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In Confidence

Office of the Minister of Energy and Resources

Cabinet Economic Development Committee

NZ Battery Project – proposal to advance two options to a detailed business case

Proposal

1 This paper provides:

1.1 Cabinet with more information on the merits, risks and trade-offs of a Portfolio option as a possible solution to the dry year problem. This includes a discussion of potential procurement and delivery options.

1.2 An update on:

1.2.1 the potential Upper Moawhango pumped hydro scheme.

1.2.2 our developing understanding of the broader strategic case for an investment in a solution to the dry year problem which includes a discussion on the NZ Battery Project's updated understanding of the counterfactual to the various proposed solutions and connections with the rest of the transition work programme.

1.3 An overview of further work required in the detailed business case (DBC) to arrive at a preferred solution to the dry year problem.

2 I seek Cabinet agreement to advance the Portfolio option to the DBC stage of the NZ Battery Project alongside the Lake Onslow Option.

Relation to government priorities

3 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

4 In February 2023, Cabinet invited me to report back to the Cabinet Economic Development Committee in July 2023 with more information on the merits, risks and trade-offs of the Portfolio option and the potential Upper Moawhango pumped hydro scheme [CAB-23-MIN-0021 refers].

5 The NZ Battery Project has completed further investigations into the three technologies that comprise the Portfolio option. This work has concluded that a large scale, Crown-owned interruptible hydrogen electrolysis option is not a viable component of a portfolio solution to the dry year problem mainly because the concept

relies on a suitable market for green ammonia which does not currently exist at scale and the development prospect and timing of it remains uncertain.

6 However, the remaining portfolio technologies, biomass and geothermal, remain viable options with some uncertainties and risks remaining that can only be resolved through further work.

7 Work since February has also confirmed that viable procurement and operating models exist for the option.

8 Moreover, modelling indicates that the reconfigured option may perform better under multi-criteria analysis conducted as part of the detailed business case (DBC) for the NZ Battery Project.

9 I therefore seek Cabinet agreement to advance the Portfolio option to the DBC stage of the NZ Battery Project alongside the Lake Onslow option. The aim of the next stage will be to identify a preferred option, which will involve seeking to further narrow the uncertainties and risks around the options; and to robustly compare them on a more equal footing.

10 Furthermore, I recommend that the Upper Moawhango pumped hydro option should be excluded from further analysis in the DBC because of the challenges posed by the option. In particular, there is a lack of iwi consensus around progressing the option and the New Zealand Defence Force has raised significant concerns about the impact on our military training capacity.

11 It is important that the two remaining options (i.e. Lake Onslow and the Portfolio options) are compared to a base case in the DBC that reflects what is most likely to happen in the electricity market without an NZ Battery investment. The NZ Battery Project will therefore compare investment options against a base case that reflects our best understanding of what a future would look like without a renewable dry year solution. This would likely include ongoing limited use of fossil fuels.

12 Finally, I seek Cabinet's agreement for the project to advance to the DBC. Initial work will focus on narrowing the uncertainties across all options to get them to a more equal footing for economic assessment, in order to get to a preferred option.

Background

13 The NZ Battery Project is investigating large-scale, long-term renewable energy storage options that could address New Zealand's 'dry year problem'. The first stage of this work has been completed resulting in an Indicative Business Case (IBC) which was reviewed by the Treasury's Gateway Review Panel in October 2022.

14 The IBC considered two main options:

14.1 A pumped hydro scheme at Lake Onslow.

14.2 A Portfolio option which includes the following components:

- new geothermal plant operated flexibly

- combustion of processed woody biomass
- interruptible hydrogen electrolysis and storage as green ammonia.

15 The Portfolio option showed promise in the IBC; it outperformed the Lake Onslow option in a multi-criteria analysis (MCA) used to identify a preferred Battery option although at a slightly higher financial cost. It was noted that significant uncertainties remain around the deliverability and technical and economic feasibility of each of the elements of the Portfolio option that would need further investigation.

16 In February 2023 Cabinet agreed to progress the project to the next phase of work:

16.1 Phase 2a on the option of a pumped hydro scheme at Lake Onslow which would include further technical design and development and policy work. The purpose of the next phase of the project will be to prepare detailed designs and undertake policy work to further inform the potential operating models of such a scheme and its impact on the market.

16.2 Further work on a Portfolio of other technologies option.

16.3 Subject to iwi engagement, further preliminary investigations into a potential North Island pumped hydro location at Upper Moawhango.

17 I was invited to report back to the Cabinet Economic Development Committee (DEV) in July 2023 with more information on the merits, risks and trade-offs of the Portfolio option and the potential Upper Moawhango pumped hydro scheme.

18 Subsequently, officials have provided me with further advice on the feasibility of the Portfolio option as well as potential Portfolio procurement and delivery options; and on the Upper Moawhango option.

19 This paper recommends advancing the Portfolio option to the DBC stage of the NZ Battery Project alongside the Lake Onslow option.

20 This paper also provides an update on the strategic case for a solution to the dry year problem and officials' evolving understanding of the nature of the problem, the appropriate base case against which to compare the options, and connections with the rest of the transition work programme.

Technical feasibility of the Portfolio option as a potential dry year solution

21 The Ministry of Business, Innovation and Employment (MBIE) commissioned WSP to conduct a study into the feasibility of a Portfolio option as a potential solution to the dry year problem. The resulting report, and more specifically the concept designs for the three portfolio technologies, was used as a key input into the description and assessment of this option in the IBC.

22 Following the presentation of the IBC in February 2023, officials have conducted further analysis of the Portfolio option. This involved a more detailed analysis of the WSP report, economic modelling and discussions with stakeholders and agencies.

23 This section of the Cabinet paper, which is divided into three subsections covering each of the individual Portfolio technologies, summarises the key findings of this investigation.

New geothermal plant operated flexibly

Summary of geothermal solution

24 Based on the WSP report, a geothermal component of the Portfolio option would involve operating geothermal electricity generation in a novel flexible manner[1] by running it at 25 per cent capacity during normal years and running it at full capacity in dry years producing an additional 0.6 TWh of energy over a three-month period.

25 There are technical reasons for running plant continuously in a low mode rather than shutting it down altogether. Most geothermal systems operate on a continuous basis for economic and technical reasons. Shutting down or turning down the system may cause issues such as: degradation of the well, accumulation of potentially hazardous gases around surface facilities, and difficulties starting flow again.

26 To minimise CO_2 emissions associated with the operation of geothermal sites, WSP's concept design proposes to use gas reinjection technology that would extract and reinject CO_2 back into the reservoir.

Merits of geothermal generation

27 A key advantage of geothermal is that it is inherently stored and renewable and does not need to be "recharged" like the other proposed Portfolio technology options. It can be reliably called on to provide energy during a dry year event and can do so continuously.

28 Other merits of a geothermal battery solution include:

28.1 **It allows for staged development** - The base case assumes multiple geothermal sites and power stations. Having more than one site and associated power station allows for a staged development, with expenditure committed over time.

28.2 **North Island location close to demand centres and transmission** - Known geothermal fields are (mainly) in the Taupo Volcanic Zone, therefore any development will be close to existing transmission infrastructure and close to upper North Island demand centres.

Potential benefits for Māori

29 Land overlying many of our geothermal resources belongs to Māori trusts and Māori might benefit either as active partners or in a more passive way from a geothermal scheme.

30 Māori have taken a lead role in several geothermal developments. The Tuaropaki Trust took the lead and was initially the sole owner of the Mokai power scheme.

[1] Normally geothermal runs at full capacity. This solution would allow for flexibility and allow it to run at lower capacity settings.

Mercury operates five geothermal stations in the central North Island, two of which, Rotokawa and Nga Awa Purua, are joint venture partnerships with Tauhara North No.2 Trust (representing about 800 owners affiliated to Ngati Tahu).

31 Engagement with Māori is critical to the success of the NZ Battery Project. This option could create opportunities for iwi/Māori; but may also have impacts that would need to be understood through engagement. The project will seek to better understand these opportunities and impacts through the next phase of work.

CO_2 reinjection challenges, risks, and mitigations

32 Some concerns remain around the long-term operation of the wellfield in a schedulable manner and the ability to mitigate emission impacts through reinjection of CO_2 into geothermal reservoirs.

33 A staged development approach would allow experience to be gained and the development of techniques/technologies to operate geothermal plant in a schedulable manner which may help avoid undue subsurface issues and manage effects.

34 A complicating factor is that every geothermal site is different which precludes a one size fits all approach/solution to running a geothermal plant in a schedulable way and to CO_2 reinjection. It will not be possible to fully understand potential subsurface issues before specific field/locations are identified and drilled. Any issues arising may well be unique to the specific site requiring bespoke technical solutions. This will not be able to be resolved until post-DBC work, should the Portfolio option incorporating flexible geothermal be identified as the preferred option.

35 However, it is important to note that both Mercury and Contact have invested in reinjection technology trials, with Mercury successfully reinjecting CO_2 back to the subsurface at Ngatamariki Power Station in the Waikato region. Contact Energy is in the process of installing equipment at Te Huka Power Station in Taupō, to trial CO_2 reinjection.

Electricity market challenges and risks

36 A proposed geothermal solution would require the development of costly infrastructure and plant. Operating costs are very low – mostly associated with carbon costs which would be largely mitigated through reinjection – and do not vary much between running the plant at 25 per cent or at full output. There is therefore an economic incentive to run the plant at full capacity all the time.

37 Using geothermal in a flexible manner thus comes with potential energy market consequences that need to be managed. To avoid interfering with investment incentives in the electricity market, market participants would need certainty about how a geothermal battery would operate. How this could be managed is discussed under the *Portfolio procurement and delivery options* heading.

Geothermal remains a viable Portfolio option

38 Based on the analyses set out above, I consider that geothermal plant operated flexibly may provide a viable component of a Portfolio battery solution and warrants further consideration.

Combustion of processed woody biomass

Summary of processed woody biomass

39 Combustion of processed biomass is a proven technology and a form of thermal power generation in which sustainably produced biomass from plantation forestry would be used to fire generation plants rather than fossil fuels such as coal or fossil gas.

40 The WSP concept design envisages the building of a single power plant which would have a generation capacity of approximately 500 MW, providing an additional (dry year) generation capacity of 1 TWh over three months.

41 Under WSP's concept design, the plant would be fired using processed (chipped) logs which, to reduce emissions associated with the transport of these logs, would be sourced within a 70km radius of the facility. Alternatively, biomass with a higher energy content in the form of heat-treated (torrefied) biomass could be used to power the generation plant.

42 The choice of fuel-type would be dependent on considerations such as: biomass durability, cost and the potential use of torrefied pellets in existing generation plants.

Key merits of a woody biomass solution

43 A biomass solution offers the advantage of being able to be scaled up from providing 1 TWh to 4 TWh of capacity. This could be achieved by replicating the system with separate generation plants and biomass supply chains across New Zealand. Several locations with smaller sustainably managed exotic forest could support this.

44 There is also potential to re-use/re-purpose existing generation plant if a decision is taken to use torrefied biomass as the energy source.

45 Recently, Genesis has successfully completed a burn trial of torrefied biomass pellets at Huntly Power Station, to prove the technical viability of operating a Rankine unit solely on biomass. With some minor adaptation, the existing plant can utilise (torrefied) biomass.

Key challenge: the ability of the biomass solution to cover concurrent dry years

46 Some questions remain about the ability of the biomass solution to cover concurrent dry years due to potential biomass supply constraints and to relatively slow stockpile replenishment rates.

47 To put this in context, some 560,000 tonnes of logs would be required for WSP's proposed biomass solution. This equates to approximately 4 per cent of the total annual exotic log export quantity of 14,000,000 tonnes (or 1.5 per cent of the total annual New Zealand exotic log harvest of approximately 36,000,000 tonnes[2].

48 Additional feedstock (logs) could be found on the local spot market, however this may come at a significant financial cost because of rapid increase in demand.

[2] The concept design assumes that the biomass required for this solution would comprise of lower grade logs that would otherwise be exported.

49 Ministry for Primary Industries' advice states that we can expect to see a 2025 peak in harvested logs followed by a period of decrease which will bottom out around 2033. Harvest levels are not expected to return to current levels until the mid-2030s. This would likely have an impact in terms of log availability and the associated price point.

50 The Forestry and Wood Processing Industry Transformation Plan acknowledges that biofuels provide a pathway for transitioning away from fossil fuels as the most immediate and available means to reduce emissions in some of our most hard-to-abate sectors, such as transport and process heat (e.g., milk processing).

51 It is unclear how much biomass those industrial customers will demand, and what the impact will be on the forestry industry. Using substantial volumes of biomass for electricity generation may present an opportunity cost for transitioning process heat. This will be further investigated as part of the Energy Strategy.

Woody biomass may be considered a viable component of a Portfolio solution

52 Notwithstanding the remaining challenges, I consider that woody biomass remains a viable component of a portfolio battery solution that warrants further consideration.

Interruptible hydrogen electrolysis and storage as green ammonia

Summary of Interruptible hydrogen electrolysis

53 This technology would, under WSP's concept design, involve the building of a large scale, 350 MW electrolyser plant to produce hydrogen which would then be converted into ammonia at a green ammonia synthesis plant and collected in bulk storage tanks and exported at a rate of 22,000 m3 per month.

54 In a dry year, the green ammonia stored on site would be cracked back to hydrogen and combusted for electricity generation through a 100 per cent hydrogen-fuelled 150 MW combined cycle gas turbine (CCGT).

55 These combined operations would likely require an energy hub at a port with access to a large fresh water source.

56 Interruptible hydrogen electrolysis would contribute to a dry year solution in the following manner:

56.1 Electricity load demand response, via switching off the hydrogen production plant in dry years and halting the associated green ammonia production and exports. The demand response over a three-month dry period would be 0.50TWh.

56.2 Converting (cracking) stored green ammonia back to hydrogen for dry year hydrogen-fuelled electricity generation. This would generate 0.29 TWh of electricity over a three-month dry period.

Key merits of a hydrogen solution

57 Green hydrogen constitutes a potential long-term dry year solution with minimal carbon emissions. Unlike biomass and geothermal, it has a demand response

component which could utilise ‘spilled’ renewable energy (i.e. wind and solar energy overproduction).

58 Short response times for both the demand response and generation components of the hydrogen solution could help manage shorter term peak electricity demand in the market.

Challenge: the concept relies on a suitable market for renewable ammonia that does not yet exist

59 The concept envisages that the plant would need to sell its surplus green ammonia during times of electricity abundance. During dry years, those supply contracts would need to be interrupted as the electrolysis plant would be turned off/down. When this interruption might occur, and its duration, cannot be foreseen in advance. This makes it a different proposition from the type of flexibility hydrogen production is commonly associated with, which relates to operating the plant around short-term (hours/days) and/or predictable seasonal variation in wind and solar generation.

60 Green ammonia markets are in their infancy and do not yet exist in New Zealand or internationally at a scale or level of liquidity that would provide confidence that interrupting ammonia production and sales is a mechanism that could provide a reliable, long-term solution to a dry year risk.

61 This would be most assured in a highly liquid market with many buyers and sellers allowing sales without making long term supply commitments and withdrawal of supply at short notice. Whether or not the market will reach that kind of maturity within the timeframes set for the NZ Battery Project dry year solution is uncertain.

62 It is difficult to predict how any future international green ammonia market will develop. It is also uncertain whether New Zealand would be competitive in producing green ammonia, what the end-use and value of that product would be, and what the commercial implications of interrupting production and sales for prolonged periods would be.

Health and safety risks

63 The proposed ammonia storage facility containing four 50,000m^3 tanks would be larger than any that currently exists in the world. While there is considerable familiarity with handling ammonia, storage at such a scale comes with health and safety risks. Ammonia is a highly toxic substance. Breach of storage vessels could result in the release of ammonia into the atmosphere and the contamination of land and waterways which could lead to harm to health and the environment.

64 This risk may be managed, by good site selection, proper design and response plans, but residual risks remain high. Regardless of whether these risks can be mitigated, public tolerance for such a large-scale storage facility needs to be considered.

Risk: the concept relies on emerging technology which is unproven at the proposed scale

65 The hydrogen concept relies on technology that has not reached maturity and is yet to be deployed at scale. This relative lack of maturity applies to multiple components of

the system including: the hydrogen electrolyser, ammonia synthesis process plant that can tolerate variable operation, and the ammonia cracking plant.

66 In addition, questions remain whether equipment could be delivered on time given the likely international demand for hydrogen-related technology in future.

Conclusion

67 Based on these risks and challenges, I consider interruptible hydrogen electrolysis is unlikely to be a viable component of a Crown-owned and operated portfolio solution to the dry year problem. I recommend that it is not taken forward for consideration under that delivery model as part of the DBC, but note that hydrogen could still play a role in a scenario in which the government would tender for reserve energy services if a party proposes a robust service based on it.

68 Hydrogen does have a potentially important role to play more broadly in the energy transition. Its production could offer some benefits for covering short term variability in energy supply from renewable sources (e.g., wind and solar). It also has a possible role to play in decarbonising emissions-intensive activities in New Zealand such as heavy transport and hard to abate industries (e.g., fertiliser and steel production). Feedback on consultation on the interim Hydrogen Roadmap that is currently underway will inform our understanding of the possible range of Portfolio procurement and delivery options

There is likely a feasible way for the Crown to deliver a multi-technology approach

69 In conjunction with the technical feasibility assessment outlined above, officials have investigated the following three delivery models for the Portfolio option which have been the basis for further work:

69.1 Option 1. The Crown owns reserve energy assets - The Crown would, after market testing, specify, construct where necessary, and own dry year reserve generation assets employing the technologies used as the basis of the Portfolio option in the IBC for initial modelling purposes.

69.2 Option 2. The Crown procures reserve energy services - The Crown would procure by tender or auction a series of one-to-one contracts for dry year reserve energy services to meet an identified shortfall. This would avoid asset ownership. The procurement approach would be agnostic as to the technologies providers might propose, beyond a requirement for proposals based on renewable energy sources and potential scale and deliverability criteria. At this stage, we expect that these technologies could include biomass, geothermal and hydrogen, along with pumped hydro and demand response.

69.3 Option 3. Development of a reserve energy/capacity market - Under this option, a government agent (e.g., the regulator), would set the amount of reserve capacity required and form this into standardised tradable certificates or tickets. The tradable nature of these certificates in an organised market distinguishes option 3 from option 2. Market participants (e.g., retailers) could then be obligated by regulation to procure sufficient tickets to cover their forecast electricity sales during winter

70 Based on an initial assessment of the three delivery models, officials conclude that options 1 and 2 appear feasible.

71 The identified risks and complexities associated with introducing a capacity mechanism (option 3) into New Zealand's market would be very complex and potentially costly. However, officials advise me that more investigatory work is required to ascertain its feasibility in the dry-year context and to confidently rule this delivery option in or out.

72 MBIE's Electricity Market Measures (EMM) Issues Paper, which will go out for consultation soon, considers whether capacity mechanisms (or other forms of incentives) are required to support the development of new renewable or dispatchable capacity during transition. Submissions on the EMM Issues Paper will help inform NZ Battery Project analysis and further market engagement on this option can proceed through the DBC process if it appears viable/promising.

Potential operating models for the Portfolio option

A key challenge is how to operate dry year assets and not discourage wider market investment in new generation

73 A principal concern for the operation of dry year reserve assets is the potential disincentive on wider investment in generation if the assets are not quarantined for dry year use only and able to always make offers into the market. New investors expect to recoup their investment at least in part from periodic spot market price spikes. Their concern arises if the offer price from a dry-year asset is too low or if investors in new generation fear a future government or regulator may "change the rules" and operate outside dry year risk conditions to lower electricity prices.

74 The IBC identified that there are a range of operating models for Lake Onslow that would involve a greater or lesser degree of private sector involvement. This applies equally for Portfolio delivery options 1 and 2 described above.

75 One option is security of supply operation mode (SOS) where energy is reserved/quarantined for dry-year risk use only with offers into the spot market triggered by deployment rules around when a dry year event is called. This approach would work best for technologies like geothermal which, once built, have a low marginal operating cost. However, these cost economics make running geothermal as baseload very attractive. Under this model, then, capacity would need to be clearly ring fenced to operate only in a dry year.

76 An alternative would be to regulate for flexible operation of an asset in a non-dry year, but with adequate storage required. The regulator could cut up (slice) and auction interests in asset operation out to multiple market participants, who could then decide when and at what price to offer electricity into the market. This approach would work for technologies that have higher operating costs and a large amount of storage such as pumped hydro and woody biomass.

77 Flexible operation is likely the most economically attractive option for private investment because the plant could be earning revenue by providing firming capacity during more normal market conditions, while always retaining the storage to deliver in a dry year. In turn, this would reduce the level of Crown support required.

78 These options would require further exploration through the DBC which will involve industry engagement.

Feasibility assessment of the three Portfolio option delivery models

79 A clear advantage shared by all portfolio delivery models over the Lake Onslow solution is that they would offer a greater ability to vary the scale and timing of commitments and costs to the Crown. Moreover, some of the portfolio assets would be based in the North Island, close to demand centres, which is advantageous from a transmission perspective. On the other hand, there would be greater contractual, administrative, and regulatory complexity compared to the Lake Onslow option which would involve just one Crown-owned asset.

Too early to determine preferred model: more work is required through the DBC

80 At this stage, the three portfolio delivery models described above all remain potentially feasible/viable and consequently warrant further DBC consideration. A key part of this work would involve market engagement to test its willingness and ability to provide a portfolio solution.

Update on Portfolio option modelling results

A portfolio solution without hydrogen remains viable

81 Further modelling results indicate that there are few electricity system benefits from hydrogen as a dry year solution. This reflects that, while it is assumed to operate in a flexible way outside of peak times, the additional demand, and hence new generation investment required, would add costs to the system.

82 Modelling suggests that the 0.79 TWh contribution previously assumed from interruptible hydrogen could be offset by overbuild of wind and solar and increased use of peakers (i.e. generation plant that services short term peak demand).

83 Consequently, a smaller Portfolio option, reduced in scale from 2.4 TWh to 1.6 TWh over three months has been modelled. This utilises the same scale of biomass and flexible geothermal as in the IBC but excludes the hydrogen component.

84 Work since February indicates that a portfolio solution that excludes hydrogen may perform better through an MCA performed as part of the DBC given some risks are avoided.

Conclusion: The Portfolio option should be advanced to DBC

85 Based on the analyses set out in the preceding three sections, further analysis of the Portfolio option through the DBC is justified. The option remains technically viable, feasible procurement and operating models are likely to exist, and updated modelling results indicate that the option could improve its performance through an MCA.

Update on pumped hydro scheme at Upper Moawhango

86 In early 2021 the NZ Battery Project commissioned NIWA to run a scan over the country's waterways to identify potential sites for a pumped hydro scheme, with the potential for storage of at least 1TWh of energy. Upper Moawhango in the central North Island was identified as potentially having the necessary features.

87 The Upper Moawhango area is in use by the New Zealand Defence Force (NZDF) as part of the Waiouru Military Training Area. Other portions of the area are either privately owned or owned by the Department of Conservation. The NZDF has routinely used the area for live fire training, and it contains unexploded ordnance.

88 Relative to the Lake Onslow option, less is known about the suitability of the Upper Moawhango for pumped hydro (including how pumped hydro would affect the existing Tongariro hydro generation scheme).

89 As part of further work to ascertain whether the Upper Moawhango option should be considered in the DBC for the NZ Battery Project, officials have sought to understand:

89.1 iwi perspectives

89.2 the implications for the NZDF; and

89.3 whether the presence of unexploded ordnance from defence training can be mitigated.

Outcome of engagement with local iwi and NZDF on a potential pumped hydro scheme at Upper Moawhango

90 There is no consensus among affected iwi whether further work on the option should be conducted. Confidential information entrusted to the Government has expressed fundamental opposition to the NZ Battery Project. Confidential position reflects continuing distress arising from earlier construction of the Tongariro Power Scheme, the effect this scheme had on the area's waterways, and the potential further effects on waterways that a pumped hydro scheme could have. Confidential information entrusted to the Government

91 Finally, Confidential information, has not expressed a position to officials.

92 The area of the Upper Moawhango within the Waiouru Military Training area remains in regular use by the NZDF, and the armed forces of partner nations. The area is specifically reserved for live firing training, including training involving heavy weapons such as artillery and air-delivered weapons. In total, the Waiouru Military Training Area comprises 63,000 hectares.

3 Confidential information entrusted to the Government

93 If a pumped hydro scheme were established in the Upper Moawhango, military training in the affected area – and live firing in particular – would need to cease to protect both lives and infrastructure. The NZDF advises that the top third of the Waiouru training area would become unavailable for defence use.

94 Since live firing training is essential to maintain the military readiness of the NZDF, an alternative training location would need to be found. This is likely to be challenging since there are unlikely to be any areas where stakeholders and iwi are comfortable with military activities that include live firing and air-delivered weapons.

95 Finally, there is the risk of unexploded ordnance in the area. NZDF considers that a clearance operation would reduce the risk posed by unexploded ordnance but that a residual risk of an uncontrolled and unexpected explosion would remain.

Conclusion: No further work should be done on the Upper Moawhango option through the NZ Battery Project

96 I consider these issues to be considerable impediments to advancing further work on the Upper Moawhango option. It is possible that the option could deliver energy system benefits, but this is uncertain. For these reasons, this option does not at this stage present a better option than the better understood Lake Onslow and Portfolio opportunities. Strong opposition by some local iwi is a matter that particularly concerns me.

97 For these reasons, I recommend that no further work be done on the Upper Moawhango option through the NZ Battery Project.

Developing understanding of the dry year problem

98 A 'dry year' is an extended period of weeks/months when reduced hydro inflows put pressure on the electricity system which results in higher use of thermal plant. New Zealand needs approximately 3 to 5 TWh[4] of energy storage or equivalent supply-side and/or demand-side flexibility to achieve reliable electricity supply in a dry year.

99 The nature of our security of supply challenges will change in the future. A sustained increase in renewable generation is necessary to meet demand from rapid electrification of the economy, and to replace the approximately 7 TWh per annum of fossil fuel generation. This is expected to primarily come from private investment in wind, solar and geothermal generation plant. Wind and solar generation are intermittent in nature and are affected by prolonged periods of calm or cloudy weather conditions. Our dry year problem may thus increasingly transform into a low rainfall, wind and solar problem.

100 The costs of a shortage will vary greatly depending on the specific nature of an event. As an example, a dry year conservation campaign in 1992 was estimated to have reduced total GDP for the June quarter of that year by approximately 0.6 per cent. If this impact was applied to 2023, this would equate to $575 million of lost GDP. However, fossil fuels were available to minimise the impact of the 1992 dry year, which was limited to a call for voluntary savings.

[4] This range represents the electricity shortfall over a period of several months during a dry year (i.e. when reduced hydro inflows put pressure on the electricity system) based on historical data from 1930 to the present.

101 Generation outages and development delays in South Africa have caused prolonged energy shortages, necessitating mandatory rolling outages affecting households and businesses. The Reserve Bank of South Africa expects this will reduce GDP by 2 per cent in 2023. An equivalent impact here would equate to NZ$7.65 billion. While the causes of South Africa's issues are deep-seated, severe and are unlikely to occur in New Zealand, rolling outages are a response we would potentially need in a dry year if there is inadequate back-up.

102 Through the DBC, officials will continue analysis to understand the nature of the dry year problem as it evolves, to inform the assessment and design of the options being considered, and the strategic case for investment.

103 Within this context, it is important to note that the success of the project will be determined not just by its ability to achieve improved outcomes for energy security but also by its ability to ensure energy affordability, and the sustainability of the energy system (i.e., the three dimensions of the so-called 'energy trilemma').

There is a need to compare against a robust base case in the DBC

104 In the NZ Battery IBC, the different investment options were compared against a counterfactual that assumed a 100% renewable electricity scenario, involving renewable overbuild supported by 'green peaking' technology[5]. This was appropriate given the context of the Project's objective to provide a pathway to net-zero carbon emissions by 2050, and the Government's stated ambition for reaching 100% renewable electricity generation by 2030.

105 A 'do nothing' scenario, where fossil fuels were not transitioned out of the electricity system, was not considered appropriate for use as a counterfactual, as it would have conflated the costs and benefits of a NZ Battery investment with the costs and benefits of achieving 100 per cent renewables – an issue beyond the project's scope. By using a 100 per cent renewable counterfactual, the ability of the different NZ Battery options to support a 100 per cent renewable system was able to be assessed on an equal footing.

106 Since the beginning of the NZ Battery Project, our understanding of what a future without an NZ Battery investment could look like has developed. This has been informed by both analysis in the IBC (e.g., development of the counterfactual) and through external analysis, including the Electricity Authority's Market Development Advisory Group (MDAG) and The Future Is Electric report commissioned by several participants from the electricity sector[6]. Further to this, MBIE's Electricity Market Measures team is actively considering what the challenges and potential responses to delivering the energy transition might be.

107 While there is uncertainty as to what may occur in the absence of an NZ Battery investment, there is a general consensus that the electricity market as currently designed is unlikely to support a transition to 100 per cent renewable electricity for the foreseeable future, and that there will be an ongoing role for fossil-fuelled generation, as peakers and as dry year reserve.

[5] Generation plant using renewable energy to service short term peak demand
[6] BCG – The Future Is Electric

A better understanding of what will happen in the absence of a NZ Battery is needed

108 In order to assess any potential NZ Battery investment through the DBC, it is critical to develop a detailed understanding of what is most likely to happen without an NZ Battery investment (i.e., the base case). This base case will act as the baseline comparator to assess the options against, particularly for the cost benefit analysis. Officials note this base case is not necessarily the same as a 'Do Nothing' scenario.

109 To develop a robust counterfactual for the DBC, it will be important to better understand a scenario that is highly renewable but may include some limited ongoing use of fossil fuels until these can be replaced by renewable alternatives. Officials consider that the "highly renewable" scenarios that have been modelled by various parties, including the Climate Change Commission, represent a viable potential pathway but that the assumption of unconstrained fossil gas availability has not been sufficiently tested.

110 The New Zealand gas industry is projected to decline in the coming years as users move to increasingly attractive low emission alternatives, The recent NZ Steel deal and announcements by Fonterra on plans to electrify key facilities show this transition is already underway. The Gas Transition Plan being developed by MBIE anticipates that there could be a staged exit of Methanex before 2050 due to increasing uncertainty around ongoing fossil gas availability. Methanex has a key role in underpinning gas exploration and development in New Zealand, and in providing gas flexibility in dry years by allowing gas to be diverted to electricity generation. Reducing demand and the closure of Methanex would make delivery of a reliable gas supply increasingly challenging.

111 Since the delivery of the IBC, officials have modelled an unconstrained fossil gas scenario. This modelling suggests that, depending on wind, solar and hydro conditions, gas use for electricity generation could be virtually nil in some years but in others could exceed the current working capacity of the Ahuroa Gas Storage Facility. Fuel and carbon costs could total around $400 million in a dry year. Most use would be concentrated within a few days or weeks.

112 Facilitating such variation in demand for gas could be challenging within a context of a gas industry in long-term decline. It would require ongoing development and maintenance of gas fields, development of new storage with sufficient withdrawal capacity, and continued maintenance and use of some portions of the gas pipeline network.

113 If imported Liquefied Natural Gas became necessary to meet demand, the necessary developments could cost around $1 billion and would expose New Zealand to international gas prices. Ensuring a long-term gas supply for electricity generation will require significant upfront investments, and it may not be straight-forward for a smaller gas industry with no major users to finance those investments.

114 Overall, the analysis to date suggests that beyond 2035 the reliance on gas for dry year and peaking will become increasingly challenging but that its continued use for electricity (peaking) generation represents the most likely counterfactual scenario. Understanding the reality, cost and feasibility of that scenario requires further detailed consideration. It will be important to build our understanding of the impact that a NZ

Battery would have on the use of gas, the potential need for investments to sustain its use, and the ability to transition away from it.

115 There is significant cross-over between any counterfactual we assume, and work being undertaken within MBIE's Energy Strategy, Gas Transition Plan, and the Electricity Market Measures projects. By using a counterfactual that better reflects the future without an NZ Battery investment, we would maximise our ability to integrate with and support that wider work programme. MBIE officials from the NZ Battery Project and from those workstreams will be working together to ensure this.

Advancing to the detailed business case

116 Getting to a preferred option is the priority for the next stage of the Project. While the work completed on the Portfolio option over the last six months has addressed some of the information asymmetry which existed in the IBC, further work is needed to develop this option to the point where it can be fairly assessed alongside Lake Onslow. As indicated above, further work is also required on the strategic case for any investment and robust development of the base case.

117 The DBC process provides a robust framework for doing this and enabling us to identify a preferred option. I consider that advancing this work through the DBC process will also reduce the chance of any potential delay.

We need to adjust our spread of work and resources accordingly

118 As the DBC will cover both the Lake Onslow and Portfolio options, the NZ Battery Project team will divide its resources. This can be done within the existing funding envelope.

Next steps

119 Subject to Cabinet approval, officials will commence work towards the delivery of a DBC. This work will integrate with the broader energy transition work programme, including the Gas Transition Plan, Electricity Market Measures and Offshore Renewable Energy projects and Hydrogen Road Map, and the Energy Strategy targeted for delivery by end of 2024.

120 Following the completion of the economic case in the DBC, I expect officials to report to me on the preferred NZ Battery option in mid-2024. Following this, I willreport back to Cabinet on the preferred option. This option would then go forward to the development of detailed procurement, funding and financing and delivery arrangements. The completed DBC would proceed through assurance processes including a "Gateway" review by an independent panel of experts before reporting back to Cabinet.

Financial Implications

121 Funding of $100.008 million was provided for the project in 2020/21. MBIE tagged approximately $30 million for the initial feasibility study (Phase 1 which finished with the IBC). Approximately $64 million of the $69 million tagged for further work has been earmarked for the next phase of work on the Lake Onslow option. Up to

approximately $5 million was earmarked for further work on the Portfolio and Upper Moawhango Hydro options in advance of the current report back. Due to the recommendation to continue work on the Portfolio option, and further work on the base case, the Phase 2 budget will require reallocation across the various options.

122 As indicated in my February 2023 report to Cabinet, to advance the Lake Onslow option beyond the DBC, Commercial Information would be needed to undertake work sufficient to inform a final investment decision (FID). This estimate covers the work required to get our understanding of the project and its associated risks and benefits to a sufficient level to make an investment decision of this scale. This work includes all aspects of the project, including design, geotechnical work, regulatory design, commercial aspects, offsets, environmental work, and property acquisition.

123 There is scope to shift some of that expenditure to after a FID, with a potential schedule trade off. Not enough is known at this stage about the Portfolio option to provide an estimate on the funding required although it is presumed to be less than for Lake Onslow.

124 As indicated under the Next steps heading, I expect officials to report back to me on a preferred NZ Battery option in mid-2024 following the completion of the economic case in the DBC. This work will give a likely indication of the required funding to take any preferred NZ battery option through to FID.

Legislative Implications

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

Impact Analysis

Regulatory Impact Statement

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

Climate Implications of Policy Assessment

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

Population Implications

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

Cost-of-Living Implications

129 There are no cost-of-living implications of this report-back. During all stages, including the next (DBC) stage of the NZ Battery Project, consideration will continue to be given to funding options for any Crown investment and the extent to which each

option could reduce wholesale electricity prices and therefore potentially increase consumer energy affordability. Use of External Resources

130 The NZ Battery Project is a one-off and highly technical project that requires resources that are not required by MBIE for business-as-usual work. It therefore relies in part on expert technical advice which is required from an engineering, design, environmental and electricity sector impacts perspective. MBIE does not have these resources in-house and consequently they must be sourced externally. This means that a significant proportion of the funds allocated to the project (see paragraph 121) have so far been spent on external resources (e.g., for work on environmental reports, engineering work, contractor and consultancy fees and the like). To the extent possible, for example for policy work, the NZ Battery Project uses internal resources.

Human Rights

131 There are no human rights implications at this stage of the project.

Treaty analysis and iwi engagement

132 Any solution proposed through the NZ Battery Project will need to be developed with the principles of Te Tiriti o Waitangi at its core. Te Tiriti o Waitangi forms the basis for the Crown-Māori relationship, and for all obligations and responsibilities of Treaty partners. Māori have significant rights to and interests in freshwater and geothermal resources, which have been considered by the Courts and Waitangi Tribunal.[7]

133 Iwi/Māori perspectives will continue to be included throughout the next stages of the NZ Battery Project. Ongoing engagement will follow Te Arawhiti engagement guidelines with the level of engagement determined through advice from Te Arawhiti and by engaging directly with Treaty partners. The engagement approach will be based on the one followed for the IBC and will give consideration on how Iwi/Māori rights and interests are likely to be impacted by the Project[8]. For the Lake Onslow option, this has involved identifying the three rūnaka that hold mana whenua status in the Lake Onslow area. Since my last report to Cabinet, members of the Project team have met with representatives of the three rūnaka to discuss the findings of the environmental, heritage and cultural values assessments and to provide an update on proposed Phase 2 work. Key messages relayed to officials have included:

133.1 ongoing engagement needs to be conducted at the appropriate level (‘mana to mana’)

133.2 MBIE needs to plan for mana whenua input into the DBC

133.3 MBIE needs to ensure that engagement works for iwi.

134 The engagement approach for the Portfolio option will essentially be the same noting that this option is conceptual in nature and (therefore) not site specific. However, it is known that possible geothermal and biomass sites are likely to be in areas with significant Māori land ownership and/or interests. Accordingly, the NZ Battery

[7] Wai 2358 (inquiry into national freshwater and geothermal resources), WAI 1999 The Whanganui River Report.

[8] Pages 185 and 186 of the IBC provide an overview of the engagement approach followed for Lake Onslow.

Project Team will identify and develop an engagement approach with relevant affected iwi once/if specific sites have been identified.

135 The NZ Battery Project will work alongside Māori to ensure authentic and appropriate use of mātauranga Māori which is about a Māori way of being and engaging in the world, including using kawa (cultural practices) and tikanga (cultural principles) to critique, examine, analyse, and understand the world.

Consultation

136 The Treasury, Te Waihanga, Department of Conservation, New Zealand Defence Force, Te Arawhiti, Te Puni Kōkiri,the Ministry for the Environment, and the Ministry for Primary Industries were consulted on this paper. The Department of Prime Minister and Cabinet has been informed.

Communications

137 I will make a public announcement shortly after Cabinet's decisions.

Proactive Release

138 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 Cabinet considered the Indicative Business Case (IBC) for the NZ Battery Project in February 2023 and invited me to report back in July 2023 with more information on the merits, risks and trade-offs of the Portfolio option and the potential Upper Moawhango pumped hydro scheme [CAB-23-MIN-0021 refers];

2 **note** that the Portfolio option assessed through the IBC consisted of the following components:

2.1 geothermal plant operated flexibly

2.2 combustion of processed woody biomass

2.3 interruptible hydrogen electrolysis and storage as green ammonia.

3 **note** that officials have provided me with further advice on the technical feasibility of the Portfolio option as well as potential portfolio procurement and delivery options;

Technical feasibility of the Portfolio option

4 **note** that advice on the technical feasibility of this option is largely based on concept designs contained in a WSP feasibility assessment report that was used as a key input into the assessment of the Portfolio option in the IBC;

5 **note** that geothermal plant operated flexibly may provide a viable component of a portfolio battery solution noting that technical and environmental concerns remain especially around the long-term operation of the wellfield in a schedulable manner and the reinjection of CO_2 into geothermal reservoirs;

6 **note** that combustion of processed woody biomass remains a viable component of a portfolio solution noting that some concerns remain around its ability to cover concurrent dry years due to potential (biomass) supply constraints;

7 **note** that based on the following risks and uncertainties interruptible hydrogen electrolysis, as per WSP's concept design, is not considered a viable component of a Crown-owned and operated portfolio solution to the dry year problem:

7.1 the concept relies on a suitable green ammonia market that does not exist at scale either in New Zealand or internationally and its development prospects and timing are uncertain

7.2 the concept relies on emerging technologies which are unproven at the proposed scale and questions remain around whether equipment could be delivered on time

7.3 there are health and safety risks associated with this concept, and very large-scale ammonia storage, which may prove hard to resolve.

8 **note** that hydrogen could still play an important role in New Zealand in the future for covering short term variability in energy supply from renewable sources and to decarbonise hard to abate industries (such as steel production);

Portfolio procurement and delivery models

9 **note** that the potential portfolio delivery models outlined in the IBC comprised:

9.1 Option 1 – The Crown owns reserve energy (portfolio) assets

9.2 Option 2 – The Crown procures reserve energy services

9.3 Option 3 – Development of a reserve energy / capacity market.

10 **note** that while each portfolio delivery model has distinct advantages, disadvantages and uncertainties relating to procurement and operation, there are insufficient grounds to remove any from further consideration in the detailed business case (DBC) at this stage;

Updated economic modelling of the Portfolio option

11 **note** that modelling suggests a smaller Portfolio option without hydrogen can still provide an effective dry year solution;

Further DBC consideration of the Portfolio option is justified

12 **agree** that the Portfolio option should be taken through to the DBC for further analysis because it remains technically viable, procurement and operating models are

likely to exist, and updated modelling suggests that its performance through a multi-criteria analysis may improve;

Update on pumped hydro scheme at Upper Moawhango

13 **note** that there are issues with a pumped hydro scheme at Upper Moawhango relating to the following:

13.1 lack of iwi consensus on whether to proceed with further investigations

13.2 New Zealand Defence Force concerns around losing a substantial part of their Waiouru Military Training Area

13.3 the existence of unexploded ordnance in the area.

14 **agree** that the Upper Moawhango option should be excluded from further analysis based on these issues;

Developing understanding of the dry year problem

15 **note** that a large and sustained increase in renewable generation is necessary to meet demand from rapid electrification of the economy, and to replace the approximately 7 TWh per annum of fossil fuel generation;

16 **note** that the required increase in generation is expected to primarily come from private investment in wind, solar and geothermal generation plant;

17 **note** that wind and solar generation are intermittent in nature and are susceptible to prolonged periods of calm or cloudy weather conditions;

18 **note** that the dry year problem may thus increasingly transform into a low rainfall, wind and solar problem;

There is a need to reconsider the base case in the DBC

19 **note** that in the NZ Battery IBC the different investment options were compared against a counterfactual that assumed a 100% renewable electricity scenario;

20 **note** to support robust decision making around a potential NZ Battery investment through the DBC, it is critical to develop a detailed understanding of what is most likely to happen without an NZ Battery investment;

21 **note** that final investment decisions on the project should not be made until the options are compared to a counterfactual that reflects what would happen if a Battery investment is not made, and that this will be a focus for the project team to inform the case for a NZ Battery investment;

22 **note** that officials consider that continued use of gas for electricity generation represents the most likely base case scenario but understanding the reality and feasibility of that scenario requires further detailed consideration;

23 **note** that the base case will be developed in close coordination with MBIE officials working on the Energy Strategy, Gas Transition Plan, and the Electricity Market Measures projects;

Detailed business case to commence

24 **note** that the DBC provides the right framework to identify a preferred option and solidify our understanding of the strategic case for investment and the base case;

25 **agree** to advance the NZ Battery Project to a DBC;

26 **note** that initial work in the DBC will focus on narrowing the uncertainties across all options to get them to an equal footing for economic assessment;

Next steps

27 **note** that, subject to Cabinet agreement to recommendation 25:

27.1 officials will commence work towards a DBC and integrate this work with wider energy transition projects in support of the commitment to reduce greenhouse gas emissions, culminating in an Energy Strategy targeted for delivery by the end of 2024

27.2 following the completion of the economic case in the DBC, officials will report to the Minister of Energy and Resources in mid-2024, on a preferred NZ Battery option to go forward to the development of detailed procurement, funding and financing and delivery arrangements

27.3 following the officials' report, the Minister of Energy and Resources will report back to Cabinet on the preferred option

27.4 the preferred would then proceed through the remaining DBC stages

27.5 the completed DBC will proceed through assurance processes including a "Gateway" review by an independent panel of experts before reporting back to Cabinet.

Hon Dr Megan Woods

Minister of Energy and Resources