

Cape Paterson Ecovillage: Zero Carbon Study Peer Review

Prepared for The Cape Paterson Partnership
and Sustainability Victoria

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Cape Paterson Partnership
ABN: 17083059850

Zero Carbon Study Peer Review is a Victorian Government initiative. It was commissioned by Sustainability Victoria and produced in partnership with the the Alternative Technology Association, the Moreland Energy Foundation, The Master Builders Association, Beaumont Concepts and TS Constructions.



About this study

This study was commissioned to test key assumptions and outputs of a Zero Carbon Study prepared for the Cape Paterson Partnership [herein referred to as undertaken by 'the authors'].

This study consists of an:

- Analysis of the calculations and assumptions used to determine the star ratings of the sample house designs
- Analysis of the calculations and assumptions used to determine the construction costs of the sample houses
- Analysis of the calculations and assumptions used to determine the energy savings and zero emissions status of the precinct
- Analysis of the benefits to residents and community identified by the authors
- An evaluation of the project's feasibility and likely benefits to residents

About the author

Anthony (Tosh) Szatow (herein referred to as 'the reviewer') has worked as an independent consultant, consumer advocate and research scientist in the field of distributed energy for more than five years. He has worked with large and small companies to develop emission reduction strategies including undertaking energy audits, feasibility studies and developing energy modelling and scenario analysis tools. His work has included peer review of distributed energy modelling tools, consulting outputs to property developers and extensive analysis of barriers and enablers of efficient local energy systems with the CSIRO and CUAC. Further details are available at www.toshszatow.com





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Foreword: Zero Carbon Study Peer Review by the Alternative Technology Association

Now more than ever, Australia needs showcase developments like the Cape Paterson Ecovillage to practically demonstrate that the achievement of high ecologically sustainable design (ESD) outcomes is both environmentally sound and makes absolute economic sense.

With the debate over carbon pricing still circling around at both community and Federal Government levels, we cannot be sure as to exactly where and when this fundamentally necessary policy reform will land. And yet increasingly we know, through evidence-based analysis and on-the-ground practice that over the longer term, ESD is increasingly economic when it comes to built form, transport, electricity generation, water management and the general health and well-being of our communities.

This peer reviewed study by the Cape Paterson Ecovillage team is one of the best indicators yet of the increasing 'truth' of ESD strategies.

With energy efficiency saving households money over time; with the continued falling costs of renewable energy; the evolution of electric vehicles and rising costs of grid supplied water and electricity set to continue over the next decade, a lifecycle assessment approach is no longer an innovative way to consider how to best to achieve a high star rated building – it is now an absolute imperative that individuals, communities and developers think in these terms, for the benefit of clients, businesses and the environment.

The Alternative Technology Association (ATA) is proud to have been involved in the evolution of this project, and glad to have been able to make a contribution to the technical analysis in our own small way. Climate change, and related environmental challenges will fundamentally only be solved by communities, working together on the ground to try and better understand, develop and implement the solutions needed to achieve greater sustainability in our development and our lifestyles.

The Cape Paterson Ecovillage project, and the development of this report, is a fantastic example of this type of community approach in action. The ATA and our members commend it to you as a best practice approach towards valuing ESD initiatives into the future.

Ian Porter
Chief Executive Officer
Alternative Technology Association



Foreword: Zero Carbon Study Peer Review by the Moreland Energy Foundation

Moreland Energy Foundation Limited (MEFL) is a not-for-profit organisation dedicated to sustainable energy. Working with the community, we use the best available expertise to create practical demonstrations of local sustainable energy solutions. We also undertake research and consulting, and advocate on energy efficiency, renewable energy and related policy and planning issues.

MEFL has a strong track record in delivering sustainable energy research in the housing sector for Federal and State Governments, including the Department of Climate Change and Energy Efficiency, Sustainability Victoria, and the Victorian Building Commission. Through these projects, we have become intimately aware of the need for robust and comprehensive analysis of energy and cost issues in residential development.

MEFL's involvement in the Cape Paterson project was initiated by our support for the project's fundamental ambition of creating a new approach to sustainable urban development, and the innovative modelling and analysis that the proponent was willing to undertake to deliver on this ambition. MEFL was pleased to have the opportunity to contribute to the study's design, provide relevant background literature, and assist in the peer review of the study's outputs.

The Zero Carbon Study is a leading example of research and analysis into the impacts, costs and benefits of delivering low-carbon residential developments. The project's incorporation of a broad range of sustainability and energy considerations including housing size, building thermal performance, appliance selection, energy systems, private transport and more, has allowed a comprehensive assessment of the benefits delivered by improvements and innovation to be undertaken. The firm integration of these issues with analyses of lifecycle affordability, not merely upfront capital costs, means the study is breaking new ground in understanding the interaction between low-carbon development and affordability.

The project's exploration of new and integrated approaches to energy efficiency, energy management and onsite energy generation as part of residential development has the potential to create widespread industry change. MEFL is highly supportive of this approach, as we believe a shift from Victoria's current centralised energy system to include a greater uptake of distributed renewable energy generation and grid interactive technologies is vital to achieving low-carbon energy and energy affordability for the future.

MEFL congratulates the developer, authors and contributors to this study on an impressive piece of analysis. The Zero Carbon Study raises the bar for future consideration of sustainable energy issues in the residential development sector, and should be seen as a catalyst for broader industry change.

Paul Murfitt
Chief Executive Officer
Moreland Energy Foundation

1 Acknowledgements

This report is an independent assessment of the value of sustainability features proposed for the Cape Paterson Ecovillage, conducted for Sustainability Victoria through a \$10,000 grant as part of the Zero Emissions Neighbourhood program. The report has also benefited from valuable in-kind support provided by Sustainability Victoria.

The report has also benefited from advice and feedback from the contributors to the original Zero Carbon Study, including the Alternative Technology Association, Moreland Energy Foundation, Master Builders Association, Beaumont Concepts and TS Constructions. In particular the report has benefitted from support and feedback by Peter Reefman from Energised Homes, Portland, Victoria. His time and insights are greatly appreciated.

The original zero carbon study was based on a predicted household energy model produced by Peter Reefman of Energised Homes and Chris Barnett of Third Skin Architecture, and the Cape Paterson Ecovillage Sustainable Housing Guidelines 2010 produced by Peter Reefman of Energised Homes. Both the model and guidelines benefited from advice, feedback and contributors including the Alternative Technology Association, Moreland Energy Foundation, Master Builders Association, Beaumont Concepts and TS Constructions.

We acknowledge the beautiful local Cape Paterson images provided by photographers Sandy Scheltema (sandys@mmnet.com.au) and Warren Reid from Coast Magazine (www.coastmagazine.net)

Any errors that remain herein are the reviewer's alone.



2 Disclaimer

Forecasting building, or precinct level energy performance and cost implications, is subject to making assumptions. In particular, the choices and behaviour of residents can significantly influence the degree to which modelled building energy performance matches real energy outcomes. While necessary to do as part of feasibility scoping, assumptions and forecasts will only be as robust as the commitment and delivery model for implementing a project, particularly the extent to which it engages, educates and encourages residents to manage energy efficiently.

In simple terms, this review of the Zero Carbon Study originally conducted by the authors aims to develop a 'line in the sand' from which the development proposed at Cape Paterson can be assessed. This 'line in the sand' aims to represent the worst of the likely development scenarios given the performance specifications set for each dwelling, so that assumed costs and benefits of the project remain conservative.

3 Executive summary

The Cape Paterson Ecovillage has set ambitious targets for energy, water and other dimensions of sustainability including zero operating emissions for all homes, and enabling zero emission electric vehicles (EVs). The reviewer finds these targets are achievable and do not entail onerous costs on purchasers when evaluated over the lifecycle of sustainability features. In the vast majority of instances, features proposed for the ecovillage provide substantial net financial benefits to complement significant environmental benefits.

When compared to a standard new home, across a range of future energy and water price scenarios, the reviewer finds that before cost reductions associated with a bulk build program are factored in, sustainability features proposed for the Cape Paterson project will provide investment returns of between 5.9% and 10% after tax based on future energy and water savings. Should capital costs associated with sustainability features assumed in this report come down 20%¹ with a bulk build program, after tax rates of return increase to between 7.2% and 11.2%.

Compared to a new 6-star house of the same size, Cape Paterson buyers could save between 2.5 years and 5.5 years on a 25 year mortgage when in-home energy and water savings accrued by virtue of sustainability features are used to accelerate mortgage repayments². Cumulative savings on energy bills and mortgage payments could exceed \$300,000 under the high future price scenario modelled in this study³. Naturally financial benefits will vary depending on future energy and water price scenarios, the final delivery cost for sustainability features, mortgage variables and other factors specific to each home buyer.

Compared to staying in the pre-existing Victorian home modelled in this review, or buying a new home of 250m², a 200m² Cape Paterson home is extremely valuable. The value of future energy and water savings are equivalent to having \$58,000 compared to an existing home, or \$70,000 for a new home of 250m² including build cost reductions, in the bank today, guaranteed to mature at 6% after tax⁴.

It is also worth noting the value of sustainability features appear to be recognised in the market, and that this is likely to increase with mandatory disclosure of home energy performance. Research conducted in the Australian Capital Territory⁵ suggests the value of a home increases by about 3% for each additional performance star rating. This means the value of a Cape Paterson home may be more than 4.5% greater than a standard new home built to a 6-star rating.

In order to provide a clear understanding of how value in the project is derived, the reviewer has broken down costs and benefits by specific sustainability features. However it is important to remember the building program, customer engagement process, design process, household sizes and final delivery model will influence the viability of the different solutions being implemented and if executed well, should further improve development's financial viability.

¹ Based on conversations with product suppliers, energy consultants and builders, such cost reductions across sustainability features are plausible

² This calculation does not include the value of an electric vehicle

³ This calculation includes the value of an electric vehicle

⁴ The scenario 2 energy and water prices have been used to derive these figures. EV use is not included in this analysis

⁵ See <http://www.nathers.gov.au/about/publications/pubs/eeer-house-price-act.pdf>





Sustainability features included in this assessment are:

- Minimum 7.5-star rating for all homes
- Minimum 2.5kW solar photovoltaics (PV), but sized to at least cover the energy demand of a home over 20 years
- Space heating and cooling systems with coefficient of performance of 4.5
- Evacuated tube solar hot water system with an efficient electric heat pump boost containing a greenhouse-neutral refrigerant
- 10,000l rainwater tank
- EV

Due to the likely influence of subjective taste on product selection, the following sustainability features proposed for the development not assessed include:

- Efficient cook-tops
- Efficient entertainment systems
- High efficiency lighting

In all future price scenarios assessed, the starting price for in-home energy is assumed to be 80c per day, 25c/kWh for peak use and 13c/kWh for off-peak use. Price increases are assumed to flow through to standing charges and usage charge equally. Forecast energy prices do not explicitly contain a future carbon price and appear possible without carbon pricing. The starting price for liquid fuel is assumed to be \$1.45l and energy used by EVs is taxed at 15%. The starting price for water is assumed to be \$1.39kl. High rainfall years are assumed to have greater than 900mm per annum and low rainfall years are assumed to have less than 650mm per annum. These have been inferred from Bureau of Meteorology rainfall data.

Scenarios are described in the tables below:

Table 1: Scenario 1 assumptions

	Price rise per annum – years 1-5	Price rise per annum – years 6-10	Price rise per annum – years 11-20	Net household cost increase in real terms to 2025 (3% CPI)
In-home energy	8%	5%	3%	31.5%
Transport energy	4%	5%	6%	130%
Water	15%	5%	3%	135%

Table 2: Scenario 2 assumptions

	Price rise per annum – years 1-5	Price rise per annum – years 6-10	Price rise per annum – years 11-20	Net household cost increase in real terms to 2025 (3% CPI)
In-home energy	9%	6%	3%	43%
Transport energy	5%	7%	9%	170%
Water	20%	10%	7%	270%

Table 3: Scenario 3 assumptions

	Price rise per annum – years 1-5	Price rise per annum – years 6-10	Price rise per annum – years 11-20	Net household cost increase in real terms to 2025 (3% CPI)
In-home energy	10%	7%	3%	56%
Transport energy	6%	10%	15%	267%
Water	30%	15%	10%	493%

It is noted that forecasts for energy and water prices and their tariff shapes may vary substantially based on future state and federal government policies, and other variables. Future price scenarios used in this study are primarily designed to test sensitivity of the Cape Paterson development to a range of possible future scenarios rather than provide a definitive view on forward prices and tariff shapes.

Results presented in Table 4 below compare the proposed Cape Paterson homes to three benchmarks. Benchmark 1 is a pre-existing Victorian home with a 4-star building fabric⁶, all electric off-peak hot water system and heating/cooling systems with coefficient of performance (COP) of 2.8/2.6 respectively. Benchmark 2 is a new Victorian home with 6-star building fabric, combined flat plate solar and electric storage hot water system, 2000l rain tank and heating/cooling systems with COP of 3.6⁷. Benchmark 3 is the same as benchmark 2 but has a larger footprint by 50m². This means it costs more to build, heat and cool but is comparable to benchmark 2 in every other way. For comparative purposes, all heating/cooling systems are assumed to be wall-mounted split systems⁸.

A discount rate of 6%⁹ on future energy savings was used to derive net present value. Therefore where net present value is positive, the rate of return on Cape Paterson sustainability features are greater than a 6% after tax return on investment.

Results presented in Table 4 below assume homes are 200m², with three bedrooms, four occupants and 80% net conditioned floor area, noting benchmark 3 has an additional 50m² footprint. It is noted the Cape Paterson development encourages homes to be no larger than 200m² and many homes may be smaller than this. Results in Table 4 exclude the use of an EV. It is worth noting here that no explicit technology subsidy beyond a clean energy premium of 5c/kWh for solar generation has been assumed. Full details underpinning modelling outputs are provided in the body of the results section of the report.

Table 4: Net present value of Cape Paterson home compared to benchmarks

	Energy scenario 1	Energy scenario 2	Energy scenario 3
Benchmark 1	\$54,985	\$58,780	\$62,870
Benchmark 2	\$195	\$3,300	\$8,250
Benchmark 3	\$67,350	\$70,570	\$75,630

6 It is noted this star rating is well above the Victorian average for existing building stock. This star rating has been chosen to ensure conservative modelling outcomes.

7 It should be noted new homes are required to have either a 2000l rain tank or solar hot water, not both.

8 It is worth noting that depending on customer preferences, a 7.5-star home may only require ceiling fans and small radiant heaters. This would result in additional capital and operating cost savings in Cape Paterson homes when compared to the alternative houses modelled in this report.

9 6% was chosen to reflect a benchmark for a reasonable after tax return on money invested in sustainability features





The following table provides a more detailed breakdown of the value of Cape Paterson sustainability features compared to Benchmark 2, specifically their internal rate of return in response to future price scenarios.

Table 5: Internal rate of return by project elements

Cape Paterson feature	Scenario 1	Scenario 2	Scenario 3	Additional capital cost
3.4kW Solar PV, no EV (EV)	12.8%	13.6%	14.5%	\$13,450
Heating system	12%	12.7%	13.5%	\$335 ⁸ per unit
Cooling system	12%	12.7%	13.5%	\$115 per unit
Hot water system	5.3%	6%	6.7%	\$3,000
Star rating	-0.3%	0.05%	0.5%	\$16,000
10,000l water tank⁹	15%	18%	25%	\$1000

Analysis of EVs has been separated from analysis of the homes as EVs will be an option for residents. The EV is assumed to have a highway driving range of at least 160km and on average, consume 12.5kWh per 100km. Benchmark car 1 is assumed to cost \$22,000 and consume 8l/100km. Benchmark car 2 is assumed to cost \$45,000 and consume 4l/100km. All vehicles are assumed to drive the same distance, 18,000km each year. Electricity prices paid to charge the EV are assumed to increase in line with in-home energy price Scenario 2. Charging is 20% at peak times, 80% at off-peak times. However it is noted the Ecovillage plans to generate the equivalent amount of energy used by EVs from PV. This is likely to reduce the charging cost in reality when compared to this analysis, as the levelised cost of PV generation is lower than the assumed rates for charging.

Full details of assumptions are available in the results section of the report. A summary of results are presented in the table below.

Table 6: Internal rate of return for EV options modelled

Cape Paterson feature	Scenario 1	Scenario 2	Scenario 3	Additional capital cost
New EV vs keeping benchmark car 1	1.2%	3.4%	6.9%	\$50,000
New EV vs keeping benchmark car 2	-5.5%	-3%	0.9%	\$50,000
New EV vs new benchmark car 1	6.3%	8.6%	12.1%	\$28,000
New EV vs new benchmark car 2	15.7%	19%	23.5%	\$5,000

¹⁰ It is assumed two split system units will be needed in Benchmark 2 and Cape Paterson, and that they serve the same thermal load, despite Cape Paterson having a lower thermal load in practice. This creates an equal basis on which to compare the value of improving the efficiency of heating/cooling systems alone. In reality, the Benchmark 2 home may require a greater number of split system units and so have higher capital costs, while the Cape Paterson home, due to lower thermal load, will realise relatively lower operating savings. In this way, assuming they serve the same thermal load is likely to have little impact on the IRR calculation. Costs are split according to the proportion of heating and cooling demand, 75% and 25% respectively.

¹¹ The results presented in this table are an average of value across high and low rainfall years for high and low water users. It is noted that higher water users in Cape Paterson realise greater value from their tanks than low users.

A number of key project elements are worth highlighting for further consideration as the project matures:

- The anticipated high penetration of solar PV and EVs may place strain on the local electricity distribution infrastructure, but may also create opportunities to alleviate constraints on the network. Further work will be required to understand how best to manage energy assets and infrastructure across the ecovillage. This research could be usefully applied to other precinct scale energy solutions and so may have value to the broader market should it be funded and made available to the market
- The products and their prices specified for modelling in this review may be subject to change as new products come to market and prices fall. This may further improve the business case for the Cape Paterson proposition
- The commercial model underpinning the delivery of proposed sustainability features will influence forecast costs and benefits. The project may benefit from exploring a range of implementation models such as a standard, single dwelling solution paid for up front by home buyers, to a precinct scale energy management model fully or partially owned and operated by local residents in partnership with a professional 3rd party service provider. Should the 3rd party service provider be tasked with educating households, creating incentives for energy conservation and managing performance of energy systems, the zero carbon objective for the precinct may be more likely to be maintained in the long run. The reviewer notes recent work published by Sustainability Victoria on business model innovation that may help inform options¹²
- It is assumed zero carbon energy outcomes will be achieved through onsite PV generation only. Over time, as households change size and their energy demands change, the original size of PV systems may not be sufficient to ensure net zero operating emissions or may provide surplus. Again, business model innovation, for example an onsite energy management company, can help ensure such variations over time are managed by either increasing onsite generation or buying greenpower from the grid when necessary
- Assessing the average cost difference between 6-star and 7.5-star homes is difficult to do without detailed, final designs and orientations. Primary costs associated with improving thermal performance include upgrades to windows and insulation, and having to polish concrete slabs used as internal thermal mass, to enable them to be exposed to direct sunlight without compromising aesthetics. As part of its building design review Floyd Energy has indicated achieving 7.5-star can often be done at no or very low cost provided the core building design is appropriate. However customer preferences may compromise design focussed on optimising thermal performance. The reviewer recommends the Cape Paterson project use a collaborative design process involving architects, customers, engineers and builders so that design solutions are fully informed by the perspective of each party. This should streamline the design process and help realise cost efficiencies in achieving the desired performance objectives



¹² See http://www.sustainability.vic.gov.au/resources/documents/Business_Models_For_Enabling_Sustainable_Precincts_Research_Report_v2.pdf



4 Method

To test the claims of the Cape Paterson Zero Carbon Study, a number of tasks were undertaken:

- Assessment of forecast building energy consumption of two concept house designs using building modelling software, undertaken by Floyd Energy consultants
- A detailed review of modelling underpinning the anticipated savings claims made by the authors of the original zero carbon study. This included identifying and testing key assumptions; establishing robust benchmarks for Cape Paterson homes; and cross checking all other data inputs against publicly available data for validity
- Cross-checking building cost assumptions by seeking alternative quotes from the market and reviewing publicly available data on building material costs

It should be noted that some key assumptions at the time the original Zero Carbon Study was developed, such as feed in tariff rates, have since become obsolete to due changes in policy and that other assumptions while necessary to make for this review may become obsolete in the future.

5 Results

5.1 Concept design performance assessment and building costs

Building performance assessment was carried out by Floyd Energy.

The objective of the assessment was to independently assess two concept designs submitted to the Cape Paterson Partnership by Beaumont concepts in terms of modelled energy performance and star rating. The assessment also aimed to explore costs associated with meeting the 7.5-star objective.

The designs do not represent actual homes to be built at Cape Paterson, rather they were submitted as concepts to assist with the design process and learning for the project. Given designs are subject to change in the future, it is difficult to discern the costs associated with meeting the 7.5-star objective at this stage in the design process.

For these reasons, the review by Floyd Energy has been used to provide indicative guidance on the anticipated energy performance and cost of design features only. Based on this, the reviewer has made an initial conservative assessment of likely costs associated with meeting the 7.5-star objective. However ultimately, an iterative process between designers, architects, energy consultants and builders will be required to develop design solutions that meet the performance objective at least cost.

For this project, Floyd Energy used CSIRO's AccuRate building thermal performance software for its improved materials libraries, revised climate data, updated occupancy settings and its ability to simulate the buildings thermal performance over 8,760 hours (a year).

Any errors caused by misinterpretation of results provided by Floyd Energy and/or designs submitted by Beaumont Concepts should be attributed to the reviewer.

Concept House 1: Beaumont Concepts



Concept designs were provided for testing by Beaumont Concepts, a Wonthaggi-based building design and architectural consultancy. The construction cost of this home has been estimated by TS Constructions, a Wonthaggi-based builder. The following table summarises design and specifications provided by Beaumont Concepts and suggested revisions made to designs and specifications made by Floyd Energy. Cost estimates for price differentials have been made by the reviewer based on price estimates provided by Floyd Energy and independent market quotes.





Beaumont Concepts	Floyd Energy amendments and feedback	Reviewer assessed price differential	Rationale for Floyd Energy amendments
Climate zone 21	Suburban Climate zone 64		Better reflect coastal and wind influence on thermal performance
Windows to be timber framed, double glazed Gen 30: Timber/uPVC double-glazed: supertoned/12 Argon gap/low-e: U = 2.35: SHGC = 0.3	G30 product not available on the market. Set window performance to a typical WERS rated product: Uw2.74 SHGC 0.63 (glazed clear/12mm air-gap/clear equivalent to Canterbury double glazed windows and sliding doors - clear/12mm air-gap/clear) The percentage of windows to floor area is 33%. The performance of the building could be improved by reducing the area of windows to approx 25%.	Saving of approximately 30%	Low E coating would be an additional 30% over the double glazing cost. In the current scenario we haven't used Argon Low E because the Canterbury product performs equally well to the Generic software figure for double glazed argon
External wall insulation to reach R2.5 + anti glare bubble wrap	2.5 batts to external walls, including thermal mass wall	Approximately \$500	No anti-glare bubble wrap – will not work effectively in the wall system specified
Ceiling insulation to reach R6.0 + anti glare bubble wrap	R4.0 to ceilings adjoining roof spaces R4.0 to cathedral ceilings (min 80mm space required for rigid board insulation) Reflective foil directly under roof surface	Save approximately \$2000	Ceiling insulation – R4.0 glass wool. Cost starts to increase over 4.0 because it is not produced in large volume over 4.0 Ceiling insulation R4.0 (178mm thick)– Used because of assumed space limitations in roof space, particularly over living areas, and because it is the thickest batt produced in high volumes, therefore economically priced. If there is room in the roof space a 50mm glass fibre roof blanket could be added directly under the colourbond. The weight of this is not taken by the plaster ceiling. This would increase the Star Rating of Concept 1 to 7.6-Star. The alternative if space is an issue is a closed cell foam board (R4.0 is 80mm thick). This board is close to 10x more expensive than glass fibre batts.
Fully insulated slab edges	Insulate the ground floor slab R1.0 (equivalent of a waffle slab)	\$0	Cost neutral between a standard slab and a waffle pod slab
Weather seal external doors & windows	Sealed external doors and windows	\$0	No difference
Sealed exhaust fans	Sealed exhaust fans Add ceiling fans to living areas and bedrooms	\$100	
n/a	Include solid timber external door to hallway	\$200	
Tiles to utility, laundry, kitchen and ensuite (9m ²)	Tiles to utility and ensuite, carpet elsewhere. Floor coverings have a minimum 17.5m ² of tiled floor area in the kitchen/meals/lounge area	\$270	The additional floor coverings will help improve thermal performance
	No recessed down-lights to ceilings adjacent to roof spaces or cathedral ceilings	n/a	No difference
	For simulation purposes no allowance has been made for overshadowing by adjacent buildings	n/a	No difference

Initial modelling results undertaken by Floyd Energy are as follows:

Heating	Cooling	Total	Stars
83.8 MJ/m ²	10.1 MJ/m ²	93.9 MJ/m ²	6.9

The reviewer notes this result is broadly line with self-assessment conducted by Beaumont Concepts. However Beaumont had a reduced net conditioned floor area which resulted in a higher self-assessed star rating.

Floyd Energy Comments:

These scores indicate that the dwelling will not require significant additional conditioning in either summer or winter. This is due to the following:

- Effective use of solar azimuth [position of the sun relative to due north] and elevation angles [height of the sun] allowing solar access in the winter, while excluding summer sun
- Thermal mass acts as a heat storage
- Small proportion of external walls are exposed to the east and west sun.

Floyd Energy azimuth review:

The following table illustrates the impact of rotating the building (with upgrades to windows, slab, fans and floor coverings). The azimuth is the direction that the front door is facing, meaning when the front door faces east, the azimuth is 90 degrees.

Deg.	Nom.	Total MJ/m ²	STAR
0	N	97.3	6.8
22.5	NNE	91.9	7
45	NE	87	7.2
67.5	ENE	81.5	7.3
90	E	78.5	7.4
112.5	ESE	78.7	7.4
135	SE	82.2	7.3
157.5	SSE	86.4	7.2
180	S	92.7	6.9
202.5	SSW	99.8	6.8
225	SW	104.9	6.6
247.5	WSW	105.7	6.6
270	W	105.2	6.6
292.5	WNW	105.4	6.6
315	NW	105.6	6.6
337.5	NNW	102.4	6.7





Total cost difference between the 6-star and 7.5-star design provided by Beaumont Concepts, is estimated at \$27,000 by TS Constructions. In this estimate, a difference of \$11,000 for polishing concrete floors is allowed for. This estimate is based on a one-off build and so appears high given the core design of the home is fundamentally sound. However some important points to note include:

- Specifications in the quote estimate made by TS Constructions, the design specifications made by Beaumont and the recommendations of Floyd Energy are not all directly comparable. For example, TS Constructions assume R5 insulation in the ceiling and aluminium window frames with thermal breaks whereas Beaumont specified R6 in the ceiling with Gen30 timber windows double glazed and a low e coating. Floyd Energy has recommended R4 in the ceiling and an alternative window system
- Builders costs are likely to come down with a bulk construction program and as supplier quotes are confirmed as orders

Original designs for concept house two were provided for testing by Beaumont Concepts, a Wonthaggi-based building design and architectural consultancy. The construction of this home has been estimated by TS Constructions, a Wonthaggi-based builder. A summary of inclusions made by Beaumont Concepts, amendments made by Floyd Energy and indicative cost differences are detailed in the table over page:



Beaumont Concepts	Floyd Energy amendments	Price differential	Rationale
Climate zone 21	Suburban Climate zone 64	n/a	Better reflect coastal and wind influence on thermal performance
Windows to be timber framed, double glazed Gen 30: Timber/uPVC double-glazed: supertoned/12 Argon gap/low-e: U = 2.35: SHGC = 0.33	G30 product not available on the market, would be very expensive even if it was Set window performance to a typical WERS rated product: Uw2.74 SHGC 0.63 (glazed clear/12mm air-gap/clear equivalent to Canterbury double glazed windows and sliding doors -clear/12mm air-gap/clear) The percentage of windows to floor area is 33%. The performance of the building could be improved by reducing the area of windows to approx 25%.	Saving approximately 30%	Low E coating would be an additional 30% over the double glazing cost. In the current scenario we haven't used Argon Low E because the Canterbury product performs equally well to the Generic software figure for double glazed argon. Windows 1,2,3,5 to be 88% openable (equivalent to awning). Windows for ventilation to kitchen east wall 1x 400hx1200w, 1x 400hx600w 88% openable
External wall insulation to reach R2.5 + anti glare bubble wrap	2.5 batts to external walls, including thermal mass wall	Save approximately \$600	No bubble wrap – will not work effectively in the wall system specified
Ceiling insulation to reach R6.0 + anti glare bubble wrap	R4.0 to ceilings adjoining roof spaces R4.0 to cathedral ceilings (min 80mm space required for rigid board insulation) Reflective foil directly under roof surface	Save \$2000	Ceiling insulation – R4.0 glass wool. Cost starts to increase over 4.0 because it is not produced in large volume over 4.0 Ceiling insulation R4.0 (178mm thick)– Used because of assumed space limitations in roof space, particularly over living areas, and because it is the thickest batt produced in high volumes, therefore economically priced, also weight on plaster ceiling. If there is room in the roof space a 50mm glass fibre roof blanket could be added directly under the colourbond. The weight of this is not taken by the plaster ceiling. This would increase the Star Rating of Concept 1 to 7.6-star. The alternative if space is an issue is a closed cell foam board (R4.0 is 80mm thick). This board is close to 10x more expensive than glass fibre batts.
Fully insulated slab edges	Insulate the ground floor slab R1.0 (equivalent of a waffle slab)	\$0	Neutral between a standard slab and a waffle pod slab
Sealed exhaust fans	Sealed exhaust fans Add ceiling fans to living areas and bedrooms	\$100	Ceiling fans have been added to assist with natural air flow and in-home comfort levels
N/a	Include solid timber external door to hallway	\$200	
Tiles to utility, laundry, kitchen and ensuite (9m ²)	Tiles to utility and ensuite, carpet elsewhere. Floor coverings – Have a minimum 17.5m ² of tiled floor area in the kitchen/ meals/lounge area	\$270	The additional floor coverings will help improve thermal performance



Beaumont Concepts	Floyd Energy amendments	Price differential	Rationale
	No recessed down-lights to ceilings adjacent to roof spaces or cathedral ceilings	n/a	
	For simulation purposes no allowance has been made for overshadowing by adjacent buildings.	n/a	No difference
	Delete courtyard		Improves winter solar access and reduces external wall surface area
	Insulate rammed earth wall core with 50mm EPS. Cannot be insulated with R2.5 if the surface is not clad		Specified insulation will not work effectively in wall system specified

Initial modelling results for concept house 2 undertaken by Floyd Energy are as follows:

Heating	Cooling	Total	Stars
131.3 MJ/m ²	12.5 MJ/m ²	1438 MJ/m ²	5.6

Floyd Comments:

These scores indicate that the dwelling will achieve reasonable thermal comfort but will not achieve the target of mid 7-stars even with recommended upgrades. This is due to the following:

- The core design does not allow for efficient solar access in the winter, while excluding summer sun
- A large proportion of external walls are exposed to the east and west sun
- There are Large areas of external walls in proportion to the building volume

Floyd Azimuth Review

The following table illustrates the impact of rotating the building (with upgrades to windows, slab, fans and floor coverings). The azimuth is the direction that the front door is facing.

Base scenario				With upgrades 1-6			
Deg.	Nom.	Total MJ/m ²	STAR	Deg.	Nom.	Total MJ/m ²	STAR
0	N	153.1	5.3	0	N	129.2	5.9
22.5	NNE	153.9	5.3	22.5	NNE	130.4	5.9
45	NE	153.9	5.3	45	NE	130	5.9
67.5	ENE	153.4	5.3	67.5	ENE	129.7	5.9
90	E	152.4	5.4	90	E	128.2	5.9
112.5	ESE	152.4	5.4	112.5	ESE	127.8	5.9
135	SE	154.3	5.3	135	SE	127.7	5.9
157.5	SSE	155.7	5.3	157.5	SSE	250	5.9
180	S	158.4	5.2	180	S	129	5.9
202.5	SSW	155.7	5.3	202.5	SSW	127.3	5.9
225	SW	150.6	5.4	225	SW	124.1	6.1
247.5	WSW	146.7	5.4	247.5	WSW	121	6.2
270	W	143.8	5.6	270	W	119.4	6.2
292.5	WNW	142.4	5.6	292.5	WNW	118.9	6.2
315	NW	143.8	5.6	315	NW	120.1	6.2
337.5	NNW	148	5.4	337.5	NNW	124.1	6.1

Total cost difference between the 6-star and 7.5-star design provided by Beaumont Concepts, is estimated at \$25,000 by TS Constructions. In this estimate, a difference of \$11,000 for polishing concrete floors is allowed for. However some important points to note include:

- As per concept design 1, specifications in the quote estimate made by TS Constructions and the design specifications made by Beaumont Concepts are not all directly comparable
- Concept home 2, as assessed by Floyd Energy, has some fundamental design characteristics to accommodate buyer preferences that limit its thermal performance. Amending designs may be more cost effective than enhancing specifications for windows, insulation and/or other features
- Should a customer have particular aspirations for the design of their home, amendments suggested by Floyd Energy such as removing courtyards space may be difficult to achieve in practice
- Builders costs are likely to come down with a bulk construction program

To develop a sense of the likely price differential between 6-star and 7.5-star homes, the reviewer has tried to isolate premiums that vary with home size and costs that are relatively fixed.

Fixed costs are primarily concrete floor polishing with a minimum spend required to bring polishing equipment to site. Costs such as windows, ceiling insulation and wall insulation will vary with home size, all other design features being equal.

The reviewer suggests a conservative estimate of \$4,000 fixed costs with a 3% premium on a base building cost of \$2000m², based on the footprint of the home, is reasonable at this stage in the project. This would suggest an additional cost of approximately \$16,000 for achieving the 7.5-star rating in a home of 200m².

However it must be noted Floyd Energy has indicated verbally that going from 6-star to 7.5-star may be possible at no cost given best practice core design features, meaning the premium for building 7.5-star may reduce substantially.

5.2 Benchmarks modelled, key assumptions and future price scenarios

The following section establishes benchmarks to compare the proposed sustainability features of the Cape Paterson home against and tests assumptions underpinning the performance of the Cape Paterson home. Performance assessment of the Cape Paterson home relative to benchmarks across a range of future scenarios is provided in section 5.3.3.

5.2.1 The three benchmark homes

Establishing benchmarks to compare the performance of Cape Paterson homes against is critical to ensuring a robust assessment of claims made in the Zero Carbon Study. In this review, benchmarks are broken down across sustainability metrics of stationary energy, water and transport energy. Three Victorian homes benchmarked for energy consumption are described below.

a) Stationary energy consumption

To benchmark against the Cape Paterson homes, the authors of the original zero carbon study used data on household energy consumption and costs from Wilkenfield, the Sustainable Energy Authority of Victoria, the Victorian Energy Efficiency Target discussion paper, National Australian Built Environment Rating System (NABERS) and other sources of public data.

The authors assumed an average Victorian home without gas consumes approximately 20kWh a day, with 25% of the thermal load being used for cooling and 75% used for heating.

The reviewer notes the authors of the first zero carbon study inferred net energy use by dividing the cost of all energy consumption by the peak rate. However when assessed with hot water energy use at the off-peak rate, net consumption is substantially increased. They also assumed relatively low use of fixed and plug-in appliances compared to the modelled Cape Paterson home.





To ensure consistency across benchmarks, the reviewer has kept the number and use of fixed and plug-in appliances constant across all homes modelled. It should be noted that heating and cooling systems are not included in the fixed appliance category.

Plug-in appliances include three televisions with DVD systems, a gaming system, three laptop computers, a coffee machine, blender, toaster and bathroom appliances. Fixed appliances include a fridge, dishwasher, oven, cook-top, microwave, exhaust fans and a rain water tank pump. Assumed use of cooking facilities is sufficient to cover in-home meal preparation daily which may overstate consumption in the modelled homes compared to Victorian averages.

The reviewer has re-calculated the benchmark pre-existing home energy use from first principles, drawing on publicly available data for Victorian homes with adjustments to ensure assumptions are conservative. This benchmark is important for establishing the case for an existing home owner to move into a new home with specifications comparable to the Cape Paterson homes. Key assumptions underpinning this benchmark are as follows:

- 160 net conditioned square meters - 80% of a 200sqm home¹³
- 4-star building shell with default AccuRate settings for deriving energy demand based on net conditioned area¹⁴
- Four full time occupants
- Climate zone 64
- 180l hot water demand per day in a 300l storage tank requiring 34.7MJ per day including 15% losses. Demand is met by an all electric off-peak hot water system with efficiency of 75%¹⁵
- Heating/cooling load met by wall mounted split systems with COP 2.6 for cooling, 2.8 for heating¹⁶
- 75% thermal load for heating, 25% for cooling
- 30 individual light fittings consuming approximately 40W per fitting

The breakdown of energy use and costs in the benchmark 1 home is as follows.

Table 7: Breakdown of assumed load in benchmark home 1

Load type	kWh	% of load
Heating/cooling	3,558	28%
Hot water	4,686	37%
Lighting	1,353	11%
Fixed appliances	1,438	11%
Plug-in Appliances	1,526	12%
Total	12,561	

Department of Human Services (DHS) Utility Consumption data suggests that the average energy use of an all electric Victorian house with four or more people is approximately 12,500 kWh/yr. Given the Cape Paterson climate zone and conservative assumptions for plug-in appliance usage, the reviewer believes 12,561 kWh/yr is a reasonable benchmark for comparing the performance of a Cape Paterson home to a pre-existing home being occupied and used in the same way.

¹³ The average Victorian home is approximately 150sqm, but has only 2.6 people.

¹⁴ The reviewer notes this is well above the average star rating for current building stock in Victoria. However a high assumption helps ensure conservative modelling outcomes. The reviewer also notes AccuRate settings may overstate actual energy use as they assume conditioned areas stay within a given temperature band, whereas in reality home occupants may allow internal temperatures to rise above or fall below that band

¹⁵ Hot water loads are inferred from the reviewers first principle modelling, cross-checked against Wilkenfield and consultants, 2005, data from DHS, 2007 and the Office of the Renewable Energy Regulator

¹⁶ Assumed coefficient of performance for existing housing stock has been inferred from sales weighted average figures for heating and cooling appliances from 2008 and through dialogue with Sustainability Victoria

However given Cape Paterson is a new home, a further benchmark has been chosen for analysis. The second benchmark is a new home built to regulated minimum building standards. Key assumptions are as follows:

- 160 net conditioned square meters - 80% of a 200sqm home
- 6-star building shell with default AccuRate settings for deriving energy demand based on net conditioned area
- Four full time occupants
- Climate zone 64
- 160l hot water demand per day with a 300l storage tank requiring 30.8 MJ per day including 15% losses. 70% of demand is met by a flat plate solar collector, the residual by an electric storage unit charged at off-peak rates with 75% efficiency
- Heating/cooling load met by wall mounted split systems with COP 3.6 for cooling, 3.6 for heating¹⁷
- 75% thermal load for heating, 25% for cooling
- 30 individual light fittings consuming approximately 32W per fitting

Table 8: Breakdown of assumed load in benchmark home 2

Load type	kWh	% of load
Heating/cooling	1567	23%
Hot water ¹⁶	1249	18%
Lighting	1062	16%
Fixed appliances	1438	21%
Plug-in Appliances	1526	22%
Total	7259	

The final benchmark for comparison chosen is a new home built to minimum regulatory standards, but with an additional 50m² footprint. While likely to entail a higher lighting load, it is assumed the increased footprint affects the heating and cooling load only, as well as the initial build cost. This results in an additional 430kWh per year.

Establishing benchmarks in this way ensures that variation in energy demand across benchmarks is primarily due to differences in building fabric, heating/cooling system efficiency and water heating system efficiency. This is appropriate given they are typically major loads within the home, relatively non-discretionary and subject to performance criteria in the Cape Paterson development.

The reviewer notes the new home benchmark is also assumed to have improved lighting efficiency relative to the pre-existing home benchmark reflecting regulatory standards, and that Cape Paterson homes aim to further improve on this.

b) Water consumption

Data provided by the Department of Sustainability and Environment¹⁹ suggest average water consumption for homes in the Wonthaggi/Cape Paterson/Inverloch district are about 200l per person, per day (199l in 2008, 204l in 2009)."

However average consumption per person will be influenced by the number of occupants in a home as water use in the garden, typically a major water use, is likely to be independent of the number of household occupants. Without detailed data on household occupancy for the district, a reasonable comparison on a per person basis becomes difficult to discern.

¹⁷ Assumed coefficient of performance was chosen to represent the new minimum performance standard for systems below 4kW capacity, as of 2011.

¹⁸ It should be noted that for new Victorian homes, developers have a choice to install a 2000l rain tank or a solar hot water system. This new benchmark home assumes both features are installed.

¹⁹ See <http://www.water.vic.gov.au/saving/towns/household-water-consumption>





For the purpose of this study, the author has assumed the pre-existing and new benchmark homes for comparison with Cape Paterson consumes 160l per person, per day. This is likely to correct for the above average number of occupants in the homes modelled. It should also be noted the relative value proposition of the Cape Paterson home improves if the benchmark homes consume less water, and so this contributes to conservative modelling outcomes.

c) Water harvesting

Establishing a benchmark for the amount of water harvesting across Victoria is not possible due to a lack of data. Therefore to establish a benchmark for water harvesting in Victoria, the reviewer has assumed a typical new home will install the minimum 2,000 litre rain tank required by regulations, plumbed to the toilet and garden and so servicing about 30% of daily demand.

d) Transport energy

Establishing a benchmark for comparison for transport is problematic given Cape Paterson proposes to facilitate EVs. Their limited range creates a fundamentally different utility value to the owner. It is also complicated by unknown existing driving patterns and how these may change on moving to Cape Paterson.

For the purpose of this comparative analysis, electric and liquid fuel vehicles are compared on a like for like basis. That is, it is assumed EVs specified for the ecovillage will be able to meet all travel demands equivalent to liquid fuel vehicles.

While this assumption may appear generous to EVs, it should be noted that studies of vehicle use typically show the vast majority of vehicle kilometres driven are for journeys below 100km, and most of those are less than 60km. In this range, EVs offer comparable services to liquid fuel vehicles. Furthermore, the EVs proposed for Cape Paterson will be able to reach Melbourne on one charge and access charge points in Melbourne CBD and/or inner suburbs.

Four benchmarks for comparing the value of EVs have been chosen. One is the purchase of a new 'low' efficiency car in lieu of the EV. The other is the purchase of a new 'high' efficiency car in lieu of the EV. The third and fourth is to continue driving a 'low' or 'high' efficiency car. Key assumptions are as follows:

Table 9: Summary of benchmark transport assumptions

	Capital cost	Fuel efficiency	Annual maintenance
New 'low' efficiency car	\$22,000	8l/100km	\$750
New 'efficient' car	\$45,000	4l/100km	\$750
EV	\$50,000	12.5kWh/100km	\$250

It is also assumed the EV option entails an additional \$10,000 outlay compared to the liquid fuel option in year 10, representing a new vehicle upgrade. Batteries are replaced in year 7 and 14. Further assumptions are detailed in the results section of this report.

5.2.2 The Cape Paterson Ecovillage

The following section provides an overview of key assumptions made by the authors of the original Zero Carbon Study and reviews these assumptions to identify where costs or benefits may have been over or underestimated.

The Cape Paterson home mandates 7.5-star building fabric and encourages a high efficiency standard for all internal thermal systems including a solar hot water system boosted with a high efficiency heat pump and a minimum PV array size of 2.5kW or 5kW should a home be coupled with an EV. Minimal use of down-lights, use of LEDs and use of light sensors for transient locations are encouraged. Induction cook-tops are required and no electric blankets are allowed. A 10,000 litre water tank is also specified.

The following sections test assumptions behind modelled energy consumption and production, water harvesting, and transport energy use.

a) Stationary energy consumption

The authors have broken down forecast energy consumption in the Cape Paterson homes by heating/cooling, hot water, lighting, fixed appliances and plug-in appliances. The authors' list of fixed and plug-in appliances is exhaustive and includes rainwater tank pumps, games consoles, three televisions, DVD player, food blender, coffee machine and phone chargers. They have allowed sufficient use of an oven, cook-top and microwave for most, if not all cooking to be done in the home over the course of a year.

As discussed previously, the reviewer has ensured all assumptions other than building fabric, thermal system efficiency and lighting systems are the same across all homes modelled. A breakdown of forecast energy consumption in the Cape Paterson home is provided below:

Table 10: Breakdown of assumed load in Cape Paterson home

Load type	kWh	% load
Heating/cooling	750	18%
Hot water	138	3%
Lighting	304	7%
Fixed appliances	1438	35%
Plug-in Appliances	1526	37%
Total energy	4226	

Key assumptions are as follows:

- 160 net conditioned square meters - 80% of a 200sqm home
- 7.5-star building shell with default AccuRate settings for deriving energy demand based on net conditioned area
- Four full time occupants
- Climate zone 64
- 160l hot water demand per day with a 300 litre storage tank requiring 30.8 MJ per day including 15% losses. 80% of demand is met by an evacuated tube solar collector²⁰, the residual by an electric heat pump unit with coefficient of performance of 4.5 using off-peak rates 100% of the time
- Heating/cooling load met by wall-mounted split systems with COP 4.5 for cooling, 4.5 for heating²¹
- 75% thermal load for heating, 25% for cooling
- 24 individual light fittings consuming approximately 13.5W per fitting

On balance, assumed energy consumption for Cape Paterson homes appear relatively conservative, and could be substantially less in practice particularly if the village attracts more environmentally conscious buyers that reduce their use of plug-in appliances.

b) Stationary energy production

The Cape Paterson homes require a minimum 2.5kW PV array. The authors' have assumed 3.8 peak sun hours in Cape Paterson giving an annual production of 3467.5kWh from the minimum system size. They have made no allowance for losses in conversion from DC to AC power, performance de-rating or capital replacement (the inverter) over time. They assumed a feed in tariff would be available, but this policy has since lapsed.

Combined, the above factors have lead to an overestimation of benefits from onsite PV generation in the original Zero Carbon Study.



²⁰ Product suppliers typically suggest 80% contribution by evacuated tubes is feasible. Anecdotal evidence suggests by optimising tube angles for winter solar gain, as much as 90% contribution may be possible.

²¹ Assumed coefficient of performance for represent the new minimum performance standard for systems below 4kW capacity, as of 2011.



The minimum 2.5kW system required for each home will not be sufficient to cover the energy demand in the concept Cape Paterson home modelled in this study. This highlights the need to ensure system size is configured to each individual home.

The reviewer has modelled a 3.4kW system which ensures cumulative generation will exceed cumulative demand for the modelled Cape Paterson home over the 20-year modelling period including PV performance degradation over time. Full detailed assumptions are available in the results section.

c) Water consumption

The authors have assumed a total water consumption of 325l per day in a four person home. Showers are assumed to consume 40l per person, per day with 90l used for garden irrigation. Other major uses include 50l for toilet flushing and about 27l for clothes washing.

The authors assume 0.5 washing loads per day at 55l per wash implying a 5.5-star or better washing machine with a loading capacity of 8kg and they assume around 48l per day is used for toilet flushing. They suggest the Cape Paterson homes will use about 325l per day for a four person home or 81l per day per person, substantially less than the district average.

The reviewer has labelled this a low water user, and has included analysis of a 'high' water user which is assumed to be twice the consumption of a low water user.

d) Water harvesting

The Cape Paterson Ecovillage specifies a minimum of 10,000l water tanks. The reviewer has modelled the value of water harvested across two scenarios – a high rainfall year and a low rainfall year of about 900mm and 630mm respectively. This has been inferred from historical rainfall data from the Bureau of Meteorology.

It is assumed in Cape Paterson, rain water is used for showers, toilet flushing, garden irrigation and clothes washing. This equates to about 90% of daily water demand.

e) Transport energy

It is proposed the Cape Paterson Ecovillage will facilitate EVs to enable zero emission transport. This includes an additional 2.5kW solar capacity to cover forecast additional energy demand. This EV capacity would enable a typical EV that does 8km/kWh to travel 76km per day, equivalent to a return trip to Melbourne (300km) every fourth day. This is an allowance for around 28,000km per annum.

Given the potential for car pooling between people travelling to and from Melbourne on a regular basis, it appears reasonable to assume 2.5kW of solar PV will be more than sufficient to enable zero carbon fuel for residents undertaking trips to Melbourne and locally on a frequent basis.

When modelling future transport costs and benefits, the authors did not account for capital replacement costs over time resulting in an overestimation of benefits. This has been amended by the reviewer with full details noted in the results section of this report.

The reviewer has assumed the annual vehicle distance travelled is 18,000km and that charging is done at grid prices with a clean energy premium of 5c/kWh, as opposed to the levelised cost of PV. This avoids the potential that charging off PV systems may distort the financial analysis of EVs. It should be noted that the more a vehicle is driven each year, the better the Cape Paterson Ecovillage proposition becomes.

5.2.3 Energy futures

A number of claims are made by the authors about how the Cape Paterson homes will result in stationary energy and transport energy cost savings over time for residents. These claims were made based on operating costs only and did not consider difference in capital costs.

It is assumed that Cape Peterson homes, with PV systems sized to cover in-home energy use and EV charging requirements are effectively zero cost to run. This may be a conservative assumption given PV generation will be at peak times, while significant consumption including EV charging is likely to be off-peak at lower tariffs.



Two scenarios were modelled by the authors in which stationary and transport energy costs were assumed to increase over time at rates of 5% and 10% each year. The authors made no distinction between fixed energy costs and variable energy costs based on energy use. As noted previously, the authors make no allowance for capital replacement, for example of batteries in the EV or inverters for the PV system.

Modelling future energy scenarios is an inherently complex and contestable exercise. Future energy policies, technology breakthroughs and more broadly, changing economic conditions over time will significantly affect the real and relative cost of energy over time. There is also uncertainty over the extent to which price increases will apply across peak and off-peak rates uniformly as retailers have a degree of flexibility with how they pass through network costs.

To peer review the authors' modelling assumptions in an efficient way (that is, without modelling from first principles), the reviewer draws on publicly available data. In a recently published report (The Intelligent Grid Report, CSIRO 2009), CSIRO present a number of retail price trajectories under various policy scenarios that describe how energy costs may change over time.

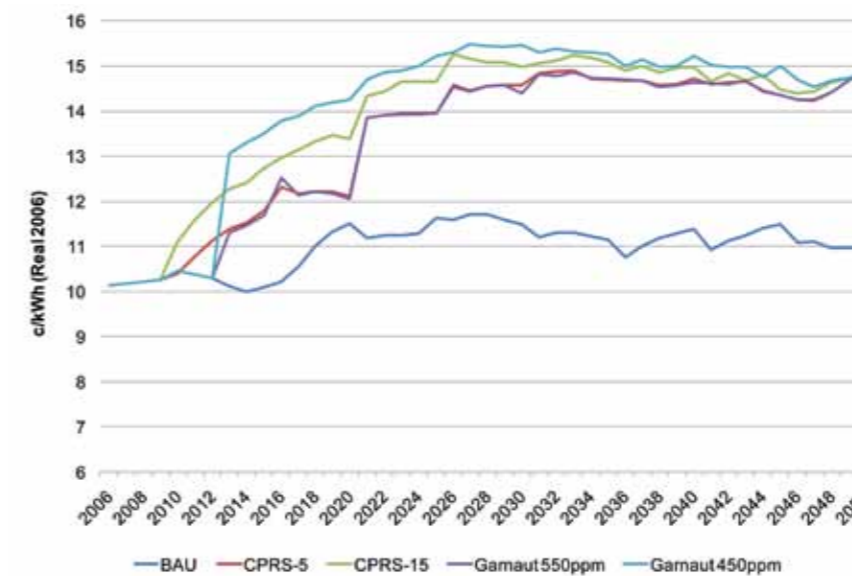


Figure 1: Retail price trajectories, urban customers (CSIRO, 2009)

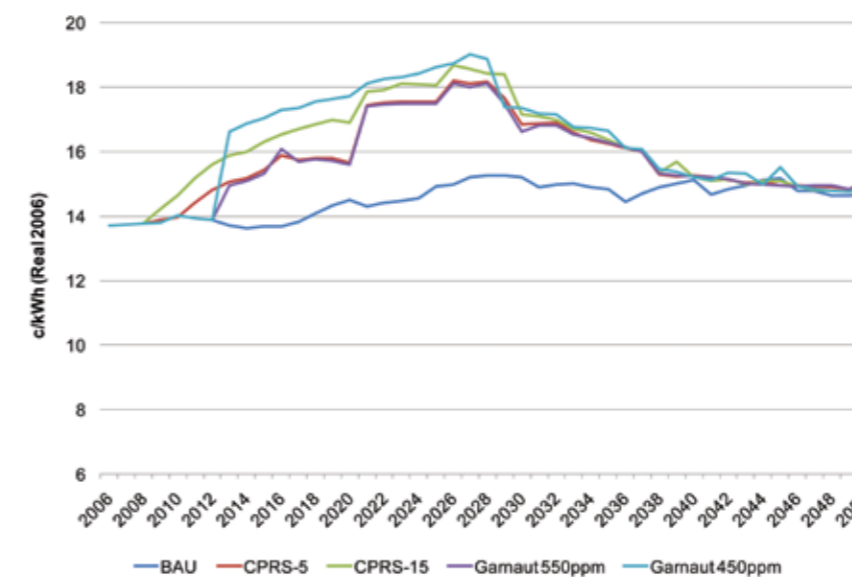


Figure 2: Retail price trajectories, rural customers (CSIRO, 2009)



A few points are worth noting. It can be seen that while rural prices are initially higher, they increase less than urban prices over time over the modelled period. This relies on assumptions about the deployment of distributed generation in the CSIRO’s energy sector model as a means of offsetting price increases in those areas. Further, the price trajectories do not distinguish between peak and off-peak price rises, nor do they fully account for changing distribution network costs over time. This is important because analysis of recent and forecast price rises suggest the dominant factor driving up prices are increasing network costs (Australian Energy Market Commission, 2011). For this reason, while the CSIRO scenarios are driven by emission reduction trajectories that entail a carbon price, real world electricity prices, without a price on carbon, have exceeded CSIRO modelling outputs.

Therefore considering the modelling outputs above are likely to underestimate future energy prices, it is conservative to assume stationary energy costs will rise by between 30 and 50% in real terms from 2011 to 2025 before flattening out and/or coming down. The reviewer has modelled three price scenarios that broadly represent the scale and shape of the CSIRO forecast range to maintain a conservative position that incorporates the potential for new technology to negate long term prices rises. The table below summarises future stationary energy price rise assumptions across three modelled scenarios.

Table 11: Future in-home energy price scenarios

	First 5 years	Second 5 years	Last 10 years	Net household cost increase in real terms to 2025 (3% CPI)
Rate of energy price rise – scenario 1	8%	5%	3%	31.5%
Rate of energy price rise – scenario 2	9%	6%	3%	43%
Rate of energy price rise – scenario 3	10%	7%	3%	56%

Transport energy costs may have a very different trajectory to stationary energy due to the relative difficulty of substituting oil-derived liquid fuels with renewable alternatives as oil reserves decline. CSIRO analysis undertaken through the future fuel forums (CSIRO, 2008) suggests petrol in Australia could range in price from \$2 to \$8 a litre by 2018 which suggests high degrees of uncertainty over future liquid fuel prices. Importantly, the International Energy Agency, historically considered conservative, has recently suggested production of conventional oil may have peaked with production likely to be flat over the medium term (World Energy Outlook, 2010).

For the purpose of stress testing a range of plausible and possible future scenarios, the effect of the following liquid fuel prices on the value of EVs in the Ecovillage have been evaluated.

Table 12: Future liquid energy price scenarios

	First 5 years	Second 5 years	Last 10 years	Net increase in real terms to 2025 (3% CPI)
Rate of energy price rise – scenario 1	4%	5%	6%	130%
Rate of energy price rise – scenario 2	5%	7%	10%	170%
Rate of energy price rise – scenario 3	6%	10%	15%	267%

5.3 Assessing benefits: modelling results

In this section, modelling assumptions and results from scenario modelling are presented. These results assess the relative costs and benefits to residents and the community from sustainability features modelled in this peer review.

Performance of the optional PV array combined with an EV is treated separately from the minimum PV array and no EV. This is appropriate given the additional PV and EV will be an option in the development and not mandatory.

5.3.1 Stationary energy

The table below compares the proposed Cape Paterson home against the benchmark Victorian homes under a range of future scenarios. The value of the Cape Paterson Home is calculated in net present value terms, with all future costs discounted at 6%.

The discount rate has been chosen to reflect a good quality after tax return on investment.

As noted previously, cost estimates for increasing performance from 6-star to 7.5-star were estimated at around \$25,000 by TS Constructions for homes of 11 and 15 squares, with about \$11,000 allowed for concrete polishing. They did not come down with scale due to different designs, with the larger home having smaller window surface area. However these costs are likely to be substantially reduced as building designs are improved and a bulk building program is implemented. As noted previously, building energy consultants Floyd Energy, has indicated going from 6-star to 7.5-star can be done for no additional cost with the right core design.

For these reasons, the cost of increasing performance from 6-star to 7.5-star has been treated as a fixed cost of \$4,000 for concrete polishing and a variable cost of 3% of a base building cost of \$2000m² for wall, window and ceiling insulation upgrades linked to building size. This equates to around \$16,000 for a home of 200m² footprint.

The value of the building fabric in this analysis is calculated over a 40-year timeframe.

PV is assumed to cost \$4,000/kW installed and have a 25-year lifetime, with inverter replacement and miscellaneous works assumed to be \$4,200 in year 10.

The solar hot water system specified for Cape Paterson is assumed to cost an additional \$3,000 up front and require an additional \$1,000 capital outlay at year 10 to replace evacuated tubes and miscellaneous works. Electricity boosting in the Cape Paterson system and the benchmark homes is assumed to occur 100% at off-peak times.

Internal heating and cooling systems at Cape Paterson are assumed to cost an additional \$450 per unit relative to systems used in the benchmark new home. This is a conservative estimate based on the price differential between systems with COP of 3.6 and 4.5. Actual costs are difficult to gauge transparently as prices vary with seasonal factors that influence stock levels and retailer willingness to discount.

To compare the value of a Cape Paterson home relative to an average home would require knowing the cost of retrofitting an existing home to zero emissions. Given the difficulty of making such an assessment due to the substantial variations across Victorian building stock, the net present value of all energy features in the Cape Paterson homes should be taken as a benchmark from which to evaluate the costs and benefits of switching from an existing home to the Cape Paterson Eco-village based on energy and water bills.

The comparison to benchmark 3 includes the savings made by reducing the building footprint by 50m².





Results are as follows:

Table 13: Net present value of Cape Paterson home compared to benchmarks

Benchmark	Energy scenario 1	Energy scenario 2	Energy scenario 3
Benchmark 1	\$54,985	\$58,780	\$62,870
Benchmark 2	\$195	\$3,300	\$8,250
Benchmark 3	\$67,350	\$70,570	\$75,630

A detailed breakdown of values for specific project elements is presented in the table below:

Table 14: Internal rate of return by project elements

Cape Paterson feature	Scenario 1	Scenario 2	Scenario 3	Additional capital cost
3.4kW Solar PV, no EV	12.8%	13.6%	14.5%	\$13,450
Heating system	12%	12.7%	13.5%	\$335 ²⁰ per unit
Cooling system	12%	12.7%	13.5%	\$115 per unit
Hot water system	5.3%	6%	6.7%	\$3,000
Star rating	-0.3%	0.05%	0.5%	\$ 16,000
10,000l water tank	15%	18%	25%	\$1000

5.3.2 Transport energy

A transparent transport comparison is made difficult by significant uncertainties over operating and maintenance costs for liquid fuel and EVs over time. Another variable to consider is whether an EV would be chosen in addition to – or instead of - an alternative liquid fuel vehicle.

A number of scenarios have been modelled to develop an understanding of what the costs and benefits of EVs powered by clean energy may be to residents, and so the extent to which the precinct may have zero operating emissions. Key assumptions include:

- Electricity is charged 20% at peak rates (25c/kWh), 80% at off-peak rates (13c/kWh) with a 5c/kWh premium for green energy. This equates to a starting price of 20.4c/kWh and increases according to stationary energy scenario 2. It is noted the ecovillage plans to produce equivalent power from solar pv as is needed to supply the EVs, with PV having a levelised cost of energy below 22c/kWh. Therefore, depending on the commercial model for delivering electricity to the vehicles, the assumption for cost of EV charging may be conservative
- Cars are driven 18,000km per year

²² It is assumed two split system units will be needed in benchmark 2 and Cape Paterson, and that they serve the same thermal load, despite Cape Paterson having a lower thermal load in practice. This creates an equal basis on which to compare the value of improving the efficiency of heating/cooling systems alone. In reality, the benchmark 2 home may require a greater number of split system units and so have higher capital costs, while the Cape Paterson home, due to lower thermal load, will realise relatively less operating savings. In this way, assuming they serve the same thermal load is likely to have little impact on the IRR calculation. Costs are split according to the proportion of heating and cooling demand, 75% and 25% respectively.

²³ The result presented in this table is an average of value across high and low rainfall years for high and low water users. It is noted that higher water users in Cape Paterson realise greater value from their tanks than low users

- Liquid fuel vehicles have an annual maintenance budget of \$750. EVs have an annual maintenance budget of \$250 and battery replacement costs at 7 and 15 years of \$8000 and \$6000 respectively. This reflects typically lower maintenance costs for EVs. It is also assumed an additional \$10,000 relative to the benchmarks is spent in year 10 on the EV to upgrade the vehicle body
- Lithium-ion batteries are assumed to have an operating life of approximately 2000 cycles with residual value equivalent to 1000 cycles at 70% capacity, charged at the assumed difference in value between clean peak and off-peak energy in years 7 and 15
- Energy used in the EV is taxed at 15%

Modelling results are presented below:

Table 15: Internal rate of return for EV options modelled

Cape Paterson feature	Scenario 1	Scenario 2	Scenario 3	Additional capital cost
New EV vs keeping benchmark car 1	1.2%	3.4%	6.9%	\$50,000
New EV vs keeping benchmark car 2	-5.5%	-3%	0.9%	\$50,000
New EV vs new benchmark car 1	6.3%	8.6%	12.1%	\$28,000
New EV vs new benchmark car 2	15.7%	19%	23.5%	\$5,000





5.3.3 Water

The reviewer has compared the difference in value between a home with 2,000l tank storage consuming 160l/pd to a Cape Paterson home with 10,000l tank storage and low consumption of 80l/pd and high consumption of 160l/pd. This was done across a high and low rainfall year.

This modelling is not intended to reflect actual water use across actual rainfall years, rather to gain perspective on the likely value of the Cape Paterson proposition across a range of possible future scenarios.

Daily rainfall data was taken from the Bureau of Meteorology representative of a high rainfall year (900mm+) and a low rainfall year (>650mm). The average daily consumption met by the rainwater tank was subtracted from the remaining tank storage each day, and new rain captured by the 200m² roof area was added.

It was assumed the benchmark new home has approximately 30% of its daily water demand able to be met by rain water and that the tank operates for 20 years. The additional cost of a 10,000l tank over a 2,000l tank is assumed to be \$1,000, and is able to service 90% of the daily water demand in the Cape Paterson home.

In this way, the reviewer developed an estimate of the net water contribution made by the different sized rain tanks over the course of the year, valued at a \$/kl rate. Naturally, this is a contrived model. In the real world, residents would have the option of avoiding watering their garden in response to high rain events, saving it for dry spells and vice versa.

A wide range of water price scenarios were tested reflecting substantial uncertainty over the future of water costs. It is understood that Cape Paterson water is likely to be priced according to Melbourne water rates, as its supply system will be linked to Melbourne's. Assumed rates of increases are as follows:

Table 16: Future water price scenarios

	First 5 years – rate of increase	5-10 years – rate of increase	10-20 years – rate of increase	Net household cost increase in real terms to 2025 (3% CPI)
Scenario 1	15%	5%	3%	135%
Scenario 2	20%	10%	7%	270%
Scenario 3	30%	15%	10%	430%

Internal rates of return across the different water scenarios are as follows:

Table 17: Value of the Cape Paterson water proposition

	Scenario 1	Scenario 2	Scenario 3
Cape Paterson high user, high rainfall	22.5%	29%	36%
Cape Paterson high user, low rainfall	13%	19%	25%
Cape Paterson low user, high rainfall	6.5%	12%	17.5%
Cape Paterson low user, low rainfall	6.5%	12%	17.5%

Naturally over a 20-year period there will be a mix of high and low rainfall years. However the modelling shows that at relatively conservative future price estimates, all scenarios provide more than reasonable returns. Of note, a low user of water in a high rainfall years gets less value out of their water tank than in any other scenario.



6 Summary

The proposed Cape Paterson Ecovillage development appears to offer very good value for buyers when the long run costs of home energy, transport energy and water use are considered.

When compared to a home of equivalent size built to minimum standards, the Cape Paterson homes are favourable even before cost reductions associated with a bulk build program are considered. Using very conservative assumptions for energy and water prices the internal rate of return on the Cape Paterson home is around 6% based on energy and water savings alone, representing a healthy after tax investment return. This would suggest the proposal is very robust to future price uncertainty. Additional value may be realised when the homes are sold, with studies locally and overseas suggesting homes with solar panels and/or higher star ratings, can attract a premium sale price.

When a 20% reduction in capital costs associated with sustainability features is assumed, rates of return increase to between 7.2% and 11.2% across the range of future price scenarios modelled. Based on conversations with product suppliers, builders and energy consultants, it is plausible these discounts will materialise as an average across sustainability features.

Compared to a new 6-star house of the same size, Cape Paterson buyers could save between 2.5 years and 5.5 years on a 25 year mortgage when in-home energy and water savings accrued by virtue of sustainability features are used to accelerate mortgage repayments²⁴. Cumulative savings on energy bills and mortgage payments could exceed \$300,000 under the high future price scenario modelled in this study²⁵. Naturally financial benefits will vary depending on future energy and water price scenarios, the final delivery cost for sustainability features, mortgage variables and other factors specific to each home buyer.

While the current costs of going from 6-star to 7.5-star appear high, and impact significantly on the net benefits of the Eco-village, these are likely to come down substantially over the course of the project as designs are refined and a bulk building program commences. Furthermore, as the impact of extreme weather due to future climate change is felt, high star ratings may have value additional to what has been modelled in this review, including better protection against extreme weather events. It should also be noted that by setting an upper limit on home size, and working with buyers to design homes that meet their needs, there may be substantial further cost savings.

With good process innovation to drive down construction costs, effective customer engagement strategies and service delivery model innovation, the Cape Paterson project is likely to deliver and exceed on its promise, with substantial net environmental and financial benefits.

²⁴ This calculation does not include the value of an electric vehicle

²⁵ This calculation includes the value of an electric vehicle

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