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Project Development of the Wayang Windu Unit 2 Geothermal Power Plant

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ABSTRACT

The development of the Wayang Windu Unit 2 Geothermal Power Plant in West Java, Indonesia, is described. From the commencement of production drilling activities in August 2006 the project achieved completion within 31 months. During this time the existing Unit 1, which is adjacent to Unit 2 with the turbine-generator housed in the same power plant building, continued to operate at full output with no interruptions.

The rating of the plant was reviewed during the detailed design phase to optimise the development for the specific conditions. While the initial concept was to implement as a repeat order of the Unit 1, 114 MWe (gross) plant built during the period 1997 to 2000 which has to date provided excellent service, the design was optimised to produce a 117 MWe (gross) concept.

The design and construction was accomplished as an Engineer, Procure, Construct (EPC) contract with the Sumitomo Corporation of Japan, with Fuji Electric of Japan and Rekayasa Industri of Indonesia performing the two main subcontracts for the power plant and the steam gathering system, respectively. Performance criteria, including specific steam usage per MWe, gross MWe output, and construction period were included in the contract, with penalties to deter non-performance, and incentives for early completion.

Safety, Health & Environmental (SHE) factors also featured as a key performance criterion and the EPC contract was implemented with no lost time accidents from the more than 3 million man hours worked.

Another key feature of the works was the need to employ local labour for all non-skilled activities, as part of the overall community development initiatives of the operating company, Star Energy Geothermal (Wayang Windu) Ltd. (SEG(WW)L), a subsidiary of the Star Energy Holdings Pte. Group. All local staff received a comprehensive induction program to ensure that they understood and could comply with the strict SHE guidelines.

Project management was led by an in-house team, and the Owners Engineer utilised existing SEG(WW)L staff who had intimate knowledge of the existing Unit 1 facility, together with key positions being provided by engineering consultants Maunsell. This concept ensured that experience would be built up within SEG(WW)L.

Financing for the project was based on conventional project finance from an international syndication of banks led by Standard Chartered Bank in Singapore. It is understood that this was the first international project finance to be placed following the Asian economic crisis of the late 1990s. While conventional, the terms of contract limited draw downs on the letters of credit to three main milestones, significantly simplifying financial controls within the project management group. Carbon credits were an integral part of the project financing and the project is in the process of seeking registration under the Clean Development Mechanism of the Kyoto Protocol.

1. INTRODUCTION

The Wayang Windu Geothermal Power Plant is located in the West Java province of Indonesia, about 150 km southeast of Jakarta and 35 km south of Bandung (Figure 1).

Figure 1: Wayang Windu Geothermal Power Plant.

The development of Wayang Windu Power Plant Complex, which was planned for 2 × 110 MW units was started on 1996. Following the financial crisis in Indonesia on 1997/8, the Government requested that the project be down-sized, completing only Unit-1 and other common facilities for two units. The Wayang Windu Unit-1 was first operated commercially in June 2000.

In 2006, Management of SEG (WW) L, decided to commence the development of Wayang Windu Unit-2 and so complete the original development plan.

2. DRILLING WORKS

The Wayang Windu Unit 2 drilling strategy was based on the assessment of existing proven reservoir that indicated the reservoir could support a development up to 247 MWe for 30 years of contract life. It was decided that the drilling of production wells for Unit-2 would be done at the existing wellpad MBD and two new wellpad MBA and MBB. It was planned to drill 10 wells with average target of 15 MWe per well.

Following completion of civil works, a drilling rig from Apexindo 5 arrived at site on 28 July 2006 and the first well, MBD-5, was spudded on 6 September 2006 and completed within 36 days.

The drilling program was considered to be successful, reaching the target steam of >140 MWe with 6 wells. The first well drilled at MBD-5 was the highest capacity well completed at Wayang Windu Geothermal Field producing 40 MWe. The average production from the 6 wells drilled was 24.5 MWe per well (Figure 2). An additional 2 wells were also drilled as Unit 1 make-up wells.

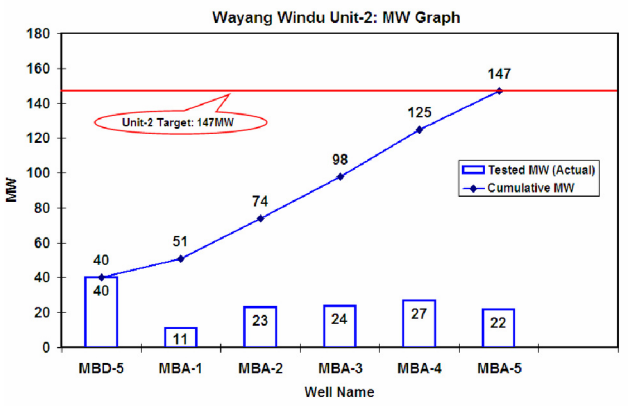


Figure 2: Summary of Unit 2 Steam Production Wells.

3. IMPROVEMENT AND OPTIMISATION OF THE DESIGN FOR WAYANG WINDU UNIT 2 POWER PLANT

During the preliminary design process there were two targets for the Unit 2 development: to improve the design of the existing unit, to increase operating efficiency, and to increase the output from the Unit 1 gross of 114 MWe.

3.1 Improvement of Unit 2 turbine design

The process of improvement was started with a review with the turbine designer, Fuji Electric of Japan, of the lessons learned from the (at that time) 7 years of operational history of Unit 1. The main issues that were identified for improvement to the Unit 1 design were corrosion at the high pressure (HP) stationary blade holders, corrosion/erosion at the rotor seal fins area, corrosion/erosion at the diaphragm holder face joint and corrosion at the low pressure (LP) stationary blade rings.

3.1.1 Corrosion at the HP stationary blade holders

The Unit-1 stationary blade holders were found to be corroded by the deposit of the boron product at the back side of these holders (Figure 3).

Figure 3: Corrosion at Unit 1 HP stationary blade holder.

The improvement that was agreed was to modify the design of the HP blade holder to avoid a deposition of the boron product at the back of these holders and adding an anticorrosion coating (WC-10Co4Cr) at that area (Figure 4).

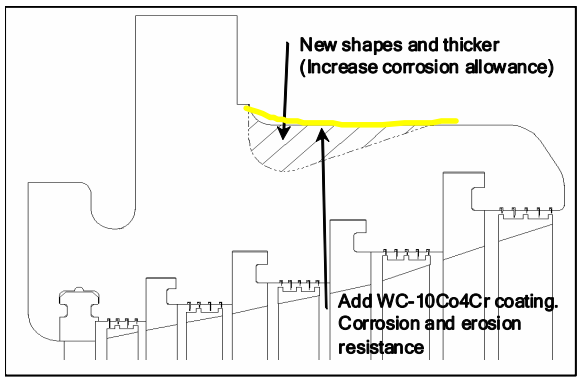


Figure 4: Modification of Unit 2 HP stationary blade holder.

3.1.2 Corrosion and erosion at the rotor seal fins area

The Unit-1 rotor seal fins area where corrosion and erosion were found (Figure 5).

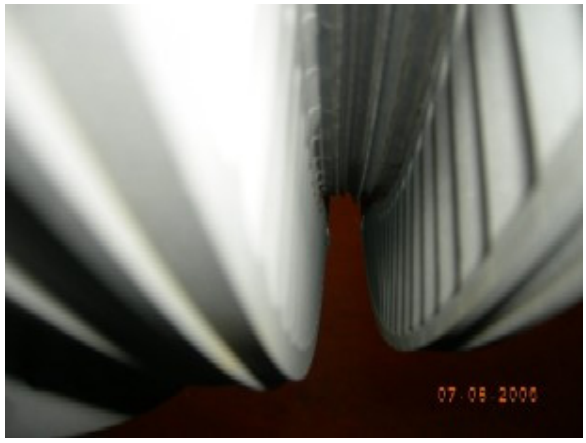


Figure 5: Corrosion and erosion at the rotor seal fins area.

The anticorrosion coating (WC – 10Co4Cr) is applied at the rotor seal fins area (Figure 6).

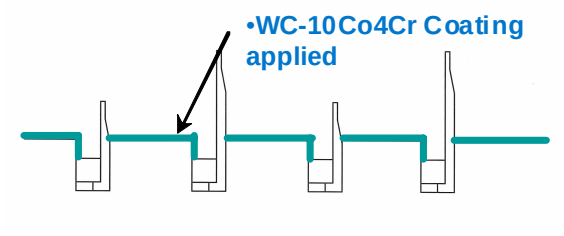


Figure 6: Anti corrosion coating applied at the rotor seal fins area.

3.1.3 Corrosion and erosion at the diaphragm holder face joints.

Corrosion and erosion are also found at the diaphragm holder face joint (Figure 7).

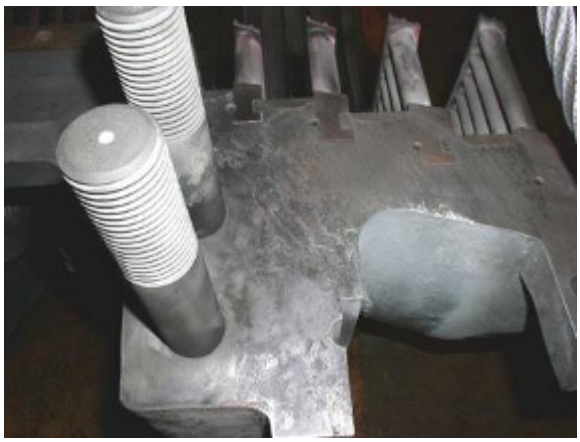


Figure 7: Corrosion and erosion at the diaphragm holder face joint

The Unit 2 diaphragm holder face joints were overlaid with stainless steel material of about 1 mm thick to avoid this problem.

3.1.4 Corrosion at the LP stationary blade ring.

It was found the Unit 1 LP stationary blade ring were corroded by the boron product deposition (Figure 8).

Figure 8: Corrosion at Unit 1 LP stationary blade ring

Material for Unit-2 LP stationary blade ring was changed to stainless steel material to avoid this problem.

3.2 Optimisation of Unit 2 design

Another objective of the Unit 2 design was to optimize the Unit 2 design to get the maximum power generation that can be achieved with the limitation of the development the Unit 2 at the existing facility. The optimisation that can be achieved to the Unit 2 design was focused on lowering the condenser pressure of the new unit. Refer to **"Design and Construction of Wayang Windu Unit 2 Geothermal Power Station"** WGC2010 paper by **Naoko Yamaguchi**.

4. ENGINEER, PROCURE AND CONSTRUCT CONTRACT FOR WAYANG WINDU UNIT 2 POWER PLANT

The development of Wayang Windu Unit-2 was contracted as a single turnkey EPC contract awarded to Sumitomo Corporation of Japan as the major contractor and Fuji Electric of Japan and Rekayasa Industri of Indonesia as major subcontractors for Plant Works and Steamfield Above Ground System (SAGS) Works respectively.

The EPC contract was signed on 30 January 2007 and the Limited Notice to Proceed (LNTP) was issued to the EPC contractor on 11 May 2007, which permitted the contractor to start their engineering works. The Final Notice to Proceed (FNTP) was issued on the 14 June 2007, thereby fixing the Performance Test Completion Deadline as 13 March 2009 (the Commercial Operation Date).

This 21 months schedule to complete the Unit-2 development was achievable because some critical materials for turbine and generator such as the turbine generator rotor; claddings for the condenser, and major civil works foundations were already available since the development of Unit 1.

Site mobilization for the Plant works was started at the end of August 2007 and the SAGS works on 17 September 2007 to start the construction works. While the construction activities generally run as planned, some initial obstacles occurred which resulted in the early phase of construction being behind the planned schedule.

Due to positive efforts by the contracting team, commissioning and testing of the SAGS and Plant was completed as schedule (Date of Commercial Operation) approximately 2 weeks ahead of schedule. Notably, it was possible to adopt an "Initial Service Test" for the SAGS pipeline. This was a significant improvement for the testing of the long and large (48" diameter) SAGS pipe line that previously required a hydrotest of the entire line.

4.1 Important milestones achievement for Wayang Windu Unit 2

SAGS Mechanical Completion was achieved on schedule at 13 December 2009.

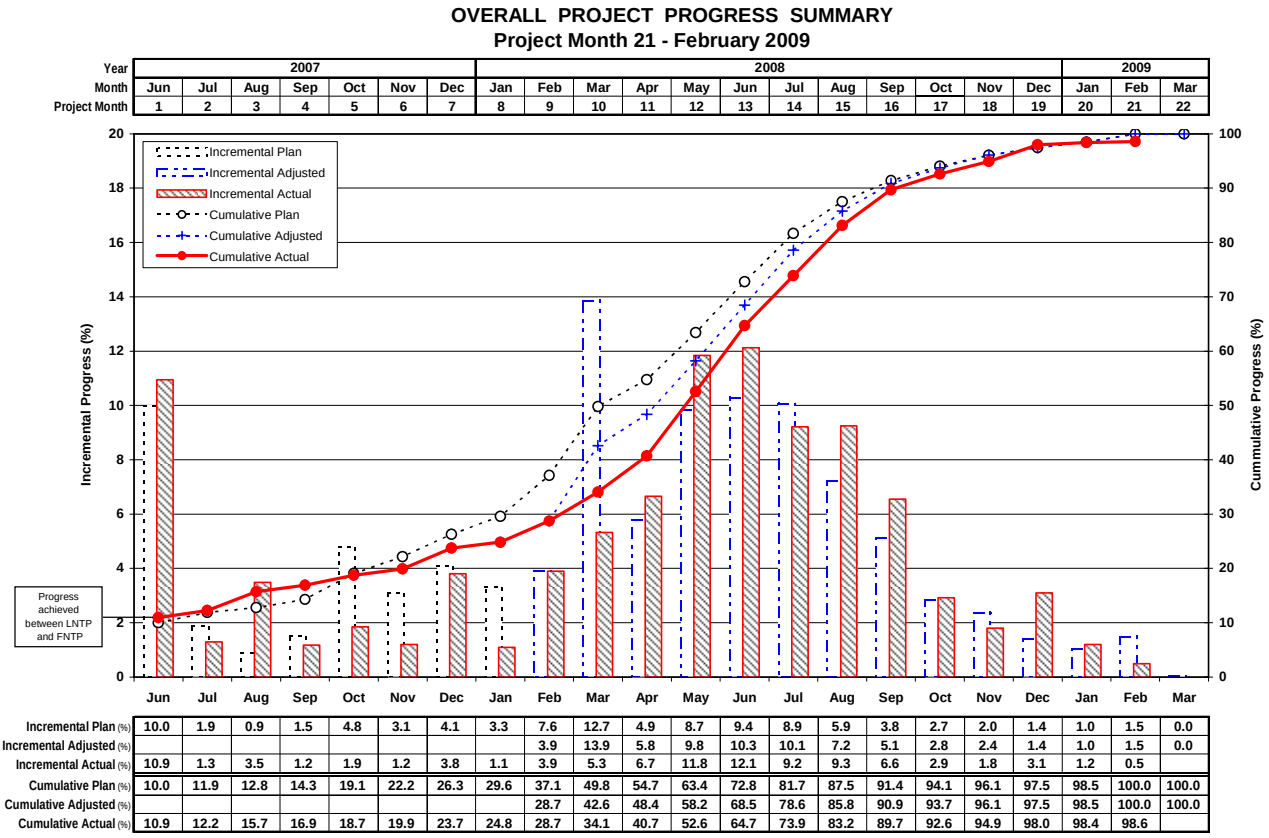
Backfeeding power from PLN system for power plant testing was done on 3 December 2008 and the Initial Synchronization of Unit 2 was done on 11 December 2008.

Plant Calibration, Testing and Pre-Commissioning was completed in January 2009 and the 3 days Maximum Continuous Running test was completed on 20 January 2009. The 28 days Reliability Run was completed on 17 February 2009 and the Performance Test on 27 February 2009. This achievement was 2 weeks ahead of the scheduled completion of 13 March 2009. (Figure 9). The Unit 2 Rated Capacity Test was completed on 2 March 2009 and accepted by Perusahaan Listrik Negara (PLN) and Pertamina Geothermal Energy (PGE) for commercial operation on the same day.

4.2 Wayang Windu Unit 2 Performance Test Result

Performance Guarantees for the EPC contract were set based on the Steam Rate and Net Deliverable Capacity for the Unit 2 performance and the Combine Performance of Units 1 and 2. The Combine Performance Test Guarantee is intended to check any interference from the new unit to the existing unit; the EPC contractor shall ensure that the new unit design does not influence the existing unit.

Other Guarantee items are Noise and H_2S emission levels during the performance test of the plants. This is intended to ensure that the operating units comply with the AMDAL (Environmental Impact Analysis) requirements to measure the impact of the project to the surrounding environment.



Year	2007							2008												2009		
Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Project Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Incremental Plan (%)	10.0	1.9	0.9	1.5	4.8	3.1	4.1	3.3	7.6	12.7	4.9	8.7	9.4	8.9	5.9	3.8	2.7	2.0	1.4	1.0	1.5	0.0
Incremental Adjusted (%)									3.9	13.9	5.8	9.8	10.3	10.1	7.2	5.1	2.8	2.4	1.4	1.0	1.5	0.0
Incremental Actual (%)	10.9	1.3	3.5	1.2	1.9	1.2	3.8	1.1	3.9	5.3	6.7	11.8	12.1	9.2	9.3	6.6	2.9	1.8	3.1	1.2	0.5	
Cumulative Plan (%)	10.0	11.9	12.8	14.3	19.1	22.2	26.3	29.6	37.1	49.8	54.7	63.4	72.8	81.7	87.5	91.4	94.1	96.1	97.5	98.5	100.0	100.0
Cumulative Adjusted (%)									28.7	42.6	48.4	58.2	68.5	78.6	85.8	90.9	93.7	96.1	97.5	98.5	100.0	100.0
Cumulative Actual (%)	10.9	12.2	15.7	16.9	18.7	19.9	23.7	24.8	28.7	34.1	40.7	52.6	64.7	73.9	83.2	89.7	92.6	94.9	98.0	98.4	98.6	

Figure 9: Wayang Windu Unit 2 Project "S" Curve (excludes drilling activities)

The Unit-2 Performance Test and Combine Performance Test were successfully completed. The result of the Net Deliverable Capacity is 1.4% higher than the guarantee value (119 MWe) and the Steam Rate was 1.5% lower than the guarantee value. The noise and H_2S emission are within the guarantee values.

5. SAFETY HEALTH AND ENVIRONMENTAL (SHE)

One of the key success factors for this project was the compliance to the SHE regulation of SEG(WW)L and the achievement of Zero Loss Time Accident during the project constructions. To achieve this within the EPC Contract activities, the approach was to standardize the SHE procedures that applied to the project execution and to ensure their strict implementation. The contractor was instructed to prepare comprehensive SHE procedures prior to start the site mobilization using the SEG(WW)L site procedures as the minimum standard of compliance. This approach was implemented to avoid confusion in implementing the SHE standard to the contractor and the operation and maintenance team that works at the same area.

Commitment and clear direction from the SEG(WW)L and Contractors also significantly contribute to the successful SHE implementation in this project. Regular joint SHE observations were performed by the high level management to reinforce the SHE implementation by the project team. 3.5 million man-hours without loss time accident (LTA) were achieved during Wayang Windu Unit 2 contract implementation. This excludes the accident-free activities of the Operation team during the same period (a combined total of approximately 6 million man-hours).

6. COMMUNITY DEVELOPMENT AND COMMUNITY RELATION

The other key feature of the works was implementation of a community development and community relations program. It was identified that this area could raise major issues during project execution, in particular the working opportunity for the local labor.

SEG(WW)L worked together with the Contractors to implement the community development programs during the project execution. All nonskilled workers were recruited from the local labor at the surrounding villages. A comprehensive induction program was implemented to ensure that the understanding and compliance to the strict SHE regulations that applied in the project.

Regular meeting and coordination among SEG(WW)L, Contractors, Local Governments, Police and Community Leaders became very effective to address the community issues during project execution.

There were no significant problems or demonstrations from the community around the project site during Wayang Windu Unit-2 execution.

7. WAYANG WINDU UNIT 2 PROJECT TEAM

Project management was led by an in-house SEG(WW)L team. The Owner's Engineer utilized some of existing SEG(WW)L engineers that had knowledge of the existing Unit 1 operation and maintenance. The engineering team was supported with the key personnel that being provided by engineering consultant (Maunsell Consulting Indonesia). The organization chat for this project is attached (Figure 10).

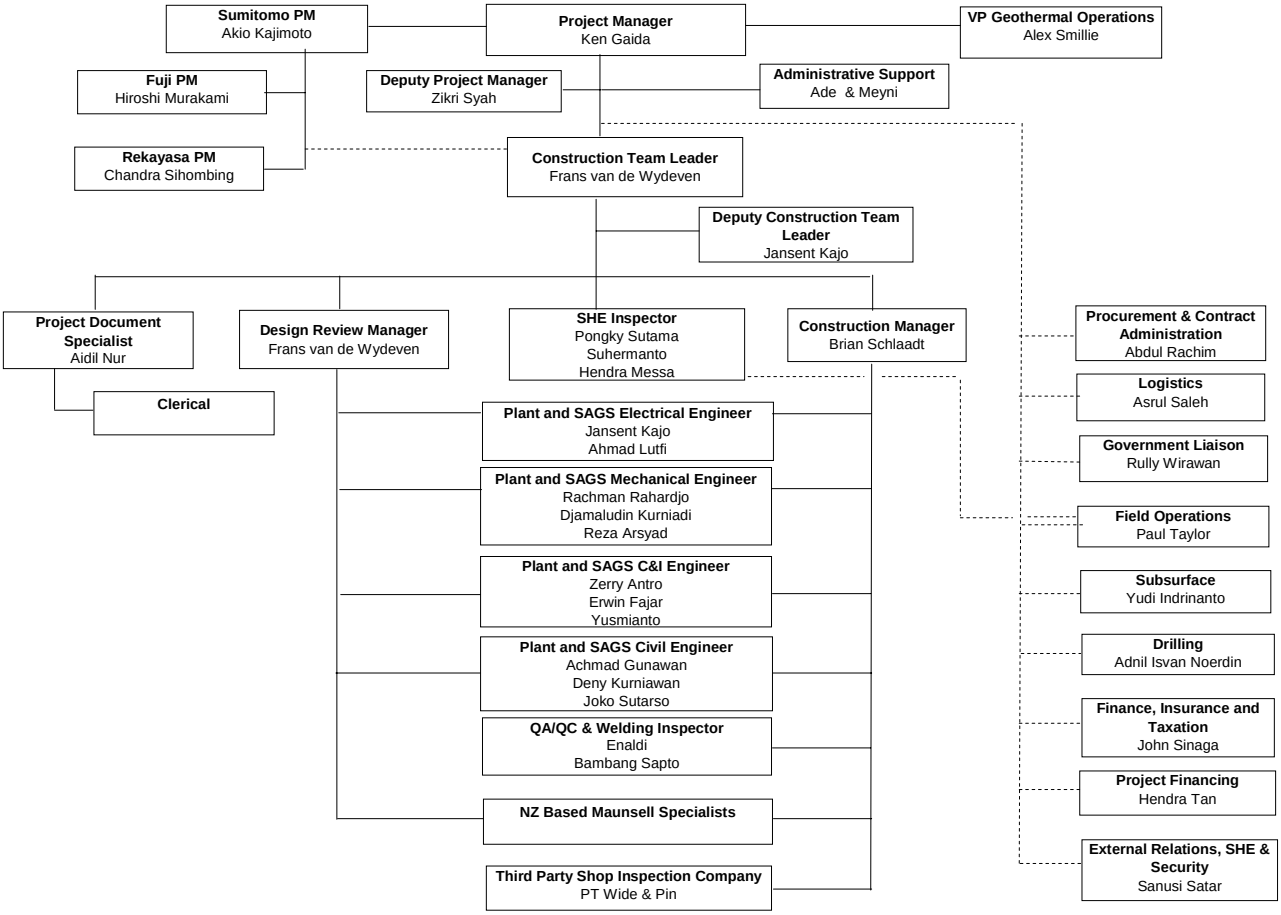


Figure 10: Structure of the Project Management Team

Support from the existing operation and maintenance team was also introduced during the installation and commissioning activities. Some specialists were hired from Indonesian engineers to strengthen the project team.

This approach was intended to optimise the learning/transfer of technology for the SEG(WW)L engineers, both in the project management process, and in the technical aspects, and retain the experiences within the SEG(WW)L.

8. CARBON CREDITS

8.1 General

In 1994, SEG(WW)L (formerly MNL) obtained the rights to utilize geothermal energy of up to 400MW(e) by developing and operating a geothermal power plant at Wayang Windu, West Java.

Based on the financial projections made between 2002 and 2005, SEG(WW)L identified the need to supplement the anticipated commercial earnings of the development to increase the rate of return to exceed the weighted average cost of capital (WACC) that will make the project economically viable. It was intended to achieve this by generating and trading Certified Emission Reductions (CERs) or "Carbon Credits" under the Clean Development Mechanism (CDM) provisions of the Kyoto Protocol. Hence activities commenced as early as 2002 in order to get the project registered with the UNFCC, and the project proceeded to implementation in the confidence that this would be achieved. Carbon credits were deemed to be an integral part of the Wayang Windu Phase 2 Project in achieving financial closure with the Standard Chartered Bank (SCB) in June 2007.

Currently, SEG(WW)L and Sindicatum Carbon Capital (SCC), as specialist consultants contracted by SCB, have prepared the Project Design Document (PDD) which, with the Letter of Approval from the Indonesian Designated National Authority (DNA), has been submitted to the UNFCCC following validation by TÜV SÜD of Germany.

8.2 Monitoring plan

As required by the UNFCCC, a detailed monitoring plan for CDM has been implemented to monitor the following variables:

1. Average mass fraction of carbon dioxide in the produced steam
2. Average mass fraction of methane in the produced steam
3. Quantity of steam produced
4. Electricity supplied by the project activity to the grid
5. Project Emissions
6. Quantity of diesel fuel consumed
7. Net calorific value of diesel
8. Weighted average CO2 emission factor of diesel fuel

Detailed SOPs have been prepared to control the monitoring process.

9. CONCLUSION

The development of Wayang Windu Unit 2 was successfully completed with all key success factors were achieved. The project was completed with performance of the unit exceeding the guarantee values, 2 weeks ahead of schedule with no lost time accident during 3.5 million man hours.

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