Planning Cities Beyond Peak Oil: A resilience approach

2012

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Cover Photo: Homme de Fer station in Strasbourg, France.
Photo credit: B. Juste

“It is not the strongest of the cities that will survive, but the ones most responsive to change.”

Charles Darwin, paraphrased in Dawson 2007

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Introduction

It is the year 2035 and the world economy has experienced one of the worst crises since World War II: cheap, accessible oil has become a distant memory. In response, cities are left scrambling to maintain economic and social stability. Transportation prices leave many unable to afford their daily commutes, putting greater pressure on the public transportation system.

Food prices are rising steeply, and many industries have fallen prey to the unaffordable cost of shipping their products and supplies. Energy prices in electricity, natural gas and coal are also rising in response to the gap between supply capacity and the massive increase in demand over a short period of time. Inflation is rising; loans and mortgage rates are high and as a result, growing numbers of low-income households may find themselves on the street, unable to afford their homes. Only the strongest and most resilient cities will come out relatively unscathed, but what does such a city look like?

Through good times and bad, the cities and towns adapt and evolve to change without sacrificing their identity or character. Their strong sense of community encourages a system of associative and non-profit groups, of solidarity among strangers. Residents, businesses, and interest groups feel a sense of ownership and pride in the region, partly due to their high level of public involvement and participation in governance matters, and partly because their efforts are publicly recognized and rewarded on a regular basis. Running the city is done in a transparent and open manner, with particular attention given to equity issues, strengthening the local economy, and enhancing the quality of life of its residents. Businesses thrive in this city, knowing that the local residents will chose their products over an external source, on the basis of trust in workmanship, solidarity for the local economy, and social connections. Unemployment is low and remains stable.

This resilient society forms the basis for the region's well-functioning public transit system that helps connect the furthest reaches of the city with frequent service. The transportation infrastructure is based on a fine grid of walkways, cycle paths and streets that prioritizes walking and cycling. Children can play safely in the street, pedestrians enjoy their walk to work, and public transportation is safe, efficient, and accessible for longer journeys. Children, the disabled and seniors alike enjoy the same accessibility to their destinations as able-bodied adults.

The quality of life in this city is world-renowned. People of all income levels can live in energy-efficient buildings that reduce their monthly expenses and stabilize the cost of energy. Local agricultural products feed the majority of the city's population, and waste materials are used to produce heat and electricity to supplement energy production from the local hydroelectric facility, wood biomass generators and wind farms. A local economy has developed around renewable energy materials, technical installation, maintenance and production, as well as in architecturally-exceptional efficient building design. New neighbourhood developments are planned with the local geography and ecological context in view to take advantage of prevailing winds, passive solar heating, and natural lighting. A few greenhouses throughout the

city supplement lower local food supplies in winter, and minimize the need for the more costly imports of fresh produce.

Money is generated and expended locally. Economic leakage is minimized by promoting a buy-local mentality, supplemented with imports where needed. Despite a localized economy, residents, businesses, and visitors lack for nothing – they are technologically up to date, live in high-tech custom-built houses, drive modern cars when the need arises, and send their kids to quality public schools.

As a result of effective measures to protect the surrounding environment in all its daily practices, the nature around these communities has remained rich in biodiversity. Forestry practices and agriculture are respectful of ecological limitations. Sprawl is largely avoided by encouraging higher-density residential construction. Water quality is protected and maintained at a high standard through conservation, waste water recycling, and careful water treatment.

This exceptional city demonstrates a remarkable competitive advantage over those who have succumbed to volatile energy prices and instable energy supply. It attracts newcomers on a daily basis who are curious to see how they did it. How did they rise from being among the poorest in their region, to achieving such success and quality of living? Who are their leaders? What are their secrets and techniques? Let us discover this beautiful place!

Sounds unrealistic, doesn't it? But it's a real place. It's a region called Vorarlberg, in north-western Austria. And in 10, 25 or 50 years, when our oil-based economy no longer greases the global economy, this region will come out on top. This city will be prepared to adapt, cope with and accept an energy transition, and will emerge relatively unscathed. On the contrary, the majority of other industrialized cities will likely suffer when people can no longer get around their cities with ease, industries weaken under higher logistics and manufacturing costs, and energy prices raise the cost of living, isolating and impoverishing low-income populations.

The cities and towns of Vorarlberg demonstrate resilience. A resilient city is capable of withstanding severe shock without either immediate chaos or permanent harm (Godschalk 2003). The result is inspiring and motivating. This document hopes to shed light on how city planners and decision-makers can make this a reality for their communities, too.

Methodology

The information in this report is the culmination of extensive research of the academic literature on the practical challenges and consequences of peak oil for cities, current resilience theories and practices, and critical analyses of case studies and examples of resilience approaches.

The resilience planning model suggested in this document is built by combining the best elements of several existing indicators and models in the current literature. These include the Resilient Cities Index, the Resilience Alliance Workbook, the World Bank's Workbook on Planning for Resilient Cities, and the Transition Town movement. Foundations have also been adapted from peak oil Plans from Portland and San Buenaventura, USA. It is also inspired by the opportunity to accompany and assist urban planner Bertrand Barrer of Strasbourg France on his consulting company's study tours of Vorarlberg, Austria. Mr. Barrere is amongst France's most progressive sustainability practitioners.

There are several limitations for the information provided in this report. First, it is not an exhaustive review of global case studies and research in urban resilience. There are numerous other approaches and examples that exist that have not been considered. Second, this report does not analyze potential differences in culture, politics, or economic contexts that could influence the practicality of certain examples or models for use. Each country, each region, and each city has its own unique context that should be considered when developing a local resilience plan. This is by no means intended to be a comprehensive checklist for practitioners. Finally, the report considers resilience in the context of peak oil, which some argue will not occur. The author assumes a precautionary approach in that, if peak oil is a real danger to cities, it is best to be prepared rather than suffer extreme financial, cultural and societal losses. (For a brief introduction to the precautionary principle, see Sidebar 1). Regardless of personal views on peak oil, nearly all of the content in this report can be adapted to apply to a plethora of other potential risks and threats, ranging from natural disasters to terrorism.

Organization of the Report

This report is organized into five parts, providing a broad sweep of practical information for policy planners, urban planners and decision-makers intent on improving the resilience of their cities. Part I provides background information about peak oil, and discusses the various vulnerabilities and risks associated with energy crises for cities. Part II provides a thorough background on the concepts and theories of resilience in urban planning. Part III delves into the practical aspects of urban resilience, reviewing several notable plans, models and examples of resilient planning. Part IV combines all the above information and proposes a comprehensive planning approach to urban resilience planning. Finally, Part V offers direction for future efforts and provides concluding remarks.

Sidebar 1: Precautionary Principle Basics

The Precautionary Principle states that if an activity raises threats of substantial or irreversible harm to human health or the environment, precautionary measures should be taken, even in the absence of scientific consensus.

This is the most commonly-cited definition, which emerged from the 1998 Wingspread Statement on the Precautionary Principle, and has been adapted and applied by the European Commission, the United Nations, and others. The concept of precautionary principle is said to have origins in German law from the 1930s. It provides policy makers with a means of making discretionary decisions on matters that may have harmful impacts on human health or the environment, and implies a social responsibility to protect them.

R.B. Stewart (Stewart 2002) reduced the precautionary principle to four basic versions:

- Scientific uncertainty should not automatically preclude regulation of activities that pose a potential risk of significant harm (Non-Preclusion PP).
- Regulatory controls should incorporate a margin of safety; activities should be limited below the level at which no adverse effect has been observed or predicted (Margin of Safety PP).
- Activities that present an uncertain potential for significant harm should be subject to best technology available requirements to minimize the risk of harm unless the proponent of the activity shows that they present no appreciable risk of harm (BAT PP).
- Activities that present an uncertain potential for significant harm should be prohibited unless the proponent of the activity shows that it presents no appreciable risk of harm

The first and third versions are most applicable to the peak oil context.

Some criticisms of the precautionary principle exist. For example, some legal definitions make reference to requiring a certain threshold of scientific certainty on the harm presented by the activity, however it is unclear who determines that threshold or how it may be determined. In addition, some authorities do not give it as much credibility as traditional risk assessments, even though the precautionary principle can be very complementary to such assessments. In Canada, these are prominent weaknesses in the application of the precautionary principle, and its implementation remains weak at best (Benevides and McClenaghan 2002).

It is worth pointing out that most precautionary principle literature makes no reference to economic or social impacts. Peak oil and energy crises fall in a grey area regarding environmental and health hazards. Increasing oil consumption can lead to air quality hazards, linked to health concerns, but the major risk considered in this paper is a social and economic one: how can cities be prepared to continue providing adequate service and quality of life to residents and businesses following a major energy disruption? The author believes that this is a great enough risk to human well-being to warrant the application of the precautionary principle.

Part I: About Peak Oil

i. What Is Peak Oil?

The foundation of our current global economic model is based on the ideal that the economy must continue to grow indefinitely. This is a potentially dangerous model. Continuous economic growth is founded on the assumption that the world will never run out of resources, particularly the resource that drives most of our economy: oil.

However, an increasing number of studies show that there are fewer and fewer new reserves of crude oil added to our global supply each year. Demand is still growing, especially as emerging economies such as China and India gather steam.

Basic assumptions on the quantity of oil remaining in the ground are uncertain, are not transparent, and have a tendency to be exaggerated if it is politically or economically advantageous to do so. As a result, peak oil may occur at any time, or according to some, may have already occurred (Schindler and Zittel 2008; Deffeyes 2006; Kunstler 2006; Hirsch, Bezdek, and Wendling 2005).

Peak oil refers to the maximum oil production rate, "which typically occurs after roughly half of the recoverable oil in an oil field has been produced" (Hirsch, Bezdek, and Wendling 2005). However, industry and geology specialists have a hard time accurately determining how much oil exists in order to determine when half of it has already been produced. The challenge stems in part from a severe lack of access to accurate, unbiased statistics on how much oil is known to already exist. Politics and economics have a tendency to influence reported figures in order to present the most advantageous outlooks (Kunstler 2006).

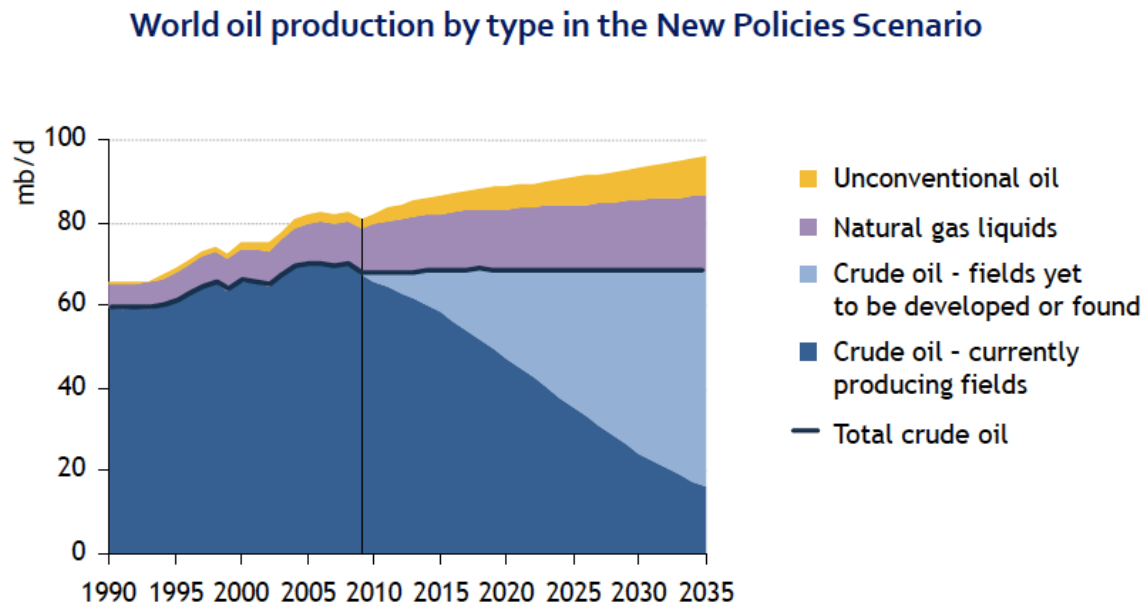

Figure 1 - The OECD and IEA predict that new oil field discoveries, natural gas and unconventional oil will more than make up for decreasing production in existing fields. Source: Birol 2010.

According to the most conservative projections by the International Energy Agency, peak oil production will be offset by new oil field discoveries, unconventional oil production and natural gas (Figure 1; Birol 2010); however, this is a very cornucopian view, and many have questioned the ability of these offset sources to meet growing demand. Slightly less optimistic, the Cambridge Energy Research Associates, an American industry-based energy consulting firm that published the famous Hirsch Report, predicts that global peak oil will occur after 2020 (Hirsch, Bezdek, and Wendling 2005).

However, most other experts, including former petroleum industry executives and various international policy research think-tanks have concluded that peak oil already occurred sometime between 2007 and 2010 (Hirsch, Bezdek, and Wendling 2005; Deffeyes 2006, 7; Schindler and Zittel 2008). For example, Kenneth Deffeyes, a retired oil industry executive, writes that "world oil production has ceased growing, and by the year 2019 production will be down to 90 percent of the peak level" (Deffeyes 2006, 7). Deffeyes and others warn that we are headed for a future of steep decline in energy production, volatile price dynamics for oil on the global markets, and complex politically-invoked feedbacks on supply, demand and price relationships world-wide (Figure 2).

Critics of peak oil projections believe that natural gas and coal products will become viable alternative fuels, which strangely are not subject to the same exploitation and finite resource trends as other natural resources have proven to be (Deffeyes 2006, 55, 79, 85; Birol 2010). As Deffeyes notes:

> "coal is cheap, coal is versatile, and the major industrial economies have extensive coal deposits. In the face of the impending oil shortage, a possible game plan is 1) move electric generating capacity from natural gas to coal, 2) move the natural gas to power automobiles and trucks, and 3) save the remaining oil for aviation,"
>
> (Deffeyes 2006, 98).

This could have disastrous environmental and health consequences, most notably on noxious emissions and global climate impacts. Others insist that new technologies for exploration, extraction, and energy efficiency will ensure that the remaining supplies last us indefinitely (Deffeyes 2006, 28; Birol 2010). Finally, the price elasticity for gas, or willingness to pay, seems to remain high through recent spikes in oil prices, suggesting that the price point at which people are no longer willing to pay may be much higher than anticipated. This could unpredictably delay the social impacts of peak oil, such mobility patterns or efficiency standards.

Figure 5: Oil producing countries ex OPEC and ex FSU

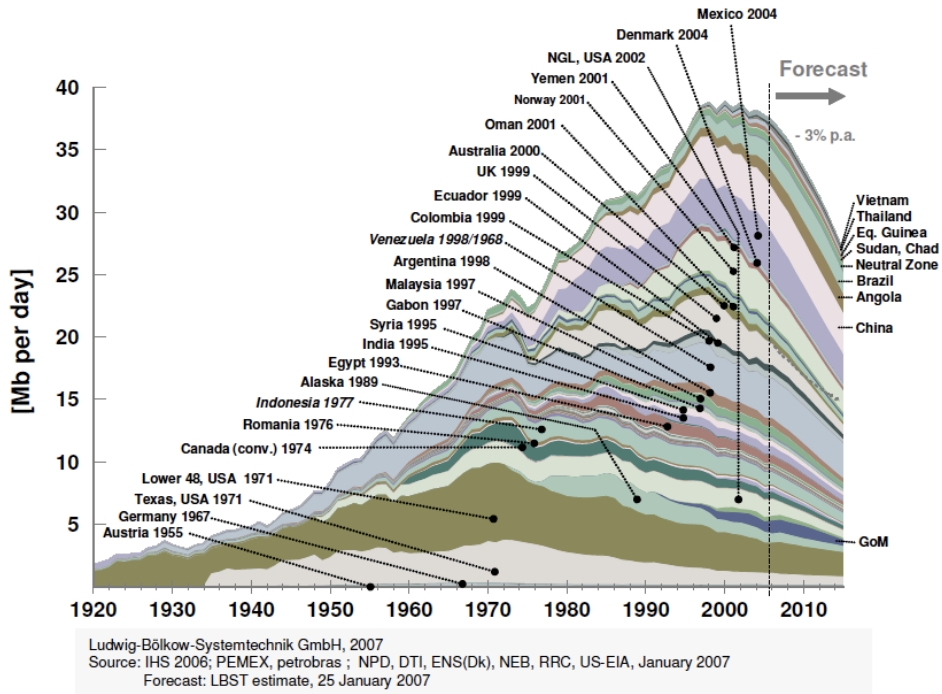

Figure 2 - Production graph of non-OPEC oil producing countries shows that global production has already peaked. Source: Schindler and Zittel 2008

Box 1.1 – Daily household products containing oil products

Aspirin, Wallpaper, panty hose, glue, paint, varnish, foam mattresses, carpeting, nylon and polyester, CDs and DVDs, plastic bottles, styling gel, brushes, toothbrushes, rubber gloves, sinks, electrical outlets, shoe polish, caulking & weather-stripping, printers, candles, plastic bags, jackets, fruit juice containers, credit cards, insulation, windows, lipstick, and many more.

Source: Hopkins 2010, 19

Nevertheless, it may be telling that many cities across North America, Australia and Europe are drafting peak oil resilience plans in anticipation of future energy crises[1]. The evidence is growing that global peak oil production has already occurred, or in a best-case scenario will occur within the next 10-15 years. Today's cities are underprepared for the economic and subsequent social consequences that diminishing supply of affordable oil will have. The Precautionary Principle (see Sidebar 1, page 10) would require that cities begin taking measures immediately to prepare for potential risks and threats associated with energy supply constraints and increasing costs. The following sections explore how cities are currently vulnerable to the threat of peak oil, and how resilience thinking can move cities toward a more secure and sustainable future.

ii. Vulnerabilities and Risks for Cities and City-Dwellers

Most vulnerabilities and risks of peak oil derive from the unstable prices that are likely to occur as the remaining oil reserves become harder to find and are depleted with increasing speed. Oil is not self-replenishing – once it has been burned, it is lost forever in the atmosphere. Unless we implement impressive conservation techniques worldwide, the supply will decline until there is no more producible oil remaining.

In the meantime, we are continuing to produce vast quantities of pollution that is swiftly changing the very chemistry and climate of our entire planet. Climate change impacts are already being felt throughout the global economy as extreme weather patterns affect global food stocks, water availability, insurance claims, and infrastructure systems. It is hard to predict exactly how oil prices will be affected. Some believe an eventual equilibrium price may be reached as we restrict supply, arguing that demand will diminish as alternatives become increasingly available. However,

1 American cities include (but are not limited to) San Buenaventura and Berkeley California, Portland Oregon, and Lawrence Kansas. Several counties have also prepared energy plans in the UK, as well as a handful of communities in Australia. See section III-Resilience and Peak Oil Plans for more information on peak oil plans.

Figure 3: Detroit Michigan, USA. An example of an unresilient city? Source: Images via Land+Living and Detroit Yes on http://weburbanist.com

Deffeyes believes it is more likely that oil prices will fluctuate wildly (Deffeyes 2006, 178). Since oil or oil by-products are used in nearly every aspect of our daily lives, price shocks will be felt everywhere (see Box 1.1 – Daily household products containing oil products). Higher oil prices will likely lead to inflation, higher transportation and logistics costs, expensive food, costly pharmaceuticals, reduced supply or access to oil-based products, among many other potential impacts (Kunstler 2005). Food production and distribution will also be affected, since fertilizers and fuel for transportation will become limited and increasingly costly. However, the most critical sectors are transportation and energy. Thus, the focus of this guide is on planning for energy-resilient transportation and energy distribution in urban settlements.

This section summarizes some of the most pertinent risks and vulnerabilities for urban regions in a peak-oil future scenario. Risks are divided into economic, social, infrastructural and environmental aspects of city life.

Economic Risks

Regional Impacts

Economic vulnerability can be described as the "degree to which a state is vulnerable to economic conditions in the rest of the world", according to Briguglio and Galea (2011). The Caribbean Development Bank has identified six indicators for measuring economic vulnerability, listed below (Crowards 1999 in Arico 2007):

1. **Peripherality and accessibility** or "remoteness" describes the economy's degree of isolation, and is measured by the ratio of transport and freight costs to imports. It helps define how easy or difficult it is to import and export goods and energy into the economy.
2. **Export concentration as a % of GDP** measures the dependence on the cost of transport for the export of goods. In an energy crisis, transportation costs will rise sharply and could influence the ability to export goods, thus impacting the local or regional economy.
3. **Convergence of export destinations** helps identify where there is a lack of diversity in the economy. When a state is dependent on a narrow range of exports that are closely related with similar clients, they are more vulnerable to disruptions.
4. **Dependence on energy imports** illustrates

how an economy may be subject to energy supply disruptions if transportation or production of energy is interrupted. Raw energy, industrial supplies and food are examples of commercial energy imports.

5. **Reliance on external finance** describes how dependent the economic system is on outside funds that may no longer be available as the economy shifts to a post-peak oil scenario.
6. **Proneness to natural disasters** defines how fragile the economy is to costly disruptions and the need for external assistance, goods, and services during a state of emergency.

While these indicators were developed for small island developing countries, they remain relevant for macro-economic resilience considerations at the local level. For example, cities should strive to reduce energy imports by producing more local energy, through renewables, district heat recapture, energy from waste, or from a variety of other available options. Diversifying export destinations speaks to the type of products and services that the municipality exports. Being too dependent on a narrow range of exports or those that have niche consumer markets could be problematic if rising transport or manufacturing costs make the product less appealing to its customer base. For example, Detroit Michigan in the USA was significantly dependent on the automotive industry. When economic conditions led to the closing of several major plants, the city went bankrupt and population experienced an exodus. Cities that diversify their economic base and expand into new technologies, including renewable energy technologies that provide jobs for a similar demographic and skill sector, could have helped to minimize the risks associated with the impacts on the automotive industry.

Local Impacts

The potential impacts of peak oil at the macro-economic level described above will likely also translate to rising unemployment numbers. Economic development agencies will be presented with challenges of filling commercial vacancies and attracting new types of economic activity to the city (and the nation) as rising fuel costs strangle the more oil-dependent economic sectors. The City of Portland and others point out that the city's corporate tax base could shrink in return, affecting the municipal budget and potentially requiring property tax rates to rise in order to compensate for the loss (City of Portland Peak Oil Task Force 2007; Mortimer 2010; Dodson and Sipe 2008).

Household socio-economic statistics can provide a useful indicator of vulnerability at the local level. According to Dodson and Sipe (2005), "household socio-economic status is a primary determinant of … vulnerability to increased consumption costs, not only for fuel but also for goods whose prices are influenced by fuel costs." A rise in fuel prices elevates the cost of driving a vehicle, but also influences inflation and causes the prices of a majority of commodities and services to rise. This, in turn, causes interest rates to rise. The low-income demographic is disproportionately threatened by these changes compared to the gainfully employed. Low-income households spend a greater proportion of their income on basic necessities such as food and transport, which are particularly susceptible to inflation caused by rising fuel prices. Moreover, as interest rates increase, debt load increases. For those with homes on the urban fringes purchased using credit, it can be difficult to maintain payments and continue paying the rising cost of commuting (Dodson and Sipe 2008). These snowball effects are eventually reflected in local economic challenges, such as sluggish housing markets, loss of small or independent local businesses, and shifts in import and export ratios.

Finally, humanity's willingness to pay could play a significant role in how quickly oil price hikes will change people's spending patterns and behaviours. For example, our relatively high price elasticity in our transportation choices, as evident from recent increases in fuel prices "has shown that …the response to fuel prices has become increasingly dominated by changes in fuel efficiency rather than changes in travel" (Kaza et al. 2011). Second to choosing more efficient vehicles is travel behaviour changes, such as trip chaining, reducing the number of trips, or reducing trip length, or choosing another mode of travel. Such pressures can drive demand for changes to urban land use planning and development densities, but current regulatory inertia poses a challenge in realizing these demands (Kaza et al. 2011). These patterns can be extrapolated to home buying patterns and food consumption choices.

Social Vulnerabilities

Social vulnerability refers to: "the characteristic of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of [a major disturbance]. It involves a combination of factors that determine the degree to which someone's life and livelihood is put at risk by a discrete or identifiable event in nature or in society" (Adger 2000).

Peak oil impacts on cost remain the principal concern for society. Experts on oil production and peak oil tend to agree that prices will become increasingly volatile, and will generally experience an overall increasing trend (Deffeyes 2006, 33). The transportation sector is guaranteed to be hard hit, since transportation is currently 90% dependent on oil sources (Schindler and Zittel 2008).

Accessibility and affordability of transportation will be the most affected from rising fuel costs. Accessibility refers

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to both the variety of transportation options (or "modes"), and the ability of individuals in a particular area to access the desired mode of travel in order to reach their destination of choice within a convenient time frame (El-Geneidy and Levinson 2006). Accessibility can be described for each mode, for all modes, or for a combination of modes and specific destinations, such as home, work, school, and/or shopping (El-Geneidy and Levinson 2006).

Innumerable studies demonstrate that accessibility is not evenly distributed. More specifically, Dodson and Sipe discovered that the distribution of social vulnerabilities to rising oil prices is geographically uneven, and highly dependent on travel patterns and access to quality public transit (Dodson and Sipe 2005). "Quality" public transit can be characterized by high-frequency service to all sectors of an urban agglomeration, including fringe neighbourhoods and isolated employment sectors. The authors developed the Vulnerability Index for Petroleum Energy Rises (VIPER) as a means to measure urban vulnerability to fuel prices within Australia's major cities. The index considers land use patterns, transportation infrastructure and services, and socio-economic data. Findings showed that travel distances for home-based work trips were typically three times longer for outer suburbs than for the inner city core of Australian cities. Moreover, outer suburban residents in Australia tended to be lower-income individuals that are more reliant on public transit for their travel needs. These results emphasize the importance of a good and affordable public transport network, especially for outer suburban regions and other isolated or poorly accessed neighbourhoods.

Dodson and Sipe (2008) followed up the VIPER study with an analysis of the relationship between rising fuel prices and the subsequent increase in interest rates (and thus mortgage rates), which they cleverly called VAMPIRE: Vulnerability Assessment for Mortgage, Petrol and Inflation Risks and Expenses. The authors used the study to identify urban areas most at risk in the event of rising fuel prices. House pricing patterns in Australia showed a "reasonably consistent spatial 'price decay gradient' as distance from the centre or urban core increases." The more remote and peripherally located homes are cheapest, and therefore most attractive for those with little means to invest. These areas tend to exhibit high debt loads per household, and are also poorly serviced by public transit, resulting in disproportionately high vulnerability to rising fuel prices. Analyses by the UK Government (2002) also support that lower-income individuals have a tendency to spend a higher proportion of their income on transportation costs, and will subsequently be more vulnerable to rising gas prices. These groups will be much more vulnerable to rising gas prices, which will limit their travel options and potentially isolate them from essential services and amenities.

Food costs will also rise. The rising costs of fuel for transportation, and potential impacts on availability and costs of petroleum-based fertilizers for industrial farming will be felt in grocery stores worldwide (see Sidebar 2: The Food Miles Argument). Cities will be forced to look for local opportunities for food production (Barrere 2010). Agricultural productivity will be particularly impacted in high-density countries where access to arable land is low, but population density is high (Conforti and Giampietro 1997). These regions typically rely on high energy inputs such as fuel, fertilizer, and pesticides to maximize land productivity per hectare, and will be most directly impacted by rising costs associated with the decline in oil availability. Broadly speaking, these impacts will be experienced strongest in Asian countries. North America and Europe's situation is more dependent on mechanical energy input with low produce output per hectare and will be less acutely impacted by rising oil prices (Conforti and Giampietro 1997).

Some may look to local food networks as a possible more resilient solution to rising fuel prices and its impacts on food production and distribution. On one hand, it ensures fresher food, closer relationships between the producer and the consumer, and an effort to keep money in the local economy (Mariola 2008; see Sidebar 2, pg 19). On the other hand, it may threaten major produce exporting economies and could limit the availability of seasonal produce off-season.

Infrastructural Vulnerabilities

The increasing dependence on information systems and the global interdependencies of many urban activities has changed the structure of cities (Allenby and Fink 2005). For example, telecommunications infrastructure permits massive movement of capital and ideas around the globe; a disruption to the Internet could be catastrophic. Infrastructure investments in highways and airports have made it possible to access cities easily from greater distances; a rise in fuel could cut off some communities. Electrical grids permit us to power huge areas on a single transformer station; a natural disaster or technical malfunction can leave millions without heat or power, as demonstrated during eastern North America's major blackout in 2003. As a result, some resilience researchers argue that we must consider shifting our emphasis from social resilience to infrastructure system resilience – especially for energy and information flows (Allenby and Fink 2005, Vugrin et al. 2009).

Ibanez and colleagues describe how transportation and energy systems in North America are linked through complex interactions that create strong interdependencies and thus, vulnerabilities (Ibanez et al. 2008). The transportation and energy systems, for example, demonstrate reciprocal demand: conventional electricity and heat often requires the transport of raw materials to generating stations, whereas some transport networks depend on electricity (e.g. subways, streetcars, electrified rail systems) to transport goods and people. Furthermore, energy resources are not always available where the demand and consumption is located, and must be transported by some means. However, these infrastructure networks are often composed of multiple parallel paths: for example, electricity can be generated by wind or by coal; transport can be via rail or via trucks, and transmission of energy can be by liquid fuel through pipelines, or by electrical transmission (Ibanez et al. 2008). Encouraging these multiple paths provides an opportunity for enhancing resilience within this infrastructure network complex.

A disruption in fuel can therefore have direct consequences on transportation and energy production, supply and price. Given our reliance on transportation and energy for nearly every activity that takes place at a given moment, this characteristic of the transportation and energy systems puts our city infrastructure at risk.

Posing a further challenge is the fact that, in North America and increasingly abroad, critical infrastructure is often privatized (Vugrin et al. 2009). Private ownership can be seen as a benefit if it increases the diversity of stakeholders who control investment and evolutions in these critical infrastructures. However, it can also be a constraint if private owners are un-cooperative or make investment and development decisions that conflict with the objectives of resilience. The public and public institutions have limited power in these cases to influence strategic decisions related to infrastructure system resilience.

Finally, infrastructure deficit issues pose another major hurdle. In North America since the 1970s and 80s, governments at all levels have been struggling to adequately grow capacity and maintain existing built infrastructure, ranging from roads and sewers, to electrical grids and nuclear power generators (Mirza and Haider 2003). The deficit is the result of a variety of issues, including economic recessions in the 70s and 80s, the fact that much post-WWII infrastructure is approaching the end of its lifespan, and a reduced budget at all government levels to fund adequate maintenance. The result is that Canada, as one example, faces a $44 billion municipal infrastructure deficit, and the federal and provincial governments have between $60 and $125 billion in deficit. Thus, building resilience into infrastructure systems will necessarily have to involve proper life-cycle costing analysis and maintenance planning for existing and new infrastructure, and should seek opportunities to create positive interdependencies between systems to increase life spans (S. Mirza 2006).

Environmental Impacts

On one hand, the peaking of world oil supplies will necessarily mean a decrease in global consumption of fossil fuels, resulting in less pollution, especially from the transportation sector. On the other hand, switching from petroleum to other forms of energy can create new resilience and sustainability issues. For instance, many regions will likely turn to electric transportation as a replacement for combustion-based mobility. Given that transportation accounts for 27% of total global energy consumption, this will represent an enormous surge in demand for electricity (EIA 2011). The demand may be supplied by coal-generated electricity or nuclear energy. Both of these have significant environmental repercussions.

In France, Austria and Germany, there is a burgeoning movement toward heating homes and small communities with biomass such as wood. Increased reliance on biomass for heating and energy needs on a local level could harm natural forest ecosystems and cause soil erosion and increased flood risks if rigorous sustainable forestry practices are not maintained. Care must be taken to avoid over-exploitation of the surrounding forest resources as demand for energy grows. Where hydroelectricity becomes the primary source of power, water quality and aquatic ecosystem health could be affected.

Land consumption is a further concern. Cheap transportation has permitted urban development to creep outwards at very low densities, particularly in North America (Jackson 1985). This type of development has consumed prime agricultural lands and open spaces, limiting future opportunities for local, decentralized food and energy production. While local food and energy farms (e.g. wind farms, solar parks) are considered measures for enhancing resilience, they both require significant space to meet current demands. Concerning food production, it is important to consider that a post-peak oil scenario could lead to unaffordable artificial fertilization for large industrial-scale crops. Organic farming is much less intensive, but produces less food per spatial measure than industrial farming. Thus more space is needed to account for biodynamic and organic farming practices that afford a certain percentage of crop loss to pests and diseases, and still produce sufficient crops to meet demands (Barrere 2010).

All of these potential risks also have a negative impact on biodiversity, which is considered one of the essential features of a resilient and healthy ecosystem (Kinzig et al. 2007).

Sidebar 2: The Food Miles Argument

The "food miles" notion is a topic of substantial discussion in the UK in particular. For example, New Zealand is concerned that their food exports will lose appeal in European markets based on the food miles argument, since many of the products they export can feasibly be grown in the UK (C. Saunders, Barber, and Taylor 2006).

However, studies suggest that the less fuel-intensive agricultural practices in New Zealand offsets the required fuel inputs to ship the food overseas, especially when the density of food products per shipment is considered. Other studies comparing local food networks to traditional supermarket networks prove that the additional kilometers driven by the consumer, on a per-unit of produce basis is higher in local networks than for shipped goods (Coley, Howard and Winter 2009). This is due in part to the fact that it requires more vehicles traveling on more roads more frequently to obtain a similar amount of produce (Mariola 2008).

Mariola argues that one must consider economies of scale: a tomato shipped from California to Connecticut does not require the full fuel amount for that trip; rather, the fuel consumption should be equally distributed among all items of produce in the same shipment such that only its fraction as a total of all the items of produce on the same shipment is counted. Other studies purport that a round trip to purchase organic produce must be less than 10 km in order to consume less fuel than the life-cycle of the same produce shipped to and supplied by traditional grocery stores (Coley, Howard, and Winter 2009).

The best solution according to Mariola is to increase the number of people growing their own produce in private or community gardens. "A rise in the number of urban and community gardens would go a longer way towards a sustainable and resilient agrifood system than an increase in the number of farmers markets…" (Mariola 2008).

"Consider the following thought experiment: a truck carries 3000 tomatoes for 3000 miles from California to the east coast, using 500 gallons of fuel. If we focus only on distance, we would state that each tomato traveled 3000 miles, which is objectively true but obscures the effects of shipping large volumes. We can more accurately parse energy use by item and state that a single tomato only accounted for one-sixth gallon of fuel, or, strange as it may sound, the equivalent of one mile of transport."
Excerpt from (Mariola 2008).

iii. Conclusions

Rising costs of oil as it becomes harder to find remains the dominant risk of peak oil. This will directly affect the cost of energy for transportation and food production and distribution.

Economically vulnerable cities are those who are highly dependent on external energy and finance resources, and are reliant on a high proportion of exports and imports. Individuals and businesses will be affected by rising costs of living, which will cause inflation that drives up lending rates, transportation costs, and the price of food.

The most vulnerable social sectors will be those who are low-income, spatially isolated, and those who have poor access to sustainable transportation options. Accessibility (transportation) and affordability (cost of living) will be the two main drivers of vulnerability among social sectors.

Our dependence on energy, transportation and communications infrastructure, and the inherent tight interdependencies between these systems makes cities vulnerable to disruptions. Private ownership of certain types of infrastructure systems also challenges efforts to enhance their resiliency.

Finally, shifting to electrified transportation systems could encourage increasing electricity production from environmentally-harmful sources such as coal, nuclear generators, natural gas and hydro-electric dams. Increasing demand for land for food and energy production can result in ecosystem fragmentation and biodiversity loss. Dependence on biomass could result in unsustainable forestry practices.

Though the risks and vulnerabilities are numerous and potentially great, the good news is that there may be a solution. Resilience is the subject of a growing body of research and practice in urban planning that takes a holistic, systems-based approach to solving complex problems such as peak oil, climate change, or sustainable development. The next section will introduce resilience in urban planning.

Part II: Resilience as an Urban Planning Approach to Peak Oil Risks

i. Understanding Resilience

Definitions and Terminology

Resilience is a relatively new term. Its earliest use was in psychology research in the 1940s and was later extensively used in the natural sciences to understand complex ecosystem interactions and dynamics. Most recently, resilience has been applied to research on concerns such as disaster and risk management, climate change adaptation and mitigation, and vulnerability reduction (Manyena 2006).

Definitions and theories of resilience have evolved quickly over the past few decades, however they remain numerous and variable. This report defines resilience according to the Resilience Alliance's definition, as applied to ecosystems:

> Resilience is the capacity of a [system] to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient [system] can withstand shocks and rebuild itself when necessary. Resilience in social systems has the added capacity of humans to anticipate and plan for the future (Walker et al. 2004 in Manyena 2006).

Adaptive capacity, a key attribute of a resilient system, refers to the ability to find ways to evolve or cope

Figure 4 - An example of modular building using repurposed shipping containers. http://inhabitat.com/prefab-friday-keetwonen-container-student-housing/wp-content/blogs.dir/1/files/keetwonen2.jpg

following a stress. A system that is adaptive is characterized by a high level of diversity, a redundancy of functions, a high degree of flexibility, and is highly interconnected within and among systems (Wildavsky 1991 in Manyena 2006; Holling et al. 1995 and Cordona 2003 in Manyena 2006; Vugrin et al. 2009; Comfort 1999 in Manyena 2006). Redundant forms and functions can be modified to serve different purposes: for example, modular homes use redundant forms in multiple possible arrangements to meet a range of needs (see Figure 3). Diversity contributes to flexibility, such as a community with a diversified economic base that remains flexible to shifting economic demand and pressures. The community can adapt easier to changing external economic pressures than a community that is dependent on a sole economic driver.

Complex networks also contribute to resilience by creating multiple paths for information, skills and resources to flow, and a choice of alternatives should any particular path fail. A resilient system functions through complex feedback systems of interacting networks at multiple spatial and temporal scales, technically referred to as "panarchies" by socio-ecological resilience researchers (Walker et al. 2004; Otto-Zimmermann (ed) 2011, 162). Any given system at a particular scale of reference is influenced by system processes at scales above and below. Communities that are connected to grassroots organizations as well as higher-level government through many different organizations and institutions, complex relationships, and cross-hierarchical connections are more resilient because information can be shared, resources exchanged, and problems solved in a collaborative manner.

Complex networks such as communication, transportation, information and economic networks are so interconnected that it can be very difficult to understand the various interactions and feedbacks that function among them. Influencing the resilience of a system will always be a relatively dynamic effort because the states of all the interacting systems at different panarchies are constantly changing (Lebel et al. 2006). This is especially true for urban resilience, which can be affected by individual or national initiatives, by global pressures and by environmental processes, all of which affect local economic and social resilience.

To summarize, resilient systems share a number of defining characteristics, which include:

- Multi-functional components of the system
- High diversity in all sectors and processes
- Interconnected networks that operate at multiple scales
- Redundancy or modularity of components
- Adaptive capacity (Novotny, Ahern, and Brown 2010).

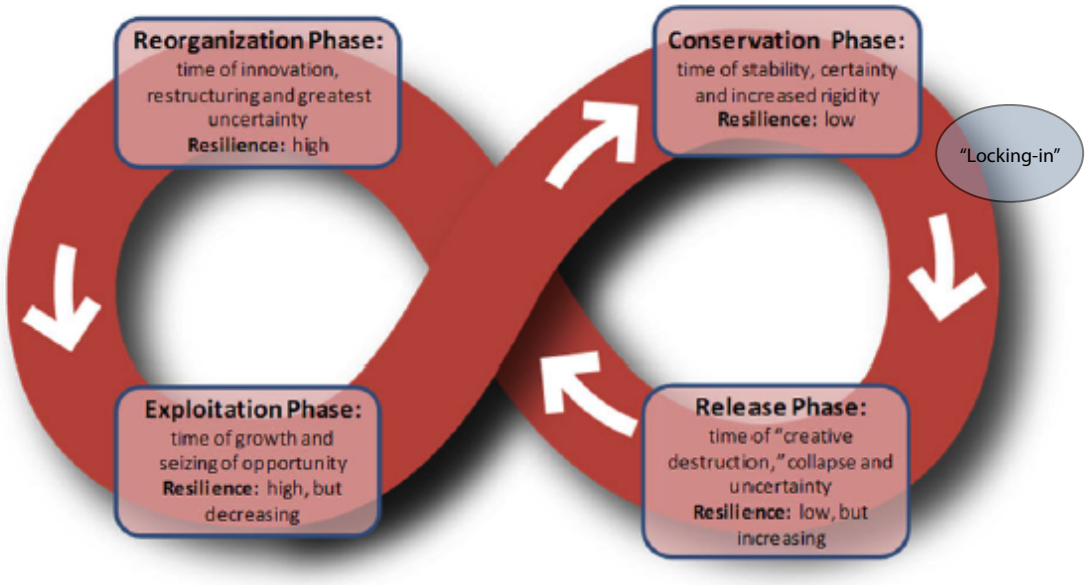


Figure 5 - The Adaptive Cycle, developed by Holling and Gunderson to describe resilience.

The Resilience Concept

Holling and Gunderson developed the Adaptive Cycle to illustrate how resilience operates (Figure 4) within a socio-ecological system (2002). The process "starts" with a growth and exploitation phase, characterized by high diversity and flexibility and many inter-linkages, which is what supports the system's high adaptive capacity. This may be comparable to a city emerging from a major natural disaster: the community comes together to find solutions, the economy diversifies to respond to immediate needs and demands, and government reaches out to support initiatives at many levels, including businesses, community groups, and non-profit organizations.

The growth and exploitation phase then evolves into a conservation phase that causes resources to be increasingly 'locked-up' into a particular equilibrium. Urban systems experience this when, for example, their economies have become highly developed in one particular sector. During this phase of the Adaptive Cycle, there can occur a 'locking-in' phenomenon (Pendall, Foster, and Cowell 2010). This locking-in of resources decreases the system's overall flexibility and places the system in a fragile state that is prone to collapse following a disturbance. Flexibility is reduced, and the system is less able to respond to external shocks.

Humanity's exploitation of natural resources, such as with the fisheries industry, 'locks us in' to a certain level of dependency and causes the natural system's diversity to decline and the ecological resilience to weaken. The dependent population becomes more vulnerable to disturbances that affect those resources (Adger 2000).

When a major shock does occur, the system collapses and then reorganizes and rebuilds. In a resilient system, the new configuration is usually similar to that prior to the disturbance, and is thus in a desirable state. Non-resilient systems are unable to reorganize and rebuild into a desirable configuration, resulting in a transformation of its identity to an undesirable state. The collapsed cod fisheries of Atlantic Canada are not likely considered desirable for anyone, indicating that this system was degraded into a non-resilient configuration. Resilient systems, on the other hand, can also collapse but have the resources and capacities outlined above to regain an adapted version of their former selves.

The adaptive cycle can be interlinked with similar cycles at different levels or scales (panarchies); for instance, the national economic resilience cycle directly influences economic resilience at the regional and local levels through feedbacks and trickle-down effects.

ii. Resilient Cities

"Resilient cities create, enable, and sustain the services and institutions required for basic ongoing survival and are characterized by their ability to generate new opportunities for their residents. They avoid relying on solutions that depend on anticipating specific hazards, and instead take a broader, integrated approach. A resilient city is able to withstand a variety of challenges because the [basic elements of resilience] are incorporated into urban systems and the ways in which people construct and maintain those systems" (Optiz-Stapelton et al. In Otto-Zimmerman 2011:405).

Goldschalk (2003) suggests that, as a general approach, resilience planning should be goal-oriented and founded on the ecosystem services provided by the region. It should be strategic in the context of the city and its existing capacities. It should be scenario-driven to find the best cost-benefit solutions to enhancing resilience in a just and equitable manner. It should be transdisciplinary in its approach to problem solving and planning. And finally, it should be an adaptive and flexible approach (Godschalk 2003).

Broadly speaking, this report defines an urban system as being made up of four cornerstones: the (i) social and (ii) economic systems functioning within an (iii) ecological system, and that are connected by (iv) infrastructure systems. This is supported by Longstaff et al., who conducted an extensive review of academic literature and policy documents (Longstaff et al. 2010). After the review of the urban vulnerabilities to peak oil in the previous section, the following section will discuss the ingredients required for resilience in each of these four cornerstones according to resilience researchers and practitioners. Since resilience operates at multiple levels within a given system, this section assumes that all of these systems must be resilient in order to improve a city or town's resilience in the face of a crisis. Each subsection concludes with specific references to how such resilience efforts can be integrated into planning practices.

Ecosystem resilience

All urban systems are situated within an ecological context. The surrounding environment provides natural resources such as fresh water, forest, or agricultural lands to sustain. Researchers who consider the future after peak oil warn that we need to enhance the resilience and sustainability of the natural ecosystems around our cities if we are to maintain our quality of living (Longstaff et al. 2010). We will not be able to convert all our forests to farms, nor all our rivers into hydro-electric dams. A certain respect for natural resilience is necessary.

A resilient ecosystem maintains high levels of biodiversity, which enables a certain level of functional redundancy within the system. This diversity and redundancy builds adaptive capacity within the ecosystem, such that in the face of prolonged changes, the natural environment is more readily able to adapt and evolve in response to new conditions. This can be facilitated by providing or protecting a variety of habitats and ecosystem types, implementing measures to increase biodiversity in the city, and creating new opportunities for nature to take root in the city. Connectivity between habitats and ecosystems is equally important, to facilitate the flow of resources, genetic material, and populations. Natural corridors, rights of way that are re-naturalized and preservation of water courses, are all measures to help connect various habitats that may be separated by the built environment or urban infrastructure.

Humans must also accept natural cycles of collapse and construction in natural systems. For example, seasonal floods or occasional forest fires are often required as part of the ecosystem's adaptive cycle described above (Figure 4). Similarly, plant and animal population dynamics experience adaptive cycles, at times experiencing population booms and at other times suffering near extirpation. These cycles need to be understood and respected by city dwellers and planners alike, and measures to accommodate these aspects of ecosystem resilience should be implemented where possible.

Anderies and colleagues observed that people connect ecosystems via information, knowledge and material flows (2006). They noted that ecosystem networks can

Since we all live within the capacities of the natural environment around us, it is important to realize how humans fit into the system, and how these interactions can be maximized to enhance our urban resilience..

be disconnected or fragmented by human activity, such as development. Moreover, people can create new ecological networks and links through their actions, such as creating a linear park, or installing an irrigation system. Not only that, but healthy agricultural practices also rely on healthy ecosystems. Since we all live within the capacities of the natural environment around us, it is important to realize how humans fit into the system, and how these interactions can be maximized to enhance our urban resilience.

City policy and municipal cooperation with regional or national-level governments can work toward preserving the natural ecosystem resilience in and around the city. Green roof and wall efforts, community gardening, and improvement of natural watercourses through cities not only contribute to natural resilience, but also have positive repercussions for reducing energy and water consumption. Other efforts such as parks planning and landscape architecture to enhance biodiversity and re-introduce native species can also be built into municipal policies, design guidelines and planning documents.

Social Resilience

What is a city without people? Building resilience among the people who live and work in our cities is quintessential to urban resilience. The first step to improving social resilience is in identifying and monitoring vulnerable communities and individuals, and ensuring that their resilience is enhanced (Godschalk 2003; Dawson 2007). In the context of urban energy, recall that the particularly vulnerable sectors include the isolated, the poor and the car-dependent. Resilience begins by enhancing the connections between these groups and those who have skills, resources, and knowledge that enable adaptation and coping capacity in response to change. Providing training and funds to promote resilience to particularly vulnerable groups is also helpful (Godschalk 2003); for example, communities may be educated about energy conservation and reducing dependence on the automobile, or trained to install residential solar panels as part of an energy decentralization and job insertion initiative.

Buckle, Mars, and Smale (2000) note that community resilience can be further enhanced by having:

- Shared community values, aspirations and goals to build trust and gain confidence
- Established social infrastructure (information, social networks, organizations) to help connect people to resources and services
- Positive social and economic trends to encourage hope and optimism in finding solutions
- Sustainability of social and economic life to provide a solid baseline
- Partnerships (linkages, networks, information-sharing)
- Appropriate resources and skills.

Urban planning can help support and encourage the development of strong community groups and public involvement in many ways. Planners should develop and support policies that encourage social resilience in their communities, and ensure that no group or individual is left behind. Providing opportunities for disadvantaged members of the community to engage and participate is essential, and should not be limited to civic engagement, but expanded to meaningful involvement in community living and the local economy (see Box 2.3 - Case Study of Vorarlberg, Austria: A Resilient Region). Public engagement in community life is very important, and cultivates pride, collaboration and a sense of ownership amongst members of the community, while also contributing to the community's overall competitive advantage in attracting new people and businesses. All this requires strong political will and leadership, and may require a shift in how we view urban governance and the roles of administrative institutions.

Governance

Governance refers to the management of politics, economy, and administrative authorities, and is comprised of a complex mechanism of processes and institutions through which citizens and groups can express their interests, mediate differences, and exercise their legal rights and obligations (Anon. No Date)

A resilient governance system is another key ingredient in building a resilient city. This implies the need for participative governance in order to build trust, shared understanding and public engagement of multiple stakeholders in decision-making processes (Anderies, Walker and Kinzig 2006; Lebel et al. 2006). Adaptive management (sometimes called "adaptive co-management) has evolved as a means of integrating aspects of resilience into governance practices.

"Adaptive co-management systems are flexible community-based systems of resource management tailored to specific places and situations and supported by, and working with, various organizations at different levels" (Olsson, Folke, and Berkes 2004). While there remain some advantages to the "silo" approach of management (e.g. ease of managing at a smaller scope or scale, efficient communication with smaller teams), the adaptive management approach

takes the idea of trans-disciplinarity[1] and panarchies to practical applications. Adaptive management is an approach to allocating responsibilities and resources in a shared and cooperative manner that promotes learning, permits cross-scale linkages to be created within the system, and ensures transparency (Plummer and Armitage 2007).

Several attributes contribute to the resilience and adaptive management of a governance system. These include high public participation, decentralized and multi-layered institutions, accountability and transparency, and leadership.

High public participation rates build trust and enable shared understanding (Godschalk 2003):

Public participation at various phases of urban planning can facilitate intergenerational knowledge, passing down experiences learned in the past and applying this knowledge to new problems. Participation is an essential ingredient to adaptive co-management: it engages actors from all levels and disciplines (Plummer and Armitage 2007; Otto-Zimmermann (ed) 2011, 117–118).

Polycentric and multi-layered institutions facilitate the fit between knowledge, action and social-ecological interactions (Anderies, Walker and Kinzig 2006):

Decentralizing and breaking down institutional behemoths allows local administrations to become more sensitive to the local context, issues, and opportunities. It improves connectivity and increases linkages between different hierarchies, sectors, and public and private interests (Godshalk 2003; Otto-Zimmermann 2011, 115). Governance structures that accommodate learning and adaptation following a disturbance are more resilient. A resilient governance structure bridges multiple scales; for example, linking national, regional and local governments (Lebel et al. 2006).

Accountable and transparent authorities pursue justice, equality of benefits and risks, and enhance adaptive capacity (Anderies, Walker and Kinzig 2006):

An accountable authority identifies the vulnerable and addresses their needs, enhancing community resilience (Godschalk 2003). Existing social networks can be used to facilitate multi-stakeholder participation that engages multiple groups from different panarchies. Multi-stakeholder participation enables shared learning and builds a common knowledge base and social memories to help deal with challenges and problem solving (Anderies, Walker, and Kinzig 2006). It also builds trust and cooperation between various organizations, institutions and stakeholders.

Leadership (Buckle, Mars, and Smale 2000; Lebel et al. 2006; Boin and McConnell 2007; Otto-Zimmermann (ed) 2011, 115):

Strong leadership that can identify weaknesses and lead communities to a state of improved self-sufficiency is critical in improving community resilience (Lebel et al. 2006; Boin and McConnell 2007; Otto-Zimmermann 2011: 115). The transformation process following a disturbance relies on competent leadership to achieve a return to a desirable stable state. Strong leadership that can identify weaknesses and lead communities to a state of improved self-sufficiency is critical in improving community resilience (Lebel et al. 2006; Boin and McConnell 2007; Otto-Zimmermann 2011: 115). Such leadership entails the ability to engage with various levels of governance and politics, promote novel solutions, and integrate multiple networks, experiences and memories (Anderies, Walker, and Kinzig 2006).

In a resilient governance system, policy planning needs to be focused on enhancing the fundamental values, assets and resources needed to enable adaptive management. The City of London's Low-Carbon policy (See Box 2.1) is a good example of how policy has guided planning objectives and projects to enhance the city's overall resilience to climate change.

Taxes can also be structured to support resilience efforts. In 2006, the Australian government – one of very few national governments that have acknowledged peak oil as a real and imminent threat – approved budget cuts designed to reduce personal taxes in order to relieve some of the fuel cost burden on residents. The Australian Senate also commissioned a detailed national survey of the country's oil vulnerability, establishing the importance of the issue among the public (Dodson and Sipe 2008). In response, several cities have invested in peak oil plans and strategies for building resilience in their communities. Budgetary spending can be adapted to shift investments toward measures that enhance resilience. Rather than investing in expanding road infrastructure, cities can invest in high-quality public transit and in enhancing the walkability of their districts.

1 Trans-disciplinarity describes a process of engagement of specialists and scientists from multiple disciplines and other stakeholders and decision makers in meaningful ways through interactions, collaboration, and through iterative processes (Novotny, Ahern, and Brown 2010). Inter-disciplinarity does not have this participative connotation, and does not suggest that other stakeholders and decision makers are included in the process.

Box 2.1 The City of London's Low-Carbon Project

London's Low-Carbon Project illustrates how political will and a well-organized planning department enabled significant carbon emission and energy consumption reductions in order to achieve a higher level of energy resilience. The city established a multi-stakeholder agency to oversee the major restructuring of development planning policies. Following a detailed review and revision process of the city's existing policies, the agency received mayoral approval for stringent new development guidelines and carbon monitoring practices that have been proven effective in achieving the city's ambitious targets in subsequent studies. On-going learning and training for existing and new planning staff supports the natural evolution of the process as new technologies and techniques become available. As a result of this project, impressive carbon emission reduction targets, as well as energy savings, have been realized (Droege 2008: 452-468).

Challenges for Resilient Governance

Politics, economic pressures, and the rigidity of existing legislative and regulatory frameworks are elements of governance that work counter to resilience. It is difficult for many leaders to make decisions on the trade-offs between short-term and long-term costs and benefits, to seek equitable distribution of risk, and to balance priorities and needs at various scales. Furthermore, it takes a minimum of a decade to build the necessary trust that is fundamental between stakeholders to adapt, change and evolve; as such, time can pose a challenge if the risks associated with peak oil require urgent action. It is unclear how best to balance the costs of creating more complex trans-hierarchical institutions with the long-term benefits of the enhanced resilience that result (Lebel et al. 2006).

While the idea of multi-level collaboration is attractive, it is difficult in practice: our current system of politics, economic powers and contrasting priorities at different levels of government often confound even the most earnest attempts (Boin and McConnell 2007).

Resilient governance also presents challenging ethical questions: for example, who benefits from resilience, and who suffers? What are the consequences of various 'resilient' options for various stakeholders in a system, and are they equitably distributed among the population (Lebel et al. 2006)?

Infrastructure Systems and the Built Environment

Critical infrastructure including transportation, communications and energy systems, are identified as the necessary networks for the basic functioning of an urban system (Vugrin et al. 2010). Boin and McConnell have outlined several steps for enhancing resilience of critical infrastructure in their 2007 article, Preparing for critical infrastructure breakdowns – the limits of crisis management and the need for resilience. Their model includes elements of adaptive capacity, public participation and trust-building, and facilitating trans-disciplinary and multi-layer interactions. This section explores how resilience can be enhanced for energy networks, transportation systems, and for the built environment.

Energy Infrastructure Networks

Our dependence on energy imports – either as primary energy (e.g. electricity and fuel) or secondary energy (transportation, food production, finished goods and products) – is a number one weak spot in a peak-oil scenario. News reports and industry advancements seem to point in the direction that, as energy prices rise, transportation will likely become increasingly electrified. Some cities, such as Langley BC, are installing charging stations, automotive industries are looking to continually improve battery and vehicle performance statistics of electric vehicles, and business journals are constantly reporting new breakthrough technologies and sales trends in the new EV industry (Krisher 2012; Winton 2012; Gathercole 2012).

Cities will need to find adequate generating capacity to meet the surge in electricity demand. While some states will build additional centralized coal and nuclear power

stations, others may opt to decentralize, and provide local power.

Allenby and Fink (2005) argue that "investments that both enhance resilience against … disaster and provide additional economic, social or environmental benefits" are essential to a resilience strategy. Decentralization enhances urban resilience by creating redundancies within the regional energy network, thereby reducing the risks of power outages over large areas. It also minimizes dependency on external resources and imports, reducing risks associated with disruptions to supply or distribution beyond the control of the urban jurisdiction.

One approach that is currently being proposed and developed in Canada is Integrated Community Energy Systems (ICES), designed by a consortium known as QUEST (Quality Urban Energy Systems for Tomorrow). The QUEST approach is one of adaptive co-management at a national scale. ICES seek opportunities and synergies at the community level through a multi-sector approach that includes land use, urban form, energy supply and distribution, transportation, community services such as water and waste management, the built environment, and industry. It is premised on six principles, which are:

- Improve efficiency first to reduce energy demand,
- Avoid using high-quality energy for low-quality purposes,
- Manage heat by finding uses for lost heat energy,
- Reduce wasted energy sources, such as landfill gases, or agricultural wastes,
- Use renewable resources, and to
- Use grids strategically, or use grid to optimize efficiency and ensure reliability (QUEST 2010).

Results of the first three major national workshops indicate that the response has been very positive from all participants; however challenges remain, including jurisdictional and legislative barriers, and challenges in finding a strong alignment for cooperation between public and private sectors.

Decentralized energy production refers to small, localized and preferably renewable energy generation through a diversity of processes. The hamlet of Mauenheim, Germany is an excellent example of how a small rural town has succeeded in producing 900% more energy than its residents consume, through a combination of solar photo-voltaic systems and a local biogas station that uses agricultural waste products to burn methane gas for electricity and heating (Barrere 2011). This project is part of an association called Solarcomplexe, which works with the state government and regional authorities to enhance decentralized energy production, with the objective of selling the surplus energy to larger urban centers such as Stuttgart. The project also includes wind farms[1].

1 http://www.solarcomplex.de/ (German only)

QUEST was launched in 2006 as a partnership between a non-government organization focused on climate change and air quality issues, and the Canadian Gas Association in response to the need to develop energy conservation policies around residential industrial and municipal energy consumers. The Initiative has since evolved into a multi-stakeholder transdisciplinary consortium of partners working with local communities to develop resources, provide data, and develop policies and strategies to support ICES. Their objective is that every Canadian community will be an ICES by 2050).

Secondary energy sources can also be decentralized: for example, economic activities may re-localize as shipping and logistics costs rise. Several major corporations in the USA, such as General Electric and Boeing, are already re-localizing their production facilities, arguing that the lower labour costs overseas are no longer enough to justify the high shipping costs to redistribute their products (Malone 2012).

Urban planning can work toward developing energy plans to improve energy resilience. Such plans provide opportunities for local energy production that otherwise would not exist, and creates a new market for alternative energy that can stimulate and diversify the local economy. The City of Guelph, for instance, has developed an ambitious and detailed Community Energy Plan that echoes many of the recommendations of QUESTS' Integrated Community Energy Systems[2]. The plan's objectives propose to use efficiency goals to achieve projected population and economic growth targets without the proportional increase in energy consumption. The plan applies adaptive management techniques to collaborate with national and provincial governments in order to pilot projects in new building code standards. Transportation demand will be diminished by 25% through urban design and transportation planning policy and programs. The city also hopes to incrementally develop "an energy distribution architecture" such as district heating networks that will benefit residents and businesses. Guelph hopes to achieve a share of 25% renewables in their energy mix within the 15 years of drafting the plan. Overall,

2 For an example, see the City of Guelph's Community Energy Plan project at http://www.guelph.ca

the Guelph Community Energy Plan provides an excellent case study of how municipalities can strategically plan for a more resilient energy system within their jurisdiction.

As the City of Guelph demonstrates, governance measures can also assist by encouraging multi-level discussions with upper levels of government in order to bridge communications between public and private sectors, diminish legal and regulatory barriers, and enable an energy transition.

Transport

The obvious approach to improving the resilience of the transportation system is to improve accessibility rather than mobility. Accessibility is based on proximity and choice of alternative modes, whereas mobility refers to the speed and ease of travel. Winkleman and colleagues (2010) point out that improved accessibility is more socially inclusive – children, seniors and the disabled can move about with equal ease. Diversifying the available transportation options helps to lower overall household costs, and improves access to jobs for workers without private transportation (Winkelman, Bishins, and Kooshian 2010). A redundancy in the number of paths available to people also encourages shorter trips and may contribute to reducing the number of trips made by motor vehicles (Ville de Strasbourg 2012).

One approach to measuring and monitoring resilience with respect to the transportation system is the energy capacity transportation model (M. Saunders, Krumdieck, and Dantas 2006). The authors define resilience as "the percentage reduction from the current transport energy consumption of the built environment to the minimum feasible consumption possible. One-hundred percent resilience occurs when no transport energy consumption is required to access the required activity."[3] The model also provides an indicator of residents' flexibility in their travel behaviours and choices. The study's findings confirm that urban form can play a large role in reducing socio-economic vulnerability to transportation disruptions. The most effective interventions include highly diversified mixed-use neighbourhoods with basic services and amenities within walking and cycling distance, and improved access, frequency and service of public transit.

Sustainable transportation planning, effective land-use planning and policies that provide incentives, subsidies, and access for vulnerable sectors of the community all contribute to enhancing community energy resilience.

Built Environment

Decisions we are making today for our built environment have direct consequences on our ability to withstand energy shocks in the future. For example, Europe is currently experiencing a boom in home and office air conditioning installations (Waide and Meier 2006). While it provides short-term relief from the heat, air conditioners contribute to the urban heat island effect by exhausting inside heat to the outside, and generate greenhouse gas emissions through the use of coolants and electricity consumption. This short-sighted adaptation response to the growing frequency of heat waves is intensifying pressure on summer electricity supply, and subsequently on freshwater resources to cool the numerous nuclear facilities. The need for artificial cooling is largely due to "universal building styles poorly adapted to the local climate, and an increase in internal heat due to electrical appliances and lighting equipment" (Waide and Meier 2006).

Neighbourhood urban design can create a more resilient "urban energy metabolism" by optimizing natural light and air circulation throughout neighbourhoods, minimizing travel distances, and maintaining naturalized corridors and environments (Droege 2007, 331–2). A biodynamic urban design approach considers the city as an extension of the natural systems surrounding it, and finds opportunities to take advantage of ecosystem services such as the cooling effects of forests, water purification by natural wetlands, or storm surge protection from sand dune ecosystems. Complemented by high-efficiency appliances, electronics and high quality insulation materials, energy consumption and demand for artificial heating and cooling can be substantially reduced.

Building design can complement the energy savings from well-designed developments. Most of the research on resilience within the built form comes from research on efficient residential building design and bio-climatic spatial planning (Ken Yeang in Droege 2008, 374). Such design is founded on ecological principles, such as recycling and reuse of materials, the integration of buildings into the ecosystem and social systems surrounding it, and the contributions that the building makes to the surrounding environment's complexity and diversity. Many view Passive House design as the ultimate objective from an ecological, social and economical perspective - especially when the building is well integrated into its surroundings (Droege 2008, 374-383). To be certified "passive house", a building must meet stringent energy consumption and conservation criteria. Passive solar hot water heating and photovoltaic energy production are common methods for achieving the strict requirements of 15 W/m2/year. The combined primary energy consumption of the living area may not exceed 120 kWh/m2year, which calculates energy needs for heating, hot water, and electricity. Additional energy needs are addressed with renewable energy (Feist, No

3 This calculation does not account for oil derivatives and indirect oil consumption from human activities, such as the fuel required to produce food eaten by a person who walks to the store, or the oil that goes into the production of their bicycle.

Date). High-quality building materials, "super-isolation", site orientation, and heat recycling are commonly-employed techniques for achieving the required standards. Stringent building codes can enhance resilience at the urban scale by contributing to reduced energy demand, decentralized energy production, and a certain level of self-sufficiency in terms of energy needs. In some German cities, and in the Province of Vorarlberg, Austria, Passive House has become an obligatory standard for new constructions, including social housing. The result is that an economy in green building design has emerged, residents can enjoy much lower and more stable household energy costs, and demand pressures on the regional electricity grid has decreased (Barrere 2011).

While most of the literature is currently focused on residential energy efficiency, similar principles can and have been applied to industrial and office buildings, including the LEED standards (Leadership in Energy and Environmental Design), and CASBEE in Japan (Comprehensive Assessment System of Building Environmental Efficiency), both of which have specific criteria for non-residential buildings[4].

One of the greatest challenges in enhancing energy resilience of the built environment is addressing high energetic (and resource) cost of demolition and reconstruction. The built environment, being essentially a permanent element of the urban landscape, lacks one of the key characteristics of resilience: flexibility and adaptability. Modular design can respond in part to this challenge. This involves using repetitive shapes and structures or removable components within buildings that can be easily moved or remodelled to respond to changing needs. For example, an apartment building may have removable walls to allow for internal configuration of space to be changed in order to accommodate multi-generational living (Friedman 2010). Alternatively, some architects have begun using recycled shipping containers – basic rectangular boxes – that can be rearranged or easily dismantled and replaced such that the volume of the building itself can be grown or shrunk. Such flexibility, demonstrated in the Henna Concept Plan in Section III, allows for building use to change over time in response to changing needs or pressures without requiring the resources involved with demolishing and rebuilding large permanent structures.

A biodynamic urban design approach considers the city as an extension of the natural systems surrounding it, and finds opportunities to take advantage of ecosystem services such as the cooling effects of forests, water purification by natural wetlands, or storm surge protection from sand dune ecosystems.

Challenges for Infrastructure Resilience

Boin and McConnell (2007) as well as Vugrin and colleagues (2009) warn that increasing privatization and growing tightly coupled interdependencies between systems are rendering cities more vulnerable to disruptions to critical infrastructure systems. While there are many examples of where private interests support and promote resilience, it can also create barriers to resiliency efforts, access to information, and evaluation initiatives. Persistence in working and collaborating positively with private interests is key to developing trust and confidence between city officials and private organisations, and can result in success. Such was the experience of the City of Guelph in obtaining critical energy information from private utility companies.

Implementation of resiliency plans at the local level can also present policy and legal challenges. The City of Bonn raises some of these issues; for example, densification targets and green construction policies will have limited impact if they only represent 5% of the building stock added each year (Otto-Zimmermann 2011: 283). Additionally, the legal framework can be prohibitive to facilitating resiliency. Updating the legal framework can take considerable time and debate before it comes into action, and may block pro-resilience projects in the meantime.

Securing a sufficient investment of time, money and resources is especially challenging at the local level. It is a 'hard sell' to encourage higher-level decision-makers to agree to major investments for long-term projects such as resilient energy infrastructure (Boin and McConnell 2007). Decision-makers and political leaders face barriers due to differences in institutional, cultural, or organizational priorities and practices. Lines of accountability at different scales of operation can also confound honest efforts, and even the best initiatives can be thwarted by bad timing during established decision-making cycles (Lebel et al. 2006). Furthermore, as with most environmental policy concerns, it can be difficult to convince decision-makers of the advantages of taking a precautionary approach when there is no easily-measurable economic benefit to be immediately realized.

4 For more information on CASBEE Japan, visit http://www.ibec.or.jp/CASBEE/english/index.htm. For informaiton on LEED in Canada, visit http://www.cagbc.org/Content/NavigationMenu/Programs/LEED/default.htm

Resilient Economy

Macro-economic resilience can be enhanced by improving economic competitiveness and governance (transparency, most notably), by diversifying the local economy to reduce excessive dependencies, and by strengthening the transportation and communication networks, especially externally (Briguglio and Galea 2011).

Economic planning for cities can provide substantial support for energy resilience. Briguglio and colleagues argue that reducing external debt levels and maintaining stable employment rates, as well as ensuring measures that allow a city to remain flexible in its response to economic shocks are measures to ensure a resilient economy (Briguglio et al. 2008). Economic vulnerability indicators (Box 2.2 – Review of economic vulnerability indicators) can be used to track and monitor the economic conditions, and guide policy and measures to improve resilience. While these are developed for the macro-economic scale, they can provide guidance for economic development policy and programs at the local level as well.

An earlier article by Briguglio and colleagues argues that economic resilience "is associated with actions undertaken by policy-makers and private economic agents" (Briguglio et al. 2008). Policies can enhance the capacity to cope with economic disruptions through taxation policies and budget expenditures in response to such shocks. Additionally, policies that enable a city's economy to withstand shocks may include those that support a flexible multi-skilled labour force and encourage economic diversification, such as incentive programs for start-ups and funding for incubator centres. Community Improvement Plans may be created to target areas requiring renewal or redevelopment. The municipality may design incentives, such as density bonusing, or changes to land-use and zoning regulations that support attracting new and different types of economic activity while also addressing energy efficiency at the same time (Patterson and Reed 2010).

Localization is another popular approach to enhancing urban economic resilience. At present, the term is sometimes confused with protectionism and insulation, but this not true localization. Economic localization aims to develop a better balance between local, regional, national and international markets (Douthwaite 1996 in North 2010), and find a more equitable and distributed division of labour (Shuman 2001 in North 2010). It does not preclude international trade for the goods that cannot be produced or acquired locally. One of the objectives of localization is to decentralise the authority and economic power of distant business leaders who are less sensitive to local conditions and context and who make decisions that have direct consequences on the local population in the form of layoffs or changes in labour policies. It is about cooperation for the best, rather than about competition for the cheapest, as Woodin and Hines put it (2004: 30, in North 2010).

The advantages for a localization approach include a reduction in transportation and logistic costs for industries, enhanced local economy that increases local employment and keeps money within the local economy, more control over local natural and human resources, and greater economic benefits within the jurisdiction.

Localization is about cooperation for the best, rather than about competition for the cheapest

The Province of Vorarlberg, Austria is an example of a region with a strong culture of localization. Initially one of the poorest regions in Austria, Vorarlberg's farmers and craftsmen learned to make do with the resources and skills available to them locally (Gauzin-Müller 2009). The isolated nature of Vorarlberg settlements caused by the mountainous topography facilitated this trend toward autonomy, which has pervaded over the past several decades despite the introduction of railway and highway infrastructure and the transition to becoming part of the Eurozone. While Vorarlberg exports large amounts of its

Box 2.2 – Review of Economic Vulnerability Indicators

Economic vulnerability can be measured by:

1. The degree of economic openness, measured by determining the ratio of exports or imports, or calculating the average of both as a percentage of the GDP.

2. Dependence on a narrow range of exports, measured as the export concentration index by UNCTAD

3. Peripherality (insularity, remoteness) measured by the ratio of transport and freight costs to imports

4. Dependence on strategic imports, measured by the average imports of commercial energy as a percent of domestic energy production.

artisan crafts, expertise in construction, and renewable energy production, it consumes very little in terms of imports. Residents prefer to purchase locally manufactured and locally grown products, and frequent local independent businesses rather than franchises and chains. They employ local tradesman for their construction and renovation needs. Several settlements are also participants in a Local Exchange and Trade System (LETS), manifested as a local currency called the Talente (see Box 2.3 – Case Study of Vorarlberg, Austria: A Resilient Region)[5] . Today, Vorarlberg is one of the wealthiest regions of the country, boasts an unemployment rate of only 4% (2008), and has a steady, stable and strong economy. Localization doesn't have to be about isolating oneself: as the case of Vorarlberg clearly demonstrates, even internationally recognized regions can employ localization strategies without cutting themselves off from the global economic system.

Challenges for Economic Resilience

Economic resilience is complex and deeply intertwined with our modern cultures and institutions. In fact, many may perceive our economic institutions as being one of the major barriers to achieving resiliency in other sectors. Capitalism and liberalism have created a rigid legal Capitalism and liberalism have created a rigid legal and regulatory structure that is founded on expansion, globalization, and constant economic growth (Atkinson 2007; Martenson 2011). Many aspects of these practices, such as centralized governance or raw resource-dependent economic development, act in opposition to resilience.

5 LETS are not unique to this region. There are several LETS systems in North America, the most notable being Ithaca NY's HOURS. For more information, visit http://www.lightlink.com/hours/ithacahours/visitingithaca.html.

Box 2.3 – Case Study of Vorarlberg, Austria: A Resilient Region

Figure 6: The Community Centre and Town Hall of Ludesh, Austria is built from locally-sourced wood products using local construction labour and craftsmanship. The building and its community have won the top award under the European 5es program for energy efficiency. Photo credit: J McDowell 2011.

Characterized by rugged and beautiful alpine scenery, Vorarlberg is situated in the north-western peninsula of Austria, cradling Lake Constance and following the Rhine valley. A third of the population resides in three major settlements: Dornbirn (pop. 44,000), Feldkirch (pop. 33,100) and Bregenz (pop. 29,000). The province has experienced continuous centre-right political leadership for over 50 years, contributing to stability in regional policy and regulatory decisions that promotes trust and confidence amongst the electorate. There is increasing political support for ecological and social projects that is reinforced by a culture of transparent and accountable governance, low corruption levels and strong public engagement. Seventy per cent of the region's population is actively involved in at least one organization (e.g. sports, non-governmental organization, social services, etc).

The province was historically very poor, and thus has a deeply entrenched culture of making do with local resources. Integration with the Eurozone in 1995 provided investments in major infrastructure and helped revive the slow economy. The region's economy is currently founded on agriculture, forestry and wood trades, tourism and textiles. Architecture has also become a major economic driver. The region is internationally recognized today for its excellence in modern ecologically- and socially-sensitive architecture and design, and now boasts a new form of "architectural tourism".

In the 1960s, architect and influential thinker Ronald Rainer founded the Baukunstler movement ("artists of building") in Vorarlberg's School of Construction. His approach was a radical new way to integrate social equity and environmental quality into building design. Building on the culture of 'making do', their projects aimed to work within the client's budgetary constraints without compromising on quality, by taking advantage of local skills and resources. This meant an emphasis on wood construction techniques and craftsmanship, use of renewable resources for heating and electricity needs, and provision of materials and labour from local sources. The movement has developed a strong following of architects, builders, and designers who have adopted the philosophy and practices of the Baukunstler movement.

Though the movement was initially met with substantial resistance amongst professionals and residents, strong leadership from Rainer, his colleagues and their students guaranteed its success. Baukunstlers successfully lobbied for changes to provincial regulations to make it easier to

implement their projects in the region and acquire public acceptance and appreciation. This bottom-up influence is characteristic of the local culture, and was possible due to strong leadership, a clear vision, and the development of local pride. By the 1980s, the movement's architects were being commissioned for public projects including community centres, schools and municipal buildings. The number of architects has ballooned from only 20 in 1970 to over 700 architects in 2008. The culture of the Baukunstler is based on passing down knowledge and expertise from senior architects to young junior architects, thus encouraging the adoption of local knowledge and social memory that is a recurring theme in social-ecological resilience literature.

Since the 1980s, the Baukunstler movement has evolved and inspired an increasingly holistic approach to development in the region. It began with the development of the Ecopass Program, which recognizes and subsidizes sustainable construction. The Ecopass certification is based on 300 points distributed among five categories:

1) location and functionality of the site;
2) energy consumption;
3) technological installations;
4) choice of materials; and
5) interior air quality.

Loans and financial subsidies are awarded based on the number of points achieved, and the surface area of the project, which rewards higher-density construction. The Ecopass program has been used as a tool to respond to multiple challenges, including home energy consumption, urban sprawl, climate change and social housing.

In response to the increasing demand for assistance and expertise in energy conservation, efficiency and renewable energy technologies, the province launched the Energieinstitut of Vorarlberg in the 1990s. Responsible for advising, educating, communicating, and partnering on a vast array of projects related to energy and sustainable development, the Energieinstitut is actively improving the region's energy resilience. As part of their services, they develop and publish the annual Baubook, which catalogues all ecologically and socially responsible products and services for the construction and development industry. Energieinstitut Vorarlberg works with local administrations and builders to address transportation, energy, and climate change issues. They champion a large number of campaigns, and advise on policy matters as well. They produce a wide variety of educational material, and organize regular conferences and meetings on related subjects for industry, governments, and the general public. This organization is an essential link in the Vorarlberg community network, helping to disseminate local knowledge, skills and resources, connect various groups, administrations, institutions and individuals, and provide leadership that is critical to ensuring the ongoing resilience of Vorarlberg.

Vorarlberg is also very committed to increasing the share of renewable energy sources in its energy production mix by 54% between 2001 and 2015. The emphasis is on solar hot water heating, biomass and biogas cogeneration. Solar panel installations have risen from 4% in 2000 to 70% in 2008, of which three quarters were manufactured by local enterprises. Part of the success is due to the establishment of a type of "green energy stock exchange". Individuals provide a south-facing wall or roof surface on which solar panels can be installed. The homeowner then decides how much money they wish to invest in renewable energy, and thus become a green energy shareholder. The energy produced by the installation is sold to the local utility company at a favourable rate, thus the shareholder receives 'dividends' in the form of a feed-in tariff that helps pay off the initial investment.

Vorarlberg's community is also economically and socially resilient. A combination of strong civic and community engagement, a culture of solidarity, and a history of poverty contribute to the region's social resilience. Residents demonstrate a preference for local products and services, which has provided ideal conditions for developing a Local Exchange Trade System (LETS), or local currency. The Talente is the local currency in Vorarlberg. Residents can acquire, trade, spend, or exchange their Talentes. Exchanging the Talentes for Euros is discouraged by unfavourable rates, while local stores and organizations provide a greater incentive by accepting Talentes for local products. The LETS strongly supports the inclusion of low-income, isolated, or minimally skilled individuals by allowing them opportunities to exchange whatever skills and services they can provide for currency that permits them to purchase basic needs and services. For instance, house cleaning for one hour can be exchanged for one hour of home renovations, or can be "paid" for with Talentes and used to purchase groceries at the local convenience store. No one is left out – young, old, able-bodied and disabled can participate in the LETS with no discrimination. This form of social inclusion is an excellent example of Vorarlberg's resilience.

Vorarlberg demonstrates strong economic, social and environmental resilience, proving that strong leadership and good governance can go a long way in enhancing a community's ability to cope with, adapt and respond to change.

Information for this case study is sourced from Dominique Gauzin-Müller's book, "L'architecture écologique du Vorarlberg", and from two site visits to the Province of Vorarlberg with REDD Urban Planning consultants in July 2011.

iii. Conclusions: Elements for Urban Resilience

Our current political, economic and governance models represent the "locked-in" phase of the adaptive cycle. Legislative and institutional structures are inflexible and present several major barriers to implementing adaptive management approaches, or improving resilience in the built environment, for example. In order to move into the growth and development phase, cities will need to proactively seek out opportunities to enhance flexibility, diversity and increased network connections within their economic, administrative, social and environmental systems.

Not all of the measures discussed previously are available to city planners and decision-makers; some actions may be beyond their jurisdiction to address. Issues such as regional energy supply, tight economic coupling with global networks, and national jurisdiction on natural resource and energy management may pose significant constraints to cities aiming to improve their resilience in the face of an energy crisis. In Canada, cities are "creatures of the state", meaning that their powers have been conveyed by higher-level governments which can still dictate much of their legislative flexibility. However, if cities are able to implement the principles of adaptive management by creating important and meaningful links between local administrations and higher-level governance structures, some of these barriers may be overcome in time. QUEST Canada is trying to accomplish this through extensive discussion and consultation with stakeholders across Canada to identify opportunities and constraints in moving forward (QUEST 2012). Communication, strong leadership, and political will are necessary ingredients. Cities may also wish to take on a stronger advocacy role in working with higher levels of government in order to achieve some of the legal and administrative changes required for resilience planning.

Nevertheless, cities retain the power to create progressive policies, guidelines, plans and by-laws within their jurisdiction to support local-level resilience. Encouraging buy-local policies, developing an intelligent, ecosystems-based natural landscape preservation plan, planning efficient neighbourhood design and development, and investing in sustainable transportation measures can all contribute significantly to enhanced local energy resilience. The following summarizes some of the resilience measures that can be applied to urban planning practices.

Figure 6 – Sunnahof Centre, Vorarlberg Austria. This working farm is a social insertion centre for developmentally and physically handicapped adults. Run almost entirely by volunteers, the farm produces organic products and trains their participants with trades and skills that can be used in future job placements. Locals can buy Sunnahof prodcuts using their euros or their Talentes. Photo credit: J McDowell 2011.

Social Resilience

- Evaluate and monitor vulnerability within the population – notably, those who are isolated, low-income, or have poor accessibility throughout the city
- Support community development and collaboration: create meaningful dialogue between interest groups, neighbourhood associations, citizen participation, the private sector and the public administration
- Provide appropriate resources and skills training, and encourage connections between groups to seek out such support
- Maintain positive and sustainable social and economic trends

Governance

- Practice good governance: participatory, transparent, accountable and equitable
- Develop a system of adaptive management within the local administration and beyond
  - Demonstrate and facilitate strong leadership
  - Engage the public on an ongoing basis
  - Integrate various disciplines and types of knowledge into decision-making processes
  - Work with private and public interests to coordinate the transitions and develop new policies
  - Facilitate closer dialogue on resilience issues between higher levels of governance, including regional, provincial/state, and national administrations
- Integrate resilient governance into local policy and legislation tools
- Follow through by introducing tax and funding structures designed to enhance urban energy resilience

Resilient Infrastructure

- Prepare cities for changes to their critical infrastructure – notably, the energy, transportation and built environment systems
- Decentralize or localize energy production and invest in renewables
- Create urban community energy plans to maximize efficient energy use and re-use
- Invest in projects that support sustainable transportation modes, such as public transit, walking and cycling, particularly for vulnerable populations and isolated districts
- Enhance accessibility and efficiency through good urban design and land use planning
- Work with development and construction industries to improve building codes that promote passive heating and cooling
- Improve urban design policies to promote enhanced passive heating and cooling
- Develop land use plans and design codes based on existing ecosystem services in a way that enhances

ecosystem health while addressing the needs of the built environment.

Economic Resilience

- Reduce external dependencies, such as unnecessary imports and exports
- Diversify the local economy by attracting new businesses, entrepreneurs and industries
- Encourage buy-local policies and programs to support a re-localization of economic activity and reduce economic leakage outside of the jurisdiction
- Work with various levels of governance to reduce regulatory and legal barriers
- Consider introducing a local currency or trade system to promote buying local products and services

Weaknesses and Challenges in Resilience Approaches Today

While the resilient city has many attractive elements, there remain some general challenges and weaknesses among resilience approaches to consider.

Common Understanding: The first consideration is to ensure that all actors and participants in resilience measures share the same understanding of the concept and definition of resilience. There are countless examples among "resilience plans" and in the scholarly literature that tend to confound emergency preparedness and crisis management with resiliency. To date, there is no unanimous agreement on the exact definition of resilience. Practitioners and decision-makers must ensure that those affected or involved in resilience efforts share the same understanding of resilience.

Time: Time is one of the greatest challenges to developing a city's resilience. Building resilience within an urban system requires a minimum of a decade to change our way of thinking of how we run our cities. It requires shifts in governance practices, changes in policy and regulation, and adjustments to priorities for government spending and investments. Even the most well-intentioned projects will meet with opposition, which also delays progress.

Our **limited understanding** of the complex feedbacks and interactions in our urban systems also pose complications for advancing resilience. Resiliency advocates will invariably make mistakes, misjudge impacts and effects of their decisions, or inaccurately predict results of their efforts. Being aware of and accepting these constraints and challenges will help us further develop practices and models for building resiliency in our cities in a conscious and careful manner.

Part III: Urban Resilience – Planning and Implementation

Urban resilience is a relatively new concept and approach in planning and policy practices. How does one make a city or a community more resilient? Economist David Fleming says a community or city is resilient if it meets the following four conditions:

1. If part is destroyed, the shock doesn't extend everywhere[1];
2. There is a great diversity of solutions for local circumstances;
3. The community can still meet its own needs even if there is a significant decrease in travel and transportation, and;
4. Economic bureaucracy and infrastructure pillars will be replaced by alternative solutions adapted to the local context at a reduced cost (Hopkins 2008, 61).

Building urban and community resilience occurs in three phases. First, the local exposures and sensitivities to a particular threat or set of threats must be understood and clearly defined (Shah and Ranghieri 2012). This is accomplished through public participation and through monitoring and evaluation of vulnerabilities and risks (Godschalk 2003). Indicators such as the Resilience Capacity Index, discussed below, can be used during this phase.

Second, measures must be developed to reduce vulnerabilities and impacts, drawing on indicators, models or plans to frame their progress (Shah and Ranghieri 2012). These, too, must be carried out with public input and multi-disciplinary contributions. Leadership is an important element at this phase to help transition from rigid regulatory and legislative structures to a more flexible and adaptive governance structure permissive of resilience initiatives (Godschalk 2003). Models such as the World Bank's Workbook on Planning for Urban Resilience, discussed below, are useful guides for developing plans or programs to enhance community resilience.

Third, they must identify resources and promote investments that limit the vulnerabilities while increasing resilience. These must fit into policy and planning documents that act as a guide or framework to improve local resilience (Shah and Ranghieri 2012). Public commitment to new policies and finance structures that promote resilience are imperative, justifying the need for representative public involvement throughout the process (Godschalk 2003).

While these three phases can be generalized to all urban planning practices, this section will explore some strong examples of how indicators, models and strategic planning have been used toward resilience planning. The order of the resilient planning practices outlined below should not be interpreted as a hierarchy, as the methods below are not mutually exclusive, but complementary.

1 While the first criteria may be debated (for example, losing an important community to a fire may not extend everywhere, but may cause psychological or social shock elsewhere), the remaining three are quite valid, and should be carefully considered in planning and building resilient cities.

i. Indicators and Assessment Frameworks

The Resilience Capacity Index

The purpose of an indicator is to evaluate, track progress, and to make comparisons. Dr. Kathryn Foster of the Building Resilient Regions Network, along with the University at Buffalo Regional Institute recently developed the Resilience Capacity Index (RCI) to evaluate regional metropolitan resilience across US cities (Foster 2011). The index provides a single statistic – the z-score – that can be used to compare resilience capacity of metropolitan regions across the USA. The z-score measures the standard deviation of a measurement from the mean. For any given indicator in the RCI, the average of all municipalities is calculated, and each individual municipality is then compared to the average to determine its relative resilience score for that indicator. For example how many standard deviations does the city of San Francisco vary from the national average on Industrial Diversity measures?

The indicators used in the RCI represent the factors most known to contribute to resilience according to the academic literature (Appendix A Table A1: Resilience Capacity Index Indicators). Indicators are chosen based on their measurability, accessibility and availability of the data, and comparability between regions. The 12 chosen indicators fall into three categories: regional economic resilience capacity, socio-demographic capacity and community connectivity (Foster 2011). They include:

Economic Indicators:	Industrial diversity
	Business Environment
	Regional Affordability
	Income Equality
Socio-demographic Indicators:	Educational attainment
	Disability
	Health-insured
	Poverty
Community Connectivity:	Civic infrastructure
	Metropolitan stability
	Homeownership
	Voter participation

The RCI is useful for comparing progress against other similarly-sized municipalities, or for comparing cities within a larger region. Comparing trends for US metropolitan regions could be useful for cities that are lobbying for funding or policy-making efforts at the national level. It can also be a good political tool at the local level to encourage policy development that enhances resilience where the Index indicates a poor grade. It also acts as a communication tool to educate and sensitize the community about resilience and the efforts being made in their metropolitan region, helping to generate local pride, participation and connections. Finally, this index can be used to monitor and evaluate progress when integrated into models or frameworks for enhancing community and urban resilience.

Critiques: The RCI provides a good, comparable snapshot of overall social and economic resilience, but is limited in its applicability to an energy resilience strategy. Because the Index uses indicators that were intended for cross-American comparisons, the authors were obliged to leave out certain indicators, including transportation, building energy efficiency, and food production.

Transportation accessibility and building energy efficiency efforts are measurable with readily available data. For example, walkability scores are an appropriate indicator that is increasingly used to evaluate how accessible the community is for pedestrians (Carr, Dunsiger, and Marcus 2010). Public transit ridership, modal share trends, trip distances or duration measurements, and origin-destination studies can also be applied to measure transportation resilience and can be easily integrated into the index.

While finding comparable data for a nation-wide indicator of building energy efficiency may not have been feasible for the RCI collaborators, there are ways to measure the energy efficiency of the built environment within one's jurisdiction. This can be achieved by evaluating home energy consumption and industrial energy use. Acquiring data may be complicated by resistance from the private sector to divulge sensitive data, but is possible with good communication and persistence, as was the case for the Guelph Community Energy Plan (See Section II: pg 29; City of Guelph 2007).

Similarly, the index lacks measures for local food production, which could also be measured as a percentage of

metropolitan territory designated for food production purposes (community gardens, green roofs, etc). However, there are few studies supporting reliable indicators of local urban food production – most depend on independent survey data (Martin and Marsden 1999).

Environmental and geographical indicators are also omitted from the RCI, justified by the authors based on challenges in obtaining easily measurable data, or difficulties in comparing different regions. The NOAA's Coastal Community Resilience Index includes such environmental indicators as water quality, air quality, biodiversity, and sensitive habitat indicators (Pine 2009).

Elements of governance that contribute to building resilience are equally difficult to measure and thus were also intentionally left out of the index.

Using the RCI as a basis, cities and towns can add these missing indicators and use a tool similar to the RCI to evaluate their own resilience on an ongoing basis. Indicators can be adjusted depending on the objectives of the city's defined threats and vulnerabilities.

Urban Resilience Assessment Framework

Developed by a graduate student at the University of Auckland, New Zealand, the Urban Resilience Assessment Framework (URAF) provides a grid to guide policy-makers in evaluating their community's resilience to threats of climate change and peak oil (Mortimer 2010). Mortimer's assessment is derived from a review of existing evaluation tools for resilience policy development, such as the Resilience Alliance's 2007 workbook, and the Canadian Centre for Community Renewal's Community Resilience Toolkit.[1]

The URAF is built on several assumptions, including that resilience is a subset of sustainability, and that resilience is broken down into both adaptation characteristics, and adaptive capacity characteristics. Adaptation enables communities to "withstand, bounce back from or adapt to a specific threat," whereas adaptive capacity refers to the general preparedness of a settlement to "respond to a range of pressures including unexpected shocks" (Mortimer 2010).

The framework's guiding questions lead practitioners to assessing the community's adaptation characteristics by examining resilience in institutional, community and economic sectors. To evaluate adaptive capacity, the framework examines transportation, energy, environmental resilience, and urban design and form. It provides several potential indicators for each sector, drawn from the academic literature. The Urban Resilience Assessment Framework can be found in Appendix A, Table A2.

According to Mortimer's research, energy and transportation resilience can be measured by indicators such as a sprawl index for measuring the effectiveness of urban design and form in reducing vehicle use. To measure the alternative transportation options available in the community, the URAF suggests using mode shares, affordability indicators, accessibility to public transit measures, and public investment figures. The URAF evaluates energy resilience by monitoring residential energy consumption per person, and evaluating the mix of energy sources for the community – how much of the community's energy comes from renewables, versus non-renewable sources?

Critiques: The framework is strictly focused on policy planning, but would also be useful in earlier phases of resilience planning as an assessment tool (as it is intended to be), as well as for ongoing monitoring and evaluation. However, it could be strengthened by including best practice benchmarks for the indicators included in the assessment tool in order to provide practitioners with a way to gauge whether their community is tending more toward resilience or vulnerability. What are the quantitative thresholds to be aware of? At what value is resilience achieved?

The author acknowledges that this is a starting point for further studies such as cost-benefit analyses and implementation analyses. It can be useful for identifying priority areas to concentrate efforts at building resilience, however this assumes that the tool is used to first determine baseline values, and then to conduct follow-up evaluations to demonstrate any trends or progress in resilience. She also notes that the framework should be subject to further peer review and piloted by practitioners.

Additionally, the framework does not address several key ingredients of a resilience strategy, including decentralization/localization and adaptive management. There are no measures that support localization and decentralization policy measures; these are particularly important to include from a policy standpoint, since the policy provides the point of reference for economic development within the community. Adaptive management (governance) is also left out of consideration in the assessment tool – there are no indicators or measures proposed to evaluate the degree of trans-disciplinary collaboration between public and private sectors, and among various levels of government. The framework assessment could include guiding questions for policy makers to address the level of collaboration and multi-level or transdisciplinary cooperation.

1 Resilience Alliance 2007 workbook available at: http://www.resalliance.org/index.php/resilience_assessment;
CCCR Community Resilience Toolkit available at: http://communityrenewal.ca/community-resilience-manual.

ii. Models

Models often incorporate indicators and measurements to help develop various scenarios and to construct a practical approach to implementation. This section reviews three models for increasing urban resilience that provide the strategy and planning process for practitioners. These include the World Bank's Workbook on Planning for Urban Resilience, the Transition Town Movement, and the Resilience Alliance's 2007 Workbook.

World Bank Workbook on Planning for Urban Resilience

The Workbook on Planning for Urban Resilience outlines a comprehensive five-phase process for creating and implementing an effective Local Resilience Action Plan – the LRAP (Shah and Ranghieri 2012). The model was designed within the context of resilience to natural disasters in developing regions using case studies from cities in Vietnam, but can be applied to respond to other risks, including energy related risks, in developing and developed regions alike.

The Workbook is founded on the principle of reducing risks and vulnerabilities in order to enhance resilience. The authors advocate a strategic planning approach for short-, medium- and long-term measures to improve resilience through addressing geographical target areas of vulnerabilities and weaknesses. The model is divided into three sections: a public awareness and educational outreach component, a technical analysis of current and projected risks and vulnerabilities, and a strategic plan for implementation of resilience-building measures.

Public Awareness, or sensitization, is achieved through education, awareness-building and engagement efforts based on an effective communication strategy. This element is important in ensuring that the whole community shares the same understanding of resilience, the goals and objectives, and the process required.

The authors stress the importance of including all levels of society from individuals to government ministers, and recommend the creation of a roundtable of representatives from various sectors and levels of society. This roundtable is responsible for:

- vulnerability mapping to determine the specific threats and risks of interest to the community, and identifying vulnerable zones and populations with the help of data provided by a technical working group;
- creating an inventory of current and envisioned plans that directly or indirectly address these vulnerabilities; and finally,
- developing a clear vision and objectives to guide the development of a Local Resilience Action Plan.

The **technical analysis** is conducted by a technical working group. This group produces and analyzes a series of current and projected risk and vulnerability assessments at the regional, city, and neighbourhood levels. The workbook provides detailed information on the types of maps and data to collect:

- the base map illustrates administrative boundaries, infrastructure systems, local geography and physical topography;
- additional layers are generated to identify vulnerable socio-demographic clusters, economic development districts, and sensitive geographic locations;
- hazards maps are created that identify the confluence of sensitive 'target' areas, or 'hot spots'.

Once the maps have been generated to identify and prioritize hot spots, the technical team undertakes a needs assessment. For each hot spot, a priority list of possible interventions is drafted. The technical team identifies who (institution, department, minister, director, interest group, etc) is responsible for each item on the target priority list. They also review which existing plans, policies and projects are already in place to address each item. Additional potential partners and resources are listed and mapped, including schools, community groups and non-government organizations. The data is assessed for institutional capacities and resources, including political commitment, support within the existing legal and regulatory framework, and technical capacity. Lastly, the needs assessment and resource inventory is assessed for gaps.

The **Local Resilience Action Plan** integrates the data accumulated from the technical analyses and the roundtable advisors to produce a set of options to address each priority target area. The result is the Local Resilience Action Plan (LRAP) – a list of actions, key actors, projected completion

dates, implementation budget, means of monitoring and evaluation and a communication plan.

The breakdown of these steps is illustrated in Figure 8 below. The World Bank's approach combines risk management and adaptation. Its strength is in considering the multi-scalar and trans-disciplinary aspect of resilience in advocating cohesion and coherence among policy and planning documents at all levels of governance. It is equally attentive to the need to identify the institutional framework and its actors from the local level up to the national level in order to know the key contacts, organizational structures, policies and resources available at each level (Shah and Ranghieri, 2012: 9-15). The framework is very general, allowing it to be adapted to the specific context of any particular town or city.

Critiques: The World Bank's workbook does not provide important background information on what makes a city resilient: there is no mention of how diversity, flexibility and redundancy contribute to enhancing resilience. Practitioners referring to this tool would need to come equipped with a solid understanding of resilience before using the framework, in order to develop interventions that would respond to the needs of a resilient system.

Considering the outcome of this workbook is an "action plan", there are in fact very few proposed actions for enhancing resilience such as decentralizing institutions, or planning for local food production. It is assumed that the technical group or roundtable of experts is to provide this knowledge and expertise, introducing it into the concrete measures and policies developed as part of this process. Instead, this document serves mostly as a tool to guide the process of defining actions within community- or city-specific contexts. It would be more useful to have a few case studies or examples for practitioners to start from.

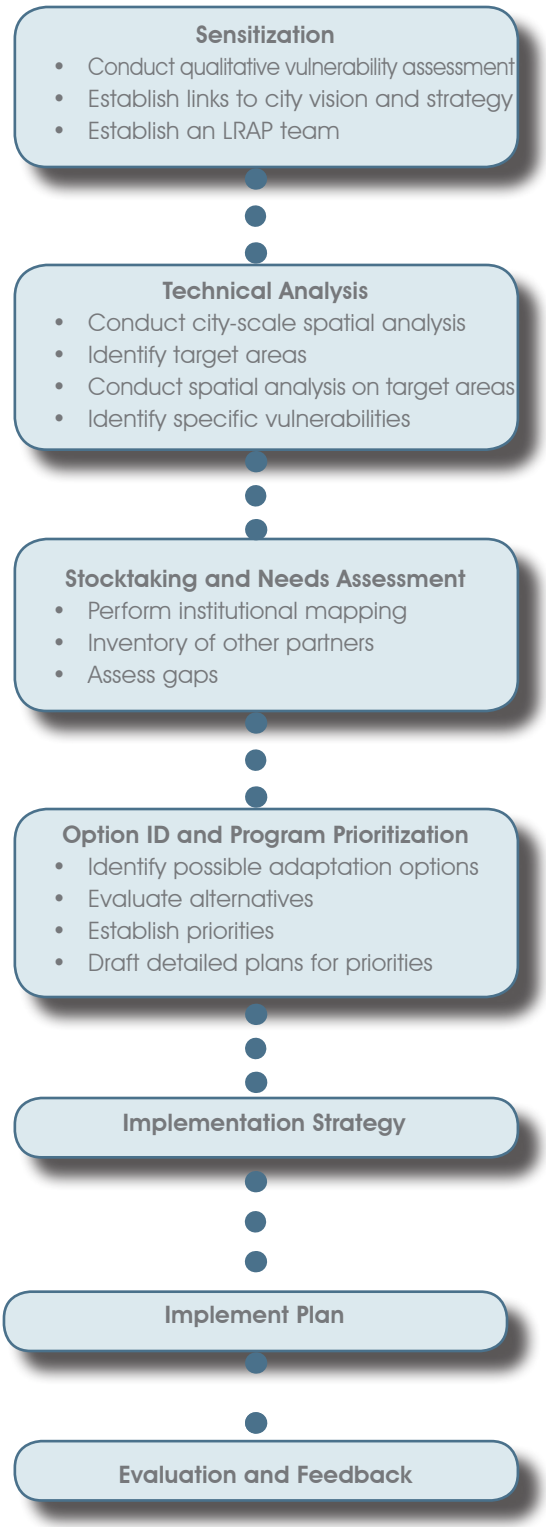


Figure 8 - The LRAP Process, adapted from Shah and Ranghieri 2012, pg 19

Resilience Alliance 2007 Workbook

The Resilience Alliance is a research organization of academics from a wide range of disciplines who explore social-ecological systems and resilience. The workbook is designed for practitioners in resource management, policy development, and strategic planners. The model presented in the workbook is built on scientific resilience research of social-ecological systems, integrating concepts such as the adaptive cycle, multi-scalar interactions, transdisciplinarity, diversity and redundancy.

While the workbook does not claim to provide a prescribed series of steps to achieve a desired outcome, it does provide a set of guidelines and strategies for assessing resilience in broad terms, and encourages a critical reflection on management and policy practices. The three key considerations of the workbook are to have its users reflect on (i) the effectiveness of current or proposed policy, (ii) the extent of financial investment and incentives, and (iii) the existence of strategic and operational plans that improve resilience.

Developed by some of the very scientists who have done the most research on resilience in the last two decades, it is not surprising that this represents the most comprehensive approach to integrating resilience science into planning and management processes. The authors integrate detailed explanations and illustrative case studies and examples to render it accessible to the layperson. The document is clear and easy to understand, and makes the direct link between resilience in science and theory, and resilience in practice.

As with the World Bank model, the Resilience Alliance process shares some of the same elements, including the creation of an inventory of primary agencies, policies, and regulations in the area, and determining key actors and their roles. Adaptive management is described in detail as a management strategy, which is unsurprising given that this approach was originally developed in response to natural resource management problems.

Critiques: The Resilience Alliance Workbook is intended for natural resource management practitioners that have a background in scientific research to begin with, and are allotted appropriate resources and time to consider systems in great detail. The proposed framework assumes users come with a thorough understanding of natural systems, ecology and sociology from a scientific standpoint. A layperson may find it very difficult – if not impossible – to adequately define the potential thresholds of a natural system subjected to these complex interactions between the built environment, urban energy metabolism and the ecosystem. As a result, what the model prioritizes, such as comprehensive understanding of systems of study and a detailed understanding of complex interactions, is neither a priority nor easily implemented by most urban planners, policy-makers, and decision-makers given their competing priorities and resource constraints. While it provides excellent links between science and practice, it will likely remain limited to use by scientific bureaucrats in natural resource management.

Second, the guiding questions in the workbook are too broad in scope, at once making them difficult to answer concretely, and yet requiring very time-consuming data collection, reflection and research. Furthermore, the approach lacks measurability: while on the one hand demanding the practitioner to delve deep into qualitative research to evaluate the current system's state of resilience, it does not provide concrete measurement tools for ongoing evaluation and monitoring. This is surprising, given that it was developed by scientists who tend to highly value quantitative measurements.

Finally, the workbook is very useful for enhancing ecological resilience in resource management situations, but it fails to make connections to the influences of and on social elements and economic processes. As such, transportation and energy issues are completely ignored. Some parts of the framework are not suitable to the energy system: for example, it would be hard to argue that there are any cycles of change worth analysing in the transportation network or the built environment (See Phase 3).

The value of this workbook lies in its integration of the adaptive cycle and certain features of resilient systems that can be adopted in social-ecological systems as well. The workbook serves more as a series of guiding questions for purposeful reflection amongst like-minded scientists than a practical tool for the average policy-maker or strategic planner.

Box 3.1 – Resilience Alliance 2007 Workbook

The workbook is divided into five sections that guide the reader through the following steps (adapted from the Resilience Alliance 2007 Workbook)

Phase 1: Resilience of what to what?

1. Define the system of interest and the risks to address
   - 1.1 Identify the main issues to be addressed
   - 1.2 Determine spatial and temporal boundaries
   - 1.3 Identify critical actors and natural resources
   - 1.4 List primary agencies, policies, and property rights governing those resources
   - 1.5 Develop a plan to obtain critical ecological, social and economic data
   - 1.6 Identify management goals for the system

2. Identify cross-scale interactions
   - 2.1 Identify primary economic, social, political and ecological scales that operate above and below the focal scale
   - 2.2 Identify information and data needs

3. Link the past to the present
   - 3.1 Create a historical timeline for the focal system noting key major events
   - 3.2 Identify connections (cause and effect, impacts on thresholds…) between events at different scales

4. Resilience to what disturbances?
   - 4.1 Document critical disturbances that have affected the focal system in terms of frequency and impact
   - 4.2 Note which of these disturbances has been changing in frequency or impact
   - 4.3 Identify potential new threats
   - 4.4 List disturbances that are potentially threatening

Phase 2: Assessing alternate states and thresholds

1. Consider alternate states of the system of interest
   - 1.1 What are the potential alternate states of the system?
   - 1.2 Summarize ecological, economic and social characteristics for each state
   - 1.3 Attempt to define the desirability of each alternative state according to the norms and values of various stakeholders
   - 1.4 Identify processes and disturbances that might shift the system to another state
   - 1.5 Develop scientifically-based dynamic models of possible alternative states for the system

2. Define thresholds
   - 2.1 Consider and identify, if possible, the critical thresholds in your systems
   - 2.2 What factors and/or disturbances might push the system closer to those thresholds?
   - 2.3 Identify attributes of the system that strongly affect the slow-changing variables in the system and that can thus influence the position of thresholds in the system
   - 2.4 Develop a plan for further understanding and managing these thresholds

3. Develop scenarios
   - 3.1 Develop three to four plausible alternative future scenarios
   - 3.2 Consider what indicators are useful to measure to determine if the system is following a particular trajectory to a particular alternative future scenario

Phase 3: Assessing and managing cycles of change
1. Adaptive cycle analysis
1.1 Identify which of the four phases of the adaptive cycle the focal system is currently in
1.2 Distinguish past adaptive cycles in the system
1.3 Determine what disturbances and vulnerabilities trigger transitions to each phase of the adaptive cycle
1.4 Develop management strategies to foster innovation, maintain critical capital, and allow flexibility in the focal system

Phase 4: Adaptability and Transformative change
1. Understand cross-scale interactions
1.1 Identify adaptive cycle phases for the level above and below the focal scale
1.2 Identify vulnerabilities that arise in the focal level from interactions with the scale below
1.3 Develop management strategies to capture benefits of system dynamics at lower levels
1.4 Identify influences, both good and bad, at higher levels
1.5 Develop management strategies to facilitate desirable influences from higher scale processes and mitigate undesirable influences

2. Understand transformability
2.1 Identify individuals and organizations that play key leadership roles
2.2 Characterize how players work together; levels of trust, partnerships etc.
2.3 Examine capacity to change
2.4 Identify governance attributes and institutions
2.5 Identify forms of capital, and where additional capital is needed

Phase 5: Interventions and management
1. Develop interventions
1.1 Develop list of high-priority interventions based on thresholds of concern
1.2 Explore potential effects of specific interventions across multiple scales
1.3 Consider types and timing of interventions in context of adaptive cycles

2. Adaptive assessment and management
2.1 Consider how and why to use an adaptive management approach

Transition Towns: A grassroots approach

The Transition Town movement began in the UK in the early 2000s by permaculturist and professor Dr. Ron Hopkins. He designed this approach for small towns, communities or neighbourhoods in response to concerns about peak oil and climate change. The Transition Town movement is founded on six principles: visioning, inclusion, awareness-raising, resilience, psychological insight and credible and appropriate solutions (Hopkins 2008, 90).

The Transition culture is "devoted to creating places that are more locally resilient to the threats posed by declining global oil production and climate change" (Mason and Whitehead 2011). This requires approaches such as economic re-localization and local currencies, enhanced community cooperation, local food production and waste management, and energy conservation complemented with renewable energy production.

Resilience is at the core of the Transition Movement. The Movement defines resilience according to the ecological definition provided by the Resilience Alliance: "ecological resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient system can withstand shocks and rebuild itself when necessary" (Resilience Alliance, in Mason and

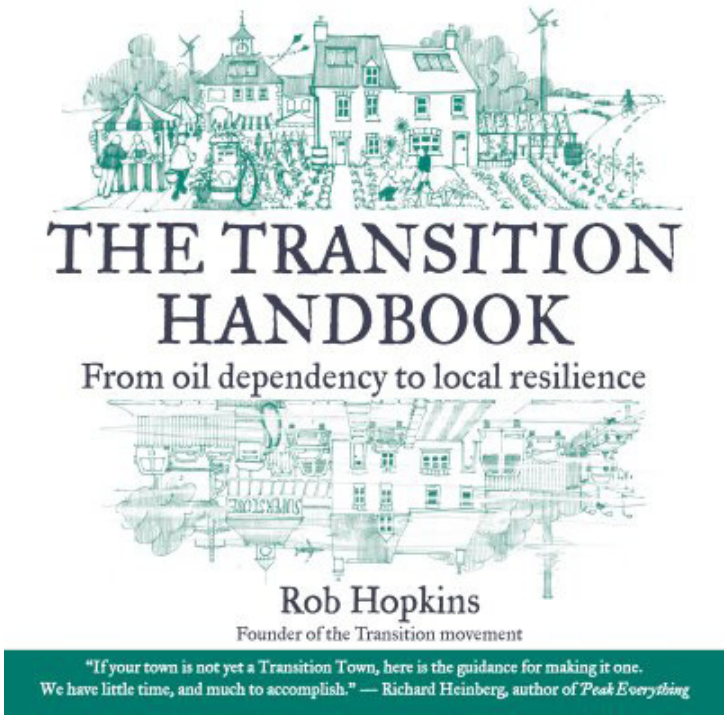
Whitehead 2011).

The role of the Transition Movement is "to engage communities in a process of envisioning positive scenarios for a post-oil future, and then begin the work of building the infrastructure, habits and institutions to move towards that future" (Haxeltine and Seyfang 2009).

In Hopkins' resilience approach, he envisions a transition town built on principles of diversity, redundancy, and public participation. His vision for 2030 includes a general culture of proactivity that pervades all institutions, administration, business and social culture. Food production has been largely localized and diversified as a result of becoming a public policy priority. Health has also decentralized and health education is a fundamental element of the curriculum. Education re-introduces life skills training such as gardening, cooking and woodworking skills, providing an improved balance between practical skills and trades, and intellectual theoretical studies. Hopkins advocates for Local Exchange and Trade Systems (LETS) economies and other means of keeping currency within the community. Land use planning is undertaken with particular attention to accessibility to employment, entertainment, and commercial destinations without needing a car. Energy conservation and renewable energy sources have enabled the transition through the peak oil crisis, with energy grids also becoming decentralized. Smaller and more energy efficient buildings facilitate energy conservation, concluding Hopkins' vision.

To achieve this vision, Hopkins sets out twelve steps to enhancing community resilience and transitioning to a post-peak oil future. These 12 step are as follow:

1. Set up a steering group - this group helps get the first five steps in place, and then dissolves to make room for those who are actively doing
2. Raise awareness – inform people about the justification for taking action, about peak oil and climate change, about resilience approaches.
3. Lay the foundations – networking with other groups and organisations and finding opportunities for cooperation. The Transition Town movement is not about replicating what is already being done, but of combining efforts and sharing resources.
4. Organise an official launch – an official launch is designed to be "powerful, passionate, informative, and inspirational".
5. Form working groups – thematic working groups will address and develop an Energy Descent Action Plan within their assigned theme (e.g. Food, Energy, Land Use Planning, Community, etc.)
6. Consult the public – suggests using the Open Space technique - a strategy for holding public consultations for large numbers of participants, where everyone has an opportunity to share their ideas and opinions, and where a vision can be drafted
7. Develop visible pilot projects – this enables the community to see that efforts are being realised immediately, and takes the Transition Town movement from a theoretical abstract notion to concrete reality.
8. Facilitate the Great Reskilling – offering workshops



and training in the basic skills we once maintained, that also brings community members together and empowers individuals to be an active part of the solution

9. Collaborate with Local Government – cultivate a positive and productive relationship with the local government, be engaged and aware of projects and plans they have in place, and find opportunities for positive collaboration
10. Consult the elders – learn from their past experiences in making do with less, develop a sense of social memory within the community
11. Support flexibility – allow the project to develop in its own direction
12. Create an Energy Descent Action Plan (EDAP) – Initiated by developing a vision and then working backwards to find means of attaining that vision. This step is made up of 10 sub-steps:
    a. Establish a baseline
    b. Get the Local Community Plan to avoid duplication and ensure cohesion between city plans and the EDAP
    c. Draft a Vision
    d. Detail the vision for each sector: food, energy, education, health, buildings, etc
    e. Back-cast in detail for each objective in the vision
    f. Transition tales (communication)
    g. Collect the back-casts into a holistic EDAP
    h. Create a first draft
    i. Finalise the EDAP
    j. Celebrate

The Transition Town model is founded on sound principles of resilience. This is evident in nearly every step, which tries to engage a wide public audience, looks for diversity in solutions and approaches, considers the community system at various levels, and promotes strong leadership. The model is built on the conviction that ecosystem resilience is the basis for social and economic resilience, and as such pays attention to sustainable resource use and issues such as renewable energy and waste reduction. This model is more detailed in the practical measures that a community may take to achieve greater resilience than the LRAP model by the World Bank, but is less useful for policy-making and governance.

The model is highly adaptable to local context through its use of working groups defined by the community. These working groups self-organize based on what the community feels are the priorities for improving local resilience. In many cases, there is a transportation and energy working group focused specifically on reducing vehicle use, promoting alternative transportation options, facilitating energy conservation and collaborating on ways to integrate more renewable energy sources into the local energy mix. Being a grassroots movement, the Transition model aims to break through some of the traditional barriers associated with grassroots initiatives by valuing networking and institutionalization and carefully encouraging appeal beyond the niche (Haxeltine and Seyfang 2009).

Critiques: Hopkins acknowledges a very important point: external socio-economic conditions have not yet imposed enough pressure to drive the general public to action. The need remains an abstract concept in many people's minds and renders it difficult to generate meaningful engagement. A paradigm shift is required in society to cross the 'tipping point' in transition efforts – and indeed, perhaps for resilience efforts in general. Furthermore, finding leaders who are competent and who are able to make the time commitment to the movement are also difficult to find. It also remains challenging to find alignments between the Transition Town movement and the often-opposing priorities of local government.

The Transition Movement is based on the assumption of an "end of suburbia" scenario – a sudden, catastrophic change to our way of life (Hopkins 2008, 46-7). According to Haxeltine and Seyfang, this may not occur if new sources of fuel and technological substitutions reach markets in time (2009). Furthermore, it isolates those involved in the movement to a niche group. Efforts proposed in the Transition Manual to raise awareness tend to focus on those who are already aware and interested (Haxeltine and Seyfang 2009).

The process lacks the professionalism required to gain credibility within the business and administrative communities, who represent important players in advancing a holistic resilience plan. As a result, it is unlikely that, in its pure form, Transition Towns will become mainstream (Haxeltine and Seyfang 2009).

iii. Resilience and Peak Oil Plans

Search the Internet for "resilience plan" and you will find a few disaster management plans, but nothing to indicate that any city has really grasped the notion of resilience and developed a plan to enhance it. However, type "peak oil plan" into your search engine, and you will be surprised to note the number of municipal peak oil plans that have emerged in the past ten years. The attention to this issue suggests that it is no longer a fringe issue, but is gaining a more mainstream acceptance and acknowledgement among the public view. More interesting is that many of these peak oil plans are, in fact, energy resilience plans. In this section, a selection of peak oil plans is reviewed and critiqued for their effectiveness at integrating resilience concepts.

Portland's Peak Oil Task Force Final Report

The City of Portland in Oregon, USA has drafted one of the most widely cited peak oil plans. Finalized in 2007, the plan was developed by a task force of 12 citizens representing an equal number of sectors deemed important to considering in a peak oil plan. These included health care, transportation, energy, planning, waste management, agriculture, environmental, educational and communications representatives plus city staff.

The objectives of the Task Force were to identify potential economic and social consequences of peak oil, and develop recommendations to mitigate impacts of increasing energy prices and decreasing supply. Two main recommendations emerged from this report: first, to reduce exposure to rising fuel prices through an aggressive target of a 50% reduction in fuel consumption in 25 years; and second, to maintain community stability and cohesion through institutional and household changes. These can be broken down into 11 more specific recommendations for Portland.

1. Provide strong leadership to reduce oil consumption by 50% in 25 years
2. Inform citizens about peak oil and foster local-level solutions
3. Engage businesses, government, and community leaders to initiate planning and policy changes
4. Facilitate land use changes that support sustainable transportation and reduce transportation demand
5. Invest in infrastructure that promotes transportation options and efficient goods movement
6. Encourage energy efficiency and renewable energy transportation choices
7. Expand building energy efficiency programs and incentives for both new and existing buildings
8. Preserve farmland, and expand local food production and processing operations
9. Identify and promote sustainable business opportunities
10. Redesign the community safety net and protect vulnerable and marginalized populations
11. Prepare emergency plans for sudden and severe energy shortages.

The Task Force then evaluated three possible scenarios based on the assumption that the global oil supply will peak between 2010 and 2040. The first scenario assumes a long-term and gradual transition. The second assumes oil shocks will cause volatility in global oil prices and destabilize the economy. The third assumes complete social and economic disintegration, and was not considered as a likely possibility for the purposes of the plan. The Task Force provides a general analysis of potential impacts

for each sector:

- Impacts on transportation and land use include the need for alternatives to the private vehicle, as well as a relocation of human populations to be closer to their main destinations. The latter will translate into a greater need for mixed-use and high-density development. The transportation of goods will likely shift from truck and air transport to rail and boat, and subsequently influence how we develop and expand our transportation infrastructure network.
- Food and agriculture will be impacted by rising costs of food transport and production. This, in turn, will negatively affect low-income households, and may increase demand for local or private garden space to grow food locally.
- Economic and business impacts cited by the Task Force include reduced success of start-ups as a result of rising energy prices, and major shifts in demand and distribution of goods. Some industries will feel the impact more than others, depending on how dependent they are on the price of fuel.
- Finally, potential impacts on public and social services include growth of marginalized and vulnerable populations, increased stress on the health care system, including first responders services, increasing housing costs which could force people into lower-quality housing, increasing demand for social services during a time of increasing overhead costs, and potential tensions between communities caused by difficult times.

They then outline context-specific steps for addressing impacts for each sector that are relatively feasible to implement quickly.

Critiques: The Portland Peak Oil Plan is not very quantitative, such that monitoring the plan's progress over time will be difficult. There is no baseline given to compare to, yet the plan proposes quantitative reductions over a set period of time. There is no timeline or work plan provided to guide implementation, providing an escape for a potentially less enthusiastic future government. Integrating a tool similar to the Resilience Capacity Index and supplementing this with some of the good indicators included in the Urban Resilience Assessment Framework could address this weakness.

The plan also underemphasizes the role of environmental resilience by not including such measures in the resilience plan. Enhancing environmental resilience means providing a richer biodiversity, healthier farmlands, and more sustainable natural resources, which could fill in the gaps that a post-peak oil scenario provides. Ecosystem resilience should not be undervalued in a holistic peak oil resilience plan.

Furthermore, there is little mention of institutional changes to enhance dialogue between community residents, the city administration, experts, and higher-level governments. Implementing an adaptive management approach would be useful from a communications and policy standpoint to ensure cohesive progress.

San Buenaventura's Post Peak Oil Plan

Also emerging from the United States, the city of San Buenaventura in California was the subject of an intensive and detailed post peak oil plan, completed by a team of university students, professors and expert consultants (Chen et al. 2007).

The plan is based on the assumption that oil peaked in 2007, and will decrease by 5% per year in the USA, representing a conservative estimate according to the literature. The authors also make general assumptions about the possible impacts that mirror those outlined in the Portland Peak Oil Task Force final report. These include rising energy, water and food costs, decreased mobility, decreasing housing affordability, economic instability and increased fragmentation of local communities. Localization is a major component of their strategy for the city of San Buenaventura, as well as urban farming, bioclimatic urban design practices, and water and energy conservation. The process was broken down into three phases.

1. The project development phase consists of research on oil depletion and consumption within the region and the city, including a careful analysis of localization theories and practices. This helped the team formulate objectives and goals for the project.
2. Analysis of the systems looked at the existing context and trends as well as probability scenarios under the existing trends for 2015, 2025 and 2050 that describe the potential consequences on quality of life, affordability and accessibility.
3. The design and planning phase provides strategies for the region and for the city, and includes a vision, an evaluation of baseline and objective quantitative and qualitative measures, followed by the plans and design guidelines for realizing the vision. Site design and policy recommendations evolve through 2015, 2025 and 2050 for both high-density and low-density type neighbourhoods. The study concludes with a brief evaluation.

The principle strategy in the San Buenaventura peak oil plan is to define three different zones, depending on whether the area is to be preserved (maintaining existing density and functions), concentrated (densified), or released

(transformed over time to a more naturalized or agricultural land use). This vision is achieved over three time periods.

2007-2015: A focus on research and monitoring of energy and water use; the public and stakeholders must be educated and made aware of peak oil and its potential impacts; policy and project incentives must be developed to prompt change in development and business practices; and investments must begin flowing for alternative transportation infrastructure and water conservation

.

2015-2025: This is the transformation and innovation phase. The built environment begins to be modified according to the three zones described above. Continued communications efforts begins to shift the mindset of residents and employers, which is evident through changes in travel behaviours, diet and energy consumption.

2025-2050: The city continues to adapt, innovate and improve the livability of San Buenaventura.

Specific interventions in the plan include concentrating development and encouraging mixed-use, which supports the free public transportation. The authors recommend prioritizing transportation investments and resources for public transport, such as expanding cycling infrastructure, and promoting development along bicycle and public transit axes. They recommend creating energy-efficient standards and incentives for sustainable landscape and building design. It also includes aggressive water conservation initiatives, measures to preserve biodiversity, actions to facilitate urban organic farming practices, and means of creating more community shared spaces. Generally speaking, this detailed plan is very thorough and includes many elements of resilience in transitioning through a peak oil crisis.

Localization is a major component of their strategy for the city of San Buenaventura, as well as urban farming, bioclimatic urban design practices, and water and energy conservation

Critiques: There are many big ideas and big ambition in this plan, but there is also a lack of resources for practitioners on how to implement their recommendations.

The plan is focused on land use planning and the built environment, leaning heavily toward design-based interventions with only some supportive policy recommendations for achieving their vision. For example, community interventions include designing public and communal space (shared backyards, outdoor markets…) without supporting this with policy recommendations of how social networks themselves can become more resilient. The authors could have proposed more public participation in planning and decision-making processes, as suggested by the World Bank Workbook, or facilitating a higher number of community organizations, as the Resilience Capacity Index and the Urban Resilience Assessment Framework suggest. Such measures will engage the public in the metamorphosis of their community, rather than impose these major changes on them in a top-down approach.

Being heavy on the urban design aspects, there is little consideration for how the public will accept the proposed interventions. What incentives will the city employ to encourage developers to implement the types of projects envisioned, such as industrial re-purposing? How will the city achieve public buy-in, as with the conversion of suburbs to open space? There is an oversight as to the impacts on land and property values as well, resulting in an oversimplification of how the plan can be implemented.

The municipality may be faced with significant administrative and economic barriers to realizing some of the proposed interventions based on pre-existing laws and regulations for planning and redevelopment. For example, one of the strategies is to initiate a "passive is massive" strategy to reduce energy consumption through renewable energy and passive heat technologies. The public today remains skeptical about these new (and expensive) technologies, as the wind energy movement in Ontario can attest. Energy industries subsidized by the government and oil industry, or those with private stakeholder interests, may also be strongly opposed to losing some of their clientele to new technologies, and will put up roadblocks where possible. At times, the city's own bylaws and regulations require updating; for example, to permit installations on rooftops, or to approve building construction permits for major renovations required to update a building to Passive House standards. Generally speaking, such considerations were left out of the discussion on policy recommendations in the San Buenaventura peak oil plan.

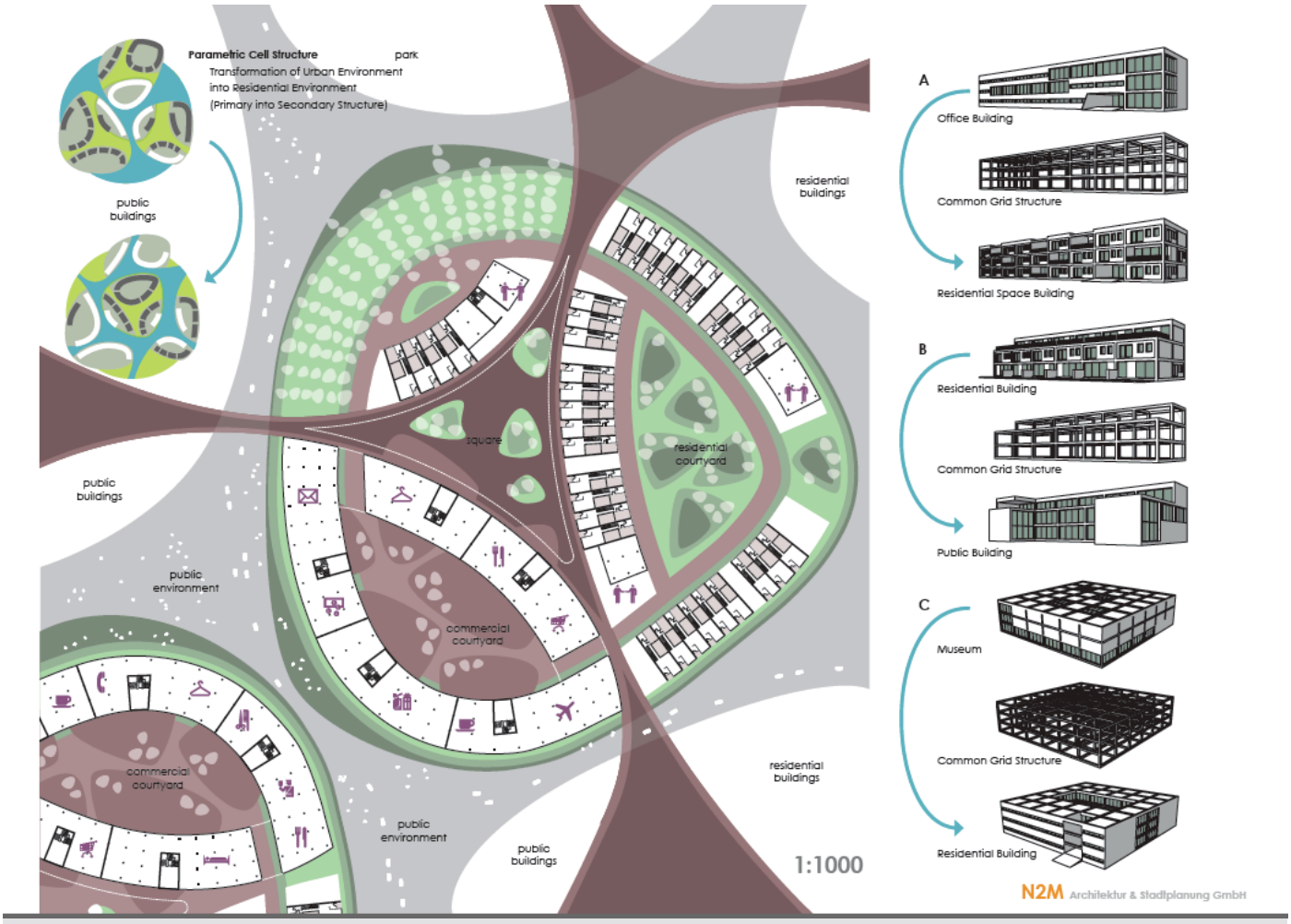
Henna Concept City - A Resilient City Plan

There are not very many urban resilience plans in existence to date, although many cities are aware of resilience approaches to planning from a climate change or natural disaster point of view (Bonometti et al. 2011). However, one group of planners and architects got it right: N2M architects, along with students from the Stockholm Resilience Centre developed an excellent case study of Henna, Finland. This is a conceptual project that challenges the view of cities as stable and predictable systems. The plan clearly illustrates a solid understanding of the fundamentals of resilient systems.

The objective of the Henna Concept City project is to create a resilient urban social-ecological system based on the principle of accepting constant change. This is accomplished by developing flexible and adaptable systems and structures that can evolve to meet future demands through time. This is one of few plans that attempts to integrate the concept of flexibility into urban planning and design – not an easy feat given the permanence of most city structures. Placing more emphasis on social-ecological resilience, this plan forms a good complement to the urban design-focus of the San Buenaventura plan.

The Henna Concept Plan works from the ouside in, beginning with an integration of ecosystem cycles and working their way inward to the social and infrastructural components of the city. Metabolic flows (demand and consumption of energy, waste and water) are assumed to take place within a closed system – that is, zero waste, locally produced construction materials and energy, and wastewater recycling and reuse. Urban food production features prominently. These approaches also help reduce the need for transportation energy and materials in and

Figure 8 - Concept illustration of Town of Henna, illustrating modular adaptive building design and flexible spatial planning.



out of the region.

The transportation network is designed to be diverse and based on carbon-free modes of travel: cycling, walking, public rapid transit and biogas busses. Destinations such as work, school, and shopping, will be planned to be within cycling or walking distance, whereas institutional functions, major cultural establishments and other attractions which are not necessarily daily destinations, may be concentrated in major regional nodes accessible by public transportation.

The built environment is flexible and adaptable to address the changing needs of society over time: a building can be converted from institutional use to condominiums with relative ease, for example. All of this is accomplished by reorganizing the urban fabric. Spaces and buildings are categorized as public, semi-public or private and assessed for their functionality and accessibility at various scales. For example, an opera may not need to be present in the smallest villages, but every settlement – large or small – requires educational facilities. This helps distribute some of the basic functional types of spaces and buildings within a region's cities, towns and villages.

Resilient governance is a priority in the Henna plan, whose goal is "to provide a variety of governance approaches to deal with the community's problems" (Bonometti et al. 2011). In Henna, governance is highly inclusive, collaborative and participatory. Social resilience is enhanced by supporting dense social connections that act to reduce inequality. A "problem-solving centre" is suggested as a space for all members from all social hierarchies and spheres to trade resources and knowledge in solving local problems. The connection between society and the natural environment is reinforced by creating opportunities for people to be out in nature during various typical daily activities, such as workplace retreat centres, natural commute (cycling or walking) routes, and naturalized public spaces.

Overall, the project authors have conceptualized an excellent prototype for a resilient city, one that should provide inspiration for future urban resilience projects worldwide.

Critiques: The most dominant critique of the Henna case study is that the document does not consider the implementation challenges that practitioners would face, particularly how such initiatives will be supported and funded. Thus, while the plan itself is quite ambitious and visionary, it lacks a link to the implementation phase.

Furthermore, there is only limited quantitative analysis in the plan, in the form of Finland's national ecological footprint, and a scattering of a few other statistics here and there. There are no initial studies of baseline energy or fuel consumption, no examination of current transportation patterns or economic import and export dependencies. The plan would benefit from integration of a baseline evaluation of key indicators, as in previous examples in this section, and a proposed on-going measurement and evaluation program to monitor progress and ensure that this vision does, in fact, enhance resilience in the long-term.

iv. Conclusion: Comparing Resilience Planning Tools

The following table summarizes this section's resilience planning tools and compares their strengths and weaknesses.

Resilience Tool	Strengths	Weaknesses
Resilience Capacity Index	• Z-score to compare cities based on mean values for indicators • Includes poverty, access to health insurance, public engagement, and voter participation as indicators • Good political and communication tool for public leaders	• No energy resilience indicators • No mention of governance or adaptive management
Urban Resilience Assessment Framework	• Good guiding questions for policy makers • Best-practice indicators include: sprawl index, availability of alternative transportation modes, residential energy consumption per capita, mix of energy sources.	• No quantitative benchmarks provided • Does not address potential thresholds between being vulnerable or being resilient • Does not address localization or governance issues
World Bank Workbook	• Implements adaptive management • Features vulnerability mapping, inventory of current and proposed plans, prioritizing hot spots and hazards, conducting needs assessments and priority action lists, and evaluating how existing plans fit in • Compares against existing regulatory and legal frameworks to complete a gap analysis and draft the Local Resilience Action Plan	• Does not provide case studies or background information on resilience • Does not provide performance indicators or measurable to assist practitioners
Resilience Alliance Workbook	• Defines spatial and temporal boundaries • Works within the adaptive cycle framework (well-founded in the science of resilience) • Identifies critical actors and partners • Identifies cross-scale interactions • Evaluates potential alternative states and transformation triggers	• Does not result in a plan • Does not provide potential indicators or measurable • Very scientific and complex, very time consuming

Resilience Tool	Strengths	Weaknesses
Transition Towns Manual	• Focus on community-accessible solutions • Emphasis on localization (economy, food, energy) • Promotes intergenerational learning (e.g. Re-skilling, working with elders) • Highly collaborative	• Attracts "fringe" audiences, such that group is usually not representative of greater community • Unprofessional, therefore difficult to collaborate with private and public sector interests
Portland Peak Oil Plan	• Provides three scenarios that range in order of hazard • Provides projected impacts on a sectoral basis	• Not very quantitative • Underemphasizes environmental resilience • Little attention to institutional resilience/ governance
San Buenaventura Peak Oil Plan	• Short, medium and long-term probability scenarios • Provides "zones" of action: preservation, conservation or release • Provides policy and investment priorities	• Implementation aspects are weak • Underemphasizes need for public consultation and transdisciplinary collaboration
Henna Concept Plan	• Attention to flexibility and adaptability • Close energy (metabolic) flows • Urban food production emphasized • Good attention to accessibility and transit service • Creates opportunities for human-nature connections	• Implementation aspects are weak • No quantitative elements: baseline, targets, indicators.

iv. Discussion

Constraints and Barriers

While the previous section provides inspiring case studies and practical tools for enhancing urban resilience, there lacks a clear discussion on the practical constraints and barriers of towns and cities in carrying out these approaches, especially from a jurisdictional perspective. While energy and transportation represent two of the most important sectors for resilient cities, they also happen to be sectors that are, in large part, regulated and operated by higher-order jurisdictions or private interests. As a result, some of the energy and transportation interventions suggested by these plans, frameworks, and indicators remain outside of the municipality's mandate to influence directly, reinforcing the importance of adaptive management techniques in resilience planning. In Canada, water navigation and shipping, and regulation of trade and commerce are under national jurisdiction, while energy, natural resource management, education, and health care is under provincial jurisdiction. Municipalities must work in close collaboration with these levels of government and the appropriate industry groups in order to influence resilience within these sectors (Government of Canada 2008).

Another example includes the revision of building codes to meet more rigorous efficiency standards. In Canada, this falls under the jurisdiction of provincial ministries. Municipalities must work closely with the provincial ministry to negotiate such changes in consultation with building and construction industry representatives and with support from other municipalities. These processes can take several years before any new regulations are drafted and approved, and another few years to phase them into action. Many Canadian municipalities have cited the provincial building codes as jurisdictional barriers to achieving improvements to energy efficiency standards (Patterson and Reed 2010).

A common energy resilience solution is to shift goods transport from road and air travel to rail and water travel. The choice of transport of goods is often left to the private company, who makes decisions purely based on economic grounds: *'what is the cheapest and fastest mode to move my product?'* Moreover, in some countries including Canada, the railway infrastructure is owned by private industry, whose infrastructure investment decisions are driven by economic principles rather than pubic interest. For a municipality to make any changes to their infrastructure (for example, converting unused rail lines into cycle paths, or providing commuter rail service) requires extensive negotiations and discussions with these companies. Further complicating things, the trucking lobbies have a strong voice at the federal level and could be successful at impeding efforts to receive or export local goods by rail rather than by truck. In the end, a municipality would have little influence on how goods get imported and exported from their jurisdiction, leaving them vulnerable to the price fluctuations following volatile energy prices in a peak-oil scenario.

Municipalities are also rather constrained in their influence on the local energy mix. Similar to transportation of goods, the energy mix is an industry-driven resource, regulated by the provinces. In Ontario, for example, the nuclear energy industry has strong lobbying power, especially where their energy plants are the major employer in several regions such as Huron and Bruce Counties. Simultaneously, Suncor Energy has invested in these region to install large-scale wind farms much to the outcry of local residents. While wind energy is widely promoted in resilient energy planning, the public perception of wind energy in this region has yet to see it as a positive change. The debate remains mostly founded upon unproven health concerns, weakly supported ecological impacts, and the subjective visual impacts on the landscape. Unless municipalities engage in ongoing and careful discussion and engagement of all affected parties (residents, industry, scientific community and government), there is little influence that a city or town can have on regional-level energy infrastructure and sources.

Finally, long-established institutions such as Ontario Canada's Ontario Energy Board and the Ontario Municipal Board have deeply engrained policies and operational structures that prohibit flexibility to adapt to shifting needs. For example, financial incentive programs offered by municipalities are prohibited in Ontario by the Municipal Property Assessment Council unless the municipality can demonstrate how the incentive will increase property assessments that would offset the incentive value. This is counteractive to the purpose of the incentive and renders the incentive void for the property owner (Rob Kerr, Personal Communication). These constraints highlight the integral role of the collaborative and transdisciplinary feature of adaptive management to achieving energy resilience in our cities. Without strong communication and cooperation between all actors, such barriers will continue to remain in place, hindering progress.

Summary of Energy Resilience Approaches

The best approaches to enhancing urban energy resilience integrate the resilience concepts not only into the anticipated end result, but into the process of creating the plan or program itself. The following table summarizes different types of plans according to what elements of resilience have been integrated into the various approaches.

Table 2 - Summary of Energy Resilience Approaches

City/Document	RCI	URAF	LRAP	Transition Towns	Resilience Alliance	Portland Oregon	San BV	Henna Finland
Type*	EM	EM M	M	M PO	M RP	PO	PO	RP
Resilience Characteristics								
Strategic	x	x	x	x	x	x	x	x
Diversity considerations	x	x		x		x	x	x
Flexibility			x	x	x			x
Adaptive Capacity	x	x	x	x	x	x	x	x
Transdisciplinary	x	x	x	x	x	x		
Resilience Measures								
Community Connectivity	x	x		x		x	x	x
Education and Communication		x	x	x	x			
Localization	x	x		x		x	x	x
Decentralization				x				x
Public Participation	x	x		x	x	x		x
Governance: Adaptive Management		x			x	x		x
Accessible Transportation		x		x		x	x	x
Energy Conservation, Renewables		x		x		x	x	x
Local Food				x		x	x	x
Ecological Resilience		x		x	x		x	x

* EM = Evaluation and Monitoring; M = Model or Strategic Framework; PO = Peak Oil plan; RP = Resilience Plan

There exists today a range of approaches to tackling energy resilience within the context of urban planning. As seen in this section, a city may opt for simply monitoring a few choice indicators and comparing its progress from year to year, and possibly comparing itself to other municipalities. Indicators can provide quick snapshots of resilience, but are unable to give us the big picture or long-term outlook due to gaps in measurement capacities and data availability. Indicators are good for politics and public communication, and certainly for long-term evaluation and monitoring, but the indicators currently in use are limited in their ability to measure some of the critical components of resilient systems, such as resilient governance practices, or ecosystem resilience. The indicators and assessments presented in this paper are good tools for preliminary studies prior to developing a more detailed resilience strategy.

A city may choose to use a pre-existing model or strategic framework, such as the Resilience Alliance workbook, in order to develop their context-specific resilience plan. Strategic planning approaches are resource and time intensive, but are the most holistic and effective. Several workbooks exist on the Internet to assist practitioners in developing a resilience strategy for their community, however there is always room for improvement. The measures proposed in these workbooks are often at a high level, and lack concrete measures for the implementation phase.

Finally, some cities are opting for resilience plans in response to particular threats, such as peak oil or climate change. These policy plans and strategic plans are an honest first effort at applying the resilience approaches from the literature to urban planning practice, but also have to make improvements in certain areas. Most notably, resilience plans need to be more participative, must address issues of transdisciplinarity and cross-scale interactions, and must have a more long-term mandate rather than focus on emergency preparedness alone. Moreover, even some of the most progressive and ambitious resilience plans lack concrete measures for implementation, and have not outlined a plan to achieve the proposed goals and objectives.

What is needed for practitioners is a guide from start to finish on the basic phases of resilience-building in urban settlements that takes the best elements of each of the previously addressed approaches and combines them into one process. The next section describes this author's attempt to create such a template.

Section IV: Enhancing the Urban Resilience Planning Model

i. Criteria and Objectives of a Resilient Peak Oil Response Approach

Effective planning to achieve resilience to future energy crises (or climate impacts, natural disasters or other risks for that matter) must integrate the main elements of resilience. As described in the previous sections, these elements include:

- Adaptive capacity-building
- Good governance and strong leadership
- Transdisciplinary collaboration
- Community connectivity and accessibility
- Decentralization or re-localisation, particularly of energy, food, and economic activities
- Social-ecological interactions
- Inter-generational learning
- Diversity and flexibility

Resilient planning must be an iterative and participative process that includes developing a vision, goals and objectives, technical analysis and strategic planning, and implementation plans. Evaluation and monitoring is important to see where improvements can be made, where new vulnerabilities appear, or to respond to changes in perceived risks. Later, measurable indicators of resilience should be used to provide snapshots of the city's resilience for communications, policy-planning and political purposes. Finally, a resilience plan should address the priority vulnerabilities across all sectors and at the neighbourhood scale up to the regional scale, taking into consideration urban metabolic processes and interactions. This section will combine the strengths of the previous resilience approaches to propose a comprehensive resilience planning strategy for practitioners.

ii. Description of the Approach

As a general approach, planning should be:

- Goal-oriented and founded on the ecosystem services provided by the region;
- Strategic in the context of the city and its existing capacities;
- Scenario-driven to compare alternative scenarios and find the best cost-benefit solutions to enhancing resilience in a just and equitable manner;
- Trans-disciplinary in its approach to problem solving and planning; and,
- Provide an adaptive and flexible approach (Godschalk 2003).

The underlying principles of a resilience-planning model include:

- Enhance adaptive capacity of the urban system
- Pursue equity and justice at all times
- Minimize external dependencies
- Practice good governance:
  - Remain transparent
  - Work in a trans-disciplinary manner
  - Practice participatory planning whenever possible

One of the products of resilience planning is a plan that details the goals, objectives, needs assessment, strategy and policies to direct and guide resilience projects and efforts in the future. The goals of a resilience plan should include (among others) to:

1. Understand and identify the risks and vulnerabilities associated with a defined set of threats
2. Evaluate the current and desired state of resilience of the urban system
3. Develop policies and interventions to reduce impacts and enhance resilience
4. Identify resources and promote investments to implement resilience-building measures (Shah and Ranghieri 2012)
5. Communicate effectively to the community at all phases; promote a culture of resilience through continuous outreach and engagement.

An Improved Framework for Energy-Resilient Urban Planning

The following general framework combines elements of the World Bank workbook, the Resilience Alliance Workbook, Transition Towns manual, and the peak oil plans from various cities.

1. Establish a transdisciplinary group from a range of social levels to inform the development of a resilience strategy or plan:

This committee may include representation from both private and public sectors of a variety of economic sectors, community groups, and scientific or research organizations. Efforts should be made to create a steering committee that is representative of youth and elderly, and of different cultural backgrounds (e.g. ethnic groups, indigenous groups, etc).

2. Define the risks or threats to local energy resilience:

- Define the geographic and temporal scales and the scope of the city's urban energy resilience strategy
- Define the major risk or threat that resilience efforts will aim to address, as well as secondary risks such as climate change, poverty, security, etc.
- Project likely impacts in a business-as-usual scenario (i.e. no action is taken).
- Develop a vision for local resiliency through a participatory transdisciplinary process.

3. Define objectives and goals:

- Identify the community's main objectives for each sector
- For each objective, list quantifiable goals based on the available indicators provided in the literature on urban resilience. Where possible, objectives and goals should find alignments with existing policy and planning documents.

4. Stocktaking and Inventory:

- Conduct an inventory of existing policies, programs and practices that support energy resilience
- Perform institutional mapping and identify potential partners, leaders, and mobilizers
- Identify existing physical, natural, and social resources that can contribute to enhancing resilience
- Assess gaps in existing policies and programs that may inhibit resilience efforts
- Assess network flows of goods, waste, people, energy

and information.

5. Generate a Baseline: Technical Analysis and Background Research:

This phase is best undertaken by a number of working groups or technical teams made up of local experts representing the various sectors of the urban system. The strategy may look to create disciplinary or sectorial working groups (e.g. Ecology and Environment, Social Sciences and Demographics, Economics, Public Institutions and Health...). Representatives from each working group should come together regularly to share progress and discuss possible links and interactions between sectors as they relate to resilience objectives. The working groups are responsible for finding the relevant research and resources for improving resilience for their particular sector.

- At a broad level, evaluate current resilience by using an index or assessment tool such as the Resilience Capacity Index, or the Urban Resilience Assessment Framework. This provides a 'snapshot' of potential resilience issues to be addressed in later stages, in combination with more technically-advanced assessments.
- Conduct city-scale spatial analysis of vulnerabilities using mapping, demographical statistics, and other data to identify specific highly-vulnerable target areas. Repeat the analysis for each target area, considering vulnerabilities within each sector that may impact resilience.
- Develop a historical timeline and note key disturbances to energy supply or prices. Attempt to understand their influence on resilience at the target area scale, and at the city scale (are there adaptive cycle dynamics at play?).
- Consider potential constraints and opportunities between sectors, and interactions between spatial scales that may influence energy resilience.
- Generate several alternative scenarios with impact projections at short-, medium- and long-term planning horizons.

The Resilience Alliance and World Bank workbooks delve into quite some detail, and can therefore be referred to for more information for this step. It is up to the practitioner to determine what level of detail is required for their particular planning purposes. In order to remain practical and accessible to the widest audience, this process has been simplified.

6. Recommendations and Needs Assessment:

This step should regroup the transdisciplinary group in order to ensure a collaborative approach to defining recommendations and needs. It is important to keep the focus on key traits of resilience for this step. Practitioners should ask themselves: how do these recommendations improve diversity, flexibility, adaptive capacity, decentralization, social-ecological interactions, and social resilience?

- Within each target area, define recommended interventions for each sector (economy, community, environment, governance, built environment, energy, food, etc…). Back-cast from the vision to develop recommendations.
- Repeat at the city scale.
- Perform a needs assessment: identify additional required resources (financial, physical, human, institutional, or natural resources) required to realize recommendations.
- Prioritize recommendations based on needs assessment and on timing (e.g. define short-term and long-term priorities). Include short-term pilot projects to implement immediately and establish momentum.

7. Implementation Plan:

- Develop priority interventions and policy measures to address the recommendations from Step 4.
- Consider additional general policy objectives and recommendations to support the underlying principles of resilience: enhancement of adaptive capacity, pursuit of justice and equity, minimization of external dependencies, and good governance.
- Create a budget and a work plan (timeline) to meet the strategy's objectives and goals.
- Implementation measures to enhance energy resilience are numerous and varied, and include the examples that have been provided in the previous sections. Installing decentralized renewable energy 'farms' and promoting energy-efficient building and urban design are examples of interventions that can be applied during this phase.

8. Monitoring and Feedback:

- Use evaluation and assessment tools to monitor and evaluate progress. Develop additional indicators where needed.
- Invite ongoing public feedback on initiatives and progress.
- Revisit the resilience strategic plan and integrate changes in response to changing risks, vulnerabilities and progress.

Sectoral Objectives

It is useful to review some of the objectives on a sector-by-sector basis when considering interventions and policy measures to address energy resiliency. The following summarizes some of the common objectives to enhance energy resilience within each sector.

Energy
- Decentralize
- Diversify the mix of energy sources, particularly with renewable sources
- Prioritize energy conservation over building additional capacity
- Make strategic infrastructure investments
- Promote shared energy and heat recapture

Water
Water treatment tends to be energy-intensive, as described by the San Buenaventura Peak Oil plan. Therefore, resiliency measures in the water sector include:
- Promote conservation
- Reuse where possible
- Look to natural purification processes (e.g. wetlands, rainwater harvesting)

Waste
- Localize waste management
- Recycle and reuse as much as possible
- Encourage local composting or implement a city-wide program to collect and manage organic waste
- Explore opportunities for generating energy from waste (e.g. methane gas generators, incineration)

Buildings and Land Use Planning
- Promote bioclimatic land use planning that respects natural lighting, air circulation and avoids contributing to heat islands
- Support energy retrofits
- Build to passive house standards
- Zone to increase density, release lands to another purpose, or preserve land uses
- Enhance accessibility and affordable transportation
- Facilitate flexibility – modular, adaptive, multifunctional urban and building design
- Develop within the constraints of the local natural ecosystem

Transportation
- Provide a diversity of services and destinations within walking and cycling distance, accessible by public transit in under 30 minutes
- Invest in public transit improvements
- Enhance connectivity
- Plan for redundancy in trip mode and path choices

Environment
- Preserve and/or conserve
- Connect habitats and ecosystems
- Practice sustainable resource use
- Encourage agricultural practices that support biodiversity and enhance ecosystem health
- Practice and encourage permaculture
- Facilitate green roofs, urban gardening and other urban nature interventions

Economy/Business Development
- Create or revise local business development plans to support buying local
- Develop local production chains
- Diversify the economy
- Develop local skills and trades

Health
- Decentralize health care and services
- Educate the public about home remedies and cures

Education
- Teach trades and life-skills
- Promote greater engagement between students and the elderly and working population in the community
- Provide resilience education for the general public
- Support smaller schools

Administration/Governance
- Practice good governance
- Implement adaptive co-management
- Encourage multi-level collaboration and coordination

The strategy outlined in this section combines the strengths and attributes of the various indicators, models and strategic plans described in the previous section in order to avoid some of their weaknesses and build upon their strengths. It is not intended to provide a rigid step-by-step manual, but provides a guiding structure to frame the urban energy resilience planning effort. Complemented by the guiding questions from some of the resources cited in the previous section, the practitioner will develop a holistic, systemic view of vulnerability and resilience to energy threats in his or her community and provide a comprehensive strategic plan to address these threats.

Section V: Moving Forward

i. Gaps in the Current Understanding of Peak Oil and Resilience

This report has explored the concept of resilience and various resilience approaches as a potential response to the threat of peak oil or energy constraints. Since resilience is a relatively new term – much like sustainability, for example – there remain several challenges to realizing the full benefits of resilience planning.

To begin with, resilience is an approach to addressing risks, and risks are often challenging in and of themselves to define. Peak oil and future energy supply issues are no different. There exists today a range of diverging opinions on the degree of risk associated with peak oil. Experts disagree on the impacts it will have on us, and when it is likely to occur. Some claim that we will develop replacement technologies before negative consequences are felt, while others believe that catastrophic crises will occur as humanity readjusts to functioning without oil. We may never know for certain – an uncertainty that poses additional political challenges. Thus, it may be difficult to harness the necessary political will and community leadership to launch and drive forward resiliency efforts.

The science of resilience, being relatively new, also poses some challenges. There is first the common problem of too many definitions and not enough consensus. However, time and research generally sort this problem out on its own. More challenging is that academics and practitioners have not yet mastered the ability to understand complex systems and interactions, which is a fundamental characteristic of resilient systems. They have yet to fully comprehend or be able to predict the various triggers and thresholds that influence and cause major systemic transformations. For transformations that increase vulnerability and exposure to risk, it becomes important to understand how to avoid such transformations.

Another challenge for planners and policy makers lies in understanding the trade-offs and benefits of redundancy versus efficiency. Redundancy is one of the fundamental characteristics of resilience: in a resilient ecosystem, for example, there are usually multiple species that perform similar functions, such that if one species is wiped out, the function is maintained by others. However, our society is obsessed with efficiency. Justifying investment in a decentralized energy infrastructure system, for example, may make resilience sense, but be completely illogical from an economic efficiency point of view. The trade-offs for long-term benefits are as yet unclear and more research and understanding is required before we can expect decision makers to accept measures that seem potentially economically inefficient for a gain in redundancy and hence, resiliency.

Specific resilience approaches such as adaptive management require more practice and experience in a greater diversity of fields and disciplines. Current examples and case studies are very few and are almost entirely based around natural resource management. To gain confidence in this process and fine-tune the practice of adaptive management in other disciplines, academics and practitioners need to pilot and document more examples and share findings with the resilience planning community.

ii. Implementation Constraints and Barriers

The practical challenges of resilience planning relate mostly to gaps in the ability to obtain and measure the data. Aspects of resilient cities, such as good governance or resilient ecosystems, are not necessarily easy to measure, evaluate and monitor over time. This makes it challenging to gauge progress, communicate successes, and compare one city to another. It may also make it hard to obtain the necessary information required to project future vulnerabilities or resilience in order to effectively plan for resilience (and not just develop another emergency preparedness plan).

Another pervasive challenge with all planning practices, but especially in resilience planning, is achieving effective participatory processes. The urban planning literature is full of studies on the challenges and barriers to representative, effective, just and equitable public participation. This will remain a challenge for resilience planning as well, but may also present an opportunity to enhance our practice and perfection of participatory planning processes.

But the most difficult challenge to overcome is likely the cultural challenge around resilience. The political and institutional frameworks within which current cities operate are highly rigid, centralized, efficient and riddled in complex dependencies that are both very vulnerable to disruptions, and yet very resistant to change. Individual behaviours and perceptions also pose barriers to implementing resilience – one need look no further than controversies over wind farms to see that it will not be easy to implement some of the changes that resiliency would require. Cities will not suddenly become resilient upon instituting a resilience plan; the changes will take a significant investment of time and resources to see meaningful results.

iii. Next Steps

Despite these challenges, the future is full of hope and opportunity for resilience planning. Already, international conferences and associations are sprouting up to support practitioners, decision-makers, and policy planners in all disciplines. The Resilience Alliance, the Stockholm Resilience Centre, and ICLEI Resilient Cities conferences are but three examples. The United Nations has also adopted the concept and makes increasing reference to resilience as a model and technique for addressing some of society's most pressing problems.

With minds around the world researching and applying resilience methods to their work, the aforementioned challenges will be diminished and barriers will be reduced. The focus for the near future is to improve our understanding of complex urban systems, improve our ability to measure and evaluate all aspects of resilience, and begin informing the general public in order to gradually foster a culture of resilience thinking.

iv. Final Remarks

Cities are complex social-ecological systems that we are just in the early phases of understanding. Institutes like the Stockholm Resilience Centre are producing leading-edge prototypes, pilot projects and research in the fields of urban and social-ecological resilience. We can also continue to learn and grow from the experiences of places like Vorarlberg, where quality of life continues to improve in step with enhancing energy resiliency efforts.

As practitioners and researchers, we are all seeking to enhance and share our understanding of how to make our cities better places to live, to work or visit. Some of us are concerned about the threat of climate change, others with security, and others still about our dwindling energy supplies. Resilience thinking can provide many practical approaches and tools to greatly improving quality of life, regardless of which threats are perceived or addressed. Resilience planning can help us achieve our objectives

for sustainable development, economic well-being, local food and energy security,

Is it possible to plan a resilient city? Of course it is, and it is being done. As numerous examples in this guide have shown, there are cities, towns, villages and communities around the world who have recognized the multitude of benefits in enhancing community, economic and ecological resilience. The path to getting there may be scattered with challenges and barriers, but the fight is well worth it: it connects communities, reinforces the links between government, residents and businesses, reduces various vulnerabilities and prepares communities for the unavoidable and unpredictable risks we face on a daily basis.

It seems sensible to make a concerted effort to integrate resilience concepts into planning practice as a fundamental concept. It goes beyond sustainable development by bridging the gaps between many of the common societal challenges our cities currently face, from poverty to climate change to economic stability. It provides home-grown solutions to global problems, recognizing the local context and resources as advantages to solving these problems. It strongly advocates for good governance and equity, and basis a large part of its effectiveness on the ability to remain flexible by responding to changing conditions and needs, evolving to new risks or vulnerabilities, and involving a wide variety of experts, from the traditional institutional experts to the unconventional local wisdom acquired from the aged population or indigenous peoples.

Resilience is not a panacea for all the world's problems, but it does provide an excellent framework within which we can strive to make our cities better places to live, work, and visit. For those who are firm adherents to the Precautionary Principle, whether peak oil occurs next year or next decade or in the next century, a resilience approach to urban planning and policy making may ensure a much smoother transition to a very different energy future. If this guide has inspired a planner to review his or her practices and integrate a few of the approaches and practices suggested herein, then it has already accomplished its mission.

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Appendix A

Table A1: Resilience Capacity Index Indicators. Source: Foster 2011.

	Measures or Subindicators	Justification
Economic Indicators		
Industrial Diversity	- Degree to which local economy (measured in jobs or GDP) differs from national economy in goods, services and government sectors.	A diverse economy reduces risk associated with a disturbance to an economic activity or sector.
Business Environment	- Proportion of small businesses; - Access to high-speed internet; - Available venture capital and support for start-ups.	A dynamic economy is more resourceful and has a higher adaptive capacity.
Regional Affordability	- The percent of households paying less than 35% of the household income on housing - Census data on rental costs and housing expenditures	Corresponds to economic security: households who spend too much on housing expenses are more precarious in economic crises (Pendall et al 2011).
Income Equality	- Gini coefficient that measures how much a population diverges from perfect income equality.	Income equality and equal distribution of economic benefits is hypothesized to correspond to a more cohesive response to disturbance (Cutter et al 2010)
Socio-Demographic Indicators		
Educational Attainment	- % of population 25 and over with a bachelor's degree or higher, divided by % of population 25+ without a high school diploma or equivalent.	Response to stress is enhanced by social capacities such as literacy and education (Norris et al, 2008).
Disability	- % of a metropolitan area's civilian non-institutionalized population that report no sensory, mobility, self-care or cognitive disabilities	Regions with higher proportions of persons with a disability more vulnerable to physical, social and economic challenges.
Poverty	- % of the urban population with an income above the government-established poverty line.	Reflects the capacity of a person, community or region to mitigate, respond or adapt to, and recover from a crisis or emergency
Health-Insured	- % of the non-institutionalized urban population with health insurance coverage.	Health insurance is an indicator of social, physical and economic security, particularly in the USA where not all residents have the same access to health insurance.

	Measures or Subindicators	Justification
Community Connectivity		
Civic Infrastructure	- Density of civic organizations per 10,000 people.	Represents community engagement, opportunities to support and assist one another during times of crisis.
Metropolitan Stability	- Annual average percentage over a 5-year period of the municipal population that lived in the same region the year before: sum of residents who lived in the same house a year ago plus residents who lived in the same region a year ago divided by the total population 1 year and older.	People who stay within a region for longer periods of time have improved connections and familiarity with support networks than newcomers.
Homeownership	- The number of owner-occupied housing units as a percentage of total occupied housing units in a metropolitan area.	Indicates sense of place and attachment, which is associated with reducing vulnerabilities associated with renters.
Voter Participation	- The number of voters in the last election as a percentage of the population of voting age.	A measure of civic engagement and desire to influence outcomes; of trust in the democratic process and in local governance.

Domain and Assessment Questions	Draft Measures or Indicators
Adaptive Capacity Characteristics	
INSTITUTIONAL • Are urban agencies systematically assessing long-term risks to their settlements? (CCCR) And are those risk assessments influencing their decision-making? • Is the council actively building its knowledge base through research and evaluation? • Is there a high level of collaboration between the council and other public agencies? • Is public input into local and regional decisions pro-actively encouraged through formal and informal processes? (CCCR)	• Evidence of broad long-term risk assessment by urban agencies (including oil and climate change vulnerability studies) (provide examples) • Evidence of joined-up planning between public agencies in settlement. (provide examples) • Evidence of council investment in research, evaluation and collaborations with research agencies. (provide examples) • Residents' level of confidence in council decision making (Quality of Life Survey 2008)
COMMUNITY/CITY • Is there a high value given to the well-being of vulnerable populations in the settlement? (CCCR) • Do residents have financial resources to cope with change /shocks • Do residents have a strong sense of community, and are they investing their time and energy in strengthening the community'. (CCCR) • Does the community believe in its collective ability to positively influence its future? (CCCR) • To what degree do residents feel they have access to support in times of difficulty?	• The proportion of children living in households with gross real income less than 60% of the median equivalised national income. (Statistics NZ. Census). • Household Ability to cover costs of everyday needs (Quality of Life Survey 2008) • The degree that residents believe that their settlement is likely to face significant change including energy and climate related shocks over the next 20 years. • The proportion of residents who feel a sense of community in their local neighbourhood (Quality of Life Survey 2008) • Number of formal unpaid work outside of the home (StatsNZ 2008a) • The degree people feel that have available support during difficult times (Quality of Life Survey 2008) • The degree that residents feel other people can be trusted (Quality of Life Survey 2008)
ENVIRONMENT • Does the settlement and hinterlands have robust ecosystem services and biodiversity? • Are there urban development practices in place to protect and enhance ecosystem services?	• Policies in place to encourage low impact urban design and development infrastructure (yes/no and examples) • Proportion of water quality variables for selected coastal areas and freshwater streams for ecosystem health (ARC, 2008 Headline indicator). • Habitat loss, habitat fragmentation and habitat condition. (ARC. State of the Environment 2010)
ECONOMIC DEVELOPMENT • Is the local economic base diversified and not over-reliant on a single industry? • Is the local workforce innovative and entrepreneurial? • Which key business sectors are most vulnerable to rising oil prices? And are they reducing their vulnerability to fossil fuel depletion?	• Rate of business innovation by type (settlement survey) • Diversity of businesses sectors (Census data of employment statistics) • Educational Attainment of Adult Population (Census) • % of oil vulnerability and climate change assessments undertaken for settlement ;s key business sectors.

Domain and Assessment Questions	Draft Measures or Indicators
Adaptation Characteristics to Peak Oil and Climate Change	
URBAN DESIGN AND FORM • Does current urban form and design reduce dependency on private vehicle use? • Does current urban design and infrastructure reduce possible climate change impacts (high summer temperatures and increased storm events)?	• Sprawl index based on; low density, low mixed real-estate uses (drawing on Smart Growth America 2002) • Percentage of total development (new building consents) in designated growth areas and greenfield areas (Statistics New Zealand • Building Consent database assessed against settlement's growth management plans. • % urban development within flood zones or areas under risk of coastal storm surges and inundation
TRANSPORT • Do all residents have alternative transport options to private motor-vehicles for accessing employment and basic services?	• Mode transport used and distance travelled to work (Census data) • Vehicle trips to work mapped against low income households (Census data) or the NZ deprivation index (University of Otago), • Ease of access and affordability of public transport (Quality of Life Survey 2008) • % public investment in public transport against roading investment over last 10 years (settlement assessment public investment) • Transport component of national CPI (Stats NZ CPI index)
ENERGY • Is residential energy conservation (non transport) decreasing? • Is the settlement's energy supply transitioning to renewables?	• Residential energy consumption per person (settlement analysis). • Number of homes insulated to building standards • Energy supply broken into; renewables versus gas and coal (settlement analysis)
INSTITUTIONAL • Have councils communicated and engaged the community on the need to take action on peak oil and climate change?	• Proportion of residents who are aware of climate change and peak oil impacts on their settlement and support action to address those impacts

Additional Resources

Stockholm Resilience Centre:	http://www.stockholmresilience.org/
ICLEI – Local Governments for Sustainability:	http://resilient-cities.iclei.org/bonn2011/resilience-resource-point/
Resilience Alliance:	http://www.resalliance.org/
Transition Towns:	http://www.transitionnetwork.org/
Post-Carbon Institute:	http://www.postcarbon.org/
QUEST Canada	http://www.questcanada.org/

Acknowledgments

I would like to express my sincere gratitude to my advisor and professor, Dr. Madhav Badami, for his expertise and teachings in environmental and transportation policy and for his guidance and contributions to the development of this report.

I must also thank Mr. Rob Kerr, Corporate Manager of Community Energy for the City of Guelph for his kind contribution of time to further advise me on additional resources and considerations for completing this report.

I thank Mr. Bertrand Barrere of l'Agence REDD in Strasbourg for inspiring me with his progressive views on resilience planning and sustainable development, and for his generosity in inviting me to join his team on the highly informative study tour of Vorarlberg, Austria in July 2011. This trip opened my eyes to some of the excellent examples of resilience planning and architecture that Europe has to offer.

And finally, I should be grateful for the ongoing love, patience and encouragement of my partner, Bastian Juste, who encouraged my progress and advancement during the writing phase of this project.

Many thanks to you all for making this an enlightening, engaging, and inspiring experience!

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