The power of natural thinking

entura Hydro Tasmania



Introduction

We're Entura, and we're one of Australia's most experienced energy and water consultants. Our experts work with utilities, governments, developers and international companies to help them achieve their business goals using clever engineering and scientific solutions.

Our full range of consulting services covers every aspect of major energy and water projects - planning, design, construction, operation and maintenance. There are over 350 dedicated minds at Entura, who work closely with our clients. Wherever they are in the world.

What makes us unique, however, is our owner/operator history. Because we're part of Hydro Tasmania, Australia's largest renewable energy generator and one of the largest resource managers, our expertise is backed by almost 100 years of developing, operating and maintaining power and water infrastructure. And that affords us a truly unique perspective.

While our history has indelibly shaped the way we approach projects and our overall outlook, we're squarely focused on the future. This brochure not only details our background, capabilities and achievements, it also outlines our history with Hydro Tasmania and how that makes us different from most other consultants.



It all begins here

Welcome to our showroom





Hydro Tasmania

Situated off the southern tip of mainland Australia is the beautiful island of Tasmania. Stunning isn't it? But it's so much more than a picturesque location. With its mountainous terrain abundant with lakes and rivers, Tasmania was considered an ideal location for major hydro-electric development as long ago as 1899. Commencing in 1914, and in a construction period spanning much of the twentieth century, the Hydro-Electric Department designed and built Tasmania's remarkable hydro-generation system. In 1994, the scheme was finally completed. The results of these labours are impressive by any measure - over 50 major dams and 30 hydro power stations, many of which are regarded as world firsts. Equally impressive is the world-class reputation for engineering excellence, innovation and sustainability that was built along the way.

Up until 1998, the Hydro-Electric Corporation was a fully integrated business delivering electricity generation, transmission and retail services to Tasmania.



Since disaggregation in 1998, Hydro Tasmania has been a leader and innovator in renewable energy generation. Not just in the operation and maintenance of its water and energy assets, but also the development of new renewable energy generation, including small-hydro, wind energy and remote energy. While Hydro Tasmania has undergone significant changes over the last century, the important things remain the same. For one, it's still government-owned and continues to return value to the state of Tasmania. Secondly, the commitment to sustainability is as strong

as ever with Hydro Tasmania being Australia's leading

producer of renewable energy, along with being one of the country's largest water managers. Have a good look around the showroom, because it's a testament to the power of natural thinking. And from that thinking, Entura was created. This is our story.



A little something about us

Entura

Now that you're familiar with Hydro Tasmania's history, this is how we use it.

We're Hydro Tasmania's consulting business. Since 1992 we've been providing consulting services around the world, sharing and building on Hydro Tasmania's incredible knowledge in water and energy. Leading the charge are our 350 industry-leading specialists delivering projects in hydro power, renewable energy, water infrastructure, water management and power engineering. Our services cover the entire delivery chain, including planning, design, construction, and the operation and maintainance of all kinds of major energy and water projects.

By this stage you might have the impression that we're different from other consultancies. It's true, we are. And we wouldn't have it any other way. Quite simply, our developmental and operational history affords us a unique perspective - a client's perspective - of every project that we undertake. Our ongoing involvement with Hydro Tasmania's operations means we've been working with the same assets for decades. So in a way, Tasmania isn't just our showroom, it's also our testing ground. It allows our experts to recalibrate, fine-tune and reassess how we do things, and gives us a complete understanding of how our solutions impact over an asset's lifetime. Armed with this knowledge, we've helped clients around the world maximise the return from their own assets - whether it's building a new one or improving an old one.

When we approach a project, we look beyond the end date and use our knowledge to provide solutions that maximise value over an asset's entire lifetime.

Some people call it seeing the big picture. We call it real-life experience.









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Hydro power

Since the completion of the Tasmanian hydro power system in 1994, we've been continuing Hydro Tasmania's work by bringing the same innovation, learnings and expertise to major projects around the world. In fact, we've worked with organisations in over 30 countries – including India, Laos, Malaysia, Papua New Guinea, South Africa and Tajikistan - to assist with the development, operation and maintenance of hydro power of all sizes.

The Hydro Tasmania story began at Great Lake, almost a century ago, when the Tasmanian Government bought the struggling Waddamana Power Station and completed its construction. Fast-forward to the present day, and thirty power stations later, the current Tasmanian hydro power system has an installed capacity of 2281 MW, producing around 9275 gigawatt hours of electricity per year.

With major development on the system complete, we continue to assist Hydro Tasmania in ongoing maintenance and technical upgrades to its hydro power stations to ensure a reliable and secure electricity supply.

It's no exaggeration to say that with our wealth of knowledge developing and operating hydro power, water runs in our veins. And we're always on the look out for opportunities to assist other companies developing, operating and maintaining their own energy and water infrastructure.



Small hydro power

Having cut our teeth on the largest hydro scheme in Australia , it's only natural that we translated those skills to a smaller scale. Indeed, when it comes to small and mini-hydro design and development, we're leading the way. As is the case with most things, finding the right balance is the key. We're renowned for our innovative and economic engineering, which balances maximum efficiency, cost effectiveness and constructability. The resulting designs are robust, economic and fit or purpose.

More importantly, we understand the old adage that one size does not fit all. Indeed, we pride ourselves in the knowledge that all our clients benefit from a tailored solution, customised to specific site conditions. That solution is in good hands, because our specialist consultants work with hydro power schemes on a daily basis, providing civil, electrical and mechanical expertise.

You'll find small and mini-hydro-generation projects we've developed for our clients all around the world, including Australia, Africa, Malaysia, New Zealand, Papua New Guinea and the Solomon Islands. Some of these developments have utilised our unique containerised design, offering simplicity and cost savings for our clients.



Case study: Chanju-I Hydroelectric Project

Indo Arya group is a leading transport company in India. With a belief in the future of renewable energy, Indo Arya has been directing its attention to electricity generation using a range of renewable energy technologies, including hydro power. The company's initiative supports the Indian Government's target for an optimum power system mix of 40 percent generated from hydro power and 60 percent from other sources.

Indo Arya's Chanju-I hydroelectric project is a 36MW run-of-the river scheme located on Chanju nullah, a tributary of the Baira stream in the Ravi basin. When Indo Arya started planning the project, it trusted Entura's history and experience to help them achieve the best outcome.

Entura provided the detailed project report, tender design and detailed design for the project, which will contribute significantly to the social and economic situation of local residents. Not only will it vastly improve electricity generation in the area, but it will also provide long-term employment opportunities through the ongoing operation of the hydro power station.



Dams

For nearly a century, Hydro Tasmania designed and built over 50 major dams using a variety of methods, including clay/earth, cored rockfill, concrete gravity and concrete arch. In particular, when it comes to the construction of concrete-faced rockfill dams, Hydro Tasmania's reputation is second to none.

With a wealth of experience and as a recognised leader in dam design, we've had the privilege of working on many of Australia's major dams over the last decade, as well as iconic international ones.

Not surprisingly, we're proud of our reputation as the concrete-faced rockfill dams experts. Which is why the Malaysian Government called on us to review the design and construction plans of the Bakun Dam - the second highest concrete rockfill dam in the world - to ensure they were safe for implementation.

Now that Hydro Tasmania's dam development days are in the past, we proudly carry on the pioneering attitude and innovative thinking. We're constantly pushing the boundaries of dam design and continually involved in developing and refining internationally-accepted design and construction methods.



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Case study: Wyaralong Dam

The Wyaralong Dam was initiated by the Queensland Government in response to the water shortage in south-east Queensland. The objective of the dam was to improve long-term water reliability in the region.

With a history steeped in dam development, Entura was the natural choice for the role of design manager. Managing the design within a six-member alliance, Entura provided a complete set of investigation and design services.

Wyaralong Dam was expected to take three years to fill, however, due to impeccable planning, the diversion pipe was plugged prior to the storm season and the dam was full when it opened in July 2011. The project was not only delivered ahead of schedule, but also under budget.

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Dam height	50m
Dam length	490m
Volume RCC	185,000 m³
Reservoir capacity	103,000 ML
Full supply level	RL 63.6
Dam yield	21,000 ML/annum
Catchment area	546 km ²
Flood capacity	6,800 m³/s (PMF)



Wind energy

As a key contributor to the development of Hydro Tasmania's wind assets, we're one of the most experienced wind energy consultants in Australia. Back in 1998, we were a driving force in the development of Hydro Tasmania's first wind farm on King Island – only the second commercial wind farm in Australia.

Soon after, we designed a further two wind farms that were built on the historic grazing property Woolnorth on the rugged north west tip of Tasmania. Today, the combined output of these wind farms supplies over 70,000 homes with green energy, reducing annual greenhouse emissions by 300,000 tonnes.

Since developing Hydro Tasmania's wind assets, we've worked on over 60 wind farm projects around the world, including Australia, New Zealand, Africa, China, India and South Korea.

Remote energy

The opening of the Huxley Hill Wind Farm on King Island also paved the way for further remote energy development. Since then, we've worked closely with Hydro Tasmania to add renewable generation to Flinders Island, and expand the capacity on King Island. These systems reduce the islands' reliability on costly diesel fuel, and provide the community with reliable, renewable electricity. Our experience with developing these systems has provided us with a unique insight into the technical requirements, as well as the challenging logistical requirements of developing renewable energy in remote areas. We've used the acquired knowledge to design, plan and deliver renewable energy systems to remote locations through-out the Asia-Pacific region. In particular, our solutions on Cape Barren Island now provide reliable and sustainable power 24 hours a day to a



remote community, which had been living with intermittent, expensive diesel power for many years. We've also designed and implemented hybrid systems for four other Tasmanian remote islands to power navigational lighthouses.

Case study: King Island wind farm

King Island is situated in the middle of Bass Strait, almost midway between Tasmania and mainland Australia. Due to its remoteness and topology, it was reliant on costly diesel fuel for electrical generation needs.

To reduce the island's reliance on diesel fuel, Entura was enlisted to help Hydro Tasmania develop the Huxley Hill Wind Farm. When the wind farm was first proposed, remote wind energy generation on this scale was virtually unheard of. Upon initial completion in 1998, the King Island system was one of the few projects of its type in the world.

The wind farm was built in two stages:

Stage One

Entura proved the feasibility of a wind farm, identified suitable locations, and liaised with landowners to secure sites. After submitting successful development applications for the farm, Entura provided designs for civil, mechanical and electrical works, and supervised the construction and commissioning, ensuring everything went to plan.

Result

The three 250 kW Nordex wind turbines that were installed during Stage One instigated a 15 per cent long-term saving of annual diesel fuel consumption on King Island.

Stage Two

After the initial installation, the wind farm was expanded and a facility for energy storage was introduced. Entura completed the design and implementation of the expanded wind farm, with two 850 kW wind turbines, a 200 kW x four hour Vanadium Redox Battery and an integrated control system.

Result

At the completion of Stage Two, a 40 per cent long-term saving of annual diesel fuel consumption and a 45 per cent renewable energy utilisation had been achieved.

Future

With the support of Entura, Hydro Tasmania continues to lead the way with clever applications of technology to further increase the amount of renewable energy used and reduce reliance on greenhouse gas emitting and costly diesel. King Island will once again be an example of what's possible for remote energy systems, as Entura works on new projects aimed at increasing the renewable energy utilisation to 65 percent. This will be done through an innovative mix of new and existing technologies including wind, solar, bio-diesel, energy storage and smart metering and load control.



Sustainability and environmental management

There is one overarching ideal to which we aspire for all our projects - a sustainable future. Whether it's a wind farm in India or a small-hydro system in Papua New Guinea, we provide the expertise to create sustainable water and energy solutions that make the most of the resources at hand.

Environmental testing, feasibility studies, and social and environmental impact assessments and approvals are all at the forefront of any venture that aims to produce a sustainable result. To achieve the optimum outcome, our scientific teams are involved throughout the life-cycle of a project from concept to feasibility, construction, and operation. Needless to say, we use the most up-to-date equipment and processes for our assessments. Equally importantly, we also liaise with local communities and stakeholders with, or on behalf of, our clients.

Our commitment to sustainability is an extension of Hydro Tasmania's long-standing reputation in the field. In fact, Hydro Tasmania is so highly regarded it was commissioned to develop (in conjunction with Hydro Quebec) the sustainability guidelines now officially adopted by the International Hydro Power Association. We were also proud to draft the sustainability and due diligence guidelines for the

World Wind Energy Association.

Our extensive involvement with Hydro Tasmania's developments and operations has shown the value of early identification of environmental and social issues. Above all, it has taught us that an inclusive and proactive approach is the best way to avoid, minimise or manage potential issues. Which is why we take an integrated risk approach to balance environmental and operational needs, ensuring compliance and avoiding costly rehabilitation or restoration of unmanaged impacts.

We practice sustainability in the way we do business too - we've been operating in Australia as a carbon neutral business since 2008. Our processes are also internationally recognised with ISO14001 accreditation. You could say we practice what we preach.





Case study: Aquatic Environment Program

As a hydro-electric generator, Hydro Tasmania manages an extensive network of lakes, rivers and streams throughout Tasmania. To put the scale of this undertaking into perspective, the catchment areas feeding into Hydro Tasmania's storage areas cover 21,500 km², which is 35 per cent of Tasmania's land area.

Fundamentally, the construction and operation of hydro-generating infrastructure involves changes to the aquatic environment through alterations to natural water flow regimes and diversion. This has implications for sediment movement, stream channel form, in-stream plants and animals, riverside habitat and water quality.

In order to manage water resources in a sustainable way, and minimise the impact of changes, Hydro Tasmania engaged Entura in 1997 to develop and implement its Aquatic Environment Program. Entura works closely with Hydro Tasmania, providing specialist scientific resources and policy advice to ensure the program functions effectively. The program has been so effective that it's still running to this day.

The program incorporates a comprehensive Waterway Health Monitoring program and ongoing Water Management Reviews. Entura also helps Hydro Tasmania consult relevant stakeholders, including agencies, downstream users and local communities, before making decisions about water management.



Capacity building



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Our consultants are not only good at what they do, they love what they do. And they love sharing their knowledge and passion with others. As such, many of our projects involve more than just the application of expert advice. We also believe that the transfer of knowledge is an important component of our work to build the capacity of our clients, suppliers and communities in which we work.

This transfer of knowledge has the potential to improve development outcomes by lifting our clients' capability to deliver significant energy or water programs that are required to meet the challenges of climate change, energy access, poverty alleviation and improving quality of life, particularly in less developed countries. We can increase the capacity of organisations through advice and support throughout a project, or via our accredited training modules. Our capacity building ranges from institutional or managerial strengthening, right through to technical and systems instruction.

Not surprisingly, given our expertise, our training modules cover every aspect of renewable energy and water management. Moreover, they can be tailored to meet the specific requirements of any organisation. They can be learnt from a textbook or from a real live asset. Our access to Hydro Tasmania's infrastructure gives participants the option of supervised hands-on experience, without exposing the plant or business to any risks. We can also provide training on site with clients' assets. Whatever the method of study, we provide all the learning materials and the appropriate structure. After all, we've practically written the book on renewable energy.

Our capacity building services have been successfully utilised by organisations around the world, and is just another way we can add value to the operations of our clients.

Case study: Sarawak Energy Berhad



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Sarawak Energy Berhad is a state-owned electricity generation, transmission and distribution business based in Kuching, Malaysia.

The Sarawak Government has set a major initiative for development, known as the Sarawak Corridor of Renewable Energy (SCORE). It aims to accelerate the State's economic growth and development, as well as improve the quality of life for the people of Sarawak. Included in the initiative is a plan to develop 20,000MW of hydro power by 2020, as well as introduce an undersea cable, similar to Australia's Basslink, to export electricity to mainland Malaysia. Who better to help Sarawak Energy Berhad with its development goals than a company with almost 100 years of experience developing renewable energy infrastructure?

In May 2010, Sarwak Energy Berhad and Hydro Tasmania signed a memorandum of understanding to recognise a shared vision for a successful working relationship together. Since then, Entura has provided expert services to help deliver new renewable energy growth opportunities, as well as supplying Entura personnel to build local skills and capabilities on the ground. In 2011, Entura guided 24 Sarawak Energy Berhad employees through a tailored hydro power operator course. The trainees, who flew to Tasmania for the training, were provided learnings through a combination of classroom work and onsite training at Hydro Tasmania's Lake Echo Power Station.

Power transmission

With over 100 electrical engineers and technicians, we have one of the largest and most experienced power engineering teams in Australia. Our depth of knowledge in power engineering is a result of our involvement in the development, operation and maintenance of Tasmania's intricate electricity network.



Today, this network includes 3469 circuit kilometres of transmission lines, 47 substations and 9 switching stations, as well as a telecommunications system and control centre. With much of the generating load located at remote sites, extensive transmission infrastructure is required, crossing difficult terrain and environmentally sensitive areas, including World Heritage sites.

We continue to work with Tasmania's transmission, distribution and retail companies to develop, maintain and upgrade their assets, affording us an intimate knowledge of an operating electricity system. Our history has given us a particular understanding of the operating conditions for transmission systems connected to hydro generation. That being said, we can deliver power engineering solutions regardless of the generation method, demonstrated by our ongoing support and services to most major Australian transmission service network providers.

Due to our long term involvement with aging infrastructure, we are also considered industry-leaders for brownfield design and substation upgrades.

Recently, our skills were put to work on the Woolooga Substation, a significant transmission substation in the Powerlink Queensland transmission network. With much of the original equipment reaching the end of its serviceable life, we provided services to upgrade plant and systems at the station, which improved security for increased load and fault levels.

Internationally, Entura has undertaken power system master planning throughout Asia. We also provided electrification services to a small community in Sri Lanka after the 2004 Tsunami.





Basslink

In 2006, Basslink commenced operation, and the Australian energy market changed forever. At nearly 300 kilometres in length, Basslink is one of the longest undersea cables in the world, and connects Tasmania to the Australian mainland and the National Electricity Market.

This means Hydro Tasmania can export renewable energy to mainland consumers. Furthermore, during periods of high mainland electricity demand, Hydro Tasmania is able to sell electricity for premium prices.

Basslink has also helped reduce the impact of drought and hydrological risk on Tasmania's generation through the ability to import electricity. It's all rather impressive, and as with many major energy projects in Tasmania, we played a key role.

On the environmental side, we undertook comprehensive studies into the impact of operating Basslink on the environmental values of the major rivers in the Hydro Tasmania system.

On the technical side we worked closely with all the major parties involved to ensure that the technical capability of Basslink met both the market needs forTasmania and the grid security requirements of the regulators. These services included conceptual design, proof of concept studies, detailed dynamic model development, design review, due diligence and testing. This work facilitated the implementation of the link and auxiliary controls that have ensured secure and reliable operation of Basslink to this day.

The Hydro Tasmania system

We're proud to play an ongoing role in upgrading and maintaining the hydro power system of Hydro Tasmania over the last century.

Historically, Tasmania has derived most of its electricity from its world-class hydro power developments. Located in seven catchment areas across the island, the remarkable system was developed and is still operated by Hydro Tasmania. Having taken almost a century to harness the natural power of Tasmania, the future looks equally bright with continual upgrades, innovations and enhancements.

The Great Lake and South Esk catchments

Consisting of three power stations - Waddamana, Shannon and Poatina - Hydro Tasmania has been generating electricity in the Great Lake/South Esk catchments since 1916.

The Waddamana Power Station was the first opened, followed by the Shannon power scheme, which was constructed between 1924 and 1931. A critical decision was made in 1957 to re-route the water flow from Waddamana and Shannon, to create a much longer drop. Implementing some of the most advanced engineering techniques available at the time, a fall of 830 metres was achieved with the opening of the Poatina Power Station.

The Derwent catchment

The enormous hydro power potential of the Derwent catchment area was identified early. Construction began in 1934, and the last major power station was commissioned in 1968. A further mini-hydro power station was added in 2004 at Butlers Gorge.

The Derwent catchment comprises an impressive ten power stations: Butlers Gorge, Tarraleah, Lake Echo, Tungatinah, Liapootah, Waytinah, Catagunya, Repulse, Cluny and Meadowbank. The upper section of the scheme uses large, deep lakes, which are used for water storage releasing water as required for generating electricity. The lower section works as a run-of-river system.

The Mersey Forth catchment

Development of the Mersey Forth catchment commenced in 1963 and was completed in 1973. A mini-hydro power station was added in 2002 at Parangana Dam. The catchment consists of eight power stations: Fisher, Rowallan, Parangana, Lemonthyme, Wilmot, Cethena, Devil's Gate and Paloona. With a combined generating capacity of 309 MW, Mersey Forth's power stations supply approximately 16 per cent of Tasmania's energy needs.

The Gordon catchment

The mighty Gordon Power Station is the only power station in this catchment, but what a power station it is. Not only is it the largest power station in Tasmania, but the development has also created Australia's largest water storage facility. The Gordon catchment accounts for an incredible 35 per cent of Tasmania's total energy storage capacity.

The Pieman – Anthony catchment

The Pieman – Anthony catchment is made up of four power stations: Mackintosh, Bastyan, Reece and Tribute. The catchment was developed in two stages with construction commencing in 1974. The first stage consisted of three power stations, five dams and a range of associated work. The second stage, which was completed in 1987, added another three dams and a power station.

The King - Yolande catchment

Commissioned in 1992, The King – Yolande catchment comprises two power stations, John Butters and Lake Margaret and two dams, including Crotty Dam, an 82 metre high concrete-faced rockfill structure on the King River.

Hydro Tasmania's hydro power stations

Power Station	Date(s) commissioned	Turbines	Capacity (MW)
Lake Margaret	1914	7 Pelton	8.4
Lake Margaret mini hydro	1931	1 Turgo	3.2
Tarraleah	1938-1951	6 Pelton	90
Butlers Gorge	1951	1 Francis	12.2
Tungatinah	1953-56	5 Francis	125
Trevallyn	1955	4 Francis	80
Lake Echo	1956	1 Francis	32.4
Wayatinah	1957	3 Francis	43
Liapootah	1960	3 Francis	83.7
Catagunya	1962	2 Francis	48
Poatina	1964,1977	6 Pelton	300
Tods Corner	1966	I Francis	1.6
Meadowbank	1967	1 Kaplan	40
Cluny	1968	1 Kaplan	17
Repulse	1968	1 Kaplan	29.1
Rowallan	1968	1 Francis	10.5
Lemonthyme	1969	1 Francis	51
Devils Gate	1969	1 Francis	60
Wilmot	1971	1 Francis	30.6
Cethana	1971	1 Francis	85
Paloona	1972	1 Kaplan	28
Fisher	1973	1 Pelton	43.2
Gordon	1978,1988	3 Francis	432
Mackintosh	1982	1 Francis	79.9
Bastyan	1983	1 Francis	79.9
Whitemark	1984,1994	4 Diesel	1.6
Currie	1985,1992	4 Diesel	4.4
Reece	1986,1987	2 Francis	231.2
John Butters	1992	1 Francis	143
Tribute	1994	1 Francis	84
Parangana mini hydro	2002	1 Francis	0.75
Nieterana mini hydro	2005	1 Francis	2.2

Total (MW)=

Hydro Tasmania's catchment areas



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Power Station

Gordon/Pedder

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