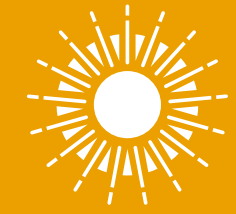


# SEE THE LIGHT



International  
Day of Light

## CLEANER ENERGY



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#SEETHELIGHT  
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If you have ever experienced an unplanned power outage — and consequently, its often debilitating effects on one's daily routine — you already realize the vital importance of having access to modern energy. But what may be a temporary inconvenience for many of us remains a permanent roadblock for the 840 million people worldwide who live without electricity.

*Photo Credit:*  
*University of Waterloo, Canada*



With no electricity at home or school, hundreds of children in Guinea study under the illumination of streetlights in the airport's parking lot, inhaling jet engine exhaust. In Uganda, students tend to work in bed with a candle on the headboard, leading to fires and burn-related accidents. Women in India and sub-Saharan Africa are exposed to household air pollution from cooking with biomass and coal.

A lack of reliable energy services means health clinics and schools can't function properly, clean water and sanitation becomes harder to come by, and agricultural productivity suffers. It has lasting repercussions for just about every area of life.

In addition, energy poverty often goes hand in hand with pollution.

Exhaust from diesel generators, used in rural areas without grid access or as a backup if the grid fails, contains more than 40 toxic air contaminants. Without clean cooking facilities, households burn solid fuels like wood and coal, which account for approximately 2 percent of global emissions. A need exists to monitor these actions and their effects on the environment to understand the full extent of the problem — and how best to solve it.

On the bright side, access to electricity is gradually expanding throughout the world with the help of light-based technologies. Off-grid solar power provides a renewable, clean energy source for rural communities, serving as a cheaper and environmentally friendly alternative to diesel generators. Light-emitting diodes (LEDs) have boosted the energy efficiency of lightbulbs and could save developing countries \$40 billion a year. We also use technologies to detect the signatures of light to measure the impact of fossil fuels — and their lower-carbon-emitting counterparts — on the environment (these are called photonic sensing technologies).



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# EXPANDING CLEAN ENERGY ACCESS WITH SOLAR TECHNOLOGIES

In 2015, the United Nations introduced a plan of action to improve the health of the planet and the prosperity of its people.

The Agenda for Sustainable Development lists 17 global goals — including climate action, zero hunger, and equitable education — intended to be achieved by 2030. Harnessing the power of the sun with solar technologies has accelerated progress towards Goal 7: “Ensuring access to affordable, reliable, sustainable and modern energy for all.”

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Solar energy has always been clean, climate-friendly, and renewable. But the piece of puzzle that went missing for decades — affordability — has finally fallen into place. Since 2010, the cost of converting sunlight into electricity has dropped by 80 percent.

Research into manufacturing processes for solar panels led to improvements in technology that automated large parts of the work and cut costs significantly. Today, solar is cheaper than natural gas or coal in many parts of the world. For those living in energy poverty,

solar solutions represent a lower-cost, environmentally-friendly alternative to the diesel generators many people currently use. According to the World Bank, more than 700,000 off-grid solar systems have been installed in Sub-Saharan Africa, and last year, it committed over \$200 million to solar projects in the same region.

A UN progress report highlighted an urban electrification project in Togo that installed 10,000 solar-powered street lights as an inspiring example for other countries. Although solar power makes up only a tiny fraction

of the world's energy consumption, that number continues to increase year after year. The world's largest countries are jumping onboard.

China has built giant solar farms and, as a result, boasts more solar energy capacity than any country in the world. The U.S. already has more than 2 million solar photovoltaic installations, mostly in California, with the amount predicted to double by 2023.





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# LIGHTING THE WORLD WITH EFFICIENT LEDs

The 2014 Nobel Prize in Physics was awarded to three Japanese scientists for an invention that would change the world, one lightbulb at a time. While red and green LEDs had existed for decades, the blue LED remained an elusive challenge for researchers, without which white LED light could not be created.

The groundbreaking work on blue LEDs by Isamu Akasaki, Hiroshi Amano and Shuji Nakamura in the early 1990s opened the door for longer-lasting, more energy-efficient lighting technology.

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Compared to incandescent bulbs and fluorescent tubes, LED lighting reduces electricity usage, materials consumption, and costs. Data shows that the growing use of LED bulbs is having a distinct, positive effect on greenhouse gas emissions.

In 2017 alone, LED lighting in buildings and outdoor spaces reduced carbon dioxide emissions by an estimated 570 million tons — roughly the equivalent of shutting down 162 coal-fired power plants. One-sixth of the world's population uses fuel-based lighting, spending 100- to 1,000-times per unit of illumination than those with electricity access. Not only are fuels like kerosene, diesel, and propane

cost-inefficient, they also dump 30 million cars-worth of greenhouse gas emissions into the air. LEDs, in combination with off-grid solar systems, have the power to free these individuals from lighting poverty. Switching to LED bulbs could save developing countries \$40 billion per year and prevent 320 million metric tonnes of carbon pollution.

Many in Africa, Asia, and Latin America have already initiated the changeover. For example, Yemen plans to install more than 3,000 stand-alone solar LED street lighting systems in the cities of Sana'a and Aden.

And the UN progress report noted that Senegal has implemented a program to

replace 3 million incandescent lights in the capital city of Dakar with LEDs by 2025.

The LED lights, which will consume 80 to 92 percent less electricity, will be installed in households, government offices, and street lights.





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## MONITORING THE HEALTH OF OUR PLANET WITH LASER LIGHT

While innovations like solar technologies and LED bulbs have the potential to greatly improve the health of our planet, measurement techniques that quantify changes in the environment will ultimately prove whether they have or not. Environmental monitoring of our waters, soils, and atmosphere is essential to realizing the full impact of humankind's actions, whether they be positive or negative.

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Light-based technologies can measure air and water quality, biomass, carbon emissions, atmospheric chemistry, and much more. For instance, satellites that orbit the Earth remotely detect greenhouse gas emissions by observing light reflected and emitted from the planet's surface and atmosphere (a technique called optical spectroscopy). One example is Japan's Greenhouse Gases Observing Satellite (GOSAT). Since every gas absorbs light at different wavelengths, the abundance of carbon dioxide and methane in a given location can be calculated from these measurements.

LIDAR (LIght Detection And Ranging) is a remote sensing technique that creates a 3D representation of elevation

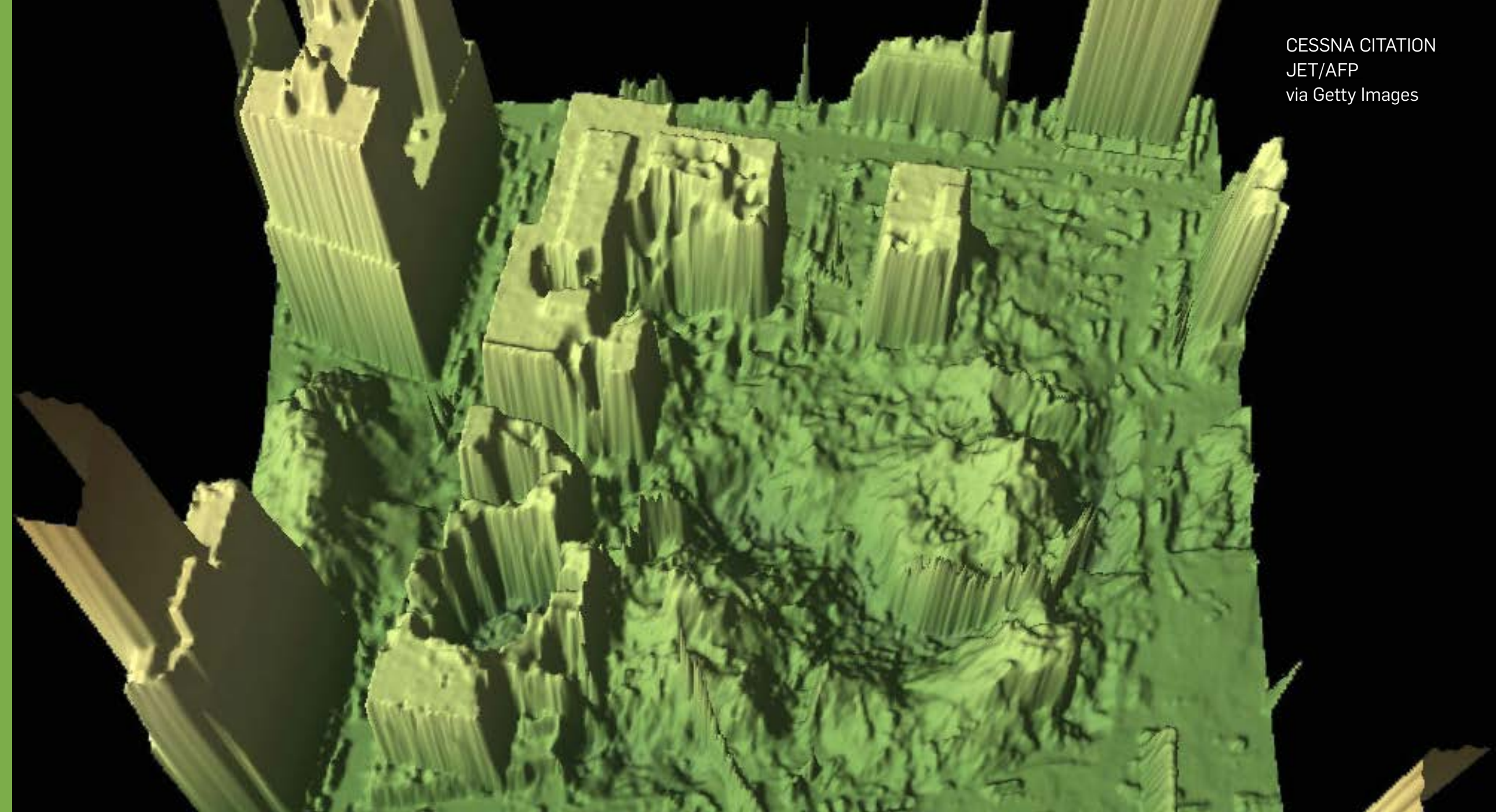
with the help of a rapidly firing airborne laser. The beam reflects off the surface and bounces back to the LIDAR sensor, which records the time it took for the light to travel to the ground and back. The time corresponds to the distance the light traveled and converted to elevation.

The technology is being used by NASA to measure the thickness of sea ice via satellite. ICESat-2, launched in September 2018, measures height changes in glaciers and ice sheets with its six laser beams. When the satellite isn't hovering over patches of ice, it measures the mass of forest vegetation by comparing the elevation of treetops and the forest floor. Another NASA satellite, called CALIPSO (Cloud-

Aerosol Lidar and Infrared Pathfinder Satellite Observations), tracked the massive vertical migration of small sea creatures with LIDAR. The upward movement of squid, fish, and krill — who feed on carbon dioxide-absorbing phytoplankton — has a huge effect on Earth's climate.

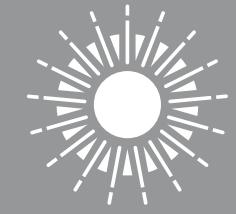
Other examples of light-based technologies for environmental sensing abound. Scientists are using jets equipped with imaging spectrometers over Australia's Great Barrier Reef to assess the health of its corals, photonics technologies to monitor ecosystem changes in the Canadian North, and lasers to track carbon flow in coastal redwood forests of California.

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JET/AFP  
via Getty Images





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## WHAT THE FUTURE HOLDS

Light contains infinite possibilities for science and technologies that can transform our world. It has the power to generate clean, renewable solar energy for all, even for those living in remote or poverty-stricken areas. In combination with more efficient lightbulbs, it paves the way for greater access to education, safer city streets, and a healthier population who doesn't have to rely on burning dangerous fuels. And the positive impact of these changes on the environment can even be measured using light.

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The future will undoubtedly bring more revolutionary innovations with light, and I look forward to seeing what the next generation of young scientists will come up with to better the state of our

planet and its inhabitants. We have got to keep playing with light-based technologies and exploring the science of light in every way that we can.

