by inevitable compromises that allow space for polluting development as the world seeks better and cheaper solutions.

The latest attempt to create a framework for thinking about this dilemma comes from 18 environmental activists and academics, who published an 'Ecomodernist Manifesto' last week (see go.nature.com/f89sls). The essay paints a hopeful picture of technological progress while placing importance on the kind of intensive development that has characterized humanity's rise so far. Only by concentrating our impact within the urban, industrial and agricultural context can we achieve a "good Anthropocene", or age of human influence, the authors argue.

Coal, oil and natural gas have improved many lives, and the essay points out that the long arc of development is already tending towards better, cleaner and more-efficient energy technologies — just not fast enough. At least in the short term, the authors contend, poor countries are right to focus on improving the lives of their citizens, even if that means expanding their use of fossil fuels until cheaper and cleaner solutions are available. These ideas are framed in terms of a larger "decoupling of humanity from nature". What this means, precisely, is left to the imagination, but the essay also underscores the role of modern agriculture, which has freed up labour, enabled the rise of cities and reduced the amount of land that we need to feed humanity. Rather than lament this trend, the authors argue that it must be encouraged and hastened.

The essay stands in sharp contrast to the gloomy outlook often provided by environmentalists and scientists. A little scepticism is warranted. For the long haul, the authors place faith in a new generation of solar cells combined with efficient energy-storage technologies, advanced nuclear fission — and even fusion energy. In the medium term, hydropower could play a part, in the same way that technologies for the capture and sequestration of carbon could improve fossil fuels over this time scale. The authors focus on large-scale power generation, but may be too quick to write off current wind and solar technologies, which can have a useful role in reducing demand for centralized power today. The wise deployment of efficient bioenergy resources may also be helpful, in tandem with agricultural intensification.

"Governments cannot write people out of the equation."

It is not yet clear what the climate fix will look like. What is clear is that governments need to invest in a portfolio of energy research, development and demonstration. They must implement strong climate policies that will push companies towards technologies that produce less air pollution and fewer greenhouse-gas emissions. They need to invest in agricultural research to secure the necessary food crops, and provide farmers and ranchers with the tools required to maximize production. And they need to set limits on the land that can be developed.

Governments cannot write people out of the equation, and hard choices will have to be made. But the first step is to point everybody in the right direction. Human ingenuity takes many forms, and we may yet surprise ourselves. ■

More from Moore

Moore's law is approaching physical limits: truly novel physics will be needed to extend it.

Hail Gordon Moore: 19 April marked the famous prediction by the (less) famous man that the late twentieth century would herald massive increases in computing power, stimulating the technological age.

Electronics and information technology now touch almost every aspect of life. Kicking off with the invention of the integrated circuit in 1958, the continuing electronics revolution is, in large part, down to the technology industry's faithful compliance with what came to be known as Moore's law.

In 1965, Moore, a chemist turned electronic engineer, noticed that in the years since the first integrated circuits were built, engineers had managed to roughly double the number of components, such as transistors, on a chip every year. He also predicted that the rate of component shrinkage — which he later revised to a doubling every two years — would continue for at least another decade.

The semiconductor industry never looked back. It has continued to shrink transistors and produce computer chips that combine increasingly high performance and functionality.

For the first few decades, the semiconductor industry met Moore's law mainly through feats of engineering genius and gigantic strides in manufacturing processes. But the key role of fundamental science is also worth remembering, especially as researchers today seek ways to maintain the rate of progress.

The invention of the transistor at Bell Laboratories in Murray Hill, New Jersey, in the 1940s was firmly based on the development of semiconductor band theory. And scientific breakthroughs played an important part in the subsequent developments of technology. Notably, in 1970, the Russian physicist Nikolay Basov and collaborators developed excimer lasers that would later be used to etch tiny circuit patterns on the silicon wafers from which chips are made.

The 1990s called for further innovation. Until then, as transistors became smaller, their speed and energy efficiency increased. But when the components reached around 100 nanometres across, miniaturization began to have the opposite effect, worsening performance. Chip-makers such as Intel, which Moore co-founded, and IBM again looked to basic science to improve the performance of transistor materials. Major help came from condensed-matter physicists. They had known for decades that the ability of silicon to conduct electricity improves substantially when its crystal lattice is stretched — for instance, by layering it on another crystal in which the atoms have a different spacing. Engineers introduced strained silicon into chips in the 2000s, and Moore's law stayed true for several more years.

State-of-the-art microprocessors now have transistors that are just 14 nanometres wide, and Moore's law is finally approaching the ultimate physical limits. Waste heat in particular has become a source of concern. It has already caused one form of Moore's law — the exponential acceleration of computer 'clock speed' — to grind to a halt. Power-hungry chips also limit the ability of mobile devices to survive more than a few hours between charges.

The introduction of advanced materials such as hafnium oxide, which provides insulation even when it is just a few atomic layers thick, has managed to keep chips a bit cooler. Heroic efforts might yet bring one or two more generations of smaller transistors, down to a size of perhaps 5 nanometres. But further improvements in performance will require fundamentally new physics.

Where are we headed? Transistors that use quantum tunnelling, perhaps? Or those in which currents transport quantum spin rather than electric charge? Labs around the world are experimenting with approaches and materials that could drastically cut energy consumption. One avenue that could be exploited is the inherent stability of the collective 'topological' properties of atoms: a modern twist on the ancient practice of encoding information by tying knots. Some researchers are trying out radical 'neuromorphic' circuit architectures inspired by the plasticity of the brain's neuronal networks.

A principle that works well in a physics lab will not necessarily translate into something that can be mass-produced. And inevitably, most of today's attempts will lead nowhere. Society should have confidence, however, that somewhere, somehow, basic science will provide a way to maintain progress. Moore should be proud that we have not yet found the exception that proves his law. ■

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