Literature Review

Peak Oil, Climate Change, and Rural Ontario Community Resilience

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Introduction

This literature review introduces community resilience, climate change, and peak oil, in the rural southern Ontario context. It is the intent to add the concept of peak oil to the dialogue on climate change as a central, contemporary crisis: to consider the possibility of two crises – both of which have the directly affect communities, and both of which require local response nested within response from all levels of government.

The interplay of climate change and peak oil is largely self-evident; however, currently the attention paid to climate change overshadows the attention that possibility of oil shortage receives. The literature review thus explores both climate change and peak oil, yet focuses more heavily on peak oil itself to deepen the understanding of this controversial subject. With a specifically rural and Ontario focus, this review elucidates the nexus of climate change and peak oil, peak oil theory, and the cultural understandings and transformations that may enable communities to increase their resilience. With climate change accepted by the international community, the consensus emerging on peak oil, as described herein, is that we are at or near the global maximum production of oil, while demand continues to rise. This posits great pressure on our communities – locally, municipally, provincially – to respond effectively to these two challenges.

Climate Change and Peak Oil

The potential realities that climate change and peak oil present rightly classify them, both in isolation and in interrelation, as "wicked problems."[1]Climate change and peak oil are increasingly "wicked" as they are also inevitably linked, in that climate change is largely attributed to fossil fuel use. However, the responses that these challenges invoke are also tied. Thus, to understand each of them and their interrelation and interdependence, is necessary to prepare for resilience in the 21st century.

[1]The 10 characteristics of wicked problems laid out by Rittel and Weber (1973: 161-166) include:

1. There is no definitive formulation of a wicked problem;
2. Wicked problems have no stopping rule, in that there can always be a better solution;
3. Solutions to wicked problems are not true-or-false, but good-or-bad;
4. There is no immediate and no ultimate test of a solution to a wicked problem;
5. Every solution to a wicked problem is a 'one-shot operation'; because there is no opportunity to learn by trial-and-error, every attempt counts significantly;
6. Wicked problems do not have an enumerable (or exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan;
7. Every wicked problem is essentially unique;
8. Every wicked problem can be considered to be a symptom of another problem;
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's solution;
10. The planner has no right to be wrong.

Research on climate change, internationally and within Canada, is multitudinous and many-faceted. Peňuelas and Carnicer's "Climate Change and Peak Oil: The Urgent Need for a Transition to a Non-Carbon-Emitting Society" (2010) clearly indicates the interplay of climate change and peak oil and the absolute necessity of addressing these. As early as 2008, peak oil had entered the public health discourse: *Public Health* published a special issue in that year, focused entirely on peak oil and its implications in the public health field. Articles including "Peak Oil: Will it be public health's greatest challenge?" and "Climate Change and Rising Energy Costs: A threat but also an opportunity for a healthier future?" both by Hanlon and McCartney, graced the pages of that special issue, and examined peak oil as a driver to change – to actively create a healthier planet with healthier humans. In 2010 *Geoforum*, an international academic journal exploring economic, political, social and environmental systems, dedicated an entire issue to "Geographies of Peak Oil."

Friedrichs published a compelling piece in *Energy Policy* in 2010, entitled "Global Energy Crunch: How different parts of the world would react to a peak oil scenario." In this, Friedrichs develops a historical basis for analyzing our current situation through examples of national peak oil scenarios in the 20th century by identifying three paths that nations have taken during times of fuel scarcity: predatory militarism, based on the Japanese experience from 1918 – 1945; totalitarian retrenchment, as exhibited by North Korea in the 1990s; and, socioeconomic adaptation, using Cuba's 1990s "Special Period" as an example. Friedrichs' analysis and hypotheses about the future arise from these case studies. He is hesitant to assert one point of view on peak oil theory, but believes that forecasting how different parts of the world might react is a timely and necessary venture. It can thus be established that peak oil is fully recognized as a valid theory in the academic world, and is generating much speculation and attention. Academia is not shying from including long-term energy supply disruptions into dialogue about climate change, and providing background to influence policy.

Despite wide recognition of the peak oil concept and its linkage to climate change, the nature of their relationship continues to be the subject of international debate. Some argue that the two challenges are similar in their cumulative effects on the economy, where the occurrence of peak oil and rising fuel prices will be delayed by increased carbon taxes aimed at mitigating climate change, or where they will both affect the comparative advantage currently experienced by the global supply chain (Partridge, 2007; Curtis, 2009). Others argue that they are linked through the effects of fossil fuel consumption on climate change, much of which is the result of global transportation and energy intensive industries; it is further argued they are linked in the intersection of the end of the period of "cheap" oil with the effects of climate change (Mehdi, Mrena, & Douglas, 2006; Heinberg, 2007; Kunstler, 2006). The commonality of these linkages is that the timeline for effects on society are unknown and impending, that institutions and organizations will have to consider these issues in tandem when making decisions for the future, and that much academic analysis of climate change has omitted an analysis of peak oil (Curtis, 2009; Reynolds, 2010; Heinberg, 2007).

Oil: Our Cultural Addiction

The challenges of climate change and peak oil – on all scales and in all sectors – are personal and professional: they have the potential to change all aspects of our lives, communities and economies. The connection between climate change and fossil fuel availability is undeniable and brings into context the culpability of our culture, as the underlying cause for which climate change and peak oil are symptoms that threaten the ecosystems that humanity depends upon, and that thereby threaten humanity itself. Upon initial consideration, peak oil may appear as an easy 'fix' for climate change, in that increasing oil prices will slow their use and thereby slow climate change. Yet in and of itself, the implications of peak oil confront the predominant western lifestyle. Both challenges, climate change and peak oil, provide fertile ground for examining local knowledge and response as communities have the opportunity to modify the dominant culture and shift towards less reliance on fossil fuels.

Oil is a liquid fossil fuel that is formed within the earth from decomposition of ancient organic matter, and is a non-renewable resource. Fossil fuels take millions of years to form and do not regenerate after use. There are many kinds of oil deposits, from clean crude oil to oil sands which require multiple processing steps to make a usable product. Despite many other types of fossil fuels being used (coal, natural gas, shale gas), oil has largely powered the industrial age, and continues to be employed by the industrial economy to produce and transport almost all goods that western culture relies on. A limited list of these includes:

> aspirins, sticky tape, trainer shoes, lycra socks, glue, paints, varnish, foam mattresses, carpets, nylon, polyester, CDs, DVDs, plastic bottles, contact lenses, hair gel, brushes, toothbrushes, rubber gloves, washing-up bowls, electric sockets, plugs, shoe polish, furniture wax, computers, printers, candles, bags, coats, bubble wrap, bicycle pumps, fruit juice containers, rawl plugs, credit cards, loft insulation, PVC windows, shopping bags, lipstick . . . and that's just some of the things made directly from oil, not those that needed fossil fuels and the energy they consume in their manufacture (which is pretty much everything). (Hopkins, 2008: 19)

Less oil availability or very high oil prices will challenge the production and distribution of almost all goods, including those central life itself; it has been observed that oil consumption follows a similar course to economic growth. Hirsch calls oil "the lifeblood of modern civilization" (2005: 8). It is what makes our current lives possible. As suggested by Monbiot (2003) in an article in *The Guardian*, "every generation has its taboo, and ours is this: that the resource upon which our lives have been built is running out. We don't talk about it because we cannot imagine it. This is a civilization in denial." Oil is essential for the most basic functions of modern society; there are currently no viable substitutes for oil at the current rates of consumption, and our entire economic system is built on the assumption that oil will continue to be a relatively inexpensive fuel source (Lerch, 2007: 3).

As early as 1913, Winston Churchill identified the degree of western culture's dependence on oil, when he stated: "If we cannot get oil, we cannot get corn, we cannot get cotton and we cannot get a thousand and one commodities necessary for the preservation of the economic energies of Great Britain" (Maugeri, 2006: 24). Almost one hundred years after this public assertion, the "problem" of oil persists.

Peak Oil Defined

The concept of "peak oil" has been an area of debate for some time (Future Scenarios); however, the debate centres on how to estimate the peak, and on whether or not the dominant culture should be concerned with peaking at present, rather than on the meaning of "peak oil" as a theory. The Hirsch Report, a watershed publication from 2005 that was funded by the government of the USA, emphasizes that "oil production peaking is not 'running out.' Peaking is a reservoir's maximum oil production rate, which typically occurs after roughly half of the recoverable oil in a reservoir has been produced" (Hirsch Report, 2005: 11). Campbell, founder of the Association for the Study of Peak Oil (ASPO), defines peak oil as "the maximum rate of the production of oil in any area under consideration, recognizing that it is a finite natural resource, subject to depletion" (*ASPO International*). Hughes, one of Canada's leading geological experts on peak oil puts this yet another way:

> We're not running out of hydrocarbons yet. What we are running out of is cheap, easily extractable hydrocarbons. This is not a resource problem, it's a rate of supply or deliverability problem. When deliverability can no longer rise to meet growing demand owing to geological, geopolitical and declining net energy issues, we have the beginning of a civilization-defining moment. We will likely never completely run out of hydrocarbons. As my colleague Charlie Hall, who is a professor at the State University of New York, says, 'We will always have enough oil for our bicycle chains.' (2009: 73)

There are many variables that influence when the peak will be reached, as reservoirs that are no longer productive often contain oil that humans do not have the technology to access. Amid the technical knowledge and the various approaches to gauging "the peak," one message is fairly consistent: oil is a finite resource, it will not last forever, and the sooner we begin to address its finite nature, the better. The Hirsch report (2005) is clear: the longer the mitigation time available, the less of a shock there will be.

The Post Carbon Institute, an alliance of scientists and professionals working to assist “societies in their efforts to re-localize communities and adapt to an energy constrained world,” (www.postcarbon.org) has developed a comprehensive “Primer on Peak Oil” (Grubb, 2010). This Primer defines peak oil as “the simplest label for the problem of energy resource depletion, or more specifically, the peak in global oil production.” Oil production is the rate of extraction and refining (currently about 85 million barrels/day), and has grown almost every year for the past 100 years. Thus “the peak” does not mean no more oil, but rather the time when the most oil is produced, after which the cost of oil is more likely to rise rapidly. Simultaneously, after the peak the rate of extraction and refining will continue to decrease. As the easiest, cleanest oil was extracted first, the remaining oil is often found in smaller, more removed or difficult areas, such as off-shore or tar sands, which creates more expensive extraction both economically and environmentally (Grubb, 2010).

Ultimately, the trend towards accelerated rates of decline of oil production support these arguments (Aleklett et al., 2010), as indicated by its fluctuating prices, which range from $28 per barrel in 2003, to $67 in 2007, peaking at $137 in July 2008, and returning to $53 in November 2008 and $36 in January 2009 (Petroleum Navigator, 2010). These arguments are further supported by data from the peak production experienced on a regional level in the United States in 1971 (Bardi, 2009) and in the fact that, between 1960 and 1989, global oil discovery was twice what it produced, whereas between 1990 and 2006, discovery was only half of what was produced (The Peak Oil Debate, 2009).

Oil Information Sources

The following organizations and government branches provide the majority of data on oil reserves, production and use. Though information is somewhat speculative, and debated on many fronts, the baseline data emerges primarily from the US Energy Information Administration, EIA (http://tonto.eia.doe.gov/), and the International Energy Agency, IEA (http://www.iea.org/). The World Energy Council, WEC (www.worldenergy.org) is included as an international energy association.

Energy Information Administration: EIA

The EIA provides independent statistics and analysis from the US Department of Energy. In 2010, it published an “International Energy Outlook” projecting use to 2035, from 2007 baseline data. This predicts increases in all fuel sources, and specifies the following:

> Fossil fuels are expected to continue supplying much of the energy used worldwide. Although liquid fuels remain the largest source of energy, the liquids share of world marketed energy consumption falls from

> 35 percent in 2007 to 30 percent in 2035, as projected high world oil prices lead many energy users to switch away from liquid fuels when feasible. (2010: 1-2)

The EIA further predicts that world oil prices will increase from $79/barrel (USD) in 2010 to $108 in 2020, and to $133 in 2035. In general, the EIA assessments are based on a model of continual growth, with a sidebar focus on environment, greenhouse gas calculations, and strategies beyond conventional energy production. This approach is necessary to perpetuate the current economic model and a culture based on continued expansion.

International Energy Agency: IEA

The IEA formed during the oil crisis of 1973-74, as an intergovernmental organization to advise twenty-eight member countries. Although the initial role of the IEA was to "coordinate measures in times of oil supply emergencies," its current mandate incorporates "the 'Three E's' of balanced energy policy making: energy security, economic development and environmental protection." This include climate change policy, market reform, technology and outreach, especially to major producer and consumers like China, India, Russia and the OPEC countries (International Energy Agency, 2010a). The IEA provides a direct link between climate change, oil production, and oil consumption: in 2009, it published current emissions data from fuel consumption in specific countries, globally, regionally and by sector (International Energy Agency, 2009 and 2011). Although the IEA provides relatively conservative estimates of when oil production will begin its decline, it has acknowledged that oil production will peak, and has revised its former estimates, forecasting peak oil production to occur earlier than previously anticipated if oil demand continues to grow as it has, and if no new reserves are found (Whipple, 2008a, 2008b; The Peak Oil Debate, 2009, International Energy Agency, 2011).

World Energy Council: WEC

The World Energy Council, founded in 1923, prides itself as "the only truly global and inclusive forum for thought-leadership and tangible engagement committed to our sustainable energy future" (World Energy Council, 2010). It is a network of 93 national committees that represent over 3000 governmental, industrial and expert institutions and organizations. The mission of the WEC is to "promote the sustainable supply and use of energy for the greatest benefit of all." (World Energy Council, 2010 and 2011). To that end, the WEC holds an annual World Energy Congress, the most recent of which was held in Montreal in September, 2010.

In 2009, WEC published "World Energy and Climate Policy: 2009 Assessment." This document identified inequality, supply/demand uncertainty, and country best practices in countries grouped according to whether they are net producers or consumers, and according to per capita income. The WEC uses a specific methodology to assess and compare countries' energy use and policy, in relation to socioeconomics and the environment, evaluating national policies, regulations and standards, and relating these to each country's ability to create and implement new policy. Secondly, the WEC looks at specific energy policies to assess how they work in practice, and provides key learnings. The WEC's 2009 findings for Canadian Policy are:

- Canada has built a diversified energy supply chain and is encouraging a number of provinces to increase the use of alternative energy sources (such as wind). Moreover, Canada is developing advanced Generation III+ nuclear technology in collaboration with the Advanced Candu Reactor to increase nuclear energy capacity.
- Canada has a long-term energy infrastructure investment policy to maintain its position as a global "energy superpower." By making multi-billion dollar investments in further developing the Canadian oil sands and increasing wind and hydroelectric capacity, Canada seeks to achieve competitive and abundant energy supply with acceptable environmental footprints.
- Canada seeks to provide energy at low cost to promote the social and economic well-bring [sic] of all Canadians. (World Energy Council, 2009: 111)

WEC's 2009 report provides statistics on Canadian reliance on different types of energy, and is replicated below to highlight how Canada's reliance on fossil fuels, including coal, oil and gas, hovers around 75% of all energy use:

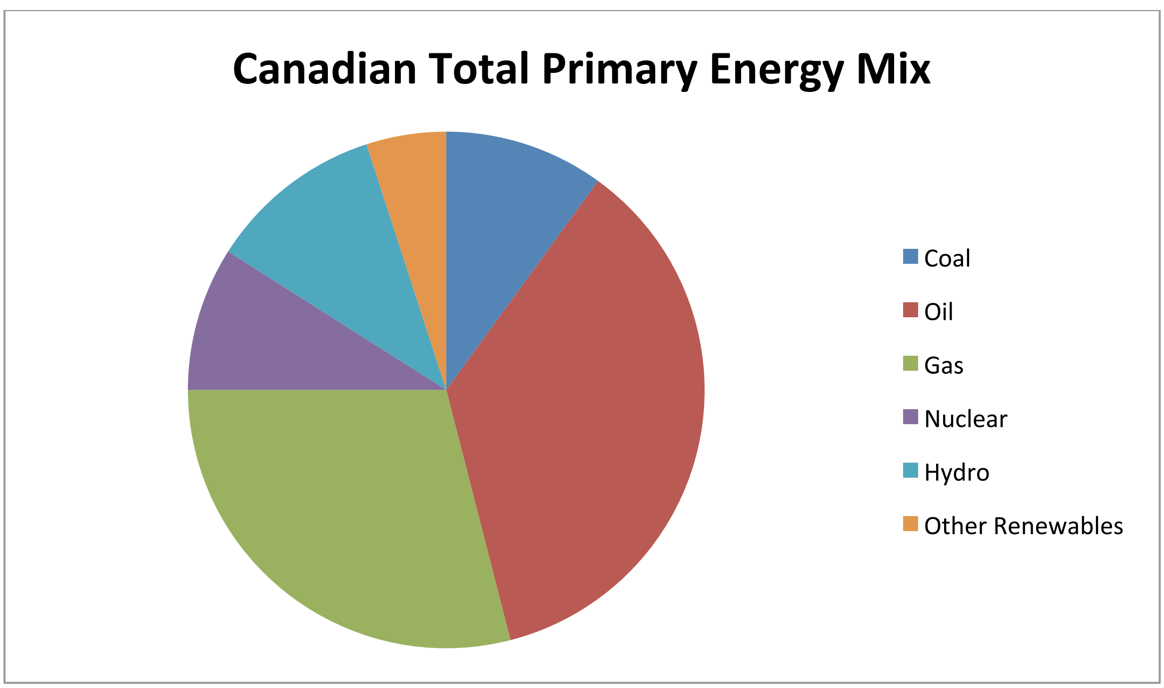

Figure 1: Canada's Energy Use

Source: World Energy Council, 2009: 111

Canadians are not alone in heavy reliance on fossil fuels. Globally, oil accounts for 43% of fuel consumption and 95% of energy used for transportation (Grubb, 2010).

Developments in Peak Oil Theory

The theories on oil production, consumption and the theory of peak oil are derived from oil information generated by oil companies, governments, and intergovernmental organizations, as indicated in the previous section. Some of the most active voices are former and current industry insiders. The personalities highlighted in this section by no means include all academics and industry insiders who have added to the dialogue on peak oil, but rather some who have made major theoretical contributions.

M. King Hubbert (1903 - 1989)

In 1956, Hubbert was the first to call attention to the tendency of oil production to peak when he accurately predicted a peak in US oil production in American Petroleum Institute's journal *Drilling and Production Practice*. An American geologist in the 1950s, Hubbert was working for Shell Oil when he noticed that a graph of oil discoveries over time produced a bell-shaped curve. From this, he postulated that the rate of oil production from these discoveries would follow a similar curve, later in time. This is now known as the Hubbert Curve, with which Hubbert accurately predicted that US oil production, in the lower 48 states, would peak between 1965 and 1970 (Grubb, 2010), as indicated in the graph below:

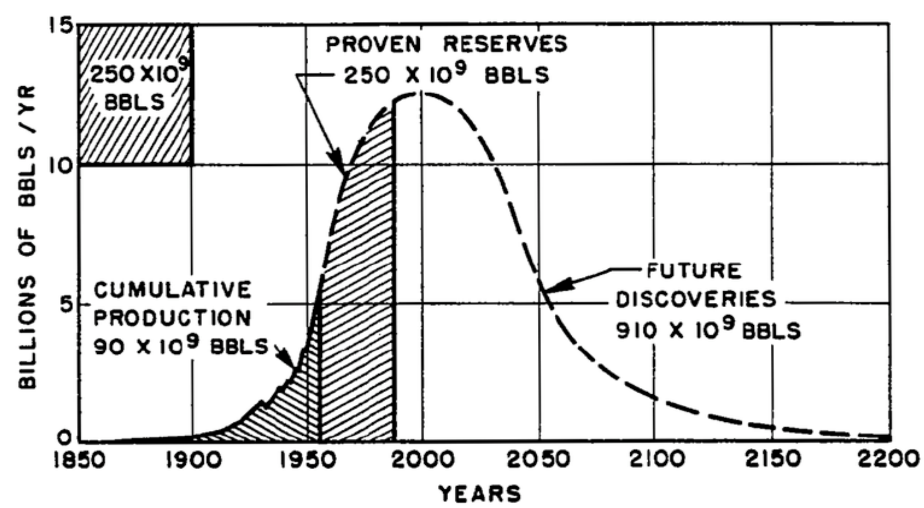

Figure 2: Hubbert's Original Curve

Source: Hubbert, 1956

Hubbert published his findings, even though Shell Oil pressured him to keep his projections out of the public arena. Despite industry dismissal of Hubbert's projections, the date of maximum US oil production (1970/71) is now a fact (Deffeyes, 2001). It is notably impossible to tell definitively when peak oil is occurring: it is only after the peak, when the records show production decline that the date of the peak is established. As long as the rate of production continues to rise or plateau, the peak has not yet been reached.

It is important to note that Hubbert's bell shaped curve does not fit any oil production curve exactly, as every area has unique geological, economic and political factors (Grubb, 2010); nonetheless, Hubbert's observations and curve continue to reverberate throughout peak predictions. In 2009, Bardi and Lavacchi published "A Simple Interpretation of Hubbert's Model of Resource Exploitation" in the journal *Energies*, which outlines the continued importance of Hubbert's work in understanding non-renewable resources. Bardi and Lavacchi revisit Hubbert's model, and emphasize its use "as a tool for understanding the mechanisms of resource exploitation." (2009: 648) Despite Hubbert's inaccurate prediction that the global peak would occur in 1995, he did come to a timely understanding of fossil fuels and the implications of their use:

> The present pattern of rapid growth in the human population, in the per capita consumption of non-renewable resource, and in the degree of human disruption of established ecosystems is an ephemeral phenomenon which will come to an end soon, either abruptly, as a result of a natural catastrophic collapse of our global technological civilization, or gradually, through a planned transition to a stable, near steady state. (Engelhardt, Goguel, Hubbert, Prentice, Price &Trümpy, 1976: 193).

Hubbert's Legacy

Hubbert's assessment and theory for understanding oil depletion rings true for many analysts and experts, including Deffeyes (2005, 2001), Simmons (2005), Campbell (2002, 1997) and Heinberg (2010, 2009, 2007, 2006, 2004, 2003). These active voices in the peak oil debate are worthy of a short overview; however, there are countless others who are weighing in on the data recording and mitigation efforts.

Deffeyes, like Hubbert, spent his early career in the oil industry, but left because of Hubbert's prediction and entered academia. In *Hubbert's Peak: The Impending World Oil Shortage* (2001), Deffeyes draws attention to strategic investment in fossil fuels, and alternative investment possibilities, while also suggesting that the global peak "may even occur before 2004," (2001: 12) which has since been proven false. When this date proved unrealistic, Deffeyes turned to studies on energy sources other than oil (including gas, coal, tar sands / heavy oil, oil shale, uranium and hydrogen) to predict a global oil peak in 2005 / 2006, which also proved incorrect. Nonetheless, Deffeyes notes an increasingly relevant fact: that "global per capita oil production peaked in 1979. Since 1979 the world has been producing people faster than we have been producing oil" (Deffeyes, 2005: 177). Deffeyes thus calls renewed attention to oil peaking, and relates it directly to consumption: even if production has not yet peaked, the potential rate of consumption is increasing exponentially with population.

Simmons, a Texan investment banker, entrepreneur in the oil industry, and self-proclaimed anti-environmentalist, published a statement in 2004 claiming that Saudi Arabia's oil reserves had been grossly overestimated (Maugeri: 188). Simmons is far from alone in his belief that OPEC member countries exaggerate their reserves, and skew reports from the EIA and IEA that depend on countries' reported reserves (Rudd, 2008: 6). In 2005, Simmons published *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy*, outlining his views on the oil industry, and the inevitable supply problems that he stoutly believes unavoidable. Simmons was convinced that sudden and drastic oil production declines could happen with no warning and made waves in his rejection of global oil estimates, and his acceptance of the coming end of the oil age.

Campbell was also greatly influenced by Hubbert's work, and moved towards public education on what he believes to be a coming crisis. Campbell started his career in the oil industry, but quickly turned to publishing and educating about peak oil. He is, perhaps, the globe's most quoted peak oil theorist, pointedly using established facts to draw attention to future implications. In 1997, Campbell authored *The Coming Oil Crisis*, which he followed in March of 1998 with an article "The End of Cheap Oil" (co-authored with Laherrere) in *Scientific American*. Campbell has played a pivotal role in gathering scientists and other experts to study peak oil's timing and potential effects. To this end, Campbell founded the Association for the Study of Peak Oil and Gas (ASPO) in 2000, which has become increasingly active and has an international branch, as well as country-specific branches. ASPO has convened annual international conferences since 2002, and has a mandate to:

1. Define and evaluate the world's endowment of oil and gas;
2. Model depletion, taking due account of demand, economics, technology and politics;
3. Raise awareness of the serious consequences for Mankind [sic]. (About ASPO, 2008).

In 2002, Campbell published "Petroleum and People" in the journal *Population and Environment*. In this, he does not shy from revealing that oil field discovery "peaked in the 1960s, meaning that the corresponding peak of production is now imminent" (2002: 193). He further writes:

> Peak oil threatens to be a historic discontinuity as the economic growth of the past century, which was driven by an abundant supply of cheap oil-based energy, gives way to decline. The population of the world, which grew six-fold in parallel with oil, faces decline probably accompanied by rising migration pressures. Radical new political structures may be needed in a world facing ever deeper resource and environmental constraints.

Campbell's work is extremely influential, particularly in contributing to Heinberg's analysis and the creation of the Post Carbon Institute to move forward by recognizing the challenge, and encouraging dialogue on how to transition from fossil fuels.

Heinberg (http://richardheinberg.com/) has written extensively on peak oil and to the dialogue on how to prepare. He has authored a number of books, including *Blackout: Coal, Climate, and the Last Energy Crisis* (2009), *Peak Everything* (2007), *The Party's Over: Oil, War and the Fate of Industrial Societies* (2003), *Powerdown: Options and Actions for a Post-Carbon World* (2004), and *The Oil Depletion Protocol* (2006). He has recently edited a book with Daniel Lerch, entitled *The Post Carbon Reader: Managing the 21st Century's Sustainability Crisis* (2010). Heinberg is a Senior Fellow with the Post Carbon Institute that works towards the "transition to a more resilient, equitable, and sustainable world" (www.postcarbon.org, 2011). In 2009, the Post Carbon Institute published a manifesto entitled "The Time for Change has Come." This document outlines the approach of the Post Carbon Institute to the dual crises of climate change and peak oil. The approach is based on seeing the problems of the 21st century as inter-related and working in concert to move towards a more sustainable, equitable world. The essays gathered the Post Carbon Institute's *The Post Carbon Reader* (2010) expand on the 2009 manifesto.

Robert Hirsch and the Hirsch Report

In February 2005, Robert Hirsch and his team, Bezdek, and Wendling, of the Science Applications International Corporation (SAIC) released "Peaking of World Oil Production: Impacts, Mitigation, & Risk Management," a report commissioned by the United States Department of Energy that has come to be referred to as the "Hirsch Report." The executive summary for this report addresses the peak oil concerns identified by analysts such as those outlined above, and the report emerged with sponsorship from the US government. The concerns about peak oil set the tone for Hirsch's analysis and discussion:

> The peaking of world oil production presents the U.S. and the world with an unprecedented risk management problem. As peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented. Viable mitigation options exist on both the supply and demand sides, but to have substantial impact, they must be initiated more than a decade in advance of peaking. (Hirsch, Bezdek, & Wendling, 2005: 4)

After 2002, Hirsch began recommending that the world spending $1 trillion annually for at least a decade before an anticipated peak to avoid dire consequences (Grubb, 2010). Hirsch has become involved with ASPO, through presenting at their conferences, and in 2010 published *The Impending World Energy Mess; What it is, and What it means to YOU!* largely focused on how to manage the crisis that peak oil would represent (Hirsch, Bezdek, &Wendling, 2010).

Criticisms of the Peak Oil Theory

Like any theory, and particularly any theory that rests on retrospection for ultimate proof, peak oil theory has had a broad spectrum of detractors.

Contrary to the accepted fact that oil is non-renewable, in the late 1990s it was suggested by Thomas Gold, a respected and acclaimed physicist (though notably not a geologist), that oil is continually produced by microbes and other life that feed on hydrocarbons deep within the earth (Gold, 1999). This “abiotic origin” theory is not taken seriously by industry, government or the scientific community, despite Gold’s proven record with unconventional theories in other realms (Morton, 2000).

Another notable academic detractor is Maugeri, who dismissed peak oil theory in a 2004 article in *Science* as "the current model of oil doomsters." Maugeri went on to publish *The Age of Oil: The Mythology, History, and Future of the World’s Most Controversial Resource* in 2006, which presents an historical account of oil use in the making of modern USA, and the various oil shocks and economic rebounds of the twentieth century. Maugeri traces peak oil alarmists within the United States government through the 20th century, including US Secretary of State Harold Ickes and the 1970s Middle East expert James Akins who repeatedly warned about the risk of running out of oil (Maugeri, 2006). Maugeri highlights the American geopolitical perspective, identifying George Bush Jr.’s Jan. 31st, 2006 State of the Union Address, wherein Bush comments that “America is addicted to oil, which is often imported from unstable parts of the world” (Ibid., 197). Maugeri uses historical analysis of the politics of oil to criticize the Hubbert model, indicating that it is “inherent[ly] incapab[le] of predicting political decisions affecting production, change of habits affecting consumption, price trends and technological evolutions” (Ibid., 204). In turn, Maugeri suggests that a peak will happen, but that “peak production can be increased or delayed” (Ibid., 205).

Maugeri's analysis is supported by Canadian economist Michael Lynch, who argues that production is determined by many factors beyond geology, including politics, economics, and the processes of exploiting reserves (Lynch, 2003). These ideas are also supported by Mouawad, who focuses on new technologies that become relevant as oil prices rise (2007). Maugeri, Lynch and Mouawad are united with other opponents to peak oil theory, who deny an impending peak based on factors beyond the physical restraints of oil production. Most argue that although oil deposits may be finite, high prices will bring about technological improvements that will make extraction from more challenging geological conditions economically feasible (The Peak Oil Debate, 2009; Bardi, 2009).

Abdullah S. Jum'ah, President, Director and CEO of Saudi Aramco until 2008, believes that conventional and non-conventional oil may total 13 to 16 trillion barrels, whereas to date 1.1 trillion barrels have been extracted (Jum'ah, 2009).John R. Boyce, an economist at the University of Calgary, concurs with Jum'ah and Hubbert detractors. Boyce studied oil discovery and production in 24 US states and 44 countries, and came to the conclusion that "the peak oil model is an inadequate empirical representation of historical patterns. This is not to say that oil production may not eventually peak. It does say that the peak oil model will have little, if anything, to say about it." (Boyce, quoted in Reynolds, 2010)The debate continues with Hubbertians and Hubbert detractors who disagree about the model of prediction, but who largely agree that oil is finite and needed for the current western lifestyle.

Estimating the Peak

In general, "the peak" is understood as the point where the rate of oil extraction reaches a maximum and then begins to decline irreversibly; it is effectively the point where roughly half of the non-renewable resource is depleted (Bardi, 2009). Although determining a date for the peak may be useful for conceptualizing what might occur afterwards, Hirsch, Bezdek and Wendling (2005) point out that determining the date is less important that the mitigation time available. Determining a specific date, whether or not it is very useful, has been the subject of much debate. Bardi (2009), Whipple (2008a, 2008b), The Economist (2009), de Almeida and Silva (2009), and Reynolds (2010) argue that the peak will occur at some point between 2010 and 2020. It is also argued that the peak of oil production has already taken place (The Peak Oil Debate, 2009; Heinberg, 2007; Future Scenarios). Analysis after the passing of time is the only way to ascertain when the actual peak occurs.

Factors that affect the date of peaking are multitudinous and include the changing political and economic global tides, technical invention as well as the physical challenges of oil production. As previously mentioned, Hubbert predicted the global peak between 1990 and 2000, but was proven incorrect (Heinberg, 2003: 90). Hubbert was not alone in this prediction. Under the energy-conscious Carter administration, The National Academy of Science (NAS) and National Academy of Engineering (NAE) conducted a thorough review of energy policy in the United States in 1977 and concluded that global oil production would peak in the 1990s (National Research Council, 1982). A team of 350 scientists from universities, government, and industry were part of this effort, and their conclusions were faulty primarily due to the 1973 and 1979 oil crises creating high prices that lowered demand, reduced consumption and caused a global economic recession that slowed the production and consumption of oil. In turn, the peak was pushed back (Heinberg, 2003: 90). Despite the seeming inadequacies of Hubbert's model, his methods have persisted and projections continue to be made with the Hubbert curve based on current data (Rudd, 2008). Perhaps the largest barrier to accurate predictions is the potentially inaccurate data on remaining reserves. It has been alleged that countries exaggerate reserves, and particular criticism has emerged to bring into question the reporting of OPEC member countries (Zittel, Schindler, Systemtechn, 2004). Despite this uncertainty, many notable geologists, politicians, researchers, economists, CEOs, journalists, and analysts continue to weigh in on "when" the peak will happen, having moved past questioning whether or not it will. There is no consensus on an actual date; however, very few are suggesting dates beyond 2030.

The IEA, in November 2010, released their World Energy Outlook 2010. The chart they outline for their "New Policies Scenario" describes a changed outlook from this energy information source: the chart suggests that the peak in crude oil has already happened, and any growth in energy supply will come from other sources:

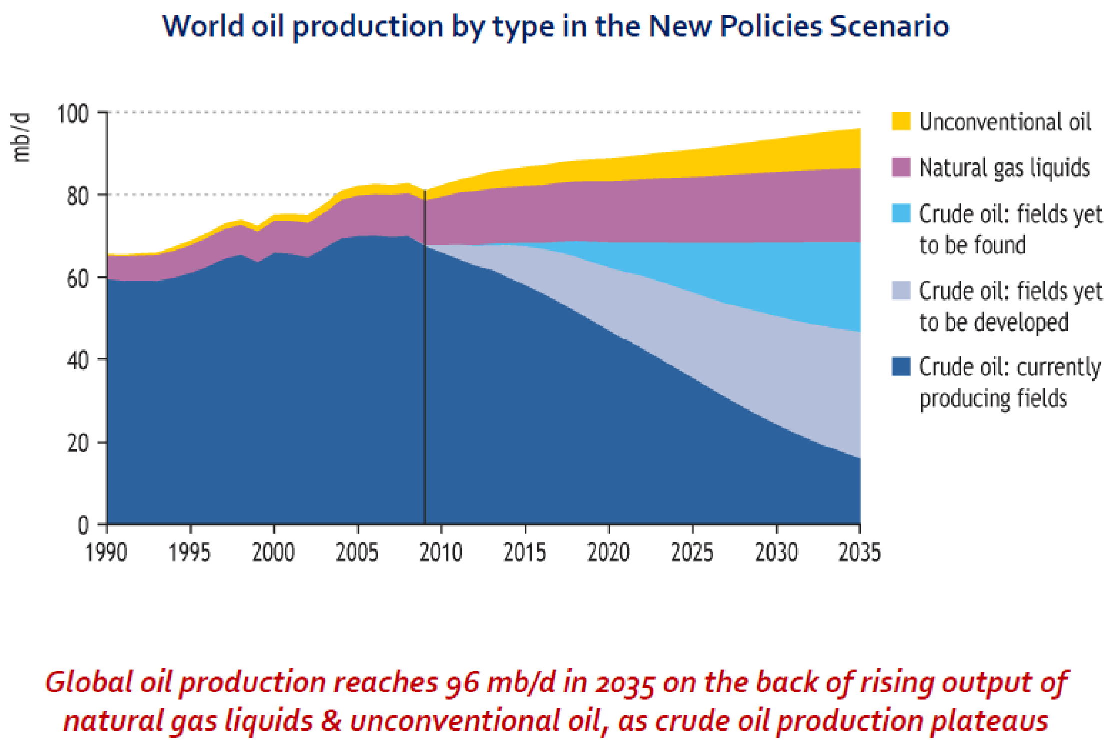

Figure 3: IEA Projections

Source: IEA World Energy Outlook, 2010c

The growing concern about peak oil in industry and political circles is also worthy of note. James Schlesinger, former CIA director, defense secretary, and energy secretary for successive US administrations, has urged the US Senate to prepare for peak oil, and spoke at the 2010 ASPO conference in Washington to this effect.[2] Similarly, the Post-Carbon Institute's "Peak Oil Primer" (Grubb, 2010) asserts that up to 54 of the world's 65 heaviest oil producing countries are now in decline (including the USA, which peaked in 1970; Indonesia, peaked in 2000; the UK, in 1999; Norway, 2001; Mexico, 2004). Further, Grubb questions the potential rate of decline, asserting that "Some form of coordinated adaptation might be possible if the annual drop in available oil was no more severe than 1-2% a year. Whereas 10% or more would soon implode the global economy. Most models project decline rates of 2-4%." The IEA's projections for the decline of current crude oil, as detailed in the graph above, suggest a sharp drop, with heavy dependence on new finds and other types of energy filling in the shortfall.

[2] Schlesinger's speech is available online at http://www.energybulletin.net/stories/2010-10-30/peak-oil-debate-over

Fossil Fuels and Alternatives

Although oil is the mainstay of the transportation sector as well as one of the top four electricity-generating industries in Canada (after coal, nuclear, and hydroelectricity) , fossil fuels as a group require consideration in terms of longer-term availability. "Peak Oil" gains much attention, but thinking only of oil can act as a blinder to considering that much of what we know and depend on relies on non-renewable resources that will eventually decline and / or become too expensive to obtain. In 2007 Heinberg, fellow of the Post Carbon Institute and peak oil aficionado, published *Peak Everything: Waking up to the Century of Declines*, the title of which summarizes the timbre of his analysis. Heinberg is firmly supported by Peňuelas and Carnicer who state that "[t]he strong environmental effects of greenhouse gas emissions derived from oil use and the negative socioeconomic consequences of future oil scarcity make it urgent that we shift to alternative affordable energy sources" (2010: 85).

The concept of Energy Returned on Energy Invested ratio (EROEI) can be useful in understanding energy availability. In the early years of oil production, one barrel of oil used for exploring could return up to 100 barrels for future use; some oil fields thus had an EROEI ratio of 1:100. When oil comes from more difficult places to access, the ratio changes dramatically, and some energy sources, including some types of biodiesel and ethanol production, and shale oil, may have an EROEI ratio that is less than one (Grubb, 2010). This results in a net loss of energy available. Another lauded replacement to oil, hydrogen gas, is largely misunderstood. Hydrogen is not an energy source, but rather an energy carrier, which requires energy to produce. Even though wind, solar thermal and hydro-power do have positive EROEI ratios, they are site specific and will require dedicated effort to replace the fossil fuels which are currently relied upon. Heinberg provides a useful simile for the comparison of renewable energy to fossil fuels: "whereas fossil fuels are akin to a massive inheritance, one spent rather drunkenly, renewables are much more like a hard won energy wage" (quoted in Grubb, 2010). Further, for those who advocate natural gas, there is little debate that European and North American production has already peaked, thus presenting a dual energy crisis in these regions (Grubb, 2010). The alternatives to energy production and transportation that seem poised to alleviate some of the dependence on fossil fuels (wind/ solar/ thermal/ tidal power, hydrogen/ electric cars etc.) might alleviate some of the shock of declining fossil fuels. Nonetheless, oil is part of everything we know, and there is no single alternative that can replace its subtle and overwhelming importance in the predominant western culture.

Climate change and peak oil are deemed to be "twin" issues because of their level of interconnectedness, as "oil use is responsible for approximately one-third of greenhouse gases"

(Newman, Beatley and Boyer, 2009: 7). Both those problems are complex, and are associated with a great deal of uncertainty. For example, it is possible that the costs of adapting to climate change may coincide with a time at which the economy is strained from rising energy prices. One typical way planners handle such uncertainty is through scenario-building exercises, which is an emerging and dynamic field for climate change and peak oil. There is a wide range of scenarios in the literature, each with specific sets of implications.

Holmgren (2009) identifies four broad categories of scenarios: *techno-explosion*, which could go so far as to include colonizing other planets for resources; *techno-stability*, a favourite of those who argue that once sustainable systems are in place, a steady-state stable sustainable society can flourish; *energy descent* that involves a reduction in economic activity, complexity, and population as fossil fuels are depleted and a ruralisation of settlement and economy; and *collapse*, a scenario characterised by a rapid decline in population and biodiversity loss. Holmgren argues that the mounting evidence on future climatic conditions and trends for global oil supply and demand suggest that the next energy transition will have transformative effects on the social and physical fabric of industrial society. His argument is based on the concept of net energy and energy quality; in short, no other source of energy has the same "bang for the buck" as fossil fuels, which makes continued and increasing supply for energy highly unlikely. Taken together, Holmgren predicts that "some sort of energy descent [is] increasingly likely despite the deep structural and psychological denial of the evidence" (Holmgren, 2009: 28). Some authors such as Curtis (2009) suggest that localization is a peak oil mitigation and adaptation strategy. He uses the term "peak globalization" to explain how peak oil and climate change undermine globalization by creating conditions for increased prices of goods and transportation, which will likely result in shorter supply chains that encourage goods to be produced close to where they are consumed.

Energy descent relates to the basic principles of Permaculture, a set of environmental design principles for low-energy lifestyles. Permaculture can play an increasing role in future decision-making by planners and local governments as an adaptive strategy for peak oil and climate change (Holmgren, 2009).Permaculture design has played a central role in Cuban urban agriculture design as it developed during Cuba's "Special Period" after the collapse of the Soviet Union, during which Cuba experienced drastically increased oil prices and oil shortages that transformed all aspects of planning (Holmgren, 2009; Morgan, 2006). According to Hopkins (2009), Permaculture principles have a role to play in planning for resilient communities and fostering the attainment of creative solutions to climate change and peak oil while respecting natural ecosystems (Hopkins, 2009). These principles include diversity of livelihoods, land use, enterprise, and energy systems; modularity, or increased self-reliance; and, tightness of feedbacks and localization of energy systems, building materials, food production, and other necessities.

Almost all peak oil and climate change literature suggests that peak oil is looming, and asserts that climate change is happening. Planning, as a future-oriented profession working for the public interest, must respond: "Adaptation to climate change is essential for municipal governments to protect the well-being of citizens and to manage public resources effectively" (C-CIARN, 2006: 26). Diamond (2006)describes how some settlements in Greenland, Iceland, and Easter Island collapsed due to mismanagement of natural resources and inability to adapt to environmental change. However, societies can create resilient communities that use less oil, which, according to Newman et al (2009: 11), could increase quality of life, reduce impacts on the environment and on human health, result in greater equity and economic gain, lessened economic vulnerability and a more peaceful geopolitical context. In a world characterized by rapidly occurring change, peak oil and climate change are two drivers that have far reaching implications for societies reliant on fossil fuels. This is the context in which "community members [can] collectively and strategically engage their resources to respond to change" (Magis, 2010: 405) by increasing community resilience.

Resilience to climate change and peak oil

Climate change adaptation specialists Nelson, Adger, and Brown (2007) argue that resilience provides a useful framework for analyzing climate change adaptation processes and identifying appropriate policy responses. Resilience is a multi-faceted and dynamic concept; as Coutu noted (2002: 42), "resilience is one of the greatest puzzles of human nature." In fact, there is a plurality of definitions for resilience from different disciplinary fields (Gallopin, 2006: 293), ranging from mental health to public health, disaster response, socio-ecological systems, community development and natural resource management. Definitional work on resilience includes Ahmed's (2006) compilation of 13 definitions from secondary sources, and Magis' (2007) literature and practice review on community resilience. This section will provide an overview of the topic to date.

The concept of resilience originates in ecology where it generally refers to the ability to withstand stress and recover quickly. Nelson, Adger et al (2007) describe resilience of socio-ecological systems as the amount of change a system can undergo while retaining the same function, and structure, and options to develop. In the planning profession, building resilience is most often conceptualized as part of disaster preparedness, and resilience often responds to specific, one-off types of natural disasters such as floods, tsunamis, earthquakes, etc. For example, Godschalk (2003, in Ahmed, 2006) suggests characteristics of resilient systems that can create disaster-resilient cities. These include:

redundancy- systems designed with multiple nodes to ensure that failure of one component does not cause the entire system to fail

diversity- multiple components or nodes versus a central node, to protect against a site specific threat

efficiency- positive ratio of energy supplied to energy delivered by a dynamic system

autonomy- capability to operate independent of outside control

strength- power to resist a hazard force or attack

interdependence- integrated system components to support each other

adaptability- capacity to learn from experience and the flexibility to change

collaboration- multiple opportunities and incentives for broad stakeholder participation

The literature suggest that the concept of resilience building can be broadened to include adaptation to other types of phenomena that are more long-term, such as those brought about by climate change and peak oil. According to Newman et al. (2009), planners can use technologies such as small scale water, waste and renewable energy systems, biomimicry, green chemistry and industrial ecology to rethink communities and move toward more localized, polycentric, distributed and eco-efficient approaches that prepare for climate change and the end of cheap oil (Newman et al, 2009). Daniel Lerch, Program Director at the Post Carbon Institute, argues that “to truly build the resilience of all our communities against the coming changes in the global oil supply, urban planners and policymakers will need to turn aggressively to more systems-informed approaches to community governance and development” (Lerch, 2009). This leads into a discussion of the concept of community resilience, with which this paper is concerned.

Community Resilience

Within the literature, consensus is emerging that building resilience at three nested levels - psychological/personal, community, and systems - must be at the centre of convergent social justice and environmental social change movements (Poland, Feitosa, Teelucksingh, Schugurensky and Motzchnig-Pitrik, 2009). Norris, Stevens, Pfefferbam, Wyche and Pfefferbam (2008) describe community resilience as a process of linking a network of adaptive capacities to adaptation after a disturbance or adversity. These capacities include economic development, social capital, information and communication, and community competence.

Change is a key word in literature on community resilience. Magis (2010) proposes that "change" is the main factor that distinguishes community resilience from the more well-known concept of community capacity. Resilience is increasingly important in planning, as change is a constant and inevitable feature of modern societies with the uncertainties brought about by climate change and peak oil. Resilient communities are able to "bounce back" in the face of change. Change, however, is not inherently negative or positive, and planners have the agency to orient the direction of change and affect it:

> Resilient communities do not simply withstand or react to external pressures; rather, they initiate positive change and are enriched and unified in the process. They embody the idea that no matter where you live, or whatever constraints you face in terms of location or resources, you can, with the right support, create a vibrant, sustainable and equitable community, which should defy even the most destructive impacts of social, economic, political, technological and economic change. (Carnegie Commission for Rural Community Development, 2007, in MacDonald, 2009: 1)

In addition to responding to change, resilience reduces vulnerability and builds adaptive capacity (Magis, 2010; Gallopin, 2006). Many authors perceive resilience as being a state that it is either achieved or not. However, others argue that community resilience is a process, not an end goal. In constructing a model based on mixed methods research in three resource-dependent rural communities in Western Canada, Kulig, Edge and Joyce (2008: 77) conceptualize community resilience as a process. That process can be seen as a flow chart in which a "sense of belonging" begets the expression of a "sense of community" and togetherness, which in turn begets "some type of community action, noted by the presence of visionary leadership, an ability to deal with change in a positive way, an ability to cope with divisions, and the emergence of a community problem-solving process." This research aligns with the findings of Maybery, Pope, Hodgins, Hitchenor and Sheperd (2009) that social and community connectedness are crucial determinants of community resilience and well-being: that the social aspects of community resilience are crucial.

Actions can be taken to increase resilience in any community. In developing community resilience, some critical elements compiled by Callaghan and Colton (2008: 932) include: planning and developing strategies that minimize vulnerabilities, developing communication and crisis response systems, supporting government/private partnerships and independent initiatives that create social support, and developing strategies that diversify risk across space, time, and institution. Also important is nurturing diversity to enable post-shock reorganization and renewal, and to enable parties with different kinds of knowledge to self-organize and engage in social learning (Berkes and Seixas, 2005, in Magis, 2010). Resilient communities have thus been described, by a group seeking to increase resilience in the San Francisco Bay area, as communities that use their assets in creative ways to withstand and recover from hard times, meet basic human needs, and show strength and creativity, no matter what the circumstances (Bay Localize, 2009). In order to “bounce back”, resilient communities are proactive, not reactive. In fact, Colussi, Lewis, Lockhart, Perry, Rowcliffe and McNair (1999: 11), in a Canadian Centre for Community Renewal publication intended to guide communities towards increased resilience, defines a resilient community as "one that takes intentional action to enhance the personal and collective capacity of its citizens and institutions to respond to, and influence the course of change".

Magis, after conducting an extensive literature review on community resilience, defines community resilience as follows (2010: 401):

> the existence, development, and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability, and surprise. Resilient communities intentionally develop personal and collective capacity to respond to and influence change, to sustain and renew the community and to develop new trajectories for the community’s future.

Magis (2007a) develops an Index of Community Resilience, which presents five key constituents. She argues that social and physical infrastructure must be in place to provide community space in which to gather, learn and collaborate. In addition, the community needs financial resources, collective knowledge, skills and abilities to anticipate and respond to change, and a diversity of community members actively engaged in strategic community planning. This can be boiled down to five key areas of community resources or capital (social, physical/financial, human, political, and cultural) that need to be present, developed and engaged in resilient communities:

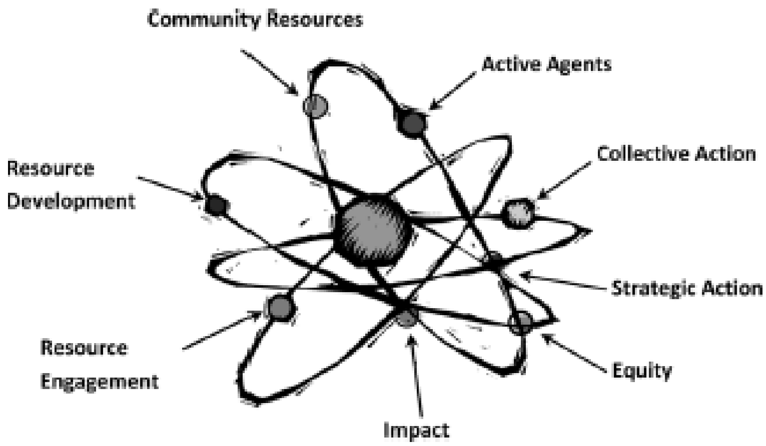

Figure 4: Conceptual Framework for Community Resilience

Source: Magis, 2007a

The place of collective action, active agents and community resource mobilization in Magis' framework echoes findings from many studies that indicate the role of community building in resilient communities, which is further explored in the next section.

Community building in resilient communities

Numerous authors have mentioned different aspects of community building as a pinnacle element of community resilience. Breton (2001, in Kulig et al, 2008: 77) has noted that resilience is dependent upon neighbour networks and active local voluntary associations. Szerzvniski (1997, in Balls, 2010: 18), argues that community-led movements are now as important as governmental top-down action in terms of practical sustainability. Narrowing in on the social side, Adger (2003) defines social resilience as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change. Adger suggests that different sources of social resilience include social networks, lessons learnt from past experience, high diversity, learning through consensus building, and strong support networks. He also argues that:

> Building trust and cooperation between actors in the state and civil society over [climate change] adaptation has double benefits. First, from an instrumentalist perspective, synergistic social capital and inclusive decision-making institutions promote the sustainability and legitimacy of any adaptation strategy. Second, adaptation processes that are built from the bottom up and are based on social capital can alter the perceptions of climate change from a global to a local problem. (Adger, 2003: 401)

Colussi (2000) has observed that social and economic development organizations in resilient communities work to inform and engage the public and demonstrate high levels of collaboration with each other. To be resilient themselves, Anderson (1994, in Cadell, Karabanow, and Sanchez, 2001: 27) states that organisations need to possess five characteristics: (a) a clear mission, (b) shared decision-making, (c) trust-building, (d) the encouragement of openness, and (e) the enhanced competence of the individual and the collective. Social aspects of community resilience relevant to the work of community organizations include engagement, education, empowerment and encouragement (Edwards, 2008: 11).

Callaghan and Colton (2008: 940) argue that "ultimately the success of building a sustainable and resilient community depends on strong leadership, vision, and clear and open communication". Here again, the multifaceted character of issues at hand, and the diversity of players involved, call for innovative responses, namely a new kind of leadership ("leading between") focused on building collaborative relationships built on mutual respect rather than formal authority; further, social innovation will be an important aspect needed in this context (Torjman, 2007). Lerch (2007) advises local governments to do anything they can to get people talking with each other, forming relationships, and investing in the larger community.

In summary, if the arguments on the role of community building in creating resilient communities hold true, then planners and local governments should consider working with civil society in responding to climate change and peak oil by building social capital. Well-connected citizens' organizations engaged in formal and informal partnerships with local governments who are committed to supporting grassroots community action could be an important piece of planning for resilient communities. However, those alliances are in early stages in Ontario and much still remains to advance potential alliances. For complex issues it has been argued that local governments cannot be content to follow public opinion, but must show leadership, engage partners, set the agenda, take risks, and be a role model (Noble and Abram, 2008: 13). The question remains as to whether or not local governments have the capacity to achieve such a level of leadership on climate change and peak oil with their current level of resources and expertise. The following section elucidates how municipalities can show such leadership.

Planning for Resilient Communities

Planners and local governments are uniquely positioned to respond to the challenges and implications of climate change and peak oil: while "resilience theory lends itself to many disciplines, few are better suited to the approach than land use planning" (Environment Commissioner of Ontario, 2009). The potential implications include strained global water resources, volatile food supplies, economic contraction, increased conflict over key natural resources, and strained ecosystems (Bay Localize, 2009: 22). Local governments have influence over three key areas of spatial and economic development: building construction and energy efficiency (through zoning by-laws, building codes and permitting processes), local land use and transportation patterns (mobility choices), and local economic activity that pose opportunities to encourage development in low-energy, zero-carbon directions by both incentive and example (Lerch, 2007: vi). It is in every municipality's best economic interest to act on these issues, because higher level governments cannot see the details that local governments can, and are often slow to respond (Lerch, 2007:27). While no easy task, building resilience to climate change and peak oil is not impossible:

> Although the climate crisis is new, many of the underlying challenges are not. Local governments have dealt with other environmental and social problems in the past. They have lots of experience managing the "messiness" and getting it done. They know the importance of leadership, of successful change management, of innovation and risk-taking, of getting started. Much of this experience is relevant to the climate change challenge (Noble and Abram, 2008: 13).

There are encouraging and effective ways that planners are responding to the impacts of climate change and peak oil; one can think of Smart Growth policies and the Healthy Communities movement, as well as the sub-field of disaster preparedness, as examples of planners confronting interrelated, complex issues. Research by Harvey (2009) and Lerch (2007) has shown that mitigation measures with the greatest potential are related to energy efficiency, reducing energy consumption, and producing fossil-fuel free renewable energy locally. All of these are areas that planners can influence through guidelines for urban land-use planning that make energy use and production the principal determinant in land-use decisions, resulting in favouring "brownfield" over "greenfield" development, planning for mixed uses and intensification, fostering vibrant centres, and ensuring low-energy transport (Gilbert, 2006: 38). In addition, according to the UK Sustainable Development Commission (Owen, 2009), social planning policy supporting a diverse local service base, as well as land use planning policy supporting the creation of public space for community involvement and neighbourliness are two important features of a resilient community.

Any element of building resilience to climate change and peak oil must include creating and implementing a strategic plan (Ligeti, Penney, Wieditz, 2007, xi). Lerch (2007) advises councils aiming for resilience to publicly commit to action by endorsing the World Mayors and Municipal Leaders Declaration on Climate Change, joining ICLEI'S Cities for Climate Protection Campaign, signing the Oil

Depletion Protocol (which sets a target for reducing oil consumption across the community) and establishing a Peak Oil Task Force to quickly identify the challenges and vulnerabilities the community faces as a result of peak oil and climate change. These steps should also increase public awareness of likely impacts of peak oil and climate change, and engage stakeholders in identifying problems and solutions.

Planning for Resilient Communities in Canada and Ontario

In 2009, Thomas Homer-Dixon and Nick Garrison published *Carbon Shift: how the twin crises of oil depletion and climate change will define the future*, a collection of Canadian articles written about what many consider the most challenging topics of our time: climate change and peak oil. It is evident in this collection of essays that those who are at the forefront of combined knowledge of these twin crises are anything but united. Despite the controversy over which "crisis" is most pressing, the contributing authors concur that change is necessary on both fronts, that communities must acknowledge the inevitability of change, and that action is necessary. *Carbon Shift* highlights the broad difference of opinion and analysis within academic and industrial circles in Canada. For example, it includes Mike Jaccard's[3] essay "Peak Oil and Market Feedbacks" that argues there is enough oil to last at least 100 years. It also includes William Marsden's[4] essay "The Perfect Moment," which offers this interpretation of the data:

> Our [global] reserves total about 1.2 trillion barrels, give or take a few hundred million. We use this oil up at a rate of more than thirty billion barrels each year. That means that world reserves will last about another thirty-nine years. Petroleum geologists, such as Andrew Miall at the University of Toronto, predict that what's left undiscovered will give us another ten to twenty years, tops. (2009: 155)

Further, David Keith[5] contributed the essay "Dangerous Abundance," which asserts that "..while it is possible to make a case that oil scarcity poses a threat to our civilization, I argue that fossil-energy abundance is where the more urgent threat lies" (2009: 28). In other words, due to human-induced climate change, continuing to emit greenhouse gas emissions by burning fossil fuels is more dangerous than the threat of running out of them.

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[3]Jaccard is professor in the School of Resource and Environmental Management at Simon Fraser University, Vancouver. He is author of *Sustainable Fossil Fuels* (2005) which won the Donner Prize for best book on Canadian Public Policy.

[4]Marsden is an author and documentary film-maker. He has won numerous awards, and his most recent book, which won the 2007 National Business Book Award, is an in-depth critical appraisal of the tar sands in Alberta.

[5]Keith is a professor in the Department of Chemical and Petroleum Engineering and Department of Economics at the University of Calgary, and is an Adjunct professor in the Department of Engineering and Public Policy at Carnegie Mellon. He has held the Canada Research Chair in Energy and the Environment, and served on a number of advisory panels at the national and international level including the IPCC.

Within *Carbon Shift* Canadian experts agree on two facts: that oil will eventually run out, and that burning fossil fuels is causing climate change, which is having grave effects on the entire globe. In general, those arguing that there is plenty of oil remaining tend to be economists, and those most concerned about supply are geologists. This divergence of expert opinion is noted by Hopkins, who suggests that economists tend to believe that market forces will manage the potential oil depletion crisis, in that as reserves are depleted, the price of oil will rise which will in turn support further innovation and technology to increase production. The geologists, however, seem to have a view somewhat outside the marketplace that highlights the ultimate limitation of oil availability (2006: 15). Regardless, peak oil is a theory that is currently contentious, and if correct the implications threaten all aspects of the current Canadian lifestyle.

Climate Change in Rural Canada

The effects of human-induced climate change should by no means be diminished by the examination of peak oil: the two are inextricably linked, and both warrant the attention of policy-makers, the media and the public. The anticipated impacts as suggested in the literature are summarized as follows:

Area of Impact	Effects
Temperature and Weather	• Temperature increases – since 1948 Ontario temperatures have increased up to 1.3 degrees Celsius in the west of the province, but not much in the east. Expected acceleration of warming, especially in the North • More moisture and warming atmosphere increases the likelihood of extreme weather events, as well as more variable and less predictable weather
Ecosystems	• Altered habitat and biodiversity • Declines in forest density and area in some regions • Expansion of arid lands • Implications on forestry include spread of disease and insects, as well as different growing conditions for trees
Water Resources	• Water shortages have occurred in southern regions and may become more frequent with higher temperatures and more evaporation. Areas of concern include Durham, Waterloo, and Wellington Counties, as well as southern Georgian Bay • Changes to water quality and quantity • Increased winter and spring runoff, decreased summer soil moisture • Severe flooding and droughts
Food and fiber	• Crop and livestock production will be influenced by changing temperatures, length of growing season, rainfall, extreme weather, snow cover, and frosts. Direct influence on pests, invasive species, weeds, and disease, as well as acid rain and smog • Susceptible to changes due to water quality, pests, diseases and fire • Some regions' crops will benefit from increased temperatures

	• Availability of water for irrigation may be an issue with changing rain pattern. • Possible beneficial implications for crop production, potentially expanding production north.
Coastal Systems	• Shift from cold/cool water fish species to warm water species • Sea level rise will expand floodplains and destroy coastal wetlands • Decreases in the Great Lakes may reduce loads carried by freighters, as well as hydroelectricity generation capacity by lowering the head driving turbine generators
Infrastructure and Human Settlement	• Infrastructure faces risks from severe storm impacts (flooding, road washouts, ice damage, windstorm damage) to softening of tarmac in summer, and cracking concrete in freezing and thawing • Wastewater and stormwater infrastructure may not be adequate • Northern communities are vulnerable to earlier spring melt
Health	• Health implications from heat waves, smog, and mosquito/tick borne diseases increase the risk of illness and premature death • Potential adverse effects on human health as a result of direct causes like temperature stress, air pollution, and extreme weather • Potential adverse effects on human health as a result of indirect causes including vector-, rodent-, and water-borne diseases, and exposure to toxic substances

Table 1: Potential Climate Change Impacts

Sources: Klug, 2009; Expert Panel on Climate Change Adaptation, 2009; and, Government of Ontario, Ontario's Adaptation Strategy and Action Plan 2011 – 2014

Human-induced climate change is now commonly perceived as a fact: despite opposition it has moved beyond the realm of theory and has been accepted as real. Ongoing analysis and research on climate change has identified it as real and dangerous. Current Canadian research identifies the status of climate change as "the paramount global environmental issue," the discussion of which "has moved from acceptance and attenuation, to seeking an understanding of the implications of change and potential adaptation and resiliency strategies" (Community Research Connections, 2010).

In 2003, the Canadian standing Senate Committee on Agriculture and Forestry released a report entitled "Climate Change: We are at Risk." This report identifies key considerations of climate change for the rural Canadian context:

> Because rural Canada relies largely on natural resource-based industries, it will be more vulnerable to climate change. Over the past several decades, rural communities in Canada have been changing dramatically, due to migration and structural transformations in resource-based industries. The livelihoods of rural Canadians are already stressed by low commodity prices and by trade conflicts such as

> the softwood lumber dispute and climate change will bring additional challenges, which may aggravate the current situation. Climate change will have significant financial and economic repercussions on natural resource-based industries, and physical infrastructure will also be challenged by increased weather-related damage. In order to cope with these changes, rural communities will have to start considering climate change effects in their planning. (Chapter 6, Summary)

In this vein, the Canadian Climate Impacts and Adaptation Research Network, in existence from 2001 to 2007, was specifically tasked to research climate change impacts and adaptation in Canada. Their online agriculture archive (http://www.c-ciarn.uoguelph.ca/documents/index.html) contains fourteen research papers pertinent to the risks of climate change on rural Canada. These types of initiatives are vital to assisting rural Canada in mitigating and adapting to climate change. Similar research and attention has not yet begun to provide knowledge and strategic actions required for the possibility of energy scarcity.

Peak Oil in Rural Canada

A decline in energy availability will have repercussions for almost every community on earth. In assessing strategies for mitigation and adaptation to a new reality, some will be applicable universally, and others will require a regional and local flavour, specific to urban, suburban, or rural challenges. There is relatively little literature detailing rural implications of Peak Oil, the exception being a report by the Groundswell Group (2007), the highlights of which have been summarized by Klug (2009: 9) in the following table:

AREA OF IMPACT	EFFECTS
Economy and Society	➢ Costs for everything will rise (electricity, fuel and heating, food, and other products) ➢ Food spending as percentage of income will rise ➢ Spending priorities will change; less money for luxury items, income spread thin between food and heating (likely to affect the poorest first, with increased deaths of elderly people during winter months) ➢ Ageing population in rural regions will require greater assistance, especially those living in the most isolated areas
Employment	➢ Lack of consumer income will affect 'the big box retailers', as consumers no longer wish to drive the long distances, and big box stores will start closing down ➢ This will cause consumers, industry, agriculture, and commerce businesses to remake the retail business model ➢ People living in rural communities will have to limit their financial capacity to commute; retail employees, who are often amongst the lower paid within the community, will be hit hard, as well as those reliant on their vehicles for work such as postal workers, care in the community, delivery personnel etc.
Energy Production	➢ Distant houses may be abandoned; more people may start living in one house to save on energy costs ➢ Frequent blackouts may occur, causing stress on the local and regional economies; it may also have major psychological effects
Fuel and Transport	➢ Increased pressure on farmers to grow biofuels on their land, could prevent them from becoming self-sufficient, and leave them more vulnerable to inflation rates ➢ Rural areas less able to afford commuting, traveling, etc.
Environment	➢ Less scope or money available for climate change mitigation, plus turning to coal as energy source exacerbates climate change problem ➢ Woodlots under threat for fuel to heat homes
Tourism	➢ Less international tourism, perhaps a greater reliance on domestic tourism (shorter distances) ➢ Huge effect on economies of places that rely heavily on tourism
Health Services	➢ Surgeries and hospitals will become less able to prescribe drugs and medicines to those in need ➢ Health systems and pharmaceuticals derived from petroleum will be in short supply (i.e. analgesics, antihistamines, antibiotics, cough syrups, creams, ointments, salves, radiological dyes and films, intravenous tubing, syringes, oxygen masks, heart valves, etc.)
Population and Migration	➢ Food shortages could put population pressure on rural areas as more people move to be closer to the food supply

Table 2: Potential Peak Oil Impacts

Sources: Groundswell Report, 2007; and Klug, 2009

Addressing these key areas of challenge requires a significant degree of understanding of rural communities in different contexts. Research into rural community strategies for resilience to peak oil is notably absent. Rural areas are of increased significance when assessing the repercussions for food supply. In the United States, it is estimated that producing one joule of food energy for consumption by humans currently requires approximately ten joules of fossil fuel energy (Grubb, 2010). The situation in Canada is equally dependent on inputs (fertilizers, machinery, transport) for food production and consumption. Some analysts believe the easiest first step is to re-tool the management of the current system, which could increase efficiency to "double the amount of energy service we get from each barrel of oil" (Ayres & Ayres, 2010: 2). Though this may partially alleviate the troubles caused by decline, local strategies for increasing resilience are essential.

Rural Canada, and rural areas in general, are particularly vulnerable to the effects of climate change (Reid, Smit, Belliveau & Caldwell, 2007; Wall et al. eds., 2007) and to fuel scarcity for essential elements as diverse as transportation and agricultural reliance on liquid fuels. The risks of climate change are becoming better understood and both mitigation and adaptation strategies are being researched. Strikingly, the potential implications of energy scarcity have not yet hit the public or policy-making consciousness in Canada, despite some efforts in other nations (notably the USA, Australia and the UK). Thus, the inevitable decline in liquid fuel production – commonly referred to as peak oil – warrants attention at all Canadian levels: grassroots, municipal, provincial and national. White, in *Issues in Canada: Climate Change in Canada* (2010: 16) details Canadian current energy use as derived from the following sources, in these percentages: fossil fuels 70%, hydroelectric 11%, nuclear 11%, biomass (wood) 6%, other renewables 1.5%. Further, White postulates on the agricultural implication for small farms in Canada – an analysis which is true for both the implications of climate change and of peak oil:

> A large agricultural corporation may be able to spread its risk by diversifying out of the most threatened regions. However, this is not an option for small family businesses, except to the extent that many farming families rely on off-farm employment to supplement their income. (2010: 35)

It is becoming apparent in current literature on the nexus of climate change and peak oil that the concept of peak oil not only provides support for initiatives to tackle climate change, but also provides a pathway to examining and responding to the resulting challenges facing communities in addressing these "twin crises." Agricultural and rural communities, with a plethora of other challenges, are not alone in being ill equipped to face these challenges.

Planning for Resilience

Canadian and Ontarian communities are still generally in an early stage of building resilience in the face of climate change and peak oil. Natural Resources Canada (NRC, 2008), in a summary of key findings on climate change impacts and adaptation in the country, indicates that climate-related disruptions to critical infrastructure, water shortages and climate-related extreme events have occurred in Canada and Ontario and are likely to become increasingly frequent in the future. The impacts of these present risks will affect the health of Canadian and Ontarian residents and ecosystems. In Canada, projects responding to such impacts may be eligible to apply for funding from the Federal government's $550-million Green Municipal Fund program, managed by the Federation of Canadian Municipalities (FCM) which, along with FCM's Centre for Sustainable Community Development, are two national efforts to support sustainable development at the municipal level. Municipalities in most provinces across Canada are obliged to prepare "Integrated Community Sustainability Plans," as part of the Federal Gas Tax Agreement, under which municipalities must demonstrate progress towards enhanced sustainability planning by 2010 in exchange for funds received (AMO, 2008).

At the municipal level, there are many ways that councils and planners can contribute to a low carbon future (Rowell, 2010).*Municipal World* has compiled case studies of Canadian municipal response to climate change (Gardner and Noble, 2008); cities such as Burnaby BC, and Hamilton ON are conducting research and creating strategic plans in response to the potential impacts of peak oil, and suggesting responses to reduce energy use in transportation, and to produce energy locally. In addition, the Canadian Institute of Planners (CIP) has published a national policy framework for climate change adaptation as part of a two-year project to mainstream climate change tools for the planning profession (CIP, 2010). The CIP policy on climate change seeks to increase planners' capacity to mitigate and adapt by facilitating networking as well as information and knowledge transfer on the links between planning and climate change.

National Resources Canada believes that Ontario has a strong adaptive capacity;[6] however, it is unevenly spread out and particularly low in rural communities. The adaptive capacity of rural communities in Ontario hinges on strong social capital, social networks, attachment to community, strong traditional and local knowledge, and high rates of volunteerism, yet it is limited by economic resources, less diversified economies, higher reliance on natural resource sectors, isolation, limited access to services,

[6]There are various views on the definition of adaptive capacity. For this paper, it will be understood as ''the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences'' (Gallopin, 2006: 300).

and a lower proportion of the population with technical training (NRC, 2008: 13). A key study, "Planning for adaptation and resilience: Canadian local government experiences and needs," is presently underway at Royal Rhodes University, Victoria BC. Led by Dr. Kevin Hanna of Wilfrid Laurier University, the project is designed to provide case studies and applied knowledge for municipalities and communities in working on climate change adaptation and community resilience. It suggests that local governments are at the fore of this work, and aims to uncover if they are planning for resilience. This will become a national portrait of local resilience, and focuses on the following core objectives:

1. Assess the extent to which Canada's local governments are integrating adaptation and resiliency themes into their planning policies and actions.
2. Understand the challenges that planning for climate change pose for local governments.
3. Understand why some local governments are planning for adaptation and resiliency and others are not.
4. Understand how adaptation and resiliency planning at the local level can best be supported by existing (or absent) provincial and national policies.
5. Determine knowledge and capacity needs for local planning.
6. Identify best practices and planning innovation based on experience in Canada and other analogous countries.
7. Communicate the results to broad policy audiences. (Community Research Connections, 2010)

Conclusion

Peak oil, regardless of when or how the peak occurs, will have resounding effects on rural Ontario, as will climate change. In combination, these challenges have the potential to devastate lives and communities, and require immediate, concerted effort on multiple levels. This effort must coincide with the efforts to mitigate and adapt to climate change: our carbon emissions are inevitably linked to fossil fuel consumption. As the subjects become personal and affect the communities where we live and work, individuals, groups, politicians and social systems can become empowered to effect change at each level, cognizant of the global realities we face together. The literature reviewed exposes the debates and realities that in turn establish a critical platform of understanding from which to examine what small, local communities are working on within their spheres of influence. The idiosyncracies of the rural Ontario context, and responses therein, can provide information and teachings for how to move forward together.

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