Comments to the

Planning and Growth Management Committee

Concerning revisions to the energy provisions of the *Toronto Green Standard*

L.D. Danny Harvey
Department of Geography
University of Toronto

Email: harvey@geog.utoronto.ca

19 June 2013

Summary

Based on the energy requirements for specific end uses (heating, cooling, ventilation, water heating, lighting and equipment) of buildings that comply with the 2012 Ontario Building Code, and a comparison of what the energy requirements would be in Toronto's climate using demonstrated best practice, it is recommended here that:

(1) The energy provisions of the *Toronto Green Standard* be cast in terms of an absolute allowed energy use per unit of building floor area; and
(2) That this standard should be 70-100 kWh/m^{2}yr (depending on the type of building) for Tier 2, and somewhat less stringent for Tier 1.

In relative terms, the recommend standards represent a 40% reduction compared to the 2012 OBC for Tier 1 and a 60% reduction for Tier 2. In contrast, proposals currently under consideration amount to only a 15% reduction for Tier 1 and a 25% reduction for Tier 2.

Introduction

There is near unanimous (97%) agreement among climate experts that the climate is warming and that humans are largely responsible, through emissions of greenhouse gases, for this warming. There is also a very strong consensus that continued emissions of greenhouse gases and associated warming will eventually have serious negative impacts worldwide; indeed, negative impacts of global warming are already becoming evident in many parts of the world. In recognition of this, many jurisdictions have promoted strict voluntary standards to significantly reduce the energy requirements of new buildings compared to conventional practice, many of which are set to become the legally required standard, and are tooling up for deep retrofits of their existing building stock, as part of a broader set of measures to significantly reduce the use of fossil fuels and the associated emissions of greenhouse gases. A co-benefit of this has been greatly reduced building operating costs, and the stimulation of innovation and new industries that have created export opportunities.

Although there have been improvements in the energy provisions of building codes in Canada, the energy requirements in Canadian buildings are significantly greater than in some other cold-climate parts of Europe, and the improvements planned in Europe over the next decade are so large that we will fall significantly further behind unless the pace of improvement in Canada is sped up significantly.

The energy provisions of the pre-2012 Toronto Green Standard (TGS) were set to match the energy performance requirements anticipated under the 2012 Ontario Building Code (OBC). With the 2012 OBC now in effect, there is a need to upgrade the TGS in order to keep ahead of the OBC, with the preferred option being to set the new TGS at the level that will be required in the next (2017) revision of the OBC. However, the 2012 OBC represents only a modest improvement from the previous (2006) edition of the OBC, and it appears that the 2017 OBC will entail only another small improvement over the 2012 OBC. Rather than pacing improvement the TGS to the slow pace of improvement in the OBC, City Council is instead urged to set the energy provisions of the next TGS at levels that are comparable to voluntary standards (such as the German *Passive House* standard) that have been in effect for many years in Europe and which are set to become close to the required EU-wide standards by 2018-2020. This in turn will ensure that buildings in Toronto are globally competitive, and will also spur the development of local industries and design expertise that will otherwise have to be imported from Europe.

Energy use for buildings in Toronto

Table 1, shown below, gives the savings in total energy use, relative to the 1996 Model National Energy Code for Buildings (MNECB), for five different building types in Toronto as built under the 2006 OBC, the 2012 NECB (which presumably is very close to or the same as the 2012 OBC), and as would occur under the 2017 OBC with only a 10% reduction in lighting power density, slightly more efficient heating, and addition of heat recovery to the ventilation system (as suggested by SBC (2012)). As seen from Table 1, the 2006 OBC entailed a 10-20% energy savings compared to the 1996 MNECB in most cases. This savings increased to 22-34% for the 2012 NECB. Suggested improvements under the 2017 OBC would increase the savings by only another 6-8%, for a total savings of about 30-40% compared to the 1996 MNECB.

Table 1: Percent savings in total energy use relative to the 1996 Model National Energy Code for Buildings (MNECB) for buildings constructed according to the 2006 Ontario Building Code (OBC), the 2012 National Energy Code for Buildings (NECB), and under a hypothetical 2017 OBC. Source: SBC (2012, Tables 5.2-2 and 5.2-4).			
Building Type	Energy Code		
	2006 OBC	2012 NECB	2017 OBC
High rise office	19	30	37
Low rise office	14	30	35
High rise MURB	12	24	30
Low rise MURB	10	22	30
Retail	18	35	41
School	5	34	41
Warehouse	16	30	29

The energy use in absolute terms (using kilowatt-hours or kWh as the energy unit, irrespective of the type of energy considered) for different kinds of buildings under the various codes is given in Table 2. Absolute total annual energy use per square meter of floor area under the 2012 NECB is in the range 180-260 kWh/m^{2}yr, whereas state-of-the-art commercial and residential buildings in a wide variety of climates have consistently achieved total energy use in the range 75-100 kWh/m^{2}yr (Harvey, 2013) – more than a factor of two smaller.

Table 2. Absolute energy use (kWh/m^{2}yr) for various building types in Canada under various energy codes. Source: deduced from SBC (2012, Tables 5.2-2 to 5.2-4).				
Building type	Energy Code			
	1996 MNECB	2006 OBC	2012 OBC	2017 OBC
High rise office	261	211	184	166
Low rise office	369	316	259	241
High rise MURB	248	218	189	174
Low rise MURB	299	268	233	209
Retail	274	225	178	162
School	304	288	201	179
Warehouse	253	213	176	181

Insight into the reasons for the very high energy use that is permitted under the 2012 OBC can be obtained by examining the breakdown in total energy use into separate end uses, which is shown in Table 3 along with benchmark energy uses for advanced buildings. As seen from Table 3, the dominant energy use – even in large commercial buildings with large internal heat gains and a small surface-to-volume ratio – is heating energy use. Heating energy use is in the range 70-135 kWh/m^{2}yr, compared to 15 kWh/m^{2}yr for the increasingly popular Passive House standard (discussed below). Cooling energy requirements are reasonable for most building types except low rise office, where the permitted energy intensity is almost four times that of any other building type, and far more than would be required with good design. The permitted lighting energy use is 9-94 kWh/m^{2}yr. For a state-of-the-art lighting systems, with daylighting, photosensors, and occupancy controls, lighting energy requirements are on the order of 7-10 kWh/m^{2}yr based on 9-5 operation (more with longer hours of building use) (Harvey, 2013, Section 3.2). I see no justification for the lighting energy uses permitted for MURBs and schools under the 2012 OBC. Energy use permitted for motors (10-27 kWh/m^{2}yr), which presumably is for ventilation, is excessive compared to the 5-10 kWh/m^{2}yr achieved for many advanced buildings around the world (see Harvey, 2013, Table S8). The permitted hot water energy use (20-60 kWh/m^{2}yr) is better than the 2010 average in Canada (50-100 kWh/m^{2}yr according to NRC (2013)), but is still very high compared to the averages for US commercial buildings given by USDOE (2003, and summarized in Table S3 of Harvey, 2013) (5-8 kWh/m^{2}yr for office buildings, and 2-8 kWh/m^{2}yr for retail buildings, for example). Advances in the energy requirements of office equipment, applicances, and consumer goods – combined with good operation – will eventually permit a factor of two reduction in energy requirements compared to recent equipment.

Based on an end-use-by-use-end comparison of the energy intensities permitted under the 2012 OBC, and that achieved by state-of-the-art buildings elsewhere, it should be possible to achieve an energy intensity of 70-100 kWh/m^{2}yr in Toronto for most building types. This is 60% below the energy intensity permitted under the 2012 OBC.

Table 3. Energy use (kWh/m^{2}yr) by end use for different building types in Toronto, when constructed according to the 2012 OBC. Also given is a benchmark based on energy use of advanced buildings in climates with cold winters and relatively hot summers. Source: SBC (2012, Table 5.2-3) for OBC energy uses; Harvey (2013) for benchmarks (all OBC data have been converted to modern (metric) units)

Building Type	End Use						
	Heating	Cooling	Lighting	Hot water	Equip	Motors	Total
High rise office	68	9	17	37	36	18	184
Low rise office	101	43	10	37	41	27	259
High rise MURB	72	6	55	19	13	23	189
Low rise MURB	86	6	94	19	14	15	233
Retail	70	9	11	59	9	20	178
School	90	11	36	29	14	20	201
Warehouse	135	0	9	20	3	10	176
Benchmark	15-25	5-10	5-15	20	20	5-10	**70-100**

Developments in Europe and the US and voluntary initiatives in Canada

Many jurisdictions have developed voluntary energy standards (summarized in Table 1 of Harvey, 2013) that go substantially beyond the suggested energy requirements under the 2017 OBC – the apparent target for the next version of the OBC.

The most stringent standard for heating is the Passive House standard, originally developed in Germany based on early work in Canada in the 1970s. It prescribes a heating load of no more than 15 kWh/m^{2}yr irrespective of the climate (typical heating loads in new condominiums in Toronto are probably at least 120-150 kWh/m^{2}yr, if the measured energy use in recent largely-glass buildings at the University of Toronto are any guide). Over 50,000 buildings – of all types - have been certified in Europe as achieving the Passive House standard. The number in Canada is probably still less than one dozen. Several cities in Europe have adopted the Passive House standard as the legally required standard for some or all categories of municipal buildings, including the cities of Frankfurt, Freiburg and Hanover in Germany; and Wels and Vorarlberg in Austria. This forces design firms that want to bid on these projects to develop in-house expertise in meeting this standard, thereby laying the foundation for making it or something close to it the legally-required building code for all buildings in the future.

Indeed, this is exactly what is happening in Europe. Energy performance standards for buildings are guided by the European Commission's *Energy Performance in Buildings Directive* (EBPD). Based on proposals presented by the European Commission in November 2008 concerning strengthening the EPBD, an update of the EPBD was adopted by the European Parliament and the Council of the European Union on 19 May 2010 that requires that all new public buildings be "nearly zero-energy" by 31 December 2018, and that all other buildings be nearly zero-energy by 31 December 2020 (ECEEE, 2011). The interpretation of what constitutes "nearly zero-energy" is left to individual European states to determine in their implementation of the directive.[1] However, a number of countries are planning a very strict tightening of the energy provisions of their building codes over the next 10 years. For example, in Norway the total allowed on-site energy use (including miscellaneous loads) in new non-residential buildings will drop from 155 kWh/m^{2}yr at present to 40 kWh/m^{2}yr in 2022 and net zero by 2027, while for Sweden the target is that all new non-residential buildings in the southern part of the country have a maximum total on-site energy use of 50-70 kWh/m^{2}yr if not heated with electricity, and 30-40 kWh/m^{2}yr if heated with electricity (Jagemar et al., 2011). Rather than implementing progressively tighter targets over time, the plan in Sweden is for a progressively larger proportion of new buildings to achieve these targets over time, since it is already known how to achieve these targets, with an interim goal that at least 25% of new buildings achieve the 2020 targets by 2015. Effective January 2015, the Passive House standard will be the legally binding standard for all new buildings in Brussels (Daoud and Huytebroeck, 2011).

There are significant efforts underway in the US to move toward net-zero-energy buildings by 2020-2030.[2] A significant initiative is *Architecture 2030* – a growing

[1] Member states are also required to develop policies "to stimulate the transformation of buildings that are refurbished into near zero-energy buildings" (EPBD Article 9, Paragraph 2).

[2] For example, in California, the California Energy Commission (which sets building standards) and the California Public Utility Commission (which regulates utilities) are pursuing the goal that all new residential construction be net zero-energy by 2020 and all new commercial construction be net zero-energy by 2030. Section 422 of the 2007 *Energy Independence and Security Act* lead to the establishment of the *Zero-Net-Energy Commercial Buildings Initiative* with the goals of developing and disseminating

movement among architects in the US and Canada to achieve net-zero energy use for all new buildings by 2030. *Architecture 2030* chapters have been established in many cities in the US, with training programs in achieving low-energy buildings, and various regions within cities are being targeted as '2030 Districts'. In order to achieve net-zero-energy at the lowest possible cost, reductions in energy demand on the order of 60% compared to current practice must be achieved (with on-site renewable energy such as solar PV used to meet or offset the remaining energy needs). Although I do not wish to endorse or dispute the merits of a net-zero-energy use target for all buildings here (because of restrictions this target places on building height, and hence on urban density), I do strongly support the reductions in building energy requirements that go along with this target.

In Canada, Natural Resources Canada built, sold, and monitored 15 net-zero-energy houses under its *Equilibrium Housing* program. The *Canadian Passive House Institute* is actively promoting the Passive House standard and offers frequent courses on the techniques required to achieve the Passive House standard. The *Ontario Association of Architects* is collaborating with *Architecture 2030* in developing a 12-week professional development course, related to achieving deep reductions in the energy use of new buildings, that will be offered later in 2013.

Finally, the 2012 revision of the R-2000 standard reduces the allowed heating energy use by a factor of two compared to the previous version. For a 200 m^2 house in Toronto (HDD = 4000 K-day) using electricity for heating, the permitted energy use (equal to the heating load in this case) is 19.6 kWh/m^2yr – which is not much more than permitted under the Passive House standard.

Recommendations concerning the next Toronto Green Energy Standard

In light of the above, it is recommended here that:

(3) Subsequent Green Energy Standards be cast in terms of an absolute allowed energy use per unit of building floor area; and
(4) That this standard should be 70-100 kWh/m^2yr (depending on the type of building) for Tier 2, and somewhat less stringent for Tier 1.

It is recommended to cast the standard in terms of absolute energy use rather than as a percentage savings relative to some hypothetical reference building that complies with OBC 2012, because if the reference building has a poor orientation or form, its absolute energy use could still be quite high and so the absolute energy use of the more efficient

---

technologies, practices and policies with the goals that (i) any new commercial buildings in the US be net zero by 2030, 50% of the commercial building stock be net zero by 2040, and the entire commercial building stock be net zero by 2050 (see http://www.govtrack.us/congress/bills/110/hr6/text).

building might not be particularly low. Nature only cares about what we actually do, in real physical terms – not our improvement compared to some hypothetical, even worse case.

However, if City Council prefers to still cast its Toronto Green Standard in relative terms, then the standard should be:

Tier 1: 40% below 2012 OBC
Tier 2: 60% below 2012 OBC.

The 60% Tier 2 standard is roughly equivalent to the 70-100 kWh/m^{2}yr absolute standard that is preferred here, which in turn has been consistently achieved by high-performance buildings in comparable or more demanding climates than Toronto's. By comparison, SBC (2012, Table 6.3-1) is suggesting Tier 1 and Tier 2 standards of only 15% and 25%, respectively, below the 2012 OBC. If 40% for Tier 1 seems, to be too large at present, then I suggest three tiers, set at 20%, 40%, and 60% savings.

With regard to the cost of meeting these standards, my own comprehensive review of all the case studies that I could find where costs are documented (Harvey, 2013) indicates that typical extra costs for achieving factors of 2-3 lower energy use, using highly competent design teams that follow an integrated design process from the start, are a few percent of the building construction cost. This extra cost is within the "noise" level of costs related to different choices throughout the design process. More importantly, by simplifying the building design while retaining good aesthetics (what one architect referred to as "elegant simplicity") or finding ways to make more efficient use of space, thereby allowing a slightly smaller building while providing the same services, it is possible to achieve factors of 2-3 reduction in energy use (and to achieve the Passive House standard for heating) at *no* additional cost.

References

Daoud I, Huytebroeck E. 2011. Adoption of Passivhaus as the Brussels city standard in 2015, *in* UK PassivHaus Conference 2011, 24-25 October 2011. http://www.ukpassivhausconference.org.uk/2011-conference-presentations-day-one-24th-october-2011

ECEEE (European Council for an Energy Efficient Economy. 2011. *Steering through the maze #2, Nearly zero-energy buildings: Achieving the EU 2020 target.* http://www.eceee.org/buildings/MazeGuide2-NetzeroEnergyBldgs.pdf

Harvey LDD. 2013. Recent advances in sustainable buildings: review of the energy and cost performance of the state-of-the-art best practices from around the world. *Annual Review of Environment and Resources* (in press) (available from the author on request).

Jagemar L, Schmidt M, Allard F, Heiselberg P, Kurnitski J. 2011. *Towards nZEB – some examples of national requirements and roadmaps*. http://www.rehva.eu/en/375.towards-nzeb-some-examples-of-national-requirements-and-roadmaps

NRC (Natural Resources Canada). 2013. Comprehensive Energy Use Database Tables, Commercial/Institutional Sector (2013-03-19 version). Natural Resources Canada, Office of Energy Efficiency. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_com_ca.cfm

SBC (Sustainable Buildings Canada). 2012. *Development of Energy Efficiency Requirements for the Toronto Green Standard: Final Report.*

US DOE (Department of Energy). 2003. Buildings Energy Data Book, The Energy Index for Commercial Building, http://buildingsdatabook.eren.doe.gov/CBECS.aspx