AUSTRALIAN PV SYSTEM MARKET ANALYSIS FOR THE POWERWALL

Sandy Rodrigues[a,b], Roham Torabikalaki[a], Fábio Faria[a], Helena G. Ramos[b], and F. Morgado-Dias[a]
[a] Instituto de Telecomunicações, Instituto Superior Técnico, Universidade de Lisboa, Portugal
[b] Madeira Interactive Technologies Institute, Caminho da Penteada, Funchal Portugal
[c] Universidade da Madeira, Caminho da Penteada, Funchal Portugal
sandy.rodrigues@tecnico.ulisboa.pt; morgado@uma.pt

ABSTRACT: Tesla chose Australia to be one of the first Powerwall Battery delivery countries in the world, because of its tariff structure, high solar radiation values, and high electricity costs. The Powerwall Battery solution was promoted as a low-cost attractive investment, therefore the purpose of this paper is to analyse four scenarios in five Australian states (ACT, SA, VIC, NSW, and QLD) to determine which scenario and respective state presents the highest investment attractiveness. Scenarios 1 and 2 consider an off-grid 5kW PV system with one Powerwall Battery and two Powerwall Batteries respectively. Scenario 3 considers a Powerwall Battery without a PV system connection, which is charged by the household grid and discharged back into the same grid. Scenario 4 studies an on-grid 3kW PV system without a Powerwall Battery practicing a 70% self-consumption regime. The results show that scenario 4 is the most attractive investment option with SA, VIC, and QLD making 3 times the investment within a 25-year investment period and in NSW the investment is doubled. Scenario 1 is currently viable in VIC and only viable after a 10% discount on the Powerwall Battery in QLD.
Keywords: Rooftop PV Systems, Economic Analysis, Powerwall Battery, Hybrid Inverter.

1 INTRODUCTION

Late 2015, the Tesla Company announced that Australia would be one of the first countries outside of the US to be supplied with the Powerwall Battery (PB) systems due to its desirable weather conditions, the high solar roof-top installation per capita and the high electricity prices that are practiced [1], [2]. The Tesla Energy Authorized Resellers in Australia include energy retail Origin Energy and solar installer company Natural Solar [3].

The Photovoltaic (PV) system and solar battery solutions may be considered as investments since they provide monetary returns through feed-in/grid injection tariffs and/or electricity bill savings making it possible to generate a payback on the investment. The feed-in tariffs were cut in Australia on January 1st 2016 and the price of the grid injected energy is currently lower than the electricity prices in almost all Australian states (except for the Northern Territory state, which has a grid injection tariff that is equal to the consumption price) [4], [5]. Now, the grid injection tariffs range from 0.04€/kWh to 0.08€/kWh which encourages the use of a 100% self-consumption regime because the electricity consumption prices are higher and more attractive than the grid injection prices.

The objective of this paper is to analyse the economic feasibility of four different self-consumption scenarios in five Australian states to determine which of the states is the most financially attractive, when it comes to investing in a PV system and/or a PB solution.

The number of Australian states used in this study was limited to those in which the private energy retailer Origin Energy operates the power generation stations. The five states are namely the Australian Capital Territory (ACT), South Australia (SA), Victoria (VIC), New South Wales (NSW), and Queensland (QLD) [6].

The Tesla Powerwall Battery system began its distribution and household usage in the beginning of 2016. This battery system is advertised to be revolutionary mainly due to its dimensions, plug and play features, storage capacity, and low price. However, this new product is surrounded by scepticism around its investment attractiveness, and investors want to know not only if this new battery system will generate an attractive profit on the investment, but also how long is the payback period.

This paper provides answers to these questions, as it indicates the Internal Rate of Return, Profitability Index, and Discounted Payback Period at the end of a 25-year investment period. Since different electricity prices are practiced in every state of Australia, one aim of this paper is to provide the reader with enough information about the different investments in the different states based on data that is up to date. This data includes all the economic parameters that can influence the PV system and solar battery system investments during a 25-year period such as the operations and maintenance (O&M) costs, inverter replacement cost rates (in years 10 and 20), electricity evolution rates, interest evolution rates, and others. This study also provides information about the types of households (depending on the number of people and total simultaneous power of appliances) that can be associated to an off-grid scenario.

Efficient and low-cost solar battery systems pave the way to efficient off-grid scenarios, which in turn contributes to reducing the CO_2 emissions and consequently reduce global warming.

The organization of the paper is the following: the methodology is in Section 2 and explains all methods used to evaluate the economic feasibility of the investments; Section 3 presents the results and discussion and finally Section 4 presents the conclusions.

2 METHODOLOGY

The Powerwall Battery (PB) is a lithium-ion battery pack used to store energy provided by a PV system or that comes from a household or business grid.

The PB can be used for load-shifting, PV storage, or backup power. The term load-shifting defines the energy management to move demand from peak to off-peak hours. Thus, the PB can be used for load-shifting by being charged by the household or business grid during the off-peak hours and discharged back into the same grid in the on-peak hours. The difference between the two tariffs (on and off-peak) provide electricity bill savings which pays back the investment made on the PB and is intended to eventually make a profit on the investment.

This paper studies the economic feasibility of four different PV systems and/or PB solution scenarios in five Australian states namely ACT, SA, VIC, NSW, and QLD. The four scenarios are as follows:

- Scenario 1 (S1) – Off-grid 5kW PV system w/ 1 PB
- Scenario 2 (S2) – Off-grid 5kW PV system w/ 2 PB
- Scenario 3 (S3) – PB, hybrid inverter, and AC/DC charger w/o a PV system
- Scenario 4 (S4) – On-grid 3kW PV system w/o a PB

2.1 Scenario Description

The PB scenarios consider a 7kWh Tesla PB in a residential setting.

The first two scenarios consist of a PB system linked to an off-grid 5kW PV system, in which scenario 1 uses one PB while scenario 2 uses two PBs. The reason behind choosing two off-grid scenarios with a different number of PB was to compare a system capable of supporting an energy consumption of a household with one or two people (one PB) and a system that would support an energy consumption of a household with three or four people (two PBs).

The Australian average daily energy consumption depends not only on the number of people in the household but also on the state since some states use more heating and cooling equipment than others due to climate conditions. Statistics about the average daily energy consumption of a household of up to four people in a household per state is available online [7]. The average daily consumption of a household of two people in any state of Australia is around 17kWh. It is known that a 5kW PV system has an average daily solar production of 17kWh [8] in Australia, and it is known that the PB is able to store a total of 6.4kWh of energy and output a maximum of 3.3kW continuous power [9]. Thus, an off-grid 5kW PV system with one PB can be associated to a household of two people given that the total power when all the appliances are working simultaneously is not more than 3.3kW. The PB limits this value, and if the simultaneous power is higher than 3.3kW, it is advised to use two PBs in the household.

Scenario 3 consists of only the PB, a hybrid inverter and an AC/DC 2kW charger, in which the PB is charged by the household grid and discharged back into the same grid without being connected to a PV system. The purpose of this solution is to buy electricity at a lower price (off-peak) and use it when the price is higher (on-peak), which saves money on the electric bill.

Scenario 4 considers an on-grid 3kW PV system practicing a 70% self-consumption regime without a PB connection. In this regime, 70% of the power from the PV system is injected into the household (self-consumption) grid while the rest of the solar power (30%) is injected into the distribution grid. This self-consumption regime reflects the consumption reality of a typical household during the day in Australia that has a 3kW PV system as shown in [10], which is based on industry averages from publically available data on Australian homes.

Scenarios 1 and 2 consist of a 5kW PV system, a PB system, and a hybrid inverter while Scenario 4 includes a 3kW PV system and a simple solar inverter (not hybrid inverter), which in turn makes this last system much cheaper. On-grid PV system prices are lower than off-grid PV system prices because of the solar subsidies associated with the on-grid PV system solutions and the low prices of simple solar inverters [11]. The PB solutions have high costs due to the high PB and hybrid inverter prices.

2.2 Economic Methods

The economic feasibility of the PV system and solar battery solution investments is determined by calculating the economic methods such as the Discounted Payback Period (DPBP), the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Profitability Index (PI). The DPBP indicates the number of years needed to make a breakeven (return of money invested) on the investment in which after that period, a profit on the investment is made. The NPV shows if the earnings generated by the investment exceeds or not the anticipated costs and is used to calculate the PI. The PI indicates how much profit is made by the end of a 25-year period. The IRR evaluates the attractiveness of an investment and is used to compare the profitability between various investments.

In order to calculate the DPBP, the Simple Cash Flow (SCF) and Discounted Cash Flow (DCF) has to be first calculated. The subtraction between the cash inflow and the cash outflow calculates the SCF as shown in equation 1 [12].

$$SCF_y = \sum_{y=1}^{Y} (Ts \times Es)_y - \sum_{y=1}^{Y} (M)_y \qquad (1)$$

The investment time in years is presented by *Y*, the self-consumption tariff is *Ts*, the annual self-consumption of the PV system production is *Es*, and *M* represents the maintenance cost. The DCF calculates the money value over time, represents the SCF value in the future, and is updated with the interest rate *r* (equation 2).

$$DCF_y = \frac{SCF_y}{(1+r)^y} \qquad (2)$$

The DPBP is calculated by using the DCF values to calculate the number of years needed to make a breakeven on the investment and therefore considers the money value over time (equation 3).

$$DPBP = A + \frac{B}{C} \qquad (3)$$

Where,
A = Last period with a negative discounted cumulative cash flow;
B = Absolute value of the discounted cumulative cash flow at the end of the period *A*;
C = Discounted cash flow during the period after *A* [13].

The short-term investment has a payback period of less than 3 years, a medium term investment of 4 to 10 years and long-term investments of more than 10 years.

The Net Present Value (NPV) calculates the present value of all cash inflows with the present value of all cash outflows associated with an investment (equation 4).

$$NPV = \sum_{y=1}^{Y} \frac{C_y}{(1+r)^y} - C_0 \qquad (4)$$

Where C_y represents the yearly net cash flow, and C_0 represents the initial investment of the PV system.

The investment is profitable when the interest rate is lower than the IRR indicator [14]. The IRR is used for comparison across locations, as there is no need to consider the local interest rates [15]. The IRR formula is presented in equation 4 when NPV = 0, and r = IRR.

The Profitability Index (PI) indicates the investor if the investment should be accepted or rejected (equation 5). When the PI is equal to 1.00, there is a breakeven on the investment which means that by the end of a 25-year PV system investment period the investor receives the money invested. This type of investment is not profitable since the life-cycle of a PV system is 25 years. If the PI is equal to 2.00 or higher, the investment is considered attractive, since the investment is doubled by the end of a 25-year period, which is equal to having a 4% annual interest rate on the return of investment [16].

$$PI = \frac{\text{NPV}}{\text{Initial Investment}} + 1 \quad (5)$$

2.3 Economic Parameters

The economic methods mentioned in the previous section are influenced by the economic parameters shown below which are based on assumptions for the purpose of this work. Table I shows the economic parameters common to all states while Table II presents the economic parameters specific to each state.

The economic parameters common to all states include the maintenance and operations cost rate; the hybrid inverter replacement cost rates for scenarios 1, 2 and 4; the PB annual charge/discharge energy amount; the PB replacement cost in year 10 and in year 20; the hybrid inverter and PB efficiency loss; the PV degradation rate; the GST rate; the Australian currency exchange rate and the annual interest evolution rate.

Table I: Common Economic Parameters

Parameter Description	Value
Annual Maintenance and operations cost rate	1.0%
Scenario 1 - Hybrid Inverter replacement cost rate	12.0%
Scenario 2 - Hybrid Inverter replacement cost rate	10.0%
Scenario 4 - On-grid Inverter replacement cost rate	20.0%
PB Annual Charge/Discharge (kWh)	2336
Powerwall Replacement Cost year 10	4,110.12 €
Powerwall Replacement Cost year 20	2,935.80 €
Hybrid Inverter efficiency loss	7.0%
Powerwall efficiency loss	8.0%
PV Degradation	0.7%
GST included in all prices	10.0%
Currency exchange AUD to EUR (1/2/2016)	0.6524 €
Annual Interest Evolution Rate	6.25%

It is assumed that all inverters and PB are replaced in years 10 and 20. Since the PB prices are expected to decrease in the upcoming years, it is assumed in this work that the PB replacement has a 30% discount in year 10 and a 50% discount in year 20 while the inverter cost remains the same in both replacement years. All prices presented in Tables I and II have the GST (Australia Sales Tax Rate) included and are subtracted from all the Federal Subsidies related to solar energy which can be consulted in [11]. The currency exchange value from Australian Dollar to Euro is referenced from the 1st of February 2016. The interest evolution rate is an average value based on the past 25 years [18]. The cost rates mentioned in Table I are relative to the investment prices presented in Table II.

The economic parameters specific to each state (Table II) include the solar production of the 5kW and 3kW PV systems, the investment prices of each scenario, the mono and tri-hourly tariffs, the grid injection tariffs, the distribution charge savings made by the off-grid scenarios and the annual electricity evolution rate.

Table II, presents the solar production values for the 5kW and 3kW PV systems calculated by using RETSCREEN software version 4 [17]. The investment costs of each scenario were obtained by calculating an average of three quotes from three different companies in a given Australian state. All quotes were obtained in March 2016. Next to the investment costs are the investment costs per watt in euros (€/W).

The hourly electricity tariff prices are the standing offers currently practiced by the energy utility company Origin Energy [6]. The hourly tariffs used in this work are the mono-hourly and tri-hourly (also known as the Time of Use tariff - TOU) which is divided into on-peak, shoulder and off-peak tariffs. The on-peak tariffs are higher than the off-peak. The mono-hourly tariff is used in scenarios 1, 2 and 4 while the tri-hourly tariffs are used in scenario 3 where the PB is charged in the off-peak hours by the household grid and discharged back into the household grid in the on-peak hours. The savings made in scenario 3 result from the subtraction between the on-peak and off-peak tariff prices, which is presented by the term "Difference" in Table II for each state. Unfortunately SA does not practice a TOU tariff, therefore scenario 3 was not analysed in SA.

In the off-grid scenarios, the supply charges are considered as yearly savings. These supply charge expenses vary among the retailers and there is no regulated history data on them in order to make an average evolution rate, therefore the cost of these expenses are maintained throughout the 25-year period in economic feasibility calculations of this work.

Just like the interest evolution rate, the electricity evolution rate was calculated in the same way just that only over the past 18 years, which is limited by the information provided by the utility company Origin Energy [19].

Table II also presents the grid injection tariffs provided by the utility company Origin Energy for each of the states, and it is assumed that these are not associated to an evolution rate due to the lack of historical data.

Australia currently practices a net-metering scheme. The grid injection tariffs are associated to net metering grid connected systems where any excess energy is delivered back into the distribution grid through a bi-directional meter in which the import and export flows are measured and recorded in separate registers. This meter is interval based (30-minute blocks), and periodically reads the exported/imported electricity to and from the grid [20], [21].

Australia lowered the feed-in tariffs but maintained the very attractive solar initial investment subsidies associated to the PV systems [11].

Table II: Economic parameters and values associated to each state of Australia

		ACT	SA	VIC	NSW	QLD
Solar Production	**3kW**	4354 kWh/year	4164 kWh/year	3846 kWh/year	4040 kWh/year	4268 kWh/year
	5kW	7257 kWh/year	6940 kWh/year	6157 kWh/year	6704 kWh/year	7114 kWh/year
Investment	**S1**	10,252.47 € 2.05 €/W	10,252.47 € 2.05 €/W	10,089.37 € 2.02 €/W	9,991.51 € 2.00 €/W	9,926.27 € 1.99 €/W
	S2	12,831.19 € 2.57 €/W	12,912.74 € 2.58 €/W	12,901.10 € 2.58 €/W	12,779.21 € 2.56 €/W	12,673.41 € 2.53 €/W
	S3	5,871.60 €	5,871.60 €	5.871.60 €	5.871.60 €	5.871.60 €
	S4	2,933.63 € 0.59 €/W	2,860.56 € 0.57 €/W	3,061.71 € 0.61 €/W	2,916.66 € 0.58 €/W	2,823.80 € 0.56 €/W
Electricity Hourly Tariff Price (€/kWh)	**Mono**	0.1127 €	**0.2232 €**	**0.1804 €**	0.1502 €	**0.1596 €**
	Tri On-Peak	0.1525 €	- €	0.3031 €	0.3302 €	0.2142 €
	Tri shoulder	0.1030 €	- €	0.1864 €	0.1322 €	0.1516 €
	Tri Off-Peak	0.0754 €	- €	0.1323 €	0.0746 €	0.1167 €
	Difference	0.0771 €	- €	**0.1707 €**	**0.2556 €**	0.0975 €
Grid Injection tariffs		0.0391 €	0.0444 €	0.0326 €	0.0391 €	0.0391 €
Savings from Grid Distribution Costs		180 €	184 €	259 €	198 €	305 €
Annual Electricity Evolution rate		5.06%	2.43%	6.87%	5.37%	5.56%

3 RESULTS AND DISCUSSION

In this section there are four sets of results. The first refers to investment prices as they are at the moment (Table III), the second considers a 10% discount on only the PB solution itself and not to the whole PV system investment (Table VI). The third result set considers a 20% discount on the PB solution (Table V) and finally the fourth result set considers a 30% discount on the PB solution (Table VI). This work studies the effects of the discount on the PB up to 30% due to the fact that shortly after 2020 (year of the facility completion) the PB production costs are expected to be reduced by 30% because of the mass production provided by the Tesla Gigafactory [22]. These four sets of results provide information about the price that should be put in place for PB solutions to become an attractive investment.

Table III shows how the on-grid scenario (scenario 4) is attractive, particularly more in SA, VIC, and QLD which make 3 times (PI > 3.00) the investment, followed by NSW that more than doubles the investment by the end of a 25-year investment period. The attractive PI values (PI ≥ 2.00) are coloured in grey and the breakeven PI values (1.00 < PI < 2.00) are in bold letters. The non-attractive investments (red) have PI values that are lower than 1.00. The payback periods of these investments are attractive because they range from 5 to 8 years (medium term investment). This is due to the high solar energy subsidies that take place in Australia [11], associated to the PV system initial cost.

The next best investment in Table III is in Victoria with the off-grid 5kW PV system connected to one PB system (scenario 1), in which the investment is doubled by the end of a 25-year investment period. The payback period is long term in VIC and, SA has a quicker payback period even though it does not make at least double the investment by the 25th year. This is due to SA´s low electricity evolution rate (2.43%) compared to the other states. Even though Victoria makes double the investment by the 25th year, the investment is viable but not considered a very good investment because of the 12-year payback period, which is longer than the 10-year warranty offered by the Tesla Company. This means that the investor will have to invest in the PB replacement without first making a breakeven on the total investment.

The IRR indicator value is always higher than the average Australian interest rate of 6.25% in all the depicted states within scenarios 1 and 4. The investment attractiveness results of scenario 1 are directly related to the electricity prices practiced in a given state because the investment costs and solar radiation values in the different states do not differ much from one another. All the other investments are long term (> 10 years) and/or have very little profit margins at the end of a 25-year investment period.

The 10% discount on the PB system, presented in Table IV, made very little improvements to the previous results, only adding Queensland to the attractive investment category. The investment is doubled by the 25th year in QLD and this payback period is considered a medium term investment, which takes place before the 10-year warranty of the PB. All the other scenarios with PB solutions remain as non-attractive investments.

The 20% discount on the PB system (Table V) also made very little improvements to the previous results except for the payback period in Victoria that lowered to 9 years instead of 12. The payback period takes place before the 10-year warranty period offered by Tesla for the PB making this an attractive investment. All the other PB scenarios in this table remain as non-attractive investments.

Considering the 30% discount on the PB system (Table VI) the changes to the previous results are also small, except for the fact that the payback period was lowered by one year in both Victoria and Queensland. All other PB scenarios remain as non-attractive investments in this table.

Table III: No Discount on the Powerwall Battery

	ACT			SA			VIC			NSW			QLD		
	IRR	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**
S1	7%	**1,079**	23	13%	**1,719**	8	14%	2,126	12	11%	**1,527**	15	14%	**1,949**	12
S2	2%	0,591	26	7%	**1,094**	19	9%	1,389	18	5%	0,917	26	8%	**1,249**	18
S3	-12%	-0,094	26	-	-	-	5%	0,796	26	8%	**1,169**	22	-6%	0,080	26
S4	13%	**1,930**	11	23%	2,962	5	20%	3,205	7	17%	2,503	8	20%	3,002	7

Table IV: Powerwall Battery with 10% Discount

	ACT			SA			VIC			NSW			QLD		
	IRR	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**
S1	7%	**1,117**	22	14%	**1,777**	8	14%	2,197	12	11%	**1,580**	15	14%	2,015	9
S2	3%	0,652	26	8%	**1,193**	17	10%	**1,510**	16	6%	**1,004**	25	9%	**1,361**	17
S3	-12%	-0,091	26	-	-	-	5%	0,886	26	9%	**1,296**	18	-5%	0,100	26
S4	13%	**1,930**	11	23%	2,962	5	20%	3,205	7	17%	2,503	8	20%	3,002	7

Table V: Powerwall Battery with 20% Discount

	ACT			SA			VIC			NSW			QLD		
	IRR	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**
S1	8%	**1,158**	22	14%	**1,838**	8	15%	2,272	9	11%	**1,636**	14	15%	2,086	9
S2	3%	0,722	26	10%	**1,307**	16	11%	**1,651**	15	7%	**1,104**	23	10%	**1,492**	16
S3	-11%	-0,087	26	-	-	-	6%	0,996	26	10%	**1,451**	17	-4%	0,125	26
S4	13%	**1,930**	11	23%	2,962	5	20%	3,205	7	17%	2,503	8	20%	3,002	7

Table VI: Powerwall Battery with 30% Discount

	ACT			SA			VIC			NSW			QLD		
	IRR	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**	**IRR**	**PI**	**DPBP**
S1	8%	**1,201**	19	15%	**1,902**	8	15%	2,351	8	12%	**1,696**	14	15%	2,161	8
S2	4%	0,806	26	11%	**1,442**	14	12%	**1,816**	14	8%	**1,222**	18	12%	**1,647**	15
S3	-10%	-0,083	26	-	-	-	7%	**1,133**	23	11%	**1,643**	15	-4%	0,155	26
S4	13%	**1,930**	11	23%	2,962	5	20%	3,205	7	17%	2,503	8	20%	3,002	7

4 CONCLUSION

We conclude that only scenario 1 (off-grid 5kW PV system connected to one PB system) PB system investment is viable at the moment and only in the state of Victoria. The state of Queensland is also viable in scenario 1 but only after applying a 10% discount on the PB solution. For the PB system investments to be viable in all the other states, the PB system investment costs have to be lowered much more than 30%.

Perhaps the prices that are now practiced are purposely high to limit the volume of manufacturing demand in this initial stage of the business. The high PB solution prices could also be influenced by the high labour costs of installation that are practiced in Australia.

Having stated earlier that the discounts were only applied to the PB system itself and not to the PV system as a whole, it is clear that the results show that all costs still need to lower in order for the PB investments to be more attractive. The investment costs include the PV system and installation costs as well as the operations and maintenance cost, the hybrid inverter costs, and the inverter replacement costs in years 10 and 20. The PB investments would benefit from the electricity cost rise, from the PB system cost reduction and from solar battery solution governmental subsidies.

Off-grid solutions do not seem plausible in the near future for any household. Therefore, the energy utilities do not have to fear the migration to solar power off-grid solutions for a long time unless the equipment costs lower drastically. This will make the energy utilities slow down their raises in the electricity prices, because the electric prices is one of the main economic parameters that help improve the PV/PB system investment attractiveness. Cheaper solar battery solutions promote highly attractive off-grid investments.

Scenario 4 (on-grid 3kW PV system with 70% self-consumption and 30% grid injection and without a PB solution) presents attractive investments in all states except for the Australian Capital Territory state ranging from double to triple the investment with a payback period between 5 and 8 years. This scenario represents a self-consumption regime of a typical household in Australia with 70% self-consumption and 30% grid injection. Scenarios 2 and 3 do not present viable results in any of the Australian states studied in this work.

Future work includes the study of the same Australian states comparing the PB to other solar batteries that are equivalent.

5 ACKNOWLEDGMENTS

This work was developed in the Instituto de Telecomunicações in Instituto Superior Técnico da Universidade de Lisboa, and supported by ARDITI - Agência Regional para o Desenvolvimento da Investigação Tecnologia e Inovação through the support provided by the FSE - Madeira 14-20. This support is gratefully acknowledged.

Also acknowledge the Portuguese Foundation for Science and Technology for their support through project PEst-OE/EEI/LA0009/2011.

6 REFERENCES

[1] S. Vorrath, “Tesla Targets Australia As 1st Market For Powerwall, Deliveries In 2015,” Renew Economy, 2015. [Online]. Available: http://goo.gl/1s8YQN. [Accessed: 15-Mar-2016].

[2] J. Nicholas, “Why Tesla Is Smart To Launch Powerwall In Australia,” Business Insider Australia, 2015. [Online]. Available: http://goo.gl/7F01fQ. [Accessed: 15-Mar-2016].

[3] S. Vorrath, “First Tesla Powerwall Installations In Homes Begin This Week In Australia,” Renew Economy, 2016. [Online]. Available: http://goo.gl/gRsGC8. [Accessed: 15-Mar-2016].

[4] Energy Matters, “Feed-In Tariff : Solar And Wind Power In Australia - Energy Matters,” Energy Matters, 2016. [Online]. Available: http://goo.gl/ypLfLe. [Accessed: 15-Mar-2016].

[5] Solar Choice, “When Do Solar Feed-In Tariffs End? NSW VIC QLD TAS SA ACT WA NT - Solar Choice,” Solar Choice, 2016. [Online]. Available: http://goo.gl/1wl8xT. [Accessed: 15-Mar-2016].

[6] Origin Energy, “Energy Price Facts Sheet,” Origin Energy, 2016. [Online]. Available: https://goo.gl/iXCYBI. [Accessed: 15-Mar-2016].

[7] Energy Made Easy, “Understand and compare your home electricity usage,” Energy Made Easy, 2016. [Online]. Available: https://goo.gl/dyLIjs. [Accessed: 15-Mar-2016].

[8] Solar Choice Staff, “Average daily production for solar PV cells in Australia,” Solar Choice, 2010. [Online]. Available: http://goo.gl/ERmVwU. [Accessed: 15-Mar-2016].

[9] Tesla Motors, “Powerwall - The Tesla Home Battery,” Tesla Motors, 2016. [Online]. Available: https://goo.gl/4XE3Fd. [Accessed: 15-Mar-2016].

[10] M. Nigel, “Solar export calculator,” Roof Juice Australia, 2015. [Online]. Available: http://roofjuice.com.au/solar-export-calculator/. [Accessed: 15-Mar-2016].

[11] Energy Matters, “Australian Solar Credits Subsidy,” Energy Matters, 2016. [Online]. Available: http://goo.gl/Ov5Cwj. [Accessed: 15-Mar-2016].

[12] R. Bernal-Agustín, J. L., and Dufo-López, “Economical and environmental analysis of grid connected photovoltaic systems in Spain,” Renewable Energy Journal, vol. 31, no. 8, pp. 1107–1128.

[13] Accountingexplained, “Discounted Payback Period Calculation | Formula | Examples,” 2013. [Online]. Available: http://goo.gl/GL9kqp. [Accessed: 01-Mar-2016].

[14] A. Campoccia, L. Dusonchet, E. Telaretti, and G. Zizzo, “An analysis of feed’in tariffs for solar PV in six representative countries of the European Union,” Solar Energy, vol. 107, pp. 530–542, 2014.

[15] T. Lang, E. Gloerfeld, and B. Girod, “Don′t just follow the sun – A global assessment of economic performance for residential building photovoltaics,” Renewable and Sustainable Energy Reviews, vol. 42, pp. 932–951, Feb. 2015.

[16] J. Obaidullah, “Profitability Index,” Accounting Explained, 2013. [Online]. Available: http://goo.gl/Kx823F. [Accessed: 01-Feb-2016].

[17] Retscreen International, “Renewable energy project analysis software,” 2014. [Online]. Available: http://www.retscreen.net/. [Accessed: 01-Jan-2015].

[18] IECONOMICS, “Interest Rate,” 2016. [Online]. Available: http://www.tradingeconomics.com/. [Accessed: 20-Apr-2016].

[19] AEMO, “Average Price Tables,” AEMO - The Australian Energy Market Operator. [Online]. Available: http://goo.gl/SAqWNu. [Accessed: 15-Mar-2016].

[20] M. Lasauce, “Your Gross or Net Solar Electricity Meter,” Solar Choice, 2009. [Online]. Available: http://goo.gl/wF5xWW. [Accessed: 15-Mar-2016].

[21] Origin Energy, “Changing from Gross to Net Metering,” Origin Energy, 2016. [Online]. Available: https://goo.gl/x8zhQs. [Accessed: 15-Mar-2016].

[22] Tesla Motors, “Tesla Gigafactory,” Tesla Motors, 2016. [Online]. Available: https://www.teslamotors.com/gigafactory. [Accessed: 15-Mar-2016].