

GEOHERMAL ENERGY THE OPPORTUNITY





Foreword



New Zealand has a long and successful history in the development of geothermal resources. The earliest installation at Wairakei reflected the first such project in the world to exploit a wet geothermal resource – still operational this plant has provided a consistently reliable source of electricity for over 50 years.

We have shared this knowledge with the world and many of today's leading geothermal engineers and scientists were trained in New Zealand under the geothermal postgraduate programme run by the University of Auckland's world-leading Geothermal Institute. New Zealand continues to offer these world-class education opportunities in geothermal science.

With the recent successful completion of new geothermal plants in Kawerau, Ngawha, Nga Awa Purua and Te Huka, and the start of construction at Te Mihi and Ngatamariki, the New Zealand geothermal industry is in the midst of an exciting resurgence. A growing range of New Zealand organisations have been key contributors to this recent success providing world class scientific, engineering and construction services.

I am pleased to have this opportunity to endorse the collaborative efforts amongst these groups, who through Geothermal New Zealand are seeking to offer their services in a much broader role within large scale international developments. The story in the pages that follow shows not only the excellent standing that New Zealand has in the international geothermal community, but I believe also demonstrates our capacity to make an even greater contribution in what is clearly a rapidly expanding global market.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Tim Groser'.

Hon. Tim Groser
Minister of Trade



A surge in demand for renewable energy and increasing concern over energy security has focused international attention on **geothermal energy**. Current global geothermal generation is around 11,000MW. Estimates suggest this will more than double in the next 10 years – an investment of some US\$40 billion.

Geothermal energy offers a significant opportunity in markets such as the United States, Chile, Japan, Indonesia, Philippines, Kenya, Turkey and Germany. And a number of other countries are actively investigating geothermal as a reliable, cleaner alternative to the diminishing reserves of carbon based fossil fuels.

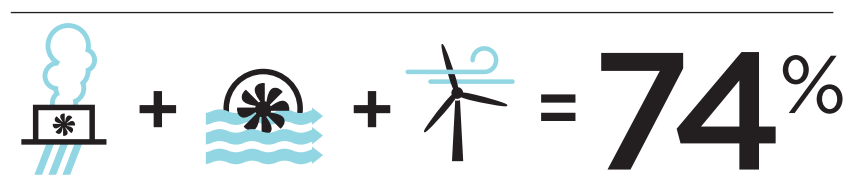


Kawerau

In 2010 renewable energy in the form of hydro, geothermal and wind generation accounted for an impressive 74 percent of New Zealand's electricity supply. With the aim of achieving 90 percent renewable electricity by 2025, New Zealand has recently commissioned new geothermal power plants; Kawerau, Ngawha, Nga Awa Purua and Te Huka.

These new plants have increased the country's geothermal generation to over 750MW, which met some 13 percent of national electricity demand in 2010. Investment of another NZ\$1 billion is enabling construction of plants at Ngatamariki and Te Mihi, adding 200MW of capacity and making New Zealand the fourth largest geothermal producer in the world.

There is growing interest from public and private utilities, corporations, and financial institutions to develop geothermal energy internationally. Many have significant power generation portfolios, but little or no geothermal experience. Close cooperation between [Geothermal New Zealand](#) and these groups is timely and mutually beneficial.



 **750** MW

Megawatt's raised by new geothermal plants; Kawerau ●, Nga Awa Purua ■ and Te Huka ▲

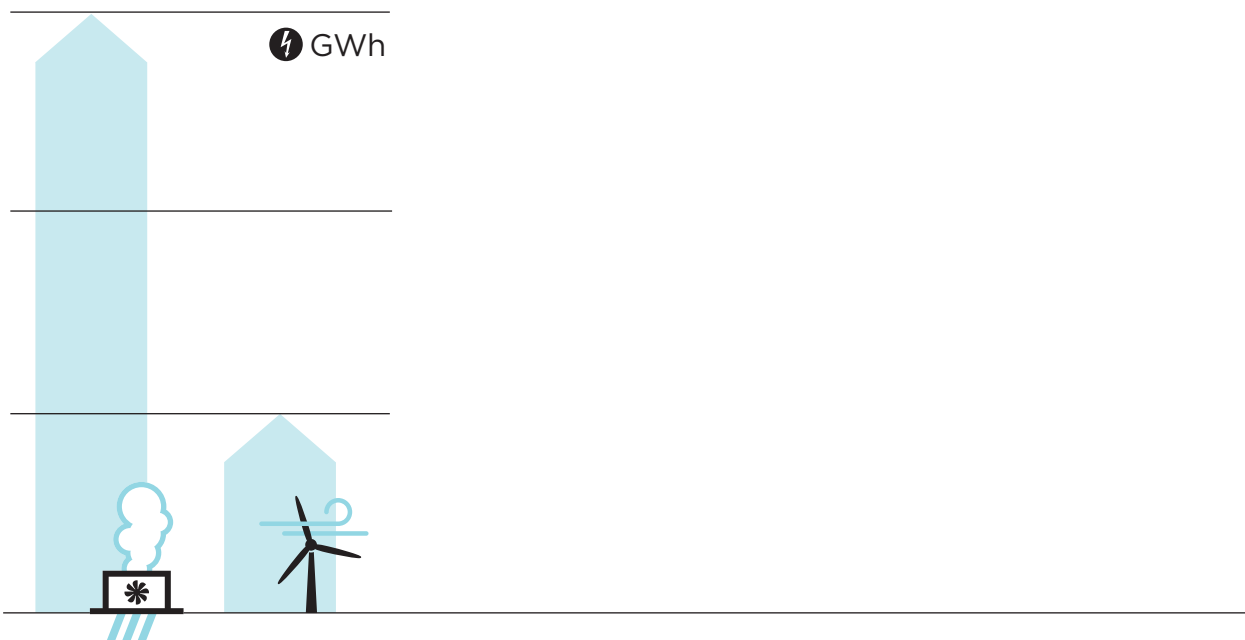


Clean, renewable and reliable

In addition to being clean and cost effective, geothermal energy offers large capacity plants with reliability unmatched by any other renewable energy resource. Drawing on heat from within the earth, it provides a consistent flow of energy day and night, in any climate, and in any weather.

Geothermal power stations have a capacity factor of almost 100 percent, producing around three times the energy of a wind farm of equal size (capacity). In a world of unstable energy prices, geothermal energy offers an almost untapped form of energy with a price largely fixed at the time of project commitment.

Geothermal power stations produce around three times more energy than a wind farm.





Nga Awa Purua



Case Study Kawerau

The Kawerau field is in the North Island of New Zealand. The field has been the site of the largest industrial direct use of geothermal energy in the world for over 50 years and that use continues to expand. The Kawerau Power Station is a 100-megawatt geothermal power plant which on its completion in July 2008 boosted the country's geothermal capacity by 25 percent and significantly increased local generation capacity.

The plant currently meets one third of residential and industrial demand in the region, and provides cost certainty to local industry. The Kawerau field is one of the largest in New Zealand. In addition to power generation, the field supplies process steam for the industrial wood fibre processing site which four companies share – Norske Skog Tasman, SCA Hygiene Australasia, CHH Tasman, and CHH Wood Products.

The steam is used for drying wood, the production of pulp, and the production and drying of paper and tissue products. Norske Skog Tasman is the largest user of geothermal heat for industrial use anywhere in the world. Efforts are underway to attract industry and businesses to Kawerau and other similarly active areas where they can tap into geothermal energy for direct use and for secure electricity.



⚡100^{MW}

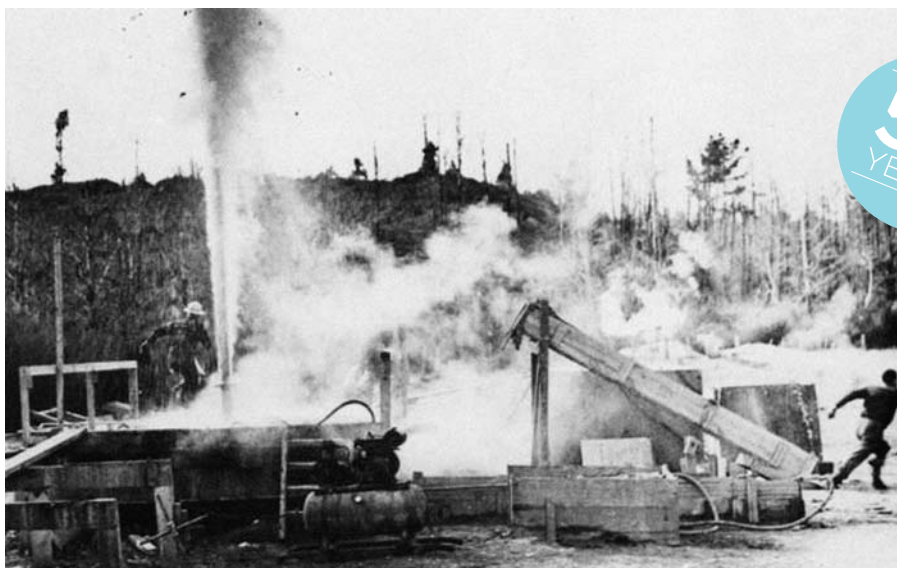
+25%

New Zealand

A pioneer in geothermal development

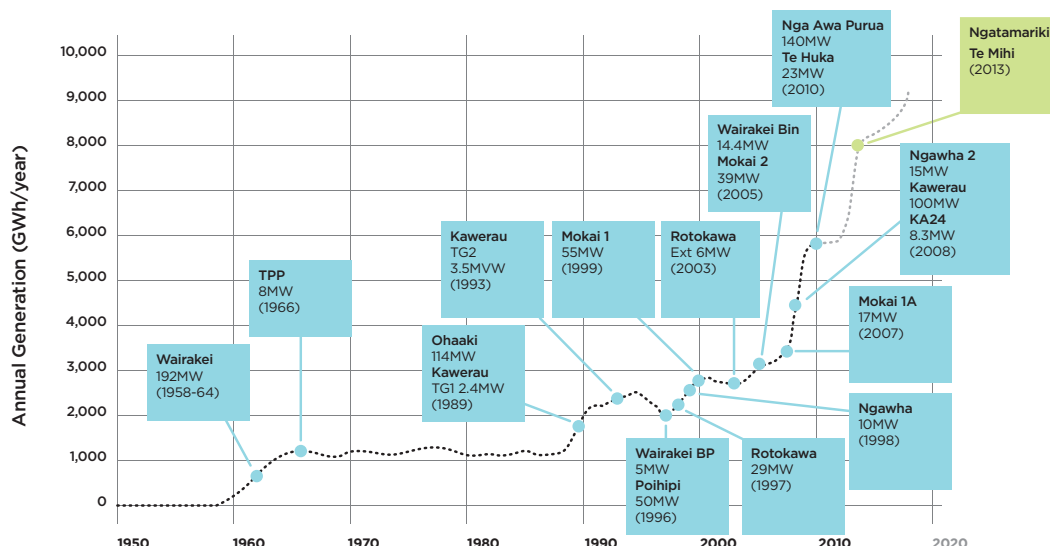
New Zealand's Wairakei geothermal power plant was the first in the world to generate electricity using a liquid-dominated geothermal resource. For 50 years Wairakei has provided the country's most reliable source of electricity.

As early adopters, New Zealand has had decades of experience harnessing geothermal energy. This has led to an innovative and world leading workforce, with experts in geothermal science and engineering.



Techniques and safety standards have improved significantly since the early 1950's but still present is the pioneering element exemplified by this early Wairakei photograph.

Geothermal Installations in New Zealand





Geothermal New Zealand

A collaborative approach

Geothermal New Zealand is an evolving collaboration that extends the diverse skills of New Zealand's geothermal expertise to countries exploring their geothermal potential. It also aims to open up opportunities for the direct use of geothermal resources within New Zealand.

The on-going contribution by New Zealand scientists and engineers in international geothermal exploration and development is well recognised. Under early United Nations Development Programmes (UNDP), New Zealand scientists led the exploration of a large number of fields internationally. The University of Auckland's Geothermal Institute became a widely acknowledged global centre for postgraduate studies in geothermal earth sciences and engineering and its recent re-opening has been welcomed by all within the industry.

Many of the earlier 800 graduates now fill senior positions in their country's geothermal programmes, working alongside New Zealand scientists and engineers. The "New Zealand" way is often a key element of project success.

New solutions for a new era

The new geothermal era brings demand for the highest standards of environmental protection, and engineering design and construction.

Other considerations include:

- a focus on reinjecting spent fluids
- increase in the depth and completion complexity of production wells
- growth in the scale of centralised generating plants
- finding effective models for small scale developments (in island nations)
- solutions for economically exploiting lower temperature resources

Additional considerations are those that come with any growing market such as:

- finding the most cost effective solution to quick resource confirmation
- minimising risk while accelerating the development schedule
- investors need for bankable feasibility studies and cost effective front-end engineering
- limited but growing involvement of private sector finance in geothermal projects
- the need for returns on geothermal investment which match those available through other energy sources
- a demand for scientific, engineering and construction skills in a resurgent market
- matching resources; scientific, engineering, manufacturing, construction, operations and maintenance, to drive the market ahead using world best practices and ensuring successful outcomes for all developments.

Meeting these challenges requires a combination of resources and a mix of national, foreign and multinational company contributions; an approach that resulted in the success of recent New Zealand projects. The aim of the Geothermal New Zealand initiative is to replicate this success internationally.

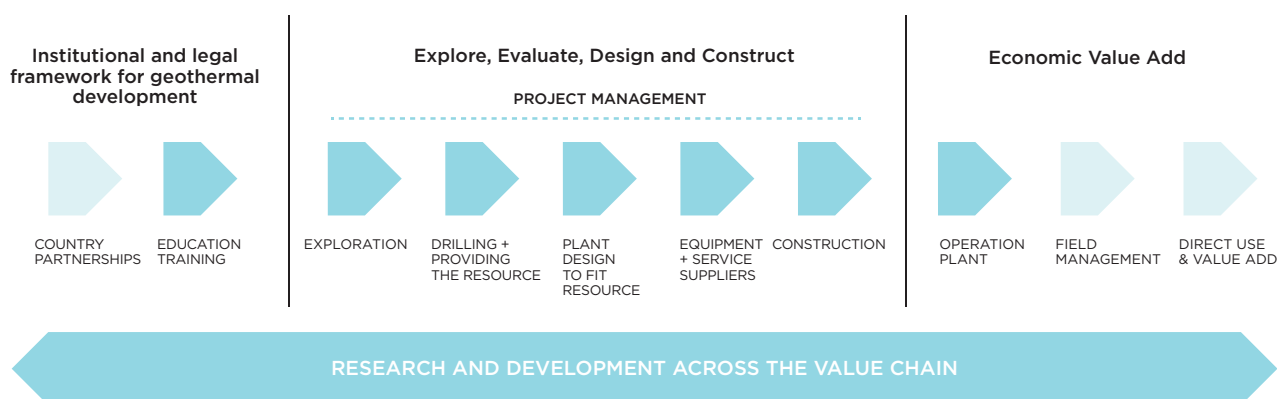
Geothermal New Zealand

Capable partners

Geothermal plants recently commissioned in New Zealand reflect world best practice and over sixty years experience in the industry. New Zealand engineering and construction experts worked with international equipment suppliers to deliver projects under budget, ahead of schedule and with performance exceeding design.

New Zealand scientists and engineers have been key contributors to many of the world's geothermal developments. Their expertise ranges from exploration, development and sustainable management to design, construction, operation and maintenance of plants. Our excellent reputation in applying geothermal energy for direct use in industry is backed by growing capabilities within our heavy engineering sector.

Geothermal New Zealand can introduce you to experts at every stage of a geothermal development, applying international best practices in exploration, resource confirmation, feasibility, design, procurement, construction, commissioning and operations.



Geothermal New Zealand

Brings expertise to any development

Education and training

- New Zealand pioneered geothermal generation in the 1950s, has maintained its activity domestically and internationally and built an outstanding reputation for its geothermal expertise around the world.
- New Zealand scientific and engineering skills have contributed to at least 2,000 MW of geothermal power developments internationally and to the identification of far greater potential resources.
- Our geothermal plants meet rigorous environmental standards under New Zealand's Resource Management Act and we carry these commitments with us to all projects, domestic and international.
- We have trained several hundred international earth scientists and engineers through the Geothermal Institute, who are now represented in every geothermal country.

Technical expertise

- New domestic plants represent global best practices from the application of exploration sciences, through feasibility, design, construction and operation.
- The heavy engineering sector is undertaking a number of equipment and process developments targeted at the more efficient utilisation of geothermal resources. There is a particular focus on binary cycle units as demand increases in smaller scale and lower temperature resource developments.

Geothermal New Zealand

Brings expertise to any development

Partnerships

- An essential element in developing New Zealand resources is that Maori, for whom geothermal has considerable traditional cultural and historic significance, are active development participants through innovative partnerships with developers, corporates and Maori trusts.
- The Tuaropaki Trust has pioneered large-scale commercially-based geothermal developments such as greenhouse and dairy plant businesses. Others have developed kiln-drying applications, which utilise specialist kilns developed and manufactured in New Zealand.

Industry growth

- New Zealand geothermal capacity is now some 750MW and will soon reach 1,000MW placing the country amongst the largest geothermal power producers in the world.
- Mighty River Power, one of New Zealand's major power utilities, has made a US\$250m commitment to international geothermal development through its cornerstone investment in GeoGlobal Energy LLC, with current projects in Chile, Germany and the United States.
- There are some 70 New Zealand companies with geothermal expertise across the value chain; from exploration and drilling through to design, project management, construction, and operation.

There is an online capability register of New Zealand companies active in geothermal energy: www.hera.org.nz



Case Study Contact Energy

Contact Energy is a world leader in geothermal electricity generation with extensive experience and expertise, owning and operating the Wairakei, Poihipi, Ohaaki and Te Huka geothermal power stations. Contact is currently constructing the 166MW Te Mihi power station and recently obtained consents for a 250MW development on the Tauhara geothermal field.

Part of the Wairakei/Tauhara geothermal system, the Tauhara geothermal field partly underlies the town of Taupo.

As is common in geothermal developments, extraction of fluid from the reservoir has caused subsidence including some subsidence bowls on the fringes of Taupo. To understand subsidence Contact commissioned an innovative 3D subsidence model linked to the reservoir model. Input to the subsidence model included pressure changes from the reservoir model, stratigraphy from the geological model, mechanical properties from core recovered as part of the subsidence drilling programme, and the results of surface levelling surveys.

The Board of Inquiry that heard the applications stated that the Tauhara ground subsidence investigation is probably the most detailed and comprehensive ever undertaken in a geothermal environment. The Board also noted that “modelling of subsidence in such detail in a geothermal system has not been attempted elsewhere as far as we know.” Contact proposed an innovative adaptive management approach to addressing possible further subsidence, which the Board accepted as the appropriate approach.



Case Study Nga Awa Purua

The Nga Awa Purua Geothermal Power Station, a joint venture between Mighty River Power and the Tauhara North No. 2 Trust, was opened near Taupo in May 2010. The project was completed ahead of schedule, under budget and with a greater capacity than originally planned. It houses the largest single shaft geothermal turbine in the world and with a capacity of 140MW will produce enough electricity to power 140,000 households.

The success of Nga Awa Purua was recognised at the inaugural Deloitte Energy Excellence Awards, where it was named Energy Project of the Year 2010.

“This partnership has gone beyond simply investing together. We have worked together at every single stage of the process in conceptualising the project and constructing this plant, and together we have built one of the biggest geothermal power stations to be constructed anywhere in the world in the past decade.”

Doug Heffernan, Chief Executive
Mighty River Power

“This project gives our people a significant stake in the long-term economic benefits of geothermal development. We’ve come from a place where we didn’t have any control over our assets and our land to one where we do have control over our destiny.”

Aroha Campbell, Chief Executive
of the Tauhara North No. 2 Trust



⚡ 140^{MW}

🏠 140,000

Research and Development

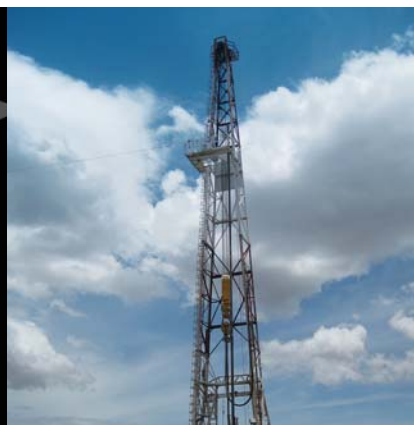
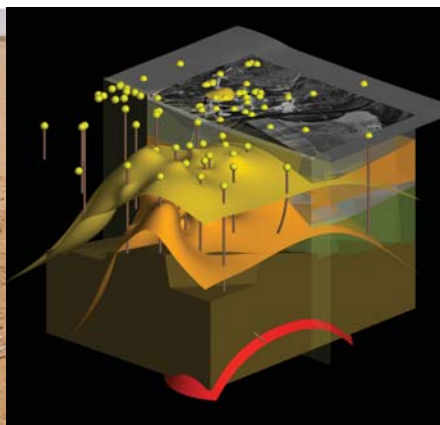
Geothermal R&D in New Zealand is intensifying to ensure the next generation of geothermal technology is aligned with the sector's current needs.

Programmes are currently underway with universities, Crown Research Institutes and a number of independent service providers. These programmes will provide high quality technical expertise for the sector's continuing growth.

Support from major geothermal developers in New Zealand anchors these programmes to the current and expected needs of “real-world” developers.

Geothermal technology innovations

The New Zealand geothermal industry has always sought new and improved methods of locating, developing and managing geothermal energy. Recent innovations include:



Joint Geophysical Imaging

Joint Geophysical Imaging (JGI) technology combines data from seismographs and other geophysical instruments. This information is analysed to locate optimum-drilling targets, which significantly lessens development risks and therefore costs.

Hydrothermal Geochemistry

Specialist equipment is now available to perform fluid rock interaction experiments at temperatures up to 400 degrees celsius and 500 bar. This equipment enables permeability, scale formation and fluid-rock interaction simulation experiments. Thermodynamic properties of minerals, the effects of inhibitors, fluid corrosion and tracer stability can also be evaluated at high temperatures and pressures.

Deep Borehole Observatories

A cable-less, down-hole seismometer and data acquisition array is available to help develop and manage a geothermal field. This new tool is capable of recording the faintest of seismic signals, perhaps the smallest ever detected in deep boreholes. In more standard applications micro earthquake monitoring networks track seismic locations related to fluid production and injection.

300 Degree Celsius Well Bore Formation Imaging

High temperature acoustic borehole imaging has been opened up to the New Zealand geothermal industry in the last two years. Interpretation specialists assess the captured data including image quality, structural orientation, density and aperture, structural dip, in-situ stress orientations and perform correlation with cut core, gamma logs and other available downhole data. This interpretation significantly improves the resolution and understanding of well bore and structural permeability.

3D Geothermal Modelling: Sophisticated Reservoir Simulator Development

Software tools have been developed for geothermal well-bore simulation, automated well test analysis and tracking geothermal tracers. Very fast solvers have been developed as part of the reservoir simulator as well as a range of visualisation tools to show the simulation results.

3D geological modelling

New Zealand has innovative visualisation software and geological models of geothermal resources. International industry participants adopting the software appreciate the ease of model construction and understand the benefits of visualisation of geology, structure and other resource data.

Government support

The New Zealand Government supports **Geothermal New Zealand**.

The Government recognises the opportunity for New Zealand companies to work offshore in the rapidly growing geothermal market. We have signed a number of international partnership agreements to share our renewable energy capabilities.

In particular the EDIN (Energy Development in Island Nations) agreement between the United States, New Zealand and Iceland, as well as recent Memorandums of Understanding with Mexico and Chile on collaboration in clean energy development.

The Government is in the process of applying for membership of the International Partnership for Geothermal Technology, which currently links the United States, Iceland, Australia and Switzerland. New Zealand is a key member of the IEA Geothermal Implementing Agreement.

We are exploring three distinct areas;

1. **Institutional Framework and training** – helping other countries develop the people, structures and processes required for sustainable geothermal development.
2. **Explore Design Build** – helping other countries to commercially develop their geothermal resources.
3. **Economic Value Add** – helping other countries to find ways to deliver greater economic value from geothermal e.g. in the development of downstream industries.

The Opportunities

The **Geothermal New Zealand**

initiative provides a more comprehensive and valuable level of support to the international geothermal market. The track record for New Zealand expertise is recognised globally and the quality and success of recently commissioned plants in New Zealand have set new standards.

The rapidly maturing global geothermal market, and the entry of a range of new players into this market, demand these standards be replicated wherever possible.

Geothermal New Zealand can provide innovative solutions in this new era of geothermal development.

If you would like to find out more information about **Geothermal New Zealand**

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