EDITORIAL

Energy transition needs new materials

The decreasing cost of electricity worldwide from wind and solar energy, as well as that of end-use technologies such as electric vehicles, reflect substantial progress made toward replacing fossil fuels with alternative energy sources. But a full transition to clean energy can only be realized if numerous challenges are overcome. Many problems can be addressed through the discovery of new materials that improve the efficiency of energy production and consumption; reduce the need for scarce mineral resources; and support the production of green hydrogen, clean ammonia, and carbon-neutral hydrocarbon fuels. However, research and development of new energy materials are not as aggressive as they should be to meet the demands of climate change.

There are two major obstacles to the clean energy transition. Parts of the world's energy system can't be electrified, such as aviation, heavy freight transport, and shipping. Alternatives include hydrogen, ammonia, biofuels, or synthetic fuels, but current costs are far too high. As well, the growth of renewables—whose availability varies both daily and seasonally—demands changes in energy storage where global adoption is driven by cost savings rather than regulation and policy.

In the United States, a strategy is needed that integrates applied research, policy, financing, and infrastructure development to address these challenges. For example, despite progress in hydrogen production through electrolysis, there are commercialization obstacles. Iridium is a catalyst for the oxygen evolution reaction that is used to make hydrogen from water. However, iridium is rare and expensive, and is primarily sourced from South Africa and Russia, which poses geopolitical challenges. Any alternatives to iridium must not only match its performance and reliability but also be globally accessible and adopt more environmentally friendly mineral extraction practices. Speeding the discovery of new materials to replace iridium—as well as other elements used in catalysts, cathodes, electrolytes, and additives—requires increased investment across federal funding agencies.

To expedite discovery, accelerating the synthesis and testing of candidate materials is vital. One approach involves creating "megalibraries," microchips designed to simultaneously test millions of positionally encoded materials, generating vast amounts of data on material properties. These data should guide the identification of new technology-enabling materials. By learning from these datasets, artificial intelligence should predict promising material compositions faster than human researchers could through traditional experimentation.

Another component of a materials revolution is talent. Scientists, from students to researchers, must become sufficiently familiar with physics, chemistry, materials science, engineering, and computer science. This will require a new approach to education. One way forward is to develop graduate curricula in which students identify their own paths to acquire the skills and knowledge needed for their specific interests and innovative projects. Nations also need to ensure that scientists can relocate to collaborate on clean technologies. This may mean moving among the sites of R&D and discovery, commercialization, and manufacturing.

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To achieve this acceleration in materials discovery, investment from industry is vital. Government support will continue to play a role, but private sector involvement is necessary to scale breakthroughs from the lab to commercialization. Establishing new kinds of partnerships between academia, industry, and government should be created that drive both innovation and deployment. Mission-oriented research, such as the design of new batteries and alternative liquid fuels, would be ideal training grounds for a new breed of scientist-engineer-entrepreneur. "Accelerator grants" from the public and private sectors that foster such activities will be essential.

Last year, global clean energy investments reached US$1.7 trillion, surpassing fossil energy investments by 70%. Yet this falls short of what is needed to mitigate the impacts of climate change. Governments must reimagine the innovation ecosystem for material discovery. As the world saw during the pandemic, lowering barriers for translating discoveries to products transformed vaccine development for the benefit of billions of people. Doing the same for clean energy materials will protect the planet, serving billions now and into the future.

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