MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

COVERSHEET

Minister	Hon Dr Megan Woods	**Portfolio**	Energy and Resources
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Information redacted **YES**

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Some information has been withheld for the reason of Confidential information entrusted to the Government.

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Office of the Minister of Energy and Resources

Cabinet Economic Development Committee

Update on the NZ Battery Project

Proposal

1 To update Cabinet on the latest and emerging findings on the New Zealand Battery Project, and to seek decisions to shape the focus of the remainder of Phase 1 of the project.

Relation to government priorities

2 This project relates to the Government's manifesto commitment to investigate dry year storage solutions to maximise renewable electricity in order to provide a pathway to 100 per cent renewable electricity in New Zealand. It also supports our commitment to reduce greenhouse gas emissions under the Paris Agreement.

Executive Summary

3 Currently, New Zealand relies on the combustion of coal and gas to maintain security of supply through dry years when there is less rainfall/snow melt in the South Island hydro lakes. Cabinet set up the New Zealand Battery Project (NZ Battery Project) to investigate renewable storage options to reduce our reliance on fossil fuels for that security of supply, with a focus on exploring the feasibility of pumped hydro at Lake Onslow [CAB-20-MIN-0900 refers].

4 Initial work shows that pumped hydro at Lake Onslow is technically feasible, could mitigate the dry year problem, and would support a pathway to a 100 per cent renewable electricity system. Furthermore, that analysis shows that Lake Onslow has the critical features required for a large-scale pumped hydro scheme, but will come with a trade off against environmental, social and cultural values. Similar impacts are anticipated with any hydro-based solution.

5 Other technologies, like renewable sources of combustion material, expanded geothermal generation, and clean hydrogen also show potential as parts of an alternative portfolio approach to solving the dry year problem.

6 The purpose of this stage of the project is to provide information primarily on the technical feasibility of different options to address dry year risk, with a focus on pumped hydro at Lake Onslow.

7 I am scheduled to report back to Cabinet in December 2022. That report back will include a complete feasibility analysis of pumped hydro at Lake Onslow, as well as comparisons with alternative options as part of an Indicative Business Case. At that point, I will seek decisions on which option (if any) to progress to a Detailed Business Case.

Background

8 The New Zealand electricity system relies heavily on hydro storage and generation, in the order of 55-60 per cent. Hydro generation is susceptible to variations in inflows within their catchment, which varies how much electricity they can generate year-to-year. Thermal plants, burning coal, gas and diesel ensure that supply is maintained through annual variations in hydro generation.

9 A ‘dry year’ is an extended period of weeks or months when reduced hydro inflows put pressure on the electricity system and result in higher-than-average use of thermal plant.

10 The NZ Battery Project is investigating feasible alternatives to the role these thermal plants play in a dry year to maintain security of supply and support the objective of 100 per cent renewable generation.

11 Demand for electricity is expected to grow rapidly with the electrification of transport and industrial process heat and increase substantially in the coming decades. Meeting the demand from this rapid electrification of the economy, along with replacing the around 7 TWh per annum of fossil fuel generation, requires a huge and sustained increase in renewable generation. This is expected to come from private investment in wind, solar and geothermal generation plant.

12 However, as both wind and solar generation are intermittent in nature, the dry year risk will continue (tempered slightly by climate change resulting in more precipitation falling as rain and flowing quickly into the lakes, and less as snow which takes time to melt before flowing into the lakes). Furthermore, a new risk of lower generation output from solar and wind during prolonged periods of calm and/or cloudy conditions will increasingly emerge as New Zealand increases its reliance on those generation types.

13 To solve the dry year problem (and contribute to solving the emerging calm, cloudy period problem) without using thermal generation, New Zealand needs approximately 3 to 5 terawatt hours (TWh) of renewable energy storage. For comparison, New Zealand has recently been consuming about 40 TWh per year.

14 The NZ Battery Project has been exploring options for storing renewable energy, primarily for use during dry years, and when the weather conditions mean that less renewable energy is available (calm, cloudy periods). The primary focus of the project is on pumped hydro, in particular pumped hydro at Lake Onslow, but other options are being considered.

15 The NZ Battery Project is divided into four workstreams: feasibility of pumped hydro at Lake Onslow, exploring other potential options for expanding hydro storage, exploring other technologies for storing renewable energy, and exploring market integration and economic benefits of developing an NZ Battery. Appendix two outlines the analysis that these four workstreams will produce before the Cabinet report back in December.

16 In December 2020, Cabinet agreed that the objective of the NZ Battery Project was "*to manage or mitigate dry year risk in the electricity system*" and set the following criteria for proposals to be assessed against:

16.1 "*provide at least [5,000 GWh] of energy storage or equivalent energy supply flexibility*

16.2 *provide significant levels of employment for post COVID-19 recovery*

16.3 *reduce emissions either directly or indirectly through facilitation decarbonisation*

16.4 *maximise renewable electricity in order to provide a pathway to achieve the goal of 100 per cent renewable electricity*

16.5 *lower wholesale electricity prices, and*

16.6 *be practical and feasible.*"

and noted "*that the assessment of any option will take into account wider social, cultural and environmental factors…*" [CBC-20-MIN-0090 refers].

17 This stage of the project has focused on feasibility of various options to mitigate the dry year and evolving calm/cloudy problem. These criteria will help support Cabinet in December in its decision making on what options (if any) to progress to a Detailed Business Case in 2023.

18 The NZ Battery Project complements a wider strategy to support the effective transition of the electricity sector to renewable sources, and continued electrification of the economy. This includes the forthcoming energy strategy, which is due by the end of 2024.

The dry year problem is complex

19 Despite having hydro-dominated generation, the hydro lakes in New Zealand are relatively small, storing weeks to months of energy when combined: 4.5 TWh of storage capacity, compared to around 25 TWh of average annual inflows. Hydro storage relies on rain and snowmelt in their catchments to regularly top up the lakes. However, inflows vary year to year. At its worst, the shortfall of annual inflows has been the equivalent of 5 TWh of electricity lower than average. A more typical dry year has around 3 TWh of shortfall.

20 The New Zealand electricity system will remain hydro dominated despite the expected increase in wind, solar and geothermal generation. This means that traditional dry years from low hydro inflows are likely to be an enduring problem in the range of 3 to 5 TWh.

21 Further, the acceleration in investment in wind and solar generation creates an emerging intermittency problem from calm and cloudy periods.

22 Hydro electricity generators are constantly managing their storage reservoirs, within resource consent limits on minimum river flows. Generators make decisions based on incomplete information, and unpredictable weather patterns.

23 When inflows and/or storage levels are low enough to make hydro generators want to conserve water, they raise the price that they offer for generation to the wholesale market. Currently, such higher prices incentivise thermal fossil fuel plants (which have a higher operating cost) to generate more, so that supply meets the demand while preserving water. This is how the market currently manages the dry year risk.

24 Alternative solutions to the dry year problem require a significant amount of stored energy, and sufficient generation capacity that it can be delivered over a few weeks or months when the electricity market is stressed from dry, calm, or cloudy conditions.

25 In a 100 per cent renewable electricity system, the dry-year problem can be addressed by building sufficient spare intermittent renewable generation capacity (most likely wind and solar) to fill the energy gap when hydro inflows are very low.

26 However, this would also result in a significant amount of ‘spilled’ (wasted) energy unless there was additional storage in the system to capture it. This so-called ‘renewable overbuild’ approach could lead to upward pressure on electricity prices, given the diminishing returns to wind and solar generators. This was identified by the Interim Climate Change Committee and the Climate Change Commission, and more recently confirmed by MBIE modelling.

27 Furthermore, there is a risk that the market would not invest in the amount of ‘overbuild’ required to cover the driest years and calmest, cloudiest periods. Each new wind turbine or solar panel will have diminishing returns on capital, given the times of higher prices will increasingly be during calm and cloudy weather, when those wind turbines and solar panels are generating less electricity. To keep the lights on in the future, we will either need to retain dependence on thermal plant or develop a solution to storing a large amount of renewable energy.

Work is underway to investigate options to solve the dry year problem

28 NZ Battery Project is investigating the feasibility of different options across its different workstreams. Key activities to date include:

28.1 A detailed engineering, geotechnical and environmental investigation into the feasibility of pumped hydro at Lake Onslow focusing on identifying the most feasible scheme design options. This investigation is in progress and will be completed in the coming months.

28.2 A programme of detailed geotechnical investigations, including drilling for rock samples in and around Lake Onslow, to support the findings of the investigation above, and to identify any fundamental geotechnical risks.

28.3 A range of environmental, cultural and social impact studies around Lake Onslow to identify how these might be affected by the development of a pumped hydro scheme. These are ongoing.

28.4 Assessment by Transpower into the transmission and power system implications of a pumped hydro scheme at Lake Onslow.

28.5 Desktop level engineering investigations into a small number of alternative hydro locations, identified from a nation-wide survey.

28.6 Feasibility studies into a small range of non-hydro based options, short-listed through expert review.

28.7 Electricity system economic modelling to capture the system cost impacts of different dry-year risk management storage options.

29 The purpose of this stage of the project is to provide information on the feasibility of different options to address dry year risk. In keeping with the intent of the NZ Battery Project, much of this work is focusing on fully investigating the feasibility of pumped hydro at Lake Onslow, although other options are also being considered.

30 'Front loading' investigations in the early stages of a project like this is important in order to make informed decisions about whether to proceed with further work. This includes the geotechnical investigations currently underway around Lake Onslow.

31 Much of this work is still ongoing ahead of final feasibility recommendations at the end of the year, however there is enough information to share some early findings and conclusions.

A pumped hydro scheme at Lake Onslow appears to be technically feasible

32 Early and emerging findings suggest that a pumped hydro scheme at Lake Onslow is technically feasible, though this work is incomplete and ongoing. At this stage, Te Rōpū Matatau[1] has not identified any technical barriers to the development and operation of a pumped hydro scheme. These findings are encouraging, but more work is required.

33 Te Rōpū Matatau has identified several design considerations, and is now analysing which combinations of design elements would most warrant progressing to any subsequent future stage. Notwithstanding ongoing geotechnical investigations, the findings to date suggest:

33.1 **There is sufficient space for storage.** Lake Onslow is in a basin and could store a large amount of water at elevation. 3 to 5 TWh of storage would be feasible, and larger storage is possible, up to 8.5TWh.

33.2 **The land appears to be able to support a dam.** The engineering and geotechnical investigation to date has identified suitable locations for a dam, to create the upper reservoir at Lake Onslow. There are two suitable types of dams: Low Paste Roller Compacted Concrete (hardfill); or rockfill. A hardfill dam would be cheaper, carry lower construction risk, and could more easily be built larger later if desired, but is more carbon intensive—although there are opportunities at additional cost for lower-carbon concrete. A rockfill dam

[1] A consortium led by Mott MacDonald New Zealand Limited with GHD Limited and Boffa Miskell Limited as key sub-consultants

would avoid some of those 'embodied' emissions but would be more expensive, more difficult to build, and be physically much larger, and there are also significant emissions involved moving very large quantities of earth from quarry sites to the dam location.

33.3 **A large generating capacity is possible.** The various tunnel options could support up to 1,500 MW, with up to six turbines/pumps of 250 MW each. For comparison, New Zealand's largest hydro plant is Lake Manapōuri, with installed capacity of 850 MW. Huntly power station has a total installed capacity of 953 MW.

33.4 **There is existing national grid infrastructure nearby.** Transpower has confirmed that a pumped hydro scheme could integrate into the grid by connecting to nearby high-voltage lines.

33.5 **There is a nearby water source at lower altitude.** The Clutha River/Mata Au is sufficiently lower in altitude than Lake Onslow and has enough water to pump from.

33.6 **There are suitable tunnel and lower intake locations.** The feasibility study is narrowing down the most feasible intake and tunnel locations. There are some prospective locations for a lower water intake along the Clutha River/Mata-Au both upstream and downstream of the Roxburgh dam, each with their own practical and geological risks to manage.

34 Contact Energy operates a series of existing hydro dams on the Clutha River/Mata-Au (Hawea, Clyde and Roxburgh) and has commercial interests in the water, and minimum river flow requirements to manage.

35 An intake point upstream of the Roxburgh dam will affect Contact Energy's operations by drawing on water that it would have otherwise used as storage or generation. Conversely if the intake was downstream of Roxburgh dam, then Contact Energy's operations would affect the flexibility to pump water to Lake Onslow.

36 Taking water from a point downstream of the Roxburgh dam would likely require a way to pool some water off the river, to create a small amount of storage Confidential information entruste Confidential information entrusted to the Government that can decouple the operation of a pumped hydro scheme from Contact Energy's operation of the Roxburgh dam. This may require the construction of a reservoir at the chosen intake site near the Clutha River/Mata-Au. The ongoing engineering work will identify and develop the most feasible option for lower intake location and design, which will inform advice for Cabinet in December.

A scheme like pumped hydro at Lake Onslow would benefit the electricity system

37 The decarbonisation of electricity generation, and particularly, shifting to 100 per cent renewable generation is a challenge that most countries are facing, to reduce carbon emissions. That transition creates a lot of uncertainty for private, and public investment. Building an asset like pumped hydro at Lake Onslow requires capital

investment upfront but would improve certainty in the market for both generators and consumers of electricity.

38 Early modelling results and electricity system analysis suggest that a large-scale pumped hydro scheme, such as at Lake Onslow will:

38.1 smooth wholesale prices by using electricity to pump water when prices are low, and later generating when prices are high, Confidential information entrusted to the Government [redacted]

38.2 generate a positive cashflow, by purchasing electricity, and pumping, when prices are low, and generating when prices are high

38.3 reduce the need for overbuilding generating capacity

38.4 assist in maintaining security of supply in a market without coal, gas and oil plant, and

38.5 substantially reduce the electricity spilt/wasted, such as during windy and sunny periods.

39 The report back in December will include an Indicative Business Case, to outline costs and benefits.

There are private interests and environmental challenges to manage

40 The NZ Battery Project aims to reduce New Zealand's greenhouse gas emissions and, hence, contribute to global emission reduction and net climate benefit. Any large-scale hydro development requires balancing its impacts against benefits.

41 Confidential information entrusted to the Government [redacted]

42 [redacted]

43 [redacted]

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44 Lake Onslow is also an important cultural, social and landscape asset. Confidential information entr

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Furthermore, Lake Onslow is a highly regarded location for local anglers, with notably high stocks of brown trout, which are likely to deteriorate with the raising and varying of the lake level that comes with a pumped hydro scheme. Finally, a pumped hydro scheme with accompanying electrical infrastructure would create a visual impact on the naturalness and uniqueness of the Lake Onslow landscape.

45 Raising the water levels at Lake Onslow to support pumped hydro would inundate private land for which the Crown would need to compensate. Confidential information entrusted to the Government

46 Confidential information entrusted to the Government

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48 Many of the features of Lake Onslow that present environmental and social challenges are the same features that make it technically attractive for developing a pumped hydro scheme, for example, an elevated basin, close to an existing water source. These challenges speak to inherent trade-offs necessary when developing large-scale hydro assets.

Operating pumped hydro at Lake Onslow

49 Early analysis suggests that there are two broad types of options for how a pumped hydro scheme at Lake Onslow could operate to ensure that there is storage available throughout dry years:

49.1 reserve solely for dry year security of supply and generate only when certain price or scarcity thresholds are met, or

49.2 interact with the market on a continuous basis (for example, by auctioning future generation potential).

50 Operating solely for dry year security by limiting its operation to set thresholds could risk distorted market signals and result in higher prices at times of scarcity and less private investment in other renewable generation. It would likely prevent it contributing to managing calm, cloudy periods of low wind and solar generation, and to unforeseen supply emergencies. Having set triggers for when a pumped hydro scheme operates could also reduce its revenue and make it more susceptible to gaming.

51 Conversely, operating on a continuous basis means that the asset can be used much more efficiently, and support security of supply through a broader range of system challenges (including future calm, cloudy periods, and events like that on 9 August 2021). If operated on a continuous basis, it could be broadly revenue positive, though will have significant variability in its revenue between wet years (where it would be a net consumer of electricity as it pumps and stores energy) and dry years (where it would generate and draw down on its storage).

52 Questions of the operation and ownership of a pumped hydro scheme are complex. These issues will be considered at a high level as part of the current feasibility phase of the NZ Battery Project, but they would need to be investigated in fuller detail as part of any subsequent stage. There are also important overlaps with MBIE's wider work on the energy strategy and the transition to a highly renewable electricity system, towards 100 per cent renewable electricity.

53 Confidential information entrusted to the Government

Other locations for pumped hydro offer their own benefits and challenges

54 MBIE engaged NIWA to run a national-level scan to identify other potential sites for pumped hydro as a comparison to Lake Onslow. It focused on potential locations that could provide more than 1 TWh of energy storage in keeping with the objectives of the NZ Battery Project.

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59 Furthermore, it is not clear that any of the sites will be able to mitigate the dry year problem to the same extent as pumped hydro at Lake Onslow. However, I wish to consider these alternatives further, and I expect to provide final advice on these pumped hydro options to Cabinet in December.

There are other technologies worth exploring

60 Officials, working with WSP NZ Ltd, have identified three possible alternatives to pumped hydro, as potential options to help solve the dry year problem without thermal generation: flexible geothermal, hydrogen, and biomass (e.g., wood pellets). Other options were identified that may one day become economic but would not be suited to solving the dry year problem for various reasons: such innovation can be left to the market.

61 This work has highlighted that there are no easy options to manage dry year risk. Each of these three potential alternatives would come with its own significant costs, risks and challenges. None would feasibly provide 3 to 5 TWh of storage on its own, but could contribute to a portfolio approach, which could improve risk and resilience by spreading development of the assets across technologies and locations.

62 Furthermore, I am encouraged to see that some electricity industry participants are themselves investigating some of these technologies. For example, Genesis has indicated it is exploring using biomass at the Huntly Power Station; and Meridian and Contact Energy have indicated they are looking into green hydrogen production in Southland as a source of flexible demand. This suggests that the industry could go some way to implementing solutions to help alleviate the dry year problem, though may seek Government support to do so.

63 By investigating a wide range of alternatives, the Government can determine what the collective effect would be among the emerging technologies and proposals, and can determine what more might be needed, and therefore the extent to which government action is necessary.

64 The early-stage feasibility study into other renewable storage technologies indicates some promise, but none of them will be able to solve the dry year problem on their own. Nevertheless, these should be part of a range of options for Cabinet to consider in December, against pumped hydro at Lake Onslow, to decide what (if anything) to progress to a Detailed Business Case in 2023.

65 Supplementary to new generation investment, it is likely that pre-planned demand response measures (e.g., temporarily scaling down energy-intensive industries) will play some role in balancing supply and demand in the future, which can also help manage periods where intermittent generation sources are not generating. Large

industrial consumers have historically shown some willingness to reduce their load during dry periods, and new industries such as data centres and hydrogen production may be willing and able to provide a helpful response in future.

66 While such demand response is to be encouraged and is expected to evolve to manage short-term issues such as winter evening peak supply, it is unlikely that large consumers could meet the full large-scale, long-term response that the dry year problem requires, given the impact that a sustained period of load reduction would have on their businesses. It is unlikely that the specific requirements of a dry year response and the independent drivers of a business' operations would always align. Further analysis on demand response will be included in the Indicative Business Case.

Market dynamics

67 The New Zealand electricity system will function substantially differently with 100 per cent renewable generation, and a large-scale renewable storage scheme would change it further. Signalling the development of a project like a pumped hydro scheme will factor into the generators' future investment decisions.

68 The storage and generating capacity that this project is investigating for pumped hydro at Lake Onslow is deliberately significant in the context of current electricity generation in New Zealand. For comparison, total current hydro storage in New Zealand is about 4.5 TWh, and Lake Manapōuri is the largest hydro power station with 850 MW of installed capacity.

69 There is a risk that a scheme this large could create significant market power in the electricity sector, though this risk is manageable. MBIE is continuing to investigate ways of mitigating this market power risk, and ways of making best use of an asset this large. There are operating models that achieve both. Further analysis on market dynamics will be provided in the Indicative Business Case.

Next steps

70 I will report back to Cabinet in December 2022 with information on final feasibility work and an Indicative Business Case on a pumped hydro scheme at Lake Onslow, as well as further information on other renewable energy storage options. The December report back will provide analysis on the matters set out in Appendix 2. This information will support Cabinet to decide whether to progress any of the options to the Detailed Business Case stage, for preparation in 2023-2024.

Financial Implications

71 Funding of $100.008 million was provided for the project – $30 million for the initial feasibility study (Phase 1) and $63.298 million for development of a Detailed Business Case (Phase 2), with the remainder for staffing and overheads.

72 The project is in Phase 1. To date, MBIE has spent $10.024 million on the feasibility work, of which $8.317 million relates to feasibility of pumped hydro at Lake Onslow. The full Phase 1 appropriation is expected to be utilised, as engineering and geotechnical investigations progress.

Legislative Implications

73 There are no legislative implications at this stage of the project.

Impact Analysis

Regulatory Impact Statement

74 A regulatory impact assessment is not required as no policy implications are proposed at this stage of the project.

Climate Implications of Policy Assessment

75 A Climate Implications of Policy Assessment (CIPA) is not required for at this stage of the project.

Population Implications

76 There are no population implications at this stage of the project.

Human Rights

77 There are no Human Rights implications at this stage of the project.

Consultation

78 The Treasury, Ministry for the Environment and the Department of Conservation were consulted on this paper. The Department of Prime Minister and Cabinet has been informed.

Communications

79 I will issue a press release detailing Cabinet's decision. Prior to this announcement, key stakeholders will be informed, including the affected landowners near Lake Onslow and the Clutha River/Mata-Au, mana whenua and relevant government agencies.

Proactive Release

80 I propose to proactively release this Cabinet paper and minutes within 30 business days, subject to redaction as appropriate consistent with the Official Information Act 1982.

Recommendations

The Minister for Energy and Resources recommends that the Committee:

1 note that in December 2020, Cabinet set up the NZ Battery Project to assess renewable storage options to address the dry year problem, and agreed the NZ Battery Project should examine the viability of pumped hydro, particularly at Lake Onslow, and consider this solution against alternative technologies [CBC-20-MIN-0090 refers],

2 note that the NZ Battery Project fits into a wider work programme to transition to highly renewable electricity generation, alongside continued electrification of the economy,

3 note that reliance on weather dependent electricity generation creates ‘dry year’ security of supply risks that equates to 3-5 terawatt hours less energy available for electricity generation, compared to an average year,

4 note that a pumped hydro scheme at Lake Onslow is technically feasible, could solve the dry year problem, support a transition to highly renewable generation, and provide gross benefits to the electricity sector including:

4.1 assisting in maintaining security of supply, without coal, gas and oil plant

4.2 reducing the need for overbuilding generating capacity

4.3 enabling the storage of energy when it is in abundance (such as windy and sunny periods), for use later when it is scarce,

4.4 smoothing wholesale electricity prices, with a likely average effect of downwards pressure on wholesale prices, compared to a scenario without the asset,

5 note that developing pumped hydro at Lake Onslow comes with some significant environmental, cultural and social trade-offs,

6 note that investigations to date have not identified an alternative renewable dry year solution that is large enough to solve the problem to the same extent as Lake Onslow, and that comes without significant challenges, costs and risks,

7 agree to continue feasibility assessments into pumped hydro at Lake Onslow as a potential solution to the dry year problem, including environmental and geotechnical investigations, engineering concept design and options for market integration,

8 agree to continue feasibility work on other hydro options, as comparisons to pumped hydro at Lake Onslow,

9 agree to continue feasibility work into the potential of biomass, hydrogen, geothermal and demand response as partial or portfolio solutions to the dry year problem,

10 direct the Minister of Energy and Resources to report back to Cabinet in December 2022, with a feasibility assessment and an Indicative Business Case on pumped hydro at Lake Onslow, and other renewable electricity storage options.

Hon Dr Megan Woods

Minister of Energy and Resources

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Appendix Two: Schedule of deliverables before December report-back

1. The Minister of Energy and Resources is scheduled to report back to Cabinet in December 2022. That report back will include an Indicative Business Case to support Cabinet's decision on which option, if any, to progress to Phase 2: detailed design and a Detailed Business Case.

2. The Indicative Business Case, to be tabled in December 2022, will include information from all four workstreams in the NZ Battery Project:

Workstream 1: Pumped hydro at Lake Onslow

- a further-developed geotechnical and engineering feasibility assessment,
- options on feasible dam size, dam type, generation/pumping capacity,
- capital cost and timing estimates, with a confidence proportionate to this stage of the feasibility assessment,
- constructability assessment,
- carbon emissions from both construction and operation,
- an assessment of ongoing operating costs of running the scheme,
- indicative assessment of environmental, cultural and social values loss, including possible mitigations,
- analysis on consenting pathways, and
- analysis on power system integration and transmission requirements.

Workstream 2: Other options to expand hydro storage

- the results of a nationwide scan for potential locations for large-scale pumped hydro schemes,

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Workstream 3: Other technologies for energy storage

- a high-level summary of a broad range of alternate technologies for solving the dry year problem,
- an outline of five more prospective alternative technologies, including a more detailed discussion of the three that appear most prospective for solving the dry year problem,
- indicative capacity and key constraints, including logistical limitations of those technologies,
- high-level environmental, cultural and social assessment,
- early estimates on capital and operating costs, and
- next steps for analysis if Ministers want to pursue any of those options.

Workstream 4: Market integration and economic analysis

- economic benefits analysis, including indicative NPV calculations of the above NZ Battery options,
- an outline of possible operating models and operational governance structures including ownership, for any of the NZ Battery options, and
- a revenue model for pumped hydro at Lake Onslow.