Climate Change and the Residential Development Industry in Ottawa, Canada.

Gary Martin, Ph.D & Patricia Ballamingie Ph.D

Community First: Impacts of Community Engagement (CFICE), a major SSHRC-funded project, aims to strengthen Canadian communities through action research on best practices of community-campus engagement. We ask how community-campus partnerships can be done to maximize the value created for non-profit, community based organizations in four key areas: poverty, community food security, community environmental sustainability, and reducing violence against women.

This research was supported by the Social Sciences and Humanities Research Council of Canada through the Community First: Impacts of Community Engagement Project.

Social Sciences and Humanities Research Council of Canada

Conseil de recherches en sciences humaines du Canada

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Gary Martin, Ph.D., Principal, Integrative Solutions Group, 1125@carleton, 5110 Human Computer Interaction Building, Carleton University, Ottawa, Canada[1]

Patricia Ballamingie, Ph.D., Associate Professor, Department of Geography & Environmental Studies, Carleton University, Ottawa, Canada.

Executive Summary

The City of Ottawa, Canada's capital, is growing and transitioning. Growth is fueled by an influx of new residents attracted by the region's employment prospects and quality of life. Growth is also fueled by a development industry operating on a decades-old model of low-density planning, and by consumers who prefer low-density housing. The transition, on the other hand, is spurred by recognition among government policy-makers that alarm about environmental issues necessitate changes in how cities, including Ottawa, spread into surrounding farmland. Changes are driven by the costs of providing and maintaining services (e.g., roads, sewage and water, transit, emergency services, etc.) into low-density suburbs, by fears about the impacts of climate change, and by an urgent need to cut greenhouse gas emissions, especially from transit and power supplies, to slow global warming.

According to a large body of research on global climate change and on down-scaled regional projections, Ottawa's weather is changing. In recent years, there have

[1] This research was made possible by funding provided by Mitacs (https://www.mitacs.ca/en) and Domicile Developments (http://domicile.ca/), Ottawa, Ontario.

been more severe weather events resulting in flooding, ice storms, short periods of dramatic temperature variations (freeze-thaw events), and hot spells with drought conditions. Ottawa's weather changes might be characterized as *more emphatic or severe*, rather than as *different* patterns from what the city has seen in the past.

While government policies at three levels (federal, provincial and municipal) generally reflect an urgent need to recognize risks to lives and property from climate change, consumers and the housing development industry, who combine to generate an entrenched economic growth model, seem to be unreceptive and unwilling to alter a half-century of (relatively) affordable housing production. The contradiction between the policies written by environment-minded public officials and the actual practices on the ground signifies a debate that can only grow more intense along with growing alarm about the environment. The paper ends with questions about the future of urban development for policymakers, planners and developers.

Abstract

This paper is intended to inform discussions between industry and government policymakers in and beyond Ottawa, Canada about climate change and potential impacts on residential development regulations and corresponding industry practices. Ultimately, both private and public stakeholders must acknowledge the impacts of urban form on greenhouse gas (GHG) emissions, and, conversely, the impacts of climate change on cities, for any meaningful progress on urban sustainability to ensue. Section 1 introduces the basic relationships between urban development and climate change. Urban form is directly tied to energy consumption and GHG emissions, mainly through building and transportation energy consumption. Section 2 summarizes regional changes from climate change projected by various research organizations. Projected weather changes include more severe heat waves, rain and freezing rain in the future, with flooding identified repeatedly as the main concern for the Ottawa region. Section 3 reflects on the potential impacts of more severe weather on buildings and on the building industry. Impacts may include risks to structures and workers, as well as shifting regulations and insurance liabilities. Section 4 provides an overview of changes to government environmental policies that may signal future regulatory change. And finally, Sections 5 and 6 pose questions of interest for future regulators and builders.

Subject keywords: climate change; climate change risk; buildings; urban development; residential construction.

1. Introduction

More than half of the world's population now lives in cities – a proportion that increases every day. Approximately 80% of Canadians live in cities, and 80% of those city dwellers are suburban (Gordon & Janzen, 2013; Gordon & Shirokoff, 2014). Likewise, cities consume the majority of the world's resources and produce the majority of the world's pollution. Cities and urban form remain key determinants of global environmental sustainability.

The residential land development and building industry is one of the largest industries in Canada, with significant impacts on the environment. The main impacts include: greenhouse gas (GHG) emissions associated with material chains and machinery used in the production of housing; GHG emissions from the production and consumption of energy for household uses and transportation; various pollutants and waste; and the disruption of farming, natural landscapes and water systems.

Current government regulations and building industry initiatives reduce some of the above impacts. However, regulations add to production costs and thus make housing less affordable. Industry officials also point out that consumers often make decisions based on short-term aesthetics over long-term green building considerations[2]. Market-based approaches have proven insufficient in and of themselves, so municipal and provincial governments in Canada are moving towards regulatory approaches to climate change.

Builders, regulators and consumers of housing in Ottawa must increasingly consider the growing debates about buildings, urban form, energy and climate change. For example, construction materials have a "carbon footprint" because energy is required to gather raw materials, to shape them into useable form, to transport them, to warehouse

[2] In Martin's research, one of the developers noted that granite countertops still outsell energy efficiency upgrades by a wide margin.

them and to fabricate and install them[3]. All methods of producing energy – including renewables like hydroelectricity, solar and wind energy[4] – have environmental consequences. As another example, large infrastructure projects – roads, bridges, culverts and so on – are built from asphalt and concrete and diesel-powered machines, all of which generate significant carbon emissions. Road right-of-ways destroy and fragment large tracts of fertile farmland, while at the same time Canadians increasingly import food. Forests and wetlands absorb carbon too, until they are disrupted by roads and development, ultimately releasing carbon into the atmosphere. Municipal governments increasingly catalogue sources of GHG emissions (and features that absorb GHGs) in attempts to cut their carbon footprint.

In the competitive drive to ensure profitability, the residential development industry in Ottawa has a half-century history of resisting government regulations including environmental regulations that may impact on business operations. There are two dynamics at play in the debate. First, in the bigger picture, business-as-usual in the industry is, without question and despite industry marketing, environmentally irresponsible over the long term (see Martin, 2013). Second, builders who wish to develop environmentally responsible housing cannot currently compete on a level playing field if conventional development and consumer preferences continue as they have for 50 years in Ottawa.

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[3] For examples of materials life cycle analysis, see Athena Sustainable Materials Institute (2014).

[4] According to Environment Canada, "Renewable energy still has other effects on the environment, such as the disturbance of land and eco-systems in hydro reservoirs or because of variable stream flow downstream of dams; the water effluent from processing of biomass or renewable fuels; ambient air pollution coming from wood smoke when heating with wood; waste ash from biomass combustion; and the impacts on land from intensive agricultural operations for bioenergy. Furthermore, in the full life cycle of renewable energy, the construction of renewable energy production facilities often involves the use of fossil fuels, which themselves have significant impacts. Given that all forms of energy production have some level of environmental impact…". (See Environment Canada, 2010). The United Nations claims that, globally, around two thirds of carbon dioxide (a main greenhouse gas) comes from burning fossil fuels and manufacturing cement (IPCC, 2014). Note that cement and concrete are main building materials for dams and hydroelectric generation, hence, even this "renewable" form of energy results in significant carbon dioxide emissions (see IPCC, 2014).

The building industry is not solely responsible for the negative impacts of their practices: governments and consumers are equally responsible for urban form. With changes in industry practices, government regulation and consumer behavior, cities will reduce negative impacts on the environment. Rather than criticizing one sector or another, this paper adopts a transitional perspective and points to issues that will affect governments, industry and consumers alike in the future. The paper is intended to inform larger conversations about mitigation and adaptation[5] to climate change.

This report deals specifically with potential impacts of climate change on housing and infrastructure, because climate change and energy efficiency represent the most significant challenges *and* opportunities for the building industry. Sections 2 and 3 summarize projected changes to climate and weather in the Ottawa region, including their potential effects on the building industry. Sections 4 and 5 discuss climate change, buildings and infrastructure. Section 6 concludes with questions for future research and consideration by Ottawa's urban development sector.

2. Global to local weather scenarios and the Ottawa building industry

Earth scientists around the world agree that the addition of greenhouse gasses to the environment, mainly from the burning of fossil fuels, is changing global climate systems. The United Nations International Panel on Climate Change (IPCC) states that, even if humans were to stop polluting today, the changes we have already made to the atmosphere will continue altering global climate systems for centuries to come (IPCC, 2014).

The most significant change to Earth in the past 200 years has been a rise in average temperatures of just under two degrees Celsius (City of Ottawa, 2005, 2014a; Gleeson et al., 2011; IPCC, 2014; Ontario Ministry of the Environment, 2014). The

[5] Mitigation refers to cutting greenhouse gas emissions. Adaptation refers to adapting to changing weather.

warmest decade on the planet since records began was 2001 to 2010, and the warming is apparently accelerating (WMO, 2013). In Canada, the winter of 2009-2010 was the warmest on record, over four degrees Celsius above a 68-year average (McBean, 2012). According to the World Meteorological Association, 2010 was the warmest (and wettest) year on record globally (WMO, 2013), until the heat temperature record was broken in 2014 (WMO, 2015). While a global temperature increase of two degrees Celsius may sound insignificant, climate scientists caution that this increase is leading to increased frequency, intensity and duration of "weather events" around the world (City of Ottawa, 2014a; Government Accountability Office, 2013; IPCC, 2014; McBean, 2012; Mladjic et al., 2011; Ontario Ministry of the Environment, 2014; WMO, 2013).

Predicting changes to global climate patterns is not the same as predicting potential weather events in the Ottawa region. In fact, there is greater uncertainty in long-range *regional* weather forecasting (City of Ottawa, 2014a). The City also recognizes that "A more in-depth review of the vulnerability of infrastructure and design criteria is needed to consider climate change adaptation" (City of Ottawa, 2013: p.55). Regardless, from historical weather patterns and "downscaling"[6] global weather projections, we have some idea what is in store regionally.

Coinciding with catastrophic storms elsewhere in Canada and around the world, the Ottawa region has experienced unprecedented rain- and wind-storms that have flooded basements, washed out roads and toppled trees in the last decade[7]. Climate scientists warn that bad weather is increasing in frequency and intensity. Also, events that were once more or less predictable from historical patterns are now more random (McBean, 2012). Weather scientists and civil engineers can no longer refer to, for

[6] Downscaling is the scientific process of applying large-scale (e.g. eastern North America) climate modeling to smaller scales (e.g. eastern Ontario).

[7] See Environment Canada (2010) and Tousignant (no date). See also City of Ottawa (2014a: p. 54). In this latter document, the City of Ottawa advises caution when projecting weather trends for Ottawa from large-scale climate data for the region.

example, “100-year flooding events” because storm patterns are changing, forcing authorities to revise flood management plans.

Despite the claim that weather will be less predictable, researchers have made projections of general patterns of change for our region[8].

A warming planet is bringing warmer winters and more hot spells in the summers to Canada [City of Ottawa, 2005, 2013, 2014a; IPCC, 2014; Lemmen et al. (eds.), 2008; McBean, 2012; Semeiuk, 2013]. Already in parts of Ontario and Québec, hotter summers have meant some longer growing seasons for fruits and vegetables, but severe weather may cancel any advantage of a longer season (Ontario Ministry of the Environment, 2014).

For example, apparently it is getting wetter across Canada (McBean, 2012; Mladjic et al., 2011; WMO, 2013) and rain storms are expected to continue to grow in intensity in our region [City of Ottawa, 2005, 2013, 2014a; Gleeson et al., 2011; Lemmen et al. (eds.), 2008; McBean, 2012]. Severe storms with damaging wind and flooding are increasing in frequency, intensity and duration in our region (CEC, 2008; City of Ottawa, 2013,,2014a, 2014b; Gleeson et al., 2011; Lemmen et al. (eds.), 2008; Semeiuk, 2013). According to the Québec Minister of Transportation, landslides have also increased, especially in areas with clay soils in the St. Lawrence lowlands, including around the Ottawa River (cited in Lemmen et al., 2008).

Rain on snow and frozen ground leads to increased risk of flooding. Winter flooding is especially hard on aging water and waste water infrastructure (City of Ottawa, 2013; Lemmen et al., 2008). Some researchers predict heavier snowfalls in winter because warmer air holds more moisture **(**Main, 2013), but there would likely be less

[8] Predictions are much more focused and certain than projections, which assume longer time frames and are based on trends developed from multiple models and research parameters. For example, the Intergovernmental Panel on Climate Change (IPCC) projections use probabilities for specific changes to climate based on a number of different research methods used by different researchers. This type of “triangulation” provides less focused but more reliable general estimations for changes over larger spatial scales.

snow and more rain over the course of the year as temperatures rise (City of Ottawa, 2014a; McBean, 2012; Ontario Ministry of the Environment, 2014; Statistics Canada, 2008).

As average temperatures increase, freeze-thaw and frost-heave cycles will likely cause more damage to asphalt and concrete and will threaten power generation and transmission lines [City of Ottawa, 2013; Lemmen et al. (eds.), 2008; McBean, 2012; Ontario Ministry of the Environment, 2014; Statistics Canada, 2008]. Freeze-thaw cycles occur when air temperatures range above and below the freezing point over short periods of time. They are particularly damaging because water that has infiltrated porous surfaces expands when it freezes. In addition, freezing rain is expected to increase, especially in the coldest months of the winter (Cheng, Li & Auld, 2011; City of Ottawa, 2005, 2014a; Gleeson et al., 2011; McBean, 2012). The 1998 ice storm killed dozens of people, downed power lines and resulted in billions of dollars of damages to property and infrastructure and lost productivity over a wide geographic area, from Western Quebec to Eastern Ontario. The 2013 ice storm in Toronto also downed trees and power lines, confirming vulnerabilities in overhead electricity and communications grids [Lemmen et al. (eds.), 2008; Ontario Ministry of the Environment, 2014), and making 2013 another record-breaking year for insurance claims from severe weather according to the Insurance Bureau of Canada (2014).

Natural Resources Canada and the Ontario Ministry of the Environment caution that patterns of precipitation are expected to change to more pronounced periods of both flooding and drought [Lemmen et al. (eds.), 2008; McBean, 2012; Ontario Ministry of the Environment, 2014]. Increased temperatures might lead to more evaporation and thus lower water levels**,** with subsequent impacts on shoreline infrastructure, water intakes and water quality (Ontario Ministry of the Environment, 2014). Droughts may also lower water levels in rivers and thus interfere with production of hydroelectricity and impact on freshwater fishing and tourism (Ontario Ministry of the Environment, 2014; Statistics Canada, 2008). The City of Ottawa reports increased frequency of hot dry periods over a thirty-year average, with associated increased risks from the urban heat island effect (City of Ottawa, 2005, 2013, 2014a). Elevated urban temperatures in Ottawa will likely

increase electricity demands for air conditioning. Dry periods followed by lightning storms further increase the risk of forest fires**,** especially in rural areas (Ontario Ministry of the Environment, 2014).

Projections of rain events and drought are not, in fact, contradictory. Intense rainfall clears wetlands and rivers relatively quickly, running off much faster than a slower, more gradual rainfall, which tends to infiltrate into the ground. A subsequent drought would result in a net loss of surface water.

In summary, according to reports reviewed for this paper, weather events that were once more or less predictable have become much less predictable (IPCC, 2014; McBean, 2012; WMO, 2013). Most sources reviewed for this report characterize weather in the Ottawa region as changing and predict more, and increasingly damaging, weather events.

Section 3 describes how changes to weather may add to the impacts of already-severe weather upon Ottawa's built environment.

3. Potential impacts of climate change on buildings and infrastructure in Ottawa

Ottawa is known for its temperature extremes and harsh climate. Ottawa high and low temperatures often vary by 60 degrees Celsius between summer and winter, and temperatures regularly vary 20 degrees within single days. Ottawa also experiences considerable precipitation year round. Ottawa's harsh climate regularly interferes with construction schedules and is also hard on buildings and materials. Freezing and thawing over short timeframes combined with moisture infiltration rapidly deteriorates building exteriors, as well as asphalt and concrete. Heavy rain combined with wind leads to water infiltration of cladding and subsequent damage to structures and interiors. Ottawa's relatively harsh and variable climate is hard on construction workers too, and will become harder. Given the previous description of potential changes to weather, Ottawa will be an even more challenging place for construction work and buildings.

At this point it is critical to note that we found no research that identifies or discusses the unique and measurable impacts of changing climate on the built environment and construction processes. In other words, because the research does not seem to exist, we can only speculate about the *potential* increases in the impacts of weather changes compared to conventional measures of environmental deterioration on structures (Pope, 2015).

Flooding

Three major rivers – the Ottawa River, the Rideau River and the Gatineau River – meet at the City of Ottawa. Since its beginnings at the turn of the 19th century, Ottawa has suffered regular floods. Until recently, flooding proved a problem mostly when water levels in streams, rivers and lakes peaked from snow melt in the spring, typically once in April and once in May. However, flooding has been increasing and occurring at other times of the year, leading the Mississippi Valley Conservation Authority (MVCA), the Rideau Valley Conservation Authority (RVCA) and the City of Ottawa, to collaborate on a climate change management plan for the region's watershed (personal communication with officials in the three organizations, January, 2015). Also, recent record-setting summer storms have flooded hundreds of homes, particularly in the west end (notably, in 2004, 2009, 2011 and 2013) causing millions of dollars of damage to finished basements, appliances and stored goods, most of which was not covered by insurance. Flooding is complicated in parts of the city by non-climate factors, including: undersized (and/or combined) septic and storm sewers; impermeable paved and roof surfaces which cut the amount of rain absorbed by the ground; drainage infrastructure that is now insufficient in older neighborhoods due to increases in rainfall; and loss of wetlands in the past to development [compiled from City of Ottawa, 2013; Government Accountability Office, 2013; Lemmen et al. (eds.), 2008; Ontario Ministry of the Environment, 2014]. Wetlands, forests and farm fields serve multiple functions: all absorb rain, cutting the risk of flooding around bodies of water; all filter toxins out of runoff; and all absorb carbon out of the atmosphere, mitigating the greenhouse effect.

In addition to damaging buildings, urban storm runoff is generally contaminated with assorted pollutants from roads, garbage, and raw sewage from combined systems,

which amplifies the negative impacts on waterways from severe rainstorms. Flooding and flood runoff can become a health hazard for people and other non-human species in or near waterways.

Wind

Climate scientists hesitate to link damaging winds directly to climate change (McBean, 2012). Regardless, wind events are becoming both more frequent and intense [City of Ottawa, 2014b; Lemmen et al. (eds.), 2008; McBean, 2012; Ontario Ministry of the Environment, 2014] and wind poses risk of damage to various roof, window and wall components. Powerful gusts of wind may stress tall buildings beyond design parameters, and wind-driven projectiles, falling trees and electrical disruptions can also be expected to increase. Wind also creates risk from waves for buildings and shoreline infrastructure near bodies of water. Winter winds will add to heating loads, and will increase challenges (and compromise safety) for workers on construction sites, especially on multi-story buildings.

Freezing Rain and Freeze-Thaw Cycles

Numerous sources state that climate change will increase freezing rain [Cheng, Li & Auld, 2011; City of Ottawa, 2005; 2014a; Lemmen et al. (eds.), 2008; McBean, 2012 citing Natural Resources Canada; Ontario Ministry of the Environment, 2014; Statistics Canada, 2008). While not directly threatening to buildings, freezing rain may interfere with exterior vents and ventilation systems, and, in the past, freezing rain has badly disrupted electrical and communication grids (Health Canada, 2012; Statistics Canada, 2008). Given the widespread reliance on electricity for space heating, grid failure increases risk for frozen water pipes and other water damage depending on how long power is disrupted, along with corresponding weather conditions during the outage. Freezing rain, hail and snow may also combine to interfere with sewers and drainage, increasing the risk of overland flooding, especially in predominantly paved urban areas. Finally, freezing rain has profound impacts on transportation and personal mobility for vulnerable populations such as seniors, people with disabilities and children, with attendant liability issues for property owners.

The Ottawa region has always experienced periods of extreme temperature swings. Winter freeze-thaw events are expected to increase as winter temperatures rise (Ontario Ministry of the Environment, 2014; Statistics Canada, 2008). Unlike freezing rain, freeze-thaw events rapidly deteriorate surfaces that regularly get wet. Further, water infiltrates as deep as cracks, so damage may be hidden but accelerating. Concrete is susceptible (Ontario Ministry of the Environment, 2014) and because dams are built from concrete, increasing freeze-thaw events may combine with freezing rain to threaten both hydroelectric dams and power lines[9].

Along with direct damage to buildings, snow and ice falling from buildings can be expected to increase. In addition to risks to pedestrians and vehicles, falling snow and ice may cause damage to protruding building components, roofs at lower levels, and vents and mechanical installations on those lower roofs[10].

Heat & Drought

Summer temperatures are expected to rise along with the frequency of extreme hot spells [City of Ottawa, 2005; Health Canada, 2012; Lemmen et al. (eds.), 2008; Ontario Ministry of the Environment, 2014; Statistics Canada, 2008). Hot spells will be amplified in urban areas by the heat island effect. Heat islands occur where built form (due to its albedo) holds heat from air conditioning, cars, buildings and the sun, releasing it more slowly than natural materials would otherwise. A lack of trees and other vegetation, and dark surfaces like asphalt, both contribute significantly to heat islands. Dark surfaces are simultaneously susceptible to deterioration from extreme heat. Some flexible joints and membranes will age prematurely during hot spells. Heat combined with sunshine will overheat and prematurely age many finishes and materials in building interiors as well.

[9] Dams will experience increased stress on structural stability from increased fluctuations in freeze/melt events in winter and will experience increased erosion due to more variable flows (Ontario Ministry of the Environment, 2014: 42).

[10] Adapted from Carter & Stangl (2012).

Increased air-cooling loads in summer months will likely offset reduced heating requirements in the winter. Spikes in demand for electricity for air conditioning have led to "brown-outs" and "black-outs"[11] where supply cannot keep up with demand. Brown-outs may combine with hot spells to increase negative health impacts for the most vulnerable people like seniors and infants, especially in multi-story buildings (Health Canada, 2012; IPCC, 2014).

As mentioned, weather scenarios include dry spells punctuated by severe rain events. Both will impact upon Ottawa landscapes, as in 2012, when water shortages led to lawn-watering restrictions for much of Ottawa. There were also many reports of foundation damages in houses as soils in Ottawa dried and trees sent roots towards houses in search of water. Soils in Ottawa consist largely of Leda or quick clay, which has varying impacts on buildings depending on precipitation. As precipitation patterns change, so will concerns about soil conditions in Ottawa. Notably, if Leda clay becomes supersaturated (e.g., due to a heavy rainfall event), it liquefies, sometimes to devastating effect, causing landslides, sinkholes and damage to building foundations.

In sum, apart from rain and flooding, most of the changes in climate projections imply that Ottawa weather will become more amplified, rather than fundamentally altered. In other words, risks will come from extremes in existing weather patterns rather than different patterns. Ottawa's already-severe climate will become more severe. The City recognizes the challenges in projected changes, and has been altering environment-related policies and regulations to match.

4. Ottawa and the environment at three levels of governance

Over the past decade, the City of Ottawa policy makers and planners have been increasingly vocal about environmental issues. These concerns are reflected in the

[11] A brown out is a reduction in the voltage of a power line. A black out is an interruption of power.

recently updated Official Plan, density and tree bylaws, and the Choosing Our Future planning initiative. Also, as mentioned earlier, the City, the RVCA and the MVCA are working together on a watershed-wide climate change management plan.

In the spring of 2014, the City produced a revised Air Quality and Climate Change Management Plan (AQCCMP) on the heels of a major official plan review. According to the AQCCMP, the City of Ottawa will work more closely with community partners "to reduce air pollution and make Ottawa more resilient" and "reduce per capita emissions by 20% between 2012 and 2024" [12] especially by increasing transit ridership. The City now has an extreme weather committee and plan, and is working on a Hazard Mitigation plan and program.

The City of Ottawa points to the connections between transportation, buildings and greenhouse gas (GHG) emissions. The previous (2005) version of the AQCCMP reads: "In Ottawa, transportation is the largest source of air emissions. This sector is responsible for 40% of our community's greenhouse gases. Use of energy in buildings contributes a similar level of greenhouse gas emissions in Ottawa at approximately 40% of our total, with the balance coming from waste generated within the community" (City of Ottawa, 2005: 8). This information provides a snapshot of the major environmental impacts of urban form – notably, GHG emissions associated with transportation infrastructure and the built environment. With regards to transportation, tailpipe emissions from cars, trucks and busses are compounded by GHGs produced during the *manufacture* of cars and fossil fuels, and through road construction. Buildings are similarly responsible for GHG emissions during their construction as well as during their operation. Energy is required to produce cars, roads and buildings, and all energy has an associated "carbon footprint". Detached, low-rise housing in commuter suburbs is generally considered the least efficient and most carbon-intensive urban form in North America because their vehicle and building energy consumption are much higher than other forms of development (CEC, 2008; City of Ottawa, 201e4b; EPA, 2011; IBI Group,

[12] See City of Ottawa (2014a). Resilience in this context usually refers to the ability of an individual city or region to endure environmental shocks while maintaining living standards.

2000)[13]. Regardless, the 2014 AQCCMP notes that, between 2005 and 2011, three quarters of all new housing was built outside of the Greenbelt, despite the City's efforts to encourage infill building in Ottawa's urban area.

One might interpret the previous sentence as contradictory. In addition to the AQCCMP, the watershed study and assorted bylaws, the City has undertaken numerous environmental policy and program initiatives at City Hall, many of which had direct input from the development industry. For example, the City of Ottawa Infrastructure Master Plan now includes the:

- Greenspace Master Plan;
- Subwatershed Plan;
- Community Design and Secondary Plans;
- Transit-Oriented Design Plans for various part of city;
- Design Guidelines for neighborhood development;
- Urban Tree Conservation Bylaw; and,
- Wet Weather Infrastructure Master Plan (City of Ottawa, 2013).

The impact (and effectiveness) of environmental plans, guidelines and bylaws will depend upon direct buy-in from bureaucrats, the voting and consumer public, and the development industry. If the initiatives add to production costs, consumers and developers will likely resist. This "clash between public and private interests"[14] is increasing along with debates about land use planning and the environment, especially around climate change, as environmental damage hits home. The debates will likely become more politically volatile at all three levels of government in coming years.

The AQCCMP notes directives from the Province of Ontario that are contained in the policy documents *Achieving Balance: Ontario's Long Term Energy Plan (2013)* and the *Revised Provincial Policy Statement (2014)*, in which the province seeks to cut

[13] See especially NRCan's Urban Archetypes project at: http://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/research/4531

[14] Quoting Ottawa planning manager Anna Hercz, personal communication, September 2011.

carbon (and risk from climate change) via green energy subsidies and land-use planning. With input from the insurance industry-sponsored Institute for Catastrophic Loss Reduction, Ontario's Ministry of Housing and Municipal Affairs (OMHMA) is working with the Canadian Commission on Building and Fire Codes to incorporate climate data, resilience and water and energy conservation into the Model Code (Ontario Ministry of Municipal Affairs and Housing, 2014). The Ministry stated that the new (2012) Building Code "...has an environmental focus, by putting in place measures that reduce greenhouse gases, protect air, water and soil quality, and conserve energy" (Ontario Ministry of Municipal Affairs and Housing, 2012). The new code contains upgrades and more oversight of building practices in the multi-unit residential building (MURB) sector along with more regulations of flood zones and water management. In addition, Ontario's Provincial Policy Statement on municipal land-use planning now provides "tools for sustainable development" (Ontario Ministry of Municipal Affairs and Housing, 2014). Although the tools are a mix of regulations and guidelines, they follow a distinct trend in provincial environmental policy. In addition to clear directions for the built environment in Ontario cities, the Province of Ontario published *Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011-2014* in 2010 which speaks directly to numerous climate change implications for: roads; water, waste water and storm water infrastructure; flooding and revised flood zone mapping; urban trees; extreme weather events such as ice storms, droughts, and forest fires; among other areas of concern for public policy. Finally, another of the Province's more recent forays into sustainability is a discussion paper released in February 2015 by the newly renamed Minister of the Environment and Climate Change entitled *Ontario's Climate Change Discussion Paper 2015.* The paper states: "…where we work, where we live and how we get there makes up most of our carbon footprint…", and goes on to make a strong case for carbon pricing.

At another level, municipalities and provinces work directly with the Canadian federal government in the realm of climate change policy. The Ontario Ministry of Environment's Community Adaptation Initiative and the federal/provincial Regional Adaptation Collaborative are both partnerships between the provinces and Natural Resources Canada. The federal government is aware of skyrocketing costs of 'natural'

disasters. The Parliamentary Budget Office claims disaster relief from floods alone ballooned over 600% to $4.1 billion in the past several years (Naumetze, 2014). Because of its impact on infrastructure and communities in general, flooding related to climate change should be of immediate and pressing concern to Canadian taxpayers, homeowners and housing producers. Section 5 briefly speculates about how climate change may directly and indirectly impact the housing industry.

5. Potential policy and economic implications for the residential development industry

Again, we must preface the following discussion by stating that *changes* to weather are difficult to predict, as are the resulting *changes* to deterioration of the built environment. However, given the previous discussion, some cautionary speculation seems warranted.

First, what might the impacts of climate change on builders and the housing industry? If climate change has projected impacts in the Ottawa region, construction staff will be obliged to work in even more difficult weather conditions than they do now. Builders can expect extra weather delays from freeze-thaw events, freezing rain, wind storms, heat spells, humidity and rain storms. Severe weather may delay delivery of building materials, quite probably around the world as well as in Ottawa, and increasingly severe weather will likely have insurance implications for construction sites as well as buildings and developments. Weather already interferes with building schedules, slowing production and delaying closing dates. There is simply no way to predict how or how much climate change will disrupt construction and costs in the future. Moreover, weather becomes less stable and more unpredictable as humans release more GHGs into the atmosphere, a compelling reason for cities to cut local GHG production.

Next, at the scale of the city, repairs, maintenance and upgrades to municipal infrastructure will inevitably result in increasing taxes. Flooding remains the biggest concern, according to weather projections for the region, and not only in the spring as in the past. The problem is amplified by the fact that much of Ottawa's water infrastructure is aging and/or inadequate. Although some insurance companies recently began to offer

overland flood coverage to home owners, coverage is not certain in existing zones that are prone to flooding. And one can only speculate about insurance coverage as the City of Ottawa and conservation authorities re-map the region's watershed.

New regulations on site preparation and engineering for storm water management in developments represent potentially expensive additions to costs. The City is increasingly adamant about restricting new development land outside the Greenbelt due to the servicing costs of new greenfield developments. Concerns about climate change and GHG emissions will likely lead to more restrictions on suburban development. Like many North American municipalities, the City is moving towards New Urbanism and Smart Growth planning principles – mainly through density and infill policies – and transit in Ottawa will both follow and stimulate infill projects. Moreover, as consumers come to understand the full costs of car ownership, urban infill housing will likely become more appealing. Also, as electricity costs rise across Ontario, consumers will gradually demand more energy-efficient housing. Finally, the federal government has promised to specify increased energy efficiency standards for housing in every building code revision. Governments and industry have both made slow, steady progress towards greener practices. However, future changes to planetary climate systems should be understood as potential disruptions, and dramatic weather events may accelerate or amplify demands for better built and more protective and adaptive housing, as well as for housing that reduces carbon emissions. What are the implications for cities including Ottawa? If a city is not climate-ready, might the municipality's credit ratings be downgraded? What are the risks to businesses that are not cutting GHGs and planning for their own resilience as climate change alters business practices around the globe?

Stronger general regulations on carbon will influence GHG emissions and fossil fuel consumption in particular. Carbon pricing increasingly appears to be a viable antidote to climate change in debates across the political spectrum. The impact(s) of carbon pricing is beyond the scope of this paper, but as the social, environmental and economic costs of fossil fuels and climate disruption become more obvious, the housing industry ought to consider the questions raised in the concluding Section 6.

6. Questions for discussion

Clearly, climate change poses both challenges *and* opportunities. A progressive builder might seek to answer the following questions:

- At some point, will Ottawa see the end of the single, detached, stick-framed houses on large lots situated a good distance from employment and shopping?
- Will fossil fuel costs remain low? If they rise significantly, through increased taxation on production, how will this impact where and how we build housing?
- Will development land on the outskirts become "stranded assets" if any of three levels of government put a price on carbon?
- Will suburbs be "revised" for a new energy economy? What are the opportunities for innovation in suburban development? How will they be tied to transit?
- How will new thinking about GHG emissions impact on development in or near natural features like forests, farmland and wetlands (all of which serve as carbon sinks)?
- If climate change makes imported food more expensive, will farmland become more valuable? And will the Ontario government restrict development of farmland similar to regulations in the Province of Québec?
- Will energy efficiency labeling on houses soon be legally tied to sales?
- Will climate disruptions force more use of prefabricated building components? What impact might such a move have on trades, material suppliers and housing prices? What are the opportunities within prefabrication?
- What are the insurance implications of climate change? Will insurance companies create new criteria to deny or raise fees for coverage in specific areas?
- Recent floods raise questions that will become more pressing with projected changes to weather. If City officials, engineers, planners, developers and builders share responsibility for building in areas that are at increased risk of flooding due to climate change, who will be liable for damages to people, livelihoods and buildings from flooding in these areas?

- In the bigger picture, will Ottawa attract climate refugees fleeing heat, drought and flooding as other parts of the world become less livable? What might that mean for Ottawa's housing market?
- **What is the development industry's "corporate social responsibility" for reducing (and mitigating) its impacts on the environment?**

In closing, there is no question that Ottawa presents a difficult environment in which to build, operate and maintain housing. Climate change science is clear: climate disruption and severe weather events will increase, and can be expected to make construction even more challenging. As a result, legislators at all levels are growing more concerned about environmental sustainability. It remains to be seen how these changes will impact construction costs, schedules, house prices, regulations and, ultimately, Ottawa's urban form.

NB This research was made possible by funding provided by Mitacs (https://www.mitacs.ca/en) and Domicile Developments (http://domicile.ca/), Ottawa, Ontario.

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