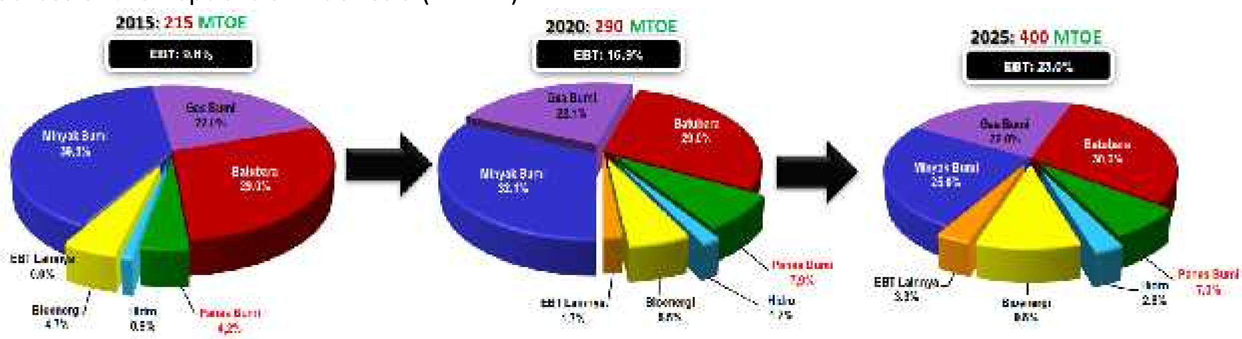
WP 1.05 Training modules for geothermal operators and inspectors for use by technical colleges

I. Introduction

Currently the demand for non-fossil energy in the world is getting large, it is based on the common awareness that would be a negative impact due to the use of fossil energy such as oil and coal. Indonesia is one of countries that known to have fairly large an environmental friendly energy resources, but unfortunately the use of energy is remain little. In Indonesia environmental friendly energy get into the group of new and renewable energy (EBT). One of energy programs owned by Indonesian government is trying to increase the use of renewable energy around 25% in 2025. Following projection are compositions of new and renewable energy up to 2025 by the Ministry of Energy and Mineral Resources of the Republic of Indonesia (MEMR).



From graphics above, one of new and renewable energy that utilized quite significant is geothermal energy. Based on studies conducted by MEMR, Indonesia has 67 geothermal areas (WKP) that spread in few islands in line with ring of fire. For the moment, only 9 WKP have been utilizing and producing electricity with total generated around 1.438,5 MW. In order to achieve target in Indonesia electricity acceleration programs, government has set up a geothermal road map program. In line with the program, there are 30 WKP are in exploration and exploitation states which planned to generate 3.210 MW. Geothermal road map program can be seen below,

Rencana Pengembangan	Status Juli 2015	Rencana Pengembangan (MW)												Total
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Tambahan Kapasitas (MW)	1,438.5	60	37	279	293.5	808.5	960	495	354	1,084	640	175	565	7,034.5
Investasi (Juta USD)	5,754	240	146	1,110	1,174	3,234	3,840	1,980	1,410	4,336	2,560	700	2,260	28,378
Serapan Tenaga Kerja (Orang)	4,315.5	180	111	837	880.5	2,425.5	2,880	1,485	1,062	3,252	1,920	525	1,695	21,283.5
Setara Produksi Minyak (BOE/YEAR)	6,191,505	258,248	155,253	1,200,655	1,263,265	3,475,897	4,131,974	2,130,549	1,523,665	4,665,637	2,754,649	753,224	2,431,839	30,535,718
CO2 Reduction	8,819,262	359,513	221,698	1,671,723	1,758,605	4,844,403	5,752,168	2,985,961	2,121,111	6,495,155	3,834,778	1,048,572	3,385,390	42,509,109

Keterangan:
1 MW = USD 4 Juta
1 MW = 3 Orang Tenaga Kerja
1 SBM = 1,626.2 KWh
Penurunan Emisi CO2 = Produksi Listrik (MWh) x Faktor

Assumption in the table is operation of 1 MW geothermal power plant requires three workers. Based on the assumption, demands of the geothermal power plant man power are about 21.284 workers until 2025 where around 30 – 40 % will be operator and inspector.

In general, operation of geothermal power plants similar with other types of steam generators such as coal power plant or nature gas power plant. The difference between them is the source of steam which used. Steam for geothermal power plants were taken from the subsurface of the earth, where the major composition of fluid is water vapor. Power generated from power plant were depended on quality of steam. Because of that one of the essentials in geothermal power plant operation is to maintain the quality of the steam from the well bore up to the generating facilities. The quality of the geothermal fluid includes temperature, pressure, vapor fraction, chemistry, etc.

According to reasons before, training modules about geothermal power plant operation are a necessity for field operators and inspectors. GEOCAP team were trying to build modules that can be used by geothermal field operators and inspectors. The modules would be contained knowledges about geothermal power plant operation techniques and expected to become a working guideline or reference. Institut Teknologi Bandung (ITB) was also taken part in GEOCAP team and ITB made a specific module. The module consists in two major topics, about thermal insulation and fluid measurement techniques. Both topics are important to understand because affecting to the quality of turbine feed steam. Thermodynamically in order to get a bigger generation power from steam turbine, geothermal fluids shouldn't lose their enthalpy during deliver from well bore to turbine. Heat is the biggest factor that affecting changes of fluid enthalpy, so that's why fluid pipe needs to be insulated from losing heat. Beside that operators and inspectors are expected to know about variation of fluid measurement gauges and their working principle. That knowledge can help power plant engineer to analyze and predict power plant performance in current and future conditions. Fluid measurement gauges that discussed in this module are temperature, pressure and flow meter gauges.

II. Main Objective

- The modules made to improve the basic knowledge of operators and inspectors in operating geothermal power plants.
- The modules were focused on thermal piping insulation and measurement techniques.

III. Involved Personnels:

Module writers	Advisors
• Agastyo Nugroho • Candra Mecca Sufyana	• Dr. Abdurrachim

IV. Module Syllabus

The module consists of 2 chapters

1. Chapter A: <u>Insulation Thermal Technique</u>
   Objective:
   1.1. Heat transfer
      1.1.1. Conduction
      1.1.2. Convection
   1.2. Heat loss on hot pipe
      1.2.1. Heat Rate
      1.2.2. Pressure drop
      1.2.3. True wetness
   1.3. Thermal Insulation
      1.3.1. Definition
      1.3.2. Objective
      1.3.3. Types and Properties of Thermal Insulation
         1.3.3.1. Thermal Properties
         1.3.3.2. Other properties
      1.3.4. Classification of heat insulator
         1.3.4.1. Based on function
         1.3.4.2. Based on temperature
      1.3.5. Insulation Technique
         1.3.5.1. Accessories
         1.3.5.2. Pre-insulation
         1.3.5.3. Insulation system
      1.3.6. Insulation design
      1.3.7. Inspection & Maintenance
         1.3.7.1. Inspection
         1.3.7.2. Maintenance
      1.3.8. Specification of insulator

2. Chapter B: <u>Techniques of Measurement</u>
   Objective:
   2.1. INTRODUCTION
      1.1.1. Background
      1.1.2. Objective
      1.1.3. Outcomes
   2.2. BASIC THEORY
      2.2.1. Physical Quantities
      2.2.2. Pressure
      2.2.3. Temperatures
      2.2.4. Mass Flow Rate
   2.3. MEASUREMENT TECHNIQUE
      2.3.1. Pressure
         2.3.1.1. Direct-Measuring Pressure Instruments
         2.3.1.2. Indirect-Measuring Pressure Instruments
      2.3.2. Temperatures

2.3.2.1. Bimetal
2.3.2.2. Thermocouple (GGL)
2.3.2.3. Thermometers (Mercury or Alcohol)
2.3.2.4. Photometry
2.3.2.5. Thermography
2.3.2.6. Infra Red

2.3.3. Mass Flow

2.3.3.1. Orifice Flowmeters

- Principle of Operation
- Types of Orifice Plates
- Machining Methods of Orifices
- Materials Chosen For Orifices
- Position of Taps in Orifice
- Installation
- Orifice Plate Calibrations
- Advantages of orifice plate steam flowmeters:
- Disadvantages of orifice plate steam flowmeters:
- Typical applications for orifice plate steam flowmeters:

2.3.3.2. Ventury Flowmeters

- Principle of Operation
- Classic Venturi Construction
- Types of Venturi Tubes
- Installation of Venturi Tubes
- Callibration of Venturi

2.3.3.3. Turbine Flowmeters

- Principle
- Working
- Advantages of turbine flowmeters:
- Disadvantages of turbine flowmeters:
- Typical applications for turbine flowmeters:
- Pitot Tube Flowmeters
- Principle
- Averaging Pitot Tube (Annubar)
- Advantages of the Pitot tube:
- Disadvantages of the Pitot tube:
- Typical applications for the Pitot tube:

2.3.3.4. Variable Area Flowmeters

- Basic Principle
- In practice, this type of flowmeter will be a mix of:
- Types of Variable Area Flow Meters
- Rotameters.
- Piston Type Meter.
- Performance Characteristics
- Rotameter-Elements

- Advantages of variable area flowmeters:
- Disadvantages of variable area flowmeters:
- Typical applications for variable area flowmeters:

2.3.3.5. Vortex Shedding Flowmeters

- Vortex Flow Meter Detection
- Features of Vortex Shedding Flow Meter
- Advantages of vortex shedding flowmeters:
- Disadvantages of vortex shedding flowmeters:
- Typical applications for vortex shedding flowmeters:

2.4. GENERAL DISCUSSION

V. Outcomes of meetings

	Date of Meeting	Participant	Affiliation	Outcomes	Place
1	3-Mar-15	Dr. Kees van den Ende	KEMA	• Discussion about budget planning WP 1.05 • Taxes calculation through LAPI ITB • Course wouldn't be held in 2015	Jakarta
		Dr.Savy Craig	KEMA		
		Dr. Abdurrachim	ITB		
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		
2	18-Mar-15	Dr. Kees van den Ende	KEMA	• Dr. Kees would go to Bandung on April 2015 to give lecture with Dr. Abdurrachim • Course material would be focused for advanced training • ITB was asked to make a simple curriculum for the course	Bandung
		Dr. Abdurrachim	ITB		
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		
3	30-Apr-15	Dr.Savy Craig	KEMA	• Training would be focused on: collecting data of operation failures, how to get the right data, and how to read and interpret data • Report would be collected in the end of 2015 • Budget for ITB couldn't be increased, but ITB could ask KEMA for extra budget • There was a meeting on August after IIGCE • ITB was asked to make a work plan	Bandung
		Dr. Ganesh	KEMA		
		Dr. Abdurrachim	ITB		
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		
4	29-Jun-15	Dr. Abdurrachim	ITB	• Discussion about course syllabus and material	Yogyakarta
		Prof. Syamsul Kamal	UGM		
5	30-Jul-15	Dr. Abdurrachim	ITB	• Visiting Kamojang Geothermal Power Plant	Garut
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		
6	18-Aug-15	Dr. Abdurrachim	ITB	• Discussion about course syllabus and material	Bandung
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		

7	21-Aug-15	Dr. Abdurrachim	ITB	• Discussion about course syllabus and material	Bandung
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		
8	24-Aug-15	Dr. Abdurrachim	ITB	• Discussion about course syllabus and material	Bandung
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		
9	5-Nov-15	Agastyo Nugroho	ITB	• Visiting Darajat Geothermal Power Plant	Garut
		Candra Mecca	ITB		
10	28-Jan-16	Dr. Abdurrachim	ITB	• Attending workshop about power plant efficiency	Jakarta
		Agastyo Nugroho	ITB		
		Candra Mecca	ITB		

VI. Cost Allocations

1.05 Operation and Maintenance Skills for Geothermal Power Plants								
Fee	Home-based (ITB)	ITB	96	3,840	96	3,840	100.0%	100.0%
Mission costs		ITB	-	1,201		1,201		100.0%
Total WP 1.05			96	5,041	96	5,041		100.0%