The Practical, The Sublime, And The Sinister

By David Shiller, President, Lighting Solution Development, LLC

As an energy-efficiency expert, I have utilized and reflected on the intersection of mathematics and sustainability, for the past 21 years. I was surprised to learn, only months ago, that this intersection has been formalized into an area of academic study. We have sustainable building, sustainable agriculture, sustainable psychology, and sustainable business. Of course, there should be a mathematics of sustainability.

The Practical

There are many practical applications of mathematics to energy efficiency. Typically, there are calculations for savings, costs, or cost-effectiveness of a retrofit or new installation, for some efficient technology or process improvement. Utility has beauty.

My own specialty is energy efficient lighting; primarily LED and fluorescent technology and their markets. I have seen and performed many calculations for energy savings, financial savings, financial costs, and cost-effectiveness of advanced lighting installations and retrofits. More often, creating the assumptions of baseline technology, hours of use, user behavior, and power costs are more interesting and challenging than the simple mathematics required in the final calculations.

Evaluation, Measurement & Verification (EM&V) has rapidly become a specialized and important subfield within the energy efficiency industry. EM&V specialists often calculate the following for utility rebate programs:

- Free ridership – *"a free-rider is someone who would install an energy-efficiency measure without any program incentives because of the return on investment of the measure, but receives a financial incentive or rebate anyway."*
- Net present value – *"allows a company to project the projects potential profitability by discounting future cash flow expectations and comparing the sum of these cash flows to the initial capital expenditure required to fund the project."*

Evaluators also calculate benefits and costs for programs. The benefits may include, but are not limited to: lower greenhouse gas emissions, improved public health, lower energy prices, job creation, increased income, improved national security, and reduced construction expenses for utilities.

The Sublime

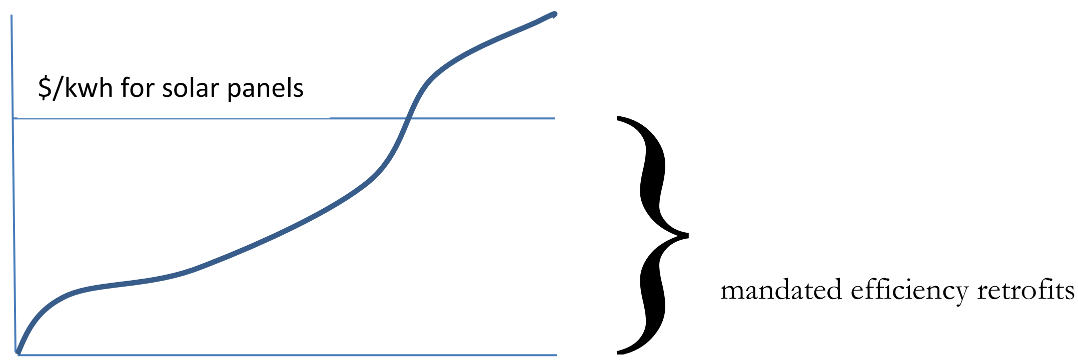
What I thought was going to be routine work travel, became far from routine. I was informed that "he" would be at the meeting. Who? Dr. Arthur Rosenfeld, the undisputed father of the field of energy efficiency. I learned online that he was a physicist and the last graduate student of Enrico

Fermi, one of the fathers of the atomic bomb and particle physics. Having studied physics myself, I looked forward to the meeting.

The meeting was running late. Everyone was in attendance except "Commissioner Rosenfeld." Finally, he arrived, apologized for his tardiness and walked over to the blackboard to share why he was late. He had just come from a California Energy Commission meeting. A committee was examining the issue of providing state funding for solar panels on buildings. Since solar panels are expensive, the state didn't want to pay for additional panels when more cost-effective energy-efficiency measures could reduce the amount of solar panels a building would require. The committee was trying to determine: what is the optimal amount of electrical efficiency retrofits that should be mandated on a building prior to funding the installation of solar panels?

Commissioner Rosenfeld went silent and let the question sink in. The pause was long and the silence in the room was deafening. This was a purely mathematical question. It should be solvable……..but how? Where to start? There was no specific information in the formulation of the problem. I was stuck.

Then Commissioner Rosenfeld shared his solution: ***"Every possible electrical efficiency retrofit should be mandated that has a cost per kilowatt-hour less than or equal to the cost per kilowatt-hour of the solar panels."*** Then he drew a quick graph with chalk, on the board:



Of course! This was so profoundly simple and elegant. To this day, it is the most interesting application of mathematics to sustainability that I've seen.

The Sinister

For many years, I've wrestled with the question of why we have a global environmental crisis? How did humanity get to this point? The deeper I dug, the more philosophical the issues became. Evolutionary biologists travel to remote places to collect and examine the fossil record, in order to understand the evolution of species. Climatologists travel to Antarctica or remote glaciers to collect and examine ice cores, in order to understand ancient occurrences of climate change. Similarly, Sustainabilists must dig into the foundations of Western thought to understand our culture's exploitation of the natural world.

It is not a coincidence that our global environmental crisis has arisen in parallel with the rise of rationalism, logic, and science. Greenhouse gases, fossil fuels, plastics, industrial-scale production, mechanized fishing and agriculture are all contributing to our global environmental crisis, but they are all also direct results of rationalist, mechanistic, and reductionist thinking. In his book, ***Turning Point***, systems theorist and particle physicist, Fritjof Capra, lays much of the blame for our society's most destructive behaviors with mechanistic and reductionist thought. He further cites Rene Descarte's ideas as particularly incompatible with the natural world. Rene Descarte is, of course, the famous geometer, mathematician, and philosopher. Descartes is one of many mathematicians that has profoundly shaped our culture's view of the world.

There are many other examples of mathematics shaping our Western worldview. The United States Bill of Rights is modeled on the logic of Euclid, the most famous of all ancient geometers. "We hold these truths to be self-evident….." This parallels how Euclid built his geometric proofs on "self-evident" axioms. It is no coincidence that Thomas Jefferson constructed the Bill of Rights using a Euclidean logic model. Jefferson studied the philosophies of John Locke and Thomas Hobbes. All of these men strove to apply Euclidean logic to human affairs.

The previous examples show how our geometric and mathematical ideas shape our worldview in ways that most of us never consider. The mechanistic and reductionist worldview of the Enlightenment is embedded in our mainstream thought and contains specific fallacies that contribute to our society's wholesale destruction of our environment:

1. The fallacy of separate self (the skin-encapsulated ego)
2. The fallacy of human exceptionalism (anthropocentrism)
3. The fallacy of viewing nature as a machine (mechanistic thinking)
4. The fallacy that any system can best be understood by understanding the nature of its constituent parts (reductionist thinking).

In many ways, mathematics has directly contributed to the Western worldview that incorrectly posits man as separate from and above nature. Of course, religion and science have made similar contributions. All of this post-modern critique points out a much deeper and darker relationship between mathematics and sustainability. Our mathematics is a direct contributor to the global environmental crisis.

Mathematics can, however, share in the work of building a sustainable society, just as it has shaped our most destructive worldviews. Similarly, each of us has the potential to contribute to a more sustainable culture. Each of us was taught a mechanistic and reductionist mindset that we must deconstruct and abandon before we can correct our own relationship with nature.

David Shiller is President of Lighting Solution Development, a firm providing consulting, recruiting, and advanced lighting technology, to light fixture manufacturers. David invented and commercialized the GU24 self-ballasted CFL lamp, the predominant lamping platform used in decorative fluorescent luminaires.