

Engineering Economy

Buying a House



Collin Heist

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Project Information & Introduction

The basic outline of this project was to identify and calculate the cost of buying a home. Because the quantitative costs of purchasing a home are vastly different depending on the person purchasing it, as well as the home itself, I have made sure to outline (in detail) the procedure by which I calculated my individual costs for this theoretical home purchase.

The House

The house I chose for this project is my grandparents' old house. I chose this house in particular because I have a lot of fond memories growing up there, and I noticed when I was researching houses to purchase that it was for sale. I also chose it not just for sentimental reasons, but because I think it is a very nice house (albeit too large for a single family, in most circumstances).

It is a five bedroom, six bathroom home located on 5,216 square feet at 11050 W. Edgehill Dr., Boise ID. The house was built in the late 80's, which although not *modern* by housing standards, is still new-enough that maintenance should be minimal for the first few years of theoretical ownership. The listing currently says that all the usual appliances are included, and there is a functional elevator inside as well. From my research, there does not seem to be an HOA for the neighborhood, which will reduce the costs of owning and purchasing the home.

The current listing says the house is available for \$637,537.

Additional Costs

Of course, there are additional costs that affect the amount of money required to purchase any house by a (sometimes) considerable amount. The primary 'costs' I'll be considering are the down payment, private mortgage insurance, the closing costs, property taxes, and homeowners insurance.

For down payments, there are actually *a lot* of options. This is money that I'd be required to give to the bank in order to obtain the loan to buy the house. This means that it actually reduces the amount of the loan by however much I pay, which is good, but of course that means I have to have that money available immediately. In real life, it is *generally* good to put down over the minimum amount, as that drastically reduces the amount you pay over the mortgage term, but that of course depends on what you can do with that money in that time. According to bankrate.com¹, a conventional mortgage will require a minimum of five percent down. But, there are many options available that are both lower, or higher.

For purposes of this project, I'll be putting **fifteen percent** down, to make the calculations and amortization more complex and interesting. But it is worth considering that this down-payment amount is directly related to whether or not you are required to pay private mortgage insurance.

That leads quite nicely into private mortgage insurance. Which, despite the somewhat misleading name, is not actually insurance for *me* on my mortgage or anything. Instead, it is insurance for the lenders themselves (in this case, the bank) to protect them in case I stop making payments. The amount you need to pay in private mortgage insurance (PMI) differs with each person, as well as how long it is required to be paid. The reason this is intermixed with down payment, as mentioned earlier, is because once about twenty percent of the home's value has been paid off, this cost goes away². For this project, I will be using **\$35 per month per \$100,000 borrowed**,

¹ <https://www.bankrate.com/mortgages/how-much-is-a-down-payment-on-a-house/>

² <https://www.zillow.com/mortgage-learning/private-mortgage-insurance/>

and ignoring the fact that once the house is twenty percent paid off, the PMI goes away for sake of simplifying the calculations, and because this is not always the case.

The term 'closing costs' is actually an all encompassing term for (sometimes) dozens of things. This can include: an application fee, appraisal, courier fee, credit report, escrow insurance, home inspection, pest inspection, property tax, recording fees, survey fees, title search fee, as well as others.

As a general rule, I found that between two and five percent of the home's value is paid in closing costs³. And I will specifically be using **3.5%** in my calculations. This can change not just depending on the state of purchase, but also the bank, personal preference, and sometimes the seller can be asked to pay these costs (at least partially).

Property taxes are included in your mortgage payments, and thus are one more cost that adds to the amount of money required on the primary mortgage. The actual property tax rates vary not just between states, but also between counties. Using an online calculator, I found that for Ada County (where the house is), **the average rate is .801%**, which I'll be using in my calculations⁴. This is not a cost, like normal taxes, that you are required to pay out of pocket come April. The property taxes required are included in the original loan amount, so depending on the term of the loan, that will increase how much is added on for property taxes over that period of time.

The final cost I am accounting for is the homeowner's insurance. This is an insurance that actually protects me, the borrower. It is a fairly simple insurance that protects the home, the property, and any liability in case people get hurt on my property⁵.

Luckily for me, Idaho has the second-lowest homeowners insurance in the nation, at **\$49 a month**, which is very small compared to Florida's \$171⁶. This additional cost is simply added to my monthly costs, along with PMI.

³ <https://www.zillow.com/mortgage-learning/closing-costs/>

⁴ <https://smartasset.com/taxes/idaho-property-tax-calculator#GENEuR9mJJ>

⁵ <https://www.zillow.com/mortgage-learning/homeowners-insurance/>

⁶ <https://www.valuepenguin.com/average-cost-of-homeowners-insurance>

All in all, a lot of these additional costs don't contribute *much* relative to the original loan value. But, in particular property tax on the longer-term loans does add a sizeable amount to the amount. This effect is mitigated by shorter-term loan periods (like 10 and 15).

The Complete Loan

The overall loan value I'll need to purchase this house varies, of course, by the mortgage length, but for the more 'traditional' 15 and 30 year mortgages, I'd need \$621,894.45 and \$688,600.36 respectively. I'll also have additional monthly payments of \$258.88 for both of these mortgages, to account for various insurances.

I've included the first and last few months of payment for both of these payment schemes in figure 1 and figure 2:

15-year Mortgage Amortization

<i>Month</i>	<i>Interest Paid</i>	<i>Principal Paid</i>	<i>Remaining Balance (15 Year)</i>
<i>0</i>			\$621,894.45
<i>1</i>	\$2,267.32	\$2,450.50	\$619,443.95
<i>2</i>	\$2,258.39	\$2,459.43	\$616,984.52
<i>3</i>	\$2,249.42	\$2,468.40	\$614,516.12
<i>...</i>	<i>...</i>	<i>...</i>	<i>...</i>
<i>177</i>	\$68.18	\$4,649.64	\$14,050.34
<i>178</i>	\$51.23	\$4,666.59	\$9,383.75
<i>179</i>	\$34.21	\$4,683.61	\$4,700.14
<i>180</i>	\$17.14	\$4,700.68	\$0.00

Figure 1. First and last rows of the 15-year mortgage amortization

30-year Mortgage Amortization

<i>Month</i>	<i>Interest Paid</i>	<i>Principal Paid</i>	<i>Remaining Balance (15 Year)</i>
<i>0</i>			\$688,600.36
<i>1</i>	\$2,510.52	\$927.56	\$687,672.80
<i>2</i>	\$2,507.14	\$930.94	\$686,741.86

3	\$2,503.75	\$934.33	\$685,807.53
...
357	\$49.69	\$3,388.39	\$10,239.62
358	\$37.33	\$3,400.75	\$6,838.87
359	\$24.93	\$3,413.15	\$3,425.72
360	\$12.49	\$3,425.59	\$0.13

Figure 2. First and last rows of the 30-year mortgage amortization

What I find most interesting about this kind of payment analysis is how ‘rounding up’ in payments can drastically reduce the overall amount paid over the period of the mortgage. To highlight this effect, I created a secondary amortization table of the same 15 and 30-year fixed term mortgages, except I compared the payout schemes of both with situations in which I rounded up my payments to the nearest \$500 mark. Below, in figure 3, is a visualization of the results:

Comparison of ‘Normal’ Mortgage Payments and Overpayments

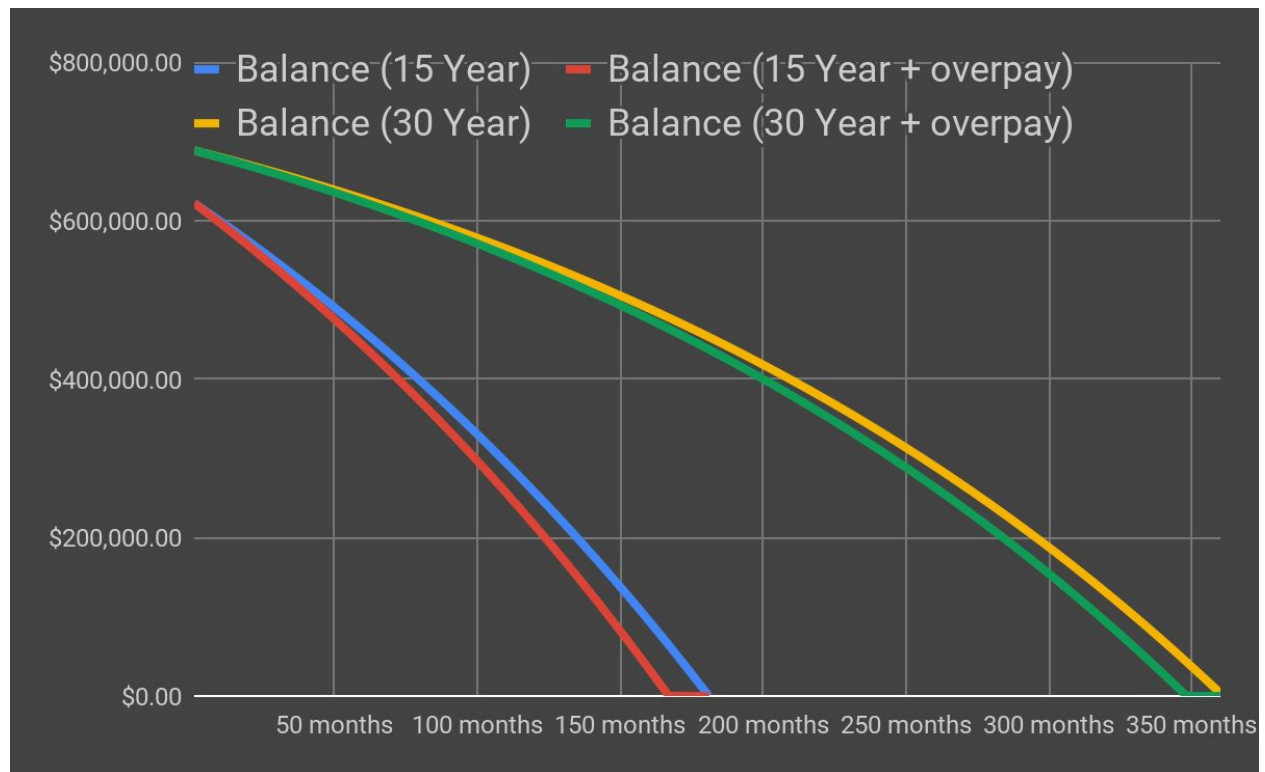


Figure 3. Loan balances remaining over time for 15 and 30-year mortgages

In both of these cases, as you'd expect, overpaying resulted in the remaining balance on the mortgage going to zero *before* the contracted end-date. For \$280 and \$60 'overpayments' each month, the two mortgages finished 12 months and 10 months ahead of schedule (for the 15 and 30-year mortgages respectively). In addition to this, this reduced the amount of lifetime interest paid on the loan, saving \$14,000 and \$20,000 over the repayment period of each mortgage. Part of the reason for different starting positions of the two mortgages is because the longer mortgage has to account for more (twice as much, in this case) property tax, thus increasing the value of the original loan.

Conclusion

The most obvious conclusion I draw from this project is how many auxiliary costs there are to consider when purchasing a home. I had obviously heard of homeowners insurance, and closing costs, but I wasn't entirely aware of their depths, and I was completely oblivious of mortgage insurance and the *real* cost of property tax.

As I expected, making overpayments on the mortgage really leaves a meaningful change on the lifetime expenditure of a house. My overpayments were quite conservative, with less than 500 dollars a month being added, but a more drastic inverse-gradient style overpayment scheme (with notably larger payments at the beginning of the term that reduce over time) could significantly reduce the amount of lifetime interest paid.

The final conclusion I drew from this project is that Idaho is actually quite a nice place to own a home. With both property tax and homeowners insurance being drastically cheaper than the national average.