, developmental, and other contextual factors, including recognizing and providing support for the opportunities and needs of all nations and societies.

10. Policy, Regulations, and Stable Investment Regimes will be Essential: A portfolio of policies to enable rapid transformation of energy systems must provide the effective incentive structures and strong signals for the deployment at scale of energy-efficient technologies and energy supply options that contribute to the overall sustainable development. The GEA pathways indicate that global investments in combined energy efficiency and supply will need to increase to between US\$1.7–2.2 trillion per year compared to present levels of about US\$1.3 trillion per year (about 2% of current world gross domestic product) including end-use components. Policies should encourage integrated approaches across various sectors and promote the development of skills and institutional capacities to improve the investment climate. Examples include applying market-oriented regulations such as vehicle emissions standards and low carbon fuel standards and as well as renewable portfolio standards to accelerate the market penetration of clean energy technologies and fuels. Reallocating energy subsidies, especially the large subsidies provided in industrialized countries to fossil fuels without CCS, and nuclear energy, and pricing or regulating GHG emissions and/or GHG-emitting technologies and fuels can help support the initial deployment of new energy systems, both end-use and supply, and help make infrastructures energy efficient. Publicly financed research and development needs to accelerate and be reoriented toward energy efficiency, renewable energy and CCS. Current research and development efforts in these areas are grossly inadequate compared with the future potentials and needs.

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The full GEA report is available for download in electronic form at www.globalenergyassessment.org. The website includes an interactive scenario database that documents the GEA pathways.