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Using ICT for Adaptation Rather Than Mitigation to Climate Change

Bill St. Arnaud

This is one in a series of papers being published by IISD's Global Connectivity team to inform and stimulate discussion and debate on the relationship between information and communication technologies (ICTs), the Internet and sustainability, surrounding the UN Conference on Sustainable Development in Rio de Janeiro in June 2012 (Rio+20), the UN Internet Governance Forum in Baku in November 2012 and the International Telecommunication Union World Conference on International Telecommunications in Dubai in December 2012 (WCIT-12).

Bill St. Arnaud, Ottawa, is an R&E Network and Green IT consultant who works with clients on a variety of subjects such as the next generation research and education and Internet networks. He also works with clients to develop practical solutions to reduce greenhouse gas emissions such as free broadband and electrical highways.[1]

To date most efforts addressing climate change have been focused on mitigation strategies such as increasing energy efficiency and/or using renewable energy sources. The fundamental philosophy of mitigation strategies is that we can still prevent the onset of climate change or at least keep the global average temperature below 2°C to prevent more severe outcomes.

Unfortunately, despite the best intentions of many committed individuals and organizations, we are currently headed in the opposite direction. We are already committed to a 2°C average global temperature increase from the greenhouse gases that have been injected into the atmosphere since the dawn of the industrial age. Total carbon dioxide emissions now exceed 392 parts per million and are accelerating with the increased emissions from newly industrializing nations such as China and India.

Many scientists believe that we need to keep carbon dioxide emissions below 450 parts per million if we are to avoid catastrophic climate disruption. There appears to be little political will in most countries to address this challenge. In many ways, concern and addressing the reality of climate change has gone almost in the exact opposite direction to the severity of the problem. "Denialism" now largely shapes the debate about climate change.

[1] Source: http://billstarnaud.blogspot.ca

Even where there is political and public acceptance for climate change, a number of economists argue that the public will never be prepared to make the huge sacrifices and substantial investments to avoid the worst possible outcomes. This is especially true in developing countries, which are now starting to experience first world energy-consuming lifestyles. Awareness and concern about climate change are very low on the public radar in nations such as India and China; water, energy, roads, education and other basic necessities are seen as higher priorities. As the noted political economist Roger Pielke, Jr. stated in his famous Iron Law on climate change, "When policies on emissions reductions collide with policies focused on economic growth, economic growth will win out every time" (Pielke, 2010). The unavoidable reality is that policy-makers and the public at large are committed to sustaining economic growth, raising society out of poverty, and expanding access to energy. Greenhouse gas emission reductions will not be achieved by policies that seek to constrict or reduce economic activity.

As many scientists and thought leaders are starting to argue, given the political climate, that economic growth will always trump any meaningful economic costs to reduce greenhouse gas emissions, we need to seriously think the unthinkable: we are unlikely to undertake any meaningful reduction in greenhouse gas emissions and, consequently, we must prepare ourselves and society as a whole to adapt to a much warmer planet. President Obama's science and technology advisor, Dr. John Holdren, said it most succinctly in his address to the National Climate Adaptation Summit: "Mitigation alone won't work, because the climate is already changing, we're already experiencing impacts. Nothing we can do in the mitigation domain can stop it overnight, so a mitigation only strategy would be insanity...we're going to have to maximize both mitigation and adaptation" (Holdren, 2010).

A recent report from the Organisation for Economic Co-operation and Development (OECD), The Environmental Outlook to 2050 (OECD, 2012), paints a grim picture of what the future will be like with ongoing planetary warming. The report forecasts that global greenhouse gas emissions are projected to increase by 50 per cent, primarily due to a 70 per cent growth in energy-related carbon dioxide emissions. Global average temperatures could be 6°C higher by the end of the century. To put this in context, it is important to note that the average global temperature during the last ice age was 6°C colder than current temperatures. At that time, most of Canada and Europe were covered by an ice sheet several kilometres thick. We are now looking at a temperature of 6°C in the opposite direction within less than 100 years. Where once there were massive ice sheets, there could soon be deserts.

We don't have to wait until the end of the century to be seriously affected by climate change. Within the coming decade we should start to witness dramatic changes to our weather patterns. Most people are under the impression that climate change will be gradual, with slightly hotter summers and milder temperatures. A warming planet, however, is more likely to significantly increase weather extremes rather than the average temperature and precipitation. A recent paper on the effect of climate change on severe weather events demonstrates that if the normal temperature/precipitation distribution curve is shifted toward the warm end by one standard deviation (well within current warming forecasts), "then, a moderately extreme temperature that is 2 standard deviations above the mean becomes 4.5 times more likely. But a seriously extreme temperature, that is 5 standard deviations above the mean, becomes 90 times more likely! Thus the same amount of global warming boosts the probability of really extreme events, like the recent US heat wave, far more than it boosts more moderate events" (Coumou & Rahmstorf, 2012).

Already we are starting to see evidence of such extreme weather events directly linked to climate change (Hansen, Sato & Ruedy, 2012), such as the 2011 drought in the southwest United States and Mexico and the 2010 forest fires in Russia. This year's warm spring in eastern North America, the floods in Pakistan and forest fires in Russia are only mild precursors to what is expected in the coming decade.

All sectors of society are going to be impacted by these extreme weather events. To date, the ICT industry and research community have largely focused on mitigation strategies with respect to ICT, both in reducing its direct environmental impact as well as in aiding and abetting other sectors in reducing their respective carbon footprints. The most often quoted study in this regard is the SMART 2020 report that claimed that up to 15 per cent reduction in greenhouse gas emissions could be achieved through the use of ICT.

Consequently, many researchers, institutions and businesses have undertaken Green IT initiatives. Most of these have focused on energy efficiency strategies by reducing the electrical energy consumption of devices such as computers, printers and networks. Despite some modest achievements in energy efficiency, the direct energy consumption and carbon dioxide emissions of the ICT sector continue to increase. The ICT sector already represents 8 per cent of global electricity consumption and this is predicted to grow to 10–12 per cent of all electrical consumption in the next decade (GreenCom'09, 2009). Future broadband-Internet alone is expected to consume 5 per cent of all electricity (Tucker, 2008). Carbon dioxide emissions from US data centres, which were virtually non-existent ten years ago, have grown to be greater than all carbon dioxide emissions from the Netherlands and Argentina combined (Lucente, 2010).

It is not only large businesses and data centres that have seen spectacular increases in energy consumption and greenhouse gas emissions. According to the International Energy Agency (2009), in many Western homes the aggregate energy consumption of ICT devices now exceeds that of traditional appliances such as refrigerators and stoves. The impact of ICT on other sectors, in terms of reducing their carbon footprints, is considered to be negligible.

Clearly, the ICT sector is moving in the wrong direction in terms of a mitigation strategy. The failure of the ICT sector to reduce, or even slow, its own emissions and/or enable other sectors to reduce their impacts is attributable to several factors: Firstly, there have been few initiatives such as carbon taxes or cap-and-trade that would place a significant cost on greenhouse gas emissions, so there has been little incentive to undertake or implement energy efficiency strategies. Secondly, the global demand and growth of new ICT applications and services continues to outstrip any modest gains in energy efficiency.

Given the imminent increase in severe weather and other dramatic climate impacts in the coming decade and the years beyond, and with little hope of global political will to deal with the problem, we need to seriously think of an adaptation strategy for ICT, even it is only for a worst case planning analysis. While we should not abandon mitigation strategies such as increased energy efficiency, it is time now to seriously look at how the ICT sector itself can adapt to a warming planet as well as assist other sectors of society in their adaptation strategies. More importantly, any adaptation strategy should, by its own right, be a complementary mitigation process as well.

The biggest impact severe weather and other climate impacts will have on ICT is disruption of the electrical power grid. Record high temperatures, droughts, deluges and hurricanes will strain the electrical distribution system and the production of power. Electricity production and distribution could be particularly affected as hydroelectric reservoirs dry up and power plants shut down due to a lack of cooling capacity. In the European heat wave of 2006, for example, French nuclear reactors had to shut down because inlet water temperature from local rivers was too high to sustain cooling of the reactor.

At the same time, many network utilities are looking to increase the amount of power they draw from renewable resources such as solar panels and windmills. The challenge with renewable power is its unpredictability and unreliability. Although energy storage is part of the solution on the supply side, utilities will also be looking to shed power loads on the demand side during periods when demand is high. Currently, demand-side management such as the use of smart

meters are only designed for short periods of demand exceeding supply. During extreme weather events, utilities may need to shed power loads over periods of days or weeks.

If nothing else, as part of an organization's disaster recovery strategy, it should look at implementing ICT solutions that will allow the organization to continue to operate regardless of whether or not they have electrical power from the grid. To date, diesel generators and battery backup have been the standard approach for providing local power in the event of loss of power from the grid. While these may be useful for relatively short outages lasting perhaps up to a week or so, they are not sustainable (and very costly) for time periods lasting weeks or longer.

Thankfully, a number of research groups have been looking at this problem for some time and have been experimenting with adaptation solutions that enable ICT products and networks to operate without being connected to the electrical grid. The foremost example of such an approach is the CANARIE-funded GreenStar project (GreenStar Network, n.d.), led by researchers at the École Polytechnique in Montreal, Canada. The GreenStar project was the first in the world to conceive of deploying what is called a "follow the wind/follow the sun" architecture of a global computing cloud and network where all the computer nodes are powered solely by renewable energy such as solar panels, windmills and hydroelectric power. The system is designed such that when the wind dies or the sun sets at a given node, the computing jobs and tasks are immediately forwarded over a high-speed optical network to another node that has power, located elsewhere in the world. The system operates completely independently of the local electrical grid and can provide services regardless of the state of the local power system. Not only is it designed to survive a much warmer planet, it is a low-carbon mitigation architecture in its own right.

Following the launch of the GreenStar network, many other research organizations have undertaken similar projects. Most notably, these include initiatives such as "Free Lunch" (Akoush et al., 2011) at the University of Cambridge, the EU-funded Mantychore Project (Mantychore, 2010) and the Hewlett-Packard and Advanced Micro Devices project GreenCloud at Clarkson University in New York state (St. Arnaud, 2011b). The GreenCloud project is notable in that it is funded by the New York state electrical regulatory authority, concerned about the many stranded windmills deployed in the state that are unable to connect to the electrical grid due to opposition from rural landowners who don't want electrical transmission lines running by their backyards. Locating distributed computing facilities right at the windmill and linking them with optical fibre is a way of circumventing the "not in my backyard" problem.

In addition to building clouds and networks that are adapted to severe climate change, we also must look at ICT devices in our homes and businesses. Up to 50 per cent of ICT energy consumption and greenhouse gas emissions are from devices in the home, business and on the person (i.e., mobile phones). Attention also must be paid as to how they could operate independently of the power grid. Many of these devices, such as cell phones and computers, may be critical in saving lives and for other emergencies during severe weather events.

As mentioned previously, the aggregate power consumption of all the ICT devices in many Western homes—televisions, set-top boxes, computers, wall chargers, etc.—now exceeds the total power consumption of traditional appliances such as stoves, dishwashers and refrigerators. The Economist (2006) reports that in one year, the aggregate power consumption of the clock on a microwave oven exceeds the actual use of the oven to heat food! Most set-top boxes also draw more power than modern refrigerators (Murphy, 2011).

In terms of an ICT adaptation strategy, the inherent advantage of these devices is that their power draw at any instant in time is very small. Most of them could be easily powered by small rooftop solar panels and/or micro windmills. As well, many of these devices have their own internal battery storage: they are not dependent on being plugged

in all of the time. As such, several teams of researchers and a number of innovative start-ups, rather than taking the conventional approach of pursuing greater energy efficiency, are looking at how to power these systems exclusively from independent renewable power sources such as small solar panels and windmills. If all such devices in our homes could be powered by small local renewable resources, then we would not have to be concerned about the ongoing proliferation of ICT devices in the home or business and their impacts on electrical consumption or greenhouse gas emissions.

Another novel approach to ICT adaptation is to use the electrical vehicle as both an energy storage and an energy transportation system in direct competition with the electrical grid. Until quite recently, the conventional thinking was that electric vehicles would be charged at home from the grid (usually overnight) and then driven around the city during the day, slowly depleting the batteries. But a number of research teams around the world are investigating what is called "dynamic" or "pathway" charging, where the electric vehicle's batteries are charged as it travels along the road (Green Car Congress, 2012). Dynamic or pathway charging, in most cases, uses independent roadside solar arrays or windmills to charge the electric vehicles as they drive by. The charging of the batteries can be done either through inductive charging plates embedded in the road or through ultra-capacitor "umbrellas" located at periodic distances along the road or at stoplights and drive-through restaurants or banks.

Instead of having the electrical vehicle arrive back at the driver's home with depleted batteries, the vehicle, with its fully charged battery bank, can provide electrical power to a multitude of devices in the home, including traditional appliances (Wikipedia, 2012). A natural extension of this idea is to think of the electrical vehicle as not only a human transportation mechanism, but also an energy transport system. Electric vehicles could be used, in essence, as energy "packet" networks delivering power from roadside renewable power sites to homes and businesses.

Delivering energy in discrete packets has considerable appeal to many researchers and businesses, as they have seen the benefits of packet networks (e.g., the Internet) versus traditional circuit switched networks. Packet networks have enabled an explosion of innovation and new business models. As such, some speculate that integrating the electrical vehicle as an energy packet delivery system with modern ICT architectures for climate adaptation will enable the future "Energy Internet" (St. Arnaud, 2011a). Not only will this reduce greenhouse gas emissions from transportation, but it will also allow the efficient transport of renewable energy from remote sites to homes and businesses. Who would have guessed that the suburban lifestyle, once seen as the epitome of waste and inefficiency, may be the solution to global warming?

There still remain many challenges and uncertainties in developing solutions to address climate change. To many of those committed to the environment, talk about "adaptation" smacks of defeatism and giving up hope of developing a successful mitigation strategy. But as we have seen, solutions designed for the worst case scenario analysis of adapting to a warmer planet are also much more prudent and credible mitigation strategies. Relying solely on tools such as increased energy efficiency for mitigation will not slow down, never mind reverse, climate change. Nor will they be very effective in adapting to a warmer planet. Efficiency is of little value if you have no power in the first place.

While we do face a very ominous future with the rapidly approaching onslaught of extreme weather caused by climate change, there may a sliver of hope that through innovation and development of such ideas as the Energy Internet and the use of ICT, to paraphrase the words of William Faulkner, humankind will not only persevere, but will prevail against such adversity.

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International Institute for Sustainable Development
Head Office
161 Portage Avenue East, 6th Floor, Winnipeg, Manitoba, Canada R3B 0Y4
Tel: +1 (204) 958-7700 | Fax: +1 (204) 958-7710 | Website: www.iisd.org

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