BUILD BETTER. BUILD FASTER.

BUILD SMART™

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Panelized Passive House Multifamily

a whitepaper

At Build SMART Good enough isn't.

Any builder that has culled through a stack of 2x4's – separating those that are **"good enough"** for plates, studs or kings, from those to be cut up for jacks and cripples - often finds themselves staring at a sizable reject pile (15-20%) **relegated to ground stakes or firewood**.

Multifamily projects produce an additional $70/mo per unit revenue! When that is considered in the context of the prefab savings, shortened construction time, reduced HVAC capital expense, and window replacement savings, the cash flow increase is 60% (*assuming a $200 per unit base line*).

In addition, the overall cost of the building is **reduced by 4.8%** compared to stick-building merely to meet code. Build SMART in particular has calculated **it costs 19% less to use our panels than to stick-build the same assembly** – and that is before you consider the above-referenced overall project savings from accelerated construction.

OVER 50% REVENUE INCREASE

And the end result?

The benefits of using better materials include:

- Faster dry-in and completion
- **Better air sealing** improves energy efficiency and durability
- Flat walls produce **better interior finishes**
- A **faster build time** reduces site management and finance costs
- A **shorter punch** list gets you on to your next project quicker
- **Early occupancy** + improved performance = happy customers.
- **Happy customers** mean fewer headaches AND more referrals.

How higher **first cost** translates into lower **total cost**

Better materials→ Faster off-site buid→ Tighter tolerances→

Faster site assembly→ Better air sealing→ Better interior finishes→

Reduced maintenance→ Higher performance→ Lower risk

→Happier Occupants

A few links to get you started with higher performing Multifamily Prefabrication:

- **Not In My Back Yard:** New study shows NIMBYism is the biggest multifamily construction barrier
- **The Noise Suppression Effects of PH Airtightness:** A large Passive House apartment building adjacent to 4 tracks that yield eighty-seven trains per day! The noise is so bad, the architect has to stop under-construction tours until the trains pass. Nevertheless, their noise study shows the occupants will not be impacted.
- **Cut construction times in half & shave up to 20% from construction costs:** Breakthroughs in modular and prefabrication techniques can now cut construction times in half and shave up to 20 percent from construction costs, according to research from the Terner Center for Housing Innovation." National Conference of State Housing Agencies.
- **There are Two Pots of Money to consider when assessing prefabrication:** (1) constructed assembly savings and (2) savings from overall schedule acceleration.
- **How a Pennsylvania affordable housing agency is making ultra-efficient buildings mainstream:** Build SMART panels were used for four of the Affordable Housing projects that are the foundation of this article plus two Market Rate buildings.

The positive impact on occupants may also be relevant to the building owner. For example, to minimize COVID-19 issues, the Centers for Disease Control is recommending 100% fresh air ventilation if it can be achieved – as it always is in Passive House design and construction.

- **Designer Air:** Abundant, Fresh,Virtually Allergen-Free
- **Designer Clean:** Infiltration Dust Free
- **Designer Comfort:** Draft-free, Uniform Temperature
- **Designer Health:** No water leaks, condensation, or mold
- **Designer Quiet:** Never hear barking dogs or Nuisance noise
- **Designer Resiliency:** Maintain 55 degrees without electricity or gas
- **Designer Savings:** The most energy efficient homes in the world!

PHIUS

Passive House Institute US

PHIUS.org

BETTER COST CONTROL

Careful attention to the quality of incoming materials, coupled with relentless Quality Control at every step of Build SMART's fabrication process contribute to a higher level of precision than possible with traditional site-built, stick frame construction.

Abstract

Panelized multifamily whole-building air tightness case study.
Passive House certified wall panels with factory-installed Passive House certified windows have been causing houses and apartment buildings constructed with them to surpass Passive House air tightness requirements on the very first blower-door test with no leak chasing. For one of these buildings in particular, a single blower door unit with a single fan was used to pressurize and test an apartment building of 52,781sqft in a single whole-building test.

The architect-contractor design-build developers of the system attribute the air tightness performance to the fluid-applied detailing materials that are used to line the rough opening and secure the window to the lined rough opening as well as to the fluid-applied material used to seal the panels at the floor, the top, and to each other. No tapes or self-adhered membranes are used.

The Passive House energy performance on the Affordable Housing project resulted in a **$300,000 increase in mortgage funding and a $300,000 increase in developer fees** – the non-profit developer says this allows them to build more Affordable Housing. Financial projections hypothesizing the same structure built for the unsubsidized market to code-only standards and for comparison to Passive House show private-sector developers can increase their cash flow (income after debt service which includes the added cost of Passive House construction) significantly by building to Passive House and paying tenant utilities. The payback period is less than a third than for blue-chip stocks and occurs without stock-market risk. If the speed of panelized construction is accounted for along with avoiding the customary 20-year window replacement because of the high quality of Passive House windows, **the payback goes to 4.92 years.**

The As-Built Project

The Whitehall is a 49-unit three-story apartment building in Spring City, PA near Philadelphia
At the 2017 New Gravity Housing Conference of the Philadelphia area US Green Building Council (Delaware Valley), the Whitehall project developer, architect, Passive House consultant and the external wall-panel vendor gave a presentation called "The Whitehall" which disclosed the **"Final Drywall Blower Door Test" result of 0.42ACH50.**

This result is well below the Passive House Institute maximum allowable of 0.6ACH50 (Air Changes Per Hour at 50 Pascals of pressure). The building was tested at shell completion, post-MEP penetrations, and final. In all three instances a single blower-door unit with a single fan was used to test the entire building at once, and in each instance, the result was lower than the maximum allowed for Passive House. **There was no leak-chasing to achieve any of the results.**

View Whitehall

Scan Me

- **49 units**
- **4.8% construction cost decrease**
- **$73,356 annual cash flow increase ($1,500/unit)**

PANELIZED WALL ASSEMBLY DESIGN

The exterior walls were provided by prefabricated 2x6” Passive House certified stud-wall panels featuring:

- 3.5” Expanded Polystyrene (EPS) rigid foam insulation laminated to the OSB
- Oriented Strand Board (OSB) sheathing (within-panel seams, panel-to-panel connections, and panel-to-floor / panel-to-top plate connections sealed with Silyl-Terminated Polymer (STP) joint and seam filler
- OSB (with OSB manufacturer-laminated water-resistive barrier) laminated to outer face of the EPS
- Rough openings lined with fluid-applied STP flashing and Passive House certified windows factory installed and air-tightened using STP sealant

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

WHITEHALL

Developer Satisfaction

At the environmental conference in Philadelphia (Delaware Valley Green Building Council 2017 New Gravity Housing Conference), the Whitehall non-profit developer provided slides relating toincreased net income and fees on their project stating:

- "Passive House Makes us Money!!"
- "Higher net fees mean we can house more people"[Increase from $1,000,000 to $1,300,000]
- "Passive House lets you borrow/leverage more money to build more housing" [Increase from $800,000 to $1,100,000]

Energy Modeling

The Kansas City modeling showed that the HVAC kilowatt hours (kWh) for the code case to be 617,760 kWh with the Passive House case at 41,098 kWh.

Passive House energy modeling and consulting for the project was performed by Certified Passive House Consultant Tim McDonald RA, CPHC, LEED AP. The Excel file containing the Passive House Planning Package modeling was provided to Paul Grahovac (co-author of this paper) who in turn provided it to Certified Passive House Consultant Skylar Swinford, energy and enclosure consultant at Energy Systems Consultants, who modeled The Whitehall project as if it were built to Passive House performance standards in Kansas City, and, alternatively, built merely to code standards there. Mr. Swinford estimated the code air changes per hour at 7.0ACH50 based on his field experience.

Passive House panelized construction cost

The company providing the exterior wall panels for Whitehall estimated that the additional cost of Passive House construction versus stick-building to code at approximately $292,297 which includes these costs:

- Wall panels and windows
- Energy heel truss
- Exterior insulation panels for energy heel truss
- Slab and footing insulation
- Additional attic insulation
- OSB ceiling lid for long-term durable ceiling air barrier performance. This was estimated to be an approximately 3.76% increase in overall construction costs.

Calculations

The wall-panel company interviewed three high-energy performance multifamily real estate developers who said they paid or planned to pay their tenants' utilities. One of them indicated they determined their rental charge by adding the market value of the space to an amount the tenant would pay for utilities if they lived in energy-inefficient premises rather than the energy-efficient structure.

The calculations below compare the net income of hypothetical owner A (who stick-builds to code and does not pay tenant utilities) to hypothetical owner B who builds to Passive House, pays tenant utilities, and determines their rental charge by adding the market value of the space to an amount the tenant would pay for utilities if they lived in energy-inefficient premises rather than the energy-efficient structure.

FASTER PROJECT COMPLETION

One trip around your building perimeter completes assembly of your Build SMART Building Envelope System. This replaces 10 or more trips - by different crews scheduled at different times - for conventional, site-built construction.

A Revenue Comparison of Passive House vs. Code Construction for a Kansas City Market-Rate Multifamily Project (table 1):

- **Code-compliant building cost:** $7,783,196
- **Passive House building cost:** $8,075,493
- **Cost difference (investment):** $292,297
- **Percent cost increase:** 3.76%

49-unit apartment building Annual Revenue	Building to Code	Building to Passive House & pays tenant power bill	HVAC Electricity use common areas	HVAC Electricity use living units	Tenant Rent	Tenant Total Cost	Owner Net Revenue	Passive House Net Revenue Increase
Apartment Building **Owner A**	X		113,250kWH $12,344	299,685kWh $32,666	$588,000	$620,666	$575,656	$0.00
Apartment Building **Owner B**		X	9,513kWh $1,037	25,225kWh $2,750	$620,666	$620,666	$616,879	$41,223

Senior Living Case *(same as multifamilly)*	Building to Code	Building to Passive House & pays tenant power bill	HVAC Electricity use common areas	HVAC Electricity use living units	Tenant Rent	Tenant Total Cost	Owner Net Revenue	Passive House Net Revenue Increase
Apartment Building **Owner A**	X		113,250kWH $12,344	299,685kWh $32,666	$620,666	$620,666	$575,656	$0.00
Apartment Building **Owner B**		X	9,513kWh $1,037	25,225kWh $2,750	$620,666	$620,666	$616,879	$41,223

*Assumes all-electric Heating, Ventilation, & Air Conditioning (HVAC). KWh cost is KCK average $0.109/kWh. Total conditioned area: **41,259sqft.***

49-unit apartment building: Passive House Annual Net Cash Flow (table 2):

- [1]Operable windows in bedrooms retained.
- [2]Owner captures in contract negotiations or bidding process.
- Fixed windows lower maintenance costs and reduce falling risks.
- [3]State affordable housing manuals and most experts maintain windows should be replaced every 20 years. Passive House certified windows are of exceptional quality, have a 20-year warranty, and are expected to last the life of the building.

Case→	**Base case.** See previous chart	HVAC capital expense savings **$120,000**	Fixed windows[1] **$34,250**	Construction loan interest decrease **$42,400**	Contractor overhead[2] **$161,510**	Rents start sooner **$102,814**	20 year window replacement avoided[3] **$456,500** Present Value: **$208,340**
Net annual cash flow	$27,190	$32,951	$34,596	$36,631	$44,385	$49,321	$59,323
Years to Payback	10.75	8.80	8.44	7.97	6.59	5.92	4.92

*Moving from left to right, each case assumes **the previous case is adopted.***

Table 2 Background Information

Table 2 shows the increased income after consideration of the additional revenue from energy savings and the additional cost of the mortgage payment attributable to the additional cost of the Passive House energy efficient construction. The "Net annual cash flow" attributable to Passive House construction and energy savings was calculated using an Excel spreadsheet created by a bank multifamily housing lending manager. Various construction cost savings amounts are used to reduce the construction cost in the calculation.

Final financial conclusions:

1. $100 per month per unit cash flow increase during 5-year payback

2. $120 per month per unit cash flow increase after 5-year payback

3. $73,356 total **annual cash flow increase** after 5-year payback

4. Panelized Passive House **reduces building cost by $377,017 compared to code (4.8% decrease)**

5. If the overall building construction cost reduction rather than the cash flow increase is used to offset the Passive House upgrade cost, **the payback is completed when the construction is completed.** The portion solely due to accelerated construction is sufficient for this purpose. The reduced HVAC capital expense and the present value of **avoiding the 20-year window replacement cycle further reduce project cost.**

HVAC first-cost savings

"Some developers even report a negative cost premium for passive building since the high-performance enclosure allows for the reduction in mechanical system size and equipment, thereby reducing both first costs and operational expenses for the life of the building."[5] For this 49-unit case study example, the first-cost savings have been estimated at 30% after accounting both for the reduction in heating and cooling equipment cost and the addition of energy recovery ventilation cost. Our thanks for this go to Barry Dicker of Decent Energy, Inc.

Speed matters

Bruce Anderson, the owner of Insulated Concrete Form company Polycrete USA, who is also an accountant, wrote a guest editorial entitled "Speed Matters" in a leading ICF publication. Anderson, Bruce, "Speed Matters," ICF Builder Magazine, November/December 2016.[6] In that piece, Anderson explains that accelerated construction reduces construction loan interest, brings in rent sooner, reduces overhead, and increases profits.

Applying that to the Whitehall case study, we assume a projected ten-month construction schedule based on conventional stick-building rather than use of prefabricated panels.w

Based on the reduction in field wall assembly construction hours, we have calculated a two-month reduction in the construction schedule from ten months to eight months. The National Association of Home Builders reports prefabrication acceleration of 2.5 homes to 1 which proportion supports a two-month reduction in a ten-month schedule.[7]

Further support on accelerated construction comes from the National Conference of State Housing Agencies: "Breakthroughs in modular and prefabrication techniques can now cut construction times in half and shave up to 20 percent from development costs, according to research from the Terner Center for Housing Innovation."[8]

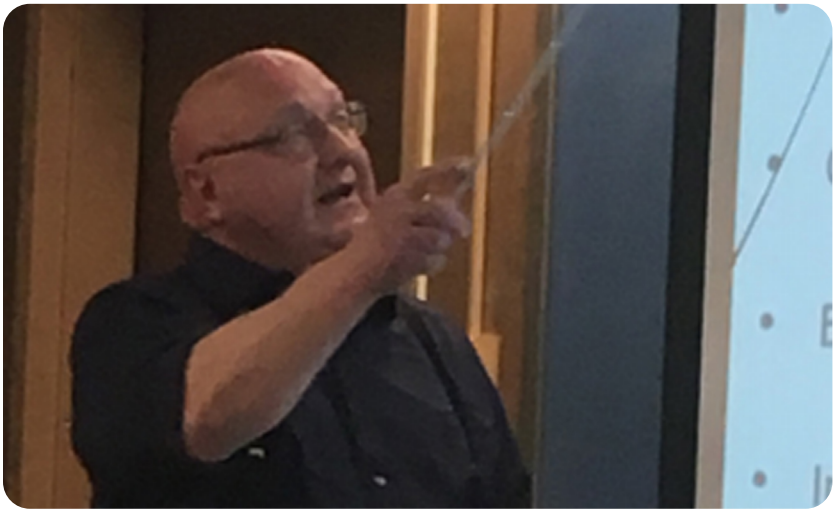
The two-month reduction does not take into account the time saved by avoiding weather delays and reduced waste management. In the report cited above, the National Association of Home Builders calculates that prefabrication results in 30 times less waste.
The faster comparative speed of wall assembly erection after the foundation is prepared and which is discussed above is only one of two elements of construction acceleration provided by panelization. The other is the concurrent construction of the wall assembly while the site is prepared and the foundation constructed. Normally, construction of the wall assembly cannot begin until the foundation is laid. So, not only do the walls go up quicker after the foundation work, but also the time necessary for mobilizations and transitions relating to field construction of the wall assembly layers and the window installations is saved. This time savings is not quantified in this paper.

SMART RISK MANAGEMENT

In traditional site-built stick frame construction, scheduling conflicts, weather delays, weather damage, material waste, and cost overruns are common-place.

Speed -- construction loan

The interest on the construction loan of $8,075,493 is calculated to be $212,000. With a ten-month duration, the monthly interest is $21,200. Ten months is reduced to eight months, so project cost is reduced by $42,400.



Speed -- sooner rents

The estimated annual revenue after paying HVAC utilities is $616,879 which yields a monthly revenue of $51,407. The project cost is accordingly reduced by the amount of two months' rent which is $102,814.

Steve Bliss is the Founding Editor of BuildingAdvisor.com, and he was Editorial Director of The Journal of Light Construction for 16 years. In a BuildingAdvisor.com article, he addressed contractor accounting. Bliss, Steve, "Pricing the Job: Mark-up, Overhead & Profit," BuildingAdvisor.com. Bliss explained that "10 and 10" for 10% overhead and 10% profit is sometimes referenced in the industry and has been borne out by a National Association of Home Builders study.[9]

Speed – reduced overhead

Starting with $8,075,493 in contractor revenue, a 10% overhead of $807,549 is calculated. Dividing this by 10 months yields a monthly overhead of $80,755. Two months overhead saved is $161,510, so the project cost is reduced by that amount. (We depart from the financial concepts provided by the Anderson and Bliss articles here by not including a project cost reduction of $161,510 corresponding to profit that would be a windfall to the contractor, so that we present a worst-case scenario where the owner is not able to negotiate the profit away from the contractor.)

Window replacement avoidance

The original formulations of the fluid-applied window rough opening flashing, joint and seam filler, and window installation sealant used in the panel prefabrication and installation were developed by Tatley-Grund Building Repair Specialists, Inc. of Seattle, Washington. Company President Stacey Grund has evaluated the Passive House Certified windows used in the wall panels and opined that because of their high quality, buildings using them will be able to save $456,500 by avoiding the customary 20-year window replacement that is also typically referenced in the architectural manuals of State Affordable Housing agencies. After present-value adjustment, the project cost is reduced by $208,159.

Tenant Amenities

Passive House tenants enjoy a 50% reduction in urban noise exposure[10], and their living space is continuously infused with abundant, fresh, virtually allergen-free air.[11]

Conclusion

Cost-effective panelized Passive House building shell construction has been demonstrated along with operational profitability.

"We align very well with the innovative mindset and high levels of quality control exhibited by the team at Build SMART"

- Aaron Wingert, LP Building Solutions

SMART PROBLEM SOLVING

Achieving substantial completion on your high-performing build - only to fail your blower door test- can add days or weeks of leak-chasing to total build time.

Footnotes

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References

1. 2017 New Gravity Housing Conference of the Philadelphia area US Green Building Council (Delaware Valley), presentation "The Whitehall."

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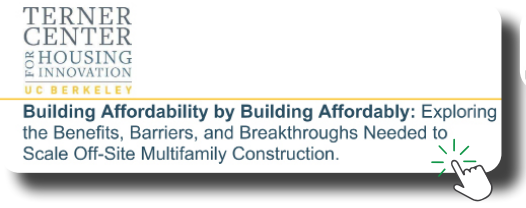
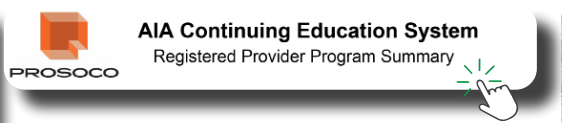
More Links





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