The impact that human beings have had on the environment is immeasurable – from the vast areas of rainforest that disappear every single day, to the country-sized island of plastic floating in the Pacific Ocean. Air pollution. Oil spills. Mass extinction. Politicians who claim they don’t believe in monsters, when a tron-like monster sits right outside our collective door, waiting. It seems that every day we draw closer to blindly falling prey to its trap: a climate catastrophe is just around the corner. In recent years, climate change and the renewable energy sector have received a lot of media attention – and you’d be forgiven for thinking that the energy use of industrialised nations has actually stabilised in recent years, while that of developing countries continues to grow. What happens when the scales begin to tip and developing countries consume more and more energy? Particularly energy from polluting fossil fuels? Professor José Goldemberg has spent his entire career looking at problems such as these and, if man-made environmental degradation in general and climate change in particular are going to be the bitterest pill our generation has to swallow, perhaps we can take a leaf out of his work to sweeten the taste with sugar.

SUGARCANE AS A SUSTAINABLE FUEL
It might seem like a starry-eyed idea from one of Isaac Asimov’s novels but, in reality, Brazil has been using sugarcane to fuel its cars for almost half a century. The idea started in 1975 when, in response to an international oil crisis, the government launched the National Alcohol Program (NAP) with the aim of alleviating some of the country’s dependence on fossil fuels. Back then, Professor Goldemberg was interested in how crops, already in production in Brazil, could be used to create ethanol and other ethyl-alcohol fuels.

In a 1978 paper, published in Science, he looked specifically at the energy cost and expenditure of several different crops: sugarcane, cassava and sweet sorghum. He focused on these specific crops because they are essentially a form of non-polluting solar energy; the sun’s rays provide the crops with the energy they need to grow – and a little extra; that extra energy is stored by the plants – quite literally saved away for a rainy day – and can be extracted in the form of ethyl-alcohol at a later date.

Professor Goldemberg’s work demonstrated that sugarcane was the most efficient crop to use when converting this solar energy into a chemical fuel and it paved the way for the Brazilian energy-boom that followed. Today, an estimated 50% of the gasoline that would be in use for fuelling cars in Brazil has been replaced with ethanol from sugarcane, a renewable fuel. An achievement that was made possible, in part, by what Professor Goldemberg calls technological leapfrogging.

Scientific research is motivated not only by curiosity of love for science, but also by fashions and the perception that some areas of research are more rewarding than others. This often leads to politicians pouring money into projects that are failed from the start because the underlying infrastructure that makes something successful in one country is missing in another. But is there a better way?
the knock-on effect that it is now feasible – leapfrog over the technologies that Professor Goldemberg believes that efficient than candles’ says Professor as kerosene and a half-million times more CFL system is some 100 times as efficient station that supplies electricity to it. ‘A PV-electricity grid and the expensive power efficient technologies, like the inefficient Compact Fluorescent Lightbulbs (CFL), though – it can be applied to a whole light bulbs would be a better solution. However, imagine skipping over this which are four times as efficient. This has shown that expanding the Brazilian ethanol program by a factor of 10 would supply enough ethanol to replace more than 20% of the gasoline used [around] the world. The work of Professor José Goldemberg, of the University of São Paulo, Brazil, resonates over more than 200 years with those wise words from Isaac Newton. He reminds us that using what others have achieved previously can solve problems in often unexpected ways – but that it is important to consider the approach used in tackling a problem. Technological leapfrogging provides a route for scientists to skip over the potential stumbling blocks of using unsuitable technologies and, in Brazil, it has been used to allow one of the biggest problems we face today: the global energy crisis and global warming. Expanding the approach globally could shape the energy-climate for future generations around the globe.

Expanding the Brazilian ethanol program by a factor of 10 would supply enough ethanol to replace more than 20% of the gasoline used [around] the world.

SUSTAINABLE DEVELOPMENT OF ENERGY AROUND THE WORLD Typically, lighting in isolated villages is currently supplied by kerosene lamps, batteries or candles and replacing these with standard incandescent light bulbs would be a better solution. However, imagine skipping over this old technology and going straight to Compact Fluorescent Lightbulbs (CFL), which are four times as efficient. This has the knock-on effect that it is now feasible to power the system using Photovoltaic (PV) solar cells, leapfrogging over less efficient technologies, like the inefficient electric grid and the expensive power station that supplies electricity to it. ‘A PV-CFL system is some 100 times as efficient as kerosene and a half-million times more efficient than candles’ says Professor Goldemberg. ‘The PV-CFL solution leapfrogs over its alternative: a large, expensive electric generating station, sending power over miles of transmission and distribution lines, supplying a bulb that ultimately converts less than 1% of the original fuel energy to light’. If a similar technological leapfrogging approach was adopted around the world in our fight against climate change, the energy crisis we are currently facing could be avoided. A simple calculation shows that expanding the Brazilian ethanol program by a factor of 10 would supply enough ethanol to replace more than 20% of the gasoline used (around) the world’ explains Professor Goldemberg. The approach isn’t limited to ethanol fuel or village lighting, though – it can be applied to a whole swathe of technologies around the world and help fight the oncoming energy crisis we are currently facing.

On describing his vision and achievements in 1675, the world-renowned scientist Sir Isaac Newton, famously said ‘If I have seen further [than others] it is by standing on the shoulders of Giants’. Serving as a source of inspiration for scientists, this adage has been repeated around the world, time and time again, when advanced technological breakthroughs have been reached. But, when focused so intensively on what has come before, it’s easy to lose perspective on where we’re going. At some point, during the years that have passed, some areas in science and technology have resorted to blindly following in the footsteps of predecessors, without considering how useful their approach might be. Vision and perspective are important. The work of Professor José Goldemberg, of the University of São Paulo, Brazil, resonates over more than 200 years with those wise words from Isaac Newton. He reminds us that using what others have achieved previously can solve problems in often unexpected ways – but that it is important to consider the approach used in tackling a problem. Technological leapfrogging provides a route for scientists to skip over the potential stumbling blocks of using unsuitable technologies and, in Brazil, it has been used to allow one of the biggest problems we face today: the global energy crisis and global warming. Expanding the approach globally could shape the energy-climate for future generations around the globe.

References

Personal Response
Having worked within the energy field for such a long time, you must have witnessed a lot of technologies come and go. Are there any technologies whose success or failure – you have found surprising?

Successful examples:
• Wind-generated electricity, which was a curiosity 50 year ago and today represents 4.4% of the world’s electricity production mostly in developing countries
• Cooking with LPG (liquid petroleum gas) replacing inefficient wood cooking stoves
• Cellular telephones eliminating fixed telephones grids

Unsuccessful examples:
• Supersonic commercial flights
• Production of gasoline and diesel oil from shale sands in Canada
• Large-scale storage of electricity in batteries

Collaborators
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Research Objectives
Professor José Goldemberg, of the University of São Paulo, research aims to relieve the world’s crushing dependence on fossil fuels with a move to cleaner ethyl-alcohol based fuels.

Detail
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Bio
Professor Goldemberg received his PhD in Physical Sciences from the University de São Paulo in 1954. Presently, Professor Emeritus he was the Rector of the University from 1986 to 1990 and Minister of Science and Technology and Minister of the Environment of Brazil. In 2000, he was awarded the Volvo Environment Prize. In 2008, he was awarded the Blue Planet Prize and in 2013 the “Lifetime Achievement Award” from the Zayed Future Energy Prize.

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