The Cape – Bill-buster study

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V1.0.4

NEWENERGY Thinking

Document information

Document Version	Date	Prepared By	Comments
V1.0	2024-09-19	Richard Keech	First release
V1.0.1	2024-10-01	Richard Keech	Changed vehicle assumptions
V1.0.2	2024-10-14	Richard Keech	Changed vehicle assumptions
V1.0.3	2024-11-06	Richard Keech	Updated star ratings of baseline scenarios
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Cover image: Photo credit: Richard Keech

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Contents

1. Introduction

Quote. This report is provided per New Energy Thinking's Quote 202402v2.

Deliverables. Deliverables are this report, and a spreadsheet model that accompanies this report.

Caveat. The spreadsheet model is in Microsoft Excel format and includes locked sheets Use of the report and the spreadsheet model is intended for the The Cape only. Re-use or onwards distribution shall be only by prior agreement.

Scope. The key ask, from the project brief, is to provide energy and cost analysis for 'super-bill-busting' initiative for The Cape.

2. Dwelling modelling

2.1. Outline

The assessment uses three different archetypes/configurations for The Cape, and compares and contrasts with two scenarios corresponding to conventional homes as follows:

	Case B1: Legacy dual-fuel	Case B2: New dual-fuel	Case C1: Cape bill-buster std	Case C2: Cape bill-buster super-efficient	Case C3: Cape bill-buster extra renewables
Effective star rating (NATHERS)	4.0	7.0	8.0	9.0	8.0
Solar PV capacity (kW DC)	0	0	9	9	13
Vehicle type	ICE	ICE	EV	EV	EV
Note				Smaller footprint: 150m^2	Includes 13kWh battery
Scenario number	1	2	4	5	6

Cases B1 and B2 are referred to as baseline cases. Scenario numbers correspond to table in Appendix 1.

Common assumptions. For the purpose of the analysis, the following common assumptions apply in relation to the home and its occupancy for all test cases, except where indicated:

- *Location*: Cape Paterson
- *Dwelling size*: 200m2
- *Occupancy*. Home is assumed to be occupied on 85% of the days of the year by a four-person household working with adults working full-time;
- *Heating and cooling operation*. It is assumed that all living spaces are conditioned as required for thermal comfort whenever the home is occupied (so energy consumption estimates are likely to be conservative);
- *Extras*. It is assumed that the home does not have any significant add-on energy-consuming items such as pool, spa, welding;
- *Fridge*. Medium-performance;
- *Shower head*. Low-flow (four stars performance, i.e., 6-7 L/min);
- *Cooking*. Baseline cases have gas cooktops, Cape cases have induction cooktops
- *Electricity tariffs*:
    - Consumption: 30.5c/kWh;
    - Export: 4c/kWh;
    - Service fee: $1.15/day
- *Gas tariffs*:
    - Consumption: 3.56c/MJ
    - Service fee: $1.10/day
- *Vehicle assumptions*:
    - Petrol price: $1.95/L
    - Vehicle: Toyota RAV 4 (ICE) and Tesla Model Y (EV);
    - EV charging assumed to be 90% from home (Cases C1, C2, C3) during off-peak or from solar PV at 2.4kW average. 10% of charging assumed to be from paid charging stations at normal rates;
    - Annual travel: 25,000km.

Home's build standard. The modelling assumes both the Cape and baseline homes are built to a comparable standard with regard to draught proofing and insulation. While there is evidence [1],[2],[3],[4],[5] that volume-built homes do not meet their badged rating - and Cape homes meet or exceed - the report takes a conservative approach.

2.2. Main comparison cases

The main conclusions of this report come from comparing Cases B1 and B2 with Case C1, summarised below.

Item	Scenario Definitions		
	1	2	**4**
Name	Baseline Legacy DF	Baseline New DF	**Cape BB std**
Star rating (nominal)	4.0	7.0	8.0
PV1 capacity [kW]	0.0	0.0	9.0
PV2 capacity [kW]	0.0	0.0	0.0
Battery usable capacity [kWh]	0.0	0.0	0.0
Occupancy (people)	4	4	4
Floor area [m2]	200	200	200
Heating	GAS DUCTED w EVAP	GAS DUCTED w EVAP	SPLIT SYSTEMS
Hot water	GAS STORAGE - LARGE	GAS STORAGE - LARGE	HEAT PUMP - MEDIUM
Cooktop	GAS	GAS	INDUCTION
Fridge	COMMON MEDIUM	COMMON MEDIUM	EFFICIENT MEDIUM
Showerhead	REGULAR	REGULAR	VERY-LOW-FLOW
Draught proofing and insulation	SLOPPY	DILIGENT	DILIGENT
Energy Class	Dual-fuel	Dual-fuel	All-electric
Vehicle	ICE	ICE	EV
Case name	B1	B2	**C1**

2.3. Additional up-front costs

Additional up-front costs for the higher-performance, all-electric, relative to the baseline scenarios, are difficult to quantify. When comparing construction of the baseline new home, with the main Cape reference home, there will be some additional build costs, and also changed costs associated with the fit out.

Build and retrofit costs. Because of the highly variable nature of construction and renovation costs, and differences in skill level across the country when it comes to higher performance builds, this analysis does not attempt to quantify the increased costs associate with building or renovating to the higher-performance level. Anecdotally, the up-lift in build cost might often be about 5%, but this is not factored into the quantitative analysis in this report.

Fitout costs. This analysis recognises that there are changed costs associated with the main high-performance scenario, for the following fit out upgrades:

- legacy ICE vehicle to a long-range EV;
- ducted heating/evaporative cooling to several reverse cycle heating/cooling split systems in the home (should be a saving);
- installation of large solar PV;
- (in retrofit case) removal of gas plumbing, gas cooktop to induction cooktop/heat pump hot water system;
- water-efficient tapware and showerheads.

For this analysis, a cost of $25,000 for these fit out items is assumed.

[1] O'Leary et al, 2016, https://www.sciencedirect.com/science/article/abs/pii/S0378778816301621

[2] Eon et al, 2020, https://www.researchgate.net/publication/343562952_The_Discrepancy_between_As-Built_and_As-Designed_in_Energy_Efficient_Buildings_A_Rapid_Review

[3] Ambrose et al, 2015, CSIRO, https://research.csiro.au/energyrating/wp-content/uploads/sites/74/2016/05/House-Energy-Efficiency-Inspect-Proj.pdf

[4] Report for Achieving Low Energy Existing Homes, Commonwealth of Australia 2019 https://www.dcceew.gov.au/sites/default/files/documents/report-for-achieving-low-energy-existing-homes.pdf

[5] Lang et al, "A national roadmap for improving the building quality of Australian housing stock", Australian Housing & Urban Research Institute, https://www.ahuri.edu.au/analysis/news/australians-deserve-better-low-quality-inefficient-housing

2.4. Vehicle savings

The analysis has been done using single-vehicle scenarios. The average number of cars per household in Australia is actually 1.8[6]. Much of the savings in household cost and energy arise because of the use of EVs charged with rooftop solar. So, it is worth noting that in many real-world cases of full home electrification, the savings associated with vehicle use will be even higher than described here.

[6] From ABS census data, 2022. https://www.abs.gov.au/statistics/industry/tourism-and-transport/transport-census/latest-release#:~:text=Key%20statistics,-The%20average%20number&text=91%20per%20cent%20of%20households,in%20every%20state%20and%20territory

3. Outputs

3.1. Key messages

Key take-away messages from the analysis are that, for the first comparison case evaluated (comparison with new baseline home):

- 83% reduction in running costs for the hypothetical reference Cape home, compared to a typical new-build home;
- Savings of $5,986 in year 1;
- The savings equate to $115/week in year 1, growing to about $389/week in year 25;
- 25-year running-cost savings of $293,681;
- Payback period of 4.1 years

Key take-away messages from the analysis are that, for the second comparison case evaluated (comparison with legacy baseline home):

- 87% reduction in running costs for the hypothetical Cape home;
- Savings of $7,765 in year 1;
- The savings equate to $149/week in year 1, growing to about $504/week in year 25;
- 25-year running cost savings of $380,975.

These and other scenarios evaluated indicate that:

- Significantly improved passive thermal comfort;
- Annual running cost (energy and vehicle costs) of only $1,190 for the main Cape case;
- Zero annual electricity cost is feasible with reasonable combinations of solar and battery;
- Car charging is the biggest single consumer of electricity (~49%);
- Active heating and cooling energy needs fall to only about 9% of overall home energy consumption;
- Homes at the Cape can easily be net-energy positive and operationally carbon-negative;

3.2. Energy use/generation

The outputs below reflect the primary comparison case outlined above. The outputs associated with all scenarios are tabulated at Appendix 1.

Table 1: Comparison case 1: Savings summary

	Baseline new home	Cape super bill buster
Elec	$1,181	$697
Gas	$2,044	$0
Petrol	$3,413	$0
Car maintenance	$538	$493
Total (yr1)	$7,175	$1,190

Table 2: Comparison case 2: Savings summary

	Baseline legacy home	Cape super bill buster
Elec	$1,354	$697
Gas	$3,650	$0
Petrol	$3,413	$0
Car maintenance	$538	$493
Total (yr1)	$8,954	$1,190

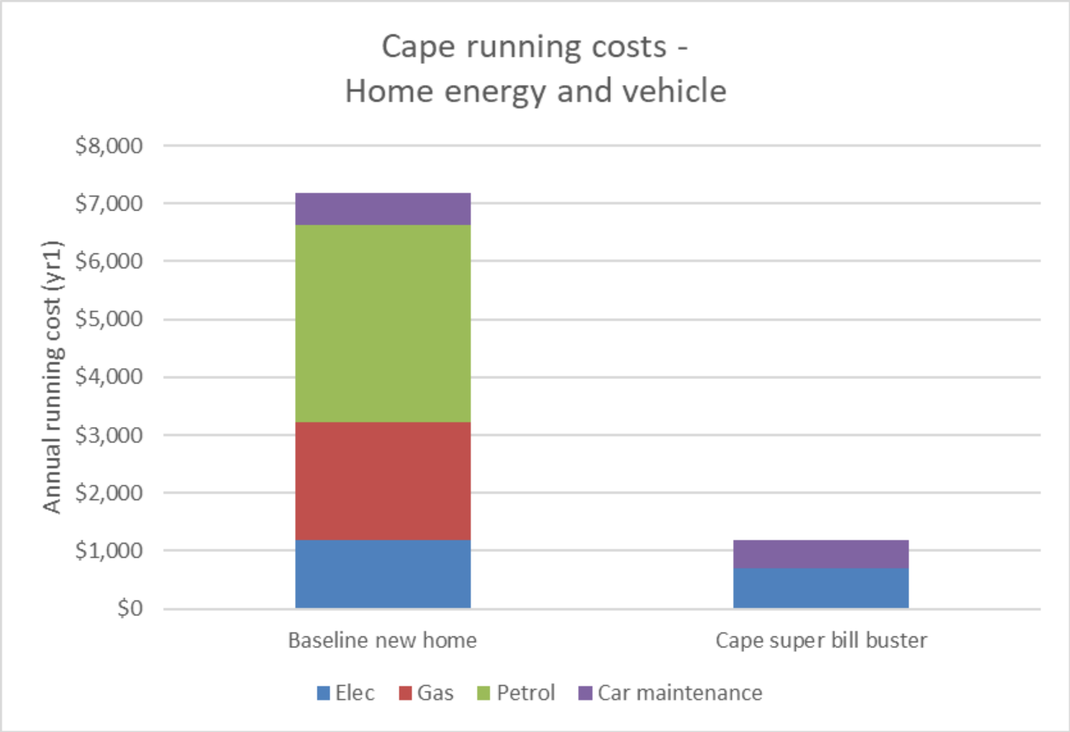

Figure 1: Comparison case 1: summary of savings

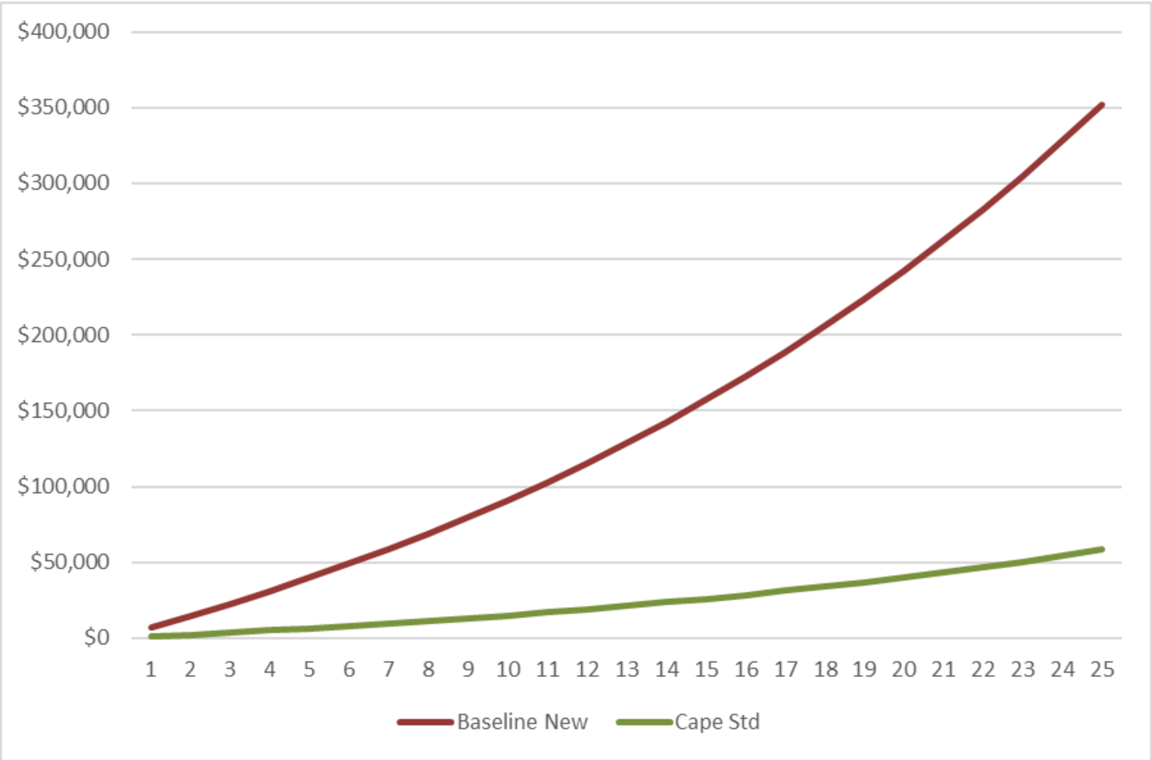

Figure 2: Comparison case 1 - 25-year cumulative home energy and vehicle spend

Table 2: Comparison case 1 - Carbon emissions [kgCO2e/annum]

	Baseline new home	Cape super bill buster
Gas	2556	0
Grid Electricity	2320	1924
Grid Electricity export	0	-8144
Petrol	5076	0
Total	9962	-6220

For comparison case 1, emissions savings amount to 16.2t per annum, or 126% reduction. This assumes that excess solar PV offsets carbon at the same rate per kWh as the standard average emission factor of Victorian grid electricity.

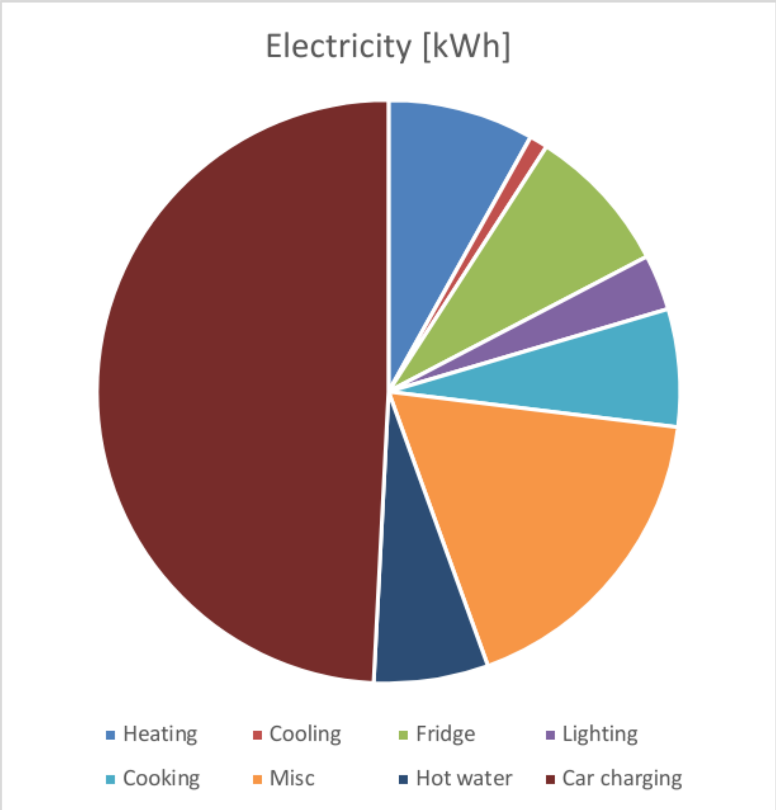

Figure 3: Split of energy loads in a bill-busting Cape home

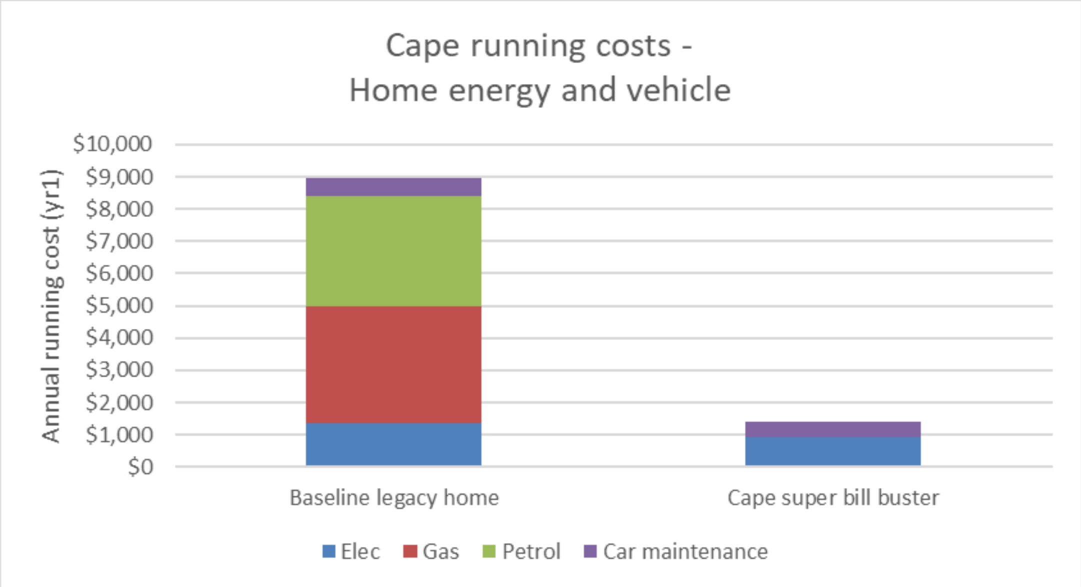

Figure 4: Comparison case 2: summary of savings

3.3. Payback

For Comparison Case 1, assuming $25,000 of additional fit out costs (excluding consideration of changed construction costs.[7]) for the Cape build vs the baseline, the savings in reduced energy cost:

- Allow the additional fit out cost to be paid back in 4.1 years;
- Give net $141,649 improved financial position over a 25-year period; and
- If the savings are fed entirely back into loan repayments, the operating savings takes about 6.0 years off the loan period of a $500,000 loan.

[7] A payback period is calculated for comparison case 1 because it compares to new-build scenarios. On the other hand, a payback period is not relevant to comparison case 2 because we're comparing a new-build scenario with a legacy home.
The payback period in the first comparison case doesn't take into account the difference in construction cost because this is to variable and difficult to quantify, as discussed at Section 2.3.

Appendix 1: Home Scenarios

Modelling of home energy is based on scenarios defined here.

Not all these scenarios are explicitly called for in the brief but are included for completeness.

Scenarios in pink or red are baseline scenarios.

Scenarios in green are Cape scenarios.

In scenario names and the table, the following conventions are used:

- DF= dual-fuel, i.e., a home with both electricity and gas;
- BB = bill-buster
- RE = renewable energy
- EV=electric vehicle
- NC=no car
- ICE=internal-combustion engine

Item	*Scenario Definitions*				
	1	2	**4**	**5**	**6**
Name	Baseline Legacy DF	Baseline New DF	**Cape BB std**	**Cape BB little gem**	**Cape BB extra RE**
Star rating (nominal)	4.0	7.0	8.0	9.0	8.0
PV1 capacity [kW]	0.0	0.0	9.0	9.0	13.0
PV2 capacity [kW]	0.0	0.0	0.0	0.0	0.0
Battery usable capacity [kWh]	0.0	0.0	0.0	0.0	13.0
Occupancy (people)	4	4	4	4	4
Floor area [m2]	200	200	200	150	200
Heating	GAS DUCTED w EVAP	GAS DUCTED w EVAP	SPLIT SYSTEMS	SPLIT SYSTEMS	SPLIT SYSTEMS
Hot water	GAS STORAGE - LARGE	GAS STORAGE - LARGE	HEAT PUMP - MEDIUM	HEAT PUMP - SMALL	HEAT PUMP - MEDIUM
Cooktop	GAS	GAS	INDUCTION	INDUCTION	INDUCTION
Fridge	COMMON MEDIUM	COMMON MEDIUM	EFFICIENT MEDIUM	EFFICIENT MEDIUM	EFFICIENT MEDIUM
Showerhead	REGULAR	REGULAR	VERY-LOW-FLOW	VERY-LOW-FLOW	VERY-LOW-FLOW
Draught proofing and insulation	SLOPPY	DILIGENT	DILIGENT	EXTRA_DILIGENT	DILIGENT
Energy Class	Dual-fuel	Dual-fuel	All-electric	All-electric	All-electric
Vehicle	ICE	ICE	EV	EV	EV
Case name	B1	B2	**C1**	**C2**	**C3**

For each Scenario, the outputs are tabulated here.

		Scenario Outputs				
	Scenario index	1	2	4	5	6
HOME OUTPUTS	Electricity cost	$1,354	$1,181	$697	$576	-$2
	Gas cost	$3,650	$2,044	$0	$0	$0
	Solar savings	$0	$0	$1,755	$1,654	$1,965
	Energy cost	**$5,004**	**$3,225**	**$697**	**$576**	**-$2**
	HVAC elec [kWh/annum]	784	211	551	113	551
	HVAC gas [MJ/annum]	61,760	16,582	0	0	0
	Consumption [kWh/annum]	3,096	2,522	6,038	5,359	6,286
	Import [kWh/annum]	3,096	2,522	2,091	1,733	253
	Winter import [kWh/annum]	788	648	752	593	128
	Export [kWh/annum]	0	0	8,853	9,174	12,455
	Generation [kWh/annum]	0	0	12,800	12,800	18,489
	Gas [MJ/annum]	91,387	46,209	0	0	0
VEHICLE OUTPUTS	Petrol [L/annum]	1750	1750	0	0	0
	Annual maintenance [$/annum]	$538	$538	$493	$493	$493
	Petrol cost [$/annum]	$3,413	$3,413	$0	$0	$0
	EV Electricity [kWh/annum]	0	0	2,970	2,970	2,970
TOTAL COST	**Home energy plus vehicle**	**$8,954**	**$7,175**	**$1,190**	**$1,069**	**$491**