CREATING LIKE NATURE

On Biomimetics, Energy Policy and the Sustainable Design of Renewable Energy Futures

by:

Ryan A. Church

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Ian Clarke, *Primary Advisor*

Associate Dean, Faculty of Liberal Studies

+

Greg van Alstyne, *Secondary Advisor*

Associate Professor, Faculty of Design and Director of Research, sLab

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Abstract

In this paper, I will argue that Canada has the technological resources to achieve a sustainable biomimetic distributed energy system, and that policy innovation and behavioural change is needed to spur developments toward this preferred future. By studying how nature operates and optimizes processes - biomimicry - to the systemic production, storage and distribution of energy, I will be able to look holistically at the current energy structure in Canada and use foresight techniques to assess drivers, trends and ultimately paths for sustainable change-making at the policy level. I will also investigate policy structures in other regions where distributed energy grids has been tackled with more political courage to highlight success cases and illuminate discussion. Finally, I will assess the possible futures that Canada could embark upon through the enactment of similar legislation.

Keywords: Biomimicry, Design, Environmental, Renewable, Energy, Society, Policy, Foresight, Systems.

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Finally, I would like to thank the members of my cohort for driving me to achieve ever greater heights, and to explore the potential of the creative imagination. The mind, it seams, is truly boundless.

Dedication:

To the Un-born Child, this be given…

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The significant problems we face cannot be solved
by the same level of thinking that created them.

- Albert Einstein

Creating conditions conducive to life is not optimal;
it's a rite of passage for any organism that manages to
fit in here over the long haul.

- *Janine Benyus*

Imagination will often carry us to worlds that never were.
But without it we go nowhere.

- Carl Sagan

But man is a part of nature, and his war against nature is inevitably a war against himself.

- Rachel Carson

The human brain now holds the key to our future. We have to recall the image of the planet from outer space: a single entity in which air, water, and continents are interconnected.
That is our home.

- David Suzuki

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Prologue: The Nature of Our Futures

Man has lost the ability to foresee and to forestall.
He will end by destroying the earth.

- *Albert Schweitzer*

Has there ever been a more critical time to think about the future? Put more specifically, in the age that we live in, has there ever been a more crucial conversation than this: how will we power the future? How will we live sustainably on this pale blue dot?

The race of *Homo Sapiens* has accomplished much since we walked out of the plains in central Africa 150,000 years ago. We *made* fire, discovered the wheel (until we discovered they already exist in the flagellum of ancient bacteria)[1], made and used tools (but not before chimpanzees and dolphins)[2], developed agriculture (not before *Atta* ants farmed fungus)[3], and built a few monuments to our greatness along the way. But we *did* use foresight to hunt our food - we thought about the future. In time, we even developed diverse cultures and civilizations which expanded the horizon of what it means to be *human*. This diversity of culture that demarcates us as humans and our collective human potential, which the Canadian ethnobotanist Wade Davis has termed, the 'Ethnosphere[4]*' is the hallmark of a highly successful and adaptable species. It allows us to live in every biome on earth, from the bitter cold of the high arctic to the sweltering heat of the Amazonian jungle. It is

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[1] Howard Berg. (2003). *The rotary motor of bacterial flagella*. Biochemistry, 72(1), p. 19.

[2] Michael Krützen, Janet Mann, Michael Heithaus, Richard Connor, Lars Bejder, & William Sherwin. (2005). *Cultural transmission of tool use in bottlenose dolphins*. Proceedings of the National Academy of Sciences of the United States of America, 102(25), 8939-8943.

[3] Hermógenes Fernández-Marín, Jess Zimmerman, David Nash, Jacobus Boomsma, & William Wcislo. (2009). *Reduced biological control and enhanced chemical pest management in the evolution of fungus farming in ants.* Proceedings of the Royal Society B: Biological Sciences, 276(1665), 2263-2269.

[4] Wade Davis. (2001). *Light at the Edge of the World: A Journey Through the Realm of Vanishing Cultures*. Douglas and McIntyre, p. 5.
* 'Ethnosphere' as defined by Wade Davis: The full complexity and complement of human potential as brought into being by culture and adaptation since the dawn of consciousness.

human creativity and ingenuity too, which has allowed us this feat, and it is this defining characteristic that we need now more then ever to bring about the changes necessary so we can develop the next civilization in the history of *Homo Sapiens*.

Since we walked out of Africa all those years ago, we have seen advanced civilizations come and go. In a sense, our advancement - what has allowed us to *progress* as a species, has also become our biggest downfall. None has stood the test of time. None has created the conditions conducive to life, which the celebrated author and conservationist Janine Benyus has noted is the hallmark of any species (of which we are one) that manages to fit in here over the long haul.[5] We have been, as Benyus has described and to which I will refer later, a type I system: Something that displays exponential growth rates and serves a specific opportunistic niche in the environment, that of a weed.[6] Weeds are designed to be short-term inhabiters of an environmental location - namely, bare soil. Furthering this, Benyus notes, 'type II systems are there for the longer haul …'[7] Type II systems have the ability to withstand the winter, shunting their energy reserves down into their roots, but are eventually eclipsed by type III systems. Type III species are designed to stay on the land in a state of relative equilibrium. They live in elaborate synergy with the species around them, and put their energy into optimizing these relationships.'[8] In our quest to be weed-imitators, our civilizations have grown exponentially, then crashed and burned, only to be resuscitated from the ashes to start the process over again. We have not existed in a state of equilibrium with the environment for a very long time. We have, in one sense, been circular in our approach to living out our place on this planet, but the circadian rhythm of our civilizations rising and collapsing is not sustainable and we are now taking the rest of the planet hostage with us - as I will describe shortly. We *must* do something to

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[5] Janine Benyus, "What do you mean by the term Biomimicry?" <http://www.biomimicryinstitute.org/about-us/what-do-you-mean-by-the-term-biomimicry.html> Retrieved August 1, 2014.

[6] Janine Benyus. (1997). *Biomimicry: Innovation Inspired by Nature.* Harper Collins, p. 249.

[7] Benyus, p. 250.

[8] *Ibid.*

change this. For the sake of full disclosure, I am taking the position that we *can* do something about it. It is in our DNA to care and to nurture, and we now possess the technology to live sustainably.

Jared Diamond, in his much celebrated and expansive book *Collapse: How Societies Choose to Fail or Succeed,* describes in great detail the mechanisms of declining civilizations. From the Pitcairn to the Anasazi, the Maya, the Viking and the New Guinean Highlanders, Diamond describes what can be attributed to other societies, the Ming, Roman, Byzantine and Mongol Empires, that resource extraction, disease, land degradation, and food security play a large role in all these calamities.[9] In short, their failure was this: that they failed to provide the energy required to power themselves and their civilization without detrimentally affecting the natural world that they relied on to extract this energy. There was an imbalance between natural capital and economic capital,[10] natural capital being defined as the air, water and land we all depend on. Their failure was breaking one of the oldest commandments of nature: a failure to respect the carrying capacity of the environment and a failure to integrate and co-exist peacefully with the natural world. Ironically, there are some *primitive* societies that have mastered this tenet beautifully: take the recently discovered Peruvian tribe of the Chitonawa people as example.[11] This native Peruvian tribe exists on the western edge of the Amazonian jungle and relies on ancient foraging techniques previously ascribed to our African ancestors: that of the hunter-gatherer society. This lifestyle maintains fitness and prevents population explosions and environmental degradation that can now be easily ascribed to our way of life. They, however, are slowly being swallowed whole by the outside world, whose insatiable thirst for energy is taking them hostage too - one culture cannibalizing another.

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[9] Jared Diamond. (2011). *Collapse: How Societies Choose to Fail or Succeed.* Penguin.

[10] Paul Hawken, Amory Lovins, & Hunter Lovins. (2013). *Natural capitalism: The next industrial revolution.* Routledge.

[11] Hannah Flint, "Who are the Amazons Un-contacted Indians." *The Telegraph.* http://www.telegraph.co.uk/news/worldnews/southamerica/brazil/11003006/Who-are-the-Amazons-Uncontacted-Indians.html Wed. July 31, 2014

The civilizations that I mentioned above all have their similarities, but there is one notable difference between these civilizations and our present: we, in our current state of being, are a force of nature. We have entered, as the Nobel Prize winning chemist Paul Crutzen has noted, the Anthropocean Epoch:[12] an era in the earth's history where *Homo Sapiens* are creating change on a geologic scale - flattening mountains, altering rivers and plundering the sea. The most widely known of these events is perhaps the changing of the atmosphere's chemistry. Global warming and climate change brought on by increased levels of carbon dioxide in the atmosphere is now the most pressing issue of the 21st century: it threatens not only Western civilization, but all of humanity. With the Anthropocene Epoch, we can also add the next great mass extinction to the list.[13] Through industrialization and capitalism, a destructive form of economy that has built within its architecture exponential growth, we have plundered the planets resources and brought about large-scale species collapse. As the acclaimed conservational biologist Stuart Pimm from Duke University has noted, we are on our way to the sixth mass extinction in the earth's history. Where the background rate is 0.1 extinctions per million species per year, our current rate is 100 to 1000 extinctions per million species per year: a 10,000 fold increase, and habitat loss is the biggest factor.[14] Thus follows the answer to my first provocative question: If we don't talk about the future now, we may never have that chance.

The next two questions open up a myriad of other questions, each with their own sub-questions, which is the purpose of this paper. How do we power our world and live sustainably *in situ*? Bearing in mind the apocalyptic narrative that I have described above, I feel it is important to note the following: that the people who think it is too late; that we have run out of time, should not

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[12] Paul Crutzen. (2006). *The 'anthropocene'*. Springer Berlin Heidelberg.

[13] Jared Diamond, Philip Ashmole, & Ellen Purves. (1989). *The present, past and future of human-caused extinctions* [and discussion]. Philosophical Transactions of the Royal Society of London. B, Biological Sciences, 325(1228), 469-477.

[14] Stuart Pimm, *et al.* (2014). *The biodiversity of species and their rates of extinction, distribution, and protection,* Science: 344(6187).

participate in the dialogue to shape this future. They do not have *locus standi* in the matter. Now more than ever, we need a concerted and unified thrust to find answers, offer optimistic scenarios, and believe that our creativity and foresight can be our biggest asset. If it got us off the African plains 150,000 years ago and set us on our trajectory to the present moment, then surly it can do something to help us stay here on this pale blue dot: as Carl Sagan famously said, the only home we have ever known.[15]

The question posed above gives away the answer sheepishly. We need to power our world sustainably so that we can live, full stop. Sustainability is a funny word, one that can take on many roles. Over the past few decades and beginning in the 1960s with Rachel Carson and the environmental movements of the Sierra Club,[16] the Whole Earth Catalogue[17] and others, this sentiment has been stirring to encompass a wide ranging definition. According to the Oxford English Dictionary:

> Sustainable
> Line breaks: sus¦tain|able
> /sə'steɪnəb(ə)l
> Adjective:
> 1. Conserving an ecological balance by avoiding depletion of natural resources.
> 2. Able to be upheld or defended.

However, the Brundtland Commission, whose roots go back to the United Nations in the 1980s, defines it thus: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'[18]

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[15] Carl Sagan, & Ann Druyan. (2011). *Pale blue dot: A vision of the human future in space*. Random House LLC.

[16] Sierra Club Wed site. (2014, September 14) Retrieved on September 14, 2014 from http://www.sierraclub.org/

[17] Stewart Brand. (1980). *The Next Whole Earth Catalog*. The Next Whole Earth Catalog.

[18] World Commission on Environment and Development. (1987). *Our common future* (Vol. 383). Oxford: Oxford University Press, p. 43.

My how Pimm's words ring true. From this definition, I am going to say that anything that aids this goal, the conservation of ecological balance - a balance between natural capital and economic capital - can be considered to be *sustainable*. Sustainable development then, is being defined as industrial, social or other development that achieves a balance between natural capital and economic capital and stays within the carrying capacity of the natural system it occupies. In essence, it fits within the integrated cybernetic paradigm: a new systemic paradigm that balances and fully integrates both economic and ecological factors *in proportion* to one another, and one that I will describe more fully later in the paper.

One final note about words before I get into the epistemology of this work, the breakdown of its parts and its role in the discourse of the growing environmental movement. As the environmentalist David Suzuki has noted, the root word for ecology and economy are one and the same, the Greek *ecos,* meaning household or domain.[19] Ecology is the study of our domain or the domain itself, while economy or economics is the management of that domain. Logically, economy fits within the grander ecology, yet we have been bamboozled into thinking this the other way around, or worse - we know the environment must take priority and yet we encourage degradation through our consumerist behaviour. We are always posed with the dichotomy: ecology *or* economy, when - according to the laws of nature, it should be ecology *not before* economy. By preaching its opposite from every rooftop and terrace, Capitalism is, in short, suicidal and inhuman: a call to every-man-for-himself ideology. Oxford defines it thus:

> Capitalism
> Line breaks: cap¦it¦al|ism
> /ˈkapɪt(ə)lɪz(ə)m
> Noun:
> 1. An economic and political system in which a country's trade and industry are controlled by private owners for profit, rather than by the state.

[19] Greg Kelly, (Executive Producer) (2014, June 19) The Global Eco-Crisis: Diversity, Resilience and Adaptability. *IDEAS*. Podcast Retrieved from: http://www.cbc.ca/ideas/episodes/2014/06/20/the-global-eco-crisis-diversity-resilience-and-adaptability/

It is a far cry from the other sacred institution of our modern age: democracy, which preaches the inclusion of everyone. With this paradigm shift in perspective, the answers to the questions become clear.

The world we live in - the silicon age - is a marvel. Advancements in productivity and the ease with which we go about our daily life have increased exponentially for those in Europe and the West - those at the top of the Capitalist pyramid. The internet has proven to be a unifying force for those who can afford to be plugged in; digital technology its hardware enabler for hardwired lives. It is therefore our moral imperative to return the favour and use this ability for the good of all - including the billions of poor whose labour has made the silicon age a reality - and deconstruct the Capitalist system which has thrown up a brick wall for so many: the vast majority of our species.

Greg van Alstyne has noted 'a striking pattern of coevolution between the increasingly intertwined and interdependent epistemologies of biology and computation … biology and ecology form a kind of connective tissue between computers and sustainability.'[20] 'It is therefore incumbent,' he continues, 'on digital technologies to help address the practical challenges of striving toward sustainability by enabling us to understand problems qualitatively and quantitatively and take action collectively.'[21] To be clear, there are many ways to achieve sustainability, given various population levels and behavioural modifications. In our industrial age, at population levels between our current 7 billion and the UN projections of 9.3 billion in 2050,[22] our technological abilities enable sustainable energy production. The real question that remains is, how to implement it before it is too late? That is the wicked problem.[23]

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[20] Greg van Alstyne. (2008). *How to Achieve Metabolo by Composing the Pluriverse: On the Role of Digital Media in Striving for Sustainability*, Unpublished manuscript, p. 9.

[21] Van Alstyne, p. 9.

[22] Policy Horizons Canada. (2011). *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness.* Government of Canada. Available from: www.horizons.gc.ca

[23] Horst Rittel, & Melvin Webber. (1973). *Dilemmas in a general theory of planning.* Policy sciences, 4(2), 155-169.

And that, in short, is what this paper is all about. This paper does not describe the detailed technical ways in which we can harness power from the sun, the wind and the waves. Rather, the discourse fits into the implementation sphere of energy policy, foresight, governance and economical structures that pay homage to the beauty and simplicity of the natural world: biomimicry.

> Biomimicry
> Line breaks: bi¦o¦mim¦ic¦ry
> [From the Greek *bios:* life and *mimesis:* imitation.]
> Noun:
> 1. Nature as model. A science that studies nature's models and then imitates and takes inspiration from these designs and processes to solve human problems.
> 2. Nature as measure. Use of ecological standards to judge the "rightness" of our innovations.
> 3. Nature as mentor. A way of viewing and valuing nature.

This paper is a systems-level approach to powering our future through biomimetic energy grids - a level where biomimicry works best. It is a policy approach that brings both the long view and the short view into focus. It is a guide book for policy makers at all levels to react with the sustained urgency that is required. If governance was ever thought to be stiff and boring, well now is your moment to shine, your - if you'll pardon the pun - fifteen minutes in the sun. Through the institution of democracy, policy makers have the ability to implement our sustainable future.

The paper that follows is thus.

PART 1: A Tale of Two Landscapes

I. First, I will describe the literature landscape, though not exhaustively, surrounding biomimicry, systems thinking and sustainable development and juxtapose this with the current energy industry and its policies - an inspiring tale and a cautionary tale.

PART 2: The Future that Awaits Us

II. Secondly, to boost your spirits, I will describe the technological ability of our current situation and our ability to power the future sustainably. As you will see, the key to this lies in the transition from a fossil-fuel based economy to a sustainable energy economy.

III. Thirdly, I will put forward possible future scenarios of energy landscapes that harness these capabilities. I will explain through story-boarding, what a sustainable energy economy may feel like, as informed by a signals, trends and drivers analysis.

PART 3: The Psycho-social Hurdle: On Policy and Behaviour

IV. Fourth, I will describe a series of energy policy innovations that work in concert with biomimicry and could begin today to make these futures a reality. In addition, to further bolster your spirits, I will touch on policy innovations that are already underway and describe how they could or should be modified.

V. Lastly, I will speak to what you can do to promote this change on a community level of systems thinking. The future, as it turns out, is in your hands.

Context

Despite the fact that I focus on Canada and the specific challenges that face this nation, the issues raised could just as easily pertain to the rest of the world. There are no boundaries of state that prevent the comprehension of policy and behavioural changes - specifically these that run to the core of our humanity and our interaction with nature. The problem of global warming is not bound by state lines, so the solutions to tackle it requires adoption and collaboration across jurisdictions. The need to reduce our dependence on carbon intensive energy sources is acute. Current methods of energy production involves an energy rich 'capture' point with huge transportation distances and costs to reach outlying markets. By studying how nature operates in the production and storage of energy at the systemic level,

we can emulate and use this newfound knowledge to drive policy and create future scenarios that mimic nature's process.

Methodology

My methodological approach will be to conduct a non-exhaustive literature review of current biomimetic strategies that relate to energy production, storage and usage. This, coupled with an investigation into future solutions involving cross-collaborative research between biology, computation and design will form the core of my empirical study. I will use a systems analysis to probe where the leverage points in our current energy industry are. Human factors[24] and horizon scanning - gathering research information to inform decision-making - will form the core of my analytical research. Coupling this to futures thinking and policy innovation, I will describe how these innovations could unfold in the Canadian context and show how it could be successfully implemented into the marketplace using behavioural policy measures. In this way, a systems analysis informs future scenario construction, and identifies leverage points to current proactive policy decisions and behavioural modifications. The effect of this will be to see solutions where others have not previously, and allow Canada to forge a path towards a sustainable energy future through the implementation of a biomimetic energy grid.

Outcomes

The desired effect of this investigation is to change how renewable energy is perceived and debated in the marketplace in terms of its viability. I will argue that it represents a key piece of the energy puzzle for our longterm survival. It is hoped then, that this will lead to a change in the social discourse and an increase in public pressure to promote healthier

[24] Kim Vicente. (2004). *The Human Factor: Revolutionizing the way people live with technology.* Psychology Press.

communities and a viable Canada. It is my wish that this MRP can act as a tool kit for policy implementation and a framework for how these discussions can be enacted and carried out.

Figure 3.
Earthrise
William Anders
December 24, 1968
http://www.nasa.gov/multimedia/imagegallery/image_feature_1249.html

PART 1: A Tale of Two Landscapes

The World We Inhabit Now

> The universe is not required to be in perfect harmony with human ambition.
>
> *- Carl Sagan*

In my efforts to marshal evidence for the cause and crusaders of sustainable development (as defined above) I encountered a broad and multidisciplinary chorus. This choir, as it turns out, is composed of a plethora of individuals from a multitude of backgrounds - not just the ecologists, conservationists and academics that we may be used to hearing (and tuning out lest their screech be deafening), but also those of industry, the banking sector and certain politicians. In fact, the choir is preaching so loudly now, at such a sustained pitch, that it is fair to say that we don't need more words. What we need, is the audience to act. We need action.

The literature landscape is a crowded tableau - one traceable from Rachel Carson's leap into the modern sustainability sphere, to the present. For much of this time - nearly half a century now - the environmentalists have sounded the alarm, and this alarm has fallen on the deaf ears of the industrialists, the politicians and the multinational corporations. Nowhere has this alarm been more forcefully blasted than the fossil fuel industry, whose practises of deceit and destruction have carried on now unchecked for nearly a century and a half. In the early 1960s, Rachel Carson started the modern environmental movement with her work *Silent Spring,* which noted that her era was 'dominated by industry, in which the right to make a dollar at whatever cost is seldom challenged. When the public protests,

confronted with some obvious evidence of damaging results of pesticide applications, it is fed little tranquilizing pills of half truth.'[25] Carson was, of course, targeting her assault on the chemical industry, which was poisoning the communities that it claimed to be protecting. However, her voice initiated the chorus which can still be heard today in every sector of environmentalism. In 1968, the environmental movement got its image, *Earthrise* (Fig. 3), when William Anders turned his camera around from the moon and took a picture of home. Through the early 1970s, a tidal wave of American governmental acts were passed, including the National Environmental Policy Act (NEPA), Natural Resources Defence Council (NRDC), the National Oceanographic and Atmospheric Administration (NOAA), the Clean Water Act (CWA), the Marine Mammal Protection Act (MMPA) and the Coastal Zone Management Act (CZMA), and all before the biggest shock to the *status quo*. In 1973-74, the Arab Oil Embargo hit, which forever made energy a political issue in the public consciousness and foreign policy the pawn of energy economics. It meant that the entire fate of nations depended on the leanings of a few states - namely the Soviet Union, the U.S., and the Arab oil pack including Iraq, Kuwait and Saudi Arabia - those that had versus those that didn't. Following this, the Emergency Energy Conservation Act (EECA) was introduced, but more as a stop-gap measure than anything else. At around the same time, *The Limits to Growth* came out. Five variables of world population, industrialization, pollution, food production and resource depletion were examined in computer models to 2050. Of the three scenarios forecasted, two resulted in overshoot and collapse. The other lead to a stabilized world.[26]

Sadly, these arguments were juxtaposed with those from the authoritarian domain like Milton Freedman, whose book *Capitalism and Freedom* tries to make this connection under

[25] Rachel L. Carson. (1962). *Silent Spring.* First Mariner Books, p. 13.

[26] Donella Meadows and Dennis Meadows. (1974). *The Limits to Growth.* Universe Books.

the banner of liberalism and liberty;[27] a ponderous anachronism in my view due to capitalism's erosion of social freedoms. As Adam Smith has noted: 'No society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable.'[28] The 1980s and 1990s brought much of the same, with George Bush Sr. quipping that if the *extremes* of the environmental movement proposed by Al Gore took over, 'we'd be up to our necks in owls and out of work for every American.'[29] By the mid-2000s however, the rhetoric changed. Ironically, it began with Davis Guggenheim's film featuring Al Gore: *An Inconvenient Truth,* which laid out in clear terms the damage of our fossil fuel industry and the impacts of Climate Change.[30] It did not stop there however. Fatih Birol, Chief Economist of the International Energy Agency claimed in 2008 that 'we must leave oil before it leaves us.'[31] Jeff Rubin, Chief Economist at CIBC, went one step further last year when he said that 'every recession has oil's finger prints all over it.'[32] This was followed by a damning report from the United Nations Intergovernmental Panel on Climate Change,[33] and each has gained speed from the next.

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[27] Milton Freedman. (2002). *Capitalism and Freedom: Fortieth Anniversary Edition.* University of Chicago Press, p. 5.

[28] Tony Judt. (2011). *Ill fares the land: a treatise on our present discontents.* Penguin UK, p. 2.

[29] David Remnick. (2006). *Ozone Man.* The New Yorker Magazine. http://www.newyorker.com/magazine/2006/04/24/ozone-man Accessed August 2, 2014.

[30] David Laurie, Scott Burns and Lawrence Bender (Producers) & Davis Guggenheim (Director). 2006. *An Inconvenient Truth* [Motion Picture]. Participant Media.

[31] Steve Conner. (2009, August 3). Warning: Oil supplies are running out fast. *The Independent Newspaper.* Retrieved from: http://www.independent.co.uk/news/science/warning-oil-supplies-are-running-out-fast-1766585.html

[32] Kelly, G. The End of Growth. *IDEAS*.

[33] Government Report by Thomas Stocker (Department of Climate and Environmental Physics, University of Bern) (electronic) (database) Intergovernmental Panel on Climate Change (2013) Climate Change 2013: The Physical Science Basis (Cambridge University Press) Retrieved from: http://www.ipcc.ch/report/ar5/wg1/

The major takeaway from this change in the narrative is that people from every cultural background are now singing the same tune. There is a true desire to ween ourselves off of fossil fuel and live sustainably. The most current studies from the *Pembina Institute* conclude that our energy industry is poised to reap major benefits from transferring over to renewable alternatives,[34] but the discussion must be, *how* do we do this sustainably and efficiently? When you try to tease out the action piece further - more specifically, when you try to figure out why we have not become sustainable in our economies, our energy extraction and our usage, you realize one disturbing fact: the domestic rules of the game do not favour it. As Clinton Andrews has noted: 'Domestically, the game has rules, but they are tilted to favour the status quo. Internationally, the rules of the game are sometimes undefined—think of Russia's use of natural gas as a geopolitical weapon last winter.'[35] Here, Russia stopped the flow of natural gas to Ukraine after talks broke down over debt payments - in the dead of winter. The current Ukraine crisis is a geo-political quagmire involving previously held Soviet territory and military bases, but the underlying motive is control of gas reserves that allow Russia to maintain its authority. Domestically, Andrews is referring to monopolies, which resist change to their money-making ways, despite the fact that it could save them money and the environment tremendously. In a sense, there is an internal policy of inaction. Internationally, the status quo is that those with oil and abundant forms of fossil fuel tend to be the ones who through their geopolitical weight around. They are the powerful vested interests behind the scenes that make change very difficult. In October 2005, a group of manufacturing countries including the US, China, and South Korea sought to persuade the World Trade Organization that all energy labels are a barrier to

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[34] Tim Weis, Shawn-Patrick Stensil, & Jeff Harti. (2013). *Renewable is Doable: Affordable and flexible options for Ontario's long-term energy plan.* Pembina Institute.

[35] Andrews, p. 5.

free trade and should be made illegal.[36] These are the sort of policies that place economy above ecology; linear growth above circular sustainability, and ones that have to stop. These vested interests, along with political will and manipulation of the political process, is the primary hurtle that renewable energy and distributed generation faces. These institutions and the politicians who play to their corporate donors represent an old linear way of thinking and doing business, and it must be overcome.

In stark juxtaposition, systems thinking movements such as Cradle-to-Cradle,[37] the Chordic Age,[38] the New Biology,[39] Swarm Systems,[40] Natural Capital,[41] the Natural Step (TNS),[42] the Limits to Growth,[43] the Blue Economy,[44] Upcycling,[45] the Sharing Economy[46] and Zero Emissions Research and Initiative (ZERI)[47] to name a few, have appeared over the last twenty years and propose to alter our consciousness about the interconnectedness of the

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[36] George Monbiot. (2007). Heat: How we can stop the planet burning. Penguin UK, p. 75.

[37] William McDonough, & Michael Braungart. (2010). *Cradle to cradle: Remaking the way we make things*. MacMillan.

[38] Dee Hock. (1999). *Birth of the chaordic age*. Berrett-Koehler Publishers.

[39] Robert Frenay. (2006). *Pulse: The Coming Age of Systems and Machines Inspired by Living Things*. Macmillan.

[40] Kevin Kelly. (1994). *Out of control: the new biology of machines, social systems and the economic world.* Basic Books.

[41] Hawken, Lovins, & Lovins. *Natural capitalism.*

[42] Karl-Henrik Robèrt & Ray Anderson. (2002). *The Natural Step story: Seeding a quiet revolution*. Gabriola Island: New Society Publishers.

[43] Donella Meadows, Dennis Meadows, & Jørgen Randers. (1992). *Beyond the limits: global collapse or a sustainable future.* Earthscan Publications Ltd..

[44] Gunter Pauli. (2010). *The blue economy: 10 years, 100 innovations, 100 million jobs*. Paradigm publications.

[45] Vilas Pol. (2010). Upcycling: converting waste plastics into paramagnetic, conducting, solid, pure carbon microspheres. Environmental science & technology, 44(12), 4753-4759.

[46] George Wenzel, Grete Hovelsrud-Broda, & Nobuhiro Kishigami. (Eds.). (2000). *The social economy of sharing: Resource allocation and modern hunter-gatherers* (No. 53). National Museum of Ethnology.

[47] Gunter Pauli. (1997). *Zero emissions: the ultimate goal of cleaner production*. Journal of cleaner production, 5(1), 109-113.

biosphere and our place in it. These movements represent a profound shift away from the status quo. They offer, as van Alstyne has noted, to redesign the waste streams so that there is a technosphere and a biosphere, with two closed loop systems.[48] They offer us a new prism with which to see our economy and our livelihoods - processes to shed new light on ideas that are as old as our Neanderthal descendants. Van Alstyne himself has noted that we are on the verge of a new era - the *metabolo* - one where waste equals food.[49] He continues:

> This concept and associated propositions form a critical threshold in the quest to rethink, redesign and rebuild our industries, our economies and our societies in a manner that can truly be called sustainable … Technologies play a decisive role in our ability to perceive sustainability, and they enable us to coordinate collective action at local and larger scales to implement it.[50]

The impasse between technology and sustainability is an interesting one, because it means the destructive road that we have travelled down now has the ability to undo its maker in a form of ontological excavation. The world we inhabit now is full of potential, where colliding epistemologies among previously compartmentalized domains offers new arrays to shape the future. Through a thoughtful design process where products are designed to decay (cradle to cradle) and exist within the technosphere in a portion of the blue economy, targets like ZERI become possible. Measurements of economic success that first measure the ecological impacts give a far better picture of economic strength than current models do. Gross Domestic Product (GDP), Per-Capita Income and consumer spending habits all tie Capitalism to unsustainable growth[51] and use perverse and incorrect math.[52]

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[48] Van Alstyne, *How to Achieve Metabolo,* p. 30.

[49] Van Alstyne, *How to Achieve Metabolo,* p. 8.

[50] *Ibid.,* p. 10.

[51] Greg Kelly. The End of Growth. *IDEAS*.

[52] Norman Myers & Jennifer Kent. (1998). *Perverse subsidies: tax $ s undercutting our economies and environments alike*. IISD.

In the case of Natural Capital, Paul Hawken, Amory Lovins and Hunter Lovins rework the idea of capitalism - as defined above - to place the natural world front and center. Through resource productivity, investing in natural capital and biomimicry, Hawken, Lovins and Lovins bring together a world where true sustainability, feedback mechanisms and economic indicators exists through the use of foresight - and all from the opening word: 'Imagine for a moment a world where cities have become peaceful and serene …'[53] This last piece that Hawken, Lovins and Lovins draw upon - the discipline of biomimicry - is especially poignant, as it is applicable to multiple levels and systems within our biosphere. From the movement of energy around our biosphere, to the energy-harvesting properties of the photosynthetic leaf, biomimicry aims to learn from the majesty and elegance of nature. As David Cook from *The Natural Step* says, '[Plants] are the ultimate producers of economic activity.'[54] Janine Benyus, in her pioneering work *Biomimicry: Innovation inspired by nature,*[55] describes the discipline with an immersive look at the possibilities of doing things nature's way. As Benyus explains, 'a mature ecosystem such as an old growth redwood forest is organized to 'run on information,' and to use 'rich communication channels that carry feedback to all members' in order to achieve its ecological efficiency, resilience, and staying power.[56] This dynamic feedback is possible due to the impasse between technology and sustainability mentioned earlier. We are entering an age of chaos and order - the *Chaordic Age* - one where complexity and emergence define the new science,[57] the new biology, and where highly effective cybernetic feedback mechanisms inform an organized biomimetic structure.

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[53] Hawken, Lovins, & Lovins. *Natural capitalism,* p. 1.

[54] David Cook. (2004). *The Natural Step: towards a sustainable society* (No. 11). Green Books.

[55] Benyus. *Biomimicry,* p. 274.

[56] *Ibid.*

[57] Van Alstyne, p. 48.

The world we inhabit now possesses a myriad of intellectual tools to shift away from the status quo and inspire the choir to action. Next, I will investigate the technological tools that lie at the impasse between ecology and economy and act to frame the discourse to a positivist narrative. In doing so, I seek to uncover the abilities that will inform my policy discussion later in the paper and produce future scenarios that are rooted in the possible.

Figure 4.
Edward Burtynsky
Oil Fields #2
Belridge, California, USA, 2003
http://www.edwardburtynsky.com/site_contents/Photographs/Oil.html

PART 2: The Future that Awaits Us

Hydrocity: Powering the Futures

We're in a giant car heading towards a brick wall
and everyone's arguing over where they're going to sit.

- David Suzuki

In part 1 of this paper, I outlined the tenants of biomimicry, systems thinking and sustainable development, and described the choir that sustains the sustainability movement in our present day. As you can see, it is a widely diverse group - a bevy of individuals with a clear and sustaining message: we need new ways to power our world that does not damage the environment.

> The oil sands are an island, thousands of miles away from the markets. And you need a pipeline to get to those markets … The oil under the arctic ocean, for example, is the bottom of the barrel. It's not just the bottom of the barrel in economic terms. It's also the bottom of the barrel in terms of [its] environmental footprint.'[58]

This provocative statement comes from Jeff Rubin. It describes the sentiment from the other side of the chorus - that we must change our ways, and fast. Every year, the U.S. economy loses between US$80 billion and $188 billion each year from power failures and disruptions.[59,60] While there is no direct data on Canadian losses, we can estimate this number to be 1/10th the amount: $8 billion to $18.8 billion, based on population and GDP. Electricity must be produced on the moment of demand, and if supplies falter, so does the grid. But can we produce electricity sustainably and more reliably then we currently do? In other words, can we transition from a fossil-fuel based economy to

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[58] Greg Kelly. The End of Growth. *IDEAS*.

[59] Kristina Hamachi LaCommare & Joseph Eto. (2006). *Cost of power interruptions to electricity consumers in the United States (US).* Energy, 31(12), 1845-1855.

[60] Massoud Amin. (2013). *The Smart-grid Solution.* Nature: 499, 145-147 (p. 145).

a sustainable energy economy? In part 2, I hope to answer these questions by laying bare our technological abilities while showing that democracy must win out over capitalism if we are to have a sustainable future. As I stated above, a paradigm shift in focus is required, one that places ecology before economy. Then and only then do the answers become clear.

First, I will begin by explaining what is needed - what power generation demands are required for the next 36 years - to 2050 - assuming no behavioural changes. To do this, I will need to impart some foresight before the next section, which deals exclusively with the subject. I will follow this with a systems level analysis of conceptualizing our energy grid through a biomimetic lens, and look at alternatives in energy distribution that take on a biological flavour. This distribution analysis will be followed by an examination of storage techniques and production strategies that work within the grid architecture described. I will also define the Technology Readiness Level (TRL) scale as a method for assessing our current technology and determine its readiness for commercialization. Finally, I will explore the medium; the energy currency, that makes this possible and the new economy that encompasses it. In the immortal words of Marshall McLuhan, the medium really is the message.[61]

Powering the Futures

The current global population sits at 7 billion people. By 2050, the U.N. predicts this number to grow to between 9.1 and 9.3 billion people. In Canada however, our population will shrink due to low fertility and a large baby-boomer generation over the age of 80, not counting immigration.[62] Global populations will also flock to the cities, growing from 50% today to 70% in 2050.[63] The

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[61] Marshall McLuhan, & Quentin Fiore. (1967). *The medium is the message.* New York, 123, 126-128.

[62] Policy Horizons Canada. (2011). *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness.* Government of Canada. Available from: www.horizons.gc.ca

[63] Non-governmental Organization Press Release. (2011). *World Populations to Reach 10 billion by 2100 if Fertility in all Countries Converges to Replacement Levels.* United Nations, embargoed until 3, May, 2011.

Canadian Electrical Association (CEA) predicts that our demand will rise from 618 TWh to 1 PWh - or 1,000,000,000,000,000 (one quadrillion) watt hours by 2050.[64] Yes - that is correct. By 2050, we will have to produce one quadrillion watt hours of energy every year, mostly because our GDP is expected to rise. While this is not science fiction, we will need to look to the future to figure out how to produce all that power. Currently, 64% of our power is renewable (61% hydroelectric and 3% wind, solar and biomass),[65] which means that 395 TWh currently comes from renewable sources. This leaves approximately 600 TWh of extra production to be achieved by mid-century. Currently, 3750 wind turbines are producing 12 TWh of electricity per year, a number which has grown thirty-fold over the last decade.[66] Even if the pace of wind installation is reduced to five-fold per decade at current efficiency rates, Canada could produce 1.5 times its energy needs (1.5 PWh) on wind power alone by mid century.

Al Gore has noted that the market for environmental goods and services is approximately $300 billion, and is expected to grow to $400 to 500 billion by the beginning of the next century. If one includes recent estimates for investments in energy infrastructure in developing countries, this figure grows to more than $1 trillion by the end of the decade.[67] Further to this, if the United States shifts to renewables and eliminates oil, coal and nuclear by 2050, Amory Lovins of Rocky Mountain Institute (RMI) has predicted $5 trillion in savings and a 158% bigger economy.[68] Using the same math as above, that equates to some $500 billion in savings for Canada - a number right in the

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[64] John Haffner & Willem Vriesendorp. (2014). *Vision 2050: The Future of Canada's Electricity System.* Canadian Electricity Association. This figure has population growth at less than 1% a year and pegs GDP to rise by 2.3% per year, despite the fact that economists such as Jeff Rubin say that we should expect negative growth. See: Greg Kelly. The End of Growth.

[65] Energy and Mines Ministers Conference. 2013. *Canada: A Global Leader in Renewable Energy.* Retrieved on November 14, 2014 from: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/www/pdf/publications/emmc/renewable_energy_e.pdf, p. 4.

[66] Energy and Mines Ministers Conference. 2013. *Canada: A Global Leader in Renewable Energy,* p. 6.

[67] Benyus. *Biomimicry*, p. 247.

[68] Amory Lovins. (2011). *Reinventing fire.* Chelsea Green Publishing, White River Jct., Vermont, p. 52.

middle of the predictions I made earlier for the cost for power failures alone.[69] Of course, these figures of capitalist convention do not consider the natural capital saved, which a paper published in *Nature* placed between 16-54 trillion per year.[70] In another convention, these services are priceless, as they make up our home and allow for our existence. Even so, by monetary standards, there is every reason to move to action.

When we look at the Canadian context, and more specifically the bitumen sands in Alberta, we see a big obstacle to action. They are the 2nd largest deposit of proven oil reserves in the world,[71] so they will be hard to turn a blind eye to. However, they also require twice the energy input to recover them as compared with conventional production.[72] Jeff Rubin's bottom of the barrel analogy comes springing to mind. We need to reconstitute our idea of what a megaproject is. In order to meet our behaviourally-absent 1 quadrillion watt requirement, we will need to radically shift our lens on the world. As Gordon Laird states: 'most new megaprojects are designed around the 20th century model of affordable and abundant fossil fuel supplies.'[73] Figure 1 shows the distribution network of the fossil fuel model: highly concentrated production and highly concentrated distribution. That, however, is not our future. We must metaphorically walk out of the plains of Africa again, to rediscover our world. For that, we shall start with how we distribute our energy.

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[69] While 1/10th of $5 trillion is $500 billion in cumulative savings by 2050, that figures also lies between the figures given for power failure aversions alone shown above. ($8 billion x 36 years = $288 billion in savings. $18 billion x 36 years = $647 billion in savings.)

[70] Robert Costanza *et al.* (1997). The value of the world's ecosystem services and natural capital. *Nature:* 387: 253-260 (p. 253).

[71] Len Bolger & Eddy Isaacs. (2005). *Shaping an Integrated Energy Future.* In Andrew Heintzman, & Evan Solomon, (Eds.). *Fueling the Future: How the Battle over Energy is Changing Everything* (pp. 56-81). House of Anansi, p. 63.

[72] Gordon Laird. (2005). *At the Frontier of Energy.* In Andrew Heintzman, & Evan Solomon, (Eds.). *Fueling the Future: How the Battle over Energy is Changing Everything* (pp. 28-53). House of Anansi, p. 33.

[73] Laird. *At the Frontier of Energy,* p. 35.

Figure 5.
The Great Energy Challenge
National Geographic: International Mapping
http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/keystone-xl-pipeline-route-map/

The Biomimetic Basis for Distributed Power Generation: Designing for Emergence

> We must draw our standards from the natural world.
> We must honour with the humility of the wise the bounds of that natural world
> and the mystery which lies beyond them, admitting that there is
> something in the order of being which evidently exceeds all our competence.
> *- Václav Havel, president of the Czech Republic*

When we walked out of the African plains 150,000 years ago, one fact would have been blatantly noticeable to our ancestors: we gathered our energy where we were; we did it *in situ*. When we needed wood for our fire, we did not go back to the Rift Valley to get it. Of course, being nomadic hunter gatherers, the situation was different - but the point is still the same. Biological organisms generate, harness, distribute and utilize its energy where it is. By doing this, biological organisms do not waste energy by obtaining or transporting energy over great distances - the world is solar powered, and that energy is harnessed *in situ*.

At a more fundamental level, we can examine one of nature's great tenets. The cell, the basic building block of life, ceaselessly metabolizes: 'through chemical and energy flow[s], life continuously produces, repairs and perpetuates itself,'[74] through autopoietic, self-generating networks. As physicist and systems thinker Fritjof Capra has noted, 'living systems are organizationally closed - they are autopoietic networks - but materially and energetically open.'[75] By this, he is referring to the fact that nature has rules about the interactions of molecules within confined spaces. Biologist Ludwig von Bertalanffy similar noticed as early as the 1950s that systems open to flows of energy can maintain a dynamic order far from equilibrium, since the second law of thermodynamics which predicts decay towards equilibrium only occurs in energetically closed

[74] Lynn Margulis. (1998). *Symbiotic Plant*. Basic Books, New York, p. 63.

[75] Fritjof Capra. (2004). *The hidden connections: A science for sustainable living*. Random House LLC, p. 13.

systems.[76] In living organisms, energy and matter are absorbed and exchanged with the outside world, while the elements that interact with them are confined. Capra goes on to explain:

> 'Th[e] spontaneous emergence of order at critical points of instability is one of the most important concepts of the new understanding of life. It is technically known as self-organization and is often referred to simply as *emergence*. It has been recognized as the dynamic origin of development, learning and evolution. In other words, creativity - the generation of new forms - is a key property of all living systems. And since emergence is an integral part of the dynamics of open systems, we reach the important conclusion that open systems develop and evolve. Life constantly reaches out into novelty.'[77]

And there's that word again: creativity. It is so intertwined with the physics of nature, and it is also the capacity that can set us on a new course. We, just as our energy systems, need to foster emergence.

Market Readiness versus Technological Readiness

When innovations come about in the marketplace, it is because the technology is feasible for commercialization and because, in the case of consumer products, the public is ready to adopt them. Here, I define technology as Everett Rogers does: 'A design for instrumental action that reduces the uncertainty in the cause-effect relationship involved in achieving a desired outcome.'[78] In my previous section, I made the case that the market for technology that allows for distributed generation and renewable energy production is ready, that the choir is calling. What is needed next, is to determine our current technological abilities in a standardized way. The method suitable for this, and the one already in use by Public Works and Government Services Canada, is the Technology Readiness Level (TRL) threshold, available in appendix B.

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[76] Ludwig von Bertalanffy. (1950). *The Theory of Open Systems in Physics and Biology.* Science, Vol. 111: 23-29.

[77] Capra. *The hidden connections*, p. 14.

[78] Everett Rogers. (2010). *Diffusion of innovations.* Simon and Schuster, p. 12.

This brings me to our first technological ability: distributed power generation. The principal idea behind this is multiple generation units spread out across a city, a community, a country, and all connected by some dynamic grid responding to feedback mechanisms, changes in input and output flows. Similarly to a cell, it would openly take in and expel energy through organizationally closed autopoietic networks that function much like the human autonomic nervous system - the Internet standing in for nerve fibres, the *Internet of things* (IoT)[79] for the multidisciplinary dexterity of our hands. As Bob Metcalfe has noted, 'the Internet can increasingly be used to reduce energy consumption by massively substituting communication for transportation … Second, starting with today's base of a billion users and Google, the Internet is becoming an unprecedented medium for collective intelligence … And third, the people, processes, and institutions that built the Internet will themselves help bring the world cheap and clean energy.'[80] This is what I mean when I say that the technological institutions that lead us down this path of folly are also our greatest asset. The internet allows for sustainability. It is so well suited for it, that you might think Tim Berners-Lee designed it with that in mind.[81] Benyus notes it this way: 'The more pathways we have for feeding off each other in the industrial ecosystem, the more loops will be closed and the less waste will be lost from the system.'[82] The internet is the ultimate loop-closer. However, using the analogy above, there is no substitute for the human brain. We will have to use our creativity and awareness to allow the internet to achieve its potential despite its TRL score of 9.

Currently, only 52% of the capital cost of electricity is incurred by generation: the rest pays for carriage and distribution.[83] Energetically, distributed generation results in far less waste - as

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[79] Sixty companies including Microsoft, IBM, GE, Intel, AT&T and Cisco have joined forces in the Industrial Internet Consortium (IIC) to tackle the upcoming trend of the Internet of Things.

[80] Van Alstyne, p. 44.

[81] Tim Berners-Lee, Robert Cailliau, Jean-François Groff, & Bernd Pollermann. (1992). *World-Wide Web: the information universe.* Internet Research, 2(1), 52-58.

[82] Benyus. *Biomimicry,* p. 259.

[83] Monbiot. *Heat,* p. 140.

energy transportation distances are cut drastically. Amory Lovins describes this beautifully with this little analogy: 'we don't crowd all the dairy cows into one state and ship milk from there. Milk is perishable, so decentralized facility makes sense. Electricity is perishable in its own way … The most sensible place for [decentralization of production facilities] to occur would be in energy production.'[84] The U.S. Energy Information Administration states that 6% of electricity is lost in transmission each year.[85] In addition to this, decentralization also increases energy security: one downed power line does not constitute thousands being cut from the grid, like in the 2003 blackout on the East Coast of North America. Conceptually, one can conceive of intertwined autonomic systems of human desirability and energy throughputs.[86] As an example: if you think it feels cold in a room, the room would respond by heating itself. Since thought is simply electrical transmission through synaptic clefs, this future remains completely within the realm of plausibility.

George Monbiot, in his book *Heat: How to Stop the Planet from Burning,* would like to see a power station in every home: hundreds of micro generators would form local distribution webs.[87] These would all be connected in the smart grids of the future. A smart grid is, by definition, 'a series of independent small power systems, or *micro-grids,* linked by a stronger, smarter high-voltage power-grid backbone.[88] As Massoud Amin, professor of electrical and computer engineering at the University of Minnesota explains, 'smart grids can measure when consumers use most power, allowing utility providers to charge variable rates according to supply and demand.'[89] This exposes an interesting policy angle which I will explore later. Just as trees grew almost everywhere our nomadic

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[84] *Ibid.* p. 269.

[85] U.S. Energy Information Administration Web site. (2014, May 7). Retrieved October 11, 2014 from: http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3

[86] Annabel Rixen. (2010). *Smart Grids, Smart Consumers? The Internet Generation's Cognitive Evolution and its "Technological Rapture" through Autonomic Technology.* Unpublished manuscript.

[87] Monbiot. *Heat,* p. 124.

[88] Amin. *The Smart-grid Solution,* p. 146.

[89] *Ibid.* p. 146.

ancestors travelled, energy production centres would be located everywhere, its connective wires being analogous to the soil that binds all trees together. Further to this, we can think of power grids equipped with self-healing properties, not unlike the blood vessels in our body. Not surprisingly, the lead users in this area of research is the U.S. military aviation sector, with work on damage-adaptive flight systems.[90] The U.S. military similarly devised Advanced Research Projects Agency Network (ARPANET) and the TCP/IP protocols, which was the forerunner for the internet. With these advances and this track-record, the U.S. military poses itself to lead innovation in this sector.

Having explained the *smarter* portion of the definition above, let me move on to the *high-voltage* piece. There are two forms or flavours of electricity. High voltage alternating current flows through the grey transmission towers that give away their purpose sheepishly: they transport electricity from place to place. Low voltage direct current is what you use in your house everyday. In North America, is it 120 volts, while in Europe it is 220 volts. The crux is that you lose electricity every time you step up to high voltage and step down to low usable voltage, and our current grid is based on a uni-directional fossil fuel model of flow from production site to consumer. So the question arrises: how do you connect a widely distributed system that has energy flowing in multiple directions while maintaining minimal electrical loss? You do it through two new technologies: High Voltage Direct Current (HVDC) cables and a Flexible Alternative Current Transmission System (FACTS).

HVDC cables cost more to install, but they save the farther they are installed. The key though, is that they *do not* lose power over distance. In addition, their TRL score is a 9, with more than 200 successful installations worldwide and a evolutionary history that goes back to 1882 in

[90] *Ibid.*

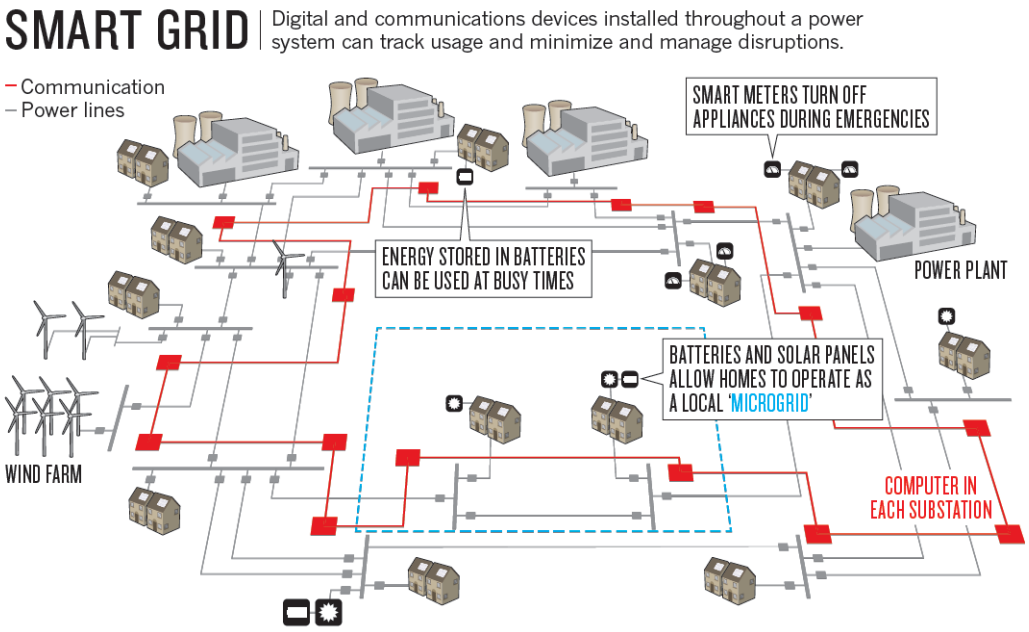

Figure 6.
Smart Grid.
Massoud Amin. (2013). Nature: 499, 145-147 (p. 146).

Germany.[91] This, as George Monbiot puts it bluntly, has the ability 'to change the world.'[92] Now, you can conceivably connect large wind farms in the North Sea - or the middle of the Atlantic - with no energy loss to its destination. As Monbiot continues: because 'wind speeds rise by around one meter per second with every 100 kilometres from shore … the cost of renewable power could actually fall with distance from the coast.'[93] Currently, Canada's two largest installations are the Nelson River Bipole 1 between Gillam and Rosser Manitoba at 1835km and the Quebec-New England Transmission between Radisson Quebec and Ayer Massachusetts at 1105km. The other breakthrough is FACTS, which 'can give measured quantities of power to specified areas of the

[91] Massimo Guarnieri. (2013). *The Alternating Evolution of DC Power Transmission [Historical]*. Industrial Electronics Magazine, IEEE, 7(3), 60-63.

[92] Monbiot. *Heat,* p. 104.

[93] *Ibid.* p. 105.

grid.' [94] Currently, FACTS has a TRL score of 7.[95] Given time, I believe that HVDC will obtain the qualities of FACTS and enable the smart grid to achieve its full potential. Allowing specific quantities of power to go to specific places at specific times is crucial to allowing real-time pricing initiatives and policies to take effect, something I will touch on later. This allows for power to obtain a *true cost,* since peak power is much more expensive to produce.[96] The Internet of Things (IoT), a series of devices connected via the internet, will truly be enabled when appliances and electronic gadgets become *smart,* and have the ability to turn themselves on and off due to feedbacks from the grid. This will be the beginning of emergence and a close analogy to autonomic feedback loops seen in the human body.

When the smarter and high-voltage pieces come together, here is what it looks like. From figure 6, you can see smart meters representing the hardware side of the IoT, while the *micro-grid* can be represented as an entity as small as your house. Smart meters like *Nest* and *Birdi* have excelled in the marketplace, and the technology behind them is a 9 on the TRL score. Wind farms, solar farms (which are between an 8-9 on the TRL score) and other remote concentrated energy harvesting locations are connected to the grid through HVDC cables where they then travel through FACTS to your house. The dynamic dance between production and consumption is controlled through computer substations that similarly cover for each other if a server goes down. The system that operates at a jurisdictional level similarly runs towns, cities, provinces and eventually the country. The true end goal is that the whole world is connected in this fashion, imitating the unilateral model of the European Union - a Global Energy Union. Peter Palensky and Friedrich Kupzog from the Austrian Institute of Technology have noted that, 'energy systems that consist of many very

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[94] Jeremy Rifkin. (2005). *The Dawn of the Hydrogen Economy.* In Andrew Heintzman, & Evan Solomon, (Eds.). *Fueling the Future: How the Battle over Energy is Changing Everything* (pp. 84-103). House of Anansi, p. 92.

[95] Dorman Wensky, *et al.* (2006). *FACTS and HVDC for grid connection of large offshore wind farms.* In European Wind Energy Conference EWEC.

[96] See. Regen Energy to see what energy management technique are available to off-set peak power costs. http://www.regenenergy.com/

different and autonomous components tend to get complex.[97] However, it is this complexity that allows for the desired biomimetic properties. Through complexity, redundancy is built in, modularity is championed, global tensions are reduced[98] and emergence flourishes through external feedback mechanisms. The system is *alive*.

Storage and Production

The batteries mentioned in figure 1 compensate for varying flow, voltage or frequency by providing or absorbing energy.[99] These can take the form of lithium ion batteries, which are already making their presence known in electric vehicles. This technology allows for Vehicle to Grid (V2G) capabilities,[100] enabling your car to be a mobile power station. At present, this technology is between a 7-8 on the TRL scale. Your car can power your house, and *visa versa.* Imagine for a moment that parking stalls also doubled as charging stations - you do your shopping, and upon your return your vehicle has been charged. On a larger scale, these batteries will more reasonably take the form of liquid metal batteries currently being pioneered by Donald Sadoway, a materials engineer at the Massachusetts Institute of Technology (MIT).[101] This is a grid-scale battery that can handle the load requirements posed by the smart-grid, and the charging and recharging losses that make it reasonable and affordable. Based on information from the group's website, they are at a 4-5 on the TRL scale.[102] To produce the energy for these batteries, we will rely on a wide variety of sources,

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[97] Peter Palensky, & Friedrich Kupzog. (2013). *Smart Grids*. The Annual Review of Environment and Resources, 38:201–26 (p. 220).

[98] Rifkin. *The Dawn of the Hydrogen Economy,* p. 87.

[99] Amin, p. 146.

[100] Jeffery Ballard. (2005). *Hydricity: The Universal Currency.* In Andrew Heintzman, & Evan Solomon, (Eds.). *Fueling the Future: How the Battle over Energy is Changing Everything* (pp. 106-125). House of Anansi, p. 105.

[101] Donald Sadoway. (2012, March). The Missing Link to Renewable Energy [Video File]. Retrieved from: http://www.ted.com/talks/donald_sadoway_the_missing_link_to_renewable_energy

[102] Group Sadoway. 2014. *Group Sadoway: Extreme Electrochemistry.* Retrieved November 14, 2014 from: http://sadoway.mit.edu/research/liquid-metal-batteries

casting our net as far as possible. Wind turbines are getting bigger and more efficient every year (the latest from Alstom are 6 MW each),[103] while their price, along with solar photovoltaics, are plummeting: since 2010, prices have been cut in half.[104]

Turning to wind power for a moment, I feel it is important to de-bunk a commonly held belief. It has been stated that wind power is not useful in large scale deployments because it is unreliable - "the wind doesn't blow all the time" - humanity desires large quantities of power instantly. When you understand distributed generation, one fact become plain: the wind is always blowing somewhere. Especially when you take into consideration the technological capabilities of HVDC cables, we will be able to harness wind power effectively. George Monbiot puts it this way: 'Wind forecasting does not matter on a daily level, so much as on an hourly level. Fluctuations in wind matter insignificantly when you take the whole wind grid into account; it is always blowing somewhere.'[105] Further to this, he states that 'between 1970 and 2003, there was not an hour, let alone a week, with no wind across the UK.'[106] With distributed generation, wind power makes a lot of sense.

There is however, a third *battery* of sorts that promises to truly liberate the energy markets and eliminate the perceived problem of insecure renewable generation: hydrogen. Hydrogen production through renewably powered electrolysis in the home would turn Canada's households into their own *micro-grid* in every sense of the word. Hydrogen not only promises to be the wonder element that makes renewable storage feasible and powers our futures, it also promises to be the new currency; the foundation of the new economy and the next industrial age: Hydricity.

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[103] *Alstrom* Web site. (2014). Retrieved August 23, 2014, from http://www.alstom.com/power/renewables/wind/offshore-wind-turbines/ See: Alstom's new Haliade wind turbine.

[104] Lovins. *Reinventing fire,* p. 44.

[105] Monbiot. *Heat,* p. 110.

[106] *Ibid.* p. 113.

Hydricity: Hydrogen and the New Currencies

'What is this inflammable air?'
-*Henry Cavendish*, on discovering hydrogen, *On Factitious Airs*, 1766.

Hydrogen may have been discovered 250 years ago, but it is just coming into its own as a fuel of choice. The proposition of its place in distributed power is part battery, part feed stock and part currency.[107] As a battery, hydrogen can be produced and used just as electricity is in its liquid metal or lithium ion housing. Hydrogen can also be used to produce electricity, thus being a feed stock, through commonly known fuel-cell technology, where innovations are happening all the time. A landmark discovery was just made and published in *Nature*[108] claiming to produce hydrogen from inexpensive nickel and lead - through the use of an AAA 1.5 volt battery. Never before has hydrogen been produced so cheaply, a strong signal that the future of this technology looks bright. Their are however still challenges to overcome, such as the cost-effective storage of hydrogen and the production of household electrolysis units that are economically viable. These two factors currently sit at a TRL level of 3[109] and 4[110] respectively. The production of hydrogen in the home allows for combined heat and power, but the storage problem still must be solved. Combined heat and power though, has a major upside. It's a process where *waste* heat is generated through the production of hydrogen and goes to heating your home, so no need for a furnace. Monbiot places this heat at 70% of the energy used,[111] which represents a major efficiency gain. The ultimate feedstock of hydrogen however is water, which means that the wars of the future may indeed be

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[107] Ballard. *Hydricity: The Universal Currency,* p. 111.

[108] Ming Gong *et. al.* (2014). *Nanoscale nickel oxide/nickel heterostructures for active hydrogen evolution electrocatalysis.* Nature Communications 4:4695.

[109] Luis Gandía, Gerutze Arzamendi & Pedro Diéguez. (2013). *Renewable hydrogen energy: an overview. Renewable hydrogen technologies. production, purification, storage, applications and safety,* Elsevier, Oxford (UK), 1-17.

[110] Siemens. (2001). *Second Wind for Hydrogen.* Retrieved November 14, 2014 from: http://www.siemens.com/innovation/apps/pof_microsite/_pof-spring-2011/_html_en/electrolysis.html

[111] Monbiot. *Heat,* p. 137.

water wars. This fact should alert Canadian politicians especially, and cause them to proactively shore up our water here at home - 7% of the world's renewable water supply.[112]

Further to this, there is also an economic stimulus to distributed hydrogen production. This is the currency piece, where production at low peak power times (7.5 cents per kilowatt-hour currently in Ontario) and distribution at high peak power times (13.5 cents per kilowatt-hour currently in Ontario)[113] can lead to a healthy profit margin.[114] Hydrogen also lends itself well because it can be produced through any energy source - meaning that it can help us transition to a circular / biomimetic economy via natural gas based production.[115] This elasticity makes it an easy choice for industry, politicians and policy-makers to strive for, since the technological infrastructure of today can support it - something I will return to later. David Sandborn Scott, one of Canada's foremost experts on the Hydrogen systems, calls for both hydrogen *and* electricity currencies,[116] since they will be seamlessly interchangeable in the smart grids of the future - and thus the term hydricity. Throughout the work, I sill also subscribe to the term *hydrogen age* as David Sandborn Scott has, in leu of the hydrogen economy because our economies will always be made up of many facets. The hydrogen age describes a time when 'hydrogen systems will have visibly and sharply reshaped the delivery of energy services.'[117]

Lastly, the safety of hydrogen must be assured if it is to be accepted as the staple energy currency with electricity. The Hindenburg effect describes people's fear with hydrogen, the images

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[112] Environment Canada Web site. (2014, February 10) Retrieved August 24, 2014 from https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=2DE7B40F-1

[113] Ontario Energy Board web site. (2014, April 29). Retrieved (2014, September 21) from http://www.ontarioenergyboard.ca/OEB/Consumers/Electricity/Electricity+Prices

[114] Ballard, p. 113.

[115] *Ibid.* p. 114.

[116] David Sandborn Scott. (2008). *Smelling land: the hydrogen defence against climate catastrophe.* Queen's Printer Publishing, p. 6.

[117] Scott. (2008). *Smelling land: the hydrogen defence against climate catastrophe,* p. 11.

of the fiery calamity that occurred on May 6, 1937 is the first thing many people think of when it comes to hydrogen. Hydrogen technology however, has come along way since 1937. Storage and sensor technology has progressed,[118] as has those of other flammable gasses such as propane. Storage in pressurized and cryogenic tanks,[119] or as solid metal hydride,[120] offer promising solutions. Ultimately, while there is no reason why hydrogen is any less safe than methane or propane, care must be taken in the public eye to ensure safety.

Biomimetic Economy as a True Democracy

Having explained the major parts of this energy grid of the future - from production and storage to transportation, let me take a moment to discuss the economy that it nestles in. A true democracy gives an equal voice to all members that reside within its bounds. Liberation of the energy markets, giving control to the very many from the very few equalizes the discourse of politics like no other revolution before it. As Jeff Rubin has noted: the dismantling of energy monopolies and the redistribution of wealth to a more *steady-state* or *homeostatic equilibrium* will limit the economic calamities and stock market crashes that have epitomized our capitalist hegemony. Liberating the world's poor to produce their own energy and redistribute the wealth that flows from such activities will impact a number of the major global crisis that face our planet. As Fritjof Capra has noted:

> 'When we look at the state of the world today, it is clear that the major problems of our time - energy, the environment, climate change, food security, and financial security - cannot be understood in isolation. They are systematic

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[118] William Buttner, *et al.* (2011). *An overview of hydrogen safety sensors and requirements*. International Journal of Hydrogen Energy, 36(3), 2462-2470.

[119] Ming Gao & Ravi Krishnamurthy. (2008). *Hydrogen Transmission in Pipelines and Storage in Pressurized and Cryogenic Tanks*. In Ram Gupta, (Ed.). *Hydrogen fuel: production, transport, and storage*. (pp. 341-365) CRC Press, p. 344.

[120] Billur Sakintuna, Farida Lamari-Darkrim, & Michael Hirscher. (2007). *Metal hydride materials for solid hydrogen storage: a review*. International Journal of Hydrogen Energy, 32(9), 1121-1140.

> problems, which means that they are all interconnected and interdependent; they require systemic thinking to be solved.'[121]

Thus, this systemic thinking also extends to what I have termed, the Biomimetic Economy - a form of circular economy that runs on the principals of nature, has the same components of modularity, redundancy and emergence at its heart, and aims to incorporate a number of the systems thinking movements mentioned above: Cradle-to-Cradle, the Chordic Age, the New Biology, Swarm Systems, Natural Capital, the Natural Step (TNS), the Limits to Growth, the Blue Economy, Upcycling, the Sharing Economy and Zero Emissions Research and Initiative (ZERI). Thought leaders such as Stewart Brand[122] and Peter Schwartz[123] at the Global Business Network have been urging the choir to act in this direction for years now - and it's time we did. Others like the environmental scientist Bradon Allenby have been warning us of our ways: 'Economies are like Ecosystems [in that] both systems take in energy and materials and transform them into products. The problem is that our economy performs a linear transformation, whereas nature's is cyclic,'[124] thus the need for a circular and biomimetic economy.

Systematizing Systems for Use: Integrated Cybernetics

Soft Systems Methodology of the second generation preaches the idea of system boundaries as malleable.[125] This means that the boundaries we place on our systems are self-induced, but also that

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[121] Fritjof Capra. (2013). *Learning from Leonardo: Decoding the Notebooks of a Genius*. Berrett-Koehler Publishers, p. 12-13.

[122] Stewart Brand. (1999). *Clock of the Long Now: Time and Responsibility.* Basic Books.

[123] Peter Schwartz. (1996). *The art of the long view: paths to strategic insight for yourself and your company.* Random House LLC.

[124] Benyus. *Biomimicry,* p. 242.

[125] Peter Checkland. (1999). *Systems thinking, systems practice: includes a 30-year retrospective.*

real change occurs at the fringes - a positive for the billions of poor around the world.[126] Since systems are occurring in flux simultaneously, we can only get a snapshot of what was; a glimpse into the past. Thus, systems thinking and foresight are perfect compliments that provide the widest angle to examine complex problems while keeping in mind the idea of the *holon.* As Alex Ryan explains, a *holon* describes the fact that systems are both a part and a whole.[127] This duality is useful in that it allows for a system to be examined on many levels, since a system is related to a hierarchical multiple of systems with carrying scopes of emergence.

Level of Analysis	Example of Emergent Properties
...	...
Biosphere	Planetary homeostasis
Ecosystem	Nutrient cycle
Community	Food webs
Population	Speciation
Organism	Consciousness
Organ system	Blood circulation
Organ	Fibrillation
Tissue	Glandular secretion
Cell	Life
Organelle	Flagellum locomotion
Molecule	Chemical reactions
Atom	Valence
Quark	

Figure 7.
An Emergence Hierarchy for Living Systems on Earth.
Alex Ryan. (2012). *Thinking in Systems,* p. 7

The literature on natural systems is well known. Given my previous mention of the economy fitting within the grander ecology, it seems only natural that man-made systems should fit within natural

[126] Due to necessity, the poor have often been drivers of change and lead users. Innovations that occur in the developed world can also be translated to these 'fringes', where they are often re-purposed in inventive ways. The saying that 'necessity is the mother of all innovation' can be applied here.

[127] Alex Ryan. (2012). *Thinking in systems,* p. 7.

systems. In my estimation, since we made these systems, they are a sub-class of systems that fit into the hierarchy at the level of the organism through the emergent property of consciousness.

When the field of cybernetics was founded during the Second World War, close comparisons of the control and communication between machines and living organisms was made.[128,129] Their field of application was in tracking devices in anti-aircraft guns and electrical control systems, lead by Jay Forester at MIT.[130] However, this traditional view of cybernetics is not useful when we want to maintain the hierarchical differences between ecology and economy. *Organizational Cybernetics* (OC), a branch of cybernetics sometimes called the viable systems model,[131] speaks to the necessities for organizational survival and is mapped in congruence with extrinsic man-made factors.[132] Yet these factors are not reflective of the larger natural systems within which these companies operate. Natural and mechanistic variables need to be accounted for with proportional representation. When bridged in an appropriate hierarchical manner, depictions of what the world needs more of are brought forth - a humble and more fully realized view of the self within the larger system: *Integrated Cybernetics* (IC).

In the spirit of Donella Meadow's primary way to intervene in a system, by transforming paradigms, I bring a new one. *Integrated Cybernetics* is different from OC, in that organizational survival is mapped through, and because of, the survival of natural systems. In this way, it is a hybrid of OC and second generation cybernetics, dubbed *New Cybernetics*, which argues for an approach of

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[128] Norbert Wiener. (1948). *Cybernetics: Control and communication in the animal and the machine*. New York: Wiley.

[129] Stuart Umpleby, & Erik Dent. (1999). *The origins and purposes of several traditions in systems theory and cybernetics.* Cybernetics & Systems, 30(2), 79-103.

[130] Jay Forrester. (1958). *Industrial Dynamics--A Major Breakthrough for Decision Makers.* Harvard Business Review: 36 (4), pp. 37–66.

[131] Stafford Beer. (1984). *The viable system model: its provenance, development, methodology and pathology.* Journal of the operational research society, 7-25.

[132] Markus Schwaninger. (2004). *Methodologies in conflict: achieving synergies between system dynamics and organizational cybernetics.* Systems Research and Behavioral Science, 21(4), 411-431.

understanding from control[133] and has its basis in the biological.[134] IC is focussed on economic systems and its embodiments, and advocates a systemic approach to understanding the various emergent properties that bridge the human and the non-human within an appropriate hierarchical manner. IC thus proposes to be a new way to view the corporation through the lens of the biological, with various systems relating to each other in proportional representation.

Summary

So let me return to the questions that began this section: can we produce electricity sustainably and more reliably then we currently do? In other words, can we transition from a fossil-fuel based economy to a sustainable energy economy? I believe that through my analysis that the answer is *yes*. There is no technical reason why this transformation cannot take place. Creativity and ingenuity, the very assets that enabled us to depart from the plains of Africa, have enabled this transformation. Since our departure, there has been a slow but measurable separation of nature from society. Bruno Latour, in his *Politics of Nature*, summarizes that we assigned freedom to society and necessity to nature.[135] In so doing, we bifurcated these epistemologies into two camps. Democracy must win out over capitalism - and its manifestations, the World Bank and the International Monetary Fund - if we are to secure a sustainable future and bridge these two disciplines. Hopefully, Integrated Cybernetics provides a paradigm shift to bridge these orders.

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[133] Erik Rosseel. (1990). *New Cybernetics and the Social Sciences* in Self-steering and Cognition. In Francis Heylighen, Erik Rosseel and Frank Demeyere , (Eds.). *Complex Systems: Toward a New Cybernetics* (pp. 17-32). OPA Amsterdam. (p. 18).

[134] Jean-Pierre Dupuy. (1986). *The autonomy of social reality: on the contribution of systems theory to the theory of society.* In: Elias L. Khalil & Kenneth E. Boulding (Eds.). Evolution, Order and Complexity.

[135] Bruno Latour. (2009). *Politics of nature.* Harvard University Press, p. 147.

Figure 8.
Edward Burtynsky
Highway #1
Los Angeles, California, USA, 2003
http://www.edwardburtynsky.com/

Distributed Generation: A Preferable Future

Humans are distinguished from other species by a massive brain that enables us to imagine a future and influence it by what we do in the present. By using experience, knowledge and insight, our ancestors recognized they could anticipate dangers and opportunities and take steps to exploit advantages and avoid hazards.

-David Suzuki

In the previous section, I imparted some futures thinking to you to frame the energy requirements that we will need by mid-century. While these requirements are high, I hope the rest of the section described that this was a feasible goal through distributed generation and the technology outlined. In this section, I will put forward a preferred future scenario of energy abundance that harnesses these capabilities using one of our most useful skills obtained through evolution: foresight. While it is impossible to know the future with any certainty, there is a level of unsureness that follows energy predictions with some vigour. As energy economics professor Christoph Weber has stated: 'Uncertainty is almost ubiquitous in energy related decision making.'[136]

The basis for this scenario *Water, Water, Everywhere* was taken from drivers, trends and signals from the collected works of Martin Rhisiart (2013), Jeremy Rifkin, (2005), Gordon Laird (2005), Thomas Homer-Dixon (2005, 2008), Len Bolger and Eddy Isaacs (2005), George Monbiot (2007), Timothy Wirth (2003), Greg van Alstyne and sLab at OCAD U, the UN, the World Economic Forum, the World Bank, the Conference Board of Canada, Shell Energy and my own observations. For the sake of space, the horizon scan of signals, trends and drivers used to construct the scenario sets are available in appendix C. In this instance, co-creation was used to provide room for later sections. The Conference Board of Canada and Shell Energy provided particularly well

[136] Christoph Weber. (2010). *Quantification of Political Risk in Energy Foresight – a Methods Overview.* EWL Working Paper No. 01/10, p. 1.

executed scenario sets which I will describe in the following section to give orientation to the themes being described in the energy futures of tomorrow. The work of Thomas Homer-Dixon was also particularly instrumental in determining the landscape of change in the future. As he says,

> 'Five *tectonic stresses* are accumulating deep underneath the surface of our societies … They are:
> - population stress arising from differences in the population growth rates between rich and poor societies, and from the spiralling growth of megacities in poor counties;
> - energy stress - above all from the increasing scarcity of conventional oil;
> - environmental stress from worsening damage to our land, water, forests, and fisheries;
> - climate stress from changes in the makeup of our atmosphere;
> - and, finally, economic stress resulting from instabilities in the global economic system and ever-widening income gaps between rich and poor people.
>
> Of the five, energy stress plays a particularly central role.'[137]

With these insights, I will seek to craft a preferred future.

The goal here is to remain as impartial as possible while inspiring future energy-rich possibilities that we can strive for if (and only if) the correct policy action is taken in the present and not too distant future and coupled with the appropriate behavioural response. The Three Horizons paradigm[138] of futures strategy posits to be an excellent way to frame the future. Here, the third horizon is seen as the preferable future, with the second horizon being the action piece from the position of the first horizon. In this way, what I will present next is a world on horizon 3; a goal to be achieved through policy innovation on horizon 2 in the following part of this paper (Part 3). The final section of part 3 deals with behavioural changes that you can make today, and thus represents a horizon 1 approach, taking us back, if you will, to the present. As I have described above, distributed generation and the biomimetic economy / circular economy are interrelated fields which cannot be examined in silos: one fits within the other. Due to the systemic nature of this paper, an

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[137] Thomas Homer-Dixon. (2008). *The upside of down: catastrophe, creativity, and the renewal of civilization*. Island Press, p. 11-12.

[138] Andrew Curry, & Anthony Hodgson. (2008). S*eeing in multiple horizons: connecting futures to strategy*. Journal of Futures Studies, 13(1), 1-20.

immersive portion was required to fully judge the intricacies of the futures we will be creating policy for.

The final part of this section will deal with an experiential futures event hosted in conjunction with the Ellen MacArthur Foundation's *Disruptive Innovation Festival* (DIF). This festival promotes disruptive thinking about the circular economy and was launched by Ellen MacArthur, the famous yachtswomen who circumnavigated the globe. The event will be held on November 14, 2014 at ImpactHub Amsterdam and gives participants the experience of being immersed in the biomimetic economy of 2050, with distributed generation and a biomimetic energy grid powering their lives. This event is the embodiment of what this paper is trying to achieve - bringing research and policy making out of the 'lab' and into the real world, and letting people experience a world that policy could shape in the future. Thus, this event occupies the useful space of being a qualitative measurement tool for success. This section is required because it gives us a different paradigm with which to view the world and ask strategic questions about its formation. Participants become emotionally involved and illicit responses to stimuli that are not easy to assert through strictly narrative means.

A Brief Dive into the Worlding of Futures

There is no *singular* future. 'The future' is necessarily undeterminable, because our world is fostered through emergence and indeterminate points of instability that bring about change. No one can know when, or how fast this change will come about. We can only speculate. But the level or degree of *usefulness* in our speculations can be altered through the examination of drivers, trends and signals that give clues to how the future may unfold. Those in the field who wish to champion a cause - or come as close to an official future as possible, can argue for a preferred future. This lies within the cone of plausibility, as shown in Figure 9 by Joseph Voros. Here, the preferable future lies on the edge of the plausible, with certain wild card events lying outside in the zone of the possible. Joseph

Voros, a professional futurist at the Swinburne University of Technology explains that 'preferable futures may be so desirable that we consciously seek to move them out of the realm of the merely possible and into the realm of the distinctly plausible by actively creating the knowledge needed to bring them about as reality.'[139] In our case, I have argued that the technological knowledge already exists to bring about this preferred future. It is instead the way that we mobilize this ability through the political process that still eludes us. Voros goes on to say, as I have about our distant ancestors: 'it is this ability to envision and then move towards desirable preferred futures (or to consciously move away from undesirable futures) which gives humanity its greatest chance for further survival.'[140] To see a third horizon and then move towards it is one of our most powerful attributes.

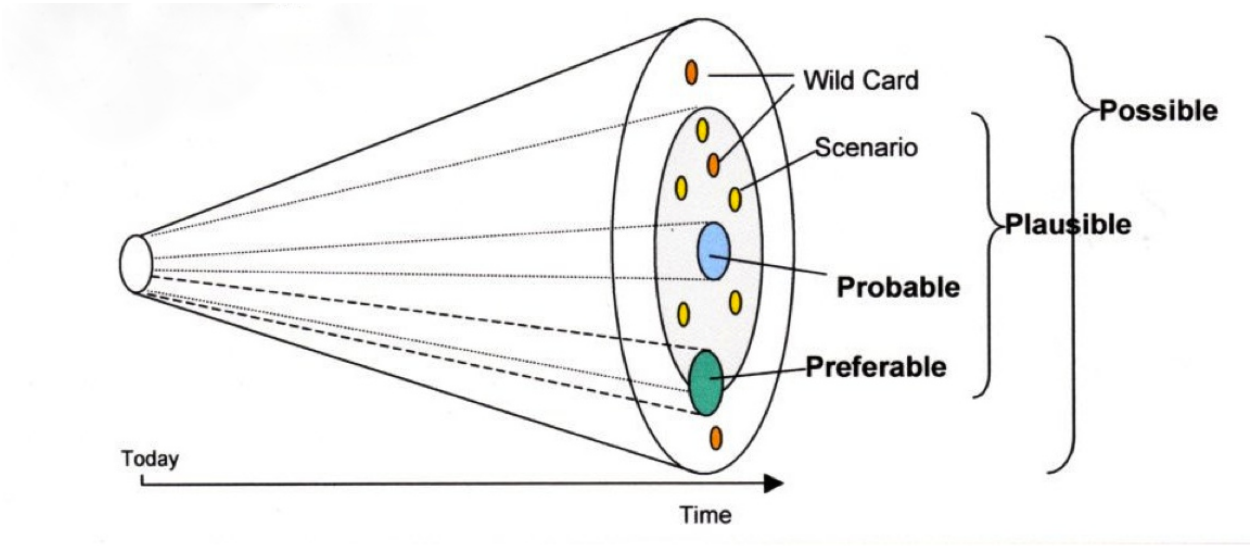

Figure 9.
A Primer on Futures Studies, Foresight and the Use of Scenarios.
Joseph Voros. (2001).

[139] Joseph Voros. (2001). *A Primer on Futures Studies, Foresight and the Use of Scenarios.* Foresight Bulletin, No 6, Swinburne University of Technology. Taken on September 23, 2014 from: http://thinkingfutures.net/what-we-do/resources/futures-foresight/a-foresight-primer/foresight-primer/

[140] Voros. (2001). *A Primer on Futures Studies, Foresight and the Use of Scenarios.*

One method of trying to achieve a preferred future is to craft a preferred world and then work backwards from that future to the present. Called *backcasting*, the ABCD method from *The Natural Step* is perhaps the most well-known,[141] and is described in more detail in appendix F. It involves four steps - or stepping stones, that lays a path towards a sustainable future. In my approach, I will be using this backcasting method in combination with the trends, drivers and signals that have been informed by a multitude of expert sources. The scenario to follow will describe the preferred future that lies within the cone of plausibility, with the policy blueprint to its completion coming in the follow chapter. I will henceforth call Canada's blueprint that champions a sustainable and renewable energy grid Canada's *Greenprint.*[142]

The Scenario Landscape

The construction of the scenario *Water, Water, Everywhere,* as mentioned earlier, owes its birth to the work of Pierre Wack and Art Kleiner at Royal Dutch Shell in the 1970s,[143] where the techniques for analyzing trends, drivers, and scenario planning was being introduced. The pioneering work of Wack and Kleiner was later followed by the work of Peter Schwartz and the Global Business Network.[144] Today, Shell has continued their use of futures work with their latest two scenario sets, *Scramble* and *Blueprints,* available online.[145] In Scramble, policy makers pay little attention to renewable energy until greenhouse gas emissions trigger major climate shocks. In Blueprints, growing local actions begin to

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[141] Applying the ABCD Method. Retrieved from *The Natural Step* on September 23, 2014 from: http://www.thenaturalstep.org/live/canada/?q=abcd

[142] Canada's *Greenprint* refers specifically to policy innovation that can bring about sustainable forms of energy production, transpiration and usage. This terminology should be used in conjunction with preferred futures work that lays ideal scenario sets and backcasting or step-wise policy frameworks in its implementation.

[143] Art Kleiner. (1996). The Age of Heretics: Heroes, Outlaws and the Forerunners of Corporate Change, Currency / Doubleday, p. 401.

[144] Schwartz. *The art of the long view*.

[145] Jeroen van der Veer. (2009). Shell Energy Scenarios to 2050. Retrieved on September 24, 2014 from: http://www.shell.com/global/future-energy/scenarios/2050.html

address the challenges, with a price being put on carbon. In these sets, Shell states that there is no ideal solution - through their acronym 'There Are No Ideal Answers' (TANIA), though they advocate that Blueprints could arise with the right combination of policy, technology and commitments from governments, industry and society globally. While neither of these scenarios has industry playing a large role in solving the energy and climate crisis, three major trends were used in the construction of these scenarios - namely: Developing nations like China and India are entering their most energy-intensive phase of industrialization, fossil fuel supply will struggle to keep pace (by 2015, easily accessible oil and gas will not match demand) and an increase in environmental stress.

Focussing on the Canadian context, the Conference Board of Canada (CBoC) developed a set of four scenarios in 2013: Hockey Stick, Green Machine, Superpower and Made in Canada.[146] Noting 'the massive investment in new energy technologies as well as the increasing pace of technological innovation,' the CBoC noted 'it is plausible that major changes in energy could occur within a 35-year time frame. This project therefore looked at the evolution of key drivers and the resulting scenarios for energy in Canada in 2050.'[147] While I will not give an exhaustive overview, I feel it is important to describe the scenario Green Machine, in the hopes that my preferred future has some grounding and context in the Canadian discourse of energy futures work. While explicitly stated[148] that any of their four scenarios are neither likely or desirable, Green Machine comes closest to mitigating the effects of climate change, spurring renewable energy growth in Canada and

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[146] The Conference Board of Canada. (2013). Energy Futures for Canada. Retrieved on September 24, 2014 from: http://www.conferenceboard.ca/temp/66384d2b-56bc-4c6f-a81d-844ab027d8a0/13-288_foresight_energyfuturecanada.pdf

[147] The Conference Board of Canada. (2013). Energy Futures for Canada. Retrieved on September 24, 2014 from: http://www.conferenceboard.ca/temp/66384d2b-56bc-4c6f-a81d-844ab027d8a0/13-288_foresight_energyfuturecanada.pdf p. 4.

[148] The Conference Board of Canada. (2013). Energy Futures for Canada. Retrieved on September 24, 2014 from: http://www.conferenceboard.ca/temp/66384d2b-56bc-4c6f-a81d-844ab027d8a0/13-288_foresight_energyfuturecanada.pdf p. 3.

ensuring a stable and healthy future for Canada. This is a scenario where technology saves the day and renewable energy is supported at the governmental, industrial and local level. Shifting proceeds of carbon-pricing to innovation has lead to expansion in the West, which was hit hard by the recession of the Oil Sands in Alberta. Canada has prospered because business, governments, and non-governmental organizations have coalesced around a technology-focused energy strategy. A set of observations that resulted from their scenario sets is available in appendix G.

The Preferred Scenario: *Water, Water, Everywhere*

With its vast tracts of land and relatively small population, Canada finds itself in a era of unprecedented prosperity. An integrated approach to policy innovation that invests in multidisciplinary stakeholders from a variety of social sectors has yielded highly innovative policies. Technology has been the major driver of prosperity, with an integrated energy innovation platform that links our government with businesses and non-governmental organizations being the major thrust. Deployed in the early 2020s, this has enabled a singular thrust that has proven especially beneficial for the public purse.

Equally as good for the public purse, subsidies for oil companies began to disappear in the early 2020s and all but ended by the late 2020s - despite their rise through the late 2010s.[149] This was catalyzed through civic demonstrations and denouncements of corporate greed at all levels of government. This was championed at the same time that true prices on carbon emissions came into effect, with significant monetary inputs being feed directly into renewable energy innovation. These policies arose through the integrated platform mentioned earlier and subsequently led to triumphs in technological innovation throughout the 2020s and 2030s.

Canada has increased its use of renewable power significantly. This renewable mix is made up of wind farms on both coasts, the west getting a boost from decreasing Oil Sands development

[149] See: http://www.pembina.org/media-release/1242

that began around 2025. Wind is also prominent in southern Alberta and Saskatchewan, Ontario, parts of Quebec and even northern Canada. Global Warming has increasingly made the arctic more desirable for renewable energy exploitation. Warmer temperatures will open up operational capacity, with large swaths remaining ice-free during the winter. Hydro-electricity has continued in B.C. and Quebec, while solar farms have increased along the U.S. boarder. Distributed generation has lead to a truly national grid, with transmission through HVDC cables.

Peak oil: the highest point in production before decline, has helped to bring about the hydrogen age. Triple digit oil prices in the mid 2020s resulting from decreasing subsidies caused emissions to stagnate, as economic growth went through a particularly turbulent period - one that is now known as the *Era of Quantitative Easing* (EQE), with large injections of cash from the central banks. During this time, our ecological footprint[150] reached its maxim before stagnating in the 2030s and dropping slightly in the 2040s. The predictions around natural gas as a crutch fuel were true however, with the remaining oil companies going into natural gas and causing a peak around 2035.[151] A remark by the economist Jeff Rubin has been proved to be only half-true: 'by the measure of my profession, economics, we'll all be poor. But by ecological standards, we'll be rich.'[152] While ecological standards did increase, so did our economies. The rise in technology has transformed our economies beyond recognition, with measures of growth coming with it. The transferring of legal rights to all plants and animals in the Canadian constitution in 2036, based on the Ecuadorian Rights of Nature in 2008,[153] has served to foster emergence in the measurement indicators around

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[150] Mathis Wackernagel & William Rees. (1998). *Our ecological footprint: reducing human impact on the earth* (No. 9). New Society Publishers.

[151] John Haffner & Willem Vriesendorp. (2014). *Vision 2050: The Future of Canada's Electricity System.* Canadian Electricity Association, p. 17.

[152] Greg Kelly. The End of Growth. *IDEAS*.

[153] Erin Daly. (2012). *The Ecuadorian exemplar: the first ever vindications of constitutional rights of nature.* Review of European Community & International Environmental Law, 21(1), 63-66.

economical growth. Advancements in hydrogen technology have continued to grow,[154] along with investment.[155] Political champions continue to emerge in positions of real power,[156] noting the rise of Xavier Trudeau in the late 2040s, the third member of the Trudeau dynasty.

Canada's hydrogen age wasn't always a sure thing however. Fortunately, signals that may have put Canada's water ownership status in jeopardy, such as The Dublin Statement on Water and Sustainable Development on January, 31, 1992, which labelled water as an economic *good,*[157] and NAFTA's similar declaration,[158] have become a thing of the past. Indicators of U.S. preparatory action for water related aggression and others, such as those in appendix H, have gone for not. With water being included in the Canadian Constitution as a human right in 2031, previous cases of water's status as a *good* have been overturned. Water is everywhere.

Most households are linked to their neighbours to form miniature versions of the national grid: generation islands.[159] These units interact dynamically with the supporting grid architecture, exchanging energy and information, and altering their states of being in response to stimuli from the outside world. Taking advantage of a buy-in scheme that offered cash incentives for replacing ancient furnace units brought about in 2027, a large proportion of homes across the country have combined heat and power units of electrolysis and fuel cells. This was made possible by the plunge

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[154] Ming Gong *et. al.* (2014). *Nanoscale nickel oxide/nickel heterostructures for active hydrogen evolution electrocatalysis.* Nature Communications 4:4695.

[155] Amin, p. 145.

[156] Rifkin, p. 88.

[157] Dublin Principles. (1992, January). *The Dublin statement on water and sustainable development*. In International conference on water and the environment.

[158] Gregory Szydlowski. (2007). *Commoditization of Water: A Look at Canadian Bulk Water Exports, the Texas Water Dispute, and the Ongoing Battle under NAFTA for Control of Water Resources,* The. Colo. J. Int'l Envtl. L. & Pol'y, 18, 665.

[159] Monbiot, p. 135

in price of fuel-cell components that started in the early 2020s when the long-distance transportation industry, championed by Wal-Mart,[160] switched to fuel-cell technology.

On the macro-level, themes of modularity in keeping with the biomimetic principals of self-assembly in the systemic design of products and services has been an ever-evolving process. This has also been seen in the energy grid architecture and other industries like transportation.[161] The internet and social media's ability to blur time, distance and space, has lead to an increasing interconnectedness which has, along with technology, broken the boundaries of many nation-states in the process. Geo-political trends around conflicts over energy have decreased significantly due to these new boundaries and the integrated interdependence of the world's energy systems.
These dissolving boarders on both fronts have followed the European Union model of integration, and has led to calls for Canada to join with the US. However, citing un-balanced renewable resources - mostly fresh water - Canadian parliament has refused such calls on two separate occasions. More recently, modularity has also been championed in green chemistry, with nature's five basic building blocks of life being endlessly interchangeable: carbon, oxygen, nitrogen, hydrogen and phosphorus. Products and services are also constructed in a bottom up fashion, instead of top down models of organization. The cradle to cradle movement long championed in academic texts throughout the early 2000s has become a reality. This has enabled a move back to a solo sphere of product compartmentalization from previous devisions between the technosphere and biosphere that occurred during the early 2030s. Much like the strive for Unification Theory in the sciences,[162]

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[160] Wal-Mart's next generation fleet prototypes use Microturbine-powered series hybrid electric drivetrains with advanced aerodynamic cabs. See: http://corporate.walmart.com/global-responsibility/environment-sustainability/truck-fleet

[161] Volvo's 'Scalable Product Architecture,' a modular form of automotive design was seen as a major driver in the field. See: http://www.volvocars.com/en-ca/all-cars/all-new-volvo-xc90/pages/default.aspx#/car/spa/top

[162] Franz Baader & Wayne Snyder. (2001). *Unification Theory. Handbook of automated reasoning.* 1: 445-532.

technologies are increasingly inter-compatible, a trend brought about from the rise of the IoT[163] throughout the 2020s. Appliance manufacturers, seeking to be accepted into the new distributed grid architecture network, began adapting smart power input and output electronics in the late 2020s.

Overall, Canada has navigated the challenges of Climate Change and energy security through an integrated and singular vision of innovation in policy and technology. Canadians remain some of the most wealthy citizens on the planet, especially since the new definitions of wealth now accurately account for natural capital.

Experiential Futures: The Biomimetic Economy @SocialBiome

Present practitioners of foresight use analysis and lab-based techniques to probe the future, veering away from such techniques as experiential futures. As Trevor Haldenby has noted, 'the Institute for the Future ha[s] been designing meaningful scenario narratives and dramas into their futures work for decades. But many of the most widely used methods in the futures toolkit, as explored by Rafael Popper, a scholar of foresight methods, veer away from the physical and interactive, towards analysis, evidence, and expertise.'[164] From the Foresight Diamond in Figure 10, the trend has been to use methods corresponding to the bottom left, instead of top right.

The preferential energy scenario *Water, Water, Everywhere* described above, is a useful exercise for policy makers to undertake. It allows them to plan ahead, to question the future, and create policies that will be beneficial, given the large uncertainties that exist. However, when you take this

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[163] Martin Rhisiart. (2013). *Foresight and "grand challenges" within research and innovation policies.* Emerald Group Publishing Limited vol. 15 no. 1, pp. 29-39(34).

[164] Trevor Haldenby. (2013). *Bringing the Future to Life:Pervasive Transmedia Scenarios and the World of Worlding.* Toronto: Self-published. PDF file retrieved from http://www.scribd.com/doc/164913914/Bringing-the-Future-to-Life-Pervasive-Transmedia-Scenarios-and-the-World-of-Worlding, p. 19.

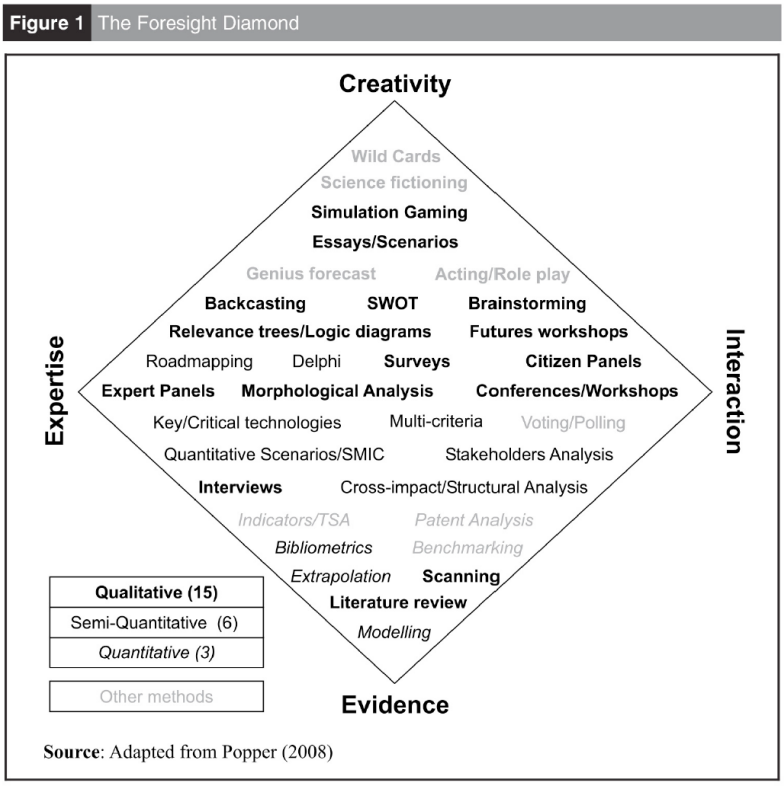

Figure 10.
Foresight Diamond
Rafael Popper. (2008). *How are foresight methods selected?*. foresight, 10(6), 62-89

exercise one step further - when you bring the future to life, you foster emergence in the policy realm. You open the door to the unexpected, and an understanding develops that is more nuances and sophisticated then before. That is what I will attempt to do on November 14, 2014. I will bring *a* future to life.

Through the Ellen MacArthur's DIF festival, I will have the opportunity to create a pervasive sensory experience that interacts with the full range of our senses. Hosted at ImpactHub Amsterdam, 200 people will be invited to participate and leave comments about the event. The comments will be left open to interpretation, so people can state what they like or dislike about the world they are experiencing. This co-creation will help refine policy frameworks and make for a

better-informed policy debate in the future. Tactile experiences and objects from the future will be woven into a narrative that embodies the energy scenario described above in 2050. The event will also be live-cast to the web through the Ellen MacArthur Foundation's site, where people can comment through twitter using #SocialBiome. These tweets will appear on the live-boards at the event so participants in both camps can feel connected through cross-media ecologies. By having such an expansive time horizon of 36 years, the range of possibilities is greatly increased. As Rafael Popper has stated, 'policy-making approaches [to foresight] adopt a longer-term perspective in the form of strategic planning, allowing flexibility and preparedness to deal with uncertainty, disruptive events and innovation.'[165]

Participants will be dropped into a world. They will have to question it and form opinions about it. Throughout the evening, the narrative will twist and turn; protestors may show up, certain products may stop working, or simply cost too much to operate. Alternate events may occur that jive with the current scenario too. As such, I am trying to allow for alternate futures to occur and stay true to the method of multiple futures. Thinking about the future in a high quality way means allowing for the possible as well as the plausible and the probable. All of these events will lead to different opinions, based on the individuals cultural background. This is a level of insight that is impossible to grasp if your foresight methods stay in the *evidence* portion of the Popper Diamond. The majority of the evening, however, will feature the preferred world of energy abundance, a functioning biomimetic energy grid, high degrees of sustainable practices and the fostering of emergence. The goal of the evening is to imagine and experience the plausible. It is hoped that people will be called to action.

[165] Rafael Popper. (2008). *How are foresight methods selected?.* foresight, 10(6), 62-89(p. 67).

Figure 11.
Subsistance.
Approximate location of maximum subsidence in the United States identified by research efforts of Dr. Joseph F. Poland (pictured). Signs on pole show approximate altitude of land surface in 1925, 1955, and 1977. The site is in the San Joaquin Valley southwest of Mendota, California. See: http://water.usgs.gov/ogw/pubs/fs00165/

Figure 12.
ImpactHub Amsterdam
A photograph showing the building as it stands in Amsterdam.
http://amsterdam.impacthub.net/2013/07/17/hub-amsterdam-moves-to-westerpark/

PART 3: The Psycho-social Hurdle: On Policy and Behaviour

In this section, I will describe a series of energy policy innovations that work in concert with the tenets of sustainability and biomimicry and could begin today to make these seemingly idilic futures a reality. I will couple this with policy innovations that are already underway in other countries and describe their mechanism. Finally, I will give a timeline for their implementation, a series of next steps and the technological considerations that must be addressed to implementing this timeline. These innovations are not merely academic considerations. As Jeremy Rifkin has noted, 'we could be leaders: by championing a fifty year plan to build a hydrogen economy for Canada.'[166] With this rhetoric, the future is an exciting prospect.

The Policy Play: Canada's Greenprint

To feel much for others and little for ourselves; to restrain our selfishness and exercise our benevolent affections, constitute the perfection of human nature.

- *Adam Smith*

After our long walk out of Africa, we started to build societies that we wished to inhabit through the implementation of organizational hierarchies, later governments, and later still with democracy and representative governance. In this last push, representational government used policy as the political tool of implementation. Governments, elected by the free will of the people, enact policies based on

[166] Rifkin, p. 95.

their mandate and their platform. Policies reflect the physical encounters that you as a citizen interact with everyday, whether you are aware of them or not. As such, their power to transform society is singular; their mechanism based on the mutual trust that every citizen has in each other - in the fabric of society. As the English conservative philosopher Michael Oakeshott has noted: 'Politics is the activity of attending to the general arrangements of a collection of people who, in respect of their common recognition of a manner of attending to its arrangements, compose a single community.'[167] Policy innovation then, lies at the heart of our communities. And again, we return to the question posed through the experiential futures event: What type of community do you want to live in?

Re-awakening a Primal Understanding

The policies and politics of our future; our collective imagination, must resonant and fit within the integrated cybernetic paradigm posited earlier. That is to say, they must place the systems of ecology and economy and their related epistemologies in proportion to one another in the correct orientation. It is not enough to say ecology before economy. No, it must now be ecology *how far ahead of* economy. What is the distance that we place between the sacred rules of nature and those of our own derived rules of hierarchies; our policies. This is a discussion that has not fully matured in academia, though it has its place in society with phrases like *the overwhelming power of nature* and *our place in the universe*. This realization of our organic place in the greater cosmos must take place - and it must form the basis of the discussion around a new politics.

Greg van Alstyne has stated that when the boundaries between the natural and artificial is erased; that of the inhuman and human, it places sustainability at the center of a newly re-conceived process of collective decision-making and representation; the heart of a new politics.[168] He

[167] Michael Oakeshott. (1962). *Rationalism in Politics and Other Essays*. New York: Basic Books, p. 56.

[168] Van Alstyne p. 59.

continues: 'This new politics, like the breaking of so many outdated epistemologies, requires a new suite of policies: a *synpolicy*. Synpolicies have thresholds. They must stand up to the tenants that sustainability trailblazers like Benyus have put forward.'[169] I would argue that these synpolicies bridge the same gaps that integrated cybernetics bridges. They argue for collective action to systemic problems with proper degrees of importance given to various stakeholders - be they people, animals or the biosphere. Bruno Latour has stated this as bringing 'political representation for the flourishing assemblies of non-humans, to bring the sciences into democracy.'[170] In a sense, our policies must be filtered through the emergence hierarchies of Table 1, each given their due; each having their *thresholds*, which our policies must clear accordingly. This, for Adam Smith, would constitute the perfection of human nature.

The state or frame with which we view our economy goes a long way to enabling its actions. A quick gaze around the world shows us that political institutions of a social democratic nature are far better at providing for their citizens than those of a conservative and capitalist bent, whose policies are fragmented, divisive and lead to government mis-trust.[171] Thomas Homer-Dixon has noted that 'healthy capitalist economies rely upon ferociously high rates of consumption of goods and services, and this reliance tends to discourage a transition to a green economy whose principal aim is to lower the throughput of energy in the economy.[172] Thus, governments of a capitalist nature will face an uphill battle to bring about a biomimetic energy grid because the lens in which they view the world is augmented. To view government and its actions as *enabler*, as that which can provide for the many what the few cannot, is a necessary realization before policy can be debated

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[169] *Ibid.*

[170] Van Alstyne p. 67.

[171] Arthur Miller, & Ola Listhaug. (1990). *Political parties and confidence in government: A comparison of Norway, Sweden and the United States.* British Journal of Political Science, 20(03), 357-386.

[172] Thomas Homer-Dixon. (2005). *Bringing Ingenuity to Energy.* In Andrew Heintzman, & Evan Solomon, (Eds.). *Fueling the Future: How the Battle over Energy is Changing Everything* (pp. 16-25). House of Anansi, p. 22.

within a democracy. Further to this, the establishment of a pseudo-circular/biomimetic economy must be taking shape in step with, or just ahead of, biomimetic energy policies and infrastructure - given the timid and uncertain nature of the industry. The groundwork must be laid, and that ground can only be prepared by government.

Political Courage in the Face of Uncertainty

The Canadian political landscape has maintained a liberal focus for the better part of 100 years, leaning occasionally to the right, only to come back to center again. We are not as socialist as those in Scandinavia, nor are we as conservative as our neighbours to the south. This middle road philosophy has allowed for the creation of government-business partnerships. Jeremy Rifkin has noted that this 'will quicken the pace of the change by underwriting the large direct and indirect costs involved in getting to the kind of economies of scale and speed that will make the new technology and infrastructure commercially viable. All earlier energy revolutions were similarly underwritten by the forging of government-business partnerships.'[173] As such, government policy should allow for the creation of more partnerships that specifically deal with the creation of circular / biomimetic economies and distributed generation and supply. Governments must take the lead, because industry alone is not likely to act. Lionel Nesta states this as electric utilities cannibalizing their core business.[174] They are unlikely to do this. There is a regime change that needs to occur that places societies *raison d'être* above that of the corporation - to fit within the integrated cybernetic paradigm. Noting that emergence is a *bottom up* phenomenon,[175] government policy must reflect this and make fostering these connections easier. Distributed generation comes from distributed

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[173] Rifkin, p. 96.

[174] Lionel Nesta, Francesco Vona, & Francesco Nicolli. (2014). *Environmental policies, competition and innovation in renewable energy.* Elsevier 67: 396–411(p. 398).

[175] Van Alstyne, p. 69.

voices.[176] Thus, aggregating these voices will be critical to the success of a biomimetic energy grid.[177] Policies that encourage self-assembly of these groups will need to act in concert with infrastructure policies that champion action. Policies that replace ageing uni-directional power lines with bi-directional lines should be implemented,[178] as should policies that enable the software implementation of the energy internet. These policies will speed demand for renewable energy, which becomes most cost-effective with this infrastructure in place.[179] The ability to buy and sell power produced and consumed in the distributive fashion creates demand, and spurs competition. Competition is a good thing in this new energy landscape. It champions fitness principals found in nature and enables a liberalization of the energy market in a self-sustaining fashion.[180] In addition, distributed generators need to be allowed to connect to the grid and sell it back in places where it is technically feasible.[181] The use and success of smart grid and renewable technologies are largely influenced by national renewable energy policies. Some countries like Germany and Denmark show impressive figures, which is why they are sometimes even not shown in global charts in order to recognize and distinguish other countries' otherwise negligible curves.[182] In Denmark, as Nesta states, 'most wind turbines are owned by households, municipalities and small communities, whereas utility-owned wind capacity accounted for only 15% of the total installed wind capacity.'[183]

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[176] Homer-Dixon. *Bringing Ingenuity to Energy,* p. 25.

[177] Rifkin, p. 93.

[178] *Ibid.* p. 91.

[179] Andrews. p. 6.

[180] Nesta *et al.,* p. 396.

[181] Rifkin, p. 100.

[182] Peter Palensky, & Friedrich Kupzog. (2013). *Smart Grids*. The Annual Review of Environment and Resources, 38:201–26 (p. 204).

[183] Nesta *et al.,* p. 397.

This buying and selling should also continue to the mobile fleet of power units: electric cars, or vehicles with a fuel-cell. Distributed generation policies championing the car as a mobile power station will give a new meaning to the idea of a car as a symbol of freedom. Jeffery Ballard envisions parking lots of the future functioning as hydrogen outlets 'that supplement the home refuelling capability that comes with regenerative fuel-cell vehicles.'[184] I see a more reasonable policy of plug-in electric stations that take advantage of the fact that you are stationary for some time, allowing electricity to come and go based on your requirements and those of the grid. There can be an *auto-setting*, where electricity is charged or discharged according to the energy rate and that which is beneficial to you, or if you really need to fill up no matter the cost, you can select *fill*. The balance between these two settings in a population should even out supply, demand, and monetary gains within a system that is as cyclical as the German *Kurzarbeit* program I will describe later. Ballard also has a plan to feed-in the fuel cell. He believes that the market should determine its introduction. Starting from material handling equipment like forklifts, 'the fuel cell engine can migrate into delivery trucks and then to the retail outlets, and from there to the parking lots to bring in customers.'[185] This feed-in mechanism allows supply and demand to dictate prices, which will fall by the time the automobile sees it. At present, we see the fuel-cell in a number of expensive vehicles and not yet targeting mainstream markets. This threatens to stunt the growth of fuel-cell technology by bringing it to the commercial market too early. Government subsidies for fuel-cell integration into the trucking fleet must must occur rapidly to spur the costs in the automotive fleet to decrease. In addition to the trucking fleet, fuel-cells must also be championed in the home. Since fuel-cells give off heat, though not as much as power,[186] a buy-back policy that replaces old furnaces with new electrolysis fuel-cell heat and power units is feasible. As Nesta states, 'the chief objective of

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[184] Ballard, p. 121.

[185] *Ibid.,* p. 123.

[186] Monbiot, p. 138.

renewable energy policies is to generate a certain volume of demand for clean energy.'[187] Demand however, can only be created if the true costs are accounted for.

True Cost: Pricing Power

Subsidies play an important role in the functioning of the global economy. In developing countries, subsidies assist consumers, whereas in developed countries, they assist producers.[188] According to the Pembina Institute, subsidies for oil companies are on the rise.[189] The International Monetary Fund pegs the figure at close to $20 Billion in 2011 - more than twenty times the budget for Environment Canada.[190] The International Institute for Sustainable Development notes 'the full cost of producing electricity by burning coal is actually 50 percent higher than the current market cost.'[191] A pricing scheme that tilts the board heavily in oil's favour is a perpetrator to its environmental impacts.[192] Paying the true cost goes further than this. As Homer-Dixon explains, 'when people don't pay the full costs of the production and use of a good, they have a tendency to waste it and a disincentive to apply ingenuity to conserve it.'[193] Gordon Laird has called this one of the biggest problems of the 21st century,[194] while Joyce McLean of Toronto Hydro states it like this:

> 'The obstacles to green energy in Canada are mainly social. The economic obstacles are that our energy prices don't reflect its true cost. The crux here is that people are not paying the true cost of their energy bill. Green power

[187] Nesta *et al.,* p. 398.

[188] Weber. (2010). *Quantification of Political Risk in Energy Foresight,* p. 5.

[189] See: http://www.pembina.org/media-release/1242

[190] See: http://www.imf.org/external/np/fad/subsidies/

[191] Homer-Dixon. *Bringing Ingenuity to Energy,* p. 20.

[192] Benyus. *Biomimicry,* p. 243.

[193] Homer-Dixon. *Bringing Ingenuity to Energy,* p. 21.

[194] Laird, p. 53.

> with no hidden cost, is far from being more expensive. But that's confusing to the average person.'[195]

Exposing the true cost of energy, if taken to its maxim, means real-time pricing. This allows for the instantaneous price of electricity to be available to the public. Policies like feed-in tariffs that allow for this information to be available to customers involves the introduction of info-electric bandwidths - with information being sent through different electromagnetic spectrums.[196] Policies that favour smart appliances - those that can respond to these bandwidths and turn themselves on or off according price[197] - by lowering their cost and adoption rate, can go a long way to enabling the hardware of this system. Japan and Australia have a policy in place where the government finds the most efficient model of fridge and freezer and insists that all others must match it.[198] Variable pricing also acts as behavioural policy, since it 'gives consumers incentive to shift their electricity use to times when demand is low, so that they can use energy more efficiently.'[199] Further to this, it creates a market for efficiency - a government spurred demand, allowing people to sell energy to the grid when prices are high and buy it back when demand is low. These policies, would go along way to answering the critics, who state that the unreliable nature of renewables is its a Achilles heel. Changing the usage pattern to match demand would greatly reduce the need for backup power.[200]

Exposing the true costs of energy does two things. It reduces the demand for harmful polluting fuels, and creates new industries around the entrepreneurial activity of production and use. Further to the latter, it creates a behavioural change that shifts sustainability to its proper imbedded place in the integrated cybernetic paradigm. The market for environmental goods and services

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[195] Homer-Dixon. *Bringing Ingenuity to Energy,* p. 19.

[196] Monbiot. *Heat,* p. 115.

[197] Rifkin, p. 92.

[198] Monbiot. *Heat,* p. 76.

[199] Amin, p. 146.

[200] Monbiot. *Heat,* p. 115.

according to Al Gore is approximately $300 billion. He continues: 'if one includes recent estimates for investments in energy infrastructure in developing countries, this figure grows to more than $1 trillion by the end of the decade.'[201] Developing countries - and especially the BRIC countries described in appendix C, play an enormous part in Canada's ability to power itself.

Circular Policies: Political Action for a New Economy

The policy measures mentioned above must fit within a new economy - an economy of hydricity and not fossil fuel. This should be the ultimate goal of policy measures now in the energy industry. A circular / biomimetic economy that runs on hydrogen and incorporates distributed generation and usage is an economy that isn't always growing. As Jeff Rubin says, we need to plan for this,[202] and this requires a different set of policies. A circular economy means that people share work so that parts of the whole are not unemployed - the German *Kurzarbeit* program, meaning 'short work', achieves this splendidly. The program revolves around the concept that it is better for everyone to work a little bit less then to have some people not work at all. During the crash of 2009, the German work force stayed stable, with the German government supplementing income in periods of decreased growth.[203] The German government then, acted like a monetary battery, soaking up excess capital when plenty was around and distributing it when it was needed. In this way, Germany's economy can rise and fall like the tides, and provide everyone with a decent standard of living. This systemic design of monetary flows mimics natures cyclical patterns of growth, death and renewal. Given that economies in both countries are based on skilled labour and exports, there is no reason why Canada couldn't do the same.

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[201] Benyus. *Biomimicry,* p. 247.

[202] Greg Kelly. The End of Growth. *IDEAS*.

[203] Megan Felter. (2012). *Short-Time Compensation: Is Germany's Success with Kurzarbeit an Answer to US Unemployment*. BC Int'l & Comp. L. Rev., 35, p. 481.

In the Netherlands, their National Environmental Policy Plan has developed a *synpolicy* of sorts, bridging the worlds of research-orientated sciences with action-orientated policy makers. This policy integration used 'long-term thinking for short-term action, keeping multiple options open,'[204] championing a *learning-by-doing and doing-by-learning* atmosphere. Here, the timeline between checkpoints in decision making is reduced to see and gauge the effectiveness of any action taken. Pivots in decision making are then applied and tested in the real world, before being brought back to the lab for review. This approach is keeping with the creative flavour of the circular economy - one that is mobile and adaptive and plays in boundary-work. Further to this, it bridges the divide between the sciences and politics that scholars like Bruno Latour, Greg van Alstyne and others have argued is desperately needed.[205]

Water Water Everywhere

Discussions about water security are relevant in the upcoming hydrogen age. Appendix C shows some of the problems, with trends of water shortages and the likelihood of water wars increasing throughout the century. While water is the key resource in this new economy, it is able to be consumed in a closed loop system that does not require endless inputs. Water, instead of natural gas, becomes the storage medium that heats and powers our homes - the only difference being that only a finite amount of water is needed to achieve this. Water molecules are endlessly broken and reformed in a closed loop system that embraces the circular economy. Canada is fortunate to have an abundance of water - so much in fact, that the ratio of freshwater/person makes the hydrogen age more feasible here than anywhere else, with water available for more water-intensive processes like agriculture. At present, the future does not look very good. Gary Mason, writing for the Globe and Mail a number of months ago, stated it this way: 'Canada's Ambassador Garry Doer says water

[204] René Kemp & Jan Rotmans. (2009). *Transitioning policy: co-production of a new strategic framework for energy innovation policy in the Netherlands.* Springer Policy Science 42:303–322 (p. 303).

[205] Van Alstyne, p. 62.

is the new oil. He predicted that water debates and disputes between the two countries will make the clash over the Keystone XL pipeline "look silly" by comparison … Parts of California are experiencing their worst drought in modern history … For every inch of water the lakes lose, freighters crossing them must lighten their loads by nearly 300 tons.'[206] Maude Barlow, Co-author of Blue Gold and National Chairperson for the Council of Canadians states the root of the problem this way: 'What we now know, is that we are now polluting and depleting this finite stock of freshwater so fast, that we are now mining the ground water faster then it can be replenished.'[207] While this may not strain the ability to transfer to the hydrogen age directly, there are indirect problems that need to be addressed, since externalities in other industries will play a role in water security. Policy measures need to be enacted that limit the amount of water leaving our borders and there needs to be a systemic approach to dealing with water, since the water cycle is the primary provider of freshwater on earth.

Taxation: A Unifying Force

The Government of Canada can also introduce progressive taxation as a policy measure that incentivizes the good and not the bad. Shifting the tax burden to include waste and pollution and not smart appliances does not change the level of taxation, so our position on the world stage would not decrease. Another incentive is to put a high price on carbon and let emergence lessen its role in our economies. Trading permits should be allowed, but only to a point. Thresholds should be set that no corporation should be allowed to breach - thresholds set within the carrying capacity of the system it operates in. Through time, the amount of permits should decrease, thus increasing their value and decreasing the amount of total carbon being emitted. 'The basic philosophy,' according to Clinton Andrews, 'should be to rely on markets whenever they work well, but to step in aggressively

[206] Gary Mason. (2014, February 28). In a water war, Canada could get hosed. *The Globe and Mail.* Retrieved from http://www.theglobeandmail.com/globe-debate/in-a-water-war-canada-could-get-hosed/article17139638/

[207] https://www.youtube.com/watch?v=B1a3tjqQiBI

when market failures appear.'[208] I would add that the markets should be bound by the parameters of the integrated cybernetic framework through regulatory policy. This places a boundary zone around economic activity that works within the carrying capacity of the environment.

With policies that are designed to nudge on a systems level, strongly urge on a community level and forcefully negate on particular individual levels, the policy framework mimics the systems approach of the integrated cybernetic paradigm. Jeremy Rifkin has done a wonderful job of summarizing the policy measures that should be taken by the Government of Canada to forge a sustainable economy in the hydrogen age. I quote them here to give some semblance of unity.[209]

1) Create a high-level working group to draft a blueprint for Canada to become a hydrogen economy by the year 2050.
2) Assemble a consortium of universities, technical institutes, and government laboratories to help facilitate research and development of hydrogen technology and related products and services.
3) Create a working group of software, chemical, automotive, energy and power companies to co-ordinate joint efforts to produce and market hydrogen technologies.
4) prepare a fiscal plan for using government funds to stimulate research and development programs in partnership with the private sector and provide tax incentives for companies and consumers to produce and use hydrogen technologies.
5) Establish a working group of financial institutions to work with the federal government to jointly underwrite new venture opportunities.
6) Establish several strategically located hydrogen technology parks and provide tax credits and incentives to lure businesses from around the world that are engaged in hydrogen technology products and services to set up shop in Canada. These hydrogen technology parks create a synergy effect.
7) Set up a task force made up of representatives of the country's main labour unions and businesses, as well as government officials, to explore ways to ensure maximum participation of organized labour at the local, provincial, and national levels in the planning, building, running and servicing of the new hydrogen infrastructure.
8) Work with local and provincial governments, public and private utilities, and civil-society organizations to set up prototype distributed-generation associations and HEWs in the poorest urban and rural communities, with the goal of creating energy independence.
9) Establish a working committee made up of provincial education ministries and the leading technical schools, colleges and universities to design curriculum and provide course instruction to train the next generation of workers in hydrogen-related technical skills.
10) Assemble an intellectual advisory board to address the many social, cultural, and political ramifications and consequences of making the transition from a fossil-fuel based economy to a hydrogen-based one.

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[208] Andrews, p. 6.

[209] Rifkin, p. 102-3.

Canada's Future? A Greenprint for Sustainable Energy Policies

Having stated the major areas and rationale for policy innovation, included areas of innovation in other countries, I will now draft a Greenprint for Canada: a timeline of action points that forges the previous section into a unified whole. The function of this Greenprint is to lay the stepping stones of the *The Natural Step's* backcasting method in a concrete manner, as applied to the Government of Canada.

Late 2010s

During the next five years, the Government of Canada should draft a Greenprint that incorporates a number of the following measures. They should establish a working group of financial institutions to work with the federal government to jointly underwrite new venture opportunities and form an integrated approach to policy innovation that invests in multidisciplinary stakeholders from a variety of social sectors. Another working committee made up of provincial education ministries and the leading technical schools, colleges and universities should also be created to design curriculum and provide course instruction to train the next generation of workers in hydrogen-related technical skills. Through this, they should assemble an intellectual advisory board to address the many social, cultural and political ramifications and consequences of making the transition from a fossil-fuel based economy to a hydrogen-based one. This will lay the academic groundwork for the circular / biomimetic economy. Further to this, an integrated communication system for the new energy grid should be designed and co-created with multidisciplinary stakeholders. This would include design elements such as signage and information that promotes conservation through suggestive behavioural modifications, such as ideal times of usage for each product (higher voltage at low peak power times).

Government subsidies for oil companies should begin to decrease at this time. The tax burden should be shifted to include waste and pollution. These funds should be re-directed to

integrate fuel-cells into the trucking fleet, which would drive demand and lower the cost of fuel-cells. Putting a price on carbon is an important step that will allow emergence to lessen its role in our economy. I see two ways to do this effectively. First, a number of trading permits should be allowed, with thresholds set within the carrying capacity of the system in place that no corporation can breach. These permits would be reduced each year until none are left and carbon is removed from our economic outputs. The second idea comes from Climatologist James Hanson,[210] and involves returning the carbon tax in the U.S. to the people each year in the form of one lump sum payment, due to the enormous mistrust that exists in the U.S. People are then free to invest that money in renewable alternatives, or spend it on fuel which would be highly taxed. I believe this to be a powerful behavioural incentive to shift activities towards positive outcomes, and one that could work for Canada too. Some of this money however, should be set aside in a separate fund from general revenue that would protect against unsettled economic times, as there is bound to be some turbulence from switching over to a new form of economy.

In the same vein as the policies above, the Government of Canada should enact strict limits around the amount of water that can leave our boarders. Towards the end of this cycle, policies should be enacted that allow distributed generators to connect to the grid and sell power back. Even if the infrastructure is not in place yet, it sends a clear signal of policies to come. Further policies championing the car as a mobile power station, such as introducing free charge points and negating taxation will give a new meaning to the idea of the car as a symbol of freedom.

Early 2020s

Following the educational push of the previous section, the Government of Canada should assemble a consortium of universities, technical institutes, and government laboratories to help

[210] James Hansen. (2009). *Carbon tax & 100% dividend vs. tax & trade.* Testimony submitted to the Committee on Ways and Means, US House of Representative, 25.

facilitate research and development of hydrogen technology and related products and services. Integrating the energy innovation platforms of government, businesses and non-governmental organizations will be a major thrust to spur the economies of the future. During this time, the government should define the economic boundaries that the markets would be allowed to work within in the coming years, which would be bound by the parameters of the integrated cybernetic framework. A task force made up of representatives from the country's main labour unions and businesses, as well as government officials should be set up to explore ways to ensure maximum participation of organized labour at the local, provincial and national levels in the planning, building, running and servicing of the new hydrogen infrastructure. This would be akin to German's *Kurzarbeit* program. Within this, a fiscal plan would be prepared for using government funds to stimulate research and development programs in partnership with the private sector and provide tax incentives for companies and consumers to produce and use hydrogen technologies. One incentive will be the price of fuel-cells, which should have decreased in price and become much more common in the marketplace, thus driving mass-market units of scale that began in the previous section.

Further free charge stations should be mandated for areas where cars are stationary, like grocery stores and parking lots, allowing electricity to come and go based on your requirements and those of the grid. There can be an *auto-setting*, where electricity is charged or discharged according to the energy rate which is beneficial to you, or if you really need to fill up no matter the cost, you can select *auto-fill*. The balance between these two settings in a population should even out supply, demand, and monetary gains within a system that is as cyclical as the German *Kurzarbeit* program.

Late 2020s

The Era of Quantitative Easing will bring about new opportunities to invest in renewable energy, and should be viewed as an opportunity to double down on infrastructure projects. The arctic will

be more desirable for renewable energy expansion at this time, and policies for prototyping micro distributed generation in the north should be adopted so that our poorest communities can achieve energy independence. Policies that replace ageing uni-directional power lines with bi-directional lines should be implemented, as should policies that enable the software implementation of the energy internet; feed-in tariffs that allow for information to travel on info-electric bandwidths. To create a truly national distributed grid, policies that replace our aged long-distance transmission cables with HVDC cables should be implemented.

Early 2030s

This era begins with water being included in the Constitution as a human right. During this period, tax incentives that create strategically located hydrogen technology parks that mimic the Klundborg Eco-park[211] should be created to lure businesses from around the world that are engaged in hydrogen technology products and services. These hydrogen technology parks create a synergistic effect that transfers to knowledge sharing and co-creation and furthers the knowledge economy begun in the first segment. Measurement tools should be implemented that accurately track economic indicators in this new emerging economy. The Government of Canada should also adopt legal rights to all plants and animals and enshrine this in the Constitution. This will foster new methods and indicators of economic success that work within the integrated cybernetic paradigm. Without this, methods of economic success that fail to properly take into consideration the ecology will be false and misleading. Lastly, learning from the prototyping of distributed generation in the previous era, expansion should begin in earnest.

Late 2030s

[211] This technology park in Denmark places companies strategically in a circle based on their waste and feed-stock requirements. Waste from one company becomes the feed-stock for the next companies, with flows of energy and matter circulating in a closed loop system.

Policies that champion modular building blocks, such as bio-polymers and other materials made through green chemistry (using nature's five building blocks) will allow cradle to cradle thinking to become a reality. Further policies that phase out the use of the technosphere should be implemented, such as those that place large penalties on the use of specific materials where alternatives are available. Further educational funding programs that champion green chemistry and place it along-side organic chemistry in the curriculum will boost knowledge adoption.

Early 2040s

In line with this, a buy-back policy that replaces old furnaces with new electrolysis fuel-cell heat and power units should be implemented. This hardware push should be furthered with policies that lower the adoption rate of smart appliances, allowing laggards to adopt to the system. Further to this, Canada should be exploring ways to integrate fully with electrical systems in other countries, as our water resources are a great source of natural capital to generate renewable power in the hydrogen age. A further policy that reduces the threshold requirements of the market should be implemented during this time to allow nature's inherent ability to heal itself take maximal effect.

Late 2040s

During this final period of policy innovation, immigration should be examined so as not to exceed the carrying capacity of our systems. Population figures show stagnant growth without immigration measures, so this measure would allow for stable populations within a circular / biomimetic economy.

These measures, if taken with commitment to the future, will serve Canada's best interests on the world stage and lead to the creation of a biomimetic energy grid and distributed generation. Naturally, the suggestions for policy implementation taper off as the cone of plausibility (Fig. 9)

widens, with uncertainty increasing. These measures however, can only go so far to achieving that third horizon; the preferred future. The movement starts and ends with you, the citizen, so I will end this paper by talking about what you can do now on the first horizon to bring about a biomimetic energy grid and a sustainable future for you and the next generation.

Canada's Greenprint: A Timeline for Action

	2015	Establish a working group of financial institutions to work with the federal government.
Establish another working committee made up of provincial education ministries and the leading technical schools, colleges and universities.	2016	
	2017	Assemble an intellectual advisory board to address consequences of making the transition to hydrogen based economy.
Create an integrated energy communication system, including signs that promote conservation.	2017	
	2017	Decrease government subsidies for oil companies. Shift tax burden to include waste and pollution.
Put a price on carbon, where the revenues are returned to the people as a personal cheque, and placed aside for renewable energy projects, not general revenue.	2018	
	2019	Enact policies that allow distributed generators to connect and sell power back to the grid.
Introduce free charge points and negate taxation on electric cars.	2019	
	2020	Assemble a consortium of universities, technical institutes, and government laboratories to help facilitate research and development of hydrogen technology and related products and services.
Define the economic boundaries that the markets would be allowed to work within in the coming years, which would be bound by the parameters of the integrated cybernetic framework.	2021	
	2022	Create a task force made up of representatives from the country's main labour unions and businesses, as well as government officials to explore ways to ensure maximum participation.
Create a fiscal plan for using government funds to stimulate research and development programs in partnership with the private sector and provide tax incentives for companies and consumers to produce and use hydrogen technologies.	2022	
	2024	Further free charge stations should be mandated for areas where cars are stationary, like grocery stores and parking lots, allowing electricity to come and go based on your requirements and those of the grid.
The Era of Quantitative Easing will bring about new opportunities to invest in renewable energy, and should be viewed as an opportunity to further increase spending on infrastructure projects.	2025	
	2027	Enact policies for prototyping micro distributed generation in the northern arctic.

cont…

The creation of a biomimetic energy grid and distributed generation for Canada.

Next Steps

The creation of a distributed generation and biomimetic energy grid on this scale requires something of the imagination. This can happen in one of two ways. First, a reimagined mega-project on this scale, made up of millions of *nodes* and requiring the technological capabilities and resources of the whole country requires a visionary unfolding in the public imagination through concerted political and media attention. This is the top-down method. The recreation of the *national dream,* from the trans-continental railway of old, to the moon-landings of the late 1960s, needs to spur the public's attention. The creation of two working groups, one to assemble the financial resources necessary, and one to assemble the intellectual resources, will help to consolidate the vision in a solid footing. To catalyze the country to action requires a special political candidate with the vision and work-ethic of a Winston Churchill or a John F. Kennedy. Failing such political candidates to take such initiative, a bottom-up approach can achieve some effect with lead-users leading the way. This is what I will speak to in the next section. As I mentioned before, history has shown that all large development projects in the past have been underwritten by a private-public partnership, but citizens can lead in the beginning to make this venture a politically safe and viable option.

Conditions for Technological Implementation of the Greenprint Timeline

The conversion of our modern industrial energy infrastructure to that of a fully distributed system will require a measured step-wise approach to achieve feasibility. After the initial steps laid out above have taken hold, and private-public partnerships have formed, a technological transformation must take place that starts with mobility-based distributed charge points, moves through an HVDC / FACTS backbone retrofit, and ends back with combined electrolysis heat and power units and smart appliances. This parabola of change that moves through the small and local to the large and national, back to the small and local is necessary so innovations can feed off their predecessors and

gain momentum in their uptake in the process. The TRL scale score for these technologies is between 7-9 at the beginning of this curve and 3-9 at the end, thus forming a series of natural technological stepping stones that compliments the Greenprint. With an understanding that it takes technology 10 to 15 years to achieve market penetration from first discovery, these timelines seem reasonable.

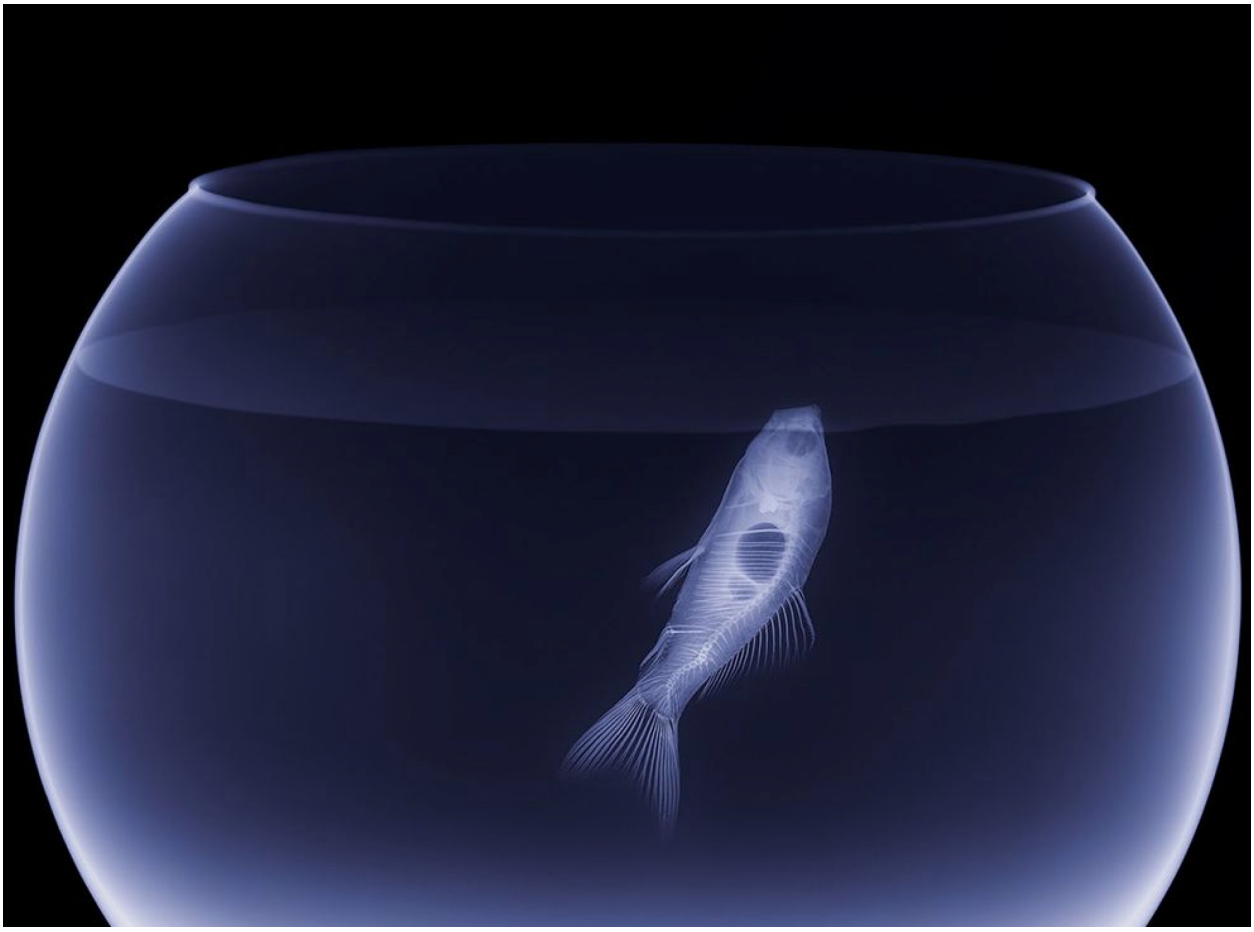

Figure 13.
See Through
Hugh Turvey
Xograms, a fusion of visible light and x-ray imagery. March 25, 2014
http://photography.nationalgeographic.com/photography/photo-of-the-day/goldfish-xogram-turvey/

Change Your Behaviour, Lest it Changes You

Those who overuse or squander energy are eventually edited out of the gene pool.

- Janine Benyus

Change is a cardinal rule of nature. Looking back in history, even through the brief history of our species, we can see that nothing is permanent; the force of evolution pushing ever onwards. We stand now on the precipice of a great decision - a decision that needs to be made on the first horizon. We need to change how we live; how we generate, store and use power. We need to shift the perspective of our place in the world so that the integrated cybernetic paradigm is satisfied. As an individual, you stand on the fringes of any society - and thus, have the most power to act. Harold Innis, the celebrated Canadian political economist once noted that powerful organizations are altered from the margins, the areas of society where risk and experimentation is acceptable.[212] Working together as individual entities, you have the power to spur positive change. Jeff Rubin, the other economist I have mentioned in the paper, notes that governments won't change unless you change first. As he says, 'their agenda is the next election cycle.'[213] If enough voices are calling for specific action, a politician will fill that void and take on the cause. The policies that I have noted in the previous section are a good place to start in calling for concrete measures and the implementation of political platforms. However, changing your behaviour - letting your actions speak for you - is the most powerful thing you can do to bring the change you want to see. As futurist Joseph Voros says, '[f]uture outcomes can be influenced by our choices in the present. Even though we can't determine which future of an infinite possible variety will eventuate, nevertheless we can influence the shape of the future which does eventuate by the choices we make regarding our actions (or inaction) in the

[212] Laird, p. 28.

[213] Greg Kelly. The End of Growth. *IDEAS*.

present (inaction is also a choice). These choices have consequences and so they need to be made as wisely as we know how.'[214]

What type of community do you want to live in? That is the main question posed in the experiential futures event hosted in Amsterdam, and it is the main question to ask yourself today. Amory Lovins believes that until we can make the switch to renewable, the best strategy is to coax every last kilowatt out of the fuels we are using. In Montana, he notes, 'the utility company is paying 2/3 the cost to insulate people's homes. It makes just as much money because it doesn't have to build a new power station.'[215] This example from rural Montana is just as applicable anywhere else, except you don't have to wait for the electric company to come forward. If it makes economic sense to them, it will make economic sense for you. The bridge to a biomimetic energy grid is a decrease in consumption, which is primarily behaviourally lead. Saving the environment and transitioning to a biomimetic economy is also about saving money, because the principal is using less. As Al Gore noted earlier, there are billions of dollars of opportunities in switching to sustainable practises. Turning off lights when they're not needed; using appliances like washing machines during low peak power times; buying smart thermostats to even out heating cycles; changing building practices to adopt *Passive House* principals[216] - these are all measures that you can adopt today to save the future.

Policy Horizons Canada explored these very issues in their 2011 report, *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness.* Through an examination of foresight techniques, they proposed the transformational scenario: *Be the change – institutions that matter support sustainability,* in which 'a rapidly changing world with a long-term view, and a strong tendency towards collective action focused on institutionally supported sustainability

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[214] Voros. *A Primer on Futures Studies.* Taken on September 23, 2014 from: http://thinkingfutures.net/what-we-do/resources/futures-foresight/a-foresight-primer/foresight-primer/

[215] Benyus. *Biomimicry,* p. 262.

[216] Wolfgang Feist, Jürgen Schnieders, Viktor Dorer, & Anne Haas. (2005). *Re-inventing air heating: Convenient and comfortable within the frame of the Passive House concept.* Energy and Buildings, 37(11), 1186-1203.

responses to emerging issues (e.g. consensus on assessing progress and measures to complement GDP, heavy investment in renewal and a functioning standard system).'[217] The scenario set from this exercise touches on a number of aspects covered in this paper, and can be seen in appendix E. It describes a world converging to the integrated cybernetic paradigm - one that is sustainable. Most strikingly though, it is collective action that is called for to bring about this change: individuals acting in unison from the fringes to bring about systemic change. In the section, *Policy Instruments beyond Regulation – Behaviour Change,* 'policy instruments which can impact behaviour, for example labelling, nudging, and social marketing,'[218] were seen as important drivers of this systemic change.

The behavioural changes noted in the preceding section can only really work if we embrace change ourselves. Policies act as nudges, to get you moving in the right way, but it must be your action, in the words of Michael Oakeshott, as a single community, that sustain these actions. As I stated earlier, policy innovation lies at the heart of our communities, so again we must ask: what sort of community do you want to live in? This is the first horizon piece, the part that can be done today, right after you finish reading this paper.

Conclusion:

Through the crafting of this paper on biomimetics, energy policy and the sustainable design of renewable energy futures, I hope that my efforts have shown that a sustainable future is possible. This paper is dedicated to the unborn child, in the hopes that when they read it, they will find themselves in a world that this paper champions. Energy policy is more than a political or academic pursuit. It is a societal pursuit that should be crafted by all members through the process of democracy. How we power our lives says something about who we are. The dawn of the hydrogen

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[217] Policy Horizons Canada. (2011). *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness.* Government of Canada. Available from: www.horizons.gc.ca, p. 13.

[218] Policy Horizons Canada. *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness,* p. 16.

age is upon us, and our switch from oil to water - the liquid of life - will say something about our place in nature.

You may be wondering why I have maintained the analogy with our distant African ancestors throughout this paper. The reason is one of remembrance. We have been here before. We used to know what it was like to live in harmony with nature. It is time to go back; to rediscover … so that we can uncover our future.

Figure 14.
Edward Burtynsky
Colorado River Delta #2
Near San Felipe, Baja, Mexico, 2011
http://edwardburtynsky.com/site_contents/Photographs/Water.html

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Appendix A: Schools of thought on Nature's principals

Systems Ecologist Howard T. Odum[219]

Organisms in a mature ecosystem:
1. Use waste as a resource (Energy produces drinking water)
2. Diversify and cooperate to fully use the habitat
3. Gather and use energy efficiently
4. Optimize rather than maximize
5. Use materials sparingly
6. Don't foul their nests (no toxins are produced)
7. Don't draw down resources
8. Remain in balance with the biosphere (Produce what you need, when you need)
9. Run on information (Energy internet communicates with system)
10. Shop locally (energy produced on site)

Janine Benyus: Nature's Laws, Strategies and Principals[220]

1. Nature runs on sunlight.
2. Nature uses only the energy it needs.
3. Nature fits form to function.
4. Nature recycles everything.
5. Nature rewards cooperation.
6. Nature banks on diversity.
7. Nature demands local expertise.
8. Nature curbs excesses from within.
9. Nature taps the power of limits.

Donella Meadows: Places to Intervene in a System (In Increasing order of their Effectiveness)[221]

12. Constants, parameters, numbers (such as subsidies, taxes, standards)
11. The sizes of buffers and other stabilizing stocks, relative to their flows.
10. The structure of material stocks and flows (such as transport networks, population age structures)
9. The lengths of delays, relative to the rate of system change
8. The strength of negative feedback loops, relative to the impacts they are trying to correct against
7. The gain around driving positive feedback loops

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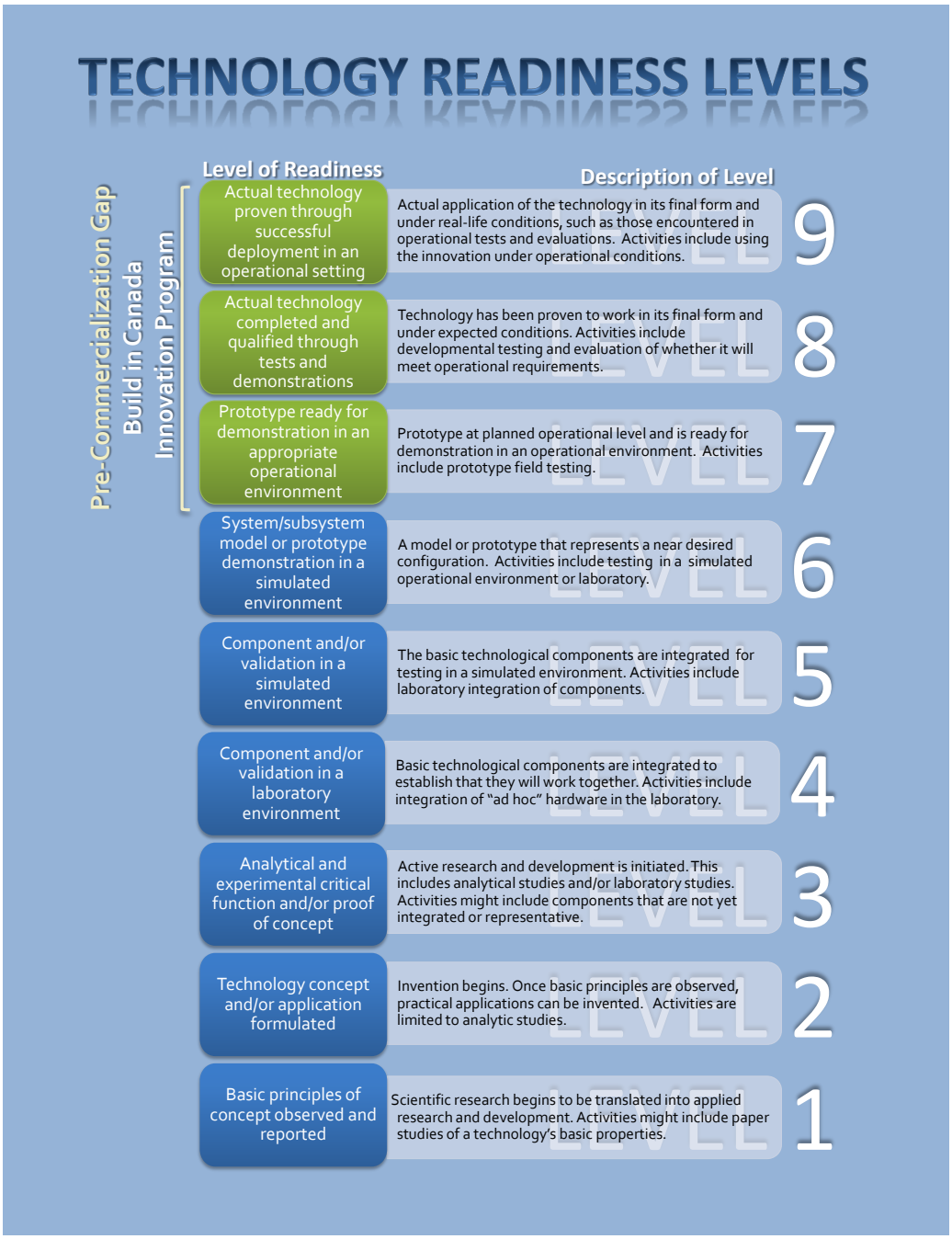
[219] Benyus. *Biomimicry,* p. 253-4.

[220] *Ibid.*, p. 7.

[221] Donella Meadows. (1999). *Leverage points: Places to intervene in a system.* The Sustainability Institute, p. 3.

6. The structure of information flows (who does and does not have access to what kinds of information)
5. The rules of the system (such as incentives, punishments, constraints)
4. The power to add, change, evolve, or self organize system structure
3. The goals of the system
2. The mindset or paradigm out of which the system—its goals, structure,rules, delays, parameters—arises
1. The power to transcend paradigms.

Appendix B: Public Works and Government Services Canada Technology Readiness Level[222]



[222] Public Works and Government Services Canada. (2013, November 21). *Technology Readiness Levels.* Retrieved November 14, 2014 from: https://buyandsell.gc.ca/initiatives-and-programs/build-in-canada-innovation-program-bcip/program-specifics/technology-readiness-levels

Appendix C: Energy Horizon Scan

We now have amplified foresight: science. We have detailed forecasted models, and we are headed down a very dangerous path.

- *David Suzuki*

Completed with the help of professional systems thinkers and futurists using the questionnaire above, below lays the positive and negative signals, trends and drivers that informed the scenario construction for the two possible energy abundant worlds and the experiential futures scenario played out at DIF 2014 through BiomeSocial2050. This scenario planning exercise allows for the construction of unbiased worlds through the process of co-creation. Signals, trends and drivers were arrived at through the work of Martin Rhisiart (2013), Jeremy Rifkin, (2005), Gordon Laird (2005), Thomas Homer-Dixon (2005), Len Bolger and Eddy Isaacs (2005), George Monbiot (2007), Timothy Wirth (2003), Greg van Alstyne and sLab at OCADU, the UN, the World Economic Forum, the World Bank and my own observations.

Signals

Modularity: There is an increasing drive towards modularity in many disciplines. Volvo even recently introduced 'Scalable Product Architecture,' a modular form of automotive design.[223]

Hydrogen Possibilities: Romano Prodi, president of the European Commission, 'shift to a hydrogen future would be the next great integrating task for Europe after the introduction of the Euro.'[224] An article in *Nature* recently claimed to produce hydrogen from inexpensive nickel and lead - through the use of a AAA 1.5 volt battery. Never before has hydrogen been produced so cheaply, a strong signal that the future of this technology looks bright.[225] China has already invested $7.3 billion and will spend $96 billion on its own smart-grid technologies by 2020 to conserve power and brace for a hydrogen future.[226]

Corporate Rights: Because corporate personhood is a reality in the US, corporations have the same legal rights as citizens, which sets a dangerous precedent.

Water War Words - WW3? - Canada's Ambassador Garry Doer says water is the new oil. He predicted that water debates and disputes between the two countries will make the clash over the Keystone XL pipeline "look silly" by comparison … Parts of California are experiencing their worst drought in modern history … For every inch of water the lakes lose, freighters crossing them must

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[223] See: http://www.volvocars.com/en-ca/all-cars/all-new-volvo-xc90/pages/default.aspx#/car/spa/top

[224] Rifkin, p. 88.

[225] Ming Gong *et. al.* (2014). *Nanoscale nickel oxide/nickel heterostructures for active hydrogen evolution electrocatalysis.* Nature Communications 4:4695.

[226] Amin, p. 145.

lighten their loads by nearly 300 tons. Economic Impact.[227] Maude Barlow, Co-author of Blue Gold and National Chairperson for the Council of Canadians. 'What we now know, is that we are now polluting and depleting this finite stock of freshwater so fast, that we are now mining the ground water faster then it can be replenished.'[228]

The Cost of Computing: 1 microchip takes 32 litres of water.[229]

'Good' Water: The Dublin Statement on Water and Sustainable Development on January, 31, 1992 labelled "Water as an economic good." NAFTA has soon followed, labelling water as a 'good'. As Maude Barlow says: "Nobody will stand up to the US administration and say 'this is out water' because they know that the US would consider that as serious a threat as putting missiles along our boarder."[230]

Water Message: Law in the US states: If you don't use the water, you may lose your water right. This does nothing to further conservation and only acts to undermine the water table.[231]

Solomon Sinking: Solomons town first in Pacific to relocate due to climate change.[232]

Drivers

Wind Wind, Everywhere - George Monbiot has noted that: 'Between 1970 and 2003, there was not an hour, let alone a week, with no wind across the UK.'[233]

Power Shift - Hydrogen will change the way power is distributed; where consumer becomes a producer.[234]

The 3rd world takes the lead? - A lack of access to electricity is a huge reason behind economic opportunity. Distributed energy webs can change that through knock down effects that narrow the gaps between the haves and have-nots.[235] The Democratic Republic of Congo currently has the

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[227] Mason. In a water war, Canada could get hosed. *The Globe and Mail.* Retrieved from http://www.theglobeandmail.com/globe-debate/in-a-water-war-canada-could-get-hosed/article17139638/

[228] https://www.youtube.com/watch?v=B1a3tjqQiBI

[229] https://www.youtube.com/watch?v=B1a3tjqQiBI

[230] https://www.youtube.com/watch?v=B1a3tjqQiBI

[231] https://www.youtube.com/watch?v=B1a3tjqQiBI

[232] http://www.reuters.com/article/2014/08/15/us-foundation-climatechange-solomons-idUSKBN0GF1AB20140815

[233] Monbiot, p. 113.

[234] Rifkin, p. 89.

[235] *Ibid.,* p. 98.

longest HVDC cable in the world at 1700km![236] As Greg van Alstyne says: 'Resistance or delay in adoption of this scheme, also known as micro-generation, may be because it involves scrapping, or gradually overwriting, the national electric grid. Given the current state of developed economies with their aging infrastructure and rising geopolitical tensions from imported energy supplies, it['s possible to imagine such a vision leading to decisive action towards the development of real energy security and sustainability.'[237] Noting that technological advancement and distributed generation may have an easier time getting started in areas where there isn't an intrenched energy system already running - nothing a Soft Systems Methodology that system boundaries are malleable. Thus, with proper initiatives, distributed power may see the biggest rise in 3rd world countries - what that cable, they are well on their way.

Rise of the BRIC - Brazil, Russia, India and China (BRIC) countries have just created a $100 billion bank to ease pressure of western finance and bypass IMF and World Bank.[238] This is in response to the The World Bank's policies to the global south, where debt relief is given in place of water privatization. This is the new colonialism. Power shifts of this magnitude have not happened in nearly a century and are likely to provide opportunities for the nimble and incite conflict for those left behind.

Converging Technologies - Much like the strive for Unification Theory in the Sciences, technologies are increasingly inter-compatible, a good thing for the IoT.[239]

Increased Information Access - The rise of the internet, especially in the 3rd world with Google's plan to *connect the world*[240] says good things for the future of Africa. The question is whether the Internet will provide not simply the technical model but also the necessary catalyst for organizing that might overcome entrenched industrial interests and institutions.[241]

From public/private to shared value - Companies are sharpening their competitive advantage by building a social value proposition into their corporate strategy and affiliating with broader social issues. This enables the biomimetic economy to take shape.[242]

From birthright to unavailable - Lack of resources, capital, skilled workers and opportunity threatens to disrupt the sense of social security. This trend seeks to break capitalism's rosy glow and shift favour to a more inclusive form of economy. (OCAD)

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[236] Monbiot, p. 104.

[237] Greg van Alstyne, (2008). *How to Achieve Metabolo by Composing the Pluriverse: On the Role of Digital Media in Striving for Sustainability,* p. 43.

[238] http://www.theguardian.com/global-development/2014/jul/16/brics-countries-development-bank

[239] Rhisiart. *Foresight and "grand challenges,"* p. 34.

[240] http://www.forbes.com/sites/matthewstibbe/2013/06/05/googles-next-cloud-product-google-blimps-to-bring-wireless-internet-to-africa/

[241] Van Alstyne, p. 44.

[242] OCAD Strategic Plan, p. 60.

Strengthening cultural values - The greatest shifts in our values, such as protecting the rights of all regardless of gender, sexual orientation or ethnic origin have already taken place. However, in the context of the dramatic shifts in our environment resulting from technological, economic, environmental, political and societal changes, it remains to be seen whether this will result in an astute oppositional and critical discourse, or in compliance and responsiveness to the dominant culture.(OCAD)

Demographic shifts (age/diversity/migration) - Canada faces an aging population and a reduced fertility rate. The labour force will shrink unless society encourages much broader participation from more women, older workers, youth, persons with disabilities and new Canadians. With more immigration come changes to shared value perceptions. Canada will require new structures to help this country navigate the challenges of living side by side with differences. A biomimetic economy would help to bridge these devices by preaching inclusiveness. (OCAD)

From profligate to frugal - Decades of prosperity have come to an end, and governments and institutions everywhere are seeking lower-cost ways of acting and intensifying productivity.(OCAD) This is because 'Western societies, and increasingly our global society as a whole, have locked themselves into an economic and social system that can remain stable only through endless growth.'[243]

Economic restructuring - Governments have a low capacity for expanding debt, and the prospect of massive additional stimulus to rewire the economy is not high. The effects of restructuring are likely to have long-term consequences and to be of great concern for the future viability of the institution. (OCAD)

Civic instability - Civil unrest is intensifying globally and Canada is not immune to the rattle. The cost to government is high, both in dollars and good will. Suppression of protest and accommodation of the disaffected result in firm security measures, a reallocation of infrastructure resources, firm tax and income distribution policies, and deployment of talent and cash.(OCAD)

Free Pass - According to the Pembina Institute, subsidies for oil companies are on the rise.[244] The International Monetary Fund pegs the figure at close to $20 Billion in 2011 - more than twenty times the budget for Environment Canada.[245] In terms of placing ecology before the economy, this is backwards.

The Gas Crutch - The National Energy Board predicts natural gas usage increasing from 6% to 15% by 2035.[246] This is because Natural Gas is seen as a crutch between oil and the hydrogen

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[243] Homer-Dixon, p. 23.

[244] See: http://www.pembina.org/media-release/1242

[245] See: http://www.imf.org/external/np/fad/subsidies/

[246] John Haffner & Willem Vriesendorp. (2014). *Vision 2050: The Future of Canada's Electricity System.* Canadian Electricity Association, p. 17.

[247] Laird, p. 33.

[248] *Ibid.*, p. 35.

age.[247]Yet, Natural Gas is being waisted on status quo.[248] We will have to find a way to use this resource as a second horizon fuel.

A Double Edged Sword - without access to modern, reliable energy sources, economic development or alteration is not possible. And in this era of globalization, economic performance around the world affects Canadian economic fortunes and Canadian security. Canada's environmental destiny is also bound up in the energy choices that developing countries will make in coming decades. And because poverty is such a long-term destabilizing force, Canadian national security compels an enlightened approach to international access to energy, especially to water. Some hold the view that the moment an ounce of our water is exported south, it will become subject to the provisions of the North American free-trade agreement. And that once that tap is turned on, there may be no stopping it – Canada's water resources will suddenly become a U.S. national security concern.[249][250]

Trends

Interconnectedness - The conventional view was to focus on one form of energy. We now appreciate that various components are interconnected.[251] The internet is leading the charge in the interconnection of our lives. Social media has the ability to blur time, distance and space.

Increasing technological abilities - Moore's law has famously been eclipsed with the pace of growth seen in the microprocessor through nanotechnology and the shrinking of transistor. Technology plays a larger and larger role in our daily lives, and with it - sustainability movements and the ability to be sustainable has grown with it.

Increasing Public Pressure - Public levels of participation in discourse with governments and institutions around the globe increased, and there is an openness to inclusive processes. (OCAD)

Demand for Environmental Goods 'Al Gore has noted that the market for environmental goods and services is approximately $300 billion, and is expected to grow to $400 to 500 billion by the beginning of the next century. If one includes recent estimates for investments in energy infrastructure in developing countries, this figure grows to more than $1 trillion by the end of the decade.'[252]

Energy Security - The Geo-political trends around conflicts over energy are growing. With increased depletion over finite resources, conflicts are sure to rise.[253]

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[249] Mason. In a water war, Canada could get hosed.

[250] See: http://www.amazon.com/Water-Struggle-Wealth-Power-Civilization/dp/0060548312

[251] Bolger & Isaacs, p. 59.

[252] Benyus. *Biomimicry*, p. 247.

[253] http://www.weforum.org/content/global-agenda-council-energy-security-2012-2014

Urbanization - The rise is seen most prominently in Asia and the Global South: South America, Africa (WEF)[254]. Global populations are flocking to the cities, which will grow from 50% today to 70% in 2050.[255]

Population: By 2050, the U.N. predicts our population of 7 billion to grow to between 9.1 and 9.3 billion people.[256]

New Energy Architecture - According to the WEF, at its present rate of deployment, energy architecture is too slow in its unfolding trajectory to solve the energy challenges we face.[257]

Climate Change - The Emissions Gap Report, published by the United Nations Environment Programme, shows that even if nations meet their current climate pledges, greenhouse gas emissions in 2020 are likely to be 8 to 12 gigatons of CO2 equivalent above the level needed to remain below temperature increases of 2°C.[258] Similarly, deforestation leads to soil erosion and desertification, while increasing the number of damned rivers means nutrients fail to make it downstream, leading to more soil erosion. All of this means less fresh potable water on the planet and an increase in hostilities to get it.

Water Security: 'According to the World Economic Forum's Global Risks 2013 report, the water supply crisis is ranked as a top-five risk, in terms of both its likelihood to happen and its impact. With global freshwater demand projected to exceed current supply by over 40% by 2030, increasing competition and stress on water poses a significant risk and impact on food, energy and industrial and human security around the world, including on close to 4 billion people living in areas where the demand for water will far exceed available supplies. While population grew fourfold in the 20th century, demand for water grew by a factor of nine.'[259]

Rising Conflicts Over Water - There has been an increasing trend to hostilities over water recently.[260] It is no wonder that the Chinese symbol for water and power is the same. Here is a non-exhaustive list of recent conflicts:

Ecuador Water Law Sparks Protests: http://www.aljazeera.com/news/americas/2010/05/20105712310338191.html

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[254] http://www.weforum.org/content/global-agenda-council-future-cities-2014-2016

[255] Non-governmental Organization Press Release. (2011). *World Populations to Reach 10 billion by 2100 if Fertility in all Countries Converges to Replacement Levels.* United Nations, embargoed until 3, May, 2011.

[256] Policy Horizons Canada (2011) *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness.* Government of Canada. Available from: www.horizons.gc.ca

[257] http://reports.weforum.org/new-energy-architecture-enabling-an-effective-transition-2012/

[258] http://www.weforum.org/content/global-agenda-council-climate-change-2014-2016

[259] http://www.weforum.org/content/global-agenda-council-water-2014-2016

[260] http://www.aljazeera.com/indepth/features/2011/06/201162219314723165 3.html

Water Crisis Plagues Peru: http://www.aljazeera.com/news/americas/2010/01/201011141037261484.html

Bolivia's Battle Against Privatization: Cochabamba Water Wars. Bolivia was prohibited from collecting rain water. https://www.youtube.com/watch?v=B1a3tjqQiBI

Egypt Has Sought To Tame The Nile and Control Its Use: http://www.aljazeera.com/programmes/struggleoverthenile/2011/06/2011667594146703.html

Cambodians Hit as Mekong Dries Up: http://www.aljazeera.com/video/asia-pacific/2010/04/2010423586919612.html

Kenya Drought May Fuel Tribal Wars: http://www.aljazeera.com/archive/2006/02/20084101414177135.html

Malaysian Government Imposed Death Penalty On Anyone Found Polluting Water: https://www.youtube.com/watch?v=B1a3tjqQiBI

Black Thought - According to Dr. Michal Kravcik, we lose 750 billion cubic meters of ground to pavement every year. This hardscape means rainwater has less area to soak into the ground and right back into the sea or evaporates.[261]

Wetland to Dry land - 67% of the worlds wetlands have been destroyed in the past 100 years.[262]

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[261] https://www.youtube.com/watch?v=B1a3tjqQiBI

[262] Heike Lotze, *et al.* (2006). *Depletion, degradation, and recovery potential of estuaries and coastal seas.* Science, 312(5781), 1806-1809.

Appendix D: Edward Burtynsky Agreement

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Appendix E: Policy Horizons Canada Transformation Scenario[263]

Transformation - be the change: institutions that matter supports sustainability

In this scenario, a number of severe environmental collapses (droughts, food scarcity and renewable resource collapse) provide the incentive for both developed and developing global powers to begin to cooperate. A new commitment to green and equitable growth is shared globally, and for the most part, is characteristic of multilateral institutions, firms, states and individuals. Industrial best practices are determined according to sustainability criteria, and are diffused within sectors as firms seek to improve upon each other's processes and share results via open innovation. There remains robust global competition in clean technologies whose value propositions consider both upstream and downstream impacts.

Collective action is taking a number of forms, and is well-coordinated and supported by governments, non-government organizations and individuals. Governments among others are taking into account short-, medium- and longer-term policy objectives that better integrate economic, social and environmental goals.

This world is not without its challenges, however. Although there are systematic and global responses to many trans-boundary issues, environmental decline is still occurring, although at a slower rate. The climate is still changing. The policy landscape is also in flux, as new measures, such as natural capital valuation, become standard practice. Increased consistency in accounting for the triple-bottom line results in a fundamental shift in corporate and consumer values – the desire to buy green products is mainstreamed.

The role of governments is changing as they adopt the role of overseer of producer/sectoral sustainability claims. This is particularly important, given the increasing number of global product and process certifications based on tested methodologies. Collaboration among actors is high, and carrots and sticks are strategically applied to achieve policy objectives, following well-informed deliberation by policy-makers. Governments are also looking at reforming taxation systems – rather than taxing investment, economic growth and employment, the shift to fiscal instruments to support efficiency gains has seriously begun. Multilateral institutions are playing an important coordinating role in increasing the availability of credible information. Capital markets are requiring this information in advance of investment decisions and are requiring third party or government verification of claims and accounts.

There are winners and losers on the natural resource and energy fronts because of robust global competition in clean technologies, in combination with a decline in the use of higher polluting energy sources (supported by a well functioning global carbon market). There is a strong push for open innovation, which is somewhat at odds with the need to continue to motivate the identification of technological solutions.

Global population growth is slowing as conditions improve in developing countries – in fact, the first steps toward stabilizing populations are being taken in least developed economies.

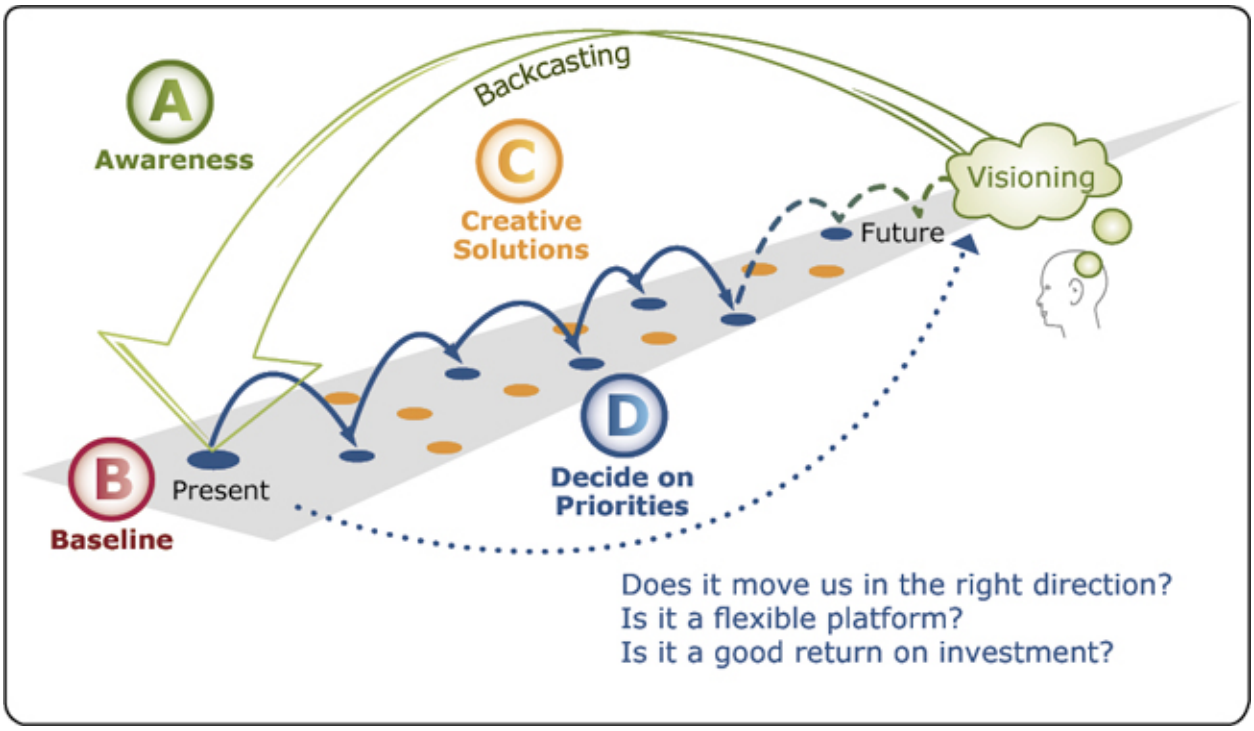
Some News Headlines from 2025

- **World body reaches consensus on global carbon deal: "The time has come"**
- **West Africa becomes the breadbasket of the continent**
- **Green choices are the new affordable choice; hybrid cars drop to mainstream prices**

[263] Policy Horizons Canada. *Leading the Pack or Lagging Behind: A Foresight Study on Environmental Sustainability and Competitiveness,* p. 21.

Appendix F: *The Natural Step's* Backcasting Method

The ABCD Method of Backcasting as prescribed by The Natural Step, as seen here: http://www.thenaturalstep.org/live/canada/?q=abcd.



A = Awareness and Visioning

This first step aligns the organization around a common understanding of sustainability and identifies a 'whole-systems' context for that organization; building a common language around sustainability as well as creating a vision of what that organization would look like in a sustainable future.
The Natural Step principles of sustainability, basic science and whole-systems approach are presented to develop strategies for living in balance with nature and our global community. Participants review details of the state of the earth's systems, including the ecological, social and economic trends that are undermining our ability to create and manage healthy and prosperous ecosystems, businesses and communities.

During the visioning process, people are encouraged to set ambitious goals which may require radical changes in how the organization operates. Some goals may take many years to achieve.

This is where businesses often begin to identify the service they provide independent of any one product (for example, providing energy services versus oil). Incorporating this awareness into the visioning process unleashes innovation and releases the company from preconceived limitations.

B = Baseline Mapping

This step uses the four sustainability principles to conduct a sustainability 'gap analysis' of the major flows and impacts of the organization to see how its activities are running counter to sustainability principles. The analysis includes an evaluation of products and services, energy, capital and human resources from 'cradle to cradle'. The assessment also looks at the social context and organizational culture in order to understand how to positively introduce change. This allows the organization to identify critical sustainability issues, their business implications, any assets they may have and opportunities for change.

C = Creative Solutions

In this step, people are asked to brainstorm potential solutions to the issues highlighted in the baseline analysis without any constraints.

Armed with their vision of success and potential actions, organizations look backwards from the vision to develop strategies toward sustainability. This is called backcasting and it prevents people from developing strategies that just solve the problems of today. Instead, they begin with the end in mind, moving towards a shared vision of sustainability, with each action providing a platform for further improvement.

D = Decide on Priorities

After identifying the opportunities and potential solutions in the 'C' step, the group prioritizes the measures that move the organization toward sustainability fastest, while optimizing flexibility as well as maximizing social, ecological and economic returns. This step supports effective, step-by-step implementation and action planning. At this stage, organizations can pick the 'low-hanging fruit' - actions that are fairly easy to implement and offer a rapid return on investment in order to build internal support and excitement for the planning process.

Appendix G: Conference Board of Canada Observations That Resulted From Their Scenario Sets

The Conference Board of Canada scenarios described here[264] suggest the following observations:
• The global price of energy will have regional impacts within Canada, but Canada does have pathways to prosperity within any price environment.
• The potential for severe climate change represents a risk to Canadian firms whether they produce energy or use it in their products and services.
• The key strategic decision at the national level concerns the optimal use of energy, whether to sell raw product into a high-demand global market or to use it for production of higher-value goods and services.
• Investment in technology is essential for both economic and environmental reasons, but the best focus of that investment depends on the expected direction of the global market and climate.
• Efficient, timely, and predictable regulatory processes will be equally important to the protection of the environment and the effective development and deployment of new energy technologies.
• Whether Canada chooses to export raw resources or focus on value-added processing within Canada, open domestic markets for people, goods, and capital will be vital for Canadian success.
• Whether Canada's non-renewable resources become increasingly valuable over time or are overtaken by increasingly low-cost renewable alternatives, Canada should convert more of the proceeds from selling finite resources into enduring financial assets for the future and move away from its dependence on commodities.[265]

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[264] The Conference Board of Canada. (2013). Energy Futures for Canada. Retrieved on September 24, 2014 from: http://www.conferenceboard.ca/temp/66384d2b-56bc-4c6f-a81d-844ab027d8a0/13-288_foresight_energyfuturecanada.pdf p. 5-8.

[265] The Conference Board of Canada. (2013). Energy Futures for Canada. Retrieved on September 24, 2014 from: http://www.conferenceboard.ca/temp/66384d2b-56bc-4c6f-a81d-844ab027d8a0/13-288_foresight_energyfuturecanada.pdf p. 12.

Appendix H: Water Crises Map of 2025

If Figure 10 is any indication, the US Administration is preparing for such events in the future. According to the World Economic Forum's Global Risks 2013 report, the water supply crisis is ranked as a top-five risk, in terms of both its likelihood to happen and its impact.[266] Signals such as the U.S. law that requires water usage, under penalty of losing the right to that water, show deteriorating legal frameworks for sustainable water management, with negative implications for Canada. The crafting of water as a good and not a right means that ownership will soon move to large corporations not on Canadian soil, sold to the highest bidder.

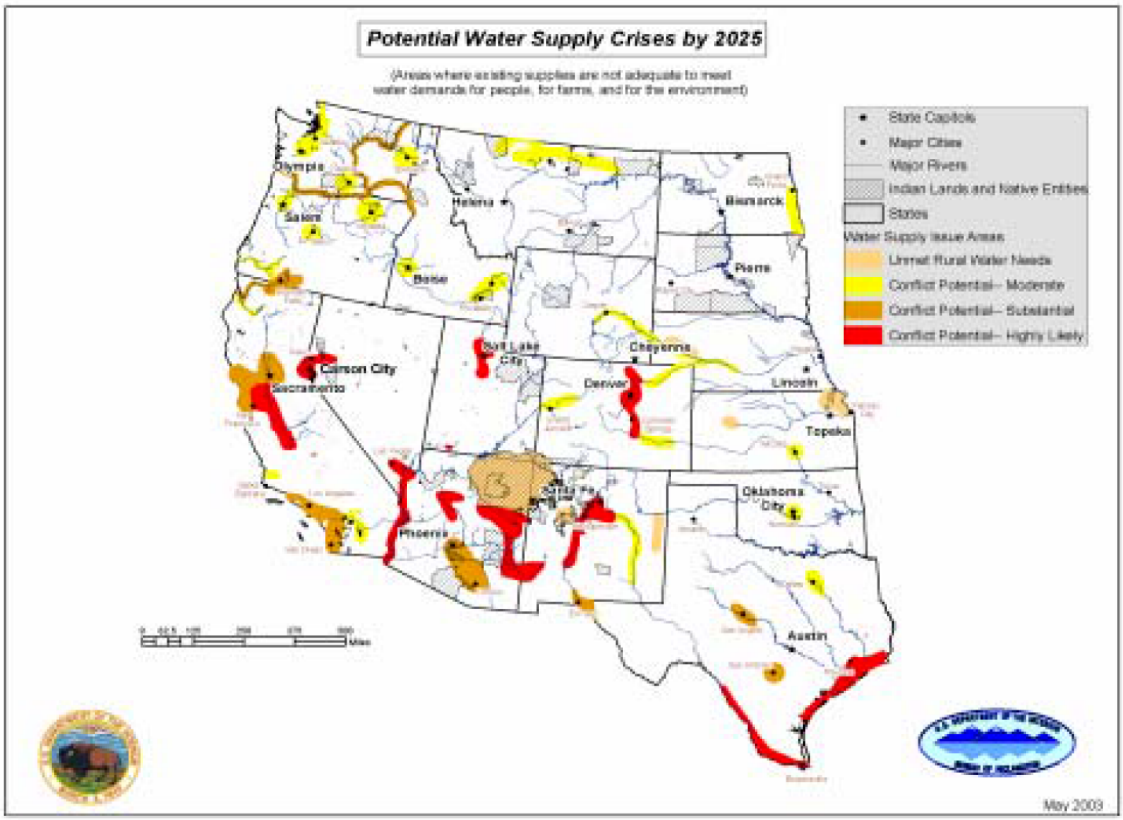

Figure 15.
Water Conflict Map for 2025
U.S. Department of the Interiors. (2003).

[266] http://www.weforum.org/content/global-agenda-council-water-2014-2016