

# STAND ALONE POWER SYSTEMS AS AN ALTERNATIVE TO GRID CONNECTION AT THE FRINGE OF THE GRID

SUMMARY FOR POLICY MAKERS



## Document Information

Document Version	Date	Prepared By	Reviewed By	Comments
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 270911 v0.1</b>	27/09/2011	Damien Moyse – Energy Projects & Policy Manager		Initial Draft
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 170112 v0.2</b>	17/01/2012	Damien Moyse – Energy Projects & Policy Manager	Craig Memery – Renewable Energy & Smart Networks Specialist	Second Draft
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 170212 v0.3</b>	17/02/2012	Damien Moyse – Energy Projects & Policy Manager	Craig Memery – Renewable Energy & Smart Networks Specialist Ian Porter – Chief Executive Officer	Third Draft
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 280212 v0.6</b>	21/05/2012	Damien Moyse – Energy Projects & Policy Manager	Craig Memery – Renewable Energy & Smart Networks Specialist Dominic Eales – Energy Analyst	Fourth Draft
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 280512 v0.9</b>	28/05/2012	Damien Moyse – Energy Projects & Policy Manager	Craig Memery – Renewable Energy & Smart Networks Specialist Dominic Eales – Energy Analyst	Final Draft
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 300512 v1.0</b>	30/05/2012	Damien Moyse – Energy Projects & Policy Manager		Final Version - NPC
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 160812 v3.0</b>	16/08/2012	Damien Moyse – Energy Projects & Policy Manager	Dominic Eales – Energy Analyst	Final Version - LCoE
<b>Fringe of Grid SAPS Research – Summary for Policy Makers – Draft 160812 v4.0</b>	16/08/2012	Damien Moyse – Energy Projects & Policy Manager		Final Version - LCoE

© 2012 Alternative Technology Association. All rights are reserved. No part of this report may be reproduced without acknowledgement of source.

### Prepared for the Consumer Advocacy Panel

#### ATA Energy Projects Team

Prepared by: Damien Moyse

#### Alternative Technology Association

Level 1, 39 Little Collins St, Melbourne VIC 3000

+61 3 9639 1500

+61 3 9639 5814

[www.ata.org.au](http://www.ata.org.au)

Promoting Renewable Energy, Energy Efficiency and Water Conservation since 1980

## Contents

<b>Executive Summary</b> .....	<b>4</b>
<b>1.0 Introduction</b> .....	<b>6</b>
1.1 Project Context .....	6
<b>2.0 Project Methodology</b> .....	<b>7</b>
2.1 Model Scenarios.....	8
2.2 Modelling Parameters.....	9
2.2.1 Cost Methodology for PV .....	10
2.2.2 Cost Methodology for Wind.....	10
2.2.3 Cost Methodology for Diesel Gensets .....	10
2.2.4 Cost Methodology for Inverters & Batteries.....	11
<b>3.0 Modelling Outputs</b> .....	<b>12</b>
3.1 Capex.....	12
3.2 Levellised Energy Cost.....	12
3.3 SAPS v Grid Augmentation.....	14
<b>4.0 Discussion of Findings</b> .....	<b>15</b>

*This project was funded by the Consumer Advocacy Panel ([www.advocacypanel.com.au](http://www.advocacypanel.com.au)) as part of its grants process for consumer advocacy projects and research projects for the benefit of consumers of electricity and natural gas.*

*The views expressed in this document do not necessarily reflect the views of the Consumer Advocacy Panel or the Australian Energy Market Commission.*

## Executive Summary

With funding from the Consumer Advocacy Panel, the Alternative Technology Association (ATA) commissioned SKM MMA to undertake economic modelling of the costs and benefits of installing stand alone power systems (SAPS) for customers on the fringe of the electricity grid, as an alternative to distribution network replacement or augmentation.

Approximately \$40 billion is to be invested in electricity distribution networks across the National Energy Market (NEM) during the current five year regulatory period – the costs of which are ultimately borne by all electricity consumers.

Given the distances involved and low density of customer connection points in fringe of grid areas, in many cases it will be more cost effective to meet customer energy requirements with a SAPS, rather than by network augmentation.

This research sought to quantify the long run energy costs (expressed as 'levellised' energy cost) from a variety of SAPS designs as compared with the long run costs of upgrading the electricity grid in fringe of grid locations.

More specifically, the research sought to identify the level of network capex at which it becomes more economically efficient to install a SAPS, rather than upgrade the electricity network.

The key finding of the research was the fact that it does not take large amounts of network capital investment to make SAPS a more economically attractive alternative.

Whilst ATA was not surprised to see that even the most costly off-grid option cost less in the long term than a \$100,000 network upgrade, the research shows that it is more cost effective to:

- spend approximately \$78,000 up-front on a high quality, automated SAPS than to upgrade the grid at a cost of \$50,000. To put that in perspective, \$50,000 broadly equates to the cost of undergrounding 100 metres of existing powerline to a single home; or
- spend about \$65,000 up-front on a high quality, automated SAPS and some basic home energy efficiency measures than upgrade the grid at a cost of \$40,000.

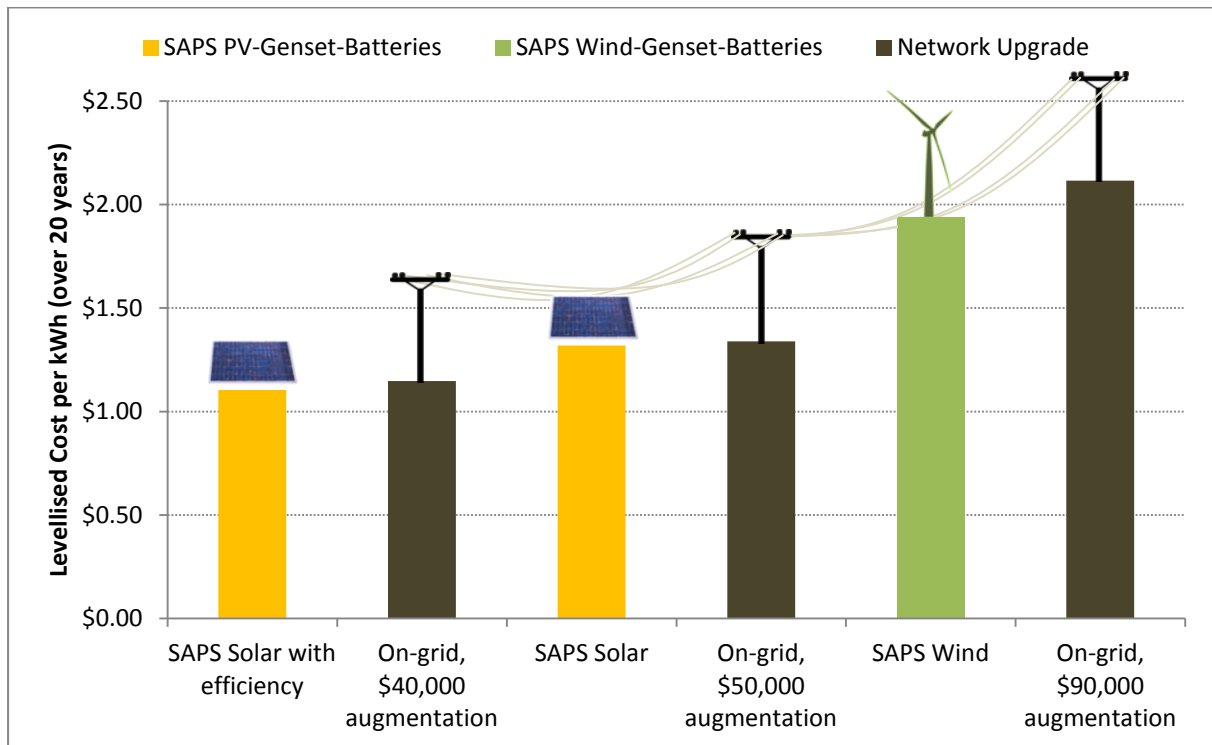
Importantly, the SAPS considered in the modelling provide power of better reliability, quality and security than rural electricity networks. Expenditure on existing networks is a cost borne by all electricity consumers on that network.

It is therefore clearly in keeping with the National Electricity Objective (NEO) to consider SAPS in place of extant network connections wherever it is more cost effective in the longer term than network upgrades.

ATA are of the view that these findings should be taken into account by governments and regulators across Australia when considering matters relating to energy supply in rural and remote areas.

The figure below compares the levelled cost per kilowatt-hour for the different SAPS scenarios modelled with those of grid augmentation:

**Figure 0-1: Levelled Energy Cost Comparison – SAPS versus Grid Augmentation**



## 1.0 Introduction

With funding from the Consumer Advocacy Panel, the Alternative Technology Association (ATA) commissioned SKM MMA<sup>1</sup> to undertake economic modelling of the costs and benefits of installing stand alone power systems (SAPS) for customers on the fringe of the electricity grid, as an alternative to distribution network replacement or augmentation.

*Stand Alone Power Systems as an alternative to Grid Connection at the Fringe of the Grid: Summary for Policy Makers* provides an overview of the process undertaken and the outcomes of the modelling undertaken for the project.

For further details regarding the process, a price sensitivity survey and the assumptions and structure of the modelling, please refer to the background documents prepared by SKM MMA:

- *Preliminary assessment of standalone power systems as an alternative to grid connections at the fringe of the grid; and*
- *Supplementary modelling on standalone power systems as an alternative to grid connection at the fringe of the grid.*

## 1.1 Project Context

Approximately \$40 billion is to be invested in electricity distribution networks across the National Energy Market (NEM) during the current five year regulatory period<sup>2</sup> – the costs of which are ultimately borne by all electricity consumers.

Given the distances involved and low density of customer connection points in fringe of grid areas, in many cases it will be more cost effective to meet customer energy requirements with a SAPS rather than by network augmentation.

Importantly, this will likely be the case irrespective of whether the policy rationale is to meet increasing demand on a constrained network; improving power quality; replacing aging or damaged assets; or for policy objectives such as for bushfire start risk mitigation.

Commenced in mid 2010, this piece of research was initiated in response to the 2009 ‘Black Saturday’ bushfires in Victoria. After the bushfires, the Victorian Government sought to understand what the costs would be to mitigate the bushfire risk of uninsulated powerlines, including ‘single wire earth return’ (SWER) lines<sup>3</sup>, by replacing them with insulated conductors, relocating them underground or by improved operation and maintenance.

The research sought to quantify the long run energy costs (expressed as ‘levellised’ energy cost) from a variety of SAPS designs as compared with the long run costs of upgrading the electricity grid in fringe of grid areas. More specifically, the research sought to identify the level of network capex at which it becomes more economically efficient to install a SAPS, rather than upgrade the network.

<sup>1</sup> ATA originally commissioned McLennan Magasanik Associates (MMA) to undertake this assignment. During the course of the project, the business of MMA was acquired by Sinclair Knight Merz (SKM) and the assignment was transferred to SKM MMA.

<sup>2</sup> AER, 2011. *State of the Energy Market*. ACCC, Canberra.

<sup>3</sup> Typically found in rural locations and were found to be the catalyst for a number of the Victorian fires.

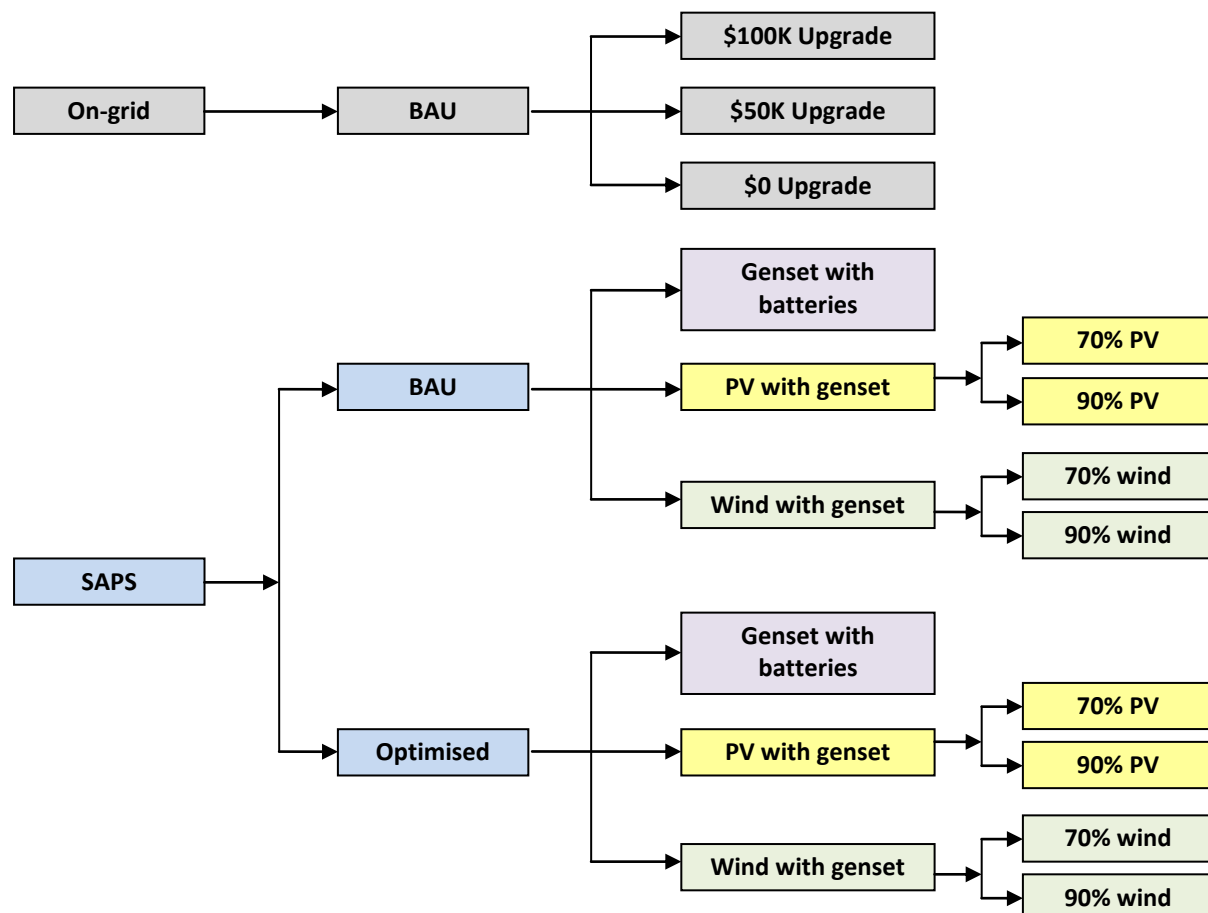
## 2.0 Project Methodology

Four approaches were utilised to determine the costs and benefits of SAPS at the fringe of the grid:

1. A survey of a reasonably energy literate cross-section of the rural population (based on members of the ATA) in order to:
  - obtain real data on electricity consumption and appliance type and use; and
  - understand the potential for end use energy efficiency improvements to reduce the capital cost of SAPS;
2. SAPS specifications and costs for high quality, fully automated SAPS provided by an independent SAPS installer, who specialises in SAPS design, installation and maintenance;
3. Modelling of the levelised and net present energy cost of various 'off-grid' scenarios with different SAPS systems; and
4. Modelling of the levelised and net present energy cost of three 'on-grid' scenarios – two reflecting the costs of distribution network upgrades that would continue to provide grid supplied electricity to fringe of grid customers and one reflecting the cost of no upgrade at all.

There were two primary options – that is, to remain grid connected ('on-grid'), or to move to a SAPS. Thirteen scenarios were then modelled that encapsulated a variety of on-grid and SAPS configurations and energy requirements. **Figure 2-1** outlines the thirteen scenarios modeled:

**Figure 2-1: Relationship between the Scenarios**



## 2.1 Model Scenarios

Within the on-grid scenarios, households continued to use their existing appliances in a business as usual (BAU) manner – meaning there was no change to the household appliances or use thereof. The electricity would be delivered via existing conductors; or by upgrades to the network<sup>4</sup>. The capital cost of upgrades to the network were valued at \$50,000 and \$100,000 respectively<sup>5</sup>.

For the purposes of this project, the capital cost of network upgrades has been considered as any expenditure incurred for works between the customer and point of common coupling with other customers on the network.

However, there may be cases where the avoided costs attributable to an individual SAPS occur elsewhere in the network (for example, through avoiding the need to upgrade the thermal capacity of a shared network component) and these values apply equally in that situation to any avoided costs.

Within the SAPS option, households could continue as business as usual (with respect to appliance or load requirements) or the household and SAPS could be 'optimised' by:

- replacing some appliances (e.g. fridges) with more efficient technology; or
- fuel switching (e.g. replacing electric hot water with electric boosted solar hot water).

Undertaking either of these investments would obviously reduce daily load requirements and therefore the cost of the SAPS. Importantly, the costs of all these improvements are incorporated into the levelised and net present energy costs for these optimised scenarios.

Based on the survey data, the average daily electricity use was assumed to be 13.7 kWh per day for the 'BAU' case; and 12.1 kWh per day for the 'Optimised' case.

ATA note that far greater cost effective efficiency gains would be achievable in reality than those within the 'optimised' scenarios. This of course would lead to SAPS with lower capital, and net present energy costs.

Within the SAPS option, there were three potential SAPS designs. The electricity could be generated by:

- a diesel generator (genset) alone;
- a solar photovoltaic (PV) system with genset backup; or
- A small wind turbine with genset backup.

All of these options included batteries. Within the solar PV and wind based systems, there were two levels of renewable contribution modelled – those being either 70% or 90%.

---

<sup>4</sup> For example, by new insulated unscreened conductors (IUC) or underground conductors, or modifications to the control or operation of the network – such as the use of smart re-closers or earth fault neutralisers.

<sup>5</sup> While the cost of upgrades to supply some homes may extend well beyond that range, it was unnecessary to consider more expensive network upgrades to capture the point at which SAPS become more cost effective.



## 2.2 Modelling Parameters

With respect to the modelled scenarios, the following parameters were fixed for each sensitivity, with the values shown in **Table 2-1** being for the base sensitivity.

**Table 2-1: Parameters for the Modelling**

Parameter	Values for base sensitivity
Diesel price	\$1.50/L
Generator operating cost, excluding fuel	\$1.50/hour
Inverter cost	\$9,290
Inverter operating cost	\$100/year
Battery operating cost	\$0/year
Wind turbine maintenance cost	\$200/year
PV maintenance cost	\$0/year
STC price	\$35

No residual values were assumed for the gensets, inverters, batteries, wind turbines or PV panels, however it is fair to assume that the salvage value of these items would further reduce the levelised and net present costs under the SAPS scenarios.

The basic SAPS parameters for each of the scenarios are shown in **Table 2-2** below.

**Table 2-2: SAPS Scenario Parameters**

Scenario	Daily electricity use	Generator size (kVA)	Generator use (h/year)	Size of PV unit (kW)	Size of wind generator (kW)
On grid BAU	13.7	N/A	N/A	N/A	N/A
SAPS BAU Genset w Batteries	13.7	13	1,004	N/A	N/A
SAPS BAU PV 70%	13.7	13	302	2.63	N/A
SAPS BAU PV 90%	13.7	13	57	3.6	N/A
SAPS BAU Wind 70%	13.7	13	300	N/A	5
SAPS BAU Wind 90%	13.7	13	75	N/A	5
SAPS Optimised Genset with Batteries	12.1	13	877	N/A	N/A
SAPS Optimised PV 70%	12.1	13	252	2.63	N/A
SAPS Optimised PV 90%	12.1	13	77	3.15	N/A
SAPS Optimised Wind 70%	12.1	13	220	N/A	5
SAPS Optimised Wind 90%	12.1	13	100	N/A	5

### 2.2.1 Cost Methodology for PV

PV units were specified by the SAPS installer, assumed to have a life of 25 years and to require no maintenance beyond the unskilled labour required to clean the surface periodically. **Table 2-3** outlines the installed capacities and capex of the PV systems.

**Table 2-3: PV Installed Capacity & Capex**

Scenario	Installed Capacity	PV Capex (\$)
SAPS BAU PV 70%	2.63	\$14,700
SAPS BAU PV 90%	3.60	\$20,160
SAPS Optimised PV 70%	2.63	\$14,700
SAPS Optimised PV 90%	3.15	\$17,640

### 2.2.2 Cost Methodology for Wind

A 5.0 kW Westwind generator was specified for all wind scenarios, as this turbine would always exceed the minimum energy requirements. Capex on a 22 metre tower was \$45,620, with the major components being the tower, the turbine, and installation costs.

Opex was based on several hours of skilled maintenance per year (not necessarily required each year, but averaged at \$200 per year over the generator life); and a major overhaul costing 50% of the original generator cost every 10 years.

The overhaul allowed for replacing major components, such as blades or controllers.

### 2.2.3 Cost Methodology for Diesel Gensets

A 13 kVA JCB generator was used for all scenarios, with mean fuel consumption of 3.5L per hour. The gensets were assumed to require a major overhaul after 20,000 hours, but they did not reach this number of hours in any of the scenarios during the 20 year system life.

Genset opex was based on fuel, consumables such as filters and lubricants and routine maintenance costed for a typical year and then converted to a cost per hour of operation for use in the scenarios.

To ensure high reliability of supply through full redundancy, the generator was sized to be able to supply the full electrical load of the house if needed.

This is important, as it meant that the systems in all scenarios would provide better reliability than the grid connections they were to replace.

## 2.2.4 Cost Methodology for Inverters & Batteries

All of the scenarios used a Selectronic 7kW fully automatic interactive inverter. As with the generator, to ensure high reliability of supply through full redundancy, the inverter was sized to be able to supply the full electrical load of the house if needed.

Hoppecke Gel batteries were specified operating to a 50% depth of discharge. One day of autonomy was specified for gensets with batteries; two days for the 70% renewables scenarios and three days for the 90% renewables scenarios.

No maintenance was required as the batteries were sealed gel batteries and the expected life of the inverter and batteries was 15 years. **Table 2-4** outlines the capacities and capex for batteries:

**Table 2-4: Battery Capacities & Capital Cost**

Scenario	Capacity (Amp hours)	Capex (\$)
On-grid BAU	N/A	N/A
SAPS BAU Genset w Batteries	1,000	\$21,120
SAPS BAU PV 70%	1,250	\$22,440
SAPS BAU PV 90%	1,700	\$33,792
SAPS BAU Wind 70%	1,250	\$22,440
SAPS BAU Wind 90%	1,700	\$33,792
SAPS Optimised Genset w Batteries	750	\$15,312
SAPS Optimised PV 70%	1,000	\$21,120
SAPS Optimised PV 90%	1,250	\$22,440
SAPS Optimised Wind 70%	1,000	\$21,120
SAPS Optimised Wind 90%	1,250	\$22,440

## 3.0 Modelling Outputs

### 3.1 Capex

**Table 3-1** summarises the capital costs in the first year of the various scenarios and their energy sources:

**Table 3-1: First Year Capital Costs**

Scenario	Capital Cost (\$)	Daily Electricity Load (kWh)
BAU On grid	\$0	13.7
BAU On grid - \$50K Upgrade	\$50,000	13.7
BAU On grid - \$100K Upgrade	\$100,000	13.7
SAPS BAU genset with batteries	\$49,242	13.7
SAPS BAU PV 70%	\$60,744	13.7
SAPS BAU PV 90%	\$78,557	13.7
SAPS BAU Wind 70%	\$96,716	13.7
SAPS BAU Wind 90%	\$109,203	13.7
SAPS Optimised genset with batteries	\$45,061	12.1
SAPS Optimised PV 70%	\$61,500	12.1
SAPS Optimised PV 90%	\$65,826	12.1
SAPS Optimised Wind 70%	\$97,472	12.1
SAPS Optimised Wind 90%	\$98,924	12.1

### 3.2 Levelled Energy Cost

The model then estimated the levelled energy cost of all scenarios – i.e. the cost per kWh over a 20 year asset life, where both costs and generation are calculated as net present costs by applying a discount rate.

For the SAPS scenarios, a discount rate of 5% was used, this being reflective of the value of money in the pocket of a household or private individual. This would be indicative of the life cycle cost of a system where, for example, a one-off payment has been made to the household to go off grid.

For the on-grid scenarios, a discount rate of 10% was selected, as this is close to the long term Weighted Average Cost of Capital (WACC) used by distribution businesses in Australia when funding network operational and capital expenditure. A 15% discount rate was also tested across all scenarios as part of the sensitivity analysis.

The on-grid scenarios used a conservative forecast of the average price of electricity (taken from mid 2010) for the next 20 years, that being \$0.38/kWh. This figure was derived from SKM MMA's energy market cost model.

It refers to the long term average price paid by customers for the service charge and the energy charge and is indicative both of the long term cost of supplying the customer, and also what the customer may be reasonably expected to contribute towards their energy consumption if a SAPS is installed.

**Table 3-2** summarises the results of the modeling and presents the levelled energy cost of each scenario over 20 years:

**Table 3-2: Levelled Energy Costs for each Scenario**

Scenario	Levelled Energy Cost (\$/kWh)
BAU On grid <sup>6</sup> (no augmentation)	\$0.38
SAPS BAU PV 70% <sup>7</sup>	\$1.24
SAPS Optimised PV 90% <sup>7</sup>	\$1.25
SAPS BAU PV 90% <sup>7</sup>	\$1.32
On grid at \$50,000 network upgrade <sup>6</sup>	\$1.34
SAPS Optimised PV 70% <sup>7</sup>	\$1.36
SAPS BAU Genset with batteries <sup>7</sup>	\$1.71
SAPS Optimised Genset with Batteries <sup>7</sup>	\$1.79
SAPS BAU Wind 70% <sup>7</sup>	\$1.92
SAPS BAU Wind 90% <sup>7</sup>	\$1.94
SAPS Optimised Wind 70% <sup>7</sup>	\$2.00
SAPS Optimised Wind 90% <sup>7</sup>	\$2.20
On grid at \$100,000 network upgrade <sup>6</sup>	\$2.31

**Table 3-2** demonstrates that a number of the SAPS scenarios were more cost effective than even a \$50,000 network upgrade.

<sup>6</sup> With 10% discount rate, for distribution network businesses, reflective of long term WACC settings.

<sup>7</sup> With 5% discount rate, for private individual / household investment.

### 3.3 SAPS v Grid Augmentation

The overall purpose of the modelling was to attempt to ascertain at what point it would be more cost effective to install a SAPS for a grid connected customer, instead of upgrading the electricity grid.

Due to the differing daily energy use profiles of the BAU and optimised loads used in the modelling, levelled cost is actually a sub-optimal metric upon which to compare across both BAU and optimised daily load requirements – as the levelled cost of energy for an optimised scenario is actually applied to a lower level of energy use than for BAU.

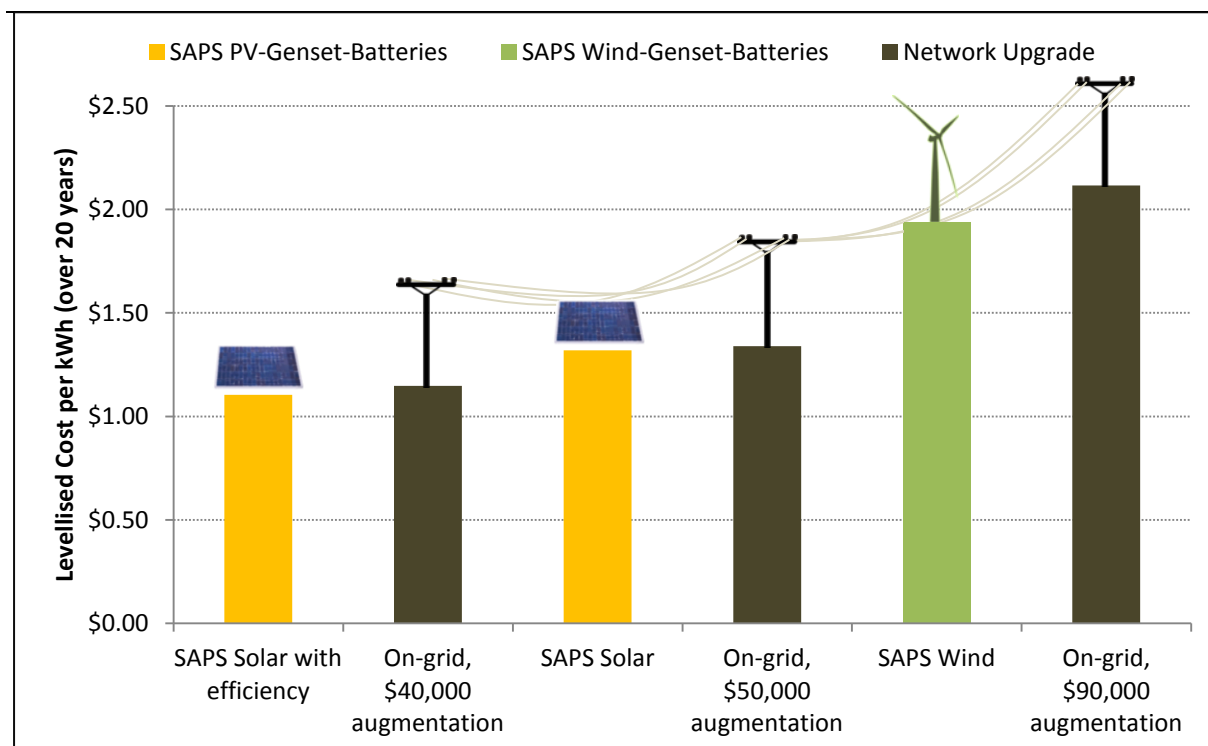
To get an accurate representation of the ‘effective’ levelled energy cost for the optimised SAPS scenarios, the ATA applied an optimisation ‘factor’ to those scenarios requiring the lower level of daily load (i.e. 12.1 kWh per day).

This optimisation factor was simply reflective of the difference between the daily load requirements of the BAU scenarios (i.e. 13.7 kWh per day) and the optimised scenarios (i.e. 12.1 kWh per day).

The factor applied to the optimised scenarios on this basis equated to a 12% reduction in the levelled cost of energy, to reflect the lower energy consumption over the 20 year period. This allowed for a more accurate cost comparison across both BAU and optimised scenarios.

In line with the above, **Figure 3-1** compares the levelled energy costs for a number of the SAPS scenarios with those of grid augmentation:

**Figure 3-1: Levelled Energy Cost Comparison – SAPS versus Grid Augmentation**



## 4.0 Discussion of Findings

A number of assumptions have been made in order to build this model. The realities driving these assumptions are constantly changing, and for the most part, these changes continue to reduce the cost of SAPS and increase the costs of network augmentation.

One of the most significant of these variables is the installed costs for SAPS – and in particular, the solar based systems. With the project commencing in 2010, relevant installed costs had to be used at that point in time. Since mid 2010, the cost of solar panels has dropped in the order of 30%.

Electricity prices are also difficult to predict, with the model using conservative figures with respect to the levellised cost of energy from the grid for the next 20 years (based on 2010 input values).

At the time of publication of this *Summary* document (May, 2012), recent increases in electricity prices in excess of earlier forecasts have been experienced in most states. With the amount of distribution investment expected nationally over the next five to ten years, it is possible that the average levellised cost of energy from the grid over the next 20 years will be higher than the \$0.38/kWh reported in this study.

The key finding however is the fact that it does not take significant amounts of network capital investment to make SAPS a more attractive economic proposition.

Whilst ATA was not surprised to see that even the most costly off-grid option was cheaper in the long term than a \$100,000 network upgrade, the report shows that it is more cost effective to:

- spend approximately \$78,000 up-front on a high quality, automated SAPS than to upgrade the grid at a cost of \$50,000. To put that in perspective, \$50,000 broadly equates to the cost of undergrounding 100 metres of existing powerline to a single home; or
- spend about \$65,000 up-front on a high quality, automated SAPS and some basic home energy efficiency measures than upgrade the grid at a cost of \$40,000.

ATA are of the view that these findings should be taken into account by governments and regulators across Australia when considering matters relating to energy supply in rural and remote areas.

**Best practice-designed, standards-compliant, SAPS provide power of better reliability, quality and security than rural electricity networks. Expenditure on existing networks is a cost borne by all electricity consumers on that network.**

**It is therefore clearly in keeping with the National Electricity Objective to consider SAPS in place of extant network connections wherever it is more cost effective in the longer term than network upgrades.**

For further project details, including all of the detailed analysis and assumptions underpinning the modeling, the following two additional documents can be obtained from ATA's Melbourne office:

- *'Preliminary assessment of standalone power systems as an alternative to grid connections at the fringe of the grid'*; and
- *'Supplementary modelling on standalone power systems as an alternative to grid connection at the fringe of the grid'*.