

## Fast Track Construction of Kawerau and Nga Awa Purua Geothermal Power Stations in New Zealand

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### ABSTRACT

Mighty River Power, one of New Zealand's largest power generating State Owned Enterprises (SOEs), is undertaking a major geothermal power expansion program with the aim of adding 400MW of new generation by 2013.

This program includes the development of the 90MW Kawerau powerstation which was completed in August 2008 and the 130MW Nga Awa Purua (NAP) powerstation which is on track for completion in early 2010. These projects are being undertaken on a 'fast-track' basis with the total program duration for design, consenting, construction and commissioning activities (for each project) to be completed within two years.

This paper primarily focuses on the power generating facility (PGF) developed within the 'fenced' boundary. Both PGFs have been undertaken by the same contracting team. This is led by the engineering, procurement and construction (EPC) contractor, Sumitomo Corporation (SC) of Japan with 'technical leadership' and the supply and installation of the generating and process equipment subcontracted to Fuji Electric Systems Ltd (FES) also of Japan. Hawkins Construction (HC) of New Zealand is the 'on-shore partner' responsible for the design and construction of the civil, structural, architectural and building services elements of the projects.

The relationship between the three companies is governed by a 'project agreement' which reflects the need for close collaboration in order to safely complete the plant to the required quality standard ahead of schedule.

This paper investigates aspects of these 'fast-track' projects from the perspective of Hawkins Construction (HC) with a special emphasis on the continuous improvement processes transferred from the first project (PGF) at Kawerau to the second NAP project PGF.

The author is a Project Director for Hawkins and has led the company's involvement in these geothermal projects.

### 1. INTRODUCTION

The proportionate share of Hawkins' involvement in the SC/FES/HC collaboration is approximately 20%. An analogous way to describe HC's contribution towards the overall project is to contemplate a painting. HC is responsible for the procurement and positioning of the canvas ensuring the artists—SC/FE—have adequate time to prepare and complete an outstanding product prior to HC locating the gallery where the painting will be shown.

From a program perspective, HC was awarded the Kawerau civil work subcontract in late November 2006 and was required to complete site investigation work, design, consenting and construction of the powerhouse facility by early October 2007 to enable installation of the FES supplied generating equipment, in accordance with the FES 'early completion' schedule. This target was achieved four weeks early. HC continued to assist SC/FES in other activities that facilitated the early completion of the overall project.

This paper will not only review the technical challenges associated with HC's work but will also provide an overview of the less tangible aspects of project implementation which have resulted in outstanding results on the first of these fast-track projects, and a continuation of these outstanding results on the current project. The client, MRP, has established a project culture, wherein all stakeholders are focussed on early completion of a quality project in a safe manner. The right people have been chosen for the project and dedicated to the project.

### 2. CREATING THE FRAMEWORK FOR SUCCESS

#### 2.1 MRP Position

In New Zealand power generation projects have, historically, been completed later than anticipated. With this precedent in mind—and noting that Kawerau was the first in a line of geothermal developments proposed by the client—MRP was keen to create an environment conducive to early completion. To achieve this there was an early alignment of project drivers for all project stakeholders.

This was manifested within MRP by:

An alliance style approach - From HC's perspective, MRP adopted an 'alliance' approach to the project choosing in-depth discussion and brain storming between all relevant stakeholders before reverting to a contractual stance. In this manner, problems that arose could be brought to the table for an open discussion—and debate—as to the optimal way forward. This expedited the effective resolution of many issues and was a key factor in early completion.

Incentivization - MRP established a scaled bonus arrangement for early completion worked up against the original contract 'taking over' date. This focused the EPC team on the financial benefits of early completion. This bonus was not available for early completion against an extended date for 'taking over'.

The People Factor - MRP staffed the project with capable and experienced people who contributed to the solutions of a number of technical—and less tangible—aspects of the project. They were also expeditious in their response to the numerous technical submissions that required their review.

Operations Input - The designated Operations Manager of the completed facility was appointed early and was able to observe, participate in and contribute to the development of the design and construction activities.

## 2.2 SC/FES Position

SC/FES tendered the EPC Contract in late 2005. Negotiation, review and refinement of the process design continued into 2006 with the EPC Contract signed in July 2006.

HC's introduction to the Kawerau Project occurred in late July 2006 with an initial pricing and technical review. These discussions and reviews continued for a further three and a half months as SC/FES process design—and the resulting HC civil design—evolved to a position where a subcontract was signed in late November 2006.

As with any new contracting relationship—in particular one that involves companies and personnel from differing countries—there is a 'bedding' down period when the culture, style and objectives of the participants are under the 'spotlight'. Fortunately, it became apparent, very early in the relationship, that there was recognition of the complementary skills and strengths of not only the organizations involved, but also the key personnel. The trust that was established early in the process was the foundation for the integrity of the combined on-going relationship, a cornerstone of the project success. Other key factors included:

The Project Agreement - this document formed the basis as to how SC/FES and HC interacted and behaved. An essential element was that HC carried the EPC liquidated damages risk for performance against the program. The agreement also embodied the requirement for the parties to co-ordinate closely and be timely in their response to other members' requirements.

The FES Team - FES displayed exemplary technical skills in meeting the challenges of the 'fast-track' project. Under the outstanding leadership of their Project Manager—Tadao Horie—they met all the challenges that faced them during design, construction and commissioning. Sheer, hard work was required to achieve the results and this was abundantly evident.

The Early Notification of the NAP Project - SC/FE entered into a Memorandum of Understanding (MOU) with MRP mid-2006 for the EPC role on the NAP Project and quickly confirmed that HC would be their 'on-shore' partner. This further cemented the relationship between the parties whilst the Kawerau project was in its early stages.

## 2.3 HC Position

There were a number of factors under the control of HC which directly contributed to the Kawerau project success. These included:

Project staffing - HC was able to mobilize an experienced and competent supervisory team that could respond to the challenges of the 'fast track' project. This team continually reviewed the program and methodology and responded, in a timely and thoroughly considered manner, with the optimal way forward. Long hours—often in the middle of winter—were required to ensure the powerhouse facility was completed to allow early installation of the FES equipment.

Design Team - HC was able to promptly assemble a knowledgeable team of consultants to design the civil and building elements (BECA), the building services elements (AECOM Maunsell). Tony Joyce also provided considerable input as Design Manager. All parties contributed to the alliance style adopted by MRP with a strong focus on 'best for project'—and early completion.

Local Community and Authority Input - The Kawerau District Council was highly supportive of the project and expedited, as quickly as possible, the review and approval of the numerous building consents that were required for construction to commence—and the code of compliance certificates necessary for the plant to operate. They also assisted with local resourcing and provided advice on a number of procurement matters.

Subcontractors -With the high level of risk and liquidated damages involved with the project it was essential that HC selected proven local subcontractors. These subcontractors were engaged very early in the project and participated in the design review and buildability studies.

## 3. PROGRAM AND IMPLEMENTATION

Key features of the program and implementation process at Kawerau included:

The Tender Process - The EPC Contract was competitively tendered by MRP on the basis of a FIDIC form of contract. The technical specification was outlined in the Employers Requirements(ER).In a similar manner, SC tendered the civil and building works with the decision to award the subcontract to HC being made in Nov 06. This process did not incorporate any front end engineering design (FEED) activity. This meant that the HC work effectively commenced from a 'cold start' which added a degree of difficulty to the tight program. HC overcame this obstacle through the early engagement of consultants and by entering into a lengthy and detailed dialogue with SC/FES on design and construction issues during the tender process.

The Target Program - Embodied within the SC/FES/HC Project Agreement was the concept of a target program with an aim being to complete the project in 100 weeks; four weeks ahead of the specified date of completion. The EPC team's planning and program efforts focused on the achievement of this program. Key milestones were established for the HC scope of works—eg the completion of the pedestal—and these were monitored on a weekly, and monthly basis. All practical steps were taken to achieve this program rather than considering contractual relief through extensions of time. This strategy worked!

Program & Co-ordination Methods - FES, as technical leader, established the overall project program on Microsoft Project incorporating the subcontractor programs. This overall program was updated on a monthly basis with major deviations noted together with agreed recovery action plans. It should also be noted, that the key program reviews were undertaken in the weekly co-ordination meetings chaired by the SC Construction Manager and attended by the representatives of the relevant organizations. All parties contributed to the success of this forum with robust, constructive debate on the best way forward. Issues were raised, debated and resolved in an 'alliance' environment.

Civil and Building Program Overview - From HC's perspective, the program was subdivided into four main phases described below and depicted in Figure 4.



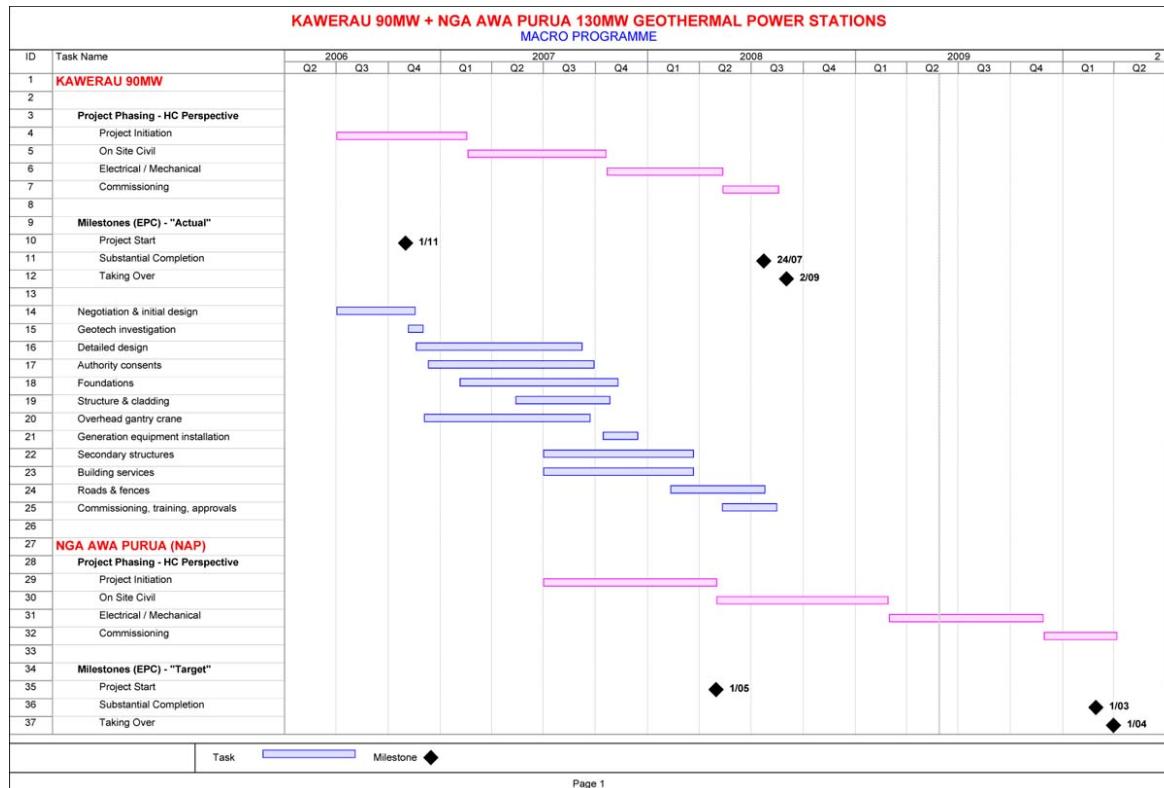
**Figure 1: Aug 07 - Aerial view of the Powerhouse Structure depicting the 'vertical' range of activities from the 14m deep U-Seal pit to the 25m high roof structure.**



**Figure 2: Feb 08 - View from the south-east edge of the cooling tower showing the extent of the mechanical erection in the steam separation area.**



**Figure 3: Oct 08-Aerial view of the powerhouse structure at NAP showing the increasing extent of precast and pedestal column construction.**



**Figure 4: Project programs for both Kawerau and Nga Awa Purua Geothermal Power Stations**

*Project Initiation* - This period covered the negotiation, geotechnical investigation, initial design, consenting with local authorities and site establishment. This was an intensely demanding time with large volumes of information transmitted, reviewed and actioned. It was further complicated through the geographic locations of the various teams (across Tokyo, Auckland, Wellington and Kawerau). However, there were benefits of operating in these different time zones: HC would forward information requests in the late afternoon New Zealand time and, with the time difference, FES was in a position to review and respond by the following morning. HC's design and construction team also was faced with the geotechnical challenges presented by a site with a variable subsurface subject to liquefaction.

*On Site Civil Phase* - HC had almost exclusive use of the site for a nine month period. During this period, the key focus was on preparation for the arrival of the FES generating equipment and cooling tower components. Close monitoring was required of the critical activities including the completion of the pedestal, erection of the powerhouse steel frame and cladding, and erection and commissioning of the overhead gantry crane. HC determined that the deep concrete structures—hot well and U-seal pits—would follow the completion of the main foundation block. This 'top down' method benefited the program, in that simultaneous activities could occur, with deep structures 14 m below ground being constructed in close proximity with structural frames 25m above ground. This approach necessitated considerable planning so that the works could be completed in a safe manner.

*Electrical & Mechanical Phase* - From the tenth month HC became the 'junior' partner in the project completing the secondary structures and, building services. SC's other subcontractors had priority of access with considerable co-ordination required to facilitate an effective operational environment for people and plant. This was particularly relevant for HC with regards to the complexity of completion of site roads and fences.

*Commissioning Phase* - There were a number of challenges that were successfully overcome by the team in the commissioning phase. During this period, operator training was completed and the code of compliance certificates attained. Significant amounts of pertinent information was developed and exchanged with MRP including as built/QA documentation/Operations and Maintenance Manuals.

Construction and Procurement Methods - The majority of structures on the project were conventionally constructed using on-site resources. Where possible, precast structures were utilised for walls and pits. This required the mobilization of a 250 tonne capacity crawler crane—which was also utilised by SC/FES for the erection of major plant and vessels.

Considerable use was made of the local Kawerau labor force (in particular—laborers and scaffolders). The Kawerau Council commented that this increase in employment enhanced the well-being of the town.

In relation to procurement, from the early stages of the project, HC negotiated and selected local area subcontractors with experience in major industrial projects. Additional attention was focused on those trades—cladding, painting air conditioning—which were critical from an H&S perspective.

#### 4. CONTINUOUS IMPROVEMENT

As noted earlier, HC was provided with confirmation of their involvement in the NAP Project mid 2007 with a planned start on site early—mid 2008. In a similar manner to Kawerau a target program was established with the intention of completing the Project in 100 weeks—six weeks ahead of the contract period.

There have been benefits through this early engagement of all parties, with everyone participating in a programmed continuous improvement process to increase implementation efficiency. This program includes:

Construction Planning - MRP required a stronger focus in the preparation of construction and work plans as part of the overall quality program. HC developed a matrix review process that covered all the elements — design, consenting, health and safety, construction, commissioning and certification—of the main areas of the civil and building work. This necessitated a thorough review of all the issues and has resulted in a more efficient and safe workplace with less labor.

Early Interaction with SC/FES - Immediately following the signing of the EPC Contract a team of HC personnel travelled to Japan and met with SC/FES to review and challenge the concept design. Numerous options were considered and key decisions made, enabling a streamlined start to the detailed design phase.

HC Management of the Geotechnical Investigations - MRP engaged HC to manage the entire geotechnical investigation program. This benefited MRP in that there was a clear delineation and transfer of the below ground risk; HC also benefited by having an extended period to study the optimum option for positioning the powerhouse foundations.

Lessons Learnt Sessions - A series of 'lessons learnt' workshops were held with HC personnel, design consultants, subcontractors and suppliers. A number of processes and structural concepts were challenged and options studied. For example, there was considerable study of the options for construction of the pedestal. At Kawerau, this structure was conventionally constructed using in-situ falsework, formwork, reinforcement and concrete. The team reviewed a number of options including precasting and post-tensioning the structure before concluding that the in-situ method was most suitable. Other areas that were challenged and 'improved' included:

Precast Usage - There was increased use of precast to reduce the requirement for on-site labor, to improve quality and to allow on-site—and off-site—activities to be undertaken concurrently.

Structural Concepts - Following consultation with FES, concept changes were made to the electrical annex and gas extraction.

Use of Post tensioning - The decision was made to post-tension the cooling tower basin to improve quality and to reduce the extent of the movement joints.

Pedestal Construction - The team considered that the powerhouse construction sequencing could be improved to enhance the health and safety environment. Less reliance was placed on the top down form of construction and the speedy completion of the pedestal columns became a top priority.

**Subcontractor Engagement** - HC enhanced its strategy of early engagement and involvement of the key subcontractors. Negotiated contracts were promptly established which facilitated input from the subcontractors in the design and buildability reviews.

**Interface Issues** - One of the successes of Kawerau was the management of interface areas across which a number of subcontractors were working simultaneously. As the 'first cab off the rank' HC made a conscious decision to increase its input into assisting SC with the management of these areas.

At the time of submitting this paper, there remain a number of obstacles to be overcome before the NAP Project is 'taken over' ahead of schedule. However, it is widely recognised that the continuous improvement program implemented by HC has been successful. Moreover, it is envisaged that further benefits will result through continuing this program on future Geothermal Projects.'

## 5. CONCLUSION

Historically, power generation projects in New Zealand have not been completed on time and have often been technically deficient in a number of areas. MRP has established a project culture, from their first major geothermal development, at Kawerau, wherein all stakeholders are focussed on early completion of a quality project in a safe manner. This culture has been underpinned by an 'alliance' philosophy where all issues and challenges are examined against a 'best for project' outcome. The right people have been chosen for the project and dedicated to the project. They have been responsible for supervising a hard working, dedicated team which has successfully responded to the constant challenges of 'fast-track' EPC implementation. Programs were monitored—and challenged—on a weekly basis with robust and open debate on the critical activities and a particular focus on the workability of interface areas.

The Kawerau project was taken over four weeks early in line with the original target program.

The same EPC team has been contracted for the larger NAP Project. At the time of preparing this paper, the project work is ahead of schedule. The civil and building work milestones have been typically completed two—three weeks ahead of the target program requirements with the application of

continuous improvement practices, a key factor in this current performance.

MRP have further geothermal projects in the planning stages and HC would welcome the opportunity to again demonstrate its ability to complete 'fast track' projects ahead of schedule.

## 6. NOMENCLATURE

EPC – Engineering, Procurement and Construction

FEED – Front end engineering design

FES – Fuji Electric Systems Ltd

HC – Hawkins Construction Ltd

H & S – Health and Safety

'Fast-track' – Implementation model where numerous interlinked activities are undertaken concurrently.

MOU – Memorandum of Understanding

MRP – Mighty River Power

NAP – Nga Awa Purua

PGF – Power generating facility

Target Programme – Early completion programme established by FES.

'Taking Over' – Date on which the plant is taken over by MRP Operations.

SC – Sumitomo Corporation

SOE – State Owned Enterprise (New Zealand Government established enterprises)

QA – Quality Assurance

## 7. REFERENCES

[www.hawkins.co.nz](http://www.hawkins.co.nz)