Reaping exponential benefits

Proponents of exponential technologies eulogise their ability to transform societies over the next 25 years. What is their potential to help tackle climate change?

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We are living in a time of exponential change. Transformations in our environment and climate are accelerating in response to rapidly rising carbon dioxide emissions. The growing threat of climate change has the power to undermine most areas of society and threatens economic development globally. The outsized importance of climate change to global development is reflected throughout the UN's Sustainable Development Goals, highlighted by Goal 13 for climate action.

Fortunately, technological progress is also driving exponential change, whereby the rate of new technology development is growing rapidly. We continue to experience an unprecedented, exponential increase in computing power with more and more individuals connected to the internet than ever before and networked sensors measuring everything from what happens inside one's body to the forces that govern our planet.

Exponential technologies, such as advanced robotics, artificial intelligence, distributed manufacturing (3D-printing) and nanotechnology, all share the fact that they are developing rapidly into accessible and flexible problem-solving tools that can be used to achieve grand impact in a highly scalable way. As a result, as exponential technologies improve, myriad different industries can simultaneously harness their power. They provide a foundational toolkit applicable to many different problems.

The intersection of these exponential forces – climate change and technology – provides us with a rare opportunity to begin solving the incredibly complex challenge of global greenhouse gas emissions by leveraging tools that, by their nature, provide the ability to scale impact.

At the centre of our global challenge is the need to take real climate action and rapidly decarbonise our energy supply. As such, it will be imperative to apply exponential tools to every part of the energy system to accelerate the pace of change.

Reducing CO_2 emissions from our energy supply can and should take the form of: increasing the proportion of carbon-free energy sources (e.g. renewables); capturing CO_2 emissions from the burning of fossil fuels and either utilising or sequestering the carbon; improving efficiencies in the use and transmission of electricity (e.g. energy-efficient devices and home appliances, smart grid and distributed power generation); and dramatically improving the structure and quantity of energy demand across industries and communities.

Exponential technologies are already being applied in the electricity market in a way that is either displacing fossil fuels or changing demand to improve efficiency dramatically. Consider the advances that have occurred in solar photovoltaic (PV) power: the price per kilowatt-hour of solar PV has dropped exponentially over the past two decades, with the price curve accelerating recently.

This is precisely the type of exponential curve that is lauded in computer engineering, yet it has been even faster than the famed Moore's law (whereby computing power has doubled every 18-24 months for the past 40 years). Further advances in materials science and nanotechnology are resulting in new breakthroughs for solar, wind and other renewable sources of electricity.

On the demand side of the equation, the rapid growth in smart-grid technology – which relies on ubiquitous sensors and cloud-based information technology – has in many developed countries begun to result in demand management that can efficiently manage their society's power requirements. This means these countries need to generate less total electricity to satisfy economic demands.

With the growth in the 'internet of things' – wherein devices ranging from appliances to cars will be connected to the internet – it will be increasingly possible to smooth energy demand across a wide system and rapidly improve energy efficiency.

Potential for innovation

These advances in efficiency are important because it means we can use less energy (and thus produce less CO_2) while still enabling all of the services and work that energy provides. In many parts of the world, access to electricity remains low or non-existent, which serves to impede economic and personal opportunity. But in some of these places, innovators are capitalising on exponential technology, such as mobile telephony, to build new business models that create affordable, carbon-free electricity.

Consider the Kenya-based company M-Kopa, which utilises mobile money and a novel business model to supply small renewable power systems for customers in the developing world. The digitisation of finance enabled by mobile phones means that there are now alternatives to the traditional central-utility model that dominates most developed countries.

Micro-utility or distributed energy systems like this have the potential to leapfrog large national-grid infrastructure in much the same way that mobile telephones leapt over the need to build landline-based infrastructure in much of the world, with benefits and technologies that flowed back into more industrialised countries.

▲ **Schoolchildren study by the light of an LED lightbulb, powered by M-Kopa solar technology in Kenya – a service paid for using mobile money**

Fossil fuels are not only the primary source of climate-altering greenhouse gas emissions, but they are anticipated to form a substantial part of our energy supply in the foreseeable future. Mitigating CO_2 emissions from fossil fuel-based energy production will therefore be critical. Already, tremendous advances in materials research have led to new, highly efficient methods of capturing carbon from the exhaust of a power plant.

In addition to this work in carbon capture and storage is the opportunity to begin utilising that carbon dioxide in other ways. The XPRIZE Foundation is running a prize competition, worth $20 million, for teams that can convert the most carbon dioxide from a power plant into products with the highest net value. There are 47 entries, representing 47 different approaches to converting carbon dioxide.

This is an example of how exponential tools, such as a prize competition that sources from a global crowd of innovations, can rapidly identify and incentivise the development of new technologies.

Increasing the pace

There is a substantial amount of pessimism about the ability to tackle the issue of carbon emissions. Some of this is likely born of our justifiable impatience in seeing solutions. But recent advances have shown that the pace of those solutions is quickening – precisely as we would expect in an exponential pattern.

When observing an exponential curve, it can be difficult to distinguish the difference from a straight line; the change appears similar even if it is destined to ultimately increase exponentially.

For years, we have been in this linear-appearing phase of exponential growth in technologies that can mitigate CO_2 emissions. But the rate of technological development is increasing rapidly, indicating that we may soon be able to harness solutions at a substantially greater rate. By integrating solutions from across the production chain of carbon emissions – from energy generation to waste management and consumer behaviour – we may more quickly see solutions increasing in scale.

Integrating multiple elements of a complex system results in important network effects, where one piece influences multiple other pieces in a positive feedback loop. This integration will drive exponential increases in our CO_2 mitigation efforts.

For example, renewable energy that is generated in excess of demand (e.g. wind power at night) can be used to convert captured CO_2 from a fossil fuel-burning power plant into a liquid fuel or other stored form of energy. This, in turn may then help reduce demand for fossil fuels during peak power demand. Combining technologies as diverse as renewable electricity generation, demand management, carbon capture and carbon conversion could thus see a rapid reduction in gross CO_2 emissions.

These technologies are at varying stages of commercial readiness. Capitalising on the power of exponentials – crowdfunding, crowdsourcing, information and communication technology, prize competitions, etc. – can enable a huge number of people, communities and institutions to both innovate and deploy climate solutions at scale.

It may not be easy to see at first, but we have the power to shape our energy future. And we have an obligation to use technology as widely and sustainably as possible to combat the causes of climate change. ●