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NZ Battery's operational governance

Agenda item 8

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

We have done a case study of NZ's Reserve Energy Scheme

- Operational governance relates to the ownership, operations and revenue of a 'NZ Battery'. This relates to our workstream on the market interactions and implications
- During agenda item 8 we will give a primer on operational governance and some early thinking on ownership models.
- As part of that discussion, we will go through a case study into the Reserve Energy Scheme that operated in New Zealand between 2003 and 2011. The Reserve Energy Scheme involved setting aside generation so that it could provide additional energy during dry years
- We talked to Steve Batstone about his views and experience of the scheme on 1 June: that discussion supplemented our own research

As per the questions we present at the end, we welcome the TRG's:

- views on the Reserve Energy Scheme case study, and what we should take from it
- suggestions of other case studies we could learn from

NZ Reserve Energy Scheme

A case study

NZ Reserve Energy Scheme

- NZ had a Reserve Energy Scheme from 2003-2011

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[redacted]

NZ established a Reserve Energy Scheme in 2003

- Followed two dry years / conservation campaigns within three years
- Minister devised concept and Ministry of Economic Development (MBIE's precursor) set it up
- Legislated through Government Policy Statement
- Once established, Electricity Commission operated the scheme

The scheme was set up quickly and started quite simple

- Max 400 MW / 1200 GWh over 4 months (1 in 60 dry year) (avg annual demand of ~40,000 GWh)
- Tender for demand response and ring-fenced generation (low capital cost)
- Crown to invest in Whirinaki (155 MW) diesel power plant in Hawke's Bay
    - Offered at $200 / MWh price or lower if dry
- Costs recovered from spot (operating costs) + levy on wholesale purchasers (capital costs)

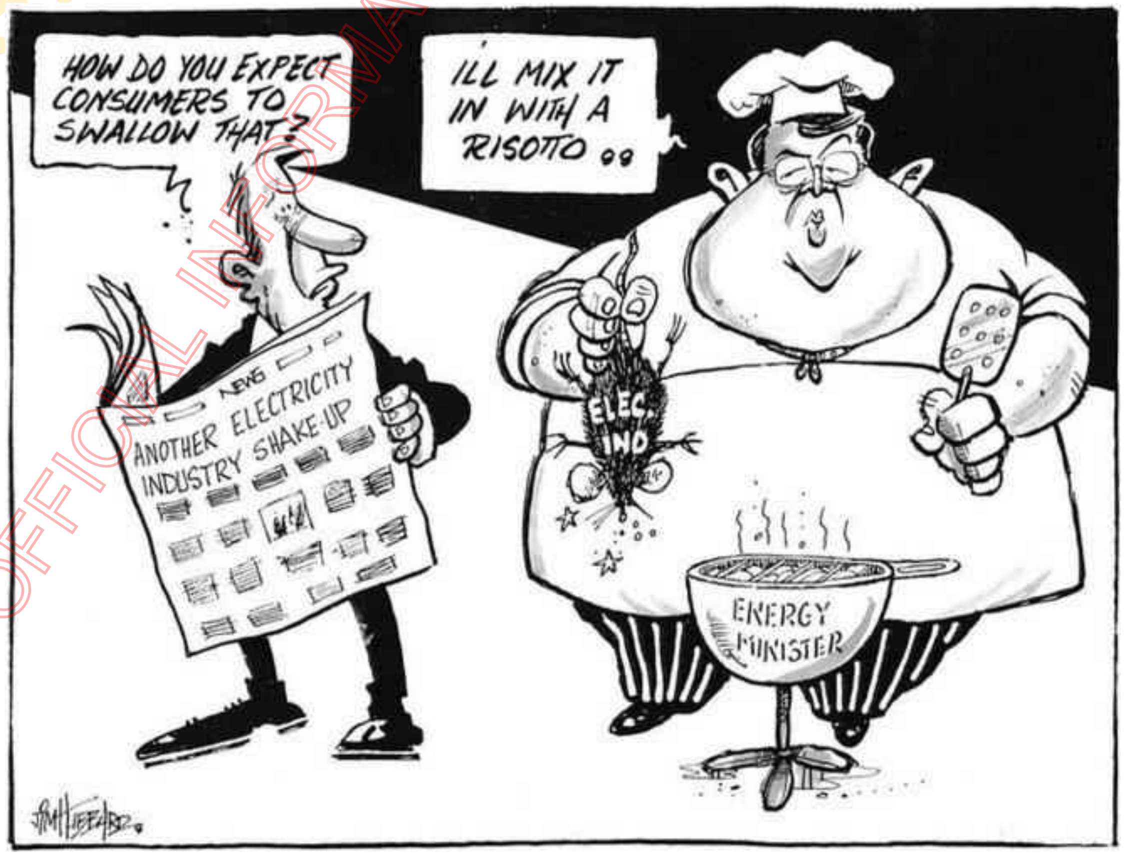
Further detail was added as the policy was implemented

- Higher of $200 / MWh or variable cost, or less in ‘min-zone’
- Enough procured to meet calculated security margin
  - Just Whirinaki
  - Regular reviews suggested no need for more
- Also used for other unexpected supply contingencies (plant/fuel/grid disruptions)
- Each contracted option to have its own offer and trigger
  - Whirinaki offer
    - $1000/ MWh standing offer
    - $200 / MWh or variable cost (ie, diesel fuel cost) if high prices in schedules
    - potentially less in min-zone
- Requirement for periodic review
- The Electricity Commission’s hydro risk calculations, monitoring and info provision improved in the background

But it unravelled during the 2008 dry year

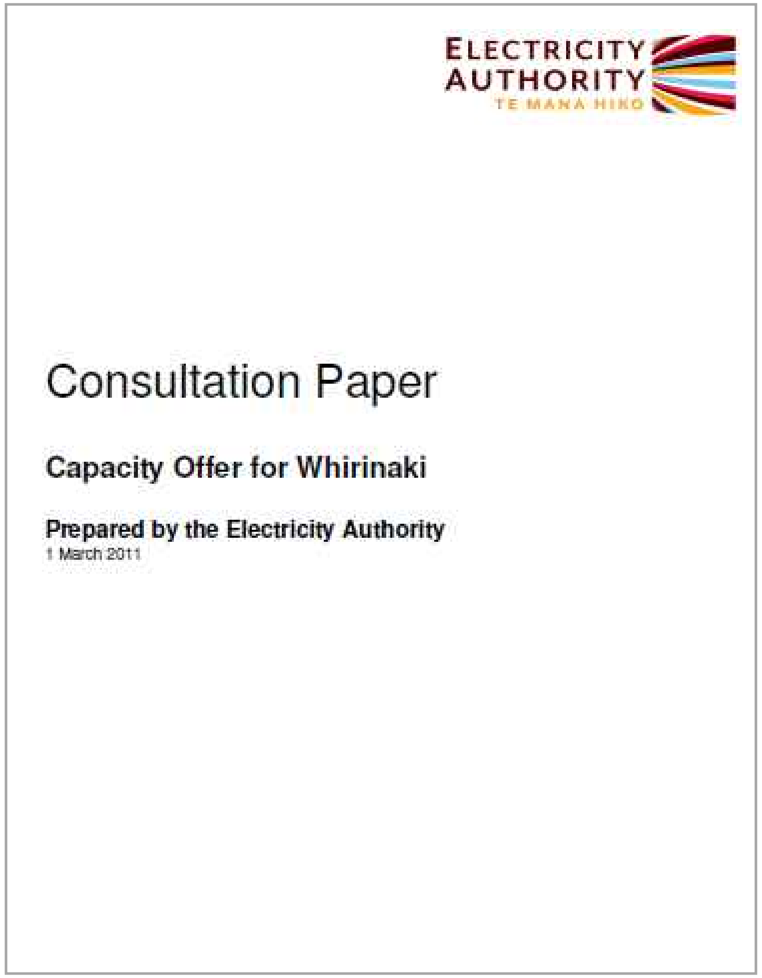
- First time used in min-zone/dry-year operation
  - Min-zone assumed all thermal operating, but it wasn't
  - Some thermal not offered – Electricity Commission enquired, "tense" exchange, no action in response
  - Whirinaki offers would drop some thermal out of the stack
- Changes were made on the fly
  - Electricity Commission chose Chose not to reflect higher fuel costs in offers to keep Huntly in stack
  - Electricity Commission started procurement for demand response
  - Changes caused confusion, winners and losers
- Whirinaki not recovering its costs
  - Levy recovery encouraged free-riding
  - Opposition to change in levy

It was dis-established given the issues it caused



There were changes to the arrangements during wind-down

- Electricity Commission increased Whirinaki's $1,000 / MWh standing offer to $5,000 / MWh
  - ~LRMC
  - Reflected concerns about peaker investment incentives
  - Transitional until sold
- But high price acted as a target -> competitors exercising market power
- Views government was profiting
- Electricity Authority subsequently dropped it to SRMC (~$500 / MWh)
  - Assuming capacity margins confirmed


ELECTRICITY AUTHORITY
TE MANA HIKO

Consultation Paper

Capacity Offer for Whirinaki

Prepared by the Electricity Authority
1 March 2011

Time series of Reserve Energy Scheme changes

Milestone	Developments
Announcement	• Generation • Ring-fenced for dry years • Offered in at high price
Draft GPS	• Up to 400 MW of low-fixed cost gen and demand response • Incl. Whirinaki plant that Crown planned to purchase • $200 / MWh offer or lower when dry
2004 GPS	• Procure enough to meet security margins • Higher of $200 / MWh or variable cost, or lower during 'min-zone' • Can be used for grid emergencies • Periodic reviews
Electricity Commission established	• Security of Supply Policy details min-zone and RES policy • Whirinaki offer published, incl. $1,000 / MWh standing offer
2007 RES Review	• Legislative detail moved out of GPS • Decision not to specify procurement approach
2009 Brownlee Review	• Decision to disband the scheme and sell Whirinaki in light of 2008 Winter Review
Electricity Commission 2010	• $1,000 / MWh standing offer increased to $5,000 / MWh
Electricity Authority 2011	• $5,000 / MWh standing offer decreased to SRMC • Scheme disestablished, Whirinaki sold, replaced with other security of supply measures

The Reserve Energy Scheme teaches us some important lessons

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[redacted]

There may be further insights we can gain

Question: What other lessons or insights can we take from the Reserve Energy Scheme?

Question: How should we reflect these insights into our future consideration of the ownership, operation and revenue of a 'NZ Battery'?

We are planning further case studies to inform our work

- Other examples of strategic reserve – Sweden/Finland/Germany/Belgium
- Other large generation with potential market power (eg, Tasmania hydro, Bath pumped hydro in Virginia)
- Strategic oil reserves

Question: Do members have any suggestions of other case studies we could learn from?

What are the broad strengths and risks to NZ of some non-hydro options

This is pre-reading ahead of a group discussion:

Purpose of this session

- We are commissioning a study that will narrow in on 2-3 non-hydro options for solving the dry year problem
- We will want your support in deciding what those 2-3 options should be, so want to build your familiarity with the options now and get you thinking about their potential pros and cons

What we want from you

- Read the following articles giving examples of the options the study is investigating
- Considering the unique perspective you bring to the TRG, think about what the strengths and risks might be for these options in NZ – be ready to discuss this as a group at the meeting

Next steps from here

- The study we're commissioning will make a recommendation for the 2-3 options before the end of the year
- We hope to have a bespoke session with you in December to consider that recommendation and decide which options to take further forward

The Feasibility Study is investigating several options

Option	Description	Sub-options
Bioenergy	Using fuels created from biological or organic sources (eg, trees, waste). The matter can be used directly (eg, wood chips) or processed into a range of different fuels in different states.	• Biomass production and storage • Biogas production and storage • Liquid biofuel production and storage • Bioenergy import with storage (including biomass, biofuel, and/or biogas)
Geothermal	Using the earth's underground heat energy - either from an aquifer, or by introducing a working fluid to transfer the heat	• Geothermal energy storage • Controlled dispatchable geothermal
Hydrogen (or other green energy vectors)	Producing hydrogen from water using electrolysis – passing an electric current through water. The hydrogen can be stored and used directly, or reacted further to create a different fuel that is more stable (green energy vector)	• Hydrogen production with subsurface storage • Hydrogen production with carrier storage • Hydrogen imports with buffer storage
Air	Using air as a working fluid, which can be stored and used to turn a turbine	• Compressed air energy storage • Liquid air energy storage
Flow batteries	A type of rechargeable electrochemical battery, where electrical energy is stored as chemical energy in electrolytes	• n/a

- There are even more detailed options within these sub-options
- Many of the options use novel tech, and most would be entirely new for NZ

The Feasibility Study is being run over 4 Tasks

Task 1 of the study focusses on technical stuff…

We want you to help us identify the broader factors that it will be more light-touch on – including social, cultural, and environmental factors.

If there are green or red flags, we want to start thinking about them now, so we progress the right options

- The first Task starts with the full list of options and sub-options
- They'll be generic options – not location specific – so any issues the study identifies will also be generic
- It will narrow that list down to just 2-3 options based on a limited set of criteria:
  - Can it deliver the required security of supply
  - Is it renewable
  - Is it practical and deliverable – eg,
    - Rough order of magnitude of costs
    - Efficiencies
    - Environmental / regulatory hurdles
    - Technology readiness
- Task 1 will also flag key uncertainties, challenges and opportunities – eg,
  - Are the necessary markets there?
  - What does the learning curve look like? … Etc etc

We've dug out articles on some of the options

- We want to understand the broad strengths and risks the options might present to NZ
- To get you thinking about what those could be, we've provided some articles that discuss a few of the technology options:
  - ➢ We haven't covered all the sub-options. Rather, for each high-level option, we've looked at one or two sub-options that seem more prospective, or might raise new or interesting issues for NZ
  - ➢ The articles aren't intended to be comprehensive. They should give you some insight into how the technologies/options work and issues or challenges that might be involved
  - ➢ Some of the articles might suggest the technology isn't suited to our problem (eg not flexible, large-scale or long-term). However, this may not reflect the full potential of the technologies, and will be fully explored by the study, so please don't focus on that for now
- Try and imagine how the technologies might be used similarly in NZ and what the implications might be
- Given limited information, your reactions, instincts and questions on what these technologies might mean for communities, iwi, workers, the environment or the economy can provide useful insights, and help us contemplate green or red-flags

Reading list

Slide	Option	Title (and web-link)	Synopsis of article	Why this article?
7	Bioenergy: biomass production or import	Why aren't northwestern Ontario's state-of-the-art energy facilities producing any energy?	Two coal power stations in Ontario, Canada were converted to run on 'advanced wood pellets'. Their use as peaker plants has proved important, but raised questions about costs and efficient fuel supply.	It's easy to imagine how a biomass converted coal plant could apply to New Zealand, and how many of the same challenges could arise.
8-9	Bioenergy: biogas production and storage (with hydrogen cross-over)	Power-to-gas: Fix for all problems or simply too expensive?	Germany is investing in technology that produces renewable methane. Renewable methane could help with seasonal demand variation and industrial gas use, but Germany may struggle to produce enough of it.	This article usefully describes the technology and how it could fit within a low-carbon economy. However, it raises the question of competitive use, as well as the prospect of imports.
10	Geothermal: geothermal energy storage	'Closed loop' technology brings the promise of geothermal everywhere	Eavor, a clean energy start-up, explains how they've utilised oil and gas drilling technology to develop a new closed-loop geothermal technology for electricity generation.	This article raises the prospect of geothermal generation that is less geographically constrained.
11	Hydrogen (or other green energy vectors):	A final link in the global hydrogen supply chain	A key challenge for the 'hydrogen economy' – transporting it efficiently – has been solved by Chiyoda, allowing for a demonstration project exporting hydrogen from Brunei to Japan.	A hydrogen solution for NZ Battery could potentially involve imports or exports of hydrogen. This article discusses a way this could work.
12	Air	Compressed-air energy storage project proposed in eastern Kern	A new compressed air development in California will be clean, safe and reliable. What's not to love?	This article usefully describes how the technology would work and some of the enthusiasm for the project.
13-14	Flow batteries	'We like its ability to scale': Honeywell targets gigawatt-scale storage opportunity with flow battery	Honeywell (a technology company) explains why they are investing in flow battery development – noting it is scalable, non-toxic, and good for longer duration storage.	This article usefully describes how the technology would work and some of the enthusiasm for the technology.
Linked in slide 15	Biomass Hydrogen	Infographics from UK Committee on Climate Change [Link 1] [Link 2]	These two infographics summarise the potential future role of biomass and hydrogen in the economy in the UK.	These provide a fairly comprehensive summary on a single page. While much broader than electricity generation, they provide useful context and background.

Bioenergy: biomass production or import

https://physicsworld.com/a/biomass-energy-green-or-dirty/

Why aren't northwestern Ontario's state-of-the-art energy facilities producing any energy?

THUNDER BAY – Atikokan, located between Thunder Bay and Fort Frances, is home to the largest 100 per cent wood biomass generating facility in North America – but between 80 and 90 per cent of the time, it generates nothing at all. Thunder Bay boasts a state-of-the-art advanced biomass station, but for approximately 98 per cent of the year, it, too, lies idle.

Both facilities came about as a result of the 2003 provincial election, which saw all major parties pledge to phase out coal-fired power plants. Bill Mauro, voted in that year as the Liberal MPP for Thunder Bay-Atikokan, knew that the shuttering of the coal plants would have serious local repercussions: a reduced tax base, fewer employment opportunities, less energy security for northwestern Ontario. "In the Atikokan example," he says, "the [declining] tax base and job loss could have fundamentally closed the town."

The coal-fired plants were reborn as biomass-generating facilities, burning wood pellets to produce energy. The Atikokan Generating Station was, at a cost of $170 million, transformed into a 205-megawatt plant that became operational in July 2014. The Thunder Bay Generating Station, with one of its two 153-megawatt units converted for under $5 million, came online in 2015.

The Auditor General's 2015 report criticized the new plants, saying generating electricity at the Thunder Bay station cost $1,600 per megawatt hour to produce – 25 times more expensive than other Ontario biomass station. The Atikokan station's energy costs $528 per megawatt hour – eight times higher than average.

The plants were never meant to run full-time: they were created to supplement existing supply, which is why they're inactive most of the year. The light production schedule prevents the creation of forestry and manufacturing industries to deliver pellet supply. Atikokan was expected to go through 90,000 tonnes of pellets each year, and a 10-year agreement was signed with California-based Rentech and Resolute Forest Products to provide them. Rentech converted a former particle board processing mill in Atikokan – located just 18 kilometres from the generating station –into a production centre for biomass pellet production.

When it came to Thunder Bay, however, the province directed Ontario Power Generation to issue a five-year contract for "up to" 14,000 tonnes of pellets every year until 2019. The plant has burned only around half that much annually.

Because of the tight timeframe and relatively small demand, private developers weren't able to profit from establishing a similar advanced biomass pellet plant for Thunder Bay. So the OPG had to look farther afield – to Norway, and a company called Arbaflame. It makes the pellets and ships them to northwestern Ontario. Thunder Bay, located in the heart of in a region long known for forestry, is now relying on wood products from halfway around the world.

The biomass facilities won't be in a position to boost production and stimulate local investment unless authorities determine the demand is there – and not everyone is convinced it is. After the 2003 Ontario election, most of the region's pulp and paper mills closed down due to a cooling global market, reducing the need for energy. Sluggish global mineral markets are casting uncertainty on the status of the two dozen mining projects in varying stages of development throughout the region.

While the technologically advanced plants have attracted interest across the continent and in Europe and Asia, the current North American political situation has made long-term export planning difficult. Doug Murray, CEO of the Thunder Bay Community Economic Development Commission, says prospective biomass producers saw potential in exporting energy to U.S. coal-producing communities along the Great Lakes. American energy producers had been inspired to look for alternatives to coal because of greenhouse-gas reduction targets contained in the U.S. government's Clean Power Plan. But the election of Donald Trump, who is an outspoken advocate of the coal industry, has thrown the regulatory demands into doubt. "The [Environmental Protection Agency] was going to dictate what they could do with their power. Now that's come off. Now you have people saying, 'Okay, which way is the future going?'" Murray says. "Legislative uncertainty is not an investment climate. Until people see direction, they're going to wait."

Biomass has also proved needed: in the summer of 2016, for example, the Atikokan plant ran for six weeks straight after an unscheduled Hydro One transformer outage. And there are some indications that local demand will rise. In August the Wataynikaneyap Power initiative added Pikangikum and Lac Des Mille Lacs First Nations to its $1.3-billion, 1,800-kilometre transmission project, which will ultimately connect 22 remote communities to the energy grid.

And while the planned East-West Tie Line promises to significantly reduce demand for regionally produced energy – the 450-kilometre transmission project would connect the provincial power grids, making it possible for the north to draw power from southern Ontario – its estimated cost has nearly doubled to $777 million, throwing the future of the project into doubt. If it never gets off the ground, biomass from Atikokan and Thunder Bay would be critical.

Iain Angus, a Thunder Bay councillor and a co-chair of the Northwestern Ontario Common Voice Energy Task Force, is urging Ontario to make a long-term commitment to transforming the Thunder Bay station into a full-time facility. He argues such a commitment would also have the benefit of creating a base market in the northwest for biomass pellet production.

"The province needs to say to the OPG, 'Make this your priority. Go ahead and put out a call for proposals for the provision of advanced biomass to the quantity you need to generate at full capacity,'" Angus says.

Mauro sees a future for industrial biomass production, co-generating plants, and possibly even residential biomass in communities without access to natural gas. He toured the Atikokan station with Premier Kathleen Wynne in August, and the government is currently putting the finishes touches on its updated Long-Term Energy Plan, scheduled for release this fall.

"The reliance on fossil fuels is coming to an end. It's not a matter of if – in my opinion – it's a matter of when. Ontario, when we look back in 10 years, is going to be seen as having been the leader – whether it's wind, whether it's solar, whether it's biomass, whether it's moving away from fossil fuels to produce energy, and all the ramifications of that. In my opinion, it's just a matter of time."

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Bioenergy: Biogas production and storage

https://www.cleanenergywire.org/factsheets/power-gas-fix-all-problems-or-simply-too-expensive

Power-to-gas: Fix for all problems or simply too expensive?

Using renewable electricity to produce hydrogen and CO2-neutral methane could solve some of the Energiewende's toughest challenges. Making gas with wind and solar power could provide carbon-neutral fuel for heating and transport, and pave the way for large-scale seasonal energy storage. But so far, power-to-gas is only used in some 30 research and pilot facilities around Germany. Many experts believe the government must now scale up the technology to make it available – and affordable – in time to meet climate targets. But some researchers say Germany will have to rely on imports from wind- or sun-rich countries with better production conditions.

The technology

Today, synthetic hydrogen and methane are mostly produced from fossil fuels and biomass. Power-to-gas (PtG/P2G), however, refers to the use of renewable electricity to produce these fuels through electrolysis and methanation. Industry and researchers have struggled to agree on what to call renewable PtG products, using terms such as synthetic gases, wind gas, solar gas, or power-based gases, among others.

The first step in the process is to produce synthetic hydrogen (H2) from water and renewable power via electrolysis. This hydrogen can either be used directly – added to the existing gas mix – or put through a second stage that reacts the H2 with carbon dioxide to produce methane (CH4)

Methane is the key ingredient of natural gas and can be used directly in any of today's standard gas applications. The CO2 used in the methanation process is captured from the air, or from biomass or biogas, to ensure a closed carbon cycle. If the carbon dioxide came from a fossil source, as it does in current industrial processes, it wouldn't count as carbon-neutral.

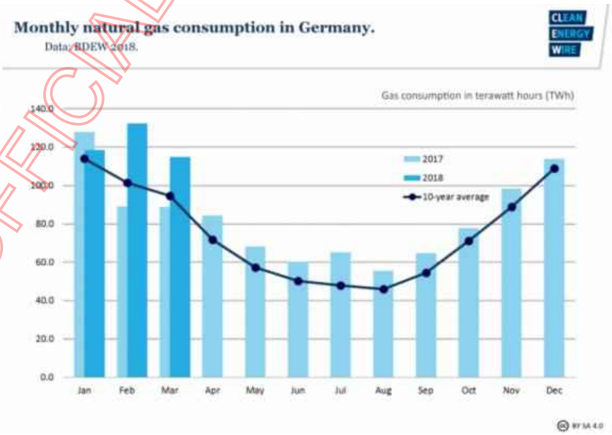
PtG: Flexible, clean – and expensive

Germany's biomass potential is limited and the gas industry presents PtG as a kind of all-purpose fix for the challenges of a decarbonised energy system. The energy resulting from PtG is of a high value. Synthetic gas can be used to store energy over long periods of time and transports well. It can be used to create the high temperatures needed in industrial processes and would allow the continued use of existing infrastructure, making extensive modernisation of power plants and appliances unnecessary – saving a lot of money.

At the same time, synthetic fuels have significant disadvantages. A lot of energy is lost during electrolysis, methanation and storage, meaning producing them requires large amounts of renewable energy. After electrolysis, only about 67 – 81 percent of the energy remain, and after the additional step of methanation, only about 54 – 65 percent is left. The production of synthetic fuels is laborious and they will always be more costly and less efficient than direct electricity use.

Storing the summer sun for winter

That's why some researchers say synthetic gases should only be used when there is no clean alternative. The large-scale, seasonal storage of renewable electricity is one such case.



German energy use is not evenly distributed over the course of a year. During the colder months, heating significantly drives up demand. Wind power production also rises in winter, but solar power is harvested mostly in summer. The electrification of heating, for example by using heat pumps, would replace the seasonal fluctuation of gas consumption with seasonal impacts on the power market.

...Continues on next page

Bioenergy: Biogas production and storage

https://www.cleanenergywire.org/factsheets/power-gas-fix-all-problems-or-simply-too-expensive

With current technology, batteries cannot store enough energy in reasonably sized facilities or at an affordable cost to balance out seasonal fluctuation. So Germany currently burns fossil gas in backup plants to meet demand when renewable power generation declines, and will continue to do so in the coming years. Synthetic methane could provide a carbon-neutral alternative from the middle of this century. It could also be used as an alternative to electric heat pumps in buildings where they cannot be installed, such as listed historic buildings.

Replacing natural gas in the industrial sector

Power-to-gas could also be key to the long-term decarbonisation of the industrial sector. It is possible to use electricity to create the high temperatures needed for processes such as steel production. However, industry has employed combustion processes for decades and would need to make significant and expensive changes, while keeping production running. PtG would be the cheaper option; simply using a different, cleaner fuel in standard combustion technology. Hydrogen – currently produced mainly from fossil fuels and used to make ammonia and in the direct reduction of iron ore – could also be made using power-to-gas. And the carbon needed in the chemicals industry, which today mostly comes from oil, could be extracted from synthetic methane.

Germany's most important industry association, BDI, published its climate path study at the beginning of 2018, concluding that for Germany to achieve its upper target of a 95-percent cut in greenhouse gas emissions by 2050, its entire natural gas supply would need to be replaced with biogas and synthetic gases to avoid emissions from essential industrial combustion processes.

A 2018 meta-analysis by consultancy enervis comparing 10 different studies on the future role of power-to-gas also concluded that the more ambitious Germany is on CO2 reduction, the greater demand will be for PtG.

Scale-up and costs

Many already see PtG as a way to make use of wind power in northern Germany that cannot be transported to areas of high demand in the south due to a shortage of power lines. However, the technology is only up and running in around 30 research and pilot projects in Germany, and these are still far from profitable.

The high cost of PtG means it's not expected to compete with fossil gas without government support and regulation – such as quotas for the share of synthetic gas in the national energy mix, or a higher price on CO_2 emissions.

For an industrial country like Germany, developing PtG could drive growth. And with pressure on countries around the world to cut fossil fuel use in line with the 2015 Paris Agreement, Germany could benefit from exporting the technology.

But the possibilities of producing synthetic gas itself at home are limited. Power-to-gas facilities are capital-intensive. Even if PtG facilities already existed at the necessary scale, Agora Energiewende and Agora Verkehrswende say not enough excess renewable electricity is currently generated in northern Germany for them to be profitable. Because of high fixed costs, they would need to run at full load as much as possible, the think tanks explain in a study on the future costs of synthetic fuels.

Imports may be needed

Some researchers say Germany will probably have to import significant amounts of synthetic gas in the future. Germany may simply not have space for the number of wind turbines and solar panels needed to produce enough synthetic gas to meet demand, particularly given that German citizens are already resisting the construction of renewable energy infrastructure.

Sun-rich countries may be able to produce it more affordably. For oil countries in North Africa or the Middle East, this could also provide an incentive to move away from fossil-fuel extraction and come on board with international climate protection efforts.

A recent study by the German Energy Agency (dena) predicts Germany importing up to 750 terawatt-hours of synthetic gas and liquid fuels in 2050. Still, higher interest rates and security risks abroad could make synthetic gas produced domestically from North Sea offshore wind competitive.

A draft amendment to the law on the development and support of offshore wind energy currently being debated by government could pave the way for combined facilities in the North Sea that generate wind power and convert it into hydrogen. These facilities would not be connected to the power grid, and so would not have to pay the renewables levy (EEG surcharge). However, according to the draft law, such facilities would be also not eligible for financial support from the government.

'Closed-loop' technology brings promise of geothermal anywhere

https://www.euractiv.com/section/energy/news/closed-loop-technology-brings-promise-of-geothermal-anywhere/

Geothermal energy has until now been constrained to areas with special geological conditions where the earth's heat is close to the surface. Today, closed-loop technologies make geothermal accessible almost anywhere in the world, opening up new prospects for mass-scale deployment.

Eavor, a clean energy start-up founded in 2017, completed last year the first prototype of a closed-loop geothermal power plant to deliver energy in Alberta, Canada.

Now, the Calgary-based company intends to deploy similar plants in Germany and gradually scale up its technology across Europe, thanks to backing from new investors.

The 'Eavor Loop', as the company calls its closed-loop technology, is a new generation of Advanced Geothermal Systems (AGS). It connects two vertical wells with many horizontal wellbores, which all together create a closed buried-pipe system.

These systems do not require the injection or extraction of any fluids from the earth. Contrary to deep geothermal techniques, it therefore does not require fracking – the controversial drilling process used in the extraction of shale gas.

"The system provides energy 24/7, independent from weather, season or if it's day or night," said Daniel Moelk, country manager for Germany at Eavor. "We can also dispatch the load and follow wind and solar by reducing the energy output when we have lots of wind and solar in the grid. And if these drop out, we can provide peak load," he told EURACTIV.

"Therefore, we can work as a renewable battery without actually having to construct a battery or construct an energy storage facility," he explained.

Geothermal energy has traditionally been developed in areas offering specific seismic and volcanic conditions, such as Iceland or Turkey, which have conventional hydrothermal sources.

But as Europe looks at measures to decarbonise its heating systems, some cities like Munich and Paris – which are sitting on deep aquifers – are now betting on geothermal energy to deliver heat and electricity in urban areas.

And closed-loop systems could offer them an option.

"I think there are places on earth where a closed loop might be the only technology that can offer a constant baseload," said Marit Brommer, executive director at the International Geothermal Association (IGA). "We need to demonstrate the technology at scale to understand how it serves this constant supply of electricity and heat," she said.

Closed-loop geothermal systems, as well as other deep-drilling technologies, could also bring an additional benefit: They enable the redeployment of both technologies and workers from the oil and gas industry who have prior experience in the field.

"The only other industry that goes down to those depths to try and visualise and understand what's going on down there is predominantly the oil and gas industry," said Robert Winsloe, vice-president for Business Development at Eavor.

"And in fact, the reason why the economics for the Eavor-Loop work is, ironically, because of the shale industry in North America," he said.

"This means that once we begin to scale quickly that volume, then we will be able to redeploy thousands of people from the oil and gas industry and redeploy a lot of that same technology as well," he told EURACTIV.

Oil and gas companies have accumulated decades of experience in drilling wells and exploring geological formations. Industry experts believe they could use the vast amounts of data collected over the years in the geothermal industry.

In fact, some of them have already started investing in geothermal. Earlier this year, oil majors including BP plc and Chevron invested $40 million in Eavor, hoping to build on the fossil fuel industry's drilling experience to expand the company's activities across the globe.

Risk and reward

It will not be an easy ride, though. Deep geothermal technologies have so far used fracking, or high-pressure water, to fragment the rock and access heat sources deep underground.

This has caused public rejection in places like Strasbourg, France, where geothermal projects have caused tremors in the recent past.

"We need to communicate well our technology. Because we are not connecting to any hydrological aquifers, we have eliminated the risk of a seismic event during drilling," Eavor's Moelk said.

"We cannot cause any earthquakes, and we cannot contaminate drinking water," he stressed.

Because of those setbacks, environmental and geological risk assessments related to geothermal have also become more stringent over the years.

"If there's one thing that oil and gas is good at is exactly that: it is the risk management and the de-risking of the subsurface where the oil and gas industry has so much more knowledge of because they have drilled millions of wells," said the IGA's Brommer.

"We need to be crystal clear on what we do, how we do that, how we manage everything in the subsurface, and take people with us in that journey. Because if we don't do that, I am very much concerned that the social acceptance that we worked so hard to gain will be lost," she added.

A final link in the global hydrogen supply chain

After almost 20 years in the making, Chiyoda Corporation's low-cost hydrogen transport technology is now a reality, with the successful demonstration of shipment from Brunei to Japan — a big step towards realizing a hydrogen-energy society

"The societal rewards were too great for us not to invest in our promising methylcyclohexane (MCH) technology, although daily setbacks in the beginning really tested our resolve," says Yoshimi Okada, principal researcher of hydrogen technologies at Chiyoda Corporation. The investment paid off with the result that Chiyoda's MCH catalyst is now a commercially viable means of safely storing and transporting hydrogen.

Hydrogen is abundant, renewable, packs a high energy density, and produces only water vapour when burnt. On paper, it is the ideal fuel source, but in practice there have been significant technical challenges to overcome, from its primary production to its storage, transport, delivery and use.

Some of these challenges have already been addressed — we now have efficient hydrogen fuel cells capable of powering vehicles, the first large-scale hydrogen power plants are starting to appear, and hydrogen production from solar and wind power is well advanced.

But the entire concept of hydrogen as a fuel hinges on its economics: it has to be producible and transportable as part of a global supply chain at prices comparable to those of petroleum. This is the grand challenge of hydrogen, and one that the Japanese engineering company Chiyoda Corporation has tackled head on.

The headache posed by hydrogen transport

"Back in the 1990s, the hydrogen development sector was really at a standstill on transport," explains Okada. "The three transport candidates, liquefied hydrogen, liquefied ammonia and a promising chemical method based on MCH, were not viable at that time — ammonia is highly toxic, while it wasn't known whether the catalyst needed for the MCH method could ever be developed."

Ten years later, in 2002, the Japanese government recognized that fuel-cell development was going well, but that large-scale hydrogen-transportation technology needed more time for development.

"MCH really stood out to us a way to solve the hydrogen-transport problem, and that's when Chiyoda pivoted towards developing an MCH catalyst," says Okada.

From partner to technology leader

Chiyoda has been an engineering and construction partner to the oil and gas industry for more than 70 years, yet in the early 2000s it began looking for opportunities to diversify by developing its own technology.

Researchers at Chiyoda experimented with finer and finer platinum particles. "At around 1 nanometre — approaching just a few MCH molecules in size — we achieved a jump in catalytic activity performance," says Okada. "That changed everything and opened a new era in catalyst chemistry."

In 2011, Chiyoda started mass producing their nanoscale MCH dehydrogenation catalyst and demonstrated the technology in a pilot plant in 2014. Named SPERA after the Latin for 'hope', Chiyoda's MCH technology was inching closer to commercial reality. All that remained was to demonstrate an end-to-end international supply chain.

Like petroleum, but hydrogen

SPERA overcomes many of the intrinsic drawbacks of liquefying hydrogen, which involves compressing or chilling hydrogen gas to cryogenic temperatures — an expensive, energy-intensive process. Instead, the SPERA process involves fixing hydrogen gas to the common petroleum product toluene at ambient temperature. It produces MCH as a stable liquid, which can be transported in large volumes using conventional petroleum tankers. At the destination, the MCH can be stored in standard tanks for long periods, and when needed, the hydrogen is efficiently separated from the toluene using Chiyoda's dehydrogenation catalyst. The toluene is recovered for reuse and shipped back to the hydrogenation plant, and the hydrogen is delivered for use at the destination.

"Liquefied hydrogen needs new technologies that will reduce energy loss due to the physical liquefaction process and transport, whereas the energy loss for SPERA is much less at just 35%," says Okada. "This has given us a great start on the way to achieving the US$3 per kilogram price target by 2030, set by the Japanese government. And, unlike with liquefied hydrogen, we see many ways we can further reduce cost and energy in our chemical process over time on the way to a US$2 price target by 2050."

On the path to commercialization

"In April 2020, Chiyoda, in collaboration with Mitsubishi Corporation, Mitsui & Co., Ltd. and NYK Line, demonstrated the world's first end-to-end global hydrogen supply chain, successfully transporting MCH produced in Brunei Darussalam to a refinery in Kawasaki, Japan," says Osamu Ikeda, head of hydrogen supply chain development at Chiyoda. "These collaborators are part of our Advanced Hydrogen Energy chain Association for technology Development (AHEAD) covering the entire supply chain, including production, maritime transport and logistics, storage and dehydrogenation."

Supported by Japan's New Energy and Industrial Technology Development Organization (NEDO), Chiyoda is now rapidly expanding the local market and conducting feasibility studies on new business models and markets using the SPERA technology.

"It's time to start building the global framework to support international hydrogen trading and safety, and we're looking for partners and collaborators to develop the global supply chain and be part of the hydrogen-energy future," Ikeda says. "The low energy losses and the ability to make use of existing infrastructure make SPERA a highly promising route to achieve this goal."

Compressed Air

https://www.bakersfield.com/news/compressed-air-energy-storage-project-proposed-in-eastern-kern/article_6f158d10-a933-11eb-ba7b-bbeb70eef846.html

Compressed-air energy storage project proposed in eastern Kern

California's ambitious climate goals have attracted interest from an international business partnership looking to build a groundbreaking, 500-megawatt compressed-air energy storage project in the Rosamond area.

The project announced Thursday would put an estimated 800 people to work during peak construction then employ the equivalent of up to 25 full-time workers while providing half a billion dollars in indirect economic benefits.

Though still very early in the process — a senior Kern County official was unaware of the proposal Thursday — the project could be a welcome diversification of the state's stored-energy portfolio, which according to the California Public Utilities Commission needs to expand three-fold to reach the goal of 10,000 megawatts of storage by 2030.

At its heart the project is an attempt to make renewable energy from solar and wind generation available when the sun isn't shining and the wind isn't blowing.

The development partnership behind the project — led by Toronto-based Hydrostor with Meridiam and Pattern Development — say surplus or off-peak energy would run a compressor producing heated, compressed air. Heat would be removed from the air stream using proprietary technology and be stored for use later in the process.

The compressed air would be stored deep underground, displacing water such that hydrostatic pressure would keep the system at a constant pressure. Later, hydrostatic pressure would bring compressed air to the surface, where, after the reintroduction of stored heat, it would expand through a turbine to generate electricity.

Hydrostor says it's clean, safe and reliable energy that uses only air, gravity and water. If all goes well the project could open by 2026, complementing projects underway elsewhere in the United States, as well as in Canada, Chile and Australia.

Customers would include the Los Angeles Department of Water and Power and the operator of the state power grid, California Independent System Operator.

The project's price tag was not available, but it and a similar project providing the same amount of storage capacity at an undisclosed site in the Central Valley by the same partnership were estimated to cost a combined $1.5 billion.

By itself the Rosamond project would offer capacity exceeding all other compress-air energy installations worldwide.

“Only a handful of (compressed-air energy storage) projects have been deployed worldwide, amounting to just over 300 (megawatt-hours) total," Larissa Y. Fair, marketing and communications director for the U.S. Energy Storage Association, said by email. "Their successful completion would represent a historic, seismic change in the bulk storage landscape.”

Part of what makes the project valuable is its novelty. Diversification is lacking within California's energy-storage portfolio, said Michael Gravely, senior electrical engineer and team lead in energy storage research at the California Energy Commission.

He said compressed-air projects are more efficient than conventional power plants but not as efficient as batteries, which generally don't discharge for more than six hours — half the duration Hydrostor's project would deliver electricity at full capacity.

Gravely noted Hydrostor's project would greatly exceed Hydrostor's current capacity of less than 5 megawatts. But the technology presents few risks and seems to be feasible if it can find financing.

"It's good technology. It's a good proposal" he said. "I hope you guys are lucky and I hope they get it done."

Hydrostor said development work including site control, transmission interconnection and engineering are all well along, with permitting activities already underway.

Lorelei Oviatt, director of Kern County's Planning and Natural Resources Department, said she has not yet seen the company's project but that she is eager to review it.

"It sounds intriguing and we look forward to them obtaining the correct permits through the Kern County Planning and Natural Resources department," she said by email Thursday.

Flow batteries

https://www.energy-storage.news/we-like-its-ability-to-scale-honeywell-targets-gigawatt-scale-storage-opportunity-with-flow-battery//

'We like its ability to scale': Honeywell targets gigawatt-scale storage opportunity with flow battery

In our sponsored webinars with Honeywell earlier this year, members of the company's Process Solutions team mentioned that the company had been working on a long-duration battery storage technology and that an announcement would be made in due course.

Yesterday, the curtain was raised and Honeywell officially announced that it has created a flow battery which it will deploy in pilot projects of increasing size in 2022 and 2023.

You may have seen from our coverage yesterday that the company is keeping the exact chemistry of the battery under wraps, but we do know that it uses non-toxic and abundant materials, is designed to be recyclable and offer up to 12 hours of energy storage duration in a durable package over many years of use.

A 400kW system is being installed at US utility Duke Energy's North Carolina testing facility in 2022 and then a 60MWh pilot is expected to go ahead the following year.

Honeywell Sustainable Technology Solutions (Honeywell STS) vice president and general manager Ben Owens spoke with *Energy-Storage.news*' Andy Colthorpe on the eve of the announcement.

It must be exciting to be telling the world about the flow battery after developing it in 'stealth mode' for a number of years. How about introducing it to our readers?

Also, we understand that this product has been developed through Honeywell Universal Oil Products (UOP), whereas your lithium-ion battery storage systems and services offerings have largely been delivered through Honeywell Process Solutions.

We've been working on it for a few years...we got interested in this space, we saw a core need for a battery that's longer duration, a utility-scale battery that uses non-rare earth elements. We have a fundamental belief that utility-scale batteries have got to use a non-rare earth element.

As for why Honeywell UOP for flow batteries: well, a flow battery looks a lot like a [power] plant, just on a lot smaller scale. You have the flow of material, just like you have in an oil or gas petrochemical plant, you have ion exchange, you have the need to be fundamental in chemistry and molecular science, which is UOP's core value proposition to the market.

And you have to be fundamental in membranes. We've been putting membranes in the market for 30 years, we have our own membrane facility, we test and launch our own membranes. So the combination of those things allowed us to develop in the space.

We're going to be bringing together the management and process control capabilities of Honeywell Process Solutions, and kind of the chemistry and know how, of UOP on the battery side, to launch this battery.

Can you reveal more about the technology? When most people hear 'flow battery', they think of vanadium electrolytes and there are other types that use iron electrolytes or zinc bromine.

We're not talking about the exact chemistry but it is a non-rare earth element. It uses easy to source materials, and we really like its ability to scale up and down. The characteristics of a flow battery, I think really lends itself well to the utility industry.

I will tell you, it's a non-rare earth element. So that gets rid of vanadium, which is usually people's first question!

We like the chemistries in that [flow battery] space. You don't get the same density [as with lithium-ion] but really, this is about cost.

At the utility-scale, density is not your primary driver. We really liked that space for its cost profile, and for the ability not to be coupled with a supply chain that could run into challenges that could swing drastically.

How about the development process? We've seen flow battery technology adopted by the renewable sector, but more broadly, the energy tech sector, from the early groundwork by people like NASA and academics decades ago. How much of the development started from scratch with what you guys are doing and what's the process been like? What have been some of the challenges that you've overcome along the way?

We started from scratch. We're really good at optimising chemistry. So if you look at UOP's core history, we're fundamental in molecular science, we're fundamental in the chemistries.

Not to say we haven't had our experiences with all the challenges, you have with a flow battery around leakage. That's something we've been fundamental on, really making sure we hit the segment correctly. That's why we really like our partnership with Duke — it's really dialling into what the utility segment's going to be looking for.

In terms of what utilities will be looking for, over the last few years, as battery storage has come into the market, at *Energy-Storage.news* we were initially mostly reporting on projects with perhaps 15 minutes of storage, typically doing frequency regulation. That's crept up — or perhaps even jumped up — to one, two-hour systems and now we're at the point that four-hour is probably the most common among projects announced in the US.

Where and at what point do you see the need for longer duration battery storage coming in?

I think that four hours is really also a dependency on the lithium-ion side. As more wind and solar come on the grid, we hear from utilities and we see in our own modelling, eight to 10 to 12 hours [duration] is really going to be the driver of energy storage over time. That full 12 hours is what we're going to need.

You also need some seasonal storage. That's most likely going to be accomplished by hydrogen. But we see in our modelling that you can get to more than 50% wind and solar on the grid with a battery that runs 12 hours. We think this is the spot to develop in.

You can't have one before the other: what's going to go first, solar and wind or batteries? No, the answer is that they're both going to go together.

We see the forecasts for wind and solar, we see the direction of wind and solar [deployment], but that's going to hit an upper bound if batteries don't follow us shortly. I think we're not late, we're not early, we're kind of right where we need to be!

One other aspect of flow batteries that flow battery companies and their investors often like to impress on the market is safety. While I think it is widely accepted that there is less fire risk and therefore less mitigation required for flow batteries than lithium, I'm yet to see that cited very often as a reason a utility is choosing to procure flow batteries at scale...

As Honeywell, we're in both spaces. We do process control and management for lithium-ion [battery storage]. Lithium-ion batteries, while they're more energy dense, they have to be greatly spaced out because of the safety concerns: they need cooling, they need fire prevention and gas detection systems, they need a lot of control.

So I think safety is a core element, but it also comes down to cost.

If you don't have to deploy the same fire and gas mitigation systems, if you have fairly safe systems, you don't have to have the redundancy that controls the process.

So, I see this as more a cost argument. Because both these batteries, lithium and flow, will deploy safety systems that are inherently safe, and the end user will demand it. But I see it more as a barrier on lithium-ion to go to a larger scale, this gigawatt-scale, that these large-scale deployments need.

...Continues on next page

Flow batteries

https://www.energy-storage.news/we-like-its-ability-to-scale-honeywell-targets-gigawatt-scale-storage-opportunity-with-flow-battery//

What can you tell us at this stage about the pilot deployment with Duke Energy, which begins next year?

Duke Energy is more aggressive in the emerging technology area than many other utilities. We've been engaged with them for over a year.

From the late prototype stage, we've been working in their feedback, asking them where they see the market, where they're looking to develop. They're obviously testing multiple chemistries — we see them as an ideal partner, because they have this kind of micro grid centre, where you can do real world testing at their Mount Holly facility.

They've really been a partner helping us as we're scaling up. There's challenges we run into and they've been great on the feedback side.

What we really like about our flow battery is its ability to scale. As a company, we know how to build large-scale plants and as I said earlier, this looks less like a battery and more like a plant in many ways.

We know how to do balance of plant, we know how to scale up. We will go from a very small pilot plant to a large-scale unit with nothing in between. We're very comfortable if we prove out the engineering, we can prove out the cell design, we understand what we had to prove out — what scales and what doesn't. That's just kind of what we do.

If you look at what we're deploying around the world today in the oil and gas market, that's fundamentally our UOP business — the ability to scale.

That's another one of the characteristics we like in this battery: we can use our core competence in scaling, to rapidly increase the size once we've proved out the the chemistry, the cell design, the flow dynamics, everything about round trip efficiency.

Then we can go very big, very quick.

The idea of really large-scale long-duration energy storage is exciting. We've seen flow batteries put in recently on industrial or remote microgrids in the past few years, as well as a few much larger megaprojects in China and Japan at the other end of the scale. Do you see a market developing for flow batteries at smaller as well as the larger scale?

I think we're kidding ourselves if we think one battery [technology] is going to win out here. There'll be multiple batteries, multiple market segments, multiple use cases. Industry data indicates there will be a US$13.7 billion market for energy storage with 115GW coming online by 2030.

There's room for multiple players, there's a need for multiple players. You have shorter duration peak shaving, you're going to have larger scale, you'll have seasonal storage. So I do think there'll be multiple batteries that play into the US grid and worldwide grids.

It seems to be commonly accepted by the energy storage industry that there will be multiple technologies, particularly for long-duration. With the vanadium flow battery, one constraint appears to be the availability of raw materials and electrolyte processing capacity, at least in the short term. While its ingredients are still a closely guarded secret, what can you tell us about Honeywell's manufacturing strategy for the flow battery and its supply chain?

It's readily abundant material for the entire use of the battery. So there's no need to build a specialised supply chain: it's abundant, non-toxic, environmentally safe material.

On the manufacturing side: we're not ready to talk about it yet. We're looking at a couple different options. Honeywell, is a core manufacturer, we're talking about exactly how we want to scale up there. So there are some decisions to come, we've not made a decision exactly how we're going to put it together.

Part of the great success of lithium-ion has been to do with how the technologies have become readily bankable. What are some of the things that need to be verified and figured out in the pilot and testing process for the flow battery over the next year or two?

The Battery Innovation Center in Indiana is going to be doing a lot of testing. There's been a lot of leakage issues with flow batteries — we believe we've solved all those.

They'll be looking at the efficiency, the duration... the value propositions says '20-year lifetime,' so we're going to be looking at degradation — we believe we've solved that.

Bankability is a fundamental issue in the market, but an area we're very comfortable with.

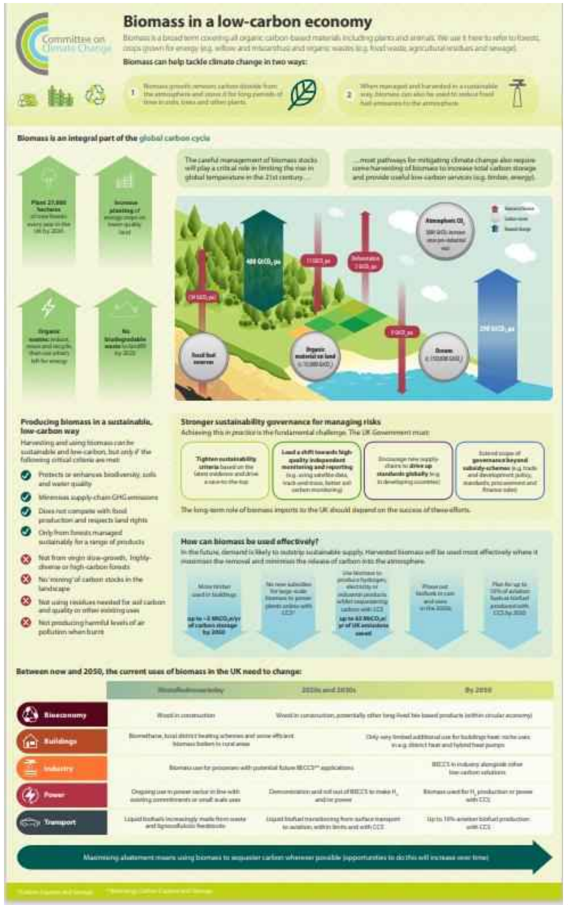
If you think about a refinery or petrochemical plant, we'll write a guarantee on the technology that fundamentally backs the design, building, construction of a billion dollar plant. So it's an area that we're very comfortable: looking at the chemistry, looking at its lifetime and writing a guarantee that you can take to the bank, or that a project developer can take to the bank and go build a project off of.

That's something else we think we bring to the market, understanding of the battery, understanding of its chemistry, understanding the degradation, and then the fact that we'll stand behind it or wrap it in a control system, and will stand behind it for its 20-year life.

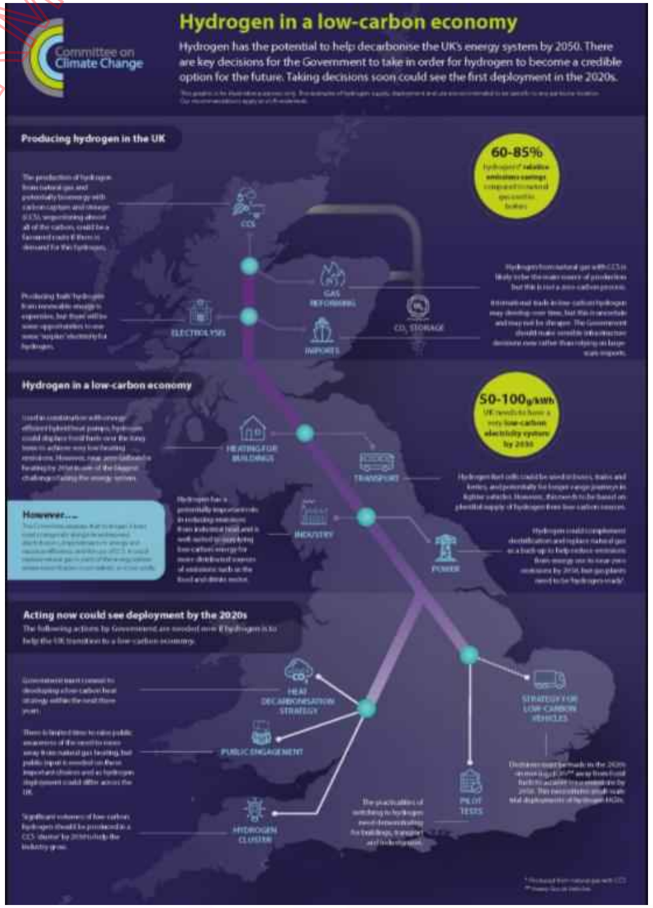
Biomass and hydrogen infographics

Infographic for CCC growth plan report (theccc.org.uk)

Hydrogen-infographic-FINAL-WEB.jpg (1654×2339) (theccc.org.uk)



You'll need to open these on the web to avoid blurry-ness



Executive summary – Stantec Report for Workstream 2 (Other hydro)

MBIE have engaged Stantec to undertake a high-level assessment of the suitability of three hydro alternatives to the Lake Onslow pumped storage scheme. The aim of the study was to determine if any of the s 9(2)(f)(iv) identified sites presented development options that were technically and environmentally feasible and would materially help in solving New Zealand's "dry year" problem. The Stantec brief did not include an assessment of the economics of the schemes.

The key requirements were for the sites to provide storage at Tera-Watt hour scale, be able to deliver the energy over an approximately three-month period and for the storage to be refilled over an approximately two year period.

The three sites of interest nominated by MBIE were:

- s 9(2)(f)(iv)

Following our investigations Stantec have identified technically feasible schemes at s 9(2)(f)(iv) that can deliver the key requirements.

- s 9(2)(f)(iv)
- s 9(2)(f)(iv)
- s 9(2)(f)(iv)

s 9(2)(f)(iv) schemes will present significant technical challenges that may impact their viability. In particular, extremely large dams will be required and significantly larger than any existing New Zealand dams, plus long tunnels and under-ground power stations.

The sites will all present very significant challenges associated with Mana Whenua, water conservation, environmental and recreational values.

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

NZ Battery Project
Technical Reference Group Agenda

Date:	Tuesday 11 May
Time::	8.30am – 5.30pm
Location:	KPMG Offices – 10 Customhouse Quay
Facilitator	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Mike Howat, Amanda Larsson, Hoani Langsbury, Stephen Batstone
Apologies:	N/A

Agenda

No	Time	Item	Lead
	8.30am	**Arrival Tea and Coffee**	
1	9.00 – 9.15am	Welcome and member introductions	Adrian Macey
2	9.15– 10.15am	Project problem definition and background information	Adrian Macey
3	10.15 – 10.45am	Admin – invoicing, logistics, Terms of Reference	Adrian Macey
	10.45 – 11.15am	**Morning Tea**	
4	11.15 – 12.00pm	Project Process – Timeline of Phase 1	Adrian Tweeddale
5	12-00 – 12.45pm	Long list options	Conrad Edwards and Adrian Tweeddale
	12.45 – 1.30pm	**Lunch**	
6	1.30 – 2.30pm	Evaluating and short listing options	Conrad Edwards and Adrian Tweeddale
7	2.30 – 3.30pm	Market modelling draft results and conclusions - Sapere report	Malcom Schenkel and Carl Walrond
	3.30– 4.00pm	**Afternoon tea**	
8	4.00 -4.45pm	Market modelling draft results and conclusions - Concept report	Malcom Schenkel and Carl Walrond
9	4.45– 5.15pm	Questions and Answers, any other business Confirm date of next meeting	Adrian Macey

Action items from previous meetings

Date Assigned	Action	Responsibility	Date Due	Progress

Next meeting

Date:	22 June 2021
Time::	9.00am
Location:	Microsoft Teams

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

NZ Battery Project
Technical Reference Group Agenda

Date:	Thursday 24 June
Time::	9.30am – 4.00pm
Location:	KPMG Offices – 10 Customhouse Quay
Facilitator	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Amanda Larsson, Hoani Langsbury, Stephen Batstone
Apologies:	Mike Howat

Agenda

No	Time	Item	Lead
	9.15am	**Arrival Tea and Coffee / Food**	
1	9.30am – 9.40am	Welcome	Adrian Macey and Andrew Millar
2	9.40am – 10.30am	NZ Battery Project news - Overall update - Last 6 weeks - Next 6 weeks	Adrian Tweeddale
3	10.30am – 10.45am	**Coffee / Tea break**	
4	10.45am– 11.30am	Non - Hydro approaches - Bubble diagram - Bio-fuels - Hydrogen	Bridget Moon
5	11.30am – 12.00pm	NIWA update - GIS Scan – reporting on other potential pumped hydro locations	Malcolm and Carl
6	**12.00pm – 12.30pm**	**Lunch**	
7	12.30pm – 1.00pm	Stakeholder update	Maria and Carl
8	1.00pm – 2.15pm	NZ Battery Operational Governance Primer - Ownership - Reserve energy case study	Conrad and Bridget
9	2.15pm – 2.30pm	**Coffee / Tea break**	
10	2.30pm – 3.30pm	DOC update - Why are they involved? - Project Impact	s 9(2)(a) [redacted]

		- What is covered in the report and what is not included - Land Ownership - Outline of the conservation values at site together with analysis on what the losses and gains in those values might be.	
11	3.30pm – 4.00pm	Q&A Summary	Adrian Macey

Next meeting

Date:	3 August 2021
Time:	9.30am – 4.00pm
Location:	MBIE Offices Wellington

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

NZ Battery Project

Technical Reference Group Agenda

Date:	Thursday 5 August
Time::	9.00am – 4.30pm
Location:	KPMG Offices – 10 Customhouse Quay
Facilitator	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Amanda Larsson, Raymond Gunn, Hoani Langsbury, Stephen Batstone, Mike Howatt Note: Steve dial in on teams for some of the sessions
Apologies:	N/A

Agenda

No	Time	Item	Lead
	8.45am	**Arrival Tea and Coffee**	
1.	9.00am – 9.05am	Welcome / Karakia	Adrian Macey and Hoani Langsbury
2.	9.05am – 9.30am	Project news • Overall update	Andrew M & Adrian T
3.	9.30am – 10.00am	Stakeholder update • Industry meetings / Otago visit update	Maria Hernandez - Curry & Carl Walrond
4.	10.00am – 10.15am	**Coffee / Tea break**	
5.	10.15am – 11.30am	Operational Governance • Present first-draft operational models	Conrad Edwards
6.	11.30am – 12.30pm	Other hydro options • Present final GIS Scan and proposed short list options	Malcolm Schenkel
7.	12.30pm – 1.00pm	**Lunch**	
8.	1.00pm – 2.00pm	Freshwater presentation • Next steps for Lake Onslow freshwater investigations	Carl Walrond, s 9(2)(a)
9.	2.00pm – 2.45pm	Driving the energy transition • Discuss the MBIE wide approach to changing the energy system	Andrew Hume
10.	2.45pm – 3.00pm	**Coffee / Tea break**	
11.	3.00pm – 4.00pm	The energy transition and the NZ Battery Project • How we might frame the strategic business case for investment?	Andrew Millar & Bridget Moon
12.	4.00pm – 4.30pm	Q&A Summary	Adrian Macey

Next meeting

Date:	21 September 2021
Time:	9.00am – 4.30pm
Location:	MBIE Offices Wellington – Level 4 – 01M

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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NZ Battery Project
Technical Reference Group Agenda

Date:	Tuesday 21 September
Time:	9.30am – 3.00pm
Location:	Zoom virtual meeting - https://mbie.zoom.us/j/83975687661?pwd=Y1dUSTZ2QUxIYkJVV0tCK3pLMGFRdz09
Facilitator:	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Amanda Larsson, Raymond Gunn, Hoani Langsbury, Stephen Batstone, Mike Howatt
NZ Battery team:	Andrew Millar, Carl Walrond, Conrad Edwards, Sam Treceno, Maria Hernandez –Curry, Bridget Moon, Malcolm Schenkel, John Hancock, Jodi Percy
Apologies:	Adrian Tweeddale

Agenda

No	Time	Item	Lead
1.	9.30am – 9.35am	Welcome / Karakia	Adrian Macey and Hoani Langsbury
2.	9.35am – 10.15am	Project news update • Project status update past and future milestones	Andrew Millar and Carl Walrond
3.	10.15am – 11.30am	**Workstream 1** – Lake Onslow update • Progress update on the Environmental and Geotechnical engineering investigation tender and next steps. **Workstream 3** – Non hydro options – next steps	Sam Treceno, Carl Walrond and Bridget Moon
4.	11.30am – 11.45am	**Coffee / Tea break (15 mins)**	
5.	11.45am – 12.45am	Stakeholder update • Environmental and cultural fieldwork – landowner access • Stakeholder timeline for the LO engineering investigation work – approach, timings, process • Industry meeting discussions	Maria Hernandez – Curry and Carl Walrond
6.	12.45am – 1.15pm	**Lunch (30 mins)**	
7.	1.15pm – 1.45pm	NIWA work on correlations between wind and rain and impact of climate change	Carl Walrond, Malcom Schenkel and s 9(2)(a) NIWA
8.	1.45pm – 2.30pm	NIWA and Cawthron scientists - Freshwater update	s 9(2)(a) NIWA

9.	2.30pm – 3.00pm	Q&A Summary	Adrian Macey

Next meeting

Date:	9 November 2021
Time:	9.00am – 4.30pm
Location:	TBC

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

NZ Battery Project
Technical Reference Group Agenda

Date:	Tuesday 9 November
Time:	9.30am – 3.00pm
Location:	Zoom virtual meeting
Facilitator:	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Amanda Larsson, Raymond Gunn, Hoani Langsbury, Stephen Batstone, Mike Howatt
NZ Battery team:	Andrew Millar, Adrian Tweeddale, Carl Walrond, Conrad Edwards, Sam Treceno, Maria Hernandez – Curry, Bridget Moon, Malcolm Schenkel, Eleanor Bell, John Hancock, Jodi Percy
Apologies:	N/A

Agenda

No	Time	Item	Lead
1.	9.30am – 9.35am	Welcome / Karakia	Adrian Macey and Hoani Langsbury
2.	9.35am – 10.15am	Project news update • Project status update past and future milestones, Stakeholder update	Andrew Millar and Adrian Tweeddale
3.	10.15am – 11.00am	Workstream 1 – Lake Onslow pumped hydro and geotechnical programme update	Adrian Tweeddale
4.	11.00am – 11.20am	**Coffee / Tea break (20 mins)**	
5.	11.20am – 12.30pm	Dry year problem – brainstorming session on what is a dry year?	Malcolm Schenkel
6.	12.30pm – 1.00pm	**Lunch (30 mins)**	
7.	1.00pm – 1.30pm	Dry year discussion – continued	Malcolm Schenkel
8.	1.30pm – 2.15pm	Workstream 4 – Progress update	Conrad Edwards
9.	2.15pm – 2.30pm	Q&A Summary	Adrian Macey

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

NZ Battery Project

Technical Reference Group Agenda

Date:	Tuesday 01 March 2022
Time::	10.00am – 3.30pm
Location:	Teams – Level 13 2M
Facilitator	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Amanda Larsson, Raymond Gunn, Hoani Langsbury, Stephen Batstone, Mike Howatt
Apologies:	N/A

Agenda

No	Time	Item	Lead
1.	10.00am – 10.05am	Welcome / Agenda overview	Adrian Macey
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11.	3.20pm – 3.30pm	Meeting Summary, next meetings	Adrian Macey

Next meeting

Date:	Yet to be determined – currently scheduled for April

NZ Battery Project Technical Reference Group Meeting

1 March 2022 – Online

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

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NZ Battery Project Workstream update

Workstream 1 - Lake Onslow Pumped Hydro – Progress

- We are continuing to work closely with Te Rōpū Matatau (TRM) as different pumped hydro design options for Lake Onslow are being explored. This has identified several key design elements for a pumped hydro scheme (**which we will discuss today**).

- The majority of our environmental and cultural fieldwork has been completed (though we remain open to filling any gap where possible or needed).

- Planning for geotechnical fieldwork is well advanced (**next slide**).

- Transpower has commenced work on the transmission and resilience implications of a pumped hydro scheme.

- We have begun to receive a range of draft and final reports which we are reviewing: DOC's environmental values report, Aukaha cultural values report, NIWA's, Cawthron's base lake ecology assessment.

- New and revised energy system modelling for Lake Onslow (**see WS 4**).

Workstream 1 - Lake Onslow Pumped Hydro – Progress (continued)

- Discussions with the remaining affected landowners for the planning detailed geotechnical work are progressing.
- Resource consent has been approved by Central Otago District Council to undertake the detailed geotechnical fieldwork component of the Lake Onslow engineering, geotechnical and environmental investigations.
- MBIE and TRM are close to finalising the procurement process for the detailed geotechnical investigations. Aim is for the preferred supplier to start fieldwork in March.
- This supplier has a great working relationship with TRM, brings good local knowledge, equipment, experience and flexibility. COVID-19 is having an impact in this work and will influence the completion.

Workstream 2 – Other Hydro options - Progress

- The procurement process for the desktop engineering and environmental assessment of other pumped hydro/hydro has been completed, with Stantec selected as the supplier of choice.
- Their began on 14th February with a series of workshops between Stantec and MBIE.
- This assessment will be completed by the end of March/early April with the aim of producing a draft report.

Workstream 3 - Non hydro options - Progress

- WSP has been undertaking a feasibility study into comparator technologies. The feasibility study will be delivered in three tasks, with key insights on preferred technologies available for the May 2022 update.

- The Project team have received a draft report (Task 1) from WSP narrowing the broad range of options down to the most prospective two or three options.

- It has recommended further study into three options:
  - Controlled dispatchable geothermal generation
  - Biomass production and storage, potentially supplemented by import/export
  - Hydrogen and ammonia production and storage, supplemented by import/export.

- The project team are currently reviewing the draft report and recommendation, which will also be reviewed by independent experts (including the TRG), before deciding which options are worth investigating further.

Workstream 4 – Market integration Progress

- Modelling work continues on assessing the economic benefits of different pumped hydro sites and options, and transmission implications for the Lake Onslow option.
- Several workshops have been had with the Treasury, the EA and the Infrastructure Commission
- Jen Purdie has provide a report on how hydro and wind inflows might change over coming decades and some findings into snowmelt predictions.
- Dr Grant Reid has provided a draft report on operational considerations for large scale pumped hydro.

Conrad will talk to this workstream later in the day

Next 4 weeks' expected milestones

Lake Onslow pumped hydro

- Begin detailed geotechnical investigations around Lake Onslow, subject to land access, a successful procurement process and resource consent.
- Receive updated environmental impact information from DOC based on fieldwork.
- Consider where and when further geotechnical investigations might be required (e.g. along tunnel routes) and continue to work closely with Te Rōpū Matatau as different pumped hydro design options for Lake Onslow are being explored.

Other hydro

- Stantec will continue with the desktop investigation work and produce a report based on their assessments of other hydro sites by the end of March or early April.

Next 4 weeks' expected milestones

Non hydro options

- Finalise the review of the narrowed down recommendations for Final Task 1 report.
- We intend to give direction to WSP next week, as to which options should be assessed in further detail to understand whether and how the options could best be designed to solve the problem, and their costs and risks.
- Commencement of Task 2, which will involve a more detailed assessment of whether and how the options could best be designed to solve the problem, and their costs and risks. These results we are aiming to include in the May report to Cabinet.

Market integration

- We are preparing to start production runs of the Stochastic Dual Dynamic Programming (SDDP) model we are employing to explore the implications of different storage options, including Lake Onslow. These results will identify how the electricity system might respond to large scale hydro options, and what the overall system costs and benefits might be.
- Finalise Dr Grant Read report on the theoretical underpinning of NZ Battery's interactions with the electricity market to refine our view of operating model options.

Upcoming milestone - Cabinet paper in May/June

- A Cabinet paper on the NZ Battery Project is planned for late May/early June. This paper will:
    - Provide an update on the work of the NZ Battery Project
    - Provide emerging findings from the work to date
    - Seek early decisions or in-principle decision to inform the remainder of the feasibility study where appropriate.

- Key information that we are likely to have for this Cabinet paper includes:
    - An updated problem definition and rationale for government intervention
    - An initial assessment about whether a pumped hydro scheme at Lake Onslow is feasible, including key design parameters, updated information on cost and constructability, and environmental and cultural impact information (WS1)
    - The results of desktop level environmental and engineering analysis into alternative hydro-based options (WS2)
    - The results of engineering analysis into non-hydro options (WS3)
    - Updated energy system modelling (WS4).

- We are currently working through in detail the contents of this paper.

Stakeholder update

- A hui is scheduled for (tomorrow) 2 March between Minister Woods and Ngāi Tahu representatives from Te Rūnanga o Ōtākou in Dunedin.

- Continuing our business case work with Treasury, Te Waihanga (NZ Infrastructure Commission) and Electricity Authority to identify and discuss the potential funding and financing options around the operational governance for the NZ Battery Project.

- We held a national level ENGO meeting in late December to provide a project update, and met with the Coal Action Network of Aotearoa separately. We are preparing for a national level ENGOs meeting in late March/early April with support from DOC.

- We have a further conversations with Contact Energy planned for March on both Lake Onslow and non-hydro options.

- We have attended a meeting this month with Snowy 2.0 and Hydro Tasmania. These meetings proved to be a great opportunity for the NZ Battery Project to gain operational insights and experiences.

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Te Rōpū Matatau & NZ Battery Project

Lake Onslow update on Key findings

Purpose

Purpose of this session

- To update you on the next steps for the Lake Onslow environmental, geotechnical and environmental investigation work that is underway with Te Rōpū Matatau (TRM) , including key design parameters.

What we want from you

- This is for your information, but please provide feedback or observations.

Next steps from here

- The Project team are working with TRM to explore different pumped hydro design options for Lake Onslow and review the current detailed geological fieldwork plan options.

Tea and Coffee Break

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Purpose

Purpose of this session

- To update you on the recent findings and completed environmental and cultural fieldwork done by DOC and Wildlands.

What we want from you

- This is for your information, but please provide feedback or observations.

Next steps from here

- DOC will send the final report to the NZ Battery Project team to review.

Conservation Values – Lake Onslow, Central Otago

Update for NZ Battery Technical Reference Group

1 March 2022

Department of Conservation
Te Papa Atawhai

New Zealand Government

Recap – What's DOC role?

- DOC signed a MOU with MBIE to provide a comprehensive report detailing the conservation values, non-conservation land recreational and landscape values, and their importance to the Lake Onslow site

- Our approach has been centred around three components:
  - desktop assessment of the known values
  - targeted engagement with iwi, hapū, whānau and interested stakeholders, and
  - surveying through fieldwork.

Our approach

- A mix of internal and external expertise

- DOC undertook freshwater fish surveying and led targeted engagement with runaka and local ENGOs.

- The recreational, landscape, terrestrial biodiversity, and freshwater invertebrate values work was subcontracted to:
  - Wildlands for terrestrial biodiversity and freshwater invertebrates.

s 9(2)(b)(ii)

- DOC is preparing a consolidated overview drawing on the reports

Our Engagement

- Targeted and focused on testing identified values

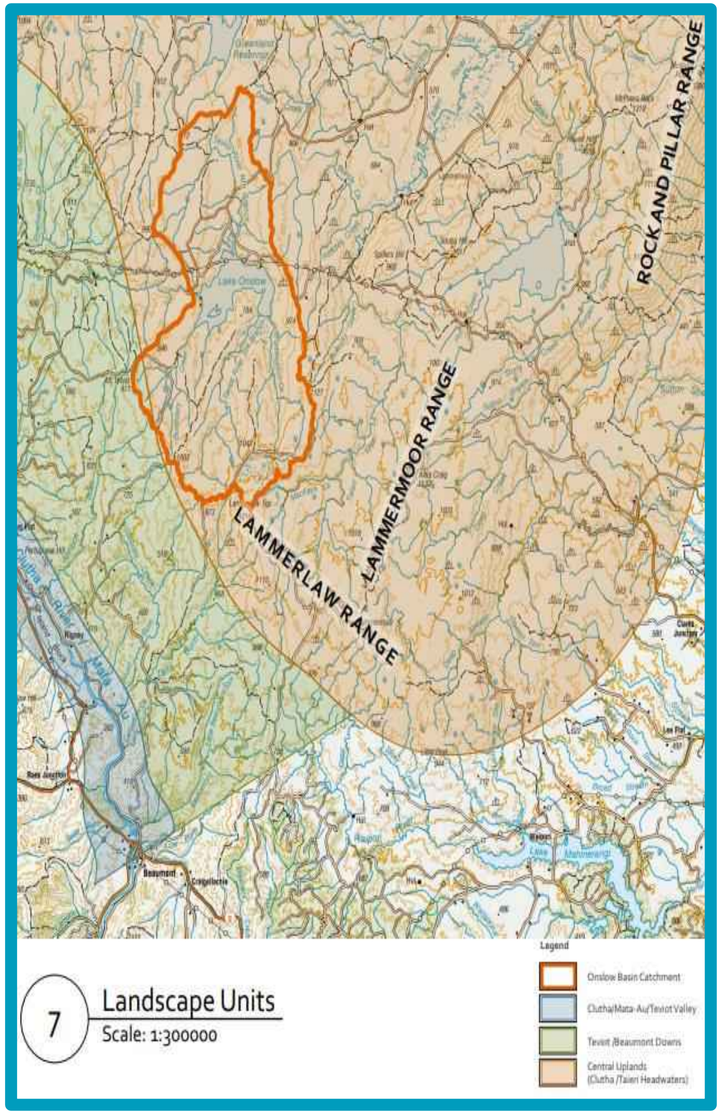
- We have engaged with:
  - Ōtākou rūnaka
  - Murihiku rūnaka
  - the Otago Conservation Board
  - national environmental non-governmental groups such as Forest and Bird and Fish and Game
  - local stakeholders including Otago Fish and Game, community board members, and environmental groups.

- This included a small workshop in Alexandra, Central Otago in December 2021.

Conservation Values

Landscape Values

- The Lake Onslow Basin is not a pristine natural landscape
- Modification from pastoral farming and hydro electricity generation
- The naturalness of the area is still high and it reflects wider landscape of the East Otago Uplands
- The naturalness and uniqueness of the values in the area would be impacted given its size
- The potential inundation of wetlands and tussock grassland which link across the landscape.



Recreation Values

- The recreational values are regionally significant
- There are high values associated with angling at Lake Onslow, given the sustained trout population and high bag limit.
- The value of cycling within the area is also considered high, with the Lake Onslow Road being relatively well used by cyclists. Lake Onslow is also close to two national cycleways.

Freshwater Fish

- The area has habitat used by Teviot flathead galaxias and dusky galaxias (Threatened – Nationally Endangered).
- The known Teviot flathead galaxias populations s 9(2)(f)(iv) [redacted]
- s 9(2)(f)(iv) [redacted]
- s 9(2)(f)(iv) [redacted]

s 9(2)(f)(iv)

- Pockets of higher values in some wetland, gully and rock outcrop habitats throughout the area.

s 9(2)(f)(iv)

s 9(2)(f)(iv)

Birds

s 9(2)(f)(iv)

s 9(2)(f)(iv)

Vegetation and Wetlands

s 9(2)(f)(iv)

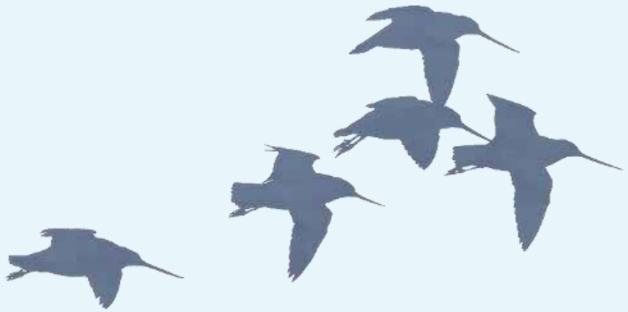
Invertebrates

s 9(2)(f)(iv)

[redacted]

Freshwater Invertebrates

s 9(2)(f)(iv)



Further Considerations

Limitations

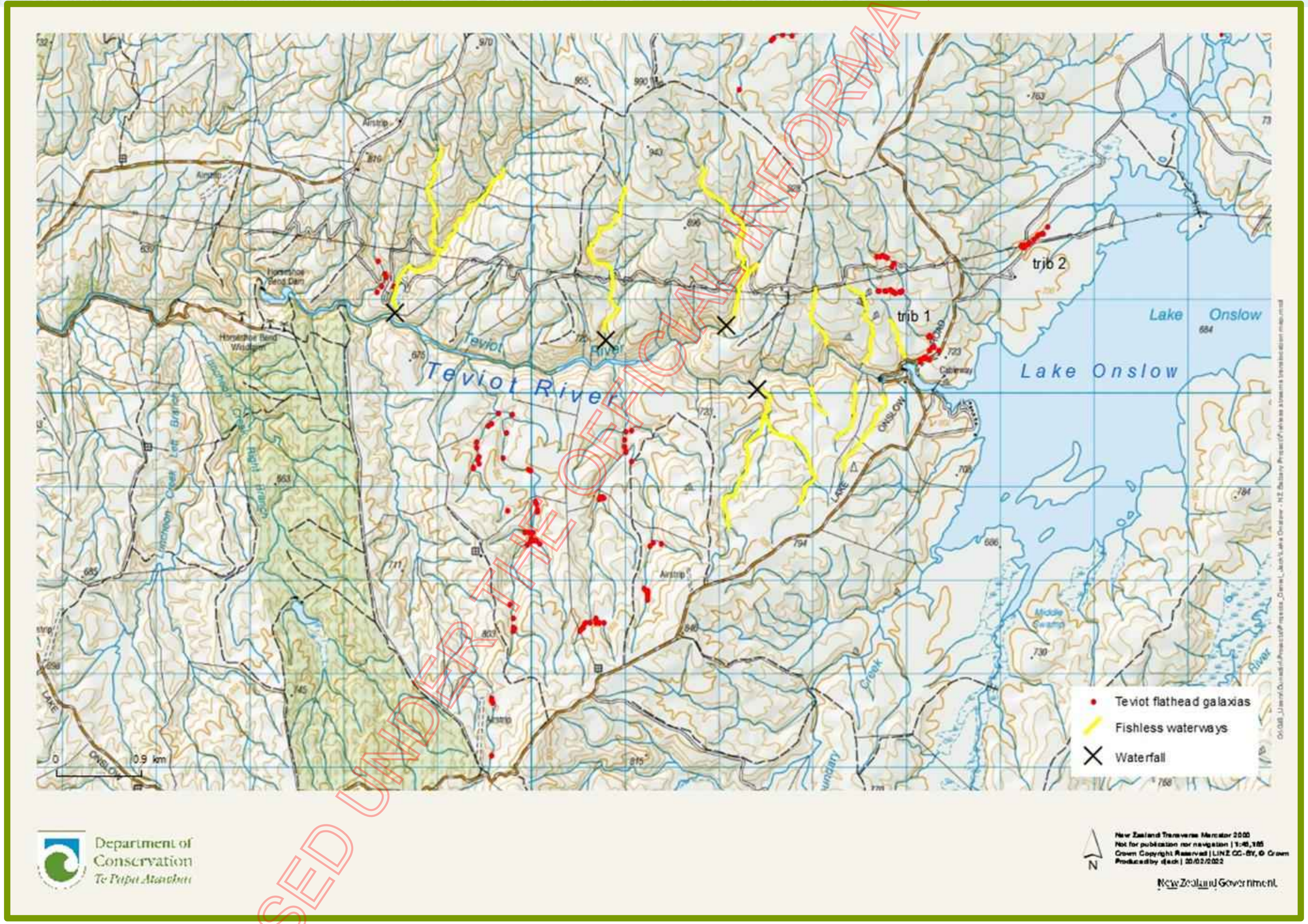
s 9(2)(f)(iv)

s 9(2)(f)(iv) [redacted]

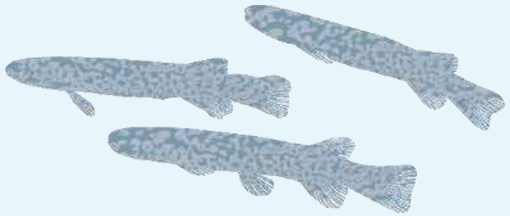
s 9(2)(f)(iv) [redacted]

s 9(2)(f)(iv) [redacted]

Fishless waterways, Teviot flathead galaxias and waterfalls, Teviot River.



Questions?



Lunch Break

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Purpose

Purpose of this session

- To update you on the work completed by Aukaha covering off two statements of values related to the proposed inundation zone for the Lake Onslow option.
  - Mana whenua cultural values.
  - Archaeological and heritage values

What we want from you

- This is for your information, but please provide feedback or observations.

Next steps from here

- We are going onsite at Lake Onslow to determine where, when and how to do archaeological fieldwork.


Kā Mahi ā kā Tīpuna:
Cultural, archaeological, and heritage values assessment
NZ Battery Project – Lake Onslow pumped hydro storage

Toitū te mana, toitū te whenua: Kā Papatipu Rūnaka

Ngāi Tahu whānui

- Te Rūnanga o Ōtākou
- Hokonui Rūnanga
- Kāti Huirapa Rūnaka ki Puketeraki

Shared mana

- Lake Onslow
- Te Awa Makarara
- The Mata-au

He mahi tautoko: Aukaha (1997) Ltd.

Aukaha

Mana Taiao

- Regional environmental entity
- Owned by five shareholder Rūnaka
- Provide professional planning and RM advice and services to Rūnaka

Contract by MBIE to provide two statements of values related to the proposed inundation zone:

- Mana whenua cultural values
- Archaeological and heritage values

Cultural values assessment

A statement of the values, interests, and associations held by mana whenua in relation to an area or natural resource.

Assessing cultural values

1. Direction from mana whenua
   - Values and associations
   - Priorities and aspirations
   - Stories, sources, and informants

2. Research
   - Cultural maps
   - Legislation, plans, and policies
   - Mahika kai and biodiversity
   - Archaeological evidence

3. Report drafting and consultation

E rite ana ki te karo o te moa: The Kāi Tahu history of loss

- The Treaty and Kemp's Deed
- The Gold Rush
- Modification of waterways
- Introduced pests
- Agriculture and horticulture

s 9(2)(g)(i)

[redacted]

Wai Māori Values

- Wai and whakapapa
- Mahika kai and biodiversity

- Wetlands
- Te Mana o te Wai

Ecological Values

- Introduced species and the impacts on biodiversity

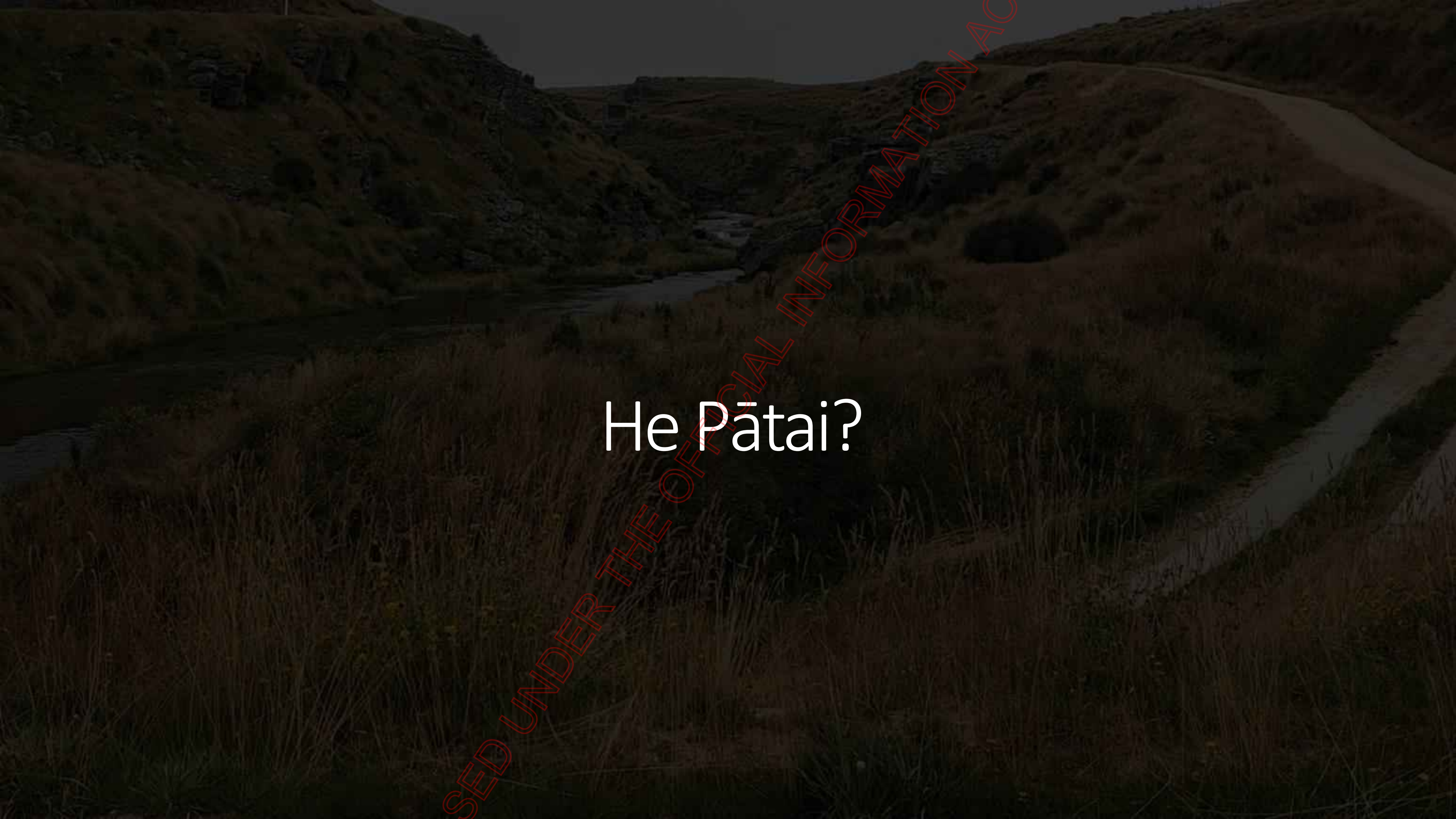
At risk species present:

- Teviot flathead galaxias
- s 9(2)(f)(iv)

- Historic populations no longer present s 9(2)(g)(i)

Equity Values

- The impacts of colonisation
- Māori and inequality in Aotearoa
- Employment and social procurement
- Opportunities to action rakatirataka and manawhenuataka


He Pātai?

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Market integration Workstream 4

MAHI TAHI
BETTER TOGETHER

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Purpose

Purpose of this session

- To remind you of the work plan for the market integration workstream 4
- Outline outputs expected, mostly by end April
- Focus in on our work in obtaining the best hydro / wind / solar matched historical inflows, led by John Culy

What we want from you

- Please provide feedback or observations, and be prepared to input as results start coming in

Next steps from here

- Focus on Jen Purdie’s work on climate change impacts at next TRG
- Delivering the workstream 4 results to support Phase 1 decisions and deliverables

s 9(2)(f)(iv)

Tea and Coffee Break

Today's programme

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Workstream 3 – Non hydro options Discuss recommendations from WSP report

Purpose

Purpose of this session

- Get TRG feedback on the WSP recommendation and report

What we want from you

- To discuss your views on the WSP recommendation and report
- Advise any feedback we should provide to WSP

Next steps from here

- WSP is pushing on with the work
- We are meeting with WSP on Thursday to discuss all the feedback we've accumulated on the recommendation and report
- The combined feedback will provide course-correction and ensure a quality deliverable

What WSP did

- 5 broad technologies, 12 sub-options
- Identified feasible pathways that are large-scale, long-term, renewable
- Assessed against broad criteria
    - Agreed with MBIE
    - TRL, logistics, environment, safety, efficiencies, vulnerabilities, existing projects etc…
    - $$$
    - RAG
    - SWOT
    - 1000 minds
- Reviewed, challenged, ranked

s 9(2)(f)(iv)

s 9(2)(f)(iv)

[redacted]

s 9(2)(f)(iv)

[redacted]

Views on the overall recommendation

- WSP recommended three options for further study:
  1. **Controlled dispatchable geothermal** (combining long-term and flexible)
  2. **Biomass production and storage** (including investigation into conversion to biofuel, and potential to supplement with import/export)
  3. **Hydrogen and ammonia liquid carrier production and storage** (combining NZ production and imported green ammonia)

- Other options it did not recommend were:
  - **Renewable synthetic methane** (an H2-based option)
  - **Air storage**
  - **Flow batteries**

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End of the day! Thankyou

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Technical Reference Group Agenda

Date:	Thursday 28 April 2022
Time::	9.30am – 3.30pm
Location:	On Teams(online) and in person at Pastoral House, MBIE offices - Level 03
Facilitator	Adrian Macey
Members:	Cristiano Marantes, George Hooper, Isla Day, Allan Miller, Amanda Larsson, Raymond Gunn, Hoani Langsbury, Mike Howatt
NZ Battery Project team:	Andrew Millar, Adrian Tweeddale, John Hancock , Carl Walrond, Malcolm Schenkel, Conrad Edwards, Bridget Moon, Daniel Wright, Sam Treceno , Vicki Singleton, Jodi Percy
Apologies:	Stephen Batstone

Agenda

No	Time	Item	Lead
1.	9.30am – 9.40am	Welcome / Karakia and Agenda overview	Adrian Macey and Hoani Langsbury
2.	9.40am – 10.00am	Project overview and upcoming milestones	Andrew Millar
3.	Part 1: 10.00am to 10.50am	Pumped hydro at Lake Onslow • Presentation follow by discussion on the selection of preferred pumped hydro design options	Adrian Tweeddale and Te Rōpū Matatau
4.	**10.50am – 11.00am**	**Tea/Coffee break - 10 mins**	
5.	Part 2: 11.00am – 12.00pm	Pumped hydro at Lake Onslow (Cont.) • Continue discussion	Adrian Tweeddale
6.	**12.00pm – 12.30pm**	**Lunch - 30mins**	
7.	Part 1: 12.30pm – 2.00pm	Update on Workstream 2 (other hydro) and 3 (non-hydro options) • Overview of the latest desktop reports and their findings, followed by discussion	Malcolm Schenkel and Bridget Moon
8.	**2.00pm – 2.10pm**	**Tea/Coffee break - 10 mins**	
9.	Part 2: 2.10pm – 2.30pm	Update on Workstream 2 (other hydro) and 3 (non-hydro options)	Malcolm Schenkel and Bridget Moon
10.	2.30pm – 3.25pm	What conclusions can we draw from our modelling?	Conrad Edwards
11.	3.25pm – 3.30pm	Wrap up and next step and closing Karakia	Adrian Macey and Hoani Langsbury