Creative Destruction: Dismantling Our Past to Build a Better Future - 15072

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Citizen

ABSTRACT

Innovation Economics hypothesizes that a firm's innovative capacity, stimulated by appropriable knowledge and technological externalities, has a greater impact on economic growth rather than the neoclassical view of capital accumulation. Under this theory, creative destruction is defined as the constant process of industrial evolution that cannibalizes older markets to create new enterprise. Economic momentum is stimulated through the creation of new markets based on demand for consumer goods and the resulting innovations for production and transportation.

For firms currently engaged in the management of radioactive waste, listening to the "Stakeholder's Voice" improves the product and service realization, leading to a competitive advantage in the marketplace. To illustrate the potential for economic development, a case study is provided on how a "Recycle and Reuse" business strategy provides the tools to leverage unique resources to ensure a firm's survival and market prominence. As a concept, creative destruction serves to educate the reader on the mutual gains to the private and public sector fuelled by improvements in our ecosystem's capacity and capabilities.

INTRODUCTION

The objective of this paper is to challenge our assumptions regarding the management of radioactive waste. I would like to know if there is a better way to handle this material as we pass on our institutional knowledge from one generation to the next. This information is presented in the simplest form possible to facilitate the free flow of information. [1] This paper in other words, is about kids' stuff. It contains pictures that most readers are going to be able to visualize; stuff like hockey sticks, baseballs, and atomic bombs. By explaining the concept of radioactive waste management in laymen terms; scientific, technical, and regulatory information can be disseminated to the general public more effectively.

The question at the core of this paper is, "Can we safely dismantle nuclear weapons in order to manufacture a windfall of carbon-free energy?" The paper is divided into three parts if you exclude this Prologue (Introduction) and the Epilogue (Conclusion). The first act examines past practices regarding nuclear waste management and how our system evolved. The second act examines the current market for radioactive waste disposal. The third proposes competitive models that improve resource efficiency in order to hypothesize how future markets will operate.

This paper relies on the lens of economics to view the subject matter. Economics is a valuable tool that helps to describe how scare resources can be used more effectively recognizing that they have competing and alternative uses. Since economics isn't an exact science, this paper only uses "ball park estimates." I hope by keeping things simple and writing for the youth of today, we can inspire the scientists of tomorrow.

THE DREAMS OF YESTERDAY

Our story begins, in the summer of 1988. North America is having one of the worst droughts in recorded history. To say it's hot would be an understatement. The heat wave continues into the following summer and result in one of the costliest natural disaster recorded. Not since the Dust Bowl of the 1930's had North America experienced a drought of this magnitude. In June of 88, the New York Times publishes an article titled "Global Warming Has Begun, Expert Tells Senate." The expert, Dr. James E. Hansen, reports that warming is attributed to the build-up of carbon dioxide in the Earth's atmosphere. [2] It's called the "greenhouse effect".

The world however, is not all doom and gloom in the late 80's. As the globe is heating up, the Cold War is coming to an end. Up until this point our planet had two competing "Super Powers", the United States and the Soviet Union, vying for global supremacy. These competing states adopted a doctrine known as "Mutually Assured Destruction". It is a military strategy of deterrence that locks both parties in a stalemate, as any conflict would result in total annihilation for all participants. In this MAD world, both the United States and the Soviet Union had accumulated more than 10,000 nuclear warheads respectively; society had live with the fear of an imminent nuclear winter.

After briefly studying the political history of the bomb, one question comes to mind. What is going to happen to those 20,000 warheads? The only things certain are death and taxes. Each bomb inevitably has to be disposed of and citizens of the state will have to cover the costs. In 1987, an amendment to the Nuclear Waste Policy Act designated Yucca Mountain as the final resting place for the US high-level waste. But what is this waste? Since this is paper deals with economics, lets talk about gadgets, and assume we had to dispose of the "Trinity" test device.

The first detonation of a nuclear weapon occurred on July 16, 1945. The test was code named "Trinity" by Robert J. Oppenheimer, in reference to John Donne's Holy Sonnets. [3], [4] At the heart of the device, "Gadget", was a sphere of plutonium. Plutonium is a fissile material, meaning that it is capable of maintaining a chain reaction. In early weapon designs this pit was a solid sphere of fissile material known as "Christy's Core" and had a mass of 6.2 kg. If each warhead has a comparable mass, the world will inevitably need to find a long-term solution for 124 metric tonnes of this high-level waste.

THE HOPE OF TODAY

Since the Revolutions of 1989, the world has kept evolving at a rapid pace. Advancement in communications through the adoption of computers, cell phones, and the internet has connected humanity like never before. However, aside from the telecommunications and tech industries not much has changed in 27 years. Any consensus on climate change is locked in political gridlock all the while scientists claim that the world is getting hotter and experiencing more extreme weather events. Stockpile stewardship also lost traction when the funding for the Yucca Mountain Waste Repository was cut in 2011. While the two problems appear separate, they are manifestations of the same symptom, a failure to internalize the waste created.

Energy is the ultimate raw material. It doesn't come from nothing and must be generated, and therefore creates some form of waste. If we do not include food, the most common sources of energy that we encounter in our daily lives are gasoline, natural gas, and electricity. Each of these commodities, however, is sold to us in different units so it hard to get a clear picture of what we are paying for. In Ontario, the average electric utility rate is $0.10 per kWh. In exchange for a "Bluenose", Canada's humble ten-cent piece; we can power a laptop for 20 hours, brew three pots of coffee, or make 13 meals in the microwave. [5] How much would that kWh cost if we used the competing energy sources gasoline or methane?

Let's assumes gasoline is selling for $1.00 per litre. By balancing the stoichiometric combustion formula, a kWh derived from burning this dinosaur wine costs $0.11 per kWh.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O + 3kWh \qquad (1)$$

$$1kWh = \frac{2}{3}C_8H_{18} = \frac{2}{3_{mol}} \times 114_{g/mol} = 76_{g\_gas} \qquad (2)$$

$$1kWh = 76_{g\_gas} \times \frac{1_{ml}}{0.703_g} = 0.108_{l\_gas} \qquad (3)$$

$$\frac{\$0.11}{kWh} = \$1.00 \Big/_{l\_gas} \times 0.108_{l\_gas} \qquad (4)$$

The competing fossil fuel, Methane, is a cheaper method of energy production. Assuming a natural gas rate of $0.20 per cubic metre, energy can be generated at $0.02 per kWh.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 0.25kWh \qquad (5)$$

$$1kWh = 4CH_4 = 4 \times 16_g = 64_{g\_methane} \qquad (6)$$

$$1kWh = 64_{g\_methane} \times \frac{1_l}{0.716_g} = 89_l = 0.089_{m^3\_methane} \quad (7)$$

$$\frac{\$0.02}{kWh} = \$0.20 \Big/_{m^3\_methane} \times 0.089_{m^3\_methane} \quad (8)$$

By examining the combustion equations for these two energy sources we get a better understanding of our energy costs. Gasoline at $1.00 per litre is no longer a competitive form of potential energy given that citizens can access natural gas and electricity at cheaper rates. Furthermore, these estimates do not internalize the costs of generating CO_2. The build-up of carbon dioxide in the earth atmosphere and the effects on temperature are aptly summarized with the "hockey stick graph". If the production of CO_2 becomes a performance metric, methane gas is once again the victor producing 25% less CO_2 than gasoline per kWh.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O + 3kWh \quad (1)$$

$$1kWh = \frac{16}{3}CO_2 = \frac{16}{3} \times 44_g = 235_{g\_CO_2} \quad (9)$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 0.25kWh \quad (5)$$

$$1kWh = 4CO_2 = 4 \times 44_g = 176_{g\_CO_2} \quad (10)$$

In order to account for the true costs of the energy generated by combustion, a price on carbon dioxide emissions is needed. We will have to save that discussion for the future section because at the time of writing there is no set price. However, we do have estimates for high-level waste disposal. One strategy explored by the US Department of Energy would be to down blend and dispose of 34 metric tonnes of plutonium at a total sunk cost of $16 billion. [6] Though these seem like large numbers, the control of a large force is the same principle as the control of a small one: it is merely a question of dividing up the numbers. So let's communicate in units that everyone can visualize, let's talk baseball. Assuming we had a sphere of plutonium oxide with a radius of 38mm, it would cost $1,250,000.00 to dispose of that Pu-ball.

$$V = \frac{4\pi}{3}r^3 = \frac{4\pi}{3} \times (3.8_{cm})^3 = 230_{cm^3\_PuO_2} \quad (11)$$

$$M = V\rho = 230_{cm^3\_Pu} \times 11.5_{g/cm^3} = 2.65_{kg/Pu\_ball} \quad (12)$$

$$\frac{\$1,250,000}{Pu\_ball} = \frac{\$16 \times 10^9}{34,000_{kg\_Pu}} \times 2.65_{kg/Pu\_ball} \quad (13)$$

Edison said, “To invent, you need a good imagination, and a pile of junk.” If the cost to dispose of a baseball of plutonium is over a millions dollars, we can understand society’s aversion to nuclear energy. But at least there is a price for the disposal obligation of this asset; the price of carbon is still up in the air. Maybe these retired pits are a lost cause worth fighting for.

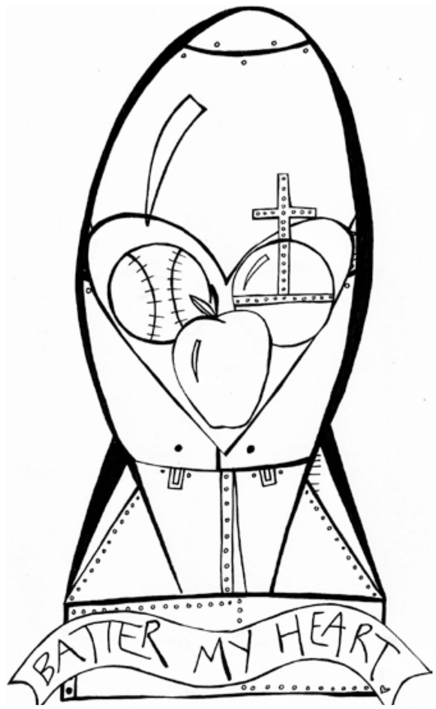

Figure 1: Celestial Orbs

THE REALITY OF TOMORROW

Technology is continuously presenting us with new frontiers. It is at these boundaries where new discoveries challenge the pre-existing conditions of the system that came before it. Free markets allow us to question and challenge the established way of doing things. It is this understanding that allows us to recognize shortcomings and seek solutions. The significance of these frontiers is that they provide the essential conditions for economic progress by encouraging competition and rewarding individual initiative. The emergence of frontiers allows for the process of continuous improvement by promoting investment, innovation, growth, and prosperity. Economic development occurs when a discovery or invention improves upon our ecosystems capacity and capabilities.

In the spirit of friendly competition, let’s create an alternative system of energy distribution. This system establishes a right to pollute market by creating carbon credits value at $25.00 a tonne. Firms that generate CO_2 must purchase credits to offset emission while the competing technologies without emissions receive a premium of an equivalent value. Gasoline is assumed to have lost its market share due to the competition from natural gas. Standardizing the carbon credit based on the energy generated yields approximately half a cent per kWh.

$$CH_4 + 2O_2 + 2H_2O + 0.25\,kWh \tag{5}$$

$$1kWh = 4CO_2 = 4 \times 44_g = 176_{g\_co_2} \tag{10}$$

$$\frac{\$0.005}{kWh} = \$25.00 \big/ 10^6{}_{g\_co_2} \times 176_{g\_co_2} \tag{14}$$

If we take a snapshot of the world's economy, the largest companies are Oil and Gas firms followed by car manufactures. Given the high costs of energy in these sectors, there is a disproportionate amount of competition. There should be greater numbers of electric vehicles available to citizens to displace the inefficient combustion engines. The International Energy Agency estimates that 80 million electric vehicles will need to be on the road by 2025 to help meet climate objectives. [7] Manufacturing electric cars is a $200,000,000.00 a year industry that has yet to materialize. The electric car is a highly disruptive technology but it is also freedom machine. It allows the person in the driver's seat the freedom to choose the source of electricity and allows the market to set a fair price.

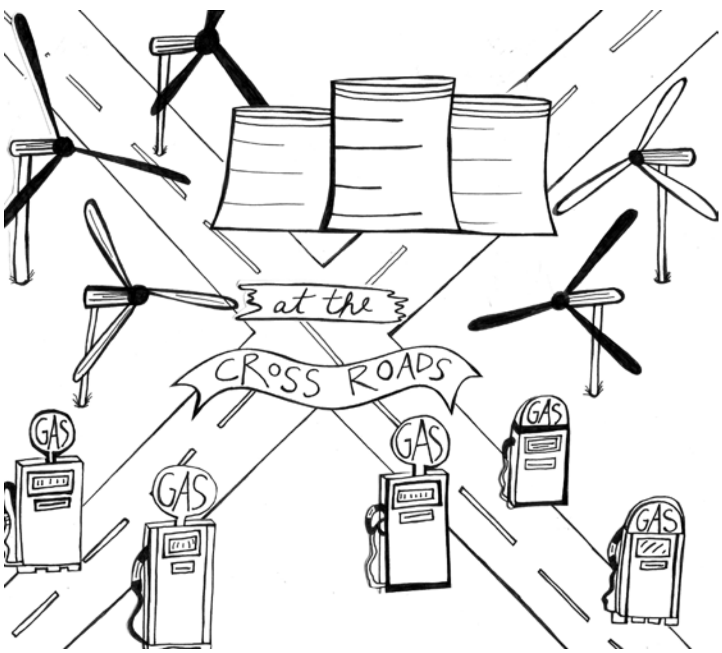

Figure 2: Operation Crossroads

If our ecosystem is comparable to a greenhouse, let's see if we can break through this glass ceiling with the help of a Pu-ball. The disposal liability attached to every Pu-ball is $1,2500,000.00. The million-dollar question is whether or not this material can be recycled to recover energy. Since this paper is a Gedanken, or thought experiment, let's pretend it can.

The reprocessing firm would accept responsibility for the stewardship of the Pu-ball in exchange for a million dollars. This is a socially responsible transaction as the public liability per unit is reduced by 25%. The recycling firm's objective is to down blend the fissile material to manufacture fuel for reactors in exchange for a small percentage of energy royalties. The assumptions are that the reactor will operate on an enrichment of 0.71%, have a burn-up of 7.5 MWD/kg, and shares \$0.005/kWh with the fuel manufacturer. Under this scenario, a recycling facility would earn \$1,335,000.00 for every Pu-ball diverted from a repository and manufactured into fuel.

$$M = \frac{2.65_{kg}}{0.0071} = 373_{kg} \tag{15}$$

$$E = {}^{7.5_{MWD}}\!\!\diagup_{kg} \times 373_{kg} = 2800_{MWD} = 67 \times 10^{6}{}_{kWh} \tag{16}$$

$$R = {}^{\$0.005}\!\!\diagup_{kWh} \times (67 \times 10^{6}{}_{kWh}) = \$335,000.00 \tag{17}$$

In this alternative energy system, we can compare the management of radioactive waste to "small ball"; it's our job to manufacture runs by getting on base safely. Assuming the average electric vehicle uses 24 kWh of energy per day, a single baseball of plutonium can fuel 7500 cars for one year. If the rate for electricity is \$0.10/kWh, the state generating the energy can distribute \$6,700,000.00 in energy revenues. By replacing combustion engines with an electric equivalent 25,000 tonnes of tailpipe emissions can be prevented.

CONCLUSION

My intention writing this paper has been to take personal responsibility for safety. I wanted to ensure that an independent "fresh look" was made on the challenges shared by society and communicate this journey openly and candidly. To ensure that implicit privilege is not present, competing energy systems were presented to promote competition where feasible. By examining these issue in the sphere of economics, I hoped that readers would be able to understand climate change and radioactive waste on a common ground.

Scientists will always hope that humanity can draw more good than evil from discoveries. This paper intended to appeal to our best hopes, not our worst fears. In the spirit of frontier ideology, competition could help solve the challenges facing society. Perhaps global warming is a universal threat that allows us to recognize our common bond and shared values. If so, then the world is at a crossroads and there is an alternate ending for this "Demon Core." [8] The ability to recycle plutonium to generate carbon free energy could prove that old habits can change, quickly, and without compromising performance. By converting these swords into ploughshares, governments have the potential to reduce the liability associated with stockpile stewardship while increasing the competition in the private sector.

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