Rob Blakeney, P.Eng.
Certified Passive House Designer
LEED Accredited Professional
226-820-2927
rob@LocalImpactDesign.ca

The Business Case for "Passive House"

We live in a changing world. The stressors of Climate Change are such that we must come up with a 'new normal' in order to maintain stability and progress. Even traditionally conservative sectors such as the insurance industry[1] and the World Bank[2] now recognize that 'business as usual' is no longer a path to success. This is not just a moral imperative, but also a new bottom line.

Striving to hold temperature to no more than 2 degrees Celsius - the goal set by the 2015 Paris Climate Conference (COP 21) - will require 80% reduction in building energy by 2020 and net zero by 2030[3]. Ontario's residential housing stock consumes 21% of total provincial energy, which means that striving for near-net-zero on new builds is a vital element in achieving this goal[4].

Luckily, this goal is achievable using a proven ultra-low building approach called Passive House (or *Passivhaus* as it is known in Europe). Passive House buildings that require 80 to 90 percent less energy for heating and cooling are not only possible today, but they are being built for little to no additional cost. With more than 50,000 examples worldwide, Passive House has moved from being a boutique energy standard to being the fastest growing near net-zero building standard in the world. Recently adopted by German, Belgian, Austrian and Irish governments as minimum building code, Passive House is fast becoming the new normal.

Passive homes are named "passive" because they are simpler, relying not on technical gadgetry but simple, robust, super-insulated envelope and windows. Passive House principles are quite easy to understand:

Ultra-low heating loads - In standard-built construction in our climate, the cost of space heating is typically 75% of the total energy used by a home. Reducing the space-heating demand therefore has the greatest impact on reducing a home's total energy consumption and related energy costs. The most cost-effective way to reduce heating loads is through passive techniques, including good insulation and air tightness to keep desired warmth in the house or undesirable heat out (depending on the season). With very low heating load requirements, internal heat gains from occupant body heat, appliances (especially cooking) and passive solar heat entering the building provide sufficient heat such that the traditional furnace and air conditioner is no longer required.

The economic sweet spot is at the Passive House heating maximum load of 15 kWh/m2/yr, or 10 W/m2, which represents a 90% reduction in energy for space heating compared to a standard built code-compliant home. At this ultra-low heating load, internal heat gains from occupant body heat, appliances and passive solar heat entering the building provide a

[1] Munich Re web page on climate change: http://www.munichre.com/en/group/focus/climate-change/index.html.
[2] World Bank overview on climate finance: http://www.worldbank.org/en/topic/climatefinance/overview.
[3] Architecture 2030: http://architecture2030.org/2030_challenges/2030-challenge/.
[4] 2012 Energy Report, Environmental Commissioner of Ontario. Vol 1: http://eco.on.ca/cdm12v1-building-momentum/; Vol 2: http://eco.on.ca/cdm12v2-building-momentum-results/.

significant portion of the building's heat. This means that, on the coldest day, keeping an average sized Passive House heated will required something on the order of 1,500 watts – equivalent to heating with a hair dryer!

Capturing passive solar heat - A critical element of Passive House is orientating buildings to optimize passive solar. Passive House methodology is not to be confused with "passive solar" homes made popular in the 70's & 80's. While both methods rely on free solar heat gains during the heating season, passive solar buildings have a reputation of providing poor comfort conditions, especially overheating in the summer and sometimes even in winter. Passive solar homes also required occupant participation - to open/close windows or thermal curtains, for example. Unlike these passive solar homes, "Passive House" removes the requirement for active involvement. The envelope does all the work. New window technology optimizes capture of solar radiation while also providing sufficient R-value so that net solar gain is greater than heat lost via thermal conductance. In other words, windows themselves become radiators for the room during the winter.

Let's look at the business case…

At its heart, Passive House is an exercise in economic optimization. The Passive House energy thresholds evolved from European research and experiments to optimize return on investment for improving building envelope to reduce heating loads. Taking energy savings over time into account, Passive House is the most economical way to build, with reduced energy costs more than covering the borrowing costs (repayment plus interest) for the upfront cost premium. Also, Passive House buildings are simpler, with fewer mechanical components and, therefore, less maintenance. In short - taking into account mortgage, energy and maintenance costs - Passive House represents the lowest cost of ownership.

How is that possible?

Specific energy refers to the energy per unit floor area. In metric units, this can be expressed as kilowatt hours per metre squared of floor area. As a building's energy efficiency increases, specific energy decreases. General consensus is that the capital investment required for a more energy-efficient home also increases, which makes sense because an energy efficient house requires more insulation and better windows (Fig 1).

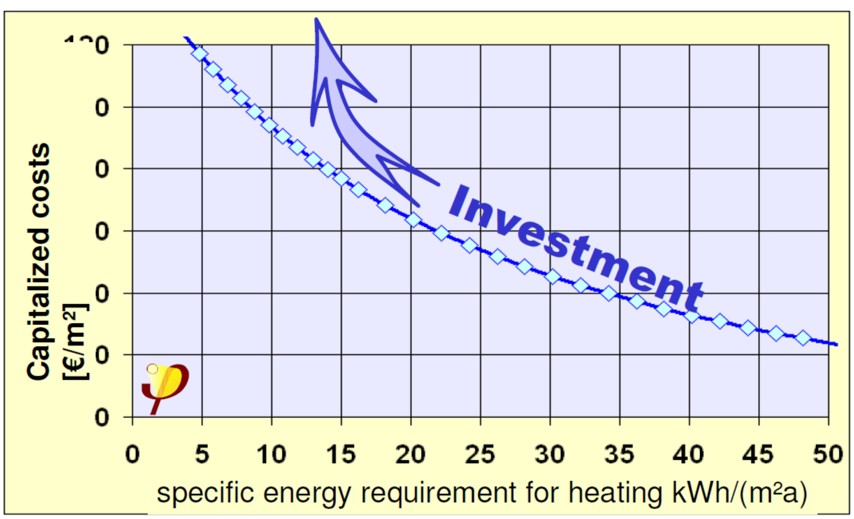

Figure 1 - Capital or first cost investment versus specific energy *(Source iPHI).*

But at the Passive House Threshold of 15 kWh/m2/year, the heating load is so low that a furnace is no longer required. Internal heat gains from occupant body heat, appliances and passive solar heat entering the building provide a significant portion of the building's heat. The remaining heat load can be met through small electric resistance heating. An air conditioner can also be eliminated. This reduces the building capital cost by between $15 and $20k (Fig. 2).

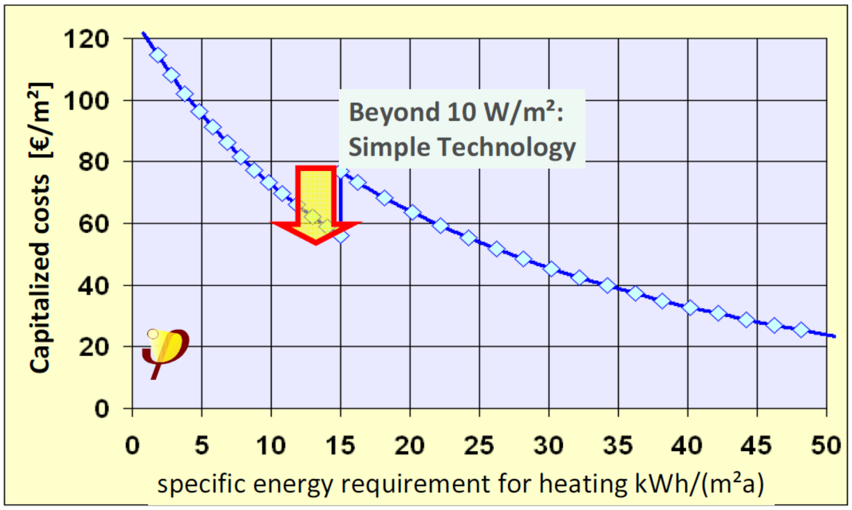

Figure 2 - At Passive House energy threshold, there is a reduction in building capital cost because furnace and air conditioner are no longer required.

Now, bringing energy use into the equation, we see that energy consumption increases as the specific energy requirement increases (green line in Fig. 3). The line represents the *capitalized* or *present value* of energy expended over the building's lifetime. This capitalized value is equivalent to the amount of money that would need to be invested today to generate enough interest to cover all future energy expenditures.

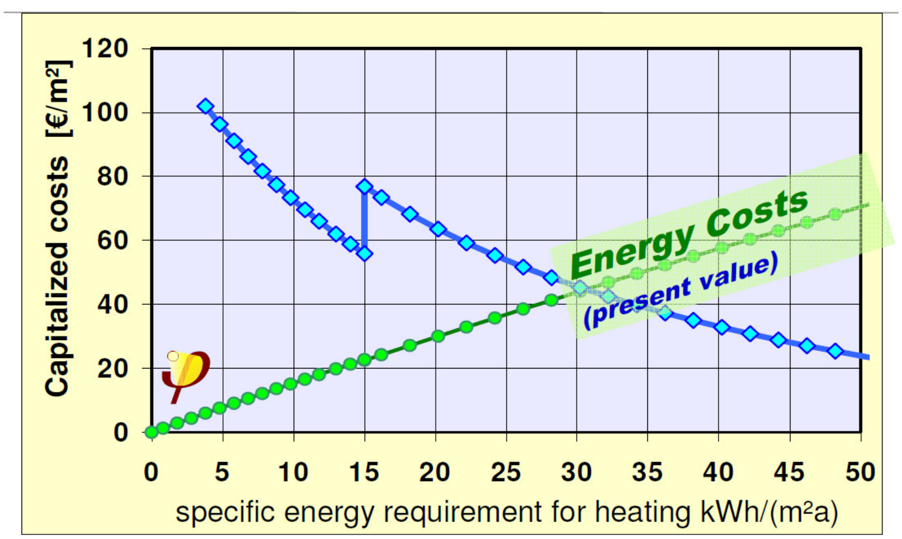

Figure 3. The green line represents the capitalized or present value of energy expended over the building's lifetime, which increases with higher specific energy (kilowatt hours per metre squared of floor area).

Combining the building's upfront capital cost with capitalized energy costs gives us the Total Cost (red line) in Figure 4. As you can see, the Passive House threshold represents the lowest capitalized cost which is the same as saying the lowest cost of ownership.

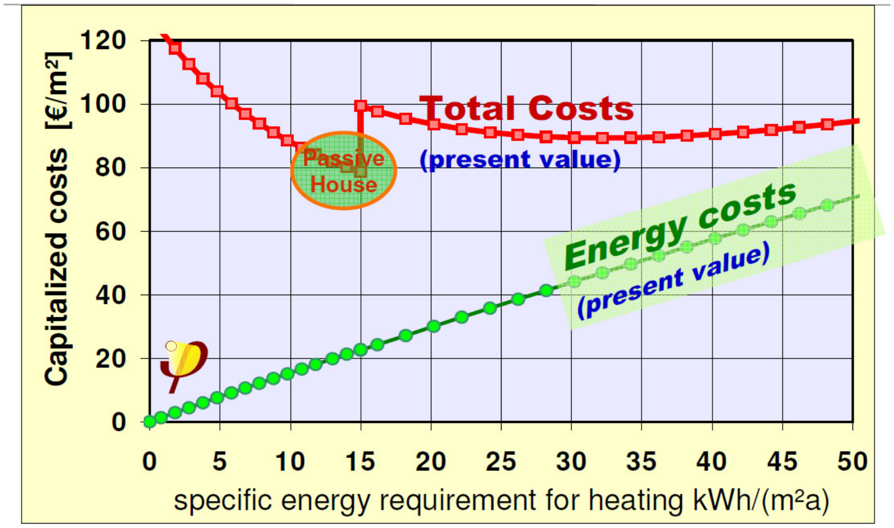

Figure 4. The lowest cost of ownership (red line) occurs at the Passive House threshold of 15 kWh/m2/year.

The following example shows how this works for a 1700 sf single family home (based on real costs).

At the ultra-low Passive House heating load, keeping a 1700 sf home at 21°C (70°F) equates to a heating load of 1,580 watts. The high-performing envelope also reduces summer cooling loads to the point where an air conditioner is not required. Using high-performance triple-glazed windows eliminate the need for perimeter heating under windows, saving on distribution piping/ducting.

The cost for a Passive House simplified heating system for a typical 1700 sf home is about $750 for a post-heater coil or baseboard heaters and thermostat. This replaces traditional heating system, which saves in the order of $15,000.

Gas furnace -	$8,000 installed including flue
Air conditioner -	$3,200 installed
Ducting -	$3,800
Total -	$15,000

This significant financial savings resulting from minimizing the heating systems is reinvested in the building shell improvements, including walls at R50, foundation at R70, roof at R80, and triple-glazed R8 windows and doors.

Here in North America, expect to pay a cost premium of 10% for these building-shell improvements for a Passive House single family home. This equates to $30,000 for a 1700 sf house costing $300k (assuming construction costs of CDN$175/sf).   Subtracting the $15k savings from the heating/cooling systems (which are no longer required), the first-cost increase for building a Passive House reduces to $15,000, or 5% of the total construction cost.   At current interest rates, this price premium works out to about $400 per year over a 10 year amortization.

Comparing a 1,700 square-feet standard-built home with a Passive House, the savings for space heating is estimated to be $1,400 per year. Net savings, taking into account heating savings and cost of borrowing, works out to about $1,000/yr. These savings begin right from day one, paying off the premium while also putting money in the homeowner's pocket. Over 30 years, energy costs savings total $170,000 (including inflation), which is over 50% of the original cost of construction.

This business case will only get better and better as we see year-on-year double digit energy cost increases plus reductions in the cost to build to Passive House standards. Near net-zero energy consumption also makes it much easier and cost-effective to achieve grid independence by adding on-site renewable energy, either now or down the road.

Here are the numbers in table form:

Operational Life Cycle Cost Analysis for a 1500 sf Passive House:

Additional Cost	**Reduced Cost**
Cost of building shell improvements **~$30k** • walls at R50 • foundation at R70 • roof at R80 • triple-glazed R8 windows and doors	Minus cost of heating and cooling systems ~**$15k**
Net premium = **$15,000**, or 6% of the total construction cost of $262,500 (CDN$175/sf).	
Interest = **$400** per year, assuming current mortgage interest rates	Savings for space heating/cooling = **$1,400/yr**
Net savings = **$1,000/yr**	
Over 30 years, energy costs savings total $170,000 (including inflation), which is over 50% of the original cost of construction.	

Other benefits of Passive House

Lifecycle benefits of envelope improvement are profitable on the basis of the energy saved alone. In addition to ultra-energy efficiency, Passive Houses are more comfortable than traditional homes. Drafts and internal temperature differentials are eliminated, and summer over-heating is minimised through insulation, orientation, and shading. 100% fresh air ventilation ensures healthy living conditions - less indoor air pollution and no mildewed walls. This provides improved comfort, and avoids indoor air quality-related health risks. Plus, Passive houses have simpler heating systems and no air conditioning, which dramatically reduces maintenance and replacement costs.

Furthermore, energy consumption is so low in the Passive House that the occupants no longer have to worry about increasing energy prices, providing security against the risk posed by fossil fuel decline and unstable international energy markets. The household's needs can even be supplied with renewable energy alone.

Passive House represents the most resilient construction standard anywhere, relying very little on mechanical systems and therefore able to maintain liveable conditions even during extended power or fuel outages. Maintenance and equipment replacement costs are diminished. Resilience also relates to durability. Passive Houses are built for many generations, not just one. We also need to place a value on future proofing our buildings. Who can be confident about uninterrupted access to power and fuel, or that the cost of energy won't skyrocket in the future? The ultra-efficiency of a Passive House locks in energy efficiency and provides insurance against future energy rate shocks.

Perhaps most important to many homeowners is the fact that future-friendly Passive Houses retain their value, and are even being sold for a higher market price.

- Consumers are starting to understand that only 'future-proofed' homes will keep their re-sale value[5].

- Builders dedicated to building green buildings report that their customers are willing to pay a premium of 6% for a green home. These same builders report that it costs then only 5% more to build green, meaning that building green results in higher profits[6].

- A US study released in June 2013 found that homes labeled as "green" (i.e., energy efficient houses) sell for a 9% premium[7].

- Plus, 70% of green builders find that green homes are easier to market[8].

Improving the Passive House Business Case Further – Pre-fabrication

One other way that the Europeans have been able to keep Passive House costs low is by using pre-fabricated wall systems that integrate insulation and air/vapour barriers within structural wall panels. Pre-fab approach is much more efficient than typical on-site framed construction, reducing construction cost by shortening project schedule and avoiding coordination delays.

Some of the most significant productivity findings from prefabrication and modularization users include the following:
- 66% report that project schedules are decreased—35% by four weeks or more.
- 65% report that project budgets are decreased—41% by 6% or more
- Off-site modular construction can save between 10 and 25 percent in building costs compared to on-site construction[9].
- 77% report that construction site waste is decreased—44% by 5% or more[10].

Additional waste reduction design and construction practices, broadly termed "Lean Project Delivery", are being introduced that will further reduce costs and lower construction footprint. Importantly, using pre-fab wall systems constructed in climate-controlled

---

5 McGraw Hill Construction SmartMarket Report. *New and Remodeled Green Homes*. http://www.wm.com/documents/pdfs-for-services-section/New%20and%20Remodeled%20Green%20Homes%20SMR%20(2012).pdf

6 ibid, p19: http://www.wm.com/documents/pdfs-for-services-section/New%20and%20Remodeled%20Green%20Homes%20SMR%20%282012%29.pdf

7 http://www.corporate-engagement.com/files/publication/KK%20Green%20Homes%20062413.pdf

8 McGraw Hill Construction SmartMarket Report. *New and Remodeled Green Homes*, p20. http://www.wm.com/documents/pdfs-for-services-section/New%20and%20Remodeled%20Green%20Homes%20SMR%20%282012%29.pdf

9 Quale, John. Sustainable Affordable Prefab. University of Virginia Press, 2012.
10 McGraw Hill Construction SmartMarket Report. *Prefabrication and Modularization*. http://www.nist.gov/el/economics/upload/Prefabrication-Modularization-in-the-Construction-Industry-SMR-2011R.pdf

environments allows for greater quality control at the factory, thus reducing the need for QA/QC at the site.

The Business Case for Green Communities

The business case improves as we move from the individual green home to green communities.

Besides reducing impact on the natural environment, clustering green homes generates additional efficiencies. Infrastructure savings of non-traditional "smart growth" development are 32 to 47 percent compared to conventional suburban development[11].

The compact nature of smart growth communities combats conventional "sprawl" land use patterns, is walkable and often mixed use, and offers a range of housing choices including affordable housing. Studies show that many consumers not only prefer these communities, they are in fact willing to pay a premium to live in them[12]. This market demand is being driven by empty nesters and singles, who are the growing demographic in North America.

Conclusion

It's clear that we need simple, affordable, low energy, healthy buildings.

A Passive House requires as little as 10 percent of the energy used by a typical building. This is not achieved through expensive technical gadgetry but rather by adopting a fabric-first approach to the design, relying on passive techniques including good insulation and air tightness to keep desired warmth in the house or undesirable heat out.

Passive House is the most economical way to build ultra-low energy buildings, with reduced energy & maintenance costs more than covering the borrowing costs (repayment plus interest) for the upfront cost premium. Passive House represents the lowest cost of ownership, which is why Passive House has been the affordable housing method of choice in Europe for two decades.

Since there are now over 50,000 Passive House examples in Europe and elsewhere, much attention has been focused in recent years on assessing the cost-effectiveness of building to this advanced standard. In Europe, Passive House is near cost parity with traditional construction methods. Here in North America, a cost premium of 6% is a reasonable estimate of what it takes to build a Passive House single family home, although this continues to quickly drop as Passive House-quality building components become more and more mainstream and therefore cheaper. Passive house-quality pre-fabricated suppliers are now claiming cost-parity with traditional stick-built housing.

The real business case for Passive House can be seen when we factor in life cycle operating costs. The evidence clearly suggests that, even at today's low Canadian heating fuel prices, a Passive House owner can enjoy lower total monthly house ownership costs from the beginning. The main reason that passive homes can "tunnel through the cost barrier" is that they are much simpler buildings, trading active, expensive, energy-sucking heating/cooling systems for cheaper, passive approaches like better envelope and windows and thermal bridge-free details.

---

[11] http://www.epa.gov/sites/production/files/2014-07/documents/mbd-epa-infrastructure.pdf).

[12] http://www.epa.gov/sites/production/files/2014-01/documents/logan.pdf

Lifecycle benefits of envelope improvement are profitable on the basis of the energy saved alone. But there are even more benefits: there are no mildewed walls, no cold draughts, and no cold feet in the Passive House. Instead, there is always fresh air and better indoor air quality in the house. Plus, Passive houses have simpler heating systems and no air conditioning, which dramatically reduces maintenance and replacement costs.

Furthermore, energy consumption is so low in the Passive House that the occupants no longer have to worry about increasing energy prices, providing security against the risk posed by fossil fuel decline and unstable international energy markets. The household needs can even be supplied with renewable energy alone.

Finally, important to many homeowners is the fact that future-friendly houses retain their value, and are even being sold for a higher market price.

Passive House is the fastest growing near-zero energy performance standard in the world and it's here to stay.

local impact design

Rob Blakeney, P.Eng.
Certified Passive House Designer
LEED Accredited Professional
226-820-2927
rob@LocalImpactDesign.ca

For more information, see the following Passive House organization websites:

- •Passive House summary - http://localimpactdesign.ca/home/passive-house/
- •The Passive House encyclopedia - passipedia.org
- •Passive Buildings Canada - passivebuildings.ca
- •Canadian Passive House Institute (CANPHI) - passivehouse.ca
- •Passive House Institute US (PHIUS) - http://www.phius.org/home-page

Cost estimates and weblinks current as of April, 2016.
For more information, see my websites:
www.LocalImpactDesign.ca & http://Leap.House