TECHNICAL REPORT:

a house without corners

NEW PROJECT B:
AVID’s Detached Lowset in Hervey Bay (QLD)

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INTRODUCTION

resilience: the capacity to withstand or recover quickly

In looking at this project, we took a view that this should be about how to deal with a house when, not if, it flooded. While we have originally tried to raise the floor level above the flood zone through landscaping and the use of a waffle pod, multiple storeys or even stilts. We determined that this is a very expensive way to deal with flooding, and it tends to give a false impression that the house will not end up inundated.

We decided to keep lower to the ground (like the existing house provided) and accept the flood, employing wetproofing measures. This meant that we started looking at ways that we could attempt to get occupants back into the house sooner, rather than flood avoidance.

Not employing stilts or additional levels has enabled us to create a house which is more accessible, with a better connection between indoor and outdoors and potentially with a reduced cost premium (relative to stilt or two storey homes)

Our final proposal became a bit of a “swiss cheese” approach where we hope that layers of avoidance, mitigation and finally flood acceptance work together to prevent a hole through all the layers.

PEOPLE FIRST

Simple, fast and accessible storm preparation
Careful consideration of resident / user needs are always critical, but in the case of a resilient home it becomes even more important to understand how the home operates in multiple modes. An early driver throughout the project has been consideration of users needs in a home which is susceptible to both cyclone and flood.

Some traditional approaches to flood resilience, (such as taking everything upstairs, having removeable kitchen cabinetry etc) may not be viable if you are not as physically able, or (if there is an incoming cyclone) short on time. There are dedicated pre-flood removalists in the area which assist people moving furniture upstairs and off site, this demonstrates simplicity, accessibility and speed are critical in being able to adapt to a flood situation (particularly if it is preceded by a cyclone)

ABOUT US
As sisters with different professions, we often engage in lively debates, with our backgrounds in architecture and engineering. Despite 20+ combined years in the industry (in engineering, architecture & urban design) this marks our first collaborative project, and we had a blast brainstorming innovative, sometimes far-fetched ideas, such as reverse swimming pool bunkers. While we were unable to fully flesh out all of our concepts, we hope that the judges appreciate our project as a promising starting point for exploring better uses of timber during floods and cyclones. Admittedly, there are sound reasons why traditional methods persist, and we acknowledge that solving global issues will require more than just our two minds.

Please note that we do not have QS and Sustainability expertise and as such all of the content relating to those items is speculative only and would be subject to further consideration and development.

All figures are indicative only and subject to further development.

This design is currently concept only and will be subject to change with further development, including coordination with consultants and client team.

CONCEPTUAL FRAMEWORK

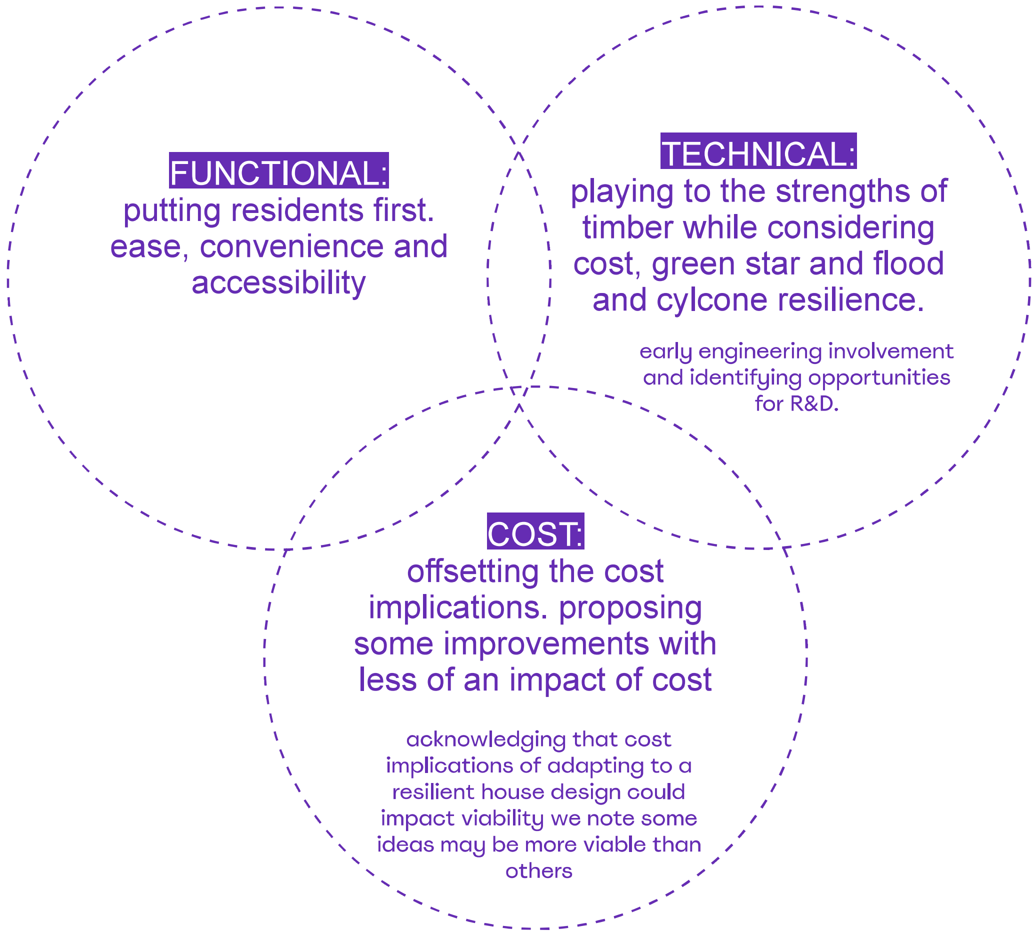
DESIGN PRINCIPLES

We started this project with lots of ideas (and not enough time). The development of core design principles became important to order and filter which ideas were valuable and important to pursue.

Aside from the resilient, functional, technical and cost related changes we have made to the provided existing house plan we have made a few planning changes to improve amenity, including;

1. Creating thresholds of privacy: making a clear distinction between public and entertaining and the front of the house to the private (bedrooms) at the back of the house.
2. increasing access to northern light and improving the relationship between the living areas and the alfresco area.
3. simplifying the roof structure for easier construction, detailing and improved aesthetic outcome.

On the follow pages we highlight some of the key initiatives we are proposing for each principle



UNDERLYING DESIGN PRINCIPLES

FUNCTIONAL:
putting residents first. ease, convenience and accessibility

KEY FUNCTIONAL MOVES

marking the flood line

While flood acceptance has to come with some acceptance that current flood levels may change in the future we believe as part of flood acceptance design we should create the requirement to try and keep as much as possible above the flood level.

This can however result in a somewhat unbalanced-looking interior. We propose that all rooms in the house have some visual flood level indicators to help balance the light switches and power points and give a base level to try to lift any possessions and soft furniture above.

The aim is that everything left below the line by the time a flood arrives should be resilient

(Also see leveraging the visual marker on the key technical moves page)

We estimate this to be a very low cost initiative.

easy lifting

If we want to raise objects above the flood level we then also have to create a means of doing so. We are suggesting that all rooms have a minimum of 4 anchors at ceiling located approximately at the corner locations of a designed bed. This would allow for the corners of the bed to be pulled up with ease well above flood level employing a pulley system.
While we cannot design the trusses we have estimates that If we use a 1.5 kPa live load, and assume half of this is furniture and bits and pieces the load per a hook would be 0.75 kPa, so for our largest room, we would be looking at 3.5m x 3m x 0.75 kPa over 4 hooks = 2 kN per a hook. This should be well within the possibilities for a roof truss designed for cyclonic loads.

While the roof trusses may need to be upgraded to suit we are hoping that our simple roof shape will allow for these anchors without seriously increasing the costs of the trusses.

We estimate this to be a medium cost initiative.

a house without corners *

Anyone who has swept a floor can understand the driver behind this one, corners are not only hard to sweep out they have a tendency to collect rubbish, we have rounded these out to ensure the post flood clean up is as easy as possible. We are also hoping the addition of rounded corners would assist in reducing stress concentrations if flowing water is encountered. These corners are to be made of Screw Laminated Timber to make them extra strong.

The curves also provide an improved amenity, smoother circulation though the house and a more special feeling space.

While this is slightly out of the norm for a “project home” meaning that initially the cost will be quite high in training and new detailing requirements, we hope that with time the cost will be reduced.

We estimate this to be a high cost initiative, however this is balanced by it's functional benefits and improved atmosphere and user experience . It also plays to the strength of timber as a material.

Openable windows and doors (that are flush with the floor) are placed to open up corners where ever possible to further enable easy removal of water post flood.

This also provides the additional amenity including good light, connection to outdoors and cross ventilation from the every room, and helps the rooms function for other purposes. To help mitigate the cost of these extra windows we have used a consistent suite of the same windows and glass doors. (also see other considerations page for more info on windows)

While there appears to be more windows in the proposed, the total elevational area of windows and doors on the provided existing house design was ~39sqm and the proposed is ~38sqm.
However the windows proposed have more openable components so will likely come with a cost premium.

*ALMOST

KEY TECHNICAL MOVES

TECHNICAL: playing to the strengths of timber while considering cost, green star and flood and cylcone resilience.

innovative timber solutions

A mix of Nail Laminated Timber (NLT) and Screw Laminated Timber (SLT) is proposed for not only the cyclone shelter (last resort only) but also the perimeter of the building to reduce the effects of wind-borne debris on the structure.
While we have been unable to find direct evidence of the performance of NLT under the projectile impact, work done in the US using CLT for defence work, including blast testing, suggests that it may be possible. Our NLT will unusually be made of hardwood rather than softwoods which we hope will increase its impact resistance.

This is an unusual suggestion and so we can see a few issues that would need further research before it could truly be suggested.

1. Which Hardwood would be the best for this application.
2. Does Hardwood NLT actually withstand the projectile required for cyclones?
3. Would the NLT dry out as well as it does in traditional framing, and will the nails still be acceptable? Can we design the NLT to make the nail sacrificial.
4. Typically cyclones are in high termite risk areas. Would a combination of hardwood and treatment be sufficient to prevent issues with termites?
5. How hard is it to manufacture NLT and whats sizes would work for prefabrication.
6. What is the actual cost implication? while we acknowledge this may be an expensive solution, We may be able to make other savings, ie may not need insulation on external envelope, may not need internal lining (or if appropriately tested and detailed (ie coatings, expansion joints) even external linings)

We estimate this will have an yet to be determined impact on cost, however if r&d is successful, we will be improving cyclone resistance, massively improving green star outcomes (volume of timber), and aesthetic outcomes

a 'resilient' slab

One of the less explored consequences of floods is the effect after saturation of the underlying soil. The change in the moisture of soil leads to movement of the foundation which if it exceeds the design limits would lead to cracking of the superstructure.
By using a “super deep” waffle to help us get to the flood height we are also increasing the stiffness of our footing design meaning that the adverse moisture conditions encountered after the flood are far more likely to be an issue for our house. (Important because we don’t intend on replacing any linings as part of our move back into the house.)

1. Suggested research into the suction profiles of post flood homes to suggest to industry an increase in suction that should be used for designs in flood probe areas. (I know this isn’t timber)
2. We've proposed a total slab depth of 600mm = 385mm waffle slab plus 215 extra pod depth. This enables us with some landscaping falls away from house to ensure we can always achieve the Australian Standard max 570mm level change at a doorway without a required full landing (max 3 x 190mm risers). Our visible floodline internally and externally is at 900mm above FFL for a total of 1500mm above ground. This provides a 500mm buffer for wave movement.

This will have a cost effect however sticking with conventional methods and therefore trades means it should be close to the cost of materials only. It is very hard to gauge without knowing the soil conditions.
Pending QS assessment the impact of this increased slab and other critical suggestions may still be less than raising the entire house on cyclone resistant stilts or two storeys

leveraging of the visual marker

The visual marker becomes a clear definition point not just for eventual users, but for consultants, designers, builders and contractors. It alerts you instantly when an item may be at risk.

As a bare minimum all electrical items will be above the line.
Some of these items may include:

- power points, light switches will be wall mounted above the line
- The oven, microwave and a drawer dishwasher can be installed within full height cabinetry. We've allowed a tolerance and with investigation it may be possible to drop these items 300mm (so the bottom is at 600mm above FFL, which would be 200mm above assumed flood, this tolerance is where the cooktop will be installed.)
- Washing machine and dryer can be installed above the line with a cavity with removeable washing baskets below - have allowed a longer bench for side by side washer and dry
- all external services, switchboard and comms / NBN

Visual marker makes a clear line where we require resilient finishes and where we don't. Below the line we may have;

- less cabinetry, or stainless steel or marine ply cabinetry and benchtop (kitchen). quick release drawers that can be removed with contents.
- resilient wall linings, finishes etc. IE marine ply, FC, hardwood
- hardwood framing (potentially exposed where appropriate)
- polished concrete floors or tiles
- any built in furniture to be hardwood or marine ply
- rigid or closed cell insulation

With value management we could investigate further reductions above the line. For example, regular plasterboard if a gap to prevent wicking is provided, more affordable insulation (if required) rather than rigid as is below the line. This approach creates a clear boundary

The increased specification of finishes below the line will have a cost implication over a non resilient home, however the visual flood line marker enables us to identify where could reduce specification in a seamless manner. It also saves money in the long run in lost items and replacements.

COST:
offsetting the cost implications. proposing some improvements with less of an impact of cost

KEY COST OFFSETS

reduced building area

Sadly you can't have everything in life, one of the biggest ways we have attempted to offset the additional costs our initiatives have added to the cost of the structure is through reducing the footprint of the structure itself.

The home we have designed is a smaller building while still providing a cyclone shelter. We have elected not to build a garage and use a off the shelf cyclone resistant carport instead.

Basically providing a smaller, higher specification more resilient building

Statistics across Australia show an oversupply of bedrooms relative to the number of people in a household, we have removed the multi purpose room, however multiple of the bedrooms are designed so they could function in many ways - ie office, home theatre, library etc. The brief calls for a 3 bed house, however the existing house is 4 bed so we have provided a 4 bed home.

We have reduced Gross Floor Area (GFA) from 205sqm to a proposed GFA of 155sqm. (including Unenclosed Covered Area)

Reduced length of external facade from ~67m to ~50m

flood & cyclone costs

The biggest potential saving or offset is simply that in the case of a flood or cyclone the house and contents is more likely to survive.

The costs associated with repair and housing people after a flood are not insignificant, if we predict that the house is going to flood over its life then even if a few of our initiatives are successful we should be well on our way to recovering these initial costs.

The incorporated resilient housing strategies may qualify homeowners for a substantial reduction in insurance rates. Suncorp have marketed up to a 40% reduction, and Queensland Reconstruction Authority highlights this is possible to be negotiated on a case by case basis.

As far as resilient construction goes, while more expensive than the provided example house, this single story proposal may (pending QS advice) still be more affordable than a resilient house on cyclone resistant stilts or a two story home

ongoing costs

Although implementing changes may incur additional costs at first, we are confident that the long-term expenses for both the homeowner and the builder will decrease over time.

For homeowners, additional to potential insurance savings, we plan to utilize solar passive principles to achieve optimal energy efficiency and potentially lower the homeowners' bills. Some of this is already evident in our plans, including orientating the windows of key spaces to the north, and excellent cross ventilation opportunities with the placement of openable windows on the corners (for flood clean up).

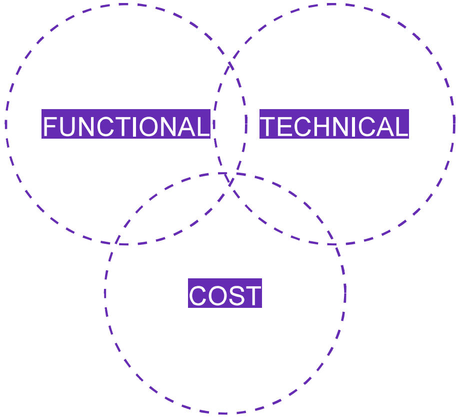
It can be challenging to measure the savings on continuous costs for builders. Labor expenses make up a substantial portion of their costs, and every time a new method is introduced, there is an added labor cost. However, we anticipate that as the team becomes more experienced with these techniques, the labor premium for the first few homes built will decrease.

THE CHALLENGE

The reality is that most of these savings are mostly for the homeowner and may not sufficiently mitigate increased construction costs to deliver resilience.

While we've taken a holistic view we would like to acknowledge the unfair challenge builders and developers face in being left to solve societal issues, and in this case environmental issues too.

Buyer education and investment is critical to improve outcomes. Even if that means buyers may need to downsize or make other compromises to be able to afford a resilient home.



OTHER CONSIDERATIONS

outside the box

We believe the connection of context, and connection to nature and the outdoors is critical in good design and as a result we have looked at this design beyond the confines of the building have started to look at some of the resilient features we can employ outside of the building

- landscaping with a gentle slope away from the building
- The introduction of swales at the site boundaries (with a wire mesh to hold down stones in cyclone)
- permeable fencing to prevent water buildup
- permeable paving under cars and carport in particular, increases the water penetration of the site across the board. On the same size lot we have a far larger area of permeable surfaces (landscape, gravel, grass etc than previously)
- Concrete slab alfresco is replaced with a hardwood timber deck or similar, which terraces down to ground with open treads for water flow
- lots of low shrubby landscaping, with cyclone appropriate trees (TBD) in the front garden

We have assumed a lot size (400sqm) which the existing house could have fitted on with high level reference to local setbacks, however this size could vary, and with a preliminary assessment of the area would be considered small for Hervey Bay

With further design development we will have a better understanding of these costs, however they are discrete items which can selected individual as is feasible.

to shutter or not to shutter

A cyclone resilient house should have shutters over all the windows. We would like to propose that we investigate options to create double "glazed" polycarbonate windows (within standard or reinforced frames, using clear polycarbonate sheets) as an alternative to shutters. **This is another opportunity for R&D, and all notes below are subject to further investigation.**

1. Cyclone resistance: Polycarb is up to 250x stronger than glass. It is common practice to bolt polycarbonate to the outside of windows as a temporary cyclone shutter. This removes user error - shutters don't have to be closed. and removes the cost of additional shutters.
2. Sustainability: Polycarbonate is recyclable. And per sheet has a marginally lower u value than glass* (lower is better in terms of green star). theoretically this means it should perform slightly better than glass. It is also possible to apply low e coating to polycarb. Less building material is also a more sustainable approach
3. Aesthetics. It may be possible to offer subtly (or bold) coloured polycarb, below the flood line. This could be at the buyers discretion - and would be a way to elevate the glazing into appearing bespoke and like lead light.
4. Lighter and more sturdy = easier installation

Glass as a raw material is usually more expensive than polycarbonate, so this may be a cost saving. Impact on cost would be dependent on R&D, frame requirements, suppliers. R&D could occur in collaboration with a local polycarb and window supplier.

**U-Values from PALSUN (W/m2. ∘K)*
3mm Glass 5.81   Poly 5.47
5mm Glass 5.72   Poly 5.19
6mm Glass 5.68   Poly 5.07

how to house

Sadly this is the missing piece in many attempts to create better housing designs, homeowners are rarely properly educated as to the risks of the structures they inhabit. They are also rarely educated on the limitations created by these risks.

We suggest that the builder run through with the owner all the bits and pieces added to this house to ensure it is as serviceable as reasonably practicable after a flood or cyclone. And also that a QR code be provided in the meter box to a “house manual” that cover these items but also many other that sadly get neglected, eg how to use an energy-efficient house and how avoid footing issues through maintenance and landscaping.

cyclone resistant materials

We need to do further testing of the applied elements and materials to the exterior of our building for cyclone resistance, including roof sheeting and cladding.

Solar panels and hot water systems while proposed need to be researched, and confirmed with suppliers.

SUSTAINABILITY

at it's heart resilience is about future proofing the home - which is innately sustainable.

Sustainability is more than carbon offsetting however in this section we are focusing on the carbon emission aspect. It's worth noting that the provision of a resilient design means less wastage, and additional building over the lifetime of the home, not just in the initial construction.

Regrettably, no one on our team possesses expertise in green star. Nonetheless, we have conducted some basic assessments looking at the affect of the changes we made from normal construction. We have ONLY assessed items which are a variation from the benchmark

Should this project develop we would recommend the engagement of a specialized sustainability consultant.

We would note that all the information provided with regard to green star and sustainability is speculative only, and provided as a high level comparison. All figures are indicative and subject to change with future research and design development.

We would also note that, despite looking closely at the upfront carbon emission calculator guide, at the time of completion the calculator referred to within was not available on the green star website (where the other calculators are found).

CARBON EMISSIONS: SUBSTRUCTURE

The extra height of the footings will add extra concrete to the structure, obviously, we don't have a site classification so we don't know exactly what sort of footings would be required but based on experience many footings across Australia are 385 deep waffle with some to full piles support.

Our structure has a extra 300 height void former (stacked), while it is very hard to find data on the void formers themselves there have been some numbers given for extra reinforced concrete. (we are assuming that the rest of the footings would be the same as our reference so only dealing with the extra depth)

The Gross Floor Area (GFA) of our building is: approx. 155sqm (existing house is approx 205sqm)

The total volume of the extra 300 deep beams (Assuming 110 width which may change based on classification) would be:

Beams long direction: 9 beams x 16.5 m long x 0.11 wide and 0.3 m high = 4.9005 m3

Beams short direction: 15 beams x 9.5 m long x 0.11 wide and 0.3 m high = 4.7025 m3

Total extra depth: 9.603 m3

Using Hansens "green concrete" we get a GWP of 221 kg CO2 eq per a m3.

This gives us a total extra GWP of 221 x 9.603 = 2,122 kg CO2 eq for the deeper floor

Therefore **in comparison to the reference project our proposal increases CO2e/m2 GFA by 13.7 kg in the substructure*** However the benchmark does not allow for flood resilience.

*Assuming minimal additional reinforcing proposed

CARBON EMISSIONS: SUPERSTRUCTURE

We have estimated the key areas of variation from the benchmark house with regards to the superstructure to be the following:

INTERNAL WALLS

While manually calculating a reference wall frame is probably a bit too hard at this stage our internal walls are maybe slightly easier to deal will:
Assuming a 90 x 45 hardwood top plate and bottom plate with studs at 600 crs and a wall height of 2.4m.

Per a meter = 2 x 0.09wide x 0.045 high x 1m for top and bottom plate and 0.09 x 0.045 x 2.4 x 1/0.6 = 0.081 plus 0.0162 = 0.0243 m3 per a m
~35m meters of internal wall:
35 x 0.0243 = 0.85m3 of internal wall hardwood

Using Wood solutions EPD for hardwood gives us a GWP of -731 kg CO2 eq per a m3 for dressed kiln-dried hardwood

(0.85m3 x -731kg CO2) / 155 GFA = -4
Therefore the internal wall framing provides a carbon emissions reduction of -4 CO2e/m2 GFA

Internal wall lining is yet to be confirmed (but will be flood resistant, ie marine plywood, FC, or even potential to be open to hardwood framing in select locations to allow easy drainage) This may also vary from benchmark project and potentially be a positive impact if timber is used.

ROOF STRUCTURE:

We are proposing a traditional timber trussed roof for our house (in alignment with the existing building). As a result we have not calculated how it would affect our carbon footprint.

However the upfront carbon emissions benchmark project utilises have a cold formed steel roof, which would have an increased carbon emissions (where timber would further offset carbon emissions)

NAIL LAMINATED TIMBER WALLS (Hard wood)

Proposed for the cyclone shelter and structure of internal walls (this is subject to research & development)

based on .09m planks x height (2.4) x length of walls (~55) we assume a volume of 11.88m

Using Woodsolutions EPD for hardwood gives us a GWP of -888 kg CO2 eq per a m3 for rough sawn kiln-dried hardwood

(11.8m3 x -888kg CO2) / 155 GFA = -67
Therefore the internal wall framing provides a carbon emissions reduction of -67 CO2e/m2 GFA

OVERVIEW:

These two major sub structure items (internal and external wall structure) which we have measured already give us **-71 CO2e/m2 GFA** which is a substantial improvement, and should offset the increase of **13.7 CO2e/m2 GFA** in the sub structure.

While we have not worked out the volume of steel in the benchmark project, the benchmark of steel frame will increase carbon emissions, unlike the timber which has decreased it, further increasing the gap between the benchmark and proposed.

Even if the extent of NLT is reduced, the use of timber in comparison to steel in will yield an reduced carbon emission impact.

COST & BUILDABILITY

resilience may have a short term cost premium, but over time intelligent design now, will pay.

Without a doubt, implementing this proposal will come at a premium cost compared to the current house design. However, the existing house is not built to withstand severe weather conditions such as cyclones and floods, which could result in even greater costs (in every sense of the word) if a non-resilient home is built.

Unfortunately, we are unable to complete a calculated example of cost-offsetting as we do not have the expertise, and the project is still a concept and not sufficiently developed. While our team lacks experience in cost estimation, we do possess a level of understanding regarding where various options stand in relation to one another. Instead of conducting an explicit cost comparison, we opted for a more philosophical approach. This decision is also influenced by the fact that the design incorporates a few unique suggestions that would require research to determine their feasibility and cost.

We have made efforts to offset costs by reducing the size of the house and simplifying its shape. Additionally, we plan to use an off-the-shelf carport instead of a built-in garage, meet requirements for insurance discounts, and create ongoing cost reductions through energy efficiency measures.

LOCAL KNOWLEDGE & R&D

It is important to note that the ideas presented in our proposal have not been tested and require further research and development. Due to this, we have not been able to provide a comprehensive cost estimate. Please note our fee excludes R&D costs, as the extent of work and scope required cannot yet be established.

We understand that labor, material access, skill levels, and individual builder preferences vary locally, as do buyer demands in different markets across the country. As a result, we are open to modifications to our design and would be pleased to collaborate with local architects, draftsmen, builders, and consultants. We would be willing to negotiate our provided architecture fee with a scope reduction.

Please note the fee / contract provided has a few comments and clarifications on it in the absence of a fee letter