



Taylorville High School Pretty Good House Project

Report 1 - Economic Justification for Building Net Zero Homes

Taylorville High School Building Trades program constructs affordable homes for their community. Equally important to their construction of high quality, energy efficient homes are education and training of students who are the future of Taylorville's home construction industry.

Taylorville HS students are stepping up to the challenge to build a net zero home for their 2023-2024 project. The goal is a home that collects as much solar energy over the course of a year as needed to power the house and provide EV transportation. Build Equinox of Urbana, Illinois is working with [Matt Blomquist](#), project leader and teacher in the THS Building Trades program, to create an energy efficient, healthy home design that economically beats conventionally constructed homes. We're excited to work and learn from Matt over this next year!

The THS project will be a 1600sqft "[Pretty Good House](#)" design by [Mottram Architecture](#). Pretty Good Houses, or PGHs, are homes that are designed to be cost and energy efficient. The 2023-2024 THS home will feature CERV2 smart ventilation, by Build Equinox of Urbana Illinois, for maintaining a healthy indoor environment. Health cost benefits are even greater than energy savings by reducing sick days, increasing cognitive performance, and improving sleep.



1 SOUTH ELEVATION
SCALE: 1/4" = 1'-0"



2 WEST ELEVATION
SCALE: 1/8" = 1'-0"



3 NORTH ELEVATION
SCALE: 1/8" = 1'-0"

NO. 1 & NO. 3 FINISHED BATHROOM WINDOWS



4 EAST ELEVATION
SCALE: 1/8" = 1'-0"

Students in the Taylorville High School Building Trades program will construct this single story, 1600ft² “Pretty Good House” designed by Mottram Architecture. The home will be an economical, healthy, net zero, high performance home.

Contractors Loose, Tight and Smart

This is the story of three contractors: Contractor Loose, Contractor Tight and Contractor Smart. Contractor Loose has built homes for decades, and pays no attention to sealing the house, uses minimal insulation, and installs poorer quality windows. Contractor Tight puts in extra effort to seal and insulate, but has not improved “mechanicals” (heating, ventilating and air conditioning or “HVAC” equipment) or paid attention to indoor air quality (IAQ). Contractor Smart builds highly sealed, optimally insulated homes with today’s high performance mechanicals.

The three contractors build the same Mottram Architecture PGH home. From the outside, all three homes look identical. As we inspect homes built by the three contractors, we have many questions to answer related to insulation thickness, windows, heat pumps, comfort, indoor air quality, energy usage, window performance, dehumidification, humidification, water heating, ventilation, lighting, and many more design details that impact home performance. Three questions stand out as the most important ones to answer up front:

- 1) What are the cost differences of the Loose, Tight and Smart homes?
- 2) What are the lifetime cost differences of the homes?
- 3) How much are monthly costs for each home?

Homes that are not economical nor affordable will not survive in the market. Contractor Loose builds the cheapest home, while Contractor Smart builds the most expensive home. Contractor Smart's homes are the most economical, however, saving thousands of dollars over the house lifetime in comparison to Contractor Loose and Contractor Tight homes. In addition, Contractor Smart homes cost homeowners less per month than Contractor Loose and Contractor Tight, making it the most affordable. But how can the most expensive home be the most economical and most affordable home?

Descriptions of Contractor Loose, Contractor Tight, and Contractor Smart Homes

Our three contractors all build quality homes that last for 100 years. As home builders, the impact of choices made today extend far into the future. Multiple generations of people will live in these homes, spending two-thirds of their time in the house. Home occupant health and well-being are highly dependent on the indoor air quality maintained in the home.

The homes our contractors build look identical from the outside. They are in the same neighborhood, and to potential buyers, nothing appears visually different. As in many things in life, looks can be deceiving.

The homes have 3 bedrooms with 1600ft² of living space and are modestly windowed with 72ft² south windows, 20ft² north windows, 16ft² east windows and 12ft² of west windows. Three occupants live in each home.

Additional construction details for the three homes are listed below:

- 1) "Contractor Loose" construction
 - a. Typical of construction past house construction practices
 - i. R9 walls (2x4 studs with sheathing board, fiberglass insulation)
 - ii. R20 ceiling (6" loose fill insulation)
 - iii. No foundation insulation
 - iv. Storm windows
 - v. 6ACH50 sealing with no active ventilation
 - vi. Electric resistance heat and SEER 10 AC
 - vii. Electric resistance water heat (either tank or tankless "instantaneous")
- 2) "Contractor Tight" construction
 - a. Typical of today's conventional house construction practices
 - i. R20 walls (2x6 on 24" spacing with 1" foam sheathing board)
 - ii. R36 ceiling (12" loose fill insulation)
 - iii. No foundation insulation
 - iv. Double glazed thermal pane windows
 - v. 3ACH50 sealing with ASHRAE 62.2 exhaust ventilation (75cfm)
 - vi. Electric resistance heat and SEER 14 AC

- vii. Electric resistance water heat (either tank or tankless “Instantaneous”)
- 3) 3) “Contractor Smart” construction
 - a. PGH, LEED, PHIUS, PHI, Vermod, or similar high performance homes
 - i. R30 walls
 - ii. R60 ceiling
 - iii. R20-30 foundation wall & footer insulation
 - iv. Double or triple pane, “low e”, gas filled windows
 - v. 1ACH50 sealing with CERV2 smart ventilation
 - vi. Cold temperature air source heat pumps with 10 HSPF and 20 SEER
 - vii. Heat pump water heater (aka “hybrid” water heater)
 - viii. Solar PV array for net zero operation

We start by comparing our three contractors on the basis of house cost, lifetime house cost, and monthly cost. There are many details hidden in the background that impact Contractor Loose, Tight and Smart homes that we will cover in later reports. At this point, we want to understand economic characteristics of the homes.

Build Equinox [ZEROs \(Zero Energy Residence Optimization software\)](#) simulation model conveniently incorporates energy, indoor air quality, economic, and financial analyses into an easy-to-use, free-to-use online simulation package. ZEROs is validated with field test data and comparison to US DOE “Bestest” results. Bestest is a benchmark comparison of prediction results with nationally recognized building simulation programs.

Table 1 shows that Contractor Loose’s house cost less to build than both Contractor Tight and Contractor Smart. Adding a solar PV array to Contractor Smart’s home makes it even more expensive. How can Contractor Smart possibly compete with Contractor Loose’s much cheaper home?

Table 2 shows 100 year lifetime energy cost for the homes. Contractors Loose and Tight homes’ lifetime energy cost add up to more than the initial cost to build those homes. Lifetime energy cost for Contractor Smart’s home is much less than the cost to build the home. Note that lifetime house cost includes the cost to replace components such as windows (30 years), HVAC units (25 years), and solar panels (25 years) at regular intervals over house lifetime.

All homes are assumed to be electric. Contractor Loose and Tight can reduce some of their lifetime energy cost by using natural gas for home heating, however, natural gas is not more economical than Contractor Smart’s all-electric homes. We will examine natural gas powered homes when we look at mechanical systems in more detail.

Table 3 shows affordability, the total monthly cost of each home. All homes are assumed to have a 30 year mortgage with 5% interest with homeowners making a \$20,000 down payment. Even though Contractor Smart’s net zero, solar powered home has almost \$200/month greater

mortgage than Contractor Loose’s home, Contractor Smart home’s utility bill is much lower, resulting in total monthly payments that are \$80 less per month for a Smart home with solar.

We note other differences between Contractor Loose’s home and Contractor Smart’s solar home. The larger mortgage payment for Contractor Smart’s solar home has a tax benefit for mortgage interest that is not included in the analyses. Contractor Loose’s higher utility bills are paid with more valuable “after tax” dollars. Homeowners living in Contractor Smart’s homes will not have large fluctuations in monthly bills in comparison to Contractor Loose and Contractor Tight homes. Contractor Smart’s homes are “insulated” from utility bill escalation, unlike Loose and Tight homes that will feel future increases in utility rates.

Table 1 Initial House Cost:

Contractor	House Cost \$
Loose	155,400
Tight	162,400
Smart	182,500
SmartSolar	190,800

Table 2 100 year Lifetime House and Energy Cost:

Contractor	Lifetime House \$	Lifetime Energy \$	Lifetime Cost \$
Loose	180,900	404,500	585,400
Tight	191,400	342,800	534,200
Smart	256,400	126,200	382,600
SmartSolar	289,400	24,000	313,400

Table 3 Monthly Mortgage, Utility, Insurance, and Real Estate Tax Expenses

Contractor	Mortgage \$	Utility \$	Insur \$	R E Tax \$	Total \$/mo
Loose	727	337	39	194	1297
Tight	764	286	41	203	1293
Smart	872	105	46	228	1251
SmartSolar	917	20	50	228	1215