

Prepared for Birdwood Energy

## **Modification Report**

Sandy Hollow Solar Farm

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Project Number: 230554



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### Acronyms and abbreviations

AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
BC Act	Biodiversity Conservation Act 2016 (NSW)
CEMP	Construction environmental management plan
СМА	Catchment management area
DPE	Department of Planning and Environment (NSW)
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
LEP	Local Environment Plan

## 1. Introduction

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### 1.1. Overview

This Modification Report has been prepared to support an application under section 4.55(1A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The application seeks Muswellbrook Shire Council's consideration for proposed modifications to development approval DA2019/102 for electricity generating works (a solar farm) at 511 Richmond Grove Road, Sandy Hollow. The subject land is Lot 12 DP1042612. It is noted the address of the land at the time of original approval was 1333 Merriwa Road, Denman.

The proposal was recommended for approval by Muswellbrook Shire Council (Council) and subsequently granted consent by the Hunter and Central Coast Regional Planning Panel on 06 May 2020. The lapse date for the consent DA2019/102 is 06 May 2025.

The landholder and original applicant for the development was Mr. Andrew King of Vernon Trust. Mr King still holds ownership of the land as the sole director of Stroud Agricultural Company as trustee for Vernon Trust. Landholder consent accompanies this modification application. Birdwood Energy Pty Ltd has acquired the proposed Sandy Hollow Solar Farm project and intends to the develop the site.

Having conducted further detailed design to progress the proposal towards a construction certificate, Birdwood Energy (now, the proponent) is seeking a modification to the development consent. The proposed modifications are outlined below and in further detailed overleaf. The modification is proposed pursuant to Section 4.55(1A) of the EP&A Act.

- 1. Inclusion of an ancillary battery energy storage system (BESS).
- 2. Modified location of the inverters.
- 3. Minor adjustment to the route of the proposed underground powerline (relocated from overhead), from the solar array immediately east to the dwelling.
- 4. Remove Condition 6 and 17 requirements relating to landscape screening.

The proposed modifications to the solar farm would be generally consistent with the approved development.

The proposed development site is agricultural land with a history of clearing for grazing. It is currently used for cattle grazing. The development footprint would comprise an area of approximately 14 hectares, located in the north-western sector of the subject site. The solar farm would include installation of solar photovoltaic (PV) cells with a capacity of approximately 6 MW on a ground-mounted tracking system of pole driven steel posts. The proposed development would connect to the existing 33kV line (Denman to Merriwa) via a new switching station.

### 1.2. Background

Development consent for the proposed development was sought under Part 4 of the EP&A Act. The estimated capital investment value (CIV) of the original proposal was approximately \$5.6 million.

The estimated CIV of the modified proposal is \$10 million. Falling within the range of \$5 million -\$30 million, the proposal is considered Regionally Significant Development (RSD). The section 4.55(1A) application would be determined by Council in accordance with the relevant Departmental directives.

## 2. The proposed development

### 2.1. Summary of original proposal

Table 2-1 Summary of key features of the original proposal

Proposal element	Description
Capacity	6 MW Note: the capacity is based on products and technology available at the time of the proposal but may change through the life of the solar farm as advances in technology occur.
Development footprint	Approximately 14 hectares solar farm infrastructure area.
Solar array	Approximately 16,200 solar panels mounted in rows on tracker tables and approximately 2, 000 array posts. One containerised power station (containing 2 x SMA MV Power Station 4950 or similar) on the eastern side of the solar array.
Substations	A grid connection switching station on the northern side of the site is proposed. This would connect to the existing 33kv transmission line which would be extended to a proposed containerised power station within the development site. A right of carriageway would need to be established on the property title, in favour of AusGrid, for access/maintenance purposes.
Site compound	Approximately 800sqm containing containerised inverter, control facilities, storage as well as temporary site office and amenities.
Access tracks	Internal access tracks would be constructed of engineered fill topped with crushed stone pavement would access the solar farm infrastructure for maintenance, as per accompanying design plans.
Perimeter fencing, lighting and CCTV	Wire mesh fencing installed around the site would indicatively be 1.94 metres high. Continuous infra-red security technology and CCTV cameras would be installed on posts around the perimeter fence and on the main access track.
Construction hours	Standard daytime construction hours would be 7.00am to 6.00pm Monday to Friday and 8.00am to 1.00pm on Saturdays.
Construction timing	9 months
Workforce	Construction – approximately 30 workers Operation – 1 operation and maintenance contractor, stationed off-site
Operation period	Up to 40 years
Decommissioning	The site would be returned to its pre-works state. All above ground infrastructure would generally be removed to a depth of 1000mm. The site would be rehabilitated in consultation with the landowner, consistent with future land use requirements.
Capital investment value	Calculated \$5.6 million.



### 2.2. Proposed modification overview

Birdwood Energy proposes the following modifications pursuant to Section 4.55(1A) of the EP&A Act.

### 1. Inclusion of an ancillary battery energy storage system (BESS).

The BESS would be scaled to the solar farm and have a proposed capacity of 4.95MW /20 MWh (4 hrs). The BESS would consist of eight (8) skid-mounted battery containers (Sungrow ST2752UX or similar).

The containers are manufactured with several inbuilt fire protection and suppression systems as well as design and siting specifications that prevent the spread of fire. The proposed BESS would substantially exceed the manufacturers separation requirements, as outlined in section 0 of this report and the accompanying Initial Hazard Analysis prepared by Pando Consulting.

The proposed BESS would make more effective use of the renewable energy created on-site, by shifting output to peak periods of community consumption, to import electricity during periods of low prices and to provide ancillary support services to the wider electricity market.



Figure 2-1 Sungrow ST2752UX containerised battery module

### 2. Modified location of the inverters.

The equipment location would change from the eastern edge of the original footprint to instead be centrally located within the array. This would reduce overall site disturbance and cost, and reduce voltage drop (energy loss).

## 3. Minor adjustment to the route of the proposed underground powerline (relocated from overhead), from the solar array immediately east to the dwelling.

The revised route would be more direct and lesser impact than the original proposal, which approached the dwelling from the south-eastern corner of the solar array.

### 4. Remove Condition 6 and 17 in relation to the originally proposed landscape screening.

It is proposed to amend Condition 6 and 17 to remove the requirement for landscape screening along the western boundary, the western side of the internal access road between the Golden Highway and the northern boundary of the solar array.

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The proposed amendments are in accordance with current approaches to landscape screening which have evolved since the project was originally approved in 20202, whereby the intention of landscape screening is to "filter" views of the proposed infrastructure and not block or screen views. The only receiver that is potentially affected is the existing property located immediately to the west of the subject site. Existing vegetation and topography already filters views from the neighbouring dwelling and therefore it is considered additional landscape screening is not warranted. The conditioned landscape screening would additionally adversely affect the solar resources the panels can access, by way of shading.

The proposed changes to landscape screening are in accordance with the results of a visual impact assessment conducted in accordance with current technical guidance provided by the Department of Planning and Environment's Large-Scale Solar Energy Guideline – Technical Supplement – Landscape and Visual Impact Assessment. Further details are provided in section 4.2 of this report.

The proposed modifications to the solar farm would be generally consistent within the approved footprint. The proposed connection point and general configuration of the proposed solar farm remain as per the original approval. The proposed relocation of the existing powerline to underground would create a new area of disturbance; however, this is generally within an already disturbed area comprising the cluster of the dwelling and rural outbuildings immediately east of the solar array.

Proposal element	Description
Capacity	4.95 MW (AC) and will produce around 12,000MWh per year. Note: the capacity is based on products and technology available at the time of the proposal but may change through the life of the solar farm as advances in technology occur.
Development footprint	Approximately 14 hectares solar farm infrastructure area.
Solar array	Approximately 13,888 solar panels mounted in rows on tracker tables and approximately 2, 970 array posts. One containerised power station (Sungrow SG4950HV-MV or similar) in the centre of the solar array.
Battery	Eight (8) skid-mounted battery containers (Sungrow ST2752UX or similar).
Substations	A switching station at the northern boundary is proposed for the connection to the existing 33kv transmission line along the Golden Highway. This would connect to a proposed internal substation kiosk within the solar farm perimeter, as per accompanying design plans.
Site compound	Not required as temporary construction storage/ hardstand would be managed within the solar farm perimeter, as shown.
Access tracks	Internal access tracks and hardstand area would be constructed of engineered fill topped with crushed stone pavement would access the solar farm infrastructure for maintenance, as per accompanying design plans.
Perimeter fencing, lighting and CCTV	Wire mesh fencing installed around the site would indicatively be 1.94 metres high. Continuous infra-red security technology and CCTV cameras would be installed on posts around the perimeter fence and on the main access track.
Construction hours	Standard daytime construction hours would be 7.00am to 6.00pm Monday to

Table 2-1 Summary of key features of the modified proposal

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	Friday and 8.00am to 1.00pm on Saturdays.
Construction timing	Estimated 9 months.
Workforce	Construction – approximately 30 workers Operation – 1 operation and maintenance contractor, stationed off-site
Operation period	Up to 40 years
Decommissioning	The site would be returned to its pre-works state. All above ground infrastructure would generally be removed to a depth of 1000mm. The site would be rehabilitated in consultation with the landowner, consistent with future land use requirements.
Capital investment value	Calculated \$10 million.

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## 3. Site analysis

### 3.1.1. Site description

The subject land comprises part of Lot 12 DP 1042612. It is approximately 152 hectares, which is bisected by the Muswellbrook Merriwa rail line. The proposed development footprint would consist of approximately 14 hectares of land, in the north-western corner of the site adjoining the Golden Highway.

The subject land is located 2.6km from the village of Sandy Hollow and is 3.5km from Hollydeen. The land is within the Muswellbrook LGA and located 30km from Muswellbrook itself. There are two existing dwellings on the subject land, referred to as associated receptors.

### 3.1.2. Character and landscape

The development site lies within a rural landscape 2.6km from the village of Sandy Hollow. The Goulburn River bisects the subject land east to west and is located south of the proposed development footprint. The development site gently slopes north to south towards the Goulburn River. The average site elevation is 140 m AHD, with a low of 133 m AHD at the southern boundary and a high of 153 m AHD on the northern boundary.

The surrounding topography is relatively flat, especially surrounding the township of Sandy Hollow, being a flood plain area for the Goulburn River. Surrounding the flood plain area are steep hills, creating a secluded valley for the township of Sandy Hollow and the development site.

The surrounding land along the Golden Highway and around Sandy Hollow contains medium-sized properties running small-scale grazing and other agricultural operations. The township of Sandy Hollow is at the same elevation, between 133 to 140 m AHD. There is no view corridor to the subject site. The residential properties that form Sandy Hollow are dispersed, with a cluster of local shops, some visitor accommodation, a community hall, and a public school. Sandy Hollow has a population of 188 according to the 2021 ABS census.

The development site falls within the Sydney Basin IBRA Bioregion and the Kerrabee Subregion. The Sydney Basin IBRA Bioregion consists of a geological basin where sedimentary rocks have been subject to uplift and gentle folding and minor faulting during the formation of the Great Dividing Range. Erosion by coastal streams has created a landscape of deep cliffed gorges and remnant plateaus. The Sydney Basin Bioregion includes coastal landscapes of cliffs, beaches, and estuaries.

The Kerrabee Subregion is characterised by sandstone plateaus with cliffed edges into wide valleys with sandy alluvial fill. The geology of the Kerrabee Subregion is comprised of Triassic Narrabeen quartz and lithic sandstones and shales.

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## 4. Consideration of modified impacts

### 4.1. Noise

### 4.1.1. Approach

A noise impact assessment has been prepared by NGH to assess the potential impacts of the modified development on sensitive receivers during construction and operational phases. It has been prepared in accordance with the relevant policies and guidance, administered by the Environment Protection Authority (EPA):

- NSW Interim Construction Noise Guideline (ICNG) (NSW and Department of Environment and Climate Change (NSW), 2009).
- NSW Noise Policy for Industry (NPI) (NSW EPA, 2017).

The TfNSW Construction and Maintenance Noise Estimator Tool (CMNET) is a tool used to estimate the construction noise impacts to nearby receivers. A distance-based assessment (construction and operational scenarios) was prepared.

### **Sensitive receivers**

There are no new receivers in the investigation area compared with those originally assessed. Three non-associated sensitive receivers (Receivers 3, 4 and 5) were identified within 1km of the development site, with the closest non-associated receiver located approximately 250 metres north of the development site, as indicated in the figure on the following page. Two residences (referred to as associated receivers – 1 and 2 on the following page) are associated with the development and are located within the subject land, east of the solar farm.

### **Background noise levels**

Consistent with the development as originally approved, the land is located in a rural setting, which is typified by a sparse settlement pattern and low background noise levels (EPA 2017). The following background noise levels, referred to as Rating Background Levels (RBL) for rural settings have been derived from the NPI and continue to be relevant to the modified proposal.

Table 4-1 Typical background noise levels/ Rating Background Levels (NSW EPA, 2017)

Setting	Daytime	Evening	Night-time
	0700-1800	1800-2200	2200-0700
Rural	40 dB(A)	35 dB(A)	30 dB(A)



Datum: GDA2020 / MGA Zone 56

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### Sandy Hollow Solar Farm Locality

### **Construction noise assessment approach**

The quantitative construction noise assessment has been conducted in accordance with the Interim Construction Noise Guideline (ICNG) as referenced above. The ICNG recommends standard hours for construction activity being Monday to Friday 7am to 6pm and Saturday 8am to 1pm. No work should be conducted on Sundays or Public Holidays.

The ICNG provides Noise Management Levels for these work periods based on the receiving environment. During the standard recommended construction work hours, the Noise Affected Level is considered to be the RBL plus 10, whilst the Highly Noise Affected Level is 75 dB(A) regardless of the RBL. Work would only be carried out during the standard construction hours. Therefore, the Noise Affected Level for receivers in the area of the proposed development would be the RBL of 40 dB(A) plus 10, being 50 dB(A).

A distanced based (scenario) was used to assess the original proposal, based on the predefined scenario of 'Construction compound site establishment' (119 dB(A) sound power level (SWL)) in the CMNET. This construction scenario was considered to be a conservative representation of the works associated with the original proposal, but also would be consistent with the modified proposal (Table 4-2). Minor additional traffic may be expected with the modified proposal, associated with the delivery of the battery modules and associated infrastructure. However, the machinery/equipment used, and their intensity of activity would be similar to those of the development as originally approved.

Plant
Piling rig - driven
Roller (large padfoot)
Mobile crane
Front end loader
Dump trucks
PC400 45t tracked excavator
Water cart
Vibratory roller
637E scraper

Table 4-2 Estimated machinery and equipment

### **Operation assessment approach**

Noise impact for operation has been assessed against the NSW Noise Policy for Industry (NPI) (EPA 2017). The assessment has two components.

- Intrusive noise levels
- Amenity noise level

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### Intrusiveness level

According to the NPI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the LAeq,15min descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is provided in Table 4-3.

Table 4-3 NSW Noise Policy for Industry intrusiveness goals

Time of day	RBL dB(A) L <sub>A90</sub>	Intrusive noise = RBL + allowance	Minimum project intrusiveness noise levels (L <sub>Aeq</sub> ,15min dB(A))
Day	40	= RBL + 5	45
Evening	35	= RBL + 5	40
Night	30	= RBL + 5	35

### Amenity level and recommended amenity noise level

The NPI outlines recommended amenity noise levels to maintain the amenity for an area. The **recommended amenity noise level** represents an objective for total industrial noise at a receiver location, the **project amenity noise level** represents the objective for noise from a **single** industrial development at a receiver location.

The project amenity noise levels for proposed new industrial noise sources is calculated by the recommended amenity noise level minus 5 dB(A); refer Table 4-4 below.

Table 4-4 Amenity noise levels for residential receivers in a rural setting (EPA 2017)

Period	Recommended level L <sub>Aeq</sub> dB(A)	Project level L <sub>Aeq</sub> dB(A)
Day (7am-6pm)	50	45
Evening (6pm-10pm)	45	40
Night (10pm-7am)	40	35

The NPI states that increases of 2 dB(A) or less do not require assessment. Further, the NTL is not intended under the NPI methodology to be a limit, but rather, to provide guidance of a threshold where the affected receptor may experience an adverse impact and mitigation measures should be considered.

### 4.1.2. Potential impacts

### Construction

As with the development as originally approved, construction works would be restricted to daytime, standard work hours. The construction of the modified proposal would be generally consistent with the original proposal, as outlined earlier in this report.

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Based on the original results of the CMNET, construction noise impacts from the original and modified proposal would impact sensitive receivers within 360 metres of the development site. One sensitive receiver is 250 metres from the development site and would potentially be exposed to noise levels of 55 dB(A). This would exceed the NML of 50 dB(A) outlined above by 5. The CMNET indicates that noise levels between 5 and 20dB(A) above NMLs are audible but unlikely to materially affect receivers. It advises that mitigation measures are not required for work carried out within the recommended construction hours.

Two sensitive receivers are further than 360 metres from the development site and are unlikely to be affected by construction noise, as they would be exposed to noise levels below 55 dB(A).

No receivers would be Highly Noise Affected, or experience Moderately to Highly intrusive noise levels.

The potential exceedances of NMLs at Receiver 1 are expected to be short-term. Noise sources would move progressively around the construction footprint during the construction phase. Installation of solar array posts by pile driving, would be the noisiest component of construction and would not be continuous for the 9-month construction period.

Table 4-5 Construction noise impact assessment

Noise impact level	Noise impact interpretation	Distance affected from proposal area
Affected/Clearly Audible	LAeq(15minute) <sup>1</sup> 5 to 20 dB(A) above background noise levels. Noise would be audible but unlikely to materially affect receivers.	360 metres
Moderately intrusive	LAeq(15minute) <sup>1</sup> 20 to 30 dB(A) above background noise levels. Noise is expected to cause minor impacts to receivers.	170 metres
Highly intrusive	LAeq(15minute) <sup>1</sup> >30 dB(A) above background noise levels. Noise is expected to cause moderate impacts to receivers. Noise at this level may disturb people sleeping during the day such as shift workers.	65 metres
Highly noise affected	LAeq(15minute) <sup>1</sup> 75 dB(A) or greater (Highly affected). Noise is expected to cause major impacts to receivers. Conversation may be difficult at this sound level. Noise at this level may disturb people sleeping during the day such as shift workers.	35 metres

As outlined previously, a Construction Noise and Vibration Management Plan (CNVMP) would be developed and provided to Council prior to the issue of the construction certificate. The construction management plan would outline any feasible and reasonable mitigation measures for Receiver 3.

### Operation

### Day time noise

As indicated in the original assessment, the proposed solar farm would operate solar panels installed on motorised single-axis trackers. Minimal additional noise (typically 2dB(A)) would be produced from the trackers, which only occur for several seconds each time the panels move tracking points (typically every 20-30 minutes) and only during daytime hours.

The proposed inverter stations would also produce some noise. The location of these inverter stations would be altered from their originally approved position on the eastern side of the arrays to a more central location within the development site. The indicative noise level would be 34dB(A) at 250m from the infrastructure, which is below the amenity and intrusive noise levels described in section 4.1.2. The operation of the inverters would not affect any sensitive receivers due to the attenuation of noise over several hundred metres. The closest receiver is 250m north-west of the perimeter of the proposed solar farm, and therefore approximately 500m from the proposed inverter locations.

Typical operating noise levels for solar farm infrastructure are provided in Table 4-6, with the addition of the BESS units. Based on this table, indicative noise levels at 200m from the solar farm perimeter would be a maximum of 42 dB(A) during daytime. This noise level is below the project amenity and intrusive noise levels described in section 4.1.2. Furthermore, the closest sensitive receiver is approximately 250 metres from the development site, as such it is unlikely that any sensitive receiver would be impacted by noise during the operation of the solar farm inclusive of the ancillary BESS.

Plant description	L <sub>Aeq</sub> Sound Power Levels, dB(A) re. 1pW	Indicative Sound Pressure Levels at 200m from infrastructure (dB(A))
Tracker motor single	78 (each)	32
Tracker motor (x10 units)	88	42
Inverter and power conversion systems	84 (each)	36
Light vehicle	88 (each)	42
Battery containers	73 (each)	27

Table 4-6 Operation noise from solar farm equipment (daytime)

### Night time noise

The addition of BESS would mean that the solar farm would have capacity to operate outside of daylight hours (defined as 7am-6pm according to NPI).

According the NPI, these are separated into evening (6pm-10pm) and night time hours (10pm-7am). The operation of the battery and inverter elements of the proposed solar farm would be limited to evening hours, being hours prior to 10pm. The project intrusiveness and project amenity noise level in the evening is 40 dB(A) as outlined above.

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Based on the night time operational scenario incorporating the inverter and battery modules, as outlined in the table below, the noise output would be up to 36 dB(A) at 200m from the solar farm perimeter. This would not exceed the project trigger level for the evening period.

Furthermore, the closest sensitive receiver is approximately 250 metres from the development site, as such it is unlikely that any sensitive receiver would be impacted by noise during the evening operation of the ancillary BESS elements of the solar farm. No further mitigation measures are required as a result of the proposed modified development.

Table 4-7 Operation noise from solar farm equipment (Nighttime)

Plant description	L <sub>Aeq</sub> Sound Power Levels, dB(A) re. 1pW	Indicative Sound Pressure Levels at 200m from infrastructure (dB(A))
Inverter and power conversion systems	84 (each)	36
Battery containers	73 (each)	27

### 4.1.3. Road traffic noise

Noise from potential increases in traffic on the surrounding road network due to construction and operational activities is considered under the *NSW Road Noise Policy* (RNP) (DECCW 2011). The RNP provides traffic noise criteria based on the road category and type of project or land use; refer Table 4-8.

Based on functionality, Merriwa Road (Golden Highway) would be categorised as a Freeway/arterial/ subarterial road.

Table 4-8 RNP Road Traffic Noise Criteria db(A)

Road	Type of project/land use	Assessment criteria dB(A) (external)		
category		Day 7am – 10pm	Night 10pm – 7am	
Freeway/arteri al/sub-arterial road.	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	LAeq (15 hour) 60 (external)	LAeq (9 hour) 55 (external	

The traffic associated with the construction and operation of the proposal would be limited to daytime hours. Accordingly, 60 dB(A) is the relevant project road noise criteria.

The additional traffic generated by the modified proposal would be minimal compared to the original development as approved. As with the original development, the proposal would be unlikely to exceed the project road traffic noise criteria. The construction noise generated by the modified proposal would be 43 dB(A) at the closest receiver and therefore it would not be achievable for the project road traffic noise criteria of 60dB(A) to be exceeded. Most vehicles accessing the site during the construction phase would not be heavy vehicles. It is considered to have an acceptable impact on receptors along the access/haulage route.

Operation phase traffic would be occasional and largely restricted to light vehicles, consistent with the development as originally approved. Increases to local road noise are not anticipated.

### 4.1.4. Vibration

The potential for vibration impact in terms of human comfort, cosmetic damage and structural damage was originally assessed with reference to *Assessing Vibration: A Technical Guideline (DECC 2006) and the Construction Noise and Vibration Guideline* (CNVG) (RMS 2016).

Vibration generating activities would occur only during the construction phase of the project. The construction activities which would produce vibration at the site include the use of vibrating padfoot rollers and array post boring or pile driving. Safe buffer distances to comply with human comfort, cosmetic damage and structural damage criteria sourced from the CNVG are presented in Table 4-9.

The closest non-associated receptor is located over 200 metres from the development footprint. Consistent with the original development, the works would not impinge on the recommended buffer distances in the CNVG and are not likely to result in significant vibration impacts in terms of cosmetic damage or human comfort.

Plant	Description	Cosmetic damage (BS 7385)	Human response (OH&E vibration guideline)
Vibratory	<50 kN (typically 1-2 tonnes)	5 m	15 m to 20 m
Roller	<100 kN (typically 2-4 tonnes)	6 m	20 m
	<200 kN (typically 4-6 tonnes)	12 m	40 m
	<300 kN (typically 7-13 tonnes)	15 m	100 m
	>300 kN (typically 13-18 tonnes)	20 m	100 m
	>300 kN (> 18 tonnes)	25 m	100 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m

Table 4-9 Safe buffer distances for vibration impacts for relevant equipment for RMS (2016)

### 4.2. Visual amenity

NGH has based a Visual Impact Assessment (VIA) in accordance with current practices, following the relevant sections of the Technical Supplement - Landscape and Visual Impact Assessment - Large-Scale Solar Energy Guideline (DPIE, 2022).

Due to the small scale of the development and its limited visual impacts, the area within two kilometres of the proposed development footprint has been considered for this visual impact assessment.

The visual impact of the modified development on key sensitive receivers would be measured based on the combination of the sensitivity of the sensitive receivers and the magnitude (scale, contrast, quality, distance) of the development on each sensitive receiver.

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**Visual Magnitude** The visual magnitude of a development is its apparent size determined by the volume of the horizontal and vertical fields of view occupied. Any sensitive receiver warranting a detailed investigation is classified as impacted for this assessment. If a receiver does not warrant a detailed investigation, it is deemed as not impacted. It is to be noted that the receiver classified as not impacted might still have some views of the solar infrastructures. However, these views will be only partial and would not be prominent against the backdrop.

**Viewpoint Sensitivity** relates to the relative importance of viewpoints and the value that the community or visitors may place on landscapes viewed from public use areas, public travel ways and private viewpoints such as dwellings. For example, a view from a residence is more sensitive to change than from a local road where views are more intermittent and less frequent. Similarly, a view from a rural residence is more sensitive if it is from principal living spaces and the front and rear of the dwelling than from other areas. Viewpoint sensitivity is classified into four different classes namely:

- Very low viewpoint sensitivity
- Low viewpoint sensitivity
- Moderate viewpoint sensitivity
- High viewpoint sensitivity

**Scenic quality** refers to the relative scenic, cultural, or aesthetic value of the landscape within the viewshed based on the presence or absence of key landscape features known to be associated with community perceptions of low, moderate, or high scenic quality.

**Visual sensitivity** Once the viewpoint sensitivity and scenic quality are determined, these can be combined using the visual sensitivity matrix in Table 4-10 to determine the overall visual sensitivity of each assessable viewpoint.

	High scenic quality	Moderate scenic quality	Low scenic quality
High viewpoint sensitivity	High	High	Moderate
Moderate viewpoint sensitivity	High	Moderate	Moderate
Low viewpoint sensitivity	Moderate	Low	Low
Very low viewpoint sensitivity	Low	Very low	Very low

Table 4-10 Viewpoint sensitivity matrix

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The combination of sensitivity and magnitude then provides an overall visual impact on individual sensitive receivers as per Table 4-11.

Table 4-11 Overall impact on sensitive receiver
Table 4-11 Overall impact on sensitive receiver

	High visual sensitivity	Moderate visual sensitivity	Low visual sensitivity	Very low visual sensitivity
Very high magnitude	High	High	Moderate	Moderate
High magnitude	High	Moderate	Moderate	Low
Moderate magnitude	Moderate	Moderate	Low	Low
Low magnitude	Moderate	Low	Low	Very low
Very low magnitude	Low	Low	Very low	Very low

Receivers/dwellings within 2km of the modified development footprint are shown in the figure on the following page. Receivers 1 and 2 are existing dwellings located on the same property as the proposed solar farm.



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### Sandy Hollow Solar Farm Sensitive receivers within 2 km

### Field of view calculations

The Technical Supplement - Landscape and Visual Impact Assessment - Large-Scale Solar Energy Guideline provides two calculations for vertical and horizontal field of view. The vertical field of view shown in Figure 3-13 takes the highest and lowest points of the proposed development and compares that with the elevation of the viewpoint. The horizontal field of view is calculated and the viewing angle of the proposed development from the viewpoint as shown in Figure 3-14. These two measures are then plotted in accordance with the values in the table on the following page to determine whether further detailed photomontage assessment is required.

### Project located above and below viewpoint (a-c)



### Project located above viewpoint (a-b)



### Project located below viewpoint (b-c)



### Figure 4-3 Relative height difference (DPIE, 2022)



Figure 4-4 Horizontal field of view (DPIE, 2022)

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Table 4-12	Preliminary visual	assessment requirements	according to the	Guideline (DPIE, 2022)
	i remining visual	assessment requirements	according to the	

Horizontal field of view of development	1° vertical field of view	2º vertical field of view	3º vertical field of view	4°+ vertical field of view
1-10°	No assessment required	No assessment required	No assessment required	No assessment required
11-20°	No assessment required	No assessment required	No assessment required	Assessment required
21-30°	No assessment required	No assessment required	Assessment required for all viewpoints except road/rail	Assessment required
31-40°	No assessment required	Assessment required for all viewpoints except road/rail	Assessment required for all viewpoints except road/rail	Assessment required
41-50°	No assessment required	Assessment required for all viewpoints except road/rail	Assessment required	Assessment required
51-60°	No assessment required	Assessment required for all viewpoints except road/rail	Assessment required	Assessment required
61-70°	No assessment required	Assessment required	Assessment required	Assessment required
71-130°	Assessment required for all viewpoints except road/rail	Assessment required	Assessment required	Assessment required
130°+	Assessment required	Assessment required	Assessment required	Assessment required

### 4.2.1. Existing conditions

As described in the original assessments for the project, the Golden Highway runs east to west along the northern boundary of subject land. The Muswellbrook-Merriwa rail line runs east to west and forms the southern boundary of the subject land.

The surrounding topography is relatively flat, being a flood plain area and fringes for the Goulburn River. However, surrounding the floodplain area are steep hills in the distance. Given the presence of substantial forested areas, this creates a secluded valley comprising the township of Sandy Hollow and the Goulburn River.

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The development site gently falls north to south towards the Goulburn River. The average site elevation is 140 m AHD, with a low of 133 m AHD at the southern boundary and a high of 153 m AHD on the northern boundary of the subject land. The township of Sandy Hollow further to the west of the subject land, is generally at the same elevation, between 133 to 140 m AHD.

The proposed development site has been significantly cleared to facilitate farming practices. The remaining vegetation surrounding the development site comprises a modified dry sclerophyll forest characterised by the presence of Narrow-leaved Ironbark *Eucalyptus crebra*. Planted areas of non-local, non-NSW native and exotic vegetation, comprising trees and shrubs of such as Sugar Gum *Eucalyptus cladocalyx*, Pepper Tree *Schinus molle*, Lemon-scented Gum *Corymbia citriodora* and Silky Oak *Grevillea robusta* are planted along the driveway and surrounding the homestead.



Figure 4-5 Planted areas to the north of the development site, within the subject land (NGH Pty Ltd, 2019)

### 4.2.2. Potential impacts

Preliminary assessment tool was used to identify receivers that needed detailed assessment. The results are presented in Table 3-4. According to the assessment tool, only receivers 3, 4 and 5 require further site assessment due to proximity and field of view.

Receiver	Horizontal field of view	Vertical field of view	Distance from Development area (m)	Detailed assessment required?
1	Associated receiver not assessed.			
2	Associated receiver not assessed.			
3	51.7°	4°	221	Yes
4	42.6°	3°	407	Yes
5	41.7°	4°	386	Yes
6	22°	1°	909	No
7	15.8°	1°	1180	No

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8	15°	1°	1359	No
9	13.6°	1°	1720	No
10	12.2°	1°	1930	No
11	15°	1°	1614	No
12	13.5°	1°	1993	No
13	13.3°	1°	1987	No
14	12.2°	1°	1851	No
15	11.3°	1°	1948	No
16	13.4°	1°	1822	No
17	14.3°	1°	1597	No
18	12.4°	1°	1948	No
19	12.6°	2°	1669	No
20	9.2°	1°	2062	No
21	10.5°	2°	2099	No
VP2	43.5°	3°	381	Yes
VP5	11.8°	1°	1863	No
VP6	13.2°	1°	1801	No
VP8	15.1°	1°	1611	No
VP9	15.6°	1°	1265	No
VP10	56.7°	4°	222	Yes

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### **Detailed assessment**

As outlined above, the preliminary assessment tool indicates that only receivers 3, 4 and 5 require further site assessment due to the theoretical proximity and field of view. These receivers were assessed together from Viewpoint 2 in the original assessment.

As noted above, the preliminary assessment only considers distance combined with angle of view. The impacts of existing vegetation are discussed below.

### **Receiver 3**

Receiver 3 is located closest to the proposed development. As concluded with the original proposal, Receiver 3 is on the northern side of the Golden Highway in a densely vegetated area. The view of the proposed development would be entirely screened from this receiver. No further assessment or mitigation measures are considered necessary.

### **Receiver 4**

Receiver 4 is located on the southern side of the Golden Highway approximately 407m west of the proposed development footprint. Receiver 4 is surrounded by scattered mature native vegetation, as indicated in the figure below.



Figure 4-6 Viewpoint 2 looking west-south-west from the embankment on the Golden Highway. Receiver 4 is on the right side of the image beyond the tree line in the middle ground (NGH, 2019).

Receiver 4 is categorised as a moderately sensitive viewpoint according to Table 4-10 adopted from the Guideline. The Guideline defines a moderately sensitive viewpoint as including "Primary view from dwellings in rural areas (zoned RU1, RU2, RU3, RU4 and RU6), large lot residential areas (zoned R5) and in environmental or conservation areas (zoned C2, C3 and C4)". Based on the orientation of Receiver 4, the view towards the proposed solar farm is more likely a secondary view; however, the primary view example, and therefore higher sensitivity rating, has been adopted in this instance to provide a conservative assessment.

Views from Receiver 4 would be categorised as of moderate scenic value according to the reference imagery in the Guideline.

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As outlined in the preliminary assessment tool table, the field of view was calculated to be 42 degrees horizontal and 3 degrees vertical. The Guideline considers 10 degrees horizontal to equate to one horizontal "cell" and 1 degree vertical to equate to 1 vertical "cell" for the purpose of calculating view magnitude by way of the number of affected/ occupied cells.

According to the Guideline, a cell is considered occupied if 25 percent or more of the cell would be comprised by infrastructure elements of the project that are unobstructed by substantial vegetation screening. Therefore 2 degrees horizontal field of view (20 percent of a horizontal cell) would not constitute occupation of a cell, whereas between 3 and 10 degrees horizontal would be considered an occupied cell.

Accordingly, the proposed development is considered to occupy 4 horizontal cells (42 degrees horizontal, which does not meet the threshold for 5 horizontal cells as outlined above) and 3 vertical cells (3 degrees vertical). According to the Guideline, this would be considered a low magnitude rating. Combined with the visual sensitivity rating of moderate, the visual impact on this receiver according to the Guideline is considered low.



Figure 4-7 Viewpoint 2 view looking east-southeast from the bottom of the road embankment on the Golden Highway. The red circle highlights the location of the proposed development site, which is behind the large tree (NGH, 2019).

The original assessment noted Receiver 4 "as a rural residence, is located on Lot 11 DP1042612. The view of the proposed solar farm would be largely screened by the existing topography and supplemented by existing planted vegetation immediately east of the residence".

The original assessment noted that each moderately affected viewpoint (including Receiver 4) is partially shielded by existing vegetation and visual impacts could be further reduced by the planting of vegetation screening. The original assessment concluded that "[s]hould vegetation screening be deemed necessary, a Landscape Plan would be prepared. The purpose of the Landscape Plan would be to address visual impact by establishing and maintaining a mature vegetation screening around the proposed solar farm, to complement established vegetation around the perimeter".

The modified development includes a proposed change to remove the original landscape screening requirement of a 10-metre-wide landscape buffer along the western boundary. According to the Guideline, there is no expectation that visual screening as a mitigation measure should eliminate the view of the development entirely but must reduce the impact to an acceptable level. As outlined above, the proposed development would have a low visual impact from this receiver. As indicated in Figure 4-6 on the preceding page, the existing neighbouring dwelling is already surrounded by mature trees on its eastern side, which

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filter views towards the proposed development site. Therefore, the combination of the following factors indicates that landscape screening along the western boundary of the proposed development site would not be warranted in this instance:

- dwelling orientation.
- existing mature vegetation surrounding the dwelling.
- distance between the dwelling and the proposed development site.
- intervening vegetation between the dwelling and the proposed development site.
- intervening topography between the dwelling and the proposed development site.

Whilst landscape screening could be implemented as a precautionary measure, it is also noted the effect that vegetation in proximity to the solar array would have. This would reduce the solar resources the panels can access and reduce the renewable electricity generated by the solar farm. Even minor shading impacts can have a considerable and compounding effect when considered across multiple panels and across the full year. This reduces the performance of the proposed solar farm and impacts project viability.

### **Receiver 5**

As concluded with the original proposal, Receiver 5 is on the northern side of the Golden Highway in a densely vegetated area. The view of the proposed development would be entirely screened. No further assessment or mitigation measures are considered necessary.

### Viewpoint 10

Viewpoint 10 represents the view of the Golden Highway motorists. The original assessment noted that each moderately affected viewpoint (including Viewpoint 10) is partially shielded by existing vegetation and visual impacts could be further reduced by the planting of vegetation screening. The original assessment concluded that "[s]hould vegetation screening be deemed necessary, a Landscape Plan would be prepared. The purpose of the Landscape Plan would be to address visual impact by establishing and maintaining a mature vegetation screening around the proposed solar farm, to complement established vegetation around the perimeter".

Viewpoint 10 is categorised as a very low sensitivity viewpoint according to the visual sensitivity matrix adopted from the Guideline. According to the Guideline, this includes "State highways, freeways and classified main roads". In accordance with current practices, visual impacts from such roads are generally not considered cause for concern.

The proposed development would be setback approximately 150 metres from the Golden Highway and mostly obscured from view by existing mature vegetation, as well as being located at a noticeably lower elevation than the Golden Highway. Furthermore, it would be unlikely to fall within the natural sight lines of motorists on the Golden Highway and poses minimal visual risk in that regard.



Figure 4-8 View from Golden Highway looking south towards the proposed development site, highlighted with a red circle (NGH, 2019).

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The modified development includes a proposed change to the original landscape screening requirement of landscape screening along the western side of the internal access road between the Golden Highway and the northern boundary of the solar array. According to the Guideline, there is no expectation that visual screening as a mitigation measure should eliminate the view of the development entirely but must reduce the impact to an acceptable level. As outlined above, the highway is considered a very low sensitivity viewpoint and already substantially obscured by topography, setbacks, and existing vegetation. This is considered to provide more than an acceptable impact on the Golden Highway.

### 4.2.3. Glint and glare

There may be concern that solar farm infrastructure creates glint or glare issues for surrounding receptors and airspace users. As outlined in the original VIA, the potential for glint or glare associated with non-concentrating PV systems is relatively limited.

PV solar panels are designed to reflect as little sunlight as possible as the PV panels are designed to absorb solar energy in order to generate the maximum amount of electricity. It is documented that PV panels may reflect as little as 2% of the light they receive (FAA, 2010). The panels also have an anti-reflective coating to further reduce the potential for glare and glint. Additionally, the Department of Planning (DoP, 2010) discussion paper on planning for renewable energy generation confirmed that solar panels do not generally create noticeable glare compared with an existing roof or building surfaces.

The modified project is generally consistent with the originally approved footprint. There would be no expected changes to glint and glare caused by the proposed solar farm.

### 4.3. Aboriginal cultural heritage

An addendum to the original Due Diligence assessment has been prepared by NGH archaeologists, in accordance with the NSW Office of Environment and Heritage's *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* (OEH 2010). The Due Diligence addendum is included as Attachment B to this report and summarised below.

On 2 February 2024, a search of the AHIMS database was undertaken over a 10 km area centred on the Project. There was a total of 49 Aboriginal sites recorded within this search area, and no Aboriginal Places. Based on the location of these sites, only three additional sites have been recorded within 3 km of the subject land since the original Due Diligence (NGH 2018). None of the new or originally recorded sites are within the subject land.

The modified project only comprises a marginal change to the development footprint as originally assessed, being a change to the underground cable serving the existing dwelling on the eastern side of the proposed solar farm. Based on the results of the NGH (2018) survey, and aerial imagery, the landform where the underground cable is situated is similar to the landform assessed within the surveyed area (undulated slopes). NGH (2018) noted that this landform has low potential to contain archaeological deposits due to the existing disturbances such as vegetation clearing, cropping, ploughing, and existing access tracks, as well as the absence of a nearby water source, which based on other local and regional studies, is associated with Aboriginal objectives. In addition, no trees are located where the underground cable is proposed to be located. As such, no culturally modified trees are located where the underground cable is proposed.

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The length of the additional underground cable outside of the previously assessed area is approximately 40m. Part of the alignment is also across a formed disturbed farm track immediately adjacent to the existing project boundary, which was used to access the area for the original survey. As such, it is considered that the alignment for the cable area has been, as a minimum, viewed by the previous survey and also has not been identified as a sensitive landform. It is considered, therefore, that there is very low potential for Aboriginal objects to be present within this modification extent and that no further visual inspection of the proposed location of the cable is required.

### Recommendations

- 1. The recommendations made in the NGH 2018 due diligence assessment for the Sandy Hollow Solar Farm are still applicable to the addition of an underground cable outside the originally assessed area.
- 2. No further assessment for Aboriginal heritage as part of this Modification Application is warranted and work may proceed with caution.
- 3. If any objects suspected of being Aboriginal in origin are found during works, work must stop, and an archaeologist called to inspect the find.



## Proposed Modifications within the Subject Land

### Legend

----- Proposed Design and surveyed area

Underground cable



Data Attribution © NGH 2024 © Birdwood Energy © LPI 2024

Ref: 230554 Sandy Hollow Modification Heritage \ Proposed Modifications within the Subject Land Author: Brendan Fisher Date created: 13.02.2024 Datum: GDA 2020 Zone 56



### 4.4. Biodiversity considerations

The original project was designed to avoid and minimise impacts to riparian corridors, forest patches and paddock trees, where possible. The modified project is largely confined to the footprint of the original project, excepting a proposed underground cable that will service the existing dwelling immediately east of the solar farm.

The direct vegetation clearing impacts of the original development consisted of pasture dominated by exotic grasses, with little biodiversity conservation value. The impacts involved 13.73 hectares of PCT 1612: Narrow-leaved Ironbark – Grey Gum – Native Olive woodland of the Central Hunter. The habitat value of this vegetation was identified as poor, and no habitat features such as hollows, nests, dens or other significant roosting features were to be removed. No threatened ecologist communities (TECs) were affected.

Section 7.17 of the *Biodiversity Conservation Act 2016* requires that the 'original development as proposed to be modified' is considered. The consent authority for the modification application is required to determine whether the proposed changes will result in an increase in impacts on biodiversity values. If the consent authority is satisfied that the proposed modification will not result in an increase in impacts on biodiversity values, then a BDAR (and new/modified BAM-C case) is not required, pursuant to section 7.17(2)(c) of the BC Act.

A review of the vegetation mapping within the BDAR (NGH 2020) was undertaken in relation to the location of the underground cable. The length of the additional underground cable outside of the previously assessed area is approximately 40m. It is proposed to run through a patch mapped as planted vegetation consisting of species not native to the region, including *Grevillea robusta* and *Eucalyptus cladocalyx*. This was identified as PCT 1612 Narrow-leaved Ironbark – Grey Gum – Native Olive woodland of Central Hunter, in a cleared condition. This vegetation zone had a Vegetation Integrity Score (VI Score) of 6.6, which resulted in no offsets being generated for impacts to this vegetation. The alignment is generally located across a formed farm track immediately adjacent to the approved project boundary.

The modified project does not involve the clearing of any additional native vegetation. Overall, it is unlikely that the proposed modification would result in an increase in impacts on biodiversity values.



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Mapped Plant Community Types (PCTs) and proposed extent of direct impacts

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Figure 4-11 Direct underground cable route


# 4.5. Hazard analysis

The proposed addition of a BESS may elevate the potential fire and ignition risks of the proposed development, compared with the development as originally approved. Further BESS specifications are provided in the table below.

Table 4-14	BESS component	s
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Item	Description
BESS unit make and model	Sungrow ST2752UX
Module make and model	Sungrow M2L-M143A or E2L-M143A
Cell make and model	CATL 001CB310, CB2W0, CB310
Total capacity	5MW/ 10MWh
Layout	8 battery units in 4 pairs (back-to-back)
Separation	8 metres between BESS unit pairs
Cell chemistry	Lithium Iron Phosphate (LFP)
Cooling	Liquid cooling system including temperature monitoring and liquid cooling of batteries to prevent thermal runaway.
Fire safety	Deluge sprinkler heads (standard), Fused sprinkler heads (optional), NFPA69 explosion prevention and ventilation IDLH gases (optional)
Compliance	CE, IEC 62477-1, IEC 61000-6-2, IEC61000-6-4, IEC62619, UL9540A, UL1973, UN38.3

A Preliminary Hazard Analysis (PHA) is typically prepared for BESS development where the capacity of the BESS exceeds 30MW and is therefore considered Designated Development and potentially hazardous development in accordance with the Resilience and Hazards SEPP. The proposed ancillary BESS for the Sandy Hollow Solar Farm would only have a capacity of 5MW and would not be considered as such.

However, an Initial Hazard Analysis (IHA) was prepared by a qualified consultant, experienced in the assessment of BESS technological hazards. The IHA is appended to this report and summarised below.

The BESS units are manufactured with several protective systems and features as follows:

- Liquid cooling system
- Battery management system
- Deluge sprinkler heads (standard)

The proposed battery cells would be Lithium Iron Phosphate (LFP), which is considered the superior option to reduce the risk of thermal runaway and fire propagation. Should a fire occur, LFP cells release carbon dioxide which reduces the oxygen concentration and subsequently reduces the combustion rate. A thermal runaway event and subsequent BESS module fire is generally considered unlikely where LFP technology is implemented.

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The benefits of LFP cell chemistry can be observed in the supporting UL9540A Test Method for *Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* report. The summary of the thermal runaway test notes that only white smoke was observed. No external flaming, explosive discharges of gases, sparks or electrical arcs were observed.

In addition to the LFP cell chemistry, the liquid cooling system would monitor for thermal runaway and remove heat if it were to occur. The fire safety system would also be employed if a BESS unit fire were to occur.

In addition to the manufacturers inbuilt systems, separation distances are also recommended between battery containers to prevent the spread of fire, should one ignite. The Department of Planning, Housing, and Infrastructure (DPHI) deems a separation distance of 3 to 4 metres between BESS units effective in preventing fire spread. The proposed BESS plan exceeds this recommendation with an 8-metre spacing to be provided, significantly lowering the fire risk for this project.

Overall, the array of mitigation measures renders the BESS risks low, with unlikely significant offsite impacts.

# 4.6. Bushfire

It is accepted the addition of a BESS may elevate the potential fire danger of the proposed development, compared with the development as originally approved.

The design of the modified proposal meets the current standards under Planning for Bushfire Protection (PBP) 2019. The modified layout incorporates an Asset Protection Zone (APZ) of 10 metres around the BESS components to contain the spread of fire if the components catch fire. The layout has also strategically placed the BESS components close to internal access roads which are 6m wide. Should it be required in an emergency, these internal roads would be suited to firefighting access.

As outlined in the preceding section, the BESS includes a variety of design measures to avoid, mitigate and manage potential ignition and fire risks, summarised as follows:

- Liquid cooling system.
- Battery management system.
- Deluge sprinkler heads.
- Fused sprinkler heads (optional)
- NFPA69 explosion prevention and ventilation IDLH gases (optional).

The potential bushfire risk remains manageable despite the inclusion of the BESS components, given the substantial ignition and fire risk management protocols that are inbuilt into the infrastructure.

# 4.7. Traffic

# 4.7.1. Existing conditions

Consistent with the development as originally approved, construction and operation traffic would access the development site via Merriwa Road (the Golden Highway). At the site access, the Golden Highway accommodates one lane of traffic in each direction and has a sealed width of approximately 9.0 metres. East

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of the access the road widens to provide a passing lane for eastbound traffic. It has a speed limit of 100km/hr in the vicinity of the site.

Traffic volume data for Golden Highway was obtained from the RMS traffic volume viewer. The closest available data was located 1.2km west of Giants Creek Road, where the 2019 data recorded an average daily traffic count of 2,142 vehicles per day (vpd). The traffic count data also indicates that 22 percent of all traffic is heavy vehicles.

# 4.7.2. Potential modified impacts

## **Traffic movements**

Consistent with the development as originally approved, the duration of construction is expected to be 9 months. There would be up to 30 staff on-site at any one time during the peak construction time. Infrastructure would arrive in shipping containers. A small mobile crane may be required for the offloading of the inverters and the delivery station.

The expected traffic movements generated during the peak of construction are summarised in Table 4-14. Only a marginal increase, if any, would occur for the modified development compared with the original.

Vehicle type	Vehicle movements per day during peak period
Light vehicles (car/utility /mini bus)	32
MRV/HRV	26
AV	6
Total:	64

Table 4-15 Summary of the estimated construction traffic volumes during peak

The construction traffic would increase the frequency of large vehicle traffic on Merriwa Road (the Golden Highway). The access points onto Merriwa Road (the Golden Highway) would be constructed to comply with Austroads Guides and Council requirements.

Traffic impacts would largely be confined to standard hours of construction. A Construction Management Plan would be developed including provision for scheduling of deliveries, carpooling/shuttle bus arrangements and notification of local residents to avoid and minimise the impacts of large vehicle traffic.

Consistent with the development as originally approved, one full time equivalent contractor would support the operations of the solar farm, primarily using a standard light vehicle (4WD). During major outages, several vehicles may be present at any one time. During the operational phase, traffic volumes using Merriwa Road would not noticeably increase compared to the current average daily traffic volume.

The additional of the ancillary BESS may result in an increase of inbound and outbound traffic during construction. It should be noted that the battery modules would not require any over size, over mass (OSOM) vehicles to be transported to the site. As such, it is anticipated that the the impact to traffic during construction will be minor and the estimated traffic volumes should not vary significantly.

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## **Access Sight Distance Assessment**

There are no changes to the proposed access point and no changes to the sight distance assessment.

# 4.8. Flood and overland flow

Given the Goulburn River to the south of the site, a Flood Impact Assessment was prepared for the original project by Cardno (2019) to review the potential flood affection of the subject land.

The peak 1% AEP flood level at the site was estimated at around 124.4 – 124.7m AHD. Consistent with the original proposal, the modified proposal, including the solar array and supporting infrastructure, would be located on land that is above the 100yr ARI flood level. As the proposed modifications are generally consistent with the approved footprint, it is anticipated that there will be no increased risk to the proposal site from potential flood affection.

Accordingly, the modified development would not be expected to have any impacts on the movement of floodwaters or the floodwater levels upstream or downstream of the subject land.



Figure 4-12 Best Estimate 1% AEP Flood Extent (Cardno, 2019)

# 4.9. Stormwater, water quality, sediment, and erosion control

The modified project would not have a notable change on stormwater runoff or infiltration patterns compared to the original project. Stormwater would fall from the panels onto the natural surface. With perennial groundcover maintained, this would infiltrate the ground and not result in increased localised runoff. The subject land is within a rural environment and as such open channels and onsite stormwater detention basin are proposed for stormwater management and are considered suitable for the rural environment.

The proposed development site is divided into catchments as illustrated on the accompanying engineering plans; the internal catchments would drain to the proposed on-site detention (OSD) basin. The external catchment to the east of the site would be captured by the swale along the boundary and bypasses the proposed OSD basin. Hydrological analysis was conducted to determine the requirement and size of detention basins needed to reduce peak post development flows to predevelopment levels.

The stormwater managed arrangements have been updated for the modified project and designed to comply with Muswellbrook Shire Council's AUS-SPEC 'Development Design Specification, 2011' and 'Australian rainfall and Runoff, 2016".

# 5. Statutory Framework

The proponent is seeking to modify development consent DA2019/201. The modified application has been submitted to Council under Section 4.55(1A) of the EP&A Act. The relevant provisions are discussed in the table below.

Table 5-1 Relevant statutory framework for the proposed modifications

4.55 Modification of consents— generally	Response
(1A) Modifications involving minimal envi made by the applicant or any other perso subject to and in accordance with the reg	ronmental impact. A consent authority may, on application being on entitled to act on a consent granted by the consent authority and gulations, modify the consent if—
(a) it is satisfied that the proposed modification is of minimal environmental impact, and	The environmental impacts of the proposed modification have been considered within this modification report. The proposed footprint is generally consistent with the approved project excepting a small corridor within the already disturbed cluster of existing buildings to provide for the relocation of the existing overhead powerline underground. Additional areas of disturbance and any changes to amenity impacts (such as visual and noise) have been assessed and are considered to be no more than minimal environmental impact, or in some cases reduced impact, compared with the proposal as originally approved.
	The proposed BESS introduces a new ancillary component to the proposed development site; however, the nature and impacts of the BESS are very similar to the proposed solar farm as originally approved. Environmental safeguards are proposed in support of the ancillary BESS which would ensure no more than minimal environmental impact.
(b) it is satisfied that the development to which the consent as modified relates is substantially the same development as the development for which the consent was originally granted and before that consent as originally granted was modified (if at all), and	From a land use perspective, the proposal remains substantially the same as the development for which consent was originally granted. The original solar farm was defined as "electricity generating works" under the Muswellbrook LEP. The definition for electricity generating works also extends to the storage of electricity, as indicated below. <i>electricity generating works</i> meaning " <i>a building or place used for</i> <i>the following purposes:</i>

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4.55 Modification of consents— generally	Response		
	(a) making or generating electricity		
	(b) electricity storage."		
	There is no change to the proposed capacity or output of the solar farm as originally approved. The modification proposes to include ancillary battery storage to control the timing of import and export of energy and provide electricity grid support services. The proposal is considered substantially the same; however, would result in more effective outcomes.		
	Qualitatively, the impacts to amenity (noise, visual), the environment, traffic and road network, heritage, agriculture, fire/bushfire, and drainage, as outlined in this report, are considered not likely to result in anything other than minimal impact.		
(c) it has notified the application in accordance with—	Council would notify this modification application as needed.		
(i) the regulations, if the regulations so require, or			
(ii) a development control plan, if the consent authority is a council that has made a development control plan that requires the notification or advertising of applications for modification of a development consent, and			
(d) it has considered any submissions made concerning the proposed modification within any period prescribed by the regulations or provided by the development control plan, as the case may be.	Submissions may be made to Council concerning the modification application.		
<ul> <li>Subsections (1), (2) and (5) do not apply to such a modification.</li> <li>(3) In determining an application for modification of a consent under this section, the consent authority must take into consideration such of the matters</li> </ul>	<ul> <li>Section 4.15(1) matters are addressed below:</li> <li>In terms of compliance with relevant provisions of the LEP, there are no material changes. The characterisation of the proposed development remains the same (though permissibility is still provided by the TI SEPP despite the LEP provisions), compatibility with the zone objectives</li> </ul>		

Sandy Hollow Solar Farm

# NGH

4.55 Modification of consents—	Response
generally	
referred to in section 4.15(1) as are of relevance to the development the subject of the application. The consent authority must also take into consideration the reasons given by the consent authority for the grant of the consent that is sought to be modified.	<ul> <li>and other relevant LEP provisions.</li> <li>In terms of compliance with relevant SEPPs, there are no material changes despite administrative changes to the various SEPPs that are applicable.</li> <li>In terms of compliance with the DCP requirements, there are no material changes. The modified development is generally consistent with the relevant DCP requirements.</li> </ul>
	remain consistent with the reasons given by the Planning Panel in granting consent, specifically:
	<ul> <li>The modified proposal would be generally consistent with the approved footprint. The visual impacts have been assessed against the detailed technical guidance that has been published by the Department since the development was originally approved.</li> <li>There would be a marginal increase in construction traffic; however, no oversize or overmass vehicles, as originally intended. Any additional traffic would not have a significant impact on the road network and be managed through the Traffic Management Plan (TMP) to be submitted to Council prior to commencement.</li> <li>The Operational Management Plan (OMP) would be developed prior to commencement, as required by conditions to provide for operation in an environmentally sustainable manner.</li> <li>The Decommissioning Plan would provide measures to support return of the site to a pre-development standard to support agriculture and the modified proposal would not significantly alter decommissioning procedures.</li> <li>The modified proposal is considered to be in the public interest as it would generate renewable energy, close to consumption centres, support the electricity distribution network as well as provide employment opportunities. The effectiveness of the proposal will be enhanced through the proposed modification to include a BESS.</li> </ul>

# 6. Conclusion

This Modification Report has been prepared to support an application under section 4.55(1A) of the EP&A Act. The application seeks Council's consideration for proposed modifications to DA2019/102 for electricity generating works (a solar farm) at 511 Richmond Grove Road, Sandy Hollow. The proposal was originally recommended for approval by Council and granted consent by the Regional Planning Panel in 2020.

Birdwood Energy Pty Ltd intends to the develop the site. Having conducted further detailed design, a modification to the development consent is now sought as follows:

- 1. Inclusion of an ancillary battery energy storage system (BESS).
- 2. Modified location of the inverters.
- 3. Minor adjustment to the route of the proposed underground powerline (relocated from overhead), from the solar array immediately east to the dwelling.
- 4. Remove Condition 6 and 17 requirements relating to landscape screening.

The proposed modifications to the solar farm would be generally consistent with the approved development. There is only a marginal change to the impact area, which is associated with a more direct and lesser impact route of an underground cable to service the existing dwelling. The modified development is therefore considered to have a positive environmental impact.

An ancillary BESS is proposed with capacity of 4.95MW /20 MWh (4 hrs). The containers are manufactured with inbuilt fire protection and suppression systems and the proposed arrangement for this project substantially exceeds the manufacturers specifications for siting/separation. The proposed BESS is necessary to make more effective use of the renewable energy created on-site, by shifting output to peak periods of community consumption and to provide ancillary support services to the wider electricity market.

Based on further technical assessment in accordance with the DPE Large-Scale Solar Energy Guideline – Technical Supplement – Landscape and Visual Impact Assessment, existing vegetation and topography is considered to provide adequate filtering of views between the neighbouring dwelling to the west and the proposed development. No other receivers are considered affected according to the Guideline. Viewpoints from the Golden Highway are considered of very low sensitivity according to the Guideline and when existing mature vegetation is considered, the impact of the proposed development is considered negligible.

The modification application has taken into consideration environmental and amenity factors relevant for such development and the rural setting. The proponent commits to carrying out the development in accordance with the safeguards and mitigation measures outlined in this report. Overall, the modified development is expected to have minimal environmental and amenity impacts. The development would result in a positive impact for the community and local economy.

Surrounding receivers would not be experience increased impacts as a result of the proposed modifications. Noise during construction and operation would have an acceptable impact. Importantly, no remnant native vegetation or sensitive biodiversity features would be impacted by the modified proposal. The impacts of the proposed development would continue to be managed to ensure the amenity of surrounding properties and their productive agricultural capacity were not affected.

# 7. References

- DPIE. (2022). Technical Supplement Landscape and Visual Impact Assessment Large-Scale Solar Energy Guideline. DPIE.
- EPA. (2017). *Noise policy for industry*. Retrieved from Environmental Protection Authority: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/noise-policy-for-industry-(2017)

NSW and Department of Environment and Climate Change (NSW). (2009). Interim. Sydney.

NSW EPA. (2017). Noise Policy for Industry (2017). NSW EPA.

Roads and Maritime Services (NSW). (2016). Construction Noise and Vibration. Sydney.



# **Appendix A Modified development plans**



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# Appendix B Due Diligence Addendum

14 February 2024

Litsa Stavrakakis Birdwood Energy Level 18, 1 Nicholson Street East Melbourne, Victoria



Litsa@birdwoodenergy.com

Dear Litsa,

# Re: 23-554 – Sandy Hollow Solar Farm Modification Letter of Advice

## Introduction

As you are aware, NGH Pty Ltd (NGH) has been engaged by Birdwood Energy to complete a desktop assessment for a proposed modification to the development approval for the Sandy Hollow Solar Farm, originally granted on 6 May 2020.

The proposed development site is Lot 12 DP1042612, located on the Golden Highway/Merriwa Road, about 2 kilometres (km) east of Sandy Hollow. The original proposal as approved comprised of a ground mounted tracking system with 6MW capacity on pole driven steel posts, connecting to the existing 33kV line (Denman to Merriwa) via a new switching station. The development footprint was approximately 14 hectares, with access from Golden Highway/Merriwa Road.

NGH previously prepared the Statement of Environmental Effects (SEE) which included an Aboriginal Due Diligence assessment (NGH 2018).

# Scope of works

Birdwood Energy has acquired the project since the development consent was granted by Muswellbrook Shire Council, and proposes the following modifications to the project approval:

- Adding a battery energy storage system (BESS) with envisaged 4.95MW/20 MWh (4hrs) capacity.
- Changing the location of the inverter.
- Other modifications to consent conditions.
- Addition of an underground cable (purpose of current assessment).

Each of these modifications, except the underground cable (inset in Figure 1), remain within the proposed design area that was assessed as part of the NGH (2018) due diligence assessment (see Figure 1) and therefore are not subject to further assessment.

Due to the time that has lapsed since NGH completed the due diligence assessment in 2018, and that the underground cable is outside the previously surveyed area, an updated assessment, including and Aboriginal Heritage Information Management System (AHIMS) search and

### Sydney

information on any additional assessments that have been completed in the nearby area are required to determine whether any additional Aboriginal heritage items will be impacted by the proposed modification. This letter report assesses the potential for Aboriginal objects where the underground cable is proposed.

## Previous Aboriginal Assessment of the Sandy Hollow Solar Farm

The 2018 due diligence assessment conducted by NGH for the Sandy Hollow Solar Farm included a visual inspection of the Subject Land to determine whether any Aboriginal objects were present, or whether any landforms with archaeological potential were present. No Aboriginal sites were identified, and all landforms were assessed as having low potential for subsurface archaeological material. As such, it was recommended that the works could proceed with caution.

## **Updated AHIMS Search**

On 2 February 2024, a search of the AHIMS database was undertaken over a 10 km area centred on the Project. The AHIMS Client Service Number is 860629. There is a total of 49 Aboriginal sites recorded within this search area, and no Aboriginal Places (see Figure 2). None of the Aboriginal sites currently recorded on AHIMS are located within or directly adjacent to the Subject Land. Based on the location of these sites, as shown in Figure 2, only three additional sites have been recorded within three km of the Subject Land since the original Due Diligence (NGH 2018). These sites are detailed below in Table 1. As these sites are well outside the Subject Land, they will not be impacted by the proposed modifications.

AHIMS ID	Site Name	Site Type	Distance to project (m)	Site Status on AHIMS
37-2-6536	Wybong Road IF- 01	Isolated find	1700 to the north	Valid
37-2-6566	BBA-23-01	Artefact scatter	2700 to the north	Valid
37-2-6567	BBA-23-02	Artefact scatter	2600 to the north	Valid

Table 1 Additional sites recorded in the region since NGH (2018).



# Proposed Modifications within the

----- Proposed Design and surveyed area





Ref: 230554 Sandy Hollow Modification Heritage \ Proposed Modifications within the Subject Land Author: Brendan Fisher Date create: 13.02.2024 Datum: GDA 2020 Zone 56 ()

100 m

Figure 1 Proposed modification cable alignment subject to assessment.



#### Location of AHIMS Sites within the Region

#### Legend

- Proposed Modification
- ----- Proposed Design and surveyed area
- ----- Underground cable
- Artefact scatter
- Artefact scatter and PAD
- Artefact scatter, burial, and ceremony and dreaming
- A Habitation structure
- A Habitation structure, isolated find, and PAD
- 🛕 Isolated find
- Isolated find and PAD
- Modified tree (carved or scarred) and PAD



Data Attribution © NGH 2024 © Birdwood Energy © LPI 2024

Ref: 230554 Sandy Hollow Modification Heritage \ Location of AHIMS Sites within the Region Author: Brendan Fisher Date create: 13 02.2024 Datum: GDA 2020 Zone 56



Figure 2 Location of AHIMS sites within the region.

# **Additional Regional Studies**

There is currently no report associated with the recording of 37-2-6566 and 37-2-6567, however, a due diligence assessment conducted by OzArk Environment and Heritage (OzArk) in 2021 was available. As this assessment had not been conducted during the original assessment for the Sandy Hollow Solar Farm, a summary has been provided below:

OzArk completed a due diligence assessment for the Denman to Sandy Hollow water pipeline, which ran along Wybong Road, approximately 1.4 km north of the Sandy Hollow Solar Farm. During the visual inspection, a single isolated find was recorded within a small erosion scald adjacent to Wybong road. It was predicted that stone artefact sites could occur on elevated landforms adjacent to waterways that intersected Wybong Road, however, AHIMS#37-2-6536 was recorded 450 m to the northwest of a water source. As such, it was concluded that any stone artefacts recorded distant to water in the area were more likely the result of transitory movement. The results of OzArk's due diligence does not change the predictions made as part of the Sandy Hollow Solar Farm assessment (NGH 2018), as the potential for occupation sites beyond 200 m of water was considered low.

# Assessment

As the underground cable extends beyond the area that has already been assessed by NGH (2018), this further assessment is required. However, based on the results of the NGH (2018) survey, and aerial imagery, the landform where the underground cable is situated is similar to the landform assessed within the surveyed area (undulated slopes). NGH (2018) noted that this landform has low potential to contain archaeological deposits due to the existing disturbances such as vegetation clearing, cropping, ploughing, and existing access tracks, as well as the absence of a nearby water source. In addition, as seen in the inset in Figure 1, no trees are located where the underground cable is proposed to be located. As such, no culturally modified trees are located where the underground cable is proposed.

The length of the additional underground cable outside of the previously assessed area is approximately 40m. Part of the alignment is also across a formed disturbed farm track immediately adjacent to the existing project boundary, which was used to access the area for the original survey. As such, it is considered that the alignment for the cable area has been, as a minimum, viewed by the previous survey and also has not been identified as a sensitive landform. It is considered, therefore, that there is very low potential for Aboriginal objects to be present within this modification extent and that no visual inspection of the underground cable is required.

# Conclusions

Given the results of the desktop assessment for the proposed modification works, it has been concluded that:

- The proposed modification areas with ground disturbance have been previously sufficiently surveyed by archaeologists and (NGH 2018) and no Aboriginal objects were found;
- No additional Aboriginal sites have since been recorded within the Subject Land;
- The additional underground cable has very low potential to impact Aboriginal heritage.

## Recommendations

- 1. The recommendations made in the NGH 2018 due diligence assessment for the Sandy Hollow Solar Farm are still applicable to the addition of an underground cable outside the originally assessed area.
- 2. No further assessment for Aboriginal heritage as part of this Modification Application is warranted and work may proceed with caution.
- 3. If any objects suspected of being Aboriginal in origin are found during works, work must stop and an archaeologist called to inspect the find.

If you have any questions, please contact me, or David Canterbury. We would be pleased to discuss any aspect of this project with you further.

Yours sincerely,

Matthew Baler

Matthew Barber Technical Director – Heritage 0407485018

# References

NGH Environmental. 2018. Aboriginal Due Diligence Assessment Report: Sandy Hollow Solar Farm. Report to Renewable Management.

OzArk Environment and Heritage. 2021. Aboriginal Due Diligence Assessment Report: Denman to Sandy Hollow Water Pipeline. Report to Muswellbrook Shire Council.



# Appendix C Biodiversity Development Assessment Report Addendum

26 March 2024

Litsa Stavrakakis Birdwood Energy Level 18, 1 Nicholson Street East Melbourne, Victoria



Litsa@birdwoodenergy.com

Dear Litsa,

#### Re: 230554 - Biodiversity assessment of proposed modification to Sandy Hollow Solar Farm

As you are aware, NGH Pty Ltd (NGH) has been engaged by Birdwood Energy to complete a desktop assessment for the Sandy Hollow Solar Farm Modification, following the approval of the Sandy Hollow Solar Farm on 6 May 2020 (development consent DA2019/102).

The project is located at 1333 Merriwa Road, Denman about 2 kilometres (km) east of Sandy Hollow, NSW. The original proposal as approved comprised a ground mounted tracking system with 6MW capacity on pole driven steel posts, connecting to the existing 33kV line (Denman to Merriwa) via a new switching station. The development footprint was approximately 14 hectares, with access from Merriwa Road.

NGH previously prepared the Statement of Environmental Effects (SEE) which included a Biodiversity Development Assessment Report (BDAR) (NGH 2020).

Having conducted further detailed design to progress the proposal towards a construction certificate, Birdwood Energy (now, the proponent) is seeking a modification to the development consent. The proposed modifications are outlined below, with further detail contained in a modification report which will be provided to Muswellbrook Shire Council. The modification is proposed pursuant to Section 4.55(1A) of the *Environmental Planning and Assessment Act 1979.* 

- Inclusion of an ancillary battery energy storage system (BESS). This would make more effective use of the renewable energy created on-site by shifting output to peak periods of community consumption, importing electricity during periods of low prices, and providing ancillary support services to the wider electricity distribution network. The BESS would be scaled to the solar farm and have a proposed capacity of 4.95 MW /20 MWh (4 hours).
- 2. Modified location of the inverters to reduce overall disturbance and cost, and reduce voltage drop (energy loss). The equipment location would change from the eastern edge of the original footprint to instead be centrally located within the array, which would reduce the overall environmental impact.
- 3. Minor adjustment to the route of the proposed underground powerline (relocated from overhead), from the solar array immediately east to the dwelling. The revised route would be more direct, reducing the impact from the original proposal which approached the dwelling from the south-eastern corner of the solar array.
- 4. Amend Condition 6 and 17 to remove the requirement for landscape screening along the western boundary of the site, the western side of the internal access road between the Golden Highway and the northern boundary of the solar array.

Each of these modifications, except the underground cable, is located within the Development Footprint that was assessed as part of the BDAR (NGH 2020) and therefore are not subject to further assessment. The underground cable extends outside of the approved development footprint (Appendix A), and therefore further assessment of this area was required.

Advice was sought from the BOS helpdesk. The response included the following (full response is provided in Appendix C):

"BC Act section 7.17 requires that the 'original development as proposed to be modified' is considered when determining if a BDAR is required (i.e. when checking the various triggers into the Biodiversity Offsets Scheme (BOS)). The 'original development as proposed to be modified' essentially means the original approved development inclusive of footprint changes that are proposed by the modification.

If the BOS is triggered based on the 'original development as proposed to be modified', the consent authority for the modification application will need to determine whether the proposed changes will result in an increase in impacts on biodiversity values. If the consent authority is satisfied that the proposed modification will not result in an increase in impacts on biodiversity values, then a BDAR is not required. See BC Act section 7.17(2)(c).

If the consent authority is satisfied that the proposed modification will not result in an increase in impacts on biodiversity values, then a BDAR and BAM-C case are not required. An explanation of the proposed changes to biodiversity impacts can be captured in the modification application."

NGH has determined that the 'original development as proposed to be modified' triggers the BOS. An overview of any potential impacts of the proposed modification on biodiversity values is outlined below.

### **Environmental Assessment**

A review of the vegetation mapping within the BDAR (NGH 2020) was undertaken in relation to the location of the underground cable. The length of the additional underground cable outside of the previously assessed area is approximately 40m. The proposed modification will not result in the removal of trees with part of the alignment across a formed farm track immediately adjacent to the existing project boundary. Although the alignment footprint is proposed to go through an area mapped as planted vegetation, there are no trees located within this section. (Appendix B). The planted vegetation area consists of species not native to the region, including *Grevillea robusta* and *Eucalyptus cladocalyx* and therefore has no existing offset obligation within the BDAR.

There is a small area of encroachment of the proposed underground cable into vegetation mapped as PCT 1612 *Narrow-leaved Ironbark – Grey Gum – Native Olive woodland of Central Hunter*, in a cleared condition. Within the BDAR for the approved development footprint, this vegetation zone had a Vegetation Integrity Score (VI Score) of 6.6, which resulted in no offsets being generated for this vegetation zone. As such, no further offsets are expected to be generated within the small area of this vegetation zone which is located outside the current approved development footprint.

The proposed modification will not result in the removal of trees, and as such there will be no loss of fauna habitat. The location of the proposed underground cable is within cleared areas, with part of the alignment across a formed farm track. Therefore, there are unlikely to be any additional impacts to threatened species.

#### Conclusion

Overall, it is unlikely that the proposed modification will result in additional offset requirements generated by the BAM-C or that there will be additional impacts to threatened species, therefore, it is unlikely that the proposed changes will result in an increase in impacts on biodiversity values.

Should the consent authority agree with NGH's assessment, a BDAR and BAM-C case will not be required, rather an explanation of the proposed changes to biodiversity impacts will be captured in the modification application.

If you have any questions, please contact me or David Canterbury on 0403 709 813. We would be pleased to discuss any aspect of this project with you further.

Yours sincerely,

Misch

Elise Keane Senior Ecologist BAM Accredited Assessor BAAS23013 0488 448 017



# Appendix A Location of proposed underground cable

# Appendix B Vegetation Mapping within the Proposed Modification Area



Appendix C BOS Helpdesk Response

Reply above this line.

Gabrielle Ryan commented:

Hi Elise

Thank you for your enquiry.

The BOS Subject Matter Officer has provided the following response to your enquiry:

Given a BDAR was prepared for the original project, the below advice is based on the assumption that section 7.17 of the *Biodiversity Conservation Act 2016* (BC Act) applies to the modification. Section 7.17 applies to proposed modifications of projects that were approved after the commencement of the BC Act (and were not classified as a 'pending or interim planning application').

BC Act section 7.17 requires that the 'original development as proposed to be modified' is considered when determining if a BDAR is required (i.e. when checking the various triggers into the Biodiversity Offsets Scheme (BOS)). The 'original development as proposed to be modified' essentially means the original approved development inclusive of footprint changes that are proposed by the modification.

If the BOS is triggered based on the 'original development as proposed to be modified', the consent authority for the modification application will need to determine whether the proposed changes will result in an <u>increase</u> in impacts on biodiversity values. If the consent authority is satisfied that the proposed modification will <u>not</u> result in an increase in impacts on biodiversity values, then a BDAR is not required. See BC Act section 7.17(2)(c).

### Scenario - BDAR not required

If the consent authority is satisfied that the proposed modification will <u>not</u> result in an increase in impacts on biodiversity values, then a BDAR and BAM-C case are not required. An explanation of the proposed changes to biodiversity impacts can be captured in the modification application.

### Scenario - BDAR is required

If the consent authority forms the opinion that the proposed changes will result in an <u>increase</u> in impacts on biodiversity values, then a BDAR and BAM-C case will be required. The BDAR must assess the impact of the 'original development as proposed to be modified', not just the new impacts, and may be an updated version of the original BDAR. See BC Act section 7.17(2)(d) for additional BDAR requirements.

With respect to the BAM Calculator, as an interim measure until updates are made to BOAMS to better accommodate modifications, the Accredited Assessor should:

• Start a new Parent case for the modification DA and enter the DA Mod number in the DA Number field.

- Start a new BAM-C case under the new Parent case. Unfortunately, there isn't the ability to make a copy of the original (approved) case, meaning the data will need to be re-entered.
- Update the data to align with the modification.
- Include the word "Mod" or "Modification" in the title for the new Parent case and BAM-C case.
- Finalise the case ready for submission to the consent authority.

The above approach enables the BOS team to identify the modification case separately to the original approval case in BOS reporting.

Note that for local Part 4 development (i.e. not state significant development), if an application for the 'original development as proposed to be modified' would have been required to be refused because of SAII on biodiversity values, the application for modification is required to be refused.

Please note you can view your enquiry and send us a follow up message via the customer portal by clicking on the '**View request**' button within this email. Once you are in the customer portal, you can send a message or add an attachment by using the 'add a comment' feature at the bottom of your enquiry.

If you are having trouble viewing a response from the BOS Help Desk Team, please try the following troubleshooting measures:

- 1. Refresh the JIRA customer portal to view any new messages from our team OR
- 2. Please check your junk/spam mailbox for the JIRA email with our response and link into the JIRA customer portal.

Kind regards

The BOS Help Desk Team

View request · Turn off this request's notifications

### **BOS Help Desk Team**

Biodiversity and Conservation Division | Department of Climate Change, Energy, the Environment and Water

BOS Help Desk mailbox BOS.helpdesk@environment.nsw.gov.au

Enquiry Line 1800 931 717 (Tuesday to Thursday from to 10am to 4pm)

www.dcceew.nsw.gov.au



The Department of Climate Change, Energy, the Environment and Water acknowledges that it stands on Country which always was and always will be Aboriginal land.

We acknowledge the traditional custodians of the land and we show our respect for elders past,

# present and emerging.

This is shared with Elise Keane.

Powered by Jira Service Management

# NGH

# **Appendix D Initial Hazard Analysis**



Steph Kurta NGH Consulting Steph.K@nghconsulting.com.au

2 February 2024

Dear Steph,

# RE: Sandy Hollow Battery Energy Storage System (BESS) Hazards Advice

It is understood that your client proposes to modify the approval for a 5MW solar farm at Sandy Hollow in the Muswellbrook Shire to add an ancillary 5MW/10MWh BESS.

The consent authority, Muswellbrook Shire Council (MSC), has requested this memo to discuss the hazards of the proposed modification including the State Environmental Planning Policy (Resilience and Hazards) 2021 (Resilience and Hazards SEPP).

# **Proposed modification**

Details of the proposed BESS are presented in Table 1. The layout of the proposed BESS is presented in Figure 1. The separation distances are presented in Figure 2.

Table 1 Details of the proposed modification

Item	Description
BESS unit make and model	Sungrow ST2752UX (refer to Appendix A)
Module make and model	Sungrow M2L-M143A or E2L-M143A
Cell make and model	CATL 001CB310, CB2W0, CB310
Total capacity	5MW/10MWh
Layout	8 battery units in 4 pairs (back to back)
Separation	8 metres between BESS unit pairs
Cell chemistry	Lithium Iron Phosphate (LFP)
Cooling	Liquid cooling system including temperature monitoring and liquid cooling of batteries to prevent thermal runaway.
Fire safety	Deluge sprinkler heads (standard), Fused sprinkler heads (optional), NFPA69 explosion prevention and ventilation IDLH gases (optional)



Compliance	CE, IEC 62477-1, IEC 61000-6-2, IEC61000-6-4, IEC62619, UL9540A, UL1973, UN38.3





Figure 1 Concept layout





Figure 2 BESS spacing

# **Proposed mitigation measures**

Separation between BESS units are considered the main mitigation measure to prevent fire propagation between BESS units. The Department of Planning, Housing and Infrastructure (DPHI) (formerly DPE) generally accepts that a separation distance of 3 to 4 metres is suitable to prevent the propagation of fire between BESS units. The proposed BESS includes a separation distance between BESS unit pairs of 8 metres (refer to Figure 2). Accordingly, there is a very low risk of fire propagating between BESS unit pairs.

In addition to the separation distance, the proposed BESS also adopts the BESS unit manufacturers (Sungrow) mitigation measures (refer to Appendix A), including:



- Liquid cooling system
- Battery management system
- Deluge sprinkler heads (standard)
- Fused sprinkler heads (optional)
- NFPA69 explosion prevention and ventilation IDLH gases (optional).

The use of LFP cell chemistry also reduces the risk of thermal runaway and fire propagation. If a fire occurs, LFP cells release carbon dioxide which reduces the oxygen concentration and subsequently reduces the combustion rate. A thermal runaway event and subsequent BESS unit fire for LFP cell chemistry is not generally a credible scenario.

The benefits of LFP cell chemistry can be observed in the UL9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* report (Appendix B). The summary of the thermal runaway test notes that only white smoke was observed. No external flaming, explosive discharges of gases, sparks or electrical arcs were observed.

In addition to the LFP cell chemistry, the liquid cooling system would monitor for thermal runaway and remove heat if it were to occur. The fire safety system would also be employed if a BESS unit fire were to occur.

Based on the proposed mitigation measures, the risks posed by the BESS are considered low and are unlikely to result in significant offsite impacts.

# **Resilience and Hazards SEPP**

The Resilience and Hazards SEPP is used in New South Wales to regulate the planning approval process for developments in hazardous and offensive industries, and potentially hazardous and potentially offensive industries. Chapter 3 deals with the regulation of hazardous and offensive industries, and potentially hazardous and potentially offensive industries. It includes definitions, land to which the chapter applies, and development controls for hazardous or offensive development.

A BESS is not defined in the Resilience and Hazards SEPP. However, it might be considered *potentially hazardous industry* (without any proposed mitigation measures to reduce or minimise its impact) if it has the potential risk of fire from thermal runaway posing a significant risk to:

- Human health, life or property
- The biophysical environment.

However, when the mitigation measures included in the proposed modification, particularly the separation distances, have been employed, the proposed modification would not pose a significant risk in relation to the locality. Additionally, DPHI has an informal threshold of 30 MW for hazard assessment for BESS (i.e. Preliminary Hazard Analysis).

As the proposed BESS is less than this informal threshold and would not pose a significant risk in relation to the locality, the proposed modification is not considered to be *potentially hazardous industry.* 

As the proposed modification is not classified as *potentially hazardous industry*, it is not necessary to prepare a Preliminary Hazard Analysis for the proposed modification as Chapter 3 of the Resilience and Hazards SEPP does not apply


If any changes to this letter are requested or clarity required, please do not hesitate to call Scott on 0477 343 018 or email scott@pandoconsulting.com.au.

Warm Regards,

Scott McGrath Principal Environmental Consultant Scott@pandoconsulting.com.au 0477 343 018



Sydney • Central Coast • Newcastle pandoconsulting.com.au 0477 343 018

## Appendix A Sungrow ST2752UX datasheet

# ST2752UX

#### Liquid Cooling Energy Storage System



#### LOW COSTS

- Highly integrated ESS for easy transportation and O&M
- All pre-assembled, no battery module handling on site
- 8 hours from installation to commissioning, drop on a pad and make electrical connections

#### SAFE AND RELIABLE

- DC electric circuit safety management includes fast breaking and anti-arc protection
- Multi level battery protection layers formed by discreet standalone systems offer impeccable safety

#### EFFICIENT AND FLEXIBLE

- Intelligent liquid cooling ensures higher efficiency and longer battery cycle life
- Modular design supports parallel connection and easy system expansion
- IP54 outdoor cablinet and optional C5 anti-corrosion

SMART AND ROBUST

- Fast state monitoring and fault record enables pre-alarm and fault location
- Integrated battery performance monitoring and logging



Type designation	ST2752UX		
Battery Data			
Cell type	LFP		
Battery capacity (BOL)	2752 kWh		
System output voltage range	500 – 1500 V		
C-rate	≤0.5C		
General Data			
Dimensions of battery unit (W * H * D)	9340*2600*1730 mm		
Weight of battery unit	26,400 kg		
Degree of protection	IP54		
Operating temperature range	-30 to 50 °C (> 45 °C derating)		
Relative humidity	0 – 95 % (non-condensing)		
Max. working altitude	3000 m		
Cooling concept of battery chamber	Liquid cooling		
Fire safety standard/Optional	Deluge sprinkler heads (standard), Fused sprinkler heads (optional), NFPA69		
	explosion prevention and ventillation IDLH gases (optional)		
Communication interfaces	RS485, Ethernet		
Compliance	CE, IEC 62477-1, IEC 61000-6-2, IEC61000-6-4, IEC62619, UL9540A, UL1973, UN38.3		



Appendix B CATL UL9540A test report



Prüfbericht-Nr.: Test Report No.:	CN214A4R 001	Auftrags-Nr.: Order No.:	244329098	Seite 1 von 36 Page 1 of 36
Kunden-Referenz-Nr.: Client Reference No.:	2182037	Auftragsdatum: Order date.:	May 06, 2021	
Auftraggeber: Client:	Sungrow Energy Storage T No. 788, Mingchuan Road, B Anhui, P.R. China	<b>echnology Co., Lto</b> oyan Technology P	<b>d.</b> ark, Hi-tech Zone,	Hefei City, 230088
Prüfgegenstand: Test item:	LFP battery module			
Bezeichnung / Typ-Nr.:	M2L-M143A			
	E2L-M143A			
Auftrags-Inhalt: Order content:	Test report			
<b>Prüfgrundlage:</b> Test specification:	UL 9540A: 2019 (Fourth Edit	ion)		
Wareneingangsdatum: Date of receipt:	Aug 29, 2021	and the		SZ NE
<b>Prüfmuster-Nr.:</b> Test sample No.:	Engineering sample			->
<b>Prüfzeitraum:</b> Testing period:	Aug 29, 2021 ~ Aug 30, 2021			
Ort der Prüfung: Place of testing:	See clause 1.1 of main report			
Prüflaboratorium: Testing laboratory:	See clause 1.1 of main report			
Prüfergebnis*: Test result*:	See main report			
geprüft von / tested by:		kontrolliert von /	reviewed by:	
September 16, 2021 Mar	rvin Peng / Engineer	September 16, 2021	Bow en Dong	/ Review er
Datum Name/Stellur Date Name/Positio	ng Unterschrift on Signature	Datum N Date A	lame/Stellung lame/Position	<b>Unterschrift</b> Signature
Sonstiges / Other:				
Zustand des Prüfgegens Condition of the test item a	tandes bei Anlieferung: at delivery:	Prüfmuster volls Test item complet	tän <b>dig und unbes</b> e and undamaged	schädigt
* Legende: 1 = sehr gut 2 = gu P(ass) = entspricht o.g.	ut 3 = bef riedigend Prüfgrundlage(n) F(ail) = entspricht nic	4 ht o.g. Prüfgrundlage(n) N	= ausreichend 5 //A = nicht anwendbar N	= mangelhalt /T = nicht getestet
Legend: 1 = v ery good 2 = go P(ass) = passed a.m. te	bod 3 = satisfactory est specifications(s) F(ail) = f ailed a.m. te	st specifications(s) 4	= sufficient 5 I/A = not applicable N	= poor /T = not tested
Dieser Prüfbericht bezig auszugsweise verviel	ieht sich nur auf das o.g. Prüfm Ifältigt werden. Dieser Bericht b	uster und darf ohne	Genehmigung der Verwendung eines	Prüfstelle nicht Prüfzeichens
This test report only relates to	the a. m. test sample. Without person	ermission of the test co	enter this test report	is not permitted to be

TÜV Rheinland (Shanghai) Co., Ltd. No.177, 178, Lane 777 West Guangzhong Road, Jing'an District, Shanghai, China



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# INTRODUCTION

Model fire codes and energy storage system standards require energy storage systems to comply with UL 9540, which in turn requires battery cells and modules to comply with UL 1973. Compliance with these standards reduces the risk of batteries and battery energy storage systems (BESS) creating fire, shock or personal injury hazards. However, they don't evaluate the ability of the BESS installed as intended and with fire suppression mechanisms in place if necessary, from contributing to a fire or explosion in the end use installations.

To address these fire and explosion hazards associated with the installation of a BESS, the fire and other codes require energy storage systems to meet certain location, separation, fire suppression and other criteria. Those codes also provide a means to provide an equivalent level of safety based on large scale fire testing of anticipated BESS installations.

UL 9540A is intended to provide a test method that can be used as a basis for validating the safety of a BESS installation in lieu of meeting the specific criteria provided in those codes. The data generated can be used to determine the fire and explosion protection required for installation of a BESS.

The test method is initiated through the establishment of a thermal runaway condition that leads to combustion within the BESS. The test method outlined in UL 9540A consists of several steps – cell level testing, module level testing, unit level testing and installation level testing. The cell and module level testing steps are information gathering steps to inform the unit and installation level testing.

The following outlines the information that may gathered as part of the testing:

a) Cell level – An individual cell fails in a manner that leads to thermal runaway and fire through a suitable method such as external heating. Data such as off-gassing contents, temperatures at venting and temperatures at thermal runaway are recorded.

b) Module level – One or more cells within a BESS module fail in the manner determined during the cell level testing. Data such as fire propagation in the module, temperatures on the failed cells and surrounding cells, off-gassing contents and heat release data are gathered.

c) Unit level – A complete BESS is installed surrounded by target (e.g. dummy) BESS and walls separated at a distance as intended in its installation. The module level test is repeated on a module located in the BESS in the most unfavorable location. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; observation of fire propagation from BESS to target units and walls as well as observance of explosions or evidence of re-ignition within the BESS; and heat release and off-gassing contents are gathered.

d) Installation level – This test is a repeat of the unit level test with the test conducted within a test room and with the intended fire suppression system installed as well as any overhead cables (that can lead to fire propagation) installed. This test is intended to validate the fire suppression system for the BESS installation. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; fire propagation from the BESS to target units, walls or overhead cables and any observable explosion incidents or re-ignition within the BESS; and off-gassing contents (if needed) and heat release are gathered.



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# 1. General information

## 1.1 Test specification

Standard: ANSI/CAN/UL 9540A: 2019 (Fourth Edition)

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

This report presents the result of module level tests of UL 9540A: 2019.

All tests were conducted at TUV Rheinland (Shanghai) Co., Ltd. and TUV Rheinland's partner labs that were under supervision of TÜV Rheinland's engineer.

Testing period: Aug 29, 2021 ~ Aug 30, 2021

All tests were under supervision of TÜV Rheinland's engineer.

Refer to Clause 4 for test and measurement instruments.

## 1.2 General remarks

This report is descriptive and provide the test data only.

The test results presented in this report relate only to the object tested.

This report shall not be reproduced, except in full, without the written approval of the testing laboratory.

Throughout this report a  $\Box$  comma /  $\boxtimes$  point is used as the decimal separator.



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## 1.3 Revision information

New report, not applicable



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#### 1.4 Summary of the test

Video records of the test from 1 direction were provided in .mp4 format. Complete records were provided in 1 separate document, file number listed as below:

One external heater was place in the module to initiating the thermal runaway inside module. The initiating cells were heated at a rate of 4°C~7°C per minute until the cell thermal runaway.

White smoke was observe during test. No flying debris or explosive discharge of gases during test. No sparks, electrical arcs, or other electrical events during test. No external flaming observed.

The battery pack weight measured was 107.8 kg (before test) and 92.8 kg (after test).

Measured peak chemical heat release rate HRR was 19.39 KW

Measured peak smoke release rate SRR was 27.2 m<sup>2</sup>/s

Total smoke release TSR was 17002.7 m<sup>2</sup>

Total hydrocarbons gas was 1092 L

Detail information see relevant clause of this report.

## 1.5 List of attachments

Video records of the test from 1 direction was provided in .mp4 format. Complete records was provided in document, file number listed as below: NY20210830Sungrow Module.mp4;



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# 2. General Product Information

### 2.1 Cell

#### 2.1.1 Product information and parameters

The product information and parameters are provided by the client as below.

Manufacturer:	CATL	
Model number:	001CB310, CB2W0, CB310	
Chemistry:	LiFePO4	
Physical configuration:	Prismatic	
	Weight:	5410 ± 300 g
Electrical rating:	Rated capacity:	280 Ah
	Nominal voltage:	3.2 V
Standard charge method:	Charge current:	280 A
	End of charge voltage:	3.65 V
	Cut off current:	14 A
Standard discharge method:	Discharge current:	280 A
	End of discharge voltage:	2.5 V
Diagram with overall dimension	71.7 ±0.8	173.9±0.8



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#### 2.1.2 Cell level test information

Cell level thermal runaway test information is from CSA cell level test report 80008629 provided by the client.

Thermal Runaway Methodology	External heating method with ceramic heater 1 PCS, rated 220/230V, 500W
Cell Surface Temperature at Gas Venting :	143.3°C
Cell Surface Temperature at Thermal Runaway:	209.8°C

## 2.2 Module

#### 2.2.1 Product information and parameters

The product information and parameters are provided by the client as below.

Manufacturer name:	SUNGROW ENERGY STORAGE TECHNOLOGY CO., LTD.			
Model number :	M2L-M143A E2L-M143A			
Physical configuration:	Metal enclosure with plastic cover			
	Weight:	105 ± 3.2 k	٨g	
	Cells in series/parallel:	16 in serie	S	
Cooling method:	Electric fan	Electric fan Air flow: Outward		
Separation between cells::	10 mm separation between cells by plastic bracket			
Electrical rating:	: Rated capacity: 280 Ah			
	Nominal voltage:	51.2 V		
Standard charge method:	Charge current:	280 A	140A	
	End of charge voltage:	58.4 V		
	Cut of current:	14 A		
Standard discharge method: :	Discharge current:	280 A	140A	
	End of discharge voltage:	43.2 V		
Compliance with UL 1973:	: Under certification, not finished			

















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# 3. Module level test (section 8 of UL 9540A)

## 3.1 General

This testing is conducted on battery modules, which are in turn installed in an enclosure or in an open rack system to form a BESS unit.

This test uses applied stresses determined during the cell level test to force a selected number of battery cells within the module into thermal runaway. If there is fire that results from the cell being driven into thermal runaway, the fire is allowed to progress within the module.

The test measures the chemical heat release rate, maximum temperature, and vent gas composition; and documents the module enclosure integrity after the test, any explosions or hazardous ejection of parts outside of the module enclosure, and the extent and duration of any flame propagation outside of the module.

The module level testing establishes a base line fire test performance that can be evaluated against the fire performance of other battery modules the BESS manufacturer may choose to use within the system.

## 3.2 Sample preparation

Module sample was conditioned, prior to testing, through charge and discharge cycles of 2 cycles to verify that the module was functional.

Each cycle was defined as a charge to 100% SOC and allowed to rest several minutes and then discharged to an end of discharge voltage (EODV) determined by the manufacturer. Refer to 2.1 for charge and discharge profile.

The module sample was put in a climate chamber during charge and discharge. The ambient is kept at  $25^{\circ}C\pm2^{\circ}C$  and  $50\%\pm5\%$  R.H.







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#### 3.3 Module level thermal runaway test

#### 3.3.1 Thermal runaway test method description

The module to be tested were charged to 100% SOC and allowed to stabilize for a minimum of 1 h and a maximum of 8 h before the start of the test.

The external heating method used for initiating thermal runaway in cell level test was used to initiate thermal runaway within the module.

Consider the unit level installation and airflow of the fan cooling in the module. #8 cell located in the back side of the module was chose as target cell to be forced into thermal runaway.

The cells was heated by three external heater rated 220VAC/512 W (size 202\*169\*0.36mm). One layer 2 mm glass fiber heat insulation sheet was placed between the heater and metal enclosure to limit the heat transfer to enclosure.

10 armored thermocouples with diameter 0.1mm (external diameter 0.5mm) were attached on the center of each wide surface of #1 ~ #8 cells. (See 3.3.2 figure 1)

10 armored thermocouples with diameter 0.1mm (external diameter 0.5mm) were attached on the center of each narrow surface of  $#9 \sim #16$  cells closed to heated cell. (See 3.3.2 figure 1)

T12 to T19 located on negative electrode of #1 ~ #8 cells.

10 thermocouples were located on top of the module enclosure.

A PID controller was used to control the voltage supply to the heater and maintain a 5°C/min to 7°C/min heating rate.

Once thermal runaway was observed, the heaters were immediately de-energized.

Three thermocouples located below the heater at the center of #5 cell and #6 cell surface was used to feedback the temperature to the controller. (See 3.3.2 figure 1)

Voltage of the module are monitored during test.

The module was placed on top of a lift with the module orientation representative of its intended final installation.

The module was located under the smoke collection hood of the calorimeter measurement system.

Ambient conditions were within 25±5 °C and 50±25% RH at the initiation of the test.



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#### 3.3.2 Location of thermocouples

Figure 2. Cell numbering, heater location and thermocouples (no. xx) locations inside the sub-module



#### Figure 3. Thermo-couples locations outside module



## 3.3.3 Observations and records

Ambient conditions at the initiation of the test	27.0°C, 59% R.H.	
Sample number:	#NY202108383	
Open circuit voltage before test (V):	53.67	
Weight before test (kg)	104.4 (with thermal couplers)	



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Time initiating the test:	11:34 start to heat the cells
Observations during test:	Audible pop was heard on 12:18 PM (the pressure relief valve burst), followed by smoke release after several seconds.
	Large amount of white smoke were observed on 12:37.
	No flying debris or explosive discharge of gases during test.
	No sparks, electrical arcs, or other electrical events during test.
	No any flaming observed.
Posttest evaluation:	Posttest evaluation were performed after 24 hours of test.
	Eight cells were damage after test.
	Photos "sample after test" in page 38 show the damage of the module enclosure, electrolyte outside and damage of the components inside enclosure.
	27.72V was measured on the module output terminal.
Weight after test (kg):	95.20 (with thermal couplers)
Weight loss (kg)	9.2

#### 3.3.4 Temperature measurements

Cell to cell propagation happened during the test.

First thermal runaway occur on the cell contact the heater in 5# cell, 64 minutes after imitating the test, with maximum temperature of 557.9°C. (T7)

Second thermal runaway occur on the cell contact the heater in 6# cell, 3 minutes after first thermal runaway, with maximum temperature of 537°C. (TKK3)

Maximum temperature measured on side of #9 cell was 146°C (TA7).





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Thermocouple no.	Location	Maximum temp.(°C)
T3	Surface of cell_6 under heater	489.1
	ТЗ	
T7	Surface of cell_5 under heater	557.9
	T7	
T14	Negative Electrode of cell_6	385.5
T15	Negative Electrode of cell_5	288.8
T22	Vent of cell_6	430.8
TKK1	Surface of cell_6 under heater	494.9
	T4	
TKK3	Surface of cell_6 under heater T5	537.0
TKK4	Surface of cell_5 under heater T6	548.3



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Thermocouple no.	Location	Maximum temp.(°C)
T11	Surface of cell_1 under heater	407.7
T10	Surface of cell_2 under heater	541.3
Т9	Surface of cell_3 under heater	869.2
Т8	Surface of cell_4 under heater	472.7
T2	Surface of cell_7 under heater	518.2
T1	Surface of cell_8 under heater	297.6

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Thermocouple no.	Location	Maximum temp.(°C)
TA4	Surface of cell_9 under heater	143.6
TA6	Surface of cell_11 under heater	205.6
TA7	Surface of cell_12 under heater	210.3
TA8	Surface of cell_13 under heater	168.1
TA9	Surface of cell_14 under heater	166.3
TA10	Surface of cell_15 under heater	134.5
TA11	Surface of cell_16 under heater	121.5





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## 3.4 Chemical heat release rate measurement

#### 3.4.1 Test method

The chemical heat release rates were measured by an oxygen consumption calorimeter measurement system consisting of a paramagnetic oxygen analyzer, non-dispersive infrared carbon dioxide and carbon monoxide analyzer, velocity probe, and a Type K thermocouple.

The instrumentations are located in the exhaust duct of the heat release rate calorimeter.

The chemical heat release rate was calculated at each of the flows as follows:



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$$HRR_{1} = \left[ E \times \varphi - (E_{co} - E) \times \frac{1 - \varphi}{2} \times \frac{X_{co}}{X_{O_{2}}} \right] \times \frac{\dot{m}_{e}}{1 + \varphi \times (\alpha - 1)} \times \frac{M_{O_{2}}}{M_{a}} \times (1 - X_{H_{2}O}^{o}) \times X_{O_{2}}^{o}$$

In which:

HRRt = total heat release rate, as a function of time (kW)

E = Net heat released for complete combustion per unit of oxygen consumed (adjusted for oxygen contained within cell chemistry, 13,100 kJ/kg)

 $E_{CO}$  = Net heat released for complete combustion per unit of oxygen consumed, for CO (adjusted for oxygen contained within cell chemistry, 17,600 kJ/kg)

 $\varphi$  = Oxygen depletion factor (non-dimensional), where:

$$\varphi = \frac{X_{O_2}^o \times [1 - X_{CO_2} - X_{CO}] - X_{O_2} \times [1 - X_{CO_2}^o]}{X_{O_2}^o \times [1 - X_{O_2} - X_{CO_2} - X_{CO}]}$$

 $X_{CO}$  = Measured mole fraction of CO in exhaust flow (non-dimensional)  $X_{CO_2}$  Measured mole fraction of CO<sub>2</sub> in exhaust flow (non-dimensional)  $X^{\circ}_{CO_2}$  = Measured mole fraction of CO<sub>2</sub> in incoming air (non-dimensional)  $X^{\circ}_{H_2O}$  = Measured mole fraction of H<sub>2</sub>O in incoming air (non-dimensional)  $X_{O_2}^{\circ}$  = Measured mole fraction of O<sub>2</sub> in exhaust flow (non-dimensional)

 $X^{\circ}_{O_2}$  = Measured mole fraction of  $O_2$  in incoming air (non-dimensional)

 $\alpha$  = Combustion expansion factor (non-dimensional; normally a value of 1.105)

Ma = Molecular weight of incoming and exhaust air (29 kg/kmol)

Mo2 = Molecular weight of oxygen (32 kg/kmol)

 $\dot{m}_{e}$  = Mass flow rate in exhaust duct (kg/s), in which:

$$\dot{m}_e = C \times \sqrt{\frac{\Delta p}{T_e}}$$

or

$$\dot{m}_e = 26.54 \times \frac{A \times k_c}{f(\text{Re})} \times \sqrt{\frac{\Delta p}{T_e}}$$

C = Orifice plate coefficient (in  $kg^{1/2}m^{1/2}K^{1/2}$ )

Δp = Pressure drop across orifice plate or bidirectional probe (Pa)

 $T_e$  = Combustion gas temperature at orifice plate or bidirectional probe (K)

A = Cross sectional area of the duct (m<sup>2</sup>)

kc = Velocity profile shape factor (non-dimensional)

f(Re) = Reynolds number correction (non-dimensional)



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The whole heat release rate measurement system were calibrated using an atomized heptane diffusion burner before the test. The calibration were performed using flows of 1078mg/s and 1510mg/s of propane (corresponding to 50kW and 70kW heat release rate).

#### 3.4.2 Test result

Peak chemical heat release rate HRR: 19.39KW

Figure 7 HRR curve







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### 3.5 Smoke release rate measurement

#### 3.5.1 Test method

The light transmission in the calorimeter's exhaust duct was measured using a white light source and photo detector for the duration of the test.

The smoke release rate was calculated as follows:

$$SRR = 2.303 \left(\frac{V}{D}\right) Log_{10} \left(\frac{I_o}{I}\right)$$

Where:

SRR = Smoke release rate ( $m^2$ /s)

V = Volumetric exhaust duct flow rate (m<sup>3</sup>/s)

D = duct diameter (m)

 $I_{o}$  = Light transmission signal of clear (pre-test) beam (V)

I = Light transmission signal during test (V)

The whole smoke release rate measurement system were self-checked using calibrated light filter before test. The self-check were performed at 100%, 79%, 50%, 32%, 16%, 10%, 1% and 0% light transmittance.

#### 3.5.2 Test result

Peak smoke release rate SRR: 27.2 m<sup>2</sup>/s

Total smoke release TSR: 17002.7 m<sup>2</sup>









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## 3.6 Gas generation measurement

#### 3.6.1 Test method

The composition, velocity and temperature of the vent gases were measured within the calorimeter's exhaust duct.

Gas composition were measured using a Fourier-Transform Infrared Spectrometer with a resolution of 1 cm<sup>-1</sup> and a path length of 4.2 m within the calorimeter's exhaust duct.

The hydrocarbon content of the vent gas was measured using flame ionization detection.

Hydrogen gas was measured with a palladium-nickel thin-film solid state sensor.

Composition, velocity and temperature instrumentation were collocated with heat release rate calorimetry instrumentation.



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#### 3.6.2 Total gas release

The flow rates of various gases were integrated over the test duration and the total cumulative volume of gas calculated for the total test duration (11:34~19:56) were presented in below table.

Total cumulative volume of gases before cell venting (11:34 ~ 12:18) were also presented in table for reference. Which may be considered as ambient gases background before test.

Gas type	Gas components		Total volume of gas (L)	
			Before cell venting	Throughout the test
Hydrocarbon	Methane	CH <sub>4</sub>	1.6	75.6
species	Acetylene	C <sub>2</sub> H <sub>2</sub>	0.7	9.4
	Ethylene	C <sub>2</sub> H <sub>4</sub>	2.0	111
	Ethane	C <sub>2</sub> H <sub>6</sub>	1.2	32.1
	Propane	C <sub>3</sub> H <sub>8</sub>	2.1	122.6
	Propylene	C <sub>3</sub> H <sub>6</sub>	0.7	225.9
Hydrogen halide species	Hydrogen Fluoride	HF	0.2	138.6
Nitrogen containing species	Nitrogen Monoxide	NO	0	114
Others	Carbon Monoxide	СО	23.2	201.3
	Carbon Dioxide 1)	CO2	4981	39727
	Hydrogen	H <sub>2</sub>	0	1182
	Dimethyl carbonate(DMC)	C3H6O3	0.6	754.8
	Diethyl carbonate(DEC)	C5H10O3	1.7	28.3
	Ethylmethyl carbonate	C4H8O3	0	138.2
	Formaldehyde	CH2O	1.2	7.2
	Ethylene oxide	C2H4O	0.2	2.8
	Ammonia	NH3	0.2	6.4
	Methanol	CH4O	1.2	42.1
	Oil as octane		0	48
Total Hydrocark	Dons			1092
Note: 1)The collec 2)The carbo	ction time is from 11:34 on dioxide in the air dur	to 19:56 this perioc	1 <sup>1)</sup> was also coun	ited


























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## Test setup



# Smoke release during test



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# Smoke release during test



Sample after test







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Sample after test





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# List of Test and Measurement Instruments

No.	Equipment		Manufacture/ Model	Rating	Inventory no.	Latest Cal. date
1.	Ambient monitor		testo/ 175H1	-20°C to +55°C 0 to 100%RH	PVE-018	20201203
2.	Data acquisition equipment		Delta/ DTM series	0 to 1500°C	S-029	20201203
3.	Digital multi-meter		Fluke/ F101	0-600V	S-038	20201203
4.	Таре		Kaptaen	0-300°C	S-040	/
5.	Electronic scale		Shanghai Xiangxu/ TCS- 500	0-500kg	S-039	20201203
6.	Oxygen consump tion calorimet er measure ment system	Paramagnetic oxygen analyzer	Servomex/ 4100	0-21%	S-024	20210319
7.		Velocity probe	Motis Fire Technology	0-200Pa		20210308
8.		Photo detector	Motis Fire Technology	0-100%		20210319
9.		Light filter	Motis Fire Technology	25%,50%,75%		20210308
10.		CO and CO <sub>2</sub> sensor	Servomex/ 4100	CO 0-1% CO <sub>2</sub> 0-10%		20210319
11.	Palladium-nickel thin-film solid state sensor		H2SCAN 740B	0.5%-100%	S-023	20210319
12.	H2 sensor		Suzhou Chint	0%-100%	S-22	20210319
13.	Fourier-Transform Infrared Spectrometer		MultiGas/ MKS6030	/	S-019	20210319
14	Flame Ionization Detector		ABB/ AO2040	0-600mgC/m <sup>3</sup>	S-025	20210319
15	Heat flux measurement equipment		Medtherm	0-50kW	S-031	20201203
16	Thermopile		Omega/ No.24	0-1040°C	S-026	20210308

## End of Test Report

# NGH

#### NGH Pty Ltd

NSW • ACT • QLD • VIC

ABN 31 124 444 622 ACN 124 444 622

E: ngh@nghconsulting.com.au

#### GOLD COAST

2B 34 Tallebudgera Creek Road Burleigh Heads QLD 4220 (PO Box 424 West Burleigh QLD 4219)

T. (07) 3129 7633

#### SYDNEY REGION

Unit 17, 21 Mary Street Surry Hills NSW 2010

T. (02) 8202 8333

#### BEGA

Suite 11, 89-91 Auckland Street (PO Box 470) Bega NSW 2550

T. (02) 6492 8333

#### MELBOURNE

Level 14, 10-16 Queen Street Melbourne VIC 3000

T: (03) 7031 9123

#### TOWNSVILLE

Level 4, 67-75 Denham Street Townsville QLD 4810

T. (07) 4410 9000

#### BRISBANE

Brisbane QLD 4000 T. (07) 3129 7633

#### NEWCASTLE - HUNTER & NORTH COAST

T3, Level 7, 348 Edward Street

Level 1, 31-33 Beaumont Street Hamilton NSW 2303

T. (02) 4929 2301

# WAGGA WAGGA - RIVERINA & WESTERN NSW

35 Kincaid Street (PO Box 5464) Wagga Wagga NSW 2650

T. (02) 6971 9696

#### CANBERRA

Unit 8, 27 Yallourn Street (PO Box 62) Fyshwick ACT 2609

T. (02) 6280 5053

#### SUNSHINE COAST

Suite 101, Level 2/30 Main Drive Birtinya QLD 4575

(07) 4410 9000

#### WODONGA

Unit 2, 83 Hume Street (PO Box 506) Wodonga VIC 3690

T. (02) 6067 2533