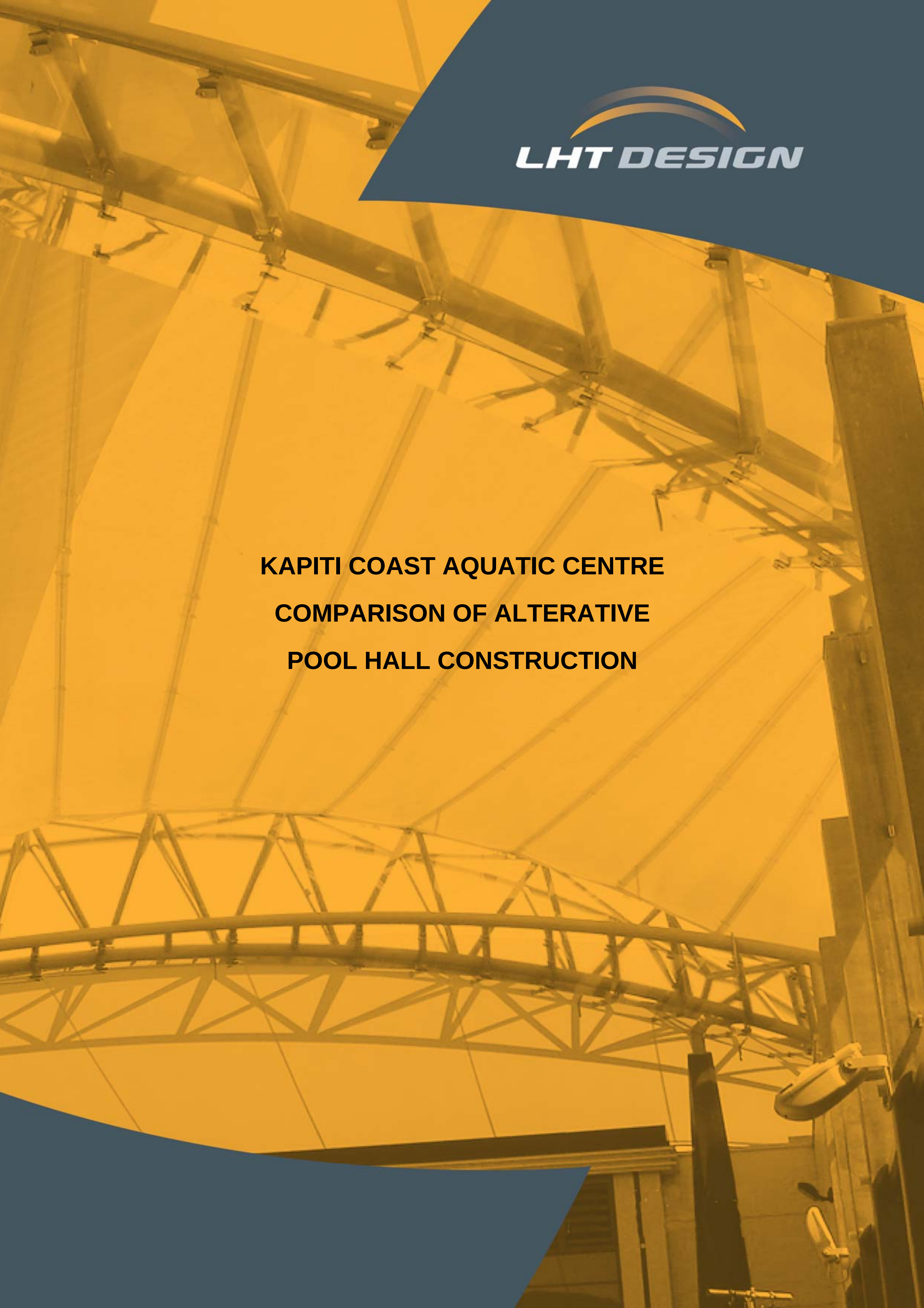
LHT DESIGN



# KAPITI COAST AQUATIC CENTRE
# COMPARISON OF ALTERATIVE
# POOL HALL CONSTRUCTION

# CONTENTS

# 1 EXECUTIVE SUMMARY

## 1.1 PURPOSE

As part of the development of the concept design there are two different types of construction that are seen by the design team as being valid for the construction of the major portion of the Aquatic Centre – the pool hall. These are:

- "Conventional". This option is based on a timber portal frame structure for the pool hall with the insulation and vapour barrier envelope being provided by prefabricated insulated panels with external and internal painted metal skins. The technology is similar to that used on coolstores and freezers and is typical of modern aquatic centres in New Zealand.
- "Foil". This option is based on the use of a timber grid shell forming a curved dome over the pools clad with triple skinned ETFE foil. This technology has been widely used overseas for decades, including for many swimming pools, and over recent years has been used for a number of iconic buildings in NZ.

This report considers the advantages and disadvantages of the two forms of construction so that a decision can be made as to which type should be used.

Once that decision is made the developed design phase for the whole project can be completed for the chosen option.

## 1.2 ARCHITECTURAL ASPECTS

The floor plan is common to both options. The 2 options are very different in form and internal environment.

### 1.2.1 Conventional

The inspiration for the building form has come from the soft but prominent forms of the existing sand dunes on the site. Conceptually the simple monopitch form also references the silhouette of Kapiti Island, visible from the upper hydroslide platform. The building heights generally denote the various functions within the building, and the resulting forms reflect the dunes and Kapiti Island in an abstract rather than literal way. A double height space is provided over the Entry/Café to allow high level windows to admit morning light into the space.

### 1.2.2 Foil

The design approach for this option is dictated by the strong curved form of the grid-shell and ETFE roof. This automatically echoes the soft forms of the existing sand dunes on the site. To contrast this dominant form, the associated building forms are 'simple boxes' so as not to compete visually with the main form.

Transparency of the roof and optimised form helps reduce the perceived mass of the building and allow the users to have a unique connection to their surroundings.

## 1.3 POOL HALL ENVELOPE

The options have very different structural forms and construction.

The conventional building has large timber portal frames and secondary framing, an external insulation and vapour barrier envelope provided by prefabricated insulated panels, an internal acoustic ceiling and a high level of artificial lighting. Because of the structural form, proximity of the building to a fault line and the type of sub-soils the seismic design has to be based on a very high lateral forces.

The foil clad building consists of a timber grid shell and triple-layer ETFE foil cushions which provide both the insulation and vapour barrier envelope and a large amount of natural light and some solar gain. Because this is a much lighter construction and no internal ceiling is required it is much lighter and therefore the seismic loading is much reduced. It will also be much quicker to construct which is likely to reduce some attendance costs that have not been quantified in this report.

ETFE has been used in many similar buildings and is robust and not particularly vulnerable to vandalism if it is carefully designed. It is practical and not too difficult to repair any such damage.

The embodied energy inherent in the foil roof construction is less than a third of that of the conventional roof. The difference is equivalent to the annual energy use of approximately 77 houses. It is also equivalent to approximately 250 tonnes of CO2 or the emissions from 50 cars over one year.

Both types of construction are appropriate for a building with a minimum life of 50 years and are durable and of low cost to maintain.

## 1.4 DAYLIGHT CONTROL

The foil option can be designed to reduce UV to a very small fraction and control radiant heat to provide good internal comfort within the normal parameters that require swimming pool halls to be operated at high temperatures and humidities to minimise energy use.

Unlike the conventional option it will provide a significant level of energy via solar gain, and although there will be a loss during night conditions there is a large overall energy gain.

A major advantage of the foil option is that during daylight hours the facility effectively becomes an outdoor pool with all the relevant advantages but without the normal disadvantages of uncontrolled air temperature and wind effects. The natural light is likely to be very popular with patrons for whom it eliminates the feeling of being trapped inside on a sunny day.

## 1.5 ENERGY COMPARISON

The foil option is calculated to need approximately 2,085GJ less energy per year. After making allowance for all consequential energy effects there is a calculated annual saving of $20,000 estimated for the foil option over the conventional. This difference will inevitably increase with time as energy tariffs increase.

Once a further allowance is made for the energy savings inherent in the reduced lighting required by the foil option the total annual savings are estimated to be approximately $30,000 using current tariffs.

These annual energy savings also relate to a saving of the equivalent annual energy use of approximately 58 houses or the annual emissions from 23 cars.

## 1.6 CAPITAL COST DIFFERENCE

The difference in capital costs for the 2 options (after ignoring all components of the project that are common to both options) is estimated by Rawlinsons as follows:

| | |
|---|---|
| Conventional Pool Hall | $2,960,282 |
| Foil Pool Hall | $3,259,086 |

The premium for the foil option is thus estimated to be $298,804.

It should be noted that because the foil and grid shell construction has only been used in NZ over the last few years (although it has more than 30 years history in Europe and the Middle East) a higher contingency allowance is included in these figures. An estimating contingency of 7.5% has been used to get the estimate for the conventional building whereas 10% has been used for the foil case. If this was brought back to 7.5% as well the difference between the two would reduce to $217,492.

## 1.7 SIMPLE PAY BACK

On the basis of a cost variation of $220,000 between the options and an annual operating cost saving of $30,000 there is a 7.3 year pay back period for the foil version. If the higher contingency sum is used for foil then this period increases to 10 years.

## 2 PURPOSE OF REPORT

The site and the facilities mix for the Kapiti Coast Aquatic Centre have been agreed and concept plans prepared.

There are two different types of construction that are seen by the design team as being valid for the construction of the major portion of the building – the pool hall. These are:

- “Conventional”. This option is based on a timber portal frame structure for the pool hall with the insulation and vapour barrier envelope being provided by prefabricated insulated panels with external and internal painted metal skins. The technology is similar to that used on cool stores and freezers and is typical of modern aquatic centres in New Zealand.

- “Foil”. This option is based on the use of a timber grid shell forming a curved dome over the pools clad with triple skinned ETFE foil. This technology has been widely used overseas for decades, including for many swimming pools, and over recent years has been used for a number of iconic buildings in NZ.

This report considers the advantages and disadvantages of the two forms of construction so that a decision can be made as to which type should be used.

Once that decision is made, Phase 1 will be complete the design team will continue with Phase 2 of the Developed Design for the project, based on the chosen option. At the completion of the developed design the KCDC will be provided with plans and a report outlining the alternatives for all plant and building elements so that informed decisions can be made on the options to be incorporated in the detailed design. To assist with this the capital costs, operating costs, lifetime costs, environmental and amenity factors for each will be investigated and presented and recommendations made by the design team.

### 2.1 DRAWINGS

The following are attached to this report to assist in setting out the options:

- Site and floor plans
- Elevations and Sections
- Perspective sketches
- Structural and mechanical drawings for the relevant portions

These are all concept level drawings. Once the choice of pool hall construction is made the design will be developed based on the chosen option.

### 2.2 ESTIMATES

Estimates of cost have been obtained from Rawlinsons and are also attached. These include comparative estimates for the 2 options ignoring all common items and an indication of overall cost based on the concept details.

## 2.3 BUILDING ELEMENTS COMMON TO BOTH OPTIONS

The elements list below, are deemed to be common for both pool hall design options and as such will be evaluated in the second stage of the developed design and will be fully assessed on the basis of the chosen Option.

Common elements to be evaluated as part of Phase 2 Developed Design:

- Site Geology
- Pools: Type & Construction
- Leisure Features
- Water Quality: Including filtration systems and treatment.
- Heating & Ventilation: Including source of primary and secondary heat.
- Energy & Water Conservation: Including rain water harvest and greywater use.
- Electrical and Lighting
- Fire Safety

## 3 THE SITE

The Aquatic Centre site is located within the proposed Paraparaumu Town Centre on a green-field site between the existing dune and residential sites facing Kapiti Rd. It has been designed in two stages, with Stage 1 housing a 25m lap pool, Toddlers, Learners & Spa pools, twin hydroslides, and associated facilities required to function as a fully operational aquatic centre. Stage 2 will contain a 50m competition pool, a hydrotherapy pool and additional spaces necessary to complete the client's long term vision.

Because of the existing high water table and predicted flood levels, it will be necessary to import significant fill to raise the base of the pools above the credible water table. This is to preclude massive heat loss from the pool water and consequent high energy costs.

Vehicle access assumes a new road connection from the existing Community Centre carpark, across the existing drain, to Kapiti Road at the north of the site, as proposed by urban designers Urbanism Plus. In allowing sufficient site to accommodate the future Stage 2 building, it has been necessary to locate Stage 1 to the NW area of the site.

Parking for approximately 128 cars is provided, including accessible parking, along with a bus/drop off area adjacent to the main entry. Staff parking is provided in the Service Yard adjacent to the Plantrooms.

As part of Stage 1, the Stage 2 site will be landscaped, the existing bike-way relocated and the existing drain converted to a stormwater detention pond. This will provide an active recreation area and attractive 'front yard' to the Aquatic Centre when viewed from the Iver Trask Place.

## 4 BUILDING PLANNING

Stage 1 of the Aquatic Centre is designed to appear complete in its own right and operate as a stand alone building until the future Stage 2 is confirmed. It is entered from the new road via an Entry/Cafe court and Wind Lobby to the main Foyer. This contains Reception and a small Shop and is backed up by an Administration area and Manager's Office. The Foyer also houses a Cafe which has a view into the Pool Hall and opens to a protected courtyard designed to receive afternoon sun.

The Pool Hall is entered from the Foyer, either via the Changerooms for swimmers, or direct for spectators. Stage 1 features and spaces include:

- Male & Female Changerooms
- 4 DP/Family Change rooms
- A Toddlers Pool with beach entry, water features and brightly coloured waterfall
- A Toddler's Playpen
- A Learners Pool, in its own enclosure for better control of classes including , an office, store and toilet
- The 10-lane 25m lap pool with movable floor
- Bleacher seating for approximately 175 spectators
- An Event Control room above the bleachers
- The Hydroslide tower with entry to twin slides on the upper platform and return chutes on the ground floor.
- A Pump Room and HVAC space located below the upper hydroslide platform
- A Spa Pool
- A Sauna
- Poolside Office
- Poolside seating, showers & bag storage
- Plant & Service spaces
- A large Store

Additional spaces include:

- A Staffroom
- Clubroom/Meeting Room
- Wellness Centre
- 2no. DP/unisex shower/toilet spaces. (facilities intended for Staff use)

# 5 ARCHITECTURAL OPTIONS

Two design options for both stages have been proposed for the building form based on similar floor layouts. The options are:

- A Traditional design assuming the use of insulated panels for both the low pitched roofs and upper walls.
- An ETFE transparent roof made up of diagonal inflated ‘pillows’ supported on an exposed timber grid-shell structure, allowing maximised daylight into the pool hall.

## 5.1 TRADITIONAL OPTION

The inspiration for the building form has come from the soft but prominent forms of the existing sand dunes on the site. Conceptually the simple monopitch form also references the silhouette of Kapiti Island, visible from the upper hydroslide platform. The building heights generally denote the various functions within the building, and the resulting forms reflect the dunes and Kapiti Island in an abstract rather than literal way. A double height space is provided over the Entry/Café to allow high level windows to admit morning light into the space.

The simple pallet of materials suggested for the exterior has been chosen for both visual coherence and practical reasons. The roofs and upper walls are clad in light coloured insulated metal panels to minimise summer heat gain, as the heat generated by darker roofs can seriously affect the integrity of the insulation/vapour barrier under these surfaces. Splashes of colour have been added to the facades to denote the recreation nature of the facility.

Lower level exterior walls are generally `thermomass’ insulated precast concrete panels, chosen to visually anchor the building into the site, and for vandal resistance. `Graffiti Guard’ may be necessary to deter `taggers’.

Double-glazed doors and windows will be specified to reduce heat loss from the building, with `Evergreen’ glass chosen to reduce solar heat gain and UV penetration into the building.

## 5.2 ETFE OPTION

The design approach for this option is dictated by the strong curved form of the grid-shell and ETFE roof. This automatically echoes the soft forms of the existing sand dunes on the site. To contrast this dominant form, the associated building forms are ‘simple boxes’ so as not to compete visually with the main form.

Transparency of the roof and optimised form helps reduce the perceived mass of the building and allow the users to have a unique connection to their surroundings.

Again the building heights generally denote the various functions within the building including a generous double height space over the Entry/Café to allow high level windows to admit morning light into the space.

The simple pallet of materials suggested for the exterior has been chosen for both visual coherence and practical reasons. The roofs and upper walls of the non-pool hall buildings are clad in light coloured insulated metal panels to minimise summer heat gain.  Splashes of colour have again been added to the facades to denote the recreation nature of the facility.

Lower level exterior walls are either insulated panel or `thermomass' insulated precast concrete panels.  `Graffiti Guard' may be necessary to deter `taggers'.

Double-glazed doors and windows will be specified to reduce heat loss from the building, with `Evergreen' glass chosen to reduce solar heat gain and UV penetration into the building.

# 6 OUTLINE CONSTRUCTION SPECIFICATION

## 6.1 TRADITIONAL OPTION

### 6.1.1 Building Exterior

- Roofing Main Building and Amenities: 40mm ‘Kingspan KS1000 RW50’ Panel or equivalent PIR sandwich panel.
- Barges & Fascias: 40mm ‘Kingspan KS1000 RW50’ Panel or equivalent PIR sandwich panel.
- Concealed Box Gutters: ‘Kingspan’ Proprietary Gutter system or equivalent
- Downpipes: Painted PVC
- Side Walls: 40mm ‘Kingspan KS900 AWP SL’ Panel or equivalent PIR sandwich panel.
- Lower Walls: Precast `Thermomas’ panels, selected texture exterior surface, clear anti-graffiti finish
- Lower Columns: Precast concrete, clear anti-graffiti finish
- Louvre Panels: Proprietary powdercoated aluminium louvers
- Windows & Doors: Powdercoated aluminium commercial grade
- Glazing: Double glazed, exterior glass `Evergreen’, internal glass clear.
- Exterior Sunshades: Kingspan KS1000 panels on steel structure with 200 micron spray metallic aluminium with acrylic sealer.

### 6.1.2 Building Interior

#### 6.1.2.1 Lower Level Floors

- Wind lobby: ‘Advance’ Axis mat system
- Wet areas: reinforced concrete slabs to 2% falls with Nuplex “Traxite Colorfine” resin aggregate applied to all pool surrounds and public areas that are not otherwise covered, excludes plant rooms and stores. Showers & Urinal floors: ceramic tiles
- Foyer: Carpet tiles & ceramic tiles
- Staffroom/Admin/Reception/Shop/Wellness: Carpet tiles
- Café & Clubroom: Carpet tiles & ceramic tiles
- Café Kitchen & Servery: selected vinyl
- Pool Concourse: ’Traxite’ resin aggregate coating, falls to drains
- Pool Hall Stairs, Risers & Landings: Precast concrete, ’Traxite’ resin aggregate coating non slip finish, drains to landings
- M&E, F&T Plantrooms: Steel trowel concrete slab to falls, clear sealed.

#### 6.1.2.2 Upper Level Floors

- M&E, Plantrooms: Steel trowel concrete slab to falls with surrounding 150mm nib, clear sealed.

- Hydro Slide platform: Prestressed Panels with insitu topping cast slab. 'Traxite' resin aggregate coating non slip finish to falls with surrounding 150mm nib,
- Event Control: carpet tiles on concrete

#### 6.1.2.3 Low Level Walls

- Structural Walls/Columns: Precast concrete panels/columns, no finish (where exposed F5/U3)
- Exposed insulated Kingpan panels: inner face of 'Kingspan' wall panels with high humidity paint system
- Changerooms & toilets – precast concrete, no finish except tiles to shower and urinal walls
- Glazed Partitions: Powdercoated aluminium commercial grade
- Interior Glazing: Single glazed, glass clear
- Aquatic Centre partitions: 9mm Villaboard, expressed joint on H3 timber, paint finish
- Amenity Areas (orange on plan) partitions: 'Gib' board on timber frame, paint finish; timber veneer MDF panelling, fire rated clear finish; STC55 to Clubroom, Offices, etc.

#### 6.1.2.4 Structural Steelwork: Corrosion protection (200 micron spray metallic aluminium with acrylic sealer) Upper Level Walls

- Structural Walls/Columns: Precast concrete panels/columns, no finish
- Exposed PIR panels: inner face of 'Kingspan' wall panels to have high humidity paint system
- Hydroslide Platform & Stair balustrade: 1.4m cantilevered toughened glass

#### 6.1.2.5 Ceilings

- Pool Spaces: 'Asona Triton' panels fixed to Laminated Veneer Lumber (LVL) timber purlins
- Exposed PIR roofing panels: underside of 'Kingspan' with high humidity paint system
- Aquatic Centre amenities: 'Villaboard', paint finish
- Amenity areas (orange on plan): 'Gib' flush joint, paint finish; 'Asona' slotted ply to part of Foyer & Cafe
- Main Beams & exposed timber: LVL Hyspan Beams , clear finish
- Hydroslide Tower plantrooms: Precast concrete, no finish
- Hydroslide platform: 'Asona Triton' panels fixed to LVL timber purlins
- Plantrooms and Store ceilings: underside of 'Kingspan' with high humidity paint system

### 6.1.3 Miscellaneous

- Waterfall & Feature walls: glass mosaic tiles & waterproofing system on moulded precast concrete

- Toilet & Change cubicle partitions: ‘Hale’ compact core system
- Bleachers: Precast concrete, ’Traxite’ resin aggregate coating non slip finish with ‘Stairtile’ nosing & proprietary plastic seats
- Beach/Pool Surrounds between Drains: Non-slip ceramic tiles
- Hydroslides: Proprietary seamless fibreglass tubes, paint finish, on steel tube structure with zinc & aluminium spray corrosion protection
- Fixed Seating: Selected hardwood, clear finish, on galvanized steel brackets

## 6.2 ETFE OPTION

### 6.2.1 Building Exterior

- Pool Hall: 3 layer ETFE cushions Standard Dot Matrix (65% transmission)/Clear/Clear.
- Roofing to Service and Amenities Areas: 40mm ‘Kingspan KS1000 RW50’ Panel or equivalent PIR sandwich panel.
- Barges & Fascias: 40mm ‘Kingspan KS1000 RW50’ Panel or equivalent PIR sandwich panel.
- Concealed Box Gutters: ‘Kingspan’ Proprietary Gutter system or equivalent
- Downpipes: Painted PVC
- Side Walls: 40mm ‘Kingspan KS900 AWP SL’ Panel or equivalent PIR, triangulated sandwich panels.
- Lower Walls: Precast `Thermomas’ panels, selected texture exterior surface, clear anti-graffiti finish
- Lower Columns: Precast concrete, clear anti-graffiti finish
- Louvre Panels: Proprietary powdercoated aluminium louvers
- Windows & Doors: Powdercoated aluminium commercial grade
- Glazing: Double glazed, exterior glass `Evergreen’, internal glass clear.
- Exterior Sunshades: Kingspan KS1000 panels on steel structure with 200 micron spray metallic aluminium with acrylic sealer

### 6.2.2 Building Interior

#### 6.2.2.1 Lower Level Floors

- Wind lobby: ‘Advance’ Axis mat system
- Wet areas: reinforced concrete slabs to 2% falls with Nuplex “Traxite Colorfine” resin aggregate applied to all pool surrounds and public areas that are not otherwise covered, excludes plant rooms and stores. Showers & Urinal floors: ceramic tiles
- Foyer: Carpet tiles & ceramic tiles
- Staffroom/Admin/Reception/Shop/Wellness: Carpet tiles
- Café & Clubroom: Carpet tiles & ceramic tiles

- Café Kitchen & Servery: selected vinyl
- Pool Concourse: ’Traxite’ resin aggregate coating, falls to drains
- Pool Hall Stairs, Risers & Landings: Precast concrete, ’Traxite’ resin aggregate coating non slip finish, drains to landings
- M&E, F&T Plantrooms: Steel trowel concrete slab to falls, clear sealed.

#### 6.2.2.2 Upper Level Floors

- M&E, Plantrooms: Steel trowel concrete slab to falls with surrounding 150mm nib, clear sealed.
- Hydro Slide platform: Prestressed Panels with insitu topping cast slab. ’Traxite’ resin aggregate coating non slip finish to falls with surrounding 150mm nib,
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- Changerooms & toilets – precast concrete, no finish except tiles to shower and urinal walls
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- Aquatic Centre partitions: 9mm Villaboard, expressed joint on H3 timber, paint finish
- Amenity Areas (orange on plan) partitions: ‘Gib’ board on timber frame, paint finish; timber veneer MDF panelling, fire rated clear finish; STC55 to Clubroom, Offices, etc.

#### 6.2.2.4 Structural Steelwork: Corrosion protection (200 micron spray metallic aluminium with acrylic sealer) Upper Level Walls

- Structural Walls/Columns: Precast concrete panels/columns, no finish
- Exposed PIR panels: inner face of ‘Kingspan’ wall panels to have high humidity paint system
- Hydroslide Platform & Stair balustrade: 1.4m cantilevered toughened glass

#### 6.2.2.5 Ceilings

- Pool Hall: 3 Layer ETFE Cushions
- Exposed PIR roofing panels: underside of ‘Kingspan’ with high humidity paint system
- Aquatic Centre amenities: ‘Villaboard’, paint finish
- Amenity areas (orange on plan): ‘Gib’ flush joint, paint finish; ‘Asona’ slotted ply to part of Foyer & Cafe

- Main Beams & exposed timber:  LVL Hyspan Beams, clear finish
- Hydroslide Tower plantrooms:  Precast concrete, no finish
- Hydroslide platform & Event Control:  ’Asona Triton’ panels fixed to LVL timber purlins
- Plantrooms and Store ceilings: underside of ‘Kingspan’ with high humidity paint system

#### 6.2.2.6 Miscellaneous

- Waterfall & Feature walls:  glass mosaic tiles & waterproofing system on moulded precast concrete
- Toilet & Change cubicle partitions:  ‘Hale’ compact core system
- Bleachers:  Precast concrete, ’Traxite’ resin aggregate coating non slip finish with ‘Stairtile’ nosing & proprietary plastic seats
- Beach/Pool Surrounds between Drains:  Non-slip ceramic tiles
- Hydroslides:  Proprietary seamless fibreglass tubes, paint finish, on steel tube structure with zinc & aluminium spray corrosion protection
- Fixed Seating:   Selected hardwood, clear finish, on galvanized steel brackets

# 7 POOL HALL BUILDING ENVELOPE

## 7.1 DESIGN PHILOSOPHY AND LOADINGS

| | | |
|---|---|---|
| **Building Use:** | Public | |
| **Importance Level:** | 3 | |
| **Building Location:** | Paraparaumu | |
| **Soil Assumption:** | 300kPa UBP as per report supplied by Aurecon | |
| **Codes:** | NZS1170, NZS3303, NZS3406, NZS3101 | |
| | | |
| **Wind Load Factors:** | | |
| Annual Probability of Exceedance: | 1/1000 | |
| Wind Region: | A7 | |
| Terrain Category: | TC2 | |
| Topography: | Flat | |
| $V_{\text{site ULS}}$ | 48.5 m/s | |
| $V_{\text{site SLS}}$ | 43 m/s | |
| | | |
| **Earthquake Load Factors:** | Limited Ductility | |
| | | |
| Annual Probability of Exceedance: | 1/1000 | |
| | ETFE Option | Traditional Option |
| Seismic Zone Factor: | 0.74 ULS, 0.14 SLS | 1.26 ULS, 0.24 SLS |
| Ductility Factor (μ): | μ=1.25 | μ=1.25 |
| Soils Class: | Deep Soil Class D | |
| | | |
| **Snow:** | N/A | |
| Annual Probability of Exceedance: | | |
| Altitude: | | |
| Snow Zone: | | |
| | | |
| **Other:** | | |
| Live load (roof no access) | 0.25kn/m2 | |

## 7.2 STRUCTURAL FORMS FOR THE MAIN POOL HALL

### 7.2.1 Traditional Option

#### 7.2.1.1 Geometry

The traditional approach uses a portalised mono-pitch roof form to enclose the main pool hall. The max apex height is between 10.5 -11.5m with a 5 degree pitch to lower eaves level at 7.5 - 8.5m. The building foot print covers an area approximately 49m long by 38m wide.

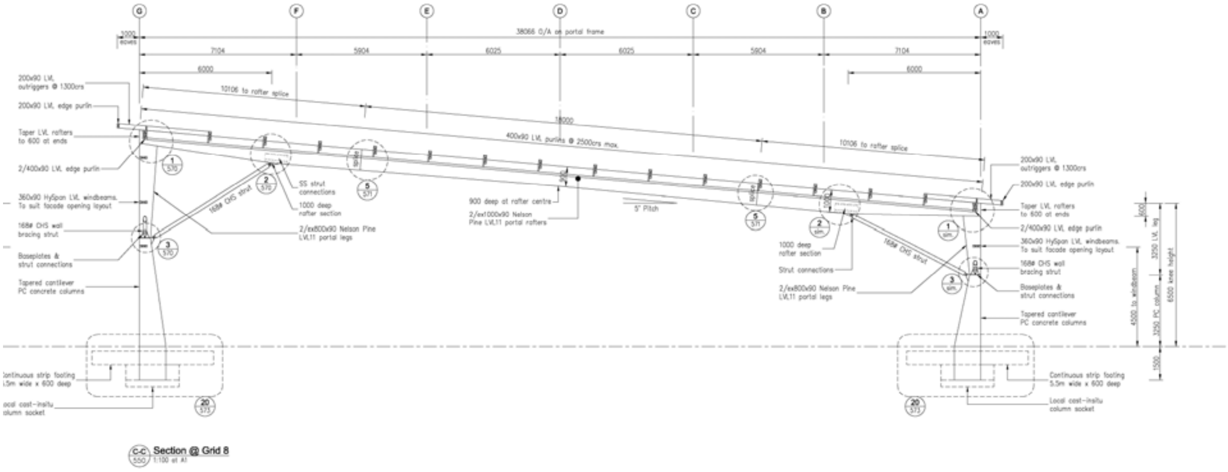
Surface area of main pool building envelop is approximately:

Roof: 1862m2 + 196m2 over hangs

Side walls above 3m level: 553m2 (Approx 40% glazed)

Gable end walls: 660m2 (Approx 40% glazed)

Total: 3270m2



#### 7.2.1.2 Primary Framing

The main building form is comprised of an orthogonal primary and secondary structural grid. Primary composite LVL rafters at 6.5m span the 38m to provide clear span support to the entire pool hall space below. The rafters are portalised with high level timber columns, which in turn are supported on precast cantilever columns.

In plane CHS struts are employed to reduce the span on the main rafter and provide moment continuity through the knee sections. The cantilevering concrete columns complete the vertical and lateral load transfer to ground.

#### 7.2.1.3 Secondary Framing

LVL purlins at 2.5mcc span the 6.5m between primary frames. These are inset to some degree within the depth of the primary member, to provide out of plane stability to these deep elements, through U frame action. They also provide the required support and fixity for the insulated roof panels above.

The purlins in turn support ceiling joists that carry the acoustic ceiling, which is inset between the rafters.

#### 7.2.1.4 Lateral Stability

The mass and the period of the traditional roof give rise to an 80% increase in lateral force required to be transferred in the advent of a design earthquake, when compared to that of the ETFE option.

The roof plate is designed to act as a stiff diaphragm to transfer the lateral wind and seismic forces acting on the building. A system of diagonal rod bracing provides the lateral shear transfer to the eaves level.

Laterally, the primary portals provide the necessary lateral transfer to ground level.

In the longitudinal direction a series of ‘V’ shaped struts brace the roof plane and transfer the longitudinal shear to the column heads. Again the concrete columns cantilever in the minor axis to provide the shear transfer to ground.

### 7.2.2 ETFE Option

#### 7.2.2.1 Geometry

The main building form is comprised of a two way spanning timber diagrid that creates an optimised clear span roof envelope to the main hall. The centres of the diagrid are defined by the ETFE cushion spans above.

The geometry is defined by taking a section of a toroid to create a form that arches in two directions. The reason for this geometry is to rationalise the curved surface into just two radii, to simplify construction of the both the foil and timber gridshell.

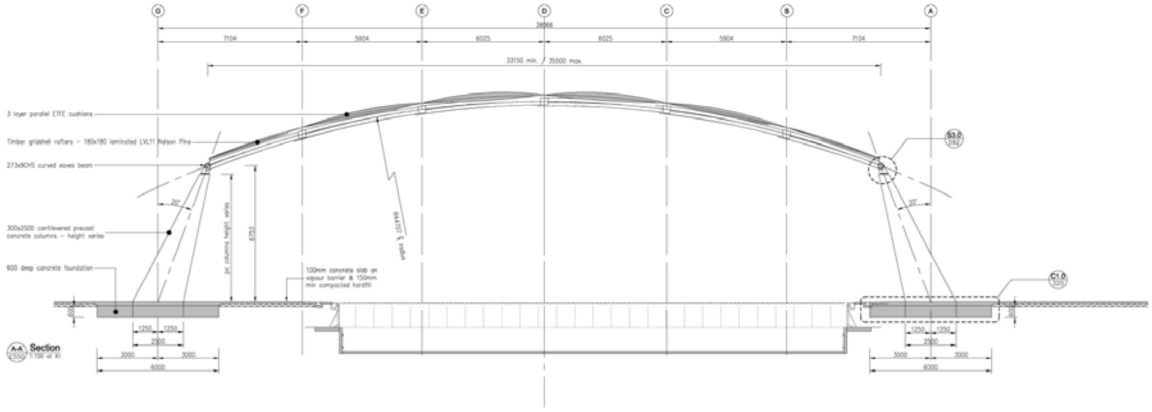
Surface area of main pool building envelope is approximately:

Roof: 1880m2

Side walls above 3m level: 260m2

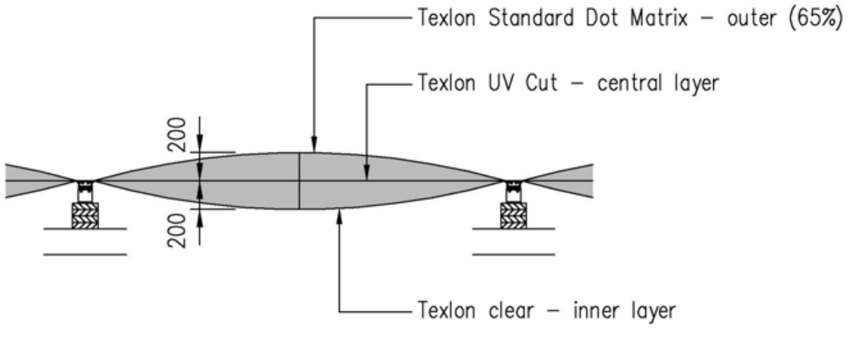
Gable end walls: 400m2 (Approx 40% glazed)

Total: 2540m2



#### 7.2.2.2 ETFE Cushion System

The system proposed for KCAC is a 3 layer foil system (refered to as Texlon), which is provided by the leading global supplier Vector Foiltec. The arrangement chosen is the most common arrangement for commercial projects.



Typical Cushion Arrangement
1:50 at A1

The design employs a parallel arrangement of 3.1m wide cushions orientated along the primary grid shell (refer to Dwg E551). Long cushions help optimise the frame to foil ratio and thus reduce the overall cost of the system. The defining geometry of the cushions is essentially constant for each, but the length varies.

The cushion themselves are held at the perimeter via a continuous extruded aluminium channel, with in turn is stooled off the primary timber structure below.

The foil type and surface treatments are determined by the insulation and transmission qualities required through thermal modelling of the building envelope. The foil thickness is governed by the environmental loads on the cushion.

The proposal at this stage is to use the following cushion arrangement:

> Outer: 200micron Foil surface fritted with standard 4mm dot matrix 65% transmission.
>
> Central: 100micron Foil Clear foil (UV Cut)
>
> Inner: 200micron Clear foil.

The above will need further review through the design process to ensure optimisation of the system is maintained.

### 7.2.2.3 Primary Roof Framing

The structure is created from a primary direction member that over sails an internal opposing secondary direction member. The connections between the two have been simplified to optimise cost and buildability.

Out of plane forces are transferred to eaves level, primarily via arching action.

The triangulated nature of the surface provides an inherent in plane stiffness ensuring the roof works as a shell like form.

Along the eaves and gable ends a connecting bending stiff member is employed to distribute both in plane and out of plane forces back to the main column line.

### 7.2.2.4 Column Supports

Cantilevering precast columns at 6.5m cc are employed to provide vertical and lateral support to the roof gridshell. The inclined nature helps resolve the axial arching forces from the roof to ground.

### 7.2.2.5 Lateral Stability

The triangulated nature of the roof diagrid means it acts as a stiff diaphragm to transfer the in plane forces acting on the building, without the need for additional roof bracing.

The primary concrete columns cantilever in the both major and minor axis to provide the shear transverse to ground.

The 55% reduction in seismic force required to be transferred by the ETFE structure is somewhat offset by the increase wind loading that the ETFE building experiences.

The lightweight nature of the domed roof generates 50% more uplift force than the Traditional option, however this can be resisted by a simpler gravity system.

If the ETFE option is chosen, we would recommend that the surface pressures for the doubly curved form are reviewed by an expert wind engineer to assess if there are any potential savings in the forces needed to be transferred.

#### 7.2.2.6 Ductility

There is the possibility with both options, to explore the benefits of ductility with a view to potentially reducing member sizes. The wind forces on the site are considerable and may limit the level to which we can go. This will be investigated in the second phase of the develop design stage.

## 7.3 DURABILITY OF STRUCTURES

The NZ Building Code requires structural members to have a life of at least 50 years. Where maintenance such as re-coating is required to obtain this life then inspections and maintenance schedules and procedures must be part of the design.

Indoor swimming pool environments are very corrosive and class as NZS 3403.1 Category E.

### 7.3.1 Construction Common to both Options:

Timber is not affected by the chemicals in an indoor pool environment. All LVL timber that is not in contact with water need not be treated. This is due to the fact that the max equilibrium moisture content is well within the 25% limit, beyond which there is a risk of decay due to the high humidity conditions. All timber in areas prone to wetting will be treated to H3.1 (LOSP) and H3.2 for LVL and glulam/solid timbers respectively.

All mild steel components will be limited, due to them requiring sophisticated paint systems. These systems can provide up to a maximum of 25 years to First Maintenance, after which time they need to be recoated. Therefore the requirement to provide access to any mild steelwork component has been carefully considered in the design – particularly over water. All steel sections have been located and detailed so that all surfaces are easily accessed for re-coating.

Aluminium appears to be inert in these environments as evidenced by the use of aluminium hatch plates over balance tanks. These show no sign of deterioration after many years in an extremely corrosive situation. 200 microns of sprayed metallic aluminium with an acrylic sealer over has been used with success in indoor pools and is the preferred treatment for steel structural components to provide at least 50 years durability when correctly maintained.

Even stainless steel 316L will rust in if it is not well passivated. Carefully designed stainless steel has been used successfully and is recommended for local steel flitch plates in timber connections. SS bolts are also recommended in these connections.

Concrete structures easily comply with the durability requirements, provided attention is given to the quality of the concrete and sufficient cover is provided to all reinforcing steel. Paint or other coatings are only used for cosmetic reasons.

### 7.3.2 ETFE Option

ETFE has been in existence as a cladding system for over 28 years. The oldest ETFE structure was constructed by Vector Foiltec in 1982 in the Netherlands, and shows no sign of deterioration. Testing has shown that the material does not degrade under UV light, sunlight, weather or atmospheric pollutants, and has a very long life. Vector Foiltec currently estimates the life expectancy of the material to be somewhere between 50 -100years.

The Aluminium (extrusion) is expected to be inert in these environments as outlined above.

## 7.4 MAINTENANCE COSTS AND WARRANTIES

### 7.4.1 Traditional Option

Timber Structure: The main timber beams are specified with a nominal clear finish and are virtually maintenance free.

Structural Steel elements coated with metallic aluminium and acrylic sealer should require limited if any maintenance, but will have a significantly higher capital cost. The cost of localised surface repair is estimated at an annualised $2,000. This work is vital and cannot be delayed because it is required to maintain the life of the steel. Any disruptive effect of maintenance is minimised by it location being to the side of the pool.

Kingspan Roof and Wall panels

Standard warranties that are available for Kingspan:

Workmanship – 2 years

Material – 15 years

Estimated maintenance costs of the system required to uphold warranties is annualised at $5,000.

### 7.4.2 ETFE Option

Timber Structure as per the above.

Structural Steel elements coated with metallic aluminium and acrylic sealer should require limited if any maintenance and have been keep to a minimum compared to the Traditional option above. An annual allowance of $500 is expected to cover this cost.

As Texlon cushions are a specialised system a maintenance agreement is generally required and forms part of the warranty conditions. This ensures the system is maintained in peak condition with regular servicing of it fan uints. Regular maintenance also prolongs the life of the system to well beyond that of other cladding materials.

Estimated maintenance costs of the system proposed in the order of $4-5000 per annum.

#### 7.4.2.1 Vandalism/Damage

The British Health and Safety Executive set up tests to assess the fragility of roof systems. The Texlon system was classified as a Class C assembly and therefore deemed as a non fragile roof, and thus requires infrequent access.

The product has been used globally on more than 600 buildings and there is numerous test data available from various institutions that have evaluated both impact and cyclonic wind pressure tests. The product has always performed to a very high degree and remains classed as a “robust” cladding system.

In the USA, the Miami Dade County Council wanted to evaluate the robustness of the material under cyclone conditions. They tested the system by firing steel ball bearings (2g) at 142km/h. The panels were then subjected to cyclonic wind pressures of up to 2.4kPa. No failures were recorded.

The system was used on Southern Cross Station in Melbourne, after they carried out impact tests. They dropped a 165kg sand bag from 1.5m height onto a 6m square cushion. In addition the cushion was cut with a 20mm slot and the pressure turned off. Inspectors of Worksafe Victoria passed the system as a robust system not requiring hand rails.

Local repairs to damaged areas can be usually be patched. This is a simple process that can be performed by 1 person. In the extreme case it would require the installation of a new cushion carried out a minimal cost by VF.

*Car loaded onto 10m Hexagonal Cushion*

#### 7.4.2.2 Operating Costs

Unlike a traditional roof, there is a small associated operating cost for the system. The pump requires a small amount of electricity estimated at 650kWh per 1,000spm per year which in this instance equates to approximately $150 per annum.

# 8 QUANTITY OF MATERIALS & EMBODIED ENERGY

## 8.1 QUANTITY OF MATERIALS

### 8.1.1 Traditional Option

Timber: There is approximately 110m$^3$ of LVL timber required to form the primary and secondary frame members.

Steelwork: There is approximately 8.5Tonnes of mild steel, and 1.5Tonnes of stainless steel required to form the connections and bracing elements to the main primary frames, respectively.

Kingspan: There is approximately 2800m$^2$ of Kingspan panelling required to form the enclosure to the main pool hall.

Glazing: There is approximately 485m$^2$ of double either end, provides views out of and natural light into the pool hall.

### 8.1.2 ETFE Option

ETFE: There is approximately 1860m$^2$ of ETFE foil required to enclose the roof form.

The foil is a thermoplastic that does not degrade over time and can be fully recycled. In fact 5% of the typical foil cushion is made form 5% recycled content form left over from manufacturing process. The aluminium extrusion can be fully recyclable.

ETFE contains no petrochemicals and uses a water base production process rather than solvents. The whole production of the extruded sheet is low temperate process at approx 260 degrees Celsius.

As a result the Texlon ETFE cladding system contains only 100th -1000th of the embodied energy of that of an equivalent glazing system.

Timber: There is approximately 45m$^3$ of LVL timber required to form the Primary and secondary frame members.

Steelwork: There is approximately 2.5Tonnes of mild steel required to form the connections within the primary elements.

Kingspan: There is approximately 260m$^2$ of Kingspan panel required to form the enclosure to the main pool hall.

Glazing: There is approximately 200m$^2$ of double glazing at either end provides views out of and additional natural light into the pool hall.

### 8.1.3 Embodied Energy – Conventional Roof vs ETFE Roof

#### 8.1.3.1 Conventional Option

| | **WEIGHT (KG)** | **RATE (MJ/KG)** | **MJ** |
|---|---:|---:|---:|
| Timber (LVL) | 55,000 | 7.9 | 434,500 |
| Mild Steel | 8,500 | 35 | 297,500 |
| Stainless Steel | 1,500 | 76 | 114,000 |
| | **AREA (m2)** | **RATE (MJ/M2)** | |
| Kingspan Panels | 2,800 | 700 | 1,960,000 |
| Glazing | 485 | 1,500 | 727,500 |
| Acoustic ceiling | 2,000 | 100 | 200,000 |
| **TOTAL** | | | **3,733,500** |

#### 8.1.3.2 ETFE Option

| | **WEIGHT (KG)** | **RATE (MJ/KG)** | **MJ** |
|---|---:|---:|---:|
| Timber (LVL) | 22,500 | 7.9 | 177,750 |
| Mild Steel | 2,500 | 35 | 87,500 |
| | | | |

| | **AREA (m2)** | **RATE (MJ/M2)** | |
|---|---|---|---|
| Kingspan panels | 260 | 700 | 182,000 |
| ETFE SYSTEM | 1,860 | 192 | 357,120 |
| Glazing | 200 | 1,500 | 300,000 |
| **TOTAL** | | | **1,104,370** |

The difference of 2,630,000MJ is equivalent to 730,000kW-hr or 730MW-hr or the equivalent annual energy use of approximately 77 houses. It is also equivalent to approximately 250 tonnes of CO2 or the emissions from 50 cars over one year.

## 8.2 COMPARATIVE COSTS OF THE STRUCTURE

There are number of factors that need to be taken into account when assessing the capital costs of the ETFE option in relation to a more traditional approach.

The Texlon ETFE system is considerably more expensive per square meter when compared to a traditional Kingspan cladding. However the system needs to be evaluated as a whole, as its offers a lighter supporting structure, higher performance, natural day light, increased design life, and potential energy saving etc, all of which need to be evaluated.

These are also additional effects on roof buildup, surface area of envelope, self weight of materials required to be transported and build ability:

> Roof Build up: Traditional Roof buildup: Kingspan, Acoustic ceiling, Primary Portals and Secondary Purlins and Counter Battens, Steelwork Connection (primary and secondary), Diaphragm Bracing.
>
> The EFTE option requires no additional treatment to control acoustics.
>
> Reduced Surface Area: The curved form of the ETFE option provides a 25% reduction in surface area when compared to a traditional mono-pitch roof.
>
> Reduction in Self weight: The ETFE roof option provides approximately 40% reduction in the self weight of the materials required for construct the envelope of a traditional pool hall. This will result in significant savings in transport and craneage costs and the size of plant required for construction.
>
> Buildability: ETFE offers significant advantages in terms of buildablity and programming that will also have an effect on total cost by reducing the overall construction time and therefore P&G costs. Not only is the material extremely light (<1kg/m2) but it is also very forgiving form of construction allowing the primary structure to be more flexible.
>
> Indications from a Timber contractor is that they envisage constructing the whole grid shell form at ground level shell and lifting it up in one piece. This will offer considerable advantages in terms of construction costs, programme and Health & Safety issues due to the ability to carry out most of the work at a lower level and the elimination of the need for “birdcage” scaffolding.

Vector Foiltec have a trafficable net system that allow the cushion to be installed at high level, while work continues in the pool hall area below.

This is not practical in the traditional approach where the entire foot print of the pool hall requires a high level deck scaffolding to erect and line the building.

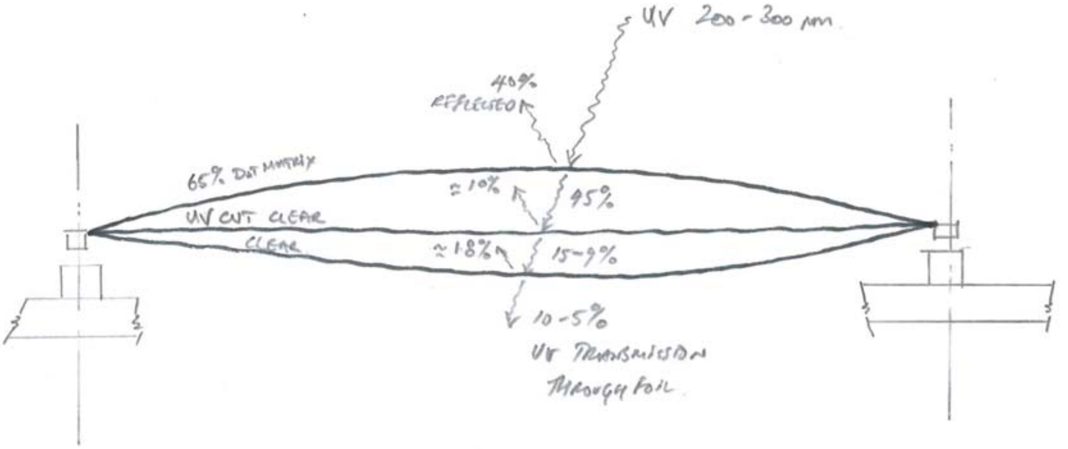
Rawlinsons have been commissioned to carry out a full evaluation of the cost impacts of the ETFE versus the Traditional approach and this is contained as an Addendum to the report.

## 9 DAYLIGHT CONTROL

This is only applicable to the ETFE option. Daylight and thermal computer modelling has been employed to ascertain the light transmission qualities that are desirable through the foil, in order to balance the light requirements within the pool hall. This is discussed in more detail in the Heating and Ventilation section of this report, however the transmission qualities of the cushions are illustrated below.

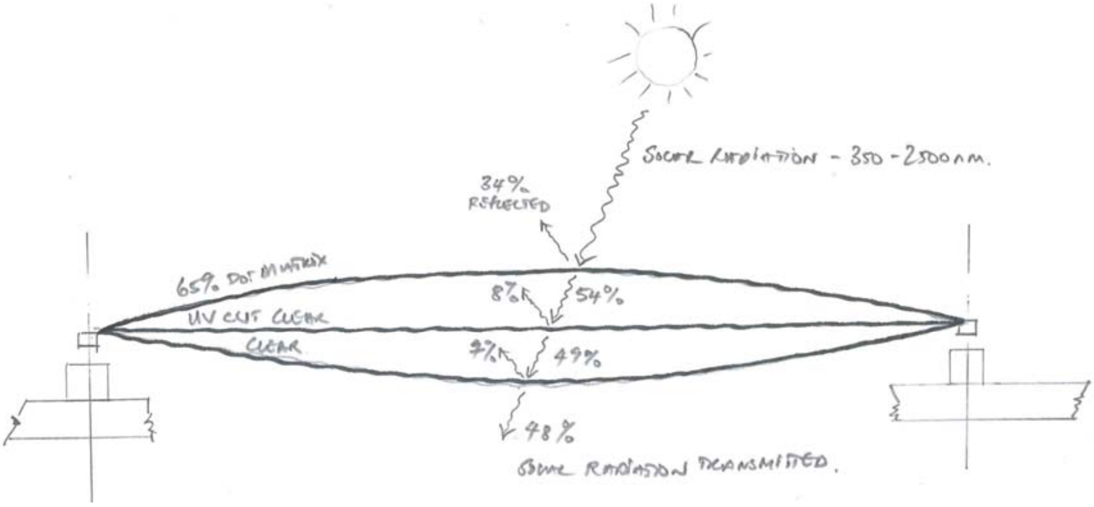
### 9.1 UV TRANSMISSION THROUGH TYPICAL ETFE CUSHION

It is proposed that the central layer is UV Cut ETFE. This is a treatment process to the Clear foil that forms an enhanced barrier to UV. Product data from Vector Foiltec illustrates that this central layer within the proposed cushion build up will reduce the UV transmission to approximately 10%.



### 9.2 SOLAR TRANSMISSION THROUGH A TYPICAL CUSHION

The light transmission of the cushion can be tuned to allow us to balance the requirements for solar gain with the requirements to create shading to the pool space. We have based the design assessment to date on the 3 layer system that in its entirety allows 48% of the sunlight to pass through.



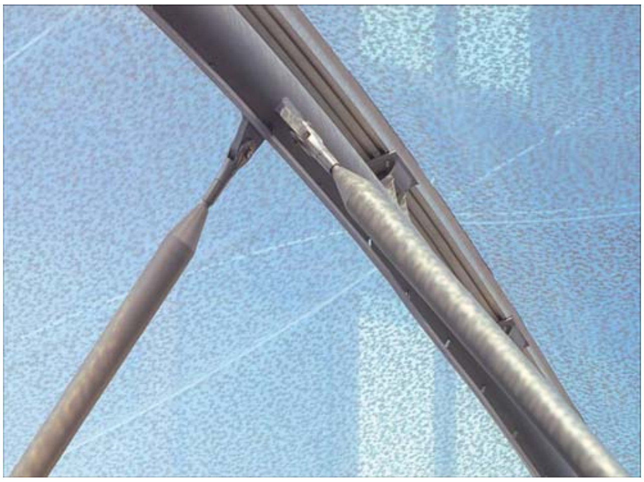
Surface Fritting

With ETFE cushions there is a vast range of frit patterns that can be printed onto the foil to control the light transmission through the cushion. The exact amount of shading versus light transmission required has yet to be finalised but is likely to be in the region of 50% net reduction in light transmission.

Examples given below illustrate some of the standard frit options available.

*Close up view standard Dot matrix*

*Standard Dot matrix viewed at a distance*



*Random Frit Pattern Close up view*

*Random frit viewed at a distance*

*Alternative patterns available at additional cost*

# 10 INDOOR ENVIRONMENTAL QUALITY

The social and economic value of obtaining a Greenstar rating for the aquatic centre, which is applicable to both options, is evaluated in a separate report.

Current research shows that projects with high ESD ratings such as Greenstar find it easier to maintaining staffing levels with higher productivity. This is due to the increased quality of working environments leading to higher perceived levels of well being, resulting in higher productivity and lower levels of sick leave.

The increased indoor environment quality is achieved through increased natural light, ventilation control, views etc and also has a direct influence on the quality of visitor experience and degree of public use.

## 10.1 NATURAL LIGHT

Traditionally, pool halls in New Zealand have limited glazing, particularly around lap pools, in order to control contrasted light within the space and to limit glare on the water surfaces. There can be an issue with discrete areas of glazing causing a “search light” effect in the space. This has a direct bearing of safety and makes it difficult for pool operators to monitor the pools safely, particularly where there is deep water. Glazing within traditional pool halls therefore needs to be carefully controlled to limit and balance natural light.

The ETFE option, on the other hand, creates a fully transparent roof form which provides balanced natural light across the entire pool hall space, thus limiting the contrast effects. It also provides enhanced deep water viewing. It is effectively an outdoor pool from the point of view of lighting but has a temperature controlled enclosure that eliminates wind and dust etc. compared to an outdoor pool. The more balance light source reduces or avoids safety issues with glare and any psychological effects caused by contrasts between artificial or natural light levels

## 10.2 EXTERNAL VIEWS

Both the ETFE and Traditional Options employ end glazing to facilitate views out of the pool space and provide the connection with external environment.

The ETFE option provides an enhanced connection with the external environment through the transparency of the roof.

## 10.3 VENTILATION RATES

Ventilation rates for either pool hall option are well in excess of the levels required by standard buildings and specified under NZBC. The ventilation rates are discussed in more detail within the section on Heating and Ventilation.

## 10.4 THERMAL CONTROL

Both options employ the same heating and ventilation control that constantly monitors both temperature and humidity levels within the pool hall. This is also discussed in more detail within the section on Heating and Ventilation.

# 11 ENERGY DEMAND

There is a difference in the energy demand throughout the year for both the Traditional and ETFE roof options. To arrive at differences between the two options we have considered only the main pool hall in either case. It has been assumed that for either option the energy demand in the amenities, the foyer and café, the wellness centre, club room and hydroslide spaces will be the same.

The pool hall spaces have been modelled using Ecotect thermal modelling software, and calculations are based upon actual weather data as measured at the NIWA station at Paraparaumu Airport. Additional supporting technical information has been provided by Vector Foiltec, a manufacturer of ETFE. This has been further supported by spreadsheet calculations for each day of the year.

## 11.1 HEATING AND VENTILATION

### 11.1.1 Tariffs

All energy cost figures have been calculated using the following tariff figures as provided by Kapiti Coast District Council during September and October 2010.
These are in summary:

| Fuel Type | Energy Unit Cost | Standing Charges | Assumed Unit Cost |
|---|---|---|---|
| Natural Gas | $15/GJ | $10.70/day | $15/GJ |
| Electricity<br>(until mid 2011) | 18.75c/kWh peak,<br>12.06c/kWh off-peak,<br>9.77c/kWh night | $0.15/day | $0.12/kWh |
| Water | $0.86/m$^3$ | | $0.86/m$^3$ |
| Wood Pellets | $15/GJ | | $15/GJ |
| Wood Chip | $9/GJ | | $9/GJ |
| Sewer Discharge | Nil | | Nil |

### 11.1.2 Heat Recovery

The overwhelming majority of heat lost from heated swimming pools is through evaporation. The rate of evaporation is dependent on the temperature difference between the pool and the air above it and the relative humidity of the air. The latent energy required to change water from liquid to vapour is taken from the body of water and therefore cools the pool water. This energy needs to be replaced for the pool temperature to be maintained.

One of the major contributors to the control of operating costs is the efficient use of energy in an indoor pool complex. There is both an implied brief and an obligation to the wider community to reduce energy use to a practical minimum.

It is essential to provide a high degree of ventilation to an indoor pool hall

- to remove chemicals such as trihalomethanes and trichloramines from the surface of the water and the air in the pool hall in order to minimise their harmful effects on swimmers and spectators
- to control humidity to a level where a balance can be found between the comfort of staff and patrons in the pool hall and the need for economy
- to provide an adequate supply of fresh air for respiration[1]

To achieve these goals it is desirable to continually exhaust large volumes of air from the pool hall. This air will for most of the time be significantly warmer than the fresh air used to replace it and will always contain a large amount of water vapour. To minimise purchased energy cost, it is essential to recover as much of the energy from this exhaust air stream as economically as possible.

For parts of the year when ambient temperatures are higher, with judicious design and use of proprietary heat recovery systems, it is possible for many sites that sufficient heat energy can be recovered to maintain pool and pool hall temperatures without the addition of boost heat. During the colder months, additional boost heat energy is required, and the colder it is outside, the more boost energy is necessary.

### 11.1.3 Heating and Heat Recovery Plant

There are several types of heat recovery plant. These include run around coils, rotary heat wheels, heat pipes, air to air heat exchangers, heat pumps and dual tower systems. Those applicable to indoor heated swimming pools are run around coils, air to air heat exchangers and heat pumps.

There are even more choices for the provision of boost heat, some more appropriate than others. These include three forms of heat pumps (those extracting heat directly from the outside air, those extracting heat from a water source e.g. water main or bore and those extracting heat from a ground source), a natural gas fired boiler, a wood fired boiler (pellet or chip fired) and solar heating.

In a great many situations, the best fit for an indoor aquatic centre in terms of capital cost versus energy use and efficiency has been a plant combining the use of a heat pump recovering energy from the exhaust air stream with a gas fired boiler for boost heat provision. A preliminary investigation suggests that this is probably also true for the Kapiti Coast Aquatic Centre. Other viable options include the use of wood fuel in combination with heat pump heat recovery, and potentially water sourced energy in combination with heat pump heat recovery. The result of a detailed comparison between these and other options will be included in the Developed Design Report which is produced in the next phase of the design process.

For the purposes of the comparison of energy use between the Traditional and ETFE options, we have assumed the use of a heat pump recovering energy from the exhaust air stream with a gas fired boiler for boost heat provision. The option for boost heat will be evaluated in phase 2 of the design process.

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[1] This is also a Building Act requirement

### 11.1.4 Building Envelope Performance

The performance of an envelope is measured by it's ability to protect the internal inhabited environment for the external environmental conditions, while minimising the energy required to heat, cool, light and ventilate the space.

The traditional option uses predominantly insulated Kingspan panels to form the building envelope. This has a high insulation value and so to some extent protects the internal climate against external temperate fluctuations. Since the Kingspan panels are solid (ie no light transmission), there is a need to artificially light the internal space. Additional heating is required internally to maintain both the pool water and air temperature at the desired temperature.

The ETFE option on the other hand provided some degree of insulation but also allows natural daylight to pass through it. During the daytime, the solar energy transmitted into the pool hall can be used to heat and light the internal space, and thus reduces the additional heating and lighting required to maintain the internal temperatures at desired level. At night time however, the lower insulation value of the ETFE, means there is tendency for more heat to be lost from inside the pool hall.

The section of the report assesses each cladding option, and evaluates which option provides the most efficiency system from and energy view point.

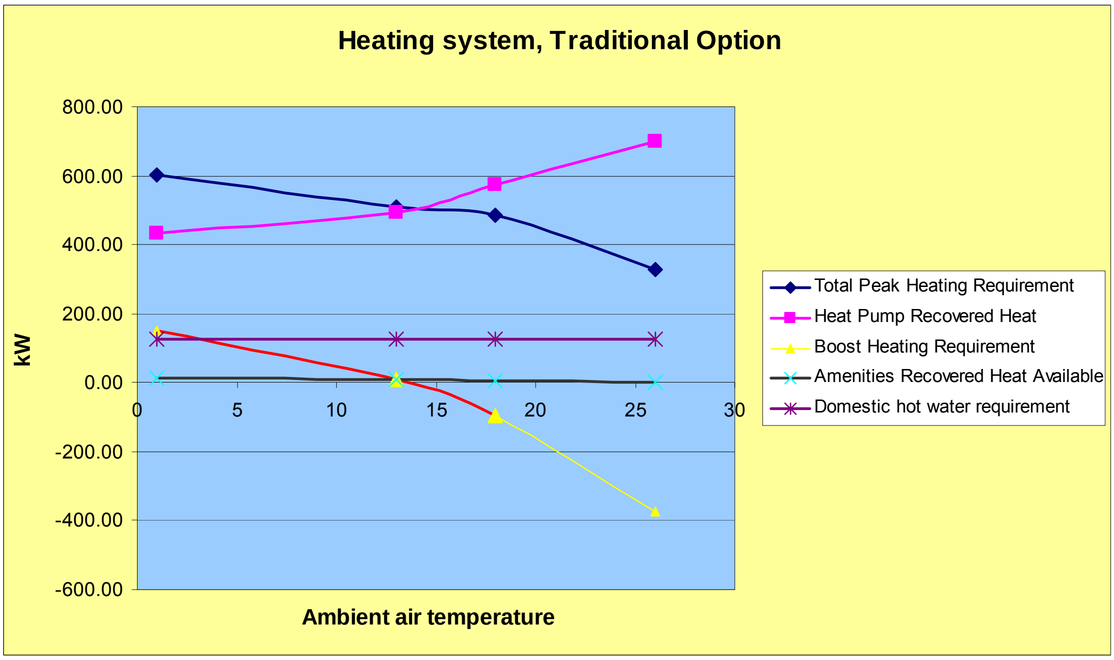
The factors that need to be assessed with regards to the two cladding options are essentially the thermal losses through the cladding versus the solar gains.

### 11.1.5 Thermal Loss

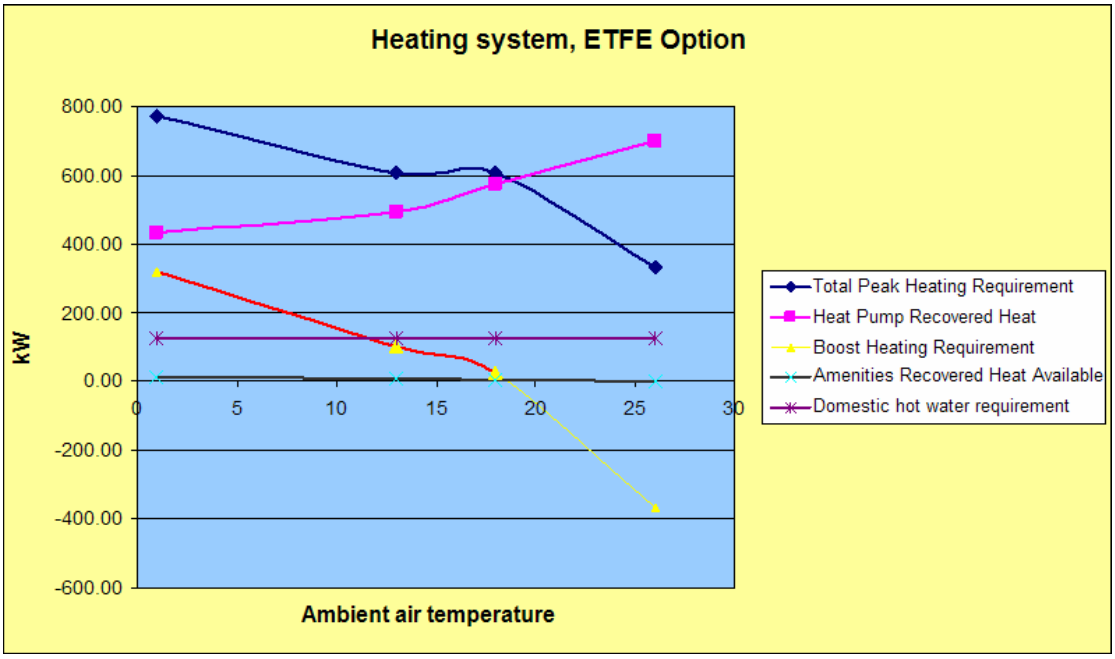
Both roof options loose thermal energy to outside, when ambient temperatures are lower than the controlled pool hall temperature. 50mm Kingspan exhibits a considerably greater R-value (a measure of thermal resistance) than triple layer ETFE, hence the ETFE option has a significantly greater thermal loss by conduction at all times.

For each option the preliminary energy profile of the site has been calculated, and peak heat loads, estimated recoverable energy and domestic hot water usage plotted to provide a visual indication of the expected maxima against an ambient temperature. Graphs are shown for both options below. Note that these figures will change during further development of either option and as assumptions made are resolved.

For each option an energy profile was established, that is particular to the site. This calculates the peak heat loads, estimated recoverable energy and domestic hot water usage, and provides a visual indication of the expected maxima against an ambient temperature. Preliminary profiles for both options are illustrated below ( these are subject to change during subsequent design development).



*Energy Profile for Traditional Option*



*Energy Profile for ETFE Option*

It can be seen for the above that the instantaneous peak heating requirement for the ETFE option, is in the range of 50-200KW greater than that of the Traditional option, at all ambient temperatures. This reflects the additional thermal losses through the roof due to the lower R-value of the ETFE.

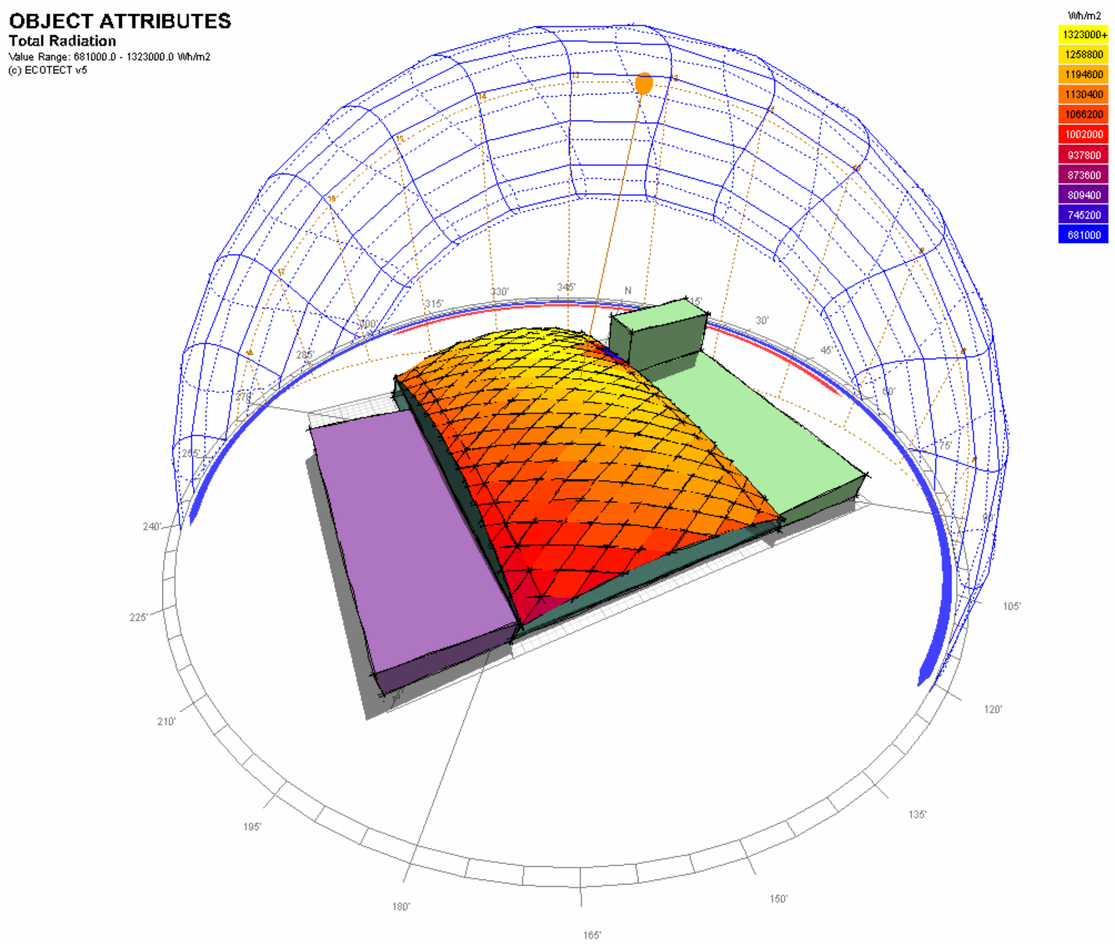
As outlined in the next section, over the period a year these losses can be more than offset by the Solar gain through an ETFE roof.

### 11.1.6 Daylight Modelling to Evaluate Solar Gain

General speaking, in the Traditional option, the enclosed pool hall relies on electrical lighting for all operating hours. Some natural light will be available through windows in the end walls but this will be low in level and insufficient to make any appreciable difference.

The ETFE option, on the other hand, has the advantage of significant daylight within the pool hall. During bright daylight there is sufficient light intensity to meet the requirements of FINA, and there is no requirement for simultaneous electric lighting. There are 4,420 hours of daylight per annum, an average of 12 hours per day. From available weather data, almost 2012 hours is bright sunshine. A period following dawn and prior to dusk, the ambient light levels will be insufficient to provide all the lighting needs of the pool hall. It is estimated that 1050 hours at 100% and 730 hours at 50% per annum of electric lighting will be required as there will be insufficient natural light available. Refer to Section 11 for the more detail on the artificial light requirements.

Daylight modelling was accomplished using Ecotect Modelling Software. This uses actual acquired weather data to simulate light intensity conditions within our model building. An example of the visual data available from this software is shown below, which includes all incident solar energy on the surface of the roof, over a one year period:



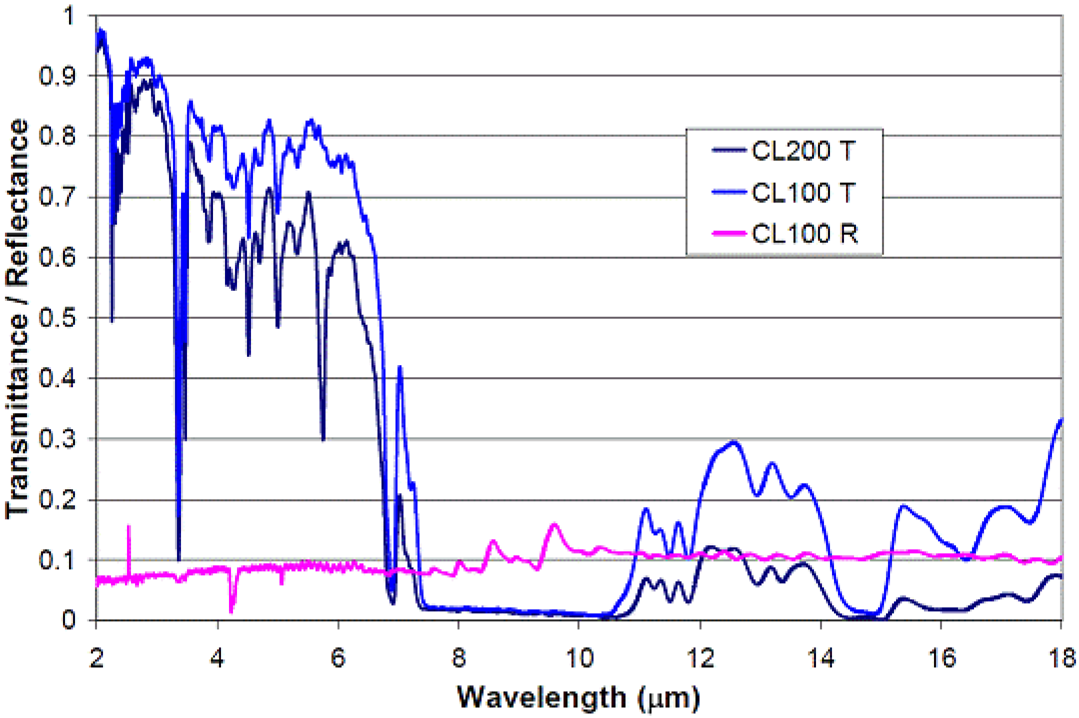
### 11.1.7 Solar Radiation Gain

The Traditional roof option is completely opaque to light and solar radiation, both inwards and outwards. It is also opaque to the transmittance of Infra Red heat energy. It therefore exhibits that there is no net radiation gain nor loss.

ETFE has unusual properties which are similar to, and yet quite distinct from, glass. This significantly complicates the analysis of the potential radiation gains and losses from this material.

ETFE has a high transparency to solar radiation within the electromagnetic spectrum at all frequencies of visible light. With appropriate treatment, this drops to around 5% at UV frequencies. In the Infra Red spectrum of frequencies (those associated with heat) it passes a proportion of the total energy, which varies with frequency, as shown on the graph below.

The graph depicts the total near-normal hemispherical spectral transmittance and reflectance (2.0 – 18.0μm) for 100 and 200μm Clear ETFE foils. Source: The Optical Properties of Vector Special Projects, ETFE Foils by M.G. Hutchins, Solar Energy Materials Research Laboratory, School of Engineering, Oxford Brookes University, Report No. 00/198, November 2000.



As visible light strikes an object, some of the energy is absorbed, some is re-radiated at light frequencies (giving the object its observed colour) and some is re-radiated as Infra Red energy. IR energy is heat radiation and is emitted from all objects at different frequencies depending upon the object's absolute temperature. In other words, all surfaces within the pool hall environment, to a greater or lesser extent, radiate Infra Red heat energy.

Neither a traditional roof, nor glass, allows Infra Red energy to pass, leaving it trapped inside. With a traditional roof, this is a positive since it is a barrier to energy loss. With a glass roof this can be a negative effect since the trapped energy is continually being topped up with further solar energy, leading to temperature build-up (akin to a greenhouse). Since ETFE loses some of the radiant Infra-Red energy, excess heat build-up is controlled to some extent.

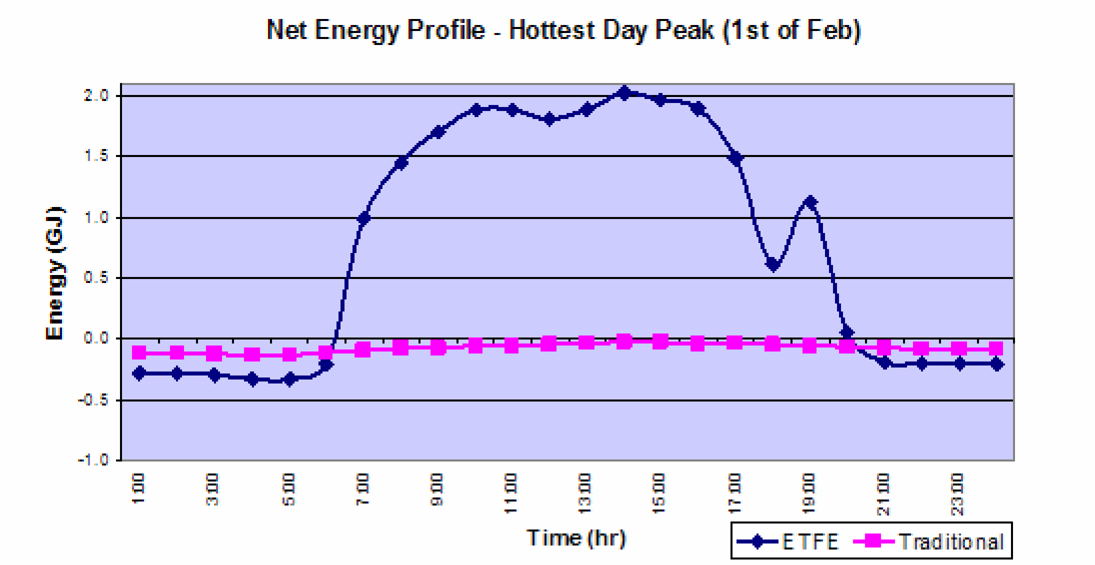
Accurate calculation of all of these factors has not been possible for a number of reasons. Whilst experimental data is available on the transmittance spectrum of various ETFE products, all data has been determined from the viewpoint of energy entering a building. No data is available on re-radiation of Infra Red energy out of a building during daylight hours, cloud conditions or black night sky. A number of assumptions have been made to arrive at representative figures. We estimate an accuracy of +/-25% has been reached.

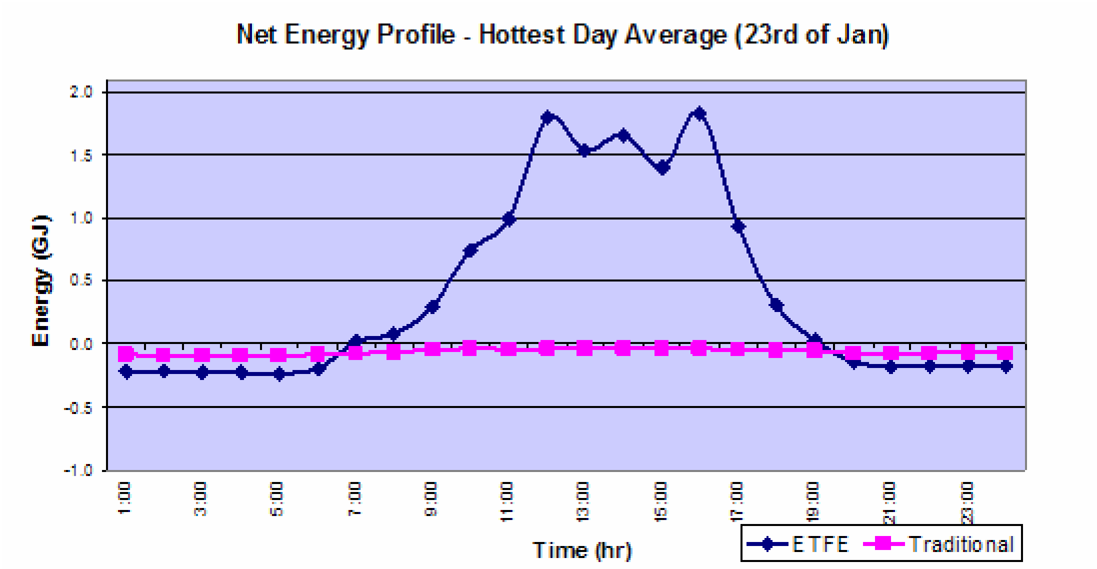
ETFE shows a considerable energy gain to the space which will offset its greater conducted thermal loss. It also shows a significant Infra Red radiation loss. These three factors have been taken together to arrive at an energy balance using real weather data on an annual basis, and this has been compared to a Traditional roof approach.

### 11.1.8 Thermal Loss versus Solar Radiation Gain

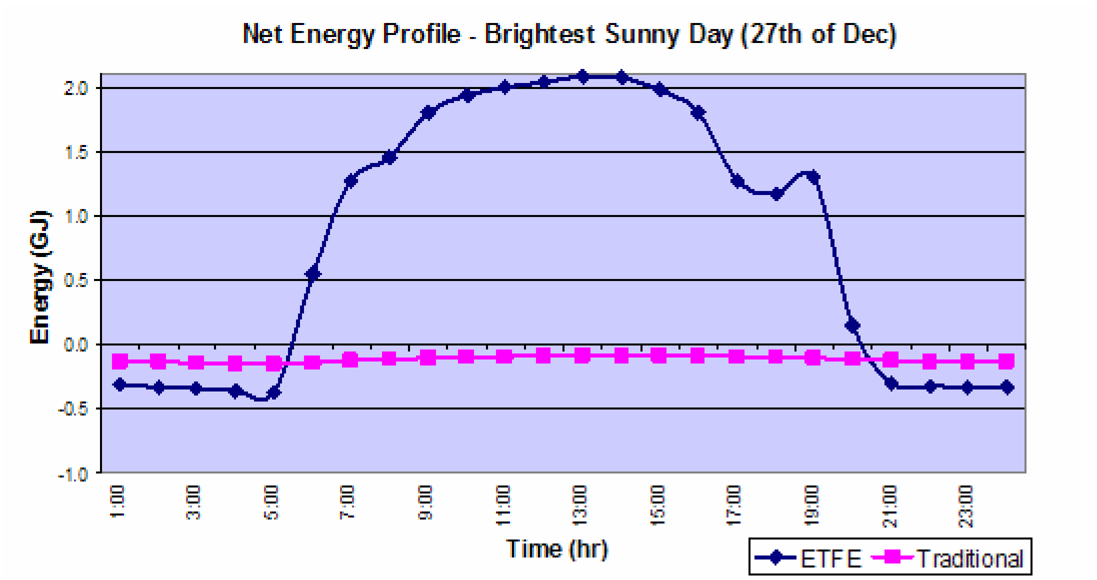
These individually titled graphs below represent the anticipated maxima and minima throughout a 24hr period, to provide visualisation of the comparative energy loss and/or gain for both options. We have identified both the average and worst case scenarios based on actual NIWA weather data for Paraparaumu Ariport.

Note: All values above zero illustrate a potential for free energy through Solar Gain

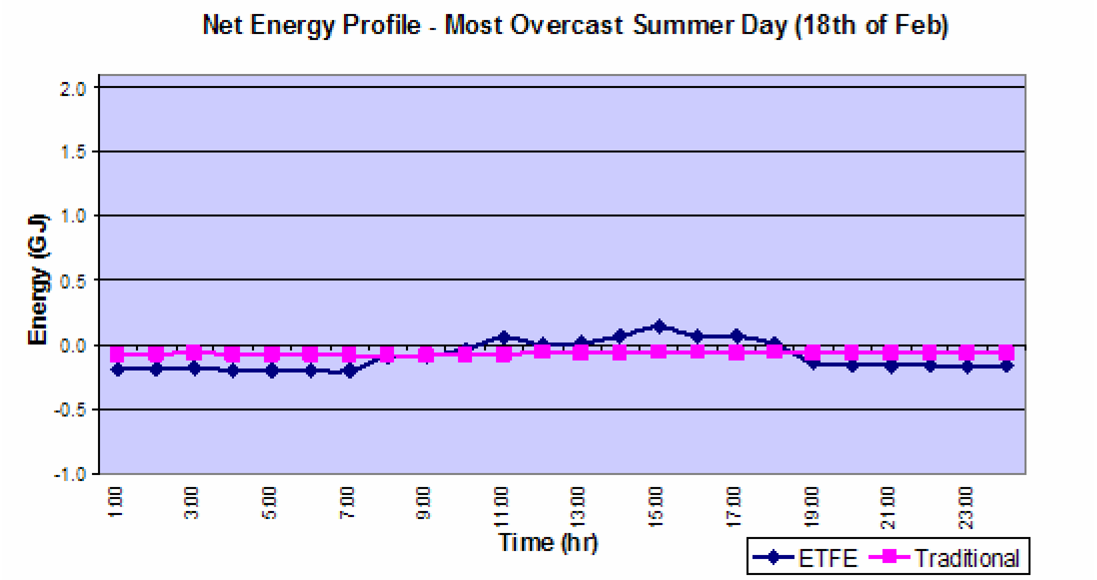




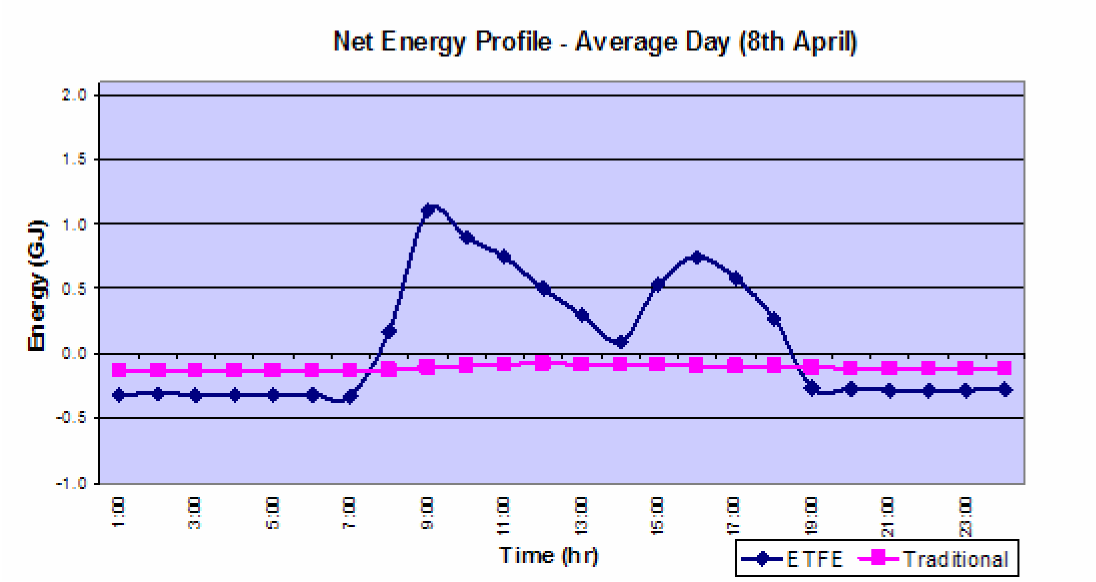
Net Energy Profile - Hottest Day Average (23rd of Jan)

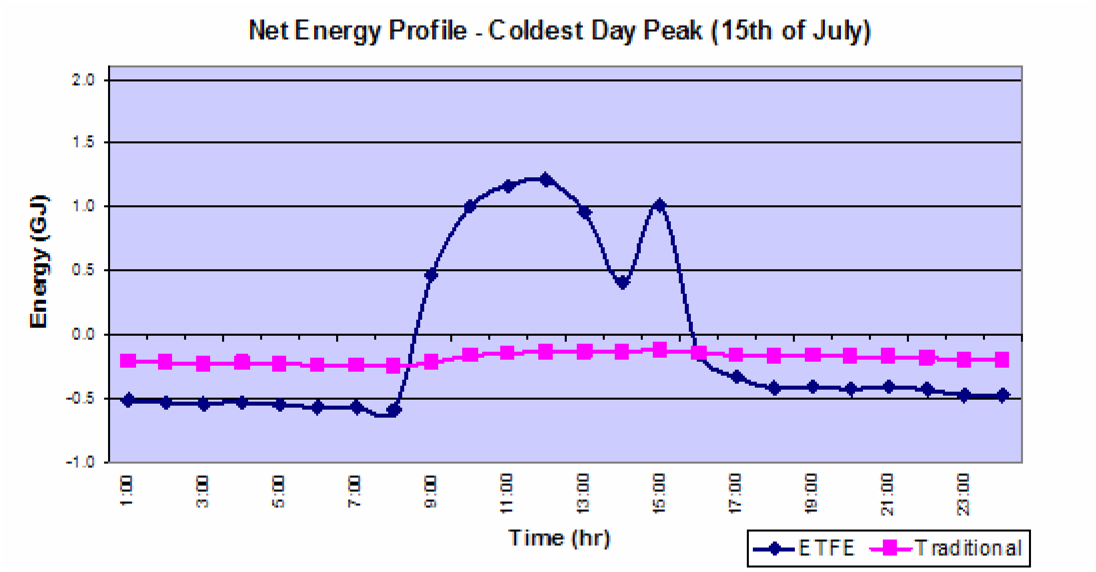


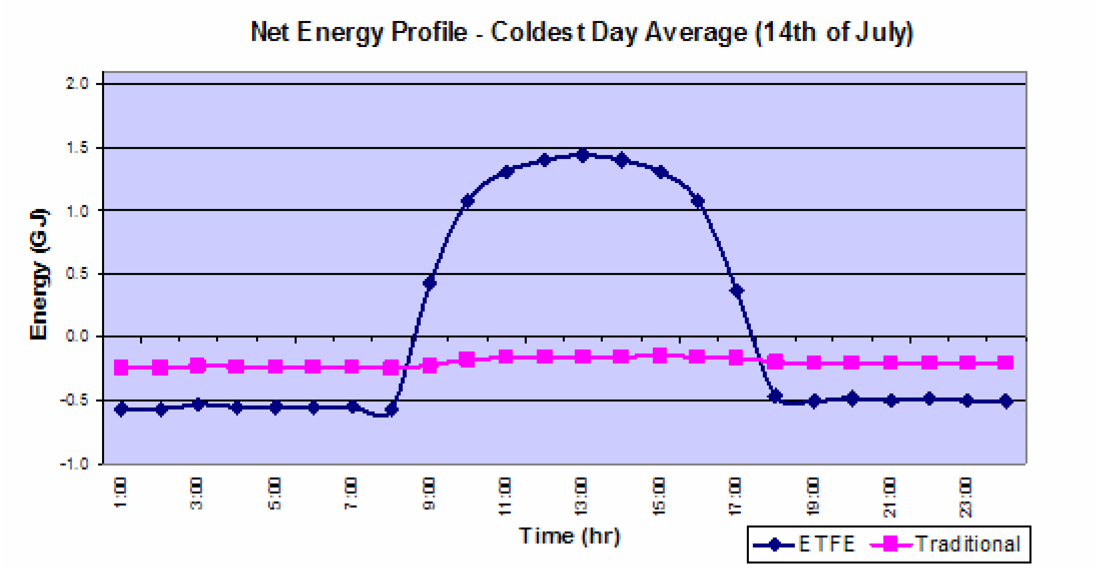
Net Energy Profile - Brightest Sunny Day (27th of Dec)

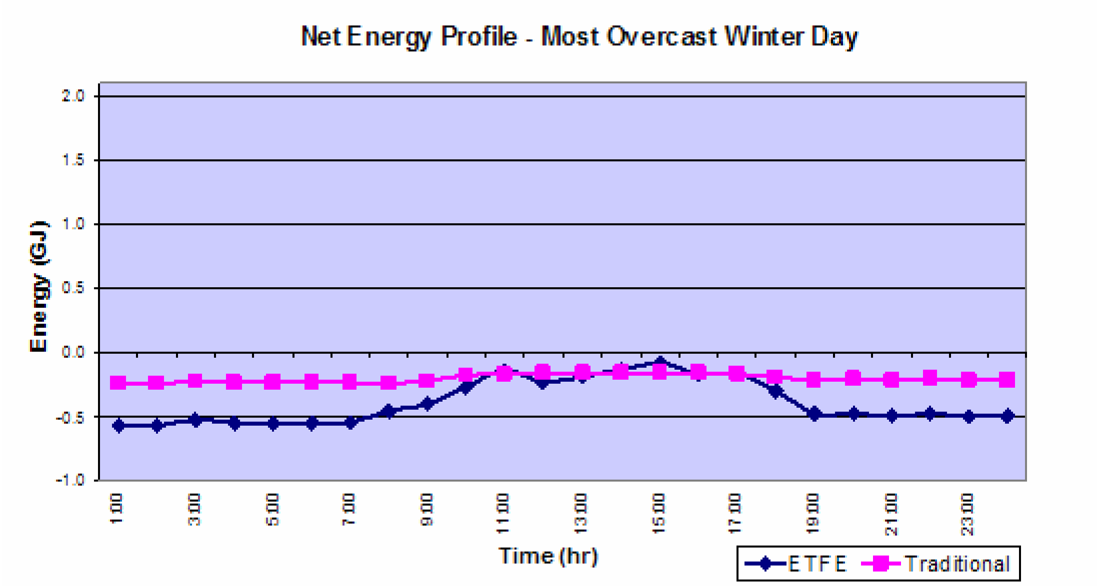


Net Energy Profile - Most Overcast Summer Day (18th of Feb)


Net Energy Profile - Average Day (8th April)
Energy (GJ)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1:00
3:00
5:00
7:00
9:00
11:00
13:00
15:00
17:00
19:00
21:00
23:00
Time (hr)
ETFE
Traditional


Net Energy Profile - Coldest Day Peak (15th of July)
Energy (GJ)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1:00
3:00
5:00
7:00
9:00
11:00
13:00
15:00
17:00
19:00
21:00
23:00
Time (hr)
ETFE
Traditional


Net Energy Profile - Coldest Day Average (14th of July)
Energy (GJ)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1:00
3:00
5:00
7:00
9:00
11:00
13:00
15:00
17:00
19:00
21:00
23:00
Time (hr)
ETFE
Traditional



It can be seen from the above graphs that for the Traditional roof option there is almost entirely a net energy loss. This to be expected since the ambient temperature will almost always be lower than the interior space temperature. The ETFE roof option shows a combination of energy gain during daylight hours and energy loss over night, with an overall net gain on the majority of graphs shown.

### 11.1.9 Heating Energy Summary

Modelling the data over a period of one year, using actual acquired local weather data, the total annual net energy balance for both options is summarised in the table below:

| | **Net Energy Balance per year (GJ)** | | |
|---|---|---|---|
| | **Radiation** | **Conduction** | **Total** |
| **ETFE** | 3448 | -2225 | 1223 |
| **Traditional** | 0.00 | -1070 | -1070 |
| **Difference** | | | **2,293** |

The above table shows that, on an annual basis, the ETFE roof option provides a net gain of 2,293 GJ of energy when compared to a Traditional roof option. If this were to replace by purchased energy at $15/GJ (for example, natural gas), it would equate to an annual energy cost saving of $34,395.

However these figure needs to be adjusted to reflect that fact that not all of this available energy is required. Also, since heat recovery is employed on both options, some of the energy cost need to be adjusted to reflect the cheaper recovered energy that's available (closer to $8/GJ). In taking these into account, we have estimated that the total usable energy gain to be closer to 1,800 GJ, at an average of $13.00/GJ, arriving at an approximate annual purchased energy cost saving of around $23,000.

This is a slight capital cost penalty associated with being able to obtain this energy saving. The HVAC plant for the ETFE option needs increase capacity, relative to the traditional option, to accommodate the increased instantaneous peak demands. In addition, the gas fired boiler which will require greater heat output. The combined increased capital cost associated with these requirements has been estimated to be in the order of $20,000.

## 11.2 ELECTRICAL AND LIGHTING

At this stage, complex computer daylight modelling of the space would require more time than is currently available. It is envisaged that modelling would be required if the ETFE option was chosen or there was a wish to gain Greenstar certification. However, sufficient modelling of the space has been carried out, to determine the number and type of luminaires that would be required to light the space when otherwise dark outside or if the space is enclosed. A manual assessment has been undertaken to establish the likely effects of daylight for the ETFE option at various times of day to assess the likely savings that can be made by reducing artificial lighting when there is sufficient sunlight available.

### 11.2.1 Pool Hall Lighting

Based upon previous successful Aquatic Centres (e.g. Alpine Aqualand in Queenstown). In the case of the ETFE option, the majority of daylight hours should require no artificial supplementary lighting as the direct sunlight is likely to provide in the order of 5,000lux. This figure will vary significantly with time of day, cloud movements and weather conditions, but it will exceed the target artificial lighting levels.

Direct lighting would be provided if the roof is ETFE. The lighting control system would make the best use of available daylight by keeping the lighting off whenever possible. During the first and last hour or so of daylight, it is estimated that lighting on one side of the pool hall would be required to reduce any strong shadowing effects. During dark very overcast days and at night, all of the lights would operate. It is anticipated that the lights would typically remain off during light overcast conditions.

Indirect lighting would be proposed if the roof is solid. This provides the best lighting solution with the least glare in this situation.

The relative glare of sunlight compared with artificial light effectively means that glare from artificial lighting is not particularly relevant for the ETFE option.

Preliminary lighting solutions and an approximate rendering of the effects within the space are enclosed for your information. Neither of these solutions includes any daylight component and the models are purely generic at this stage.

### 11.2.2 Lighting Cost Estimates

An assessment of the energy costs associated with each option is as follows.

The main parameters are as follows:

- Total daylight hours per year = 4,420 hours
- Average daylight hours per day = 12.11 hours
- Total Sunlight hours per year = 2,012 hours
- Average sunlight hours per day = 5.51 hours
- (Est) Light overcast hours per day = 4.60 hours
- (Est) Single side supplementary light per day = 2 hours
- (Est) Full supplementary light per day = 4.89 hours
- ETFE roof - Installed lighting load (kW) = 16.1 kW
- Solid roof - Installed lighting load (kW) = 19.7 kW
- (Est) Energy cost = 12c/kWh
- Assumed operating hours = 6am–9pm, 7 days

Based on the foregoing parameters and assumptions, we estimate as follows (Note: Capital cost estimate = supply & install and all figures ex GST):

- ETFE Roof – Pool Hall – Lighting:
  - Power = 16.1kW
  - Energy = 33,100kWh pa
  - Energy cost = $3972pa
- Solid Roof – Pool Hall – Lighting
  - Power = 19.7kW
  - Energy = 107,675kWh pa
  - Energy cost = $12920 pa

### 11.2.3 External Lighting

All external lighting will be designed in accordance with the requirements of the District Plan and in such a way as to minimise off site effects.

The ETFE roof option will add an element of skyglow when the facility is in use during the hours of darkness. Based upon the estimated operation hours, we envisage that this could be in the order of 3 hours per day on average – more in Winter and less in Summer. However, in our opinion, the expected skyglow should be comparable to that experienced from an outdoor sports field lit for Rugby Training. The effect of skyglow is subjective and it will be more noticeable when moisture is present in the atmosphere. However, in our opinion, the effects will be no more than minor.

### 11.2.4 Electric Power Supply

At this stage of the design it has been established that the electrical load presented by the mechanical plant will be of a similar magnitude, and there would be no cost differences between the two options for transformer and mains cabling.

## 11.3 ENERGY COST COMPARISON - HEATING AND ELECTRICAL

The findings included in this section are summarised in the following table.

| | **Traditional** | **ETFE** |
|---|---|---|
| Total energy requirement GJ/annum | Benchmark | 2,085 less |
| Total free solar energy GJ/annum available | Benchmark | 2,293 more |
| Total recovered energy GJ/annum | Benchmark | 1,800 more |
| Total purchased energy/annum | Benchmark | 2,085 less |
| Estimated purchased energy cost/annum | Benchmark | $30,200 less |
| Instantaneous peak energy requirement kW | Benchmark | 160 kW more |
| Estimated capital cost of plant | Benchmark | $20,000 more |
| Estimated Carbon evolved | Benchmark | 112.6T less |

The difference of 2,085,000MJ is equivalent to 580,000kW-hr or 580MW-hr or the equivalent annual energy use of approximately 58 houses every year. 112.6 tonnes of CO2 or the emissions from 23 cars, year on year.

## 11.4 ENVIRONMENTAL ISSUES – CARBON EMISSION FROM ENERGY USE

The more energy efficient the total HVAC plant is, the less will be the total energy use, irrespective of the source of the boost heat. The boost heat can only be supplied by burning wood, a fossil fuel or from electricity. Electricity in NZ is generated in hydro schemes supplemented by small amounts of geothermal and wind energy. The balance is generated by burning fossil fuels.

Aside from the use of wood energy, an increase in energy use therefore relies on the use of a fossil fuel as an energy source, and a consequent emission of $CO_2$ regardless of whether the fuel is burnt on site or elsewhere to generate electricity.

Heating energy from burning wood is at or near carbon neutral and any argument for the efficient use of waste wood becomes a cost issue. However there is still a compelling moral argument for the reduction of energy use, irrespective of its cost.

A full analysis of the carbon equivalent of various heating plant options will be provided in the Developed Design Report. For the purposes of this report a comparison is provided based upon a heating system using heat pump heat recovery and gas fired boost heat.

The ETFE option has been demonstrated above to require lower energy input. This is tabulated below along with its equivalent $CO_2$ emission.

The $CO_2$e factors used are the emission factors published in 2009 by the New Zealand Ministry for the Environment.

| Energy Reduction associated with the ETFE option (GJ) | Purchased Energy Replaced | MfE Emission Factor (kgCO2/unit) | $CO_2$ Equivalent (Tonnes/annum) |
|---|---|---|---|
| 1280 | Natural Gas | 54/GJ | 69.1 |
| 520 | Electricity | 0.195/kWh | 28.1 |
| 285 | Electricity | 0.195/kWh | 15.4 |
| | **Total** | | **112.6** |

Based upon an assumed heating system, the reduced energy use of the ETFE roof option translates to an annual reduction of 112.6 Tonnes of equivalent carbon emissions. Note that if boost heat were provided by the on site burning of wood, this would result in a significant reduction in carbon equivalent.

## 11.5 THERMAL COMFORT AMENITY

To enhance the amenity provided by the Kapiti Coast Aquatic Centre, a high level of perceived thermal comfort for swimmers is desirable. Factors that affect thermal comfort include space (air) temperature, relative humidity, cold surfaces, solar radiation, thermal radiation losses and drafts.

With a Traditional roof approach, thermal comfort is assured through mechanical control of the space temperature and humidity. Excessive air speeds and hence drafts are also eliminated by HVAC control. The traditional design includes some large windows to two exterior walls which will tend to feel cooler to occupants in close proximity to them, however this is unlikely to result in any thermal discomfort. Other factors are minimal. The perceived thermal comfort of spaces of this nature is generally, slightly warm to warm.

With an ETFE roof, there is a continual shift in heat losses and gains throughout a 24hour period, due to the lower R-value, high transparency to solar gain and moderate transparency to re-radiated Infra Red heat through the roof. Since the roof is a considerable size, two effects maybe apparent to the occupant; is the roof could potentially feel cool or cold at low ambient temperatures, and sun arriving on the occupant will cause the occupant to feel warmer due to radiant energy. Both of these effects are from a single direction in the space.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Fundamentals 2009 Handbook provides detailed information on thermal comfort, which is based upon experimental data and analysis. Whilst it is inappropriate to repeat all of the technical detail within this report, an overview is included to provide an understanding of the extent of importance of these effects further.

### 11.5.1 Thermal Comfort Calculation

Following actual studies, the ASHRAE thermal sensation scale has been developed based on correlations between comfort level, temperature, humidity, sex and length of exposure.

Women in this study were more sensitive to temperature and less sensitive to humidity than the men. In general about a 3 $^0$C change in temperature or a 3kPa change in water vapour pressure is necessary to change a thermal sensation vote by one unit or temperature category.

It was found that the conscious mind appears to reach a conclusion about thermal comfort and discomfort from direct temperature and moisture sensations from the skin, deep body temperatures, and the efforts necessary to regulate body temperature. In general, comfort occurs when body temperatures are held within narrow ranges, skin moisture is low, and the physiological effort of regulation is minimised.

It was also concluded that at high humidity, thermal sensation alone is not a reliable predictor of thermal comfort. The discomfort appears to be due to the feeling of the moisture itself, increased friction between skin and clothing with skin moisture, and other factors.

The ASHRAE thermal sensation scale is shown below:

| | |
|---|---|
| +3 | Hot |
| +2 | Warm |
| +1 | Slightly warm |
| 0 | Neutral |
| -1 | Slightly cool |
| -2 | Cool |
| -3 | Cold |

Calculations have been carried out for the proposed options for Kapiti Coast Aquatic Centre, following ASHRAE methods. The calculations have been based on exposure times of between 1 and 3 hours and average air speeds within the pool hall not exceeding 0.2m/s. The results indicate that the pool environment lies between “slightly warm” to “warm” for people wearing a t-shirt (spectators and pool staff). Swimmers who are wet and have low metabolic rate (for example, jumping into the pool and jump out straight away) are likely to find the pool environment slightly cool. Swimmers who have wet skin and have spent a while moving around in the pool are likely to find the pool environment neutral; however, the transition from the pool to the pool environment may cause the swimmer to feel slightly cool.

We conclude from the above that the Traditional roof option will provide good thermal comfort. Further effects must be considered in addition to the above to demonstrate the thermal comfort amenity provided, particularly by the ETFE option. These are shown below:

#### 11.5.1.1 Drafts

A study of the effect of air velocity over a person’s body found that there was no thermal discomfort from air speeds of 0.25 m/s or less (assuming a neutral environment). Since in both options the HVAC plant will control air flows within the pool hall, with a target 0.25m/s terminal velocity at the occupied spaces and pool surface, it is unlikely that there will be any dissatisfaction as a result of perceived drafts.

### 11.5.1.2 Thermal non-uniform conditions and local discomfort

A person may feel comfortable as a whole but still feel isolated discomfort if one or more parts if the body are too warm or too cold. Non-uniformities may be due to a cold window, a hot surface, a draft, or a combination of these. Even small variations in heat flow cause the body's thermal regulatory system to compensate, thus increasing the physiological effort of maintaining body temperatures. Most people are fairly insensitive to small non-uniformities.

Thermal non-uniform conditions do not apply to the Traditional roof option other than localised areas of glazing to exterior walls.

The ETFE roof option increases the likelihood of thermal non-uniform conditions due to the lower R-value, high transparency to solar gain and moderate transparency to re-radiated Infra Red heat through the roof. The relative effect of these is discussed below.

### 11.5.1.3 Point Source Thermal Radiation

It has been shown that people are more sensitive to local effects caused by an overhead warm surface than by a vertical cold surface. The influence of an overhead cold surface or a vertical warm surface is much less. Other studies of clothed persons in neutral environments found thermal acceptability unaffected by radiant temperature asymmetries of 10 $^0$C or less and comfort unaffected by asymmetries of 20 $^0$C or less.

For the ETFE roof option we conclude from the data available that an overhead cold radiant surface (e.g. winter during darkness or overcast conditions), whilst perceived by occupants as a cold surface, it is likely to cause minimal dissatisfaction to occupants. We also conclude that an overhead warm radiant surface (e.g. mid-day summer sun) will certainly be perceived; however, since it is unlikely that radiant temperature asymmetries will exceed 10 $^0$C, there is a low risk that thermal discomfort will be experienced by occupants. This can be mitigated against through localised shading.

This effect is negligible in the Traditional roof option.

### 11.5.1.4 Vertical Air Temperature Difference

It has been determined that a head level air temperature lower than that at ankle level is not as critical for occupants as vice versa, and that occupants can generally tolerate much greater differences if their heads were cooler.

For the ETFE roof option, an overhead cooler air temperature is possible during winter low ambient conditions, and whilst perceived by occupants, the effect is likely to be benign. During prolonged sunny days and concurrent higher ambient temperatures it is possible that solar energy through the roof will lead to elevated temperatures at head height with respect to feet. There is a low risk of some perceived thermal discomfort under these conditions. This will be mitigated by the use of high level opening vents.

There is no likelihood of either of these occurrences with the Traditional roof option.

### 11.5.2 Summary

The Traditional roof option will provide a thermally comfortable environment throughout the year, generally perceived to be between slightly warm to warm.

The ETFE roof option will also provide a perceived slightly warm to warm thermal comfort level. It is apparent that the conditions within the ETFE covered pool hall option will somewhat emulate a “covered outdoor pool” combining the benefits of indoor pool space conditions with the benefits of natural sunshine, with the small risk that  comfort levels may be comprised at isolated times on days of extreme cold or hot weather. These effects can be mitigated against by the introduction of discrete local secondary shade sails. The extent will be evaluated further in the second phase of the developed design.

# 12 ACOUSTICS

## 12.1 TRADITIONAL OPTION

The normal approach to both enhance and control acoustic performance in the pool hall environment is to use a quality acoustic system to line the internal ceiling spaces. We propose to use Asona Triton 50™ is a 50mm thick ISO class A high sound absorbing ceiling panel with Sonatex™ composite facer for robust durability and a clean white finish.

- It is Ideal for applications that require additional low Hz absorption, large volume spaces or direct fix
- It offers very high sound absorption, Class A, αW 1.0, NRC 1.00
- The durable resilient Sonatex™ facer resists damage from moderate impact; chip, crack, puncture resistant.

The system is required to be mounted of counter battens below secondary timber purlins.

## 12.2 ETFE OPTION

Texlon Cushions have a very low mass. For this reason they tend to be acoustically relatively transparent. This means that the foils will not reflect sound back done into the space, limiting the amount of reverberation and enhancing the internal perceived environment.

For this reason no additional acoustic treatment is deemed to be required on the foil cushions.

There is generally a perceived higher risk of noise disturbance from rainfall on the ETFE cushions as opposed to a traditional roof. There is a rain suppression system available to mitigate against such noise, and this can be retrofitted if this ever deemed to be an issue. In practice this system are very rarely ever fitted and any disturbance only becomes an issue in quieter environments such as libraries. For this reason it is felt that there is low risk on disturbance from rain.

## 13 EVALUATION MATRIX

| | Options | | | |
|---|---|---|---|---|
| | | A | B | |
| **Building Attributes** | | **Traditional** | **ETFE** | **Comments** |
| **Architecture** | | Normal | **Higher Level** | Option B: Unique, Iconic, increase visitor experience |
| **Structural Efficiency** | | Bench Mark | **Higher** | Option B: Lightweight, flexible, reduced mass |
| **Site Planning** | | Same | Same | |
| **Heating, Ventilation & Energy Performance** | Energy Consumption | Bench Mark | **Saving of 2293GJ /Per Annum** | Option B: Offer ability to use free heat for the sun |
| | Energy Cost Per Annum | Bench Mark | **$23K Saving** | Option B: Offers energy savings form reduced heating and lighting |
| | Capital Cost | Bench Mark | +20K Additional Cost | Option B: increase boiler size to cover potential energy peaks |
| | Thermal Control | Excellent | Very Good | Both Option Linked to BMS system to fully control indoor environment. Option A slightly easier to control |
| **Lighting & Electrical requirements** | Electrical Energy Consumption | Bench Mark | **Saving of 285GJ /Per Annum** | Option B: Reduced artificial lighting requirement due to daylight |
| | Electrical Energy Cost Per Annum | Bench Mark | **$9K Saving (12cents/kWh)** | Option B :Provides 70% electrical cost saving |
| | Capital Cost | Bench Mark (Uses higher wattage uplighters) | Potential Savings | Option B: Reduced size of lamps down lighters are more efficient |
| **Indoor environmental quality** | Daylight | Very Limited | **Maximised/ Optimised** | Option B: Maximised natural light, Amount tuned to suit needs |
| | Thermal Comfort | Very Good | Good | Option A slightly is easier to control |
| | External Views | Limited | **Maximised** | Option B: Maximised Connection with external environment through roof and walls |
| **Envelop: Maintenance & Warranties** | Maintenance Costs of Cladding | $7K per annum | $5.5K per annum | Similar Maintenance costs associated with both |

| | | | | |
|---|---|---|---|---|
| | Warranty Period for Cladding | 2 years Workmanship, 15 years Material | **25 years for** (whole system) | Option B: Increased performance |
| | Design Life of Cladding | 15 year King Span | **+35 years ETFE** | Option B: Cladding has extended Design Life |
| **Durability** | | Bench Mark | Higher | Option B: Cladding is extremely Durable |
| **Construction/P&G Costs** | Ease of Buildability | Medium | **Higher** | Option B: Offer s simplified construction |
| | Transportation & Crainage Costs | Bench Mark | **Lower** | Option B: Approximately 70 Tonnes saving in Material weight of pool hall envelop required to be Transported and Lifted |
| | Build Programme | Bench Mark | **Shorter** | Option B: Ease of erection and Parallel Trades - Estimate at least a month reduction in programme |
| **Greenstar** (evaluated in separate report) | Potential Rating | 4 to 5 | **5+** | Option B: Offers lower energy use, Natural daylight, Increased amenity, More sustainable materials, lower embodied energy, less materials etc |
| | Material Usage | Medium | **Lower** | Option B: Offer significant saving in volume of materials required to form building envelop |
| | Embodied Energy | Medium | **Lower** | Option B: Offer significant saving in embodied energy |
| **Misc Running costs** | Additional Running Costs for Cladding | None | $165 NZD per annum electrical | Option B: small inflation unit requires same electricity as a light bulb |
| **Asset Value** | | Medium | **Higher** | Option B: Increased performance |
| **Risk** | | Normal | Slightly Higher | Option B: Slightly increased risk due new system in NZ |
| **Marketability** | | Normal | **Higher** | Option B: Attributes above will help raise National awareness |
| **Comparative Capital Costs** | | Bench Mark | +$**200K Additional Cost + Plus $90k extra Contingency** | Option B: Higher Performance incurs a cost. |
| **Overall Energy Savings** | | Bench Mark | **$32K per annum** | Option B: Offers Significant energy savings. Estimate payback period at 7-8 years |

## 14 SUMMARY

The objective of the evaluation process was to establish the advantages and disadvantages of the two options Traditional versus ETFE and the present the associated economic effects. The report seeks to use the Traditional approach as the bench mark and provide an evaluation of the ETFE option, relative to this.

Based on this approach, in our opinion the latter appears to provide some significant advantages over a Traditional approach, particularly in the following areas: Architecture, structural efficiency, energy savings, electrical and lighting costs, increased performance and durability, indoor environment, buildability and construction.

However, there is a premium associated with the increase building attributes provided by the higher performance ETFE Option, and hence an effect on bottom line figures.

In summary the net effect of opting for the ETFE option can be outlined as follows and is expressed, relative to the Traditional approach:

| | |
|---|---|
| Overall Capital Cost Difference for ETFE: | +190,000NZD + GST (Increase) + $90,000 extra contingency over the Traditional |
| Estimated Year on Year Energy Cost Differences (per annum): | +32,000NZD+GST (Saving) |

The Council and Trust need to review all of the attributes, costs and savings outline in the report and come to their own decision as to the best approach to adopt for KCAC.

## 15 DRAWINGS

(Refer separate A3 document):

### ASC ARCHITECTS DRAWINGS

### STAGE 1 – TRADITIONAL OPTION

| | |
|---|---|
| 100 | Stage 1 Traditional Option |
| 101 | Ground Floor Plan – Stage 1 |
| 102 | Upper Floor Plan – Stage 1 |
| 103 | Ground Floor Plan – Stage 1&2 |
| 104 | Elevations |
| 105 | Aerial view from South |
| 106 | Aerial view from East |

### STAGE 1 – ETFE OPTION

| | |
|---|---|
| 100 | Stage 1 ETFE Option |
| 101 | Ground Floor Plan – Stage 1 |
| 102 | Upper Floor Plan – Stage 1 |
| 103 | Ground Floor Plan – Stage 1&2 |
| 104 | Elevations |
| 105 | Aerial view from West |
| 106 | Aerial view from East |

### LHTDESIGN DRAWINGS

### **STAGE 1** – MAIN POOL HALL

### TRADITIONAL OPTION

| | |
|---|---|
| T550 | Roof Framing Plan |
| T565 | Structural Sections A & B |
| T566 | Structural Sections C & D |
| T567 | Structural Sections E & F |
| T568 | Structural Sections G |
| T570 | Key Structural Details |
| T571 | Key Structural Details |
| T572 | Key Structural Details |
| T573 | Key Structural Details |

### ETFE OPTION

| | |
|---|---|
| E301 | Foundation Plan |
| E320 | Foundation Details |
| E510 | Column Set Out |
| E550 | Roof Framing Plan |
| E551 | Roof Framing |
| E552 | External Elevations |
| E565 | Sections A-A & B-B |
| E590 | Gridshell Rafter Elevations |
| E591 | Gridshell Rafter Details |

| | |
|---|---|
| E592 | Gridshell Eaves Connection Details |
| E593 | ETFE Foil Roof Connections |
| E594 | Timber Eaves Beam Details |

## COMMON FEATURES

## MECHANICAL

| | |
|---|---|
| 600 | F&T Schematic |
| 610 | F&T Reticulation |
| 630 | Pool Layouts |
| 635 | Pool Sections |
| 700 | HVAC System Schematic |
| 705 | Proposed HVAC layout |

# 16 ADDENDUM

## KCAC INITIAL DEVELOPED DESIGN COST PLAN BY RAWLINSONS