PERTAMINA

ENERGY TRANSITION IS A MUST, GREEN AND SUSTAINABLE

ENERGY RESOURCES ARE THE ULTIMATE SOLUTION

July 2022

PROFILE

Nama : Ardila Johan Erdiansyah

Riwayat Pekerjaan : **PT Pertamina Power Indonesia**

- Sr. Analyst II Maintenance Planning & Evaluation

PT Pertamina Geothermal Energy

- Sr. Engineer Maintenance Planning (2021 – 2022)
- Reliability Engineer (2019 – 2021)
- Engineer Operation Excellence (2016 - 2018)
- Electrical Construction Engineer (2010 - 2016)

Edc. Bgrd. : Master of Engineering Studies (2018-2019)

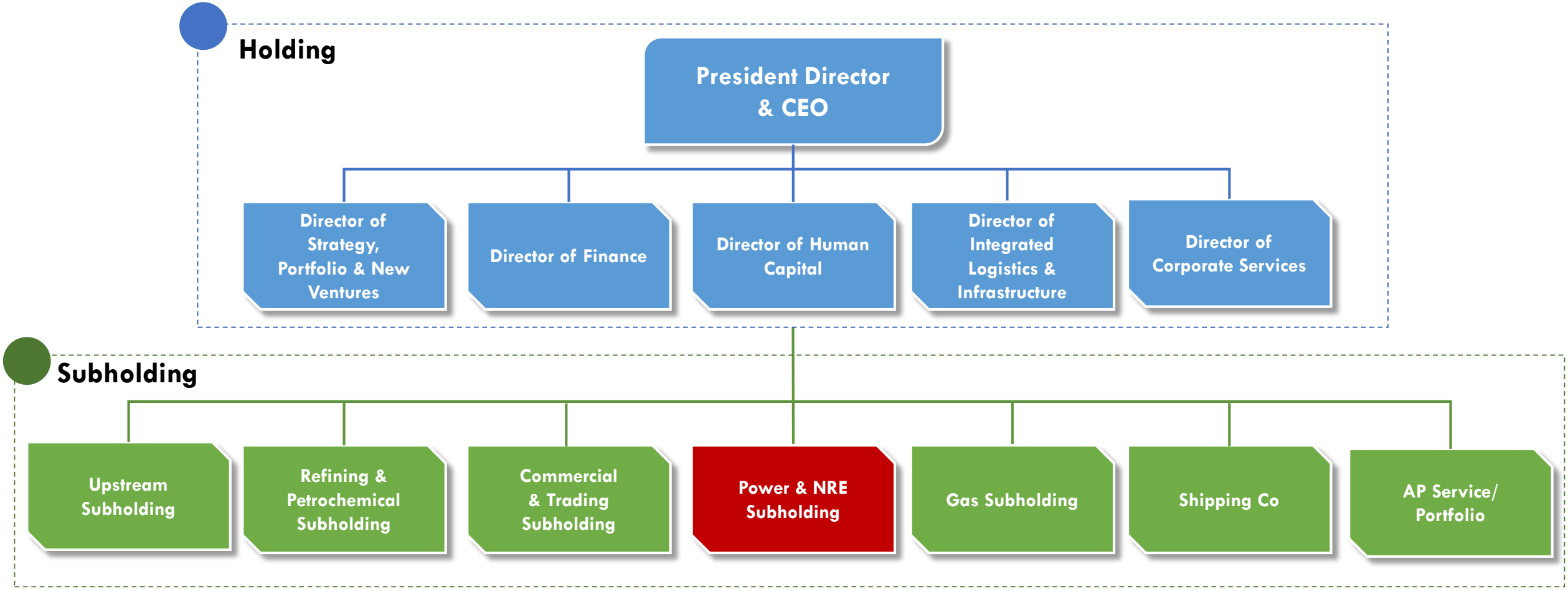
(The University of Auckland, New Zealand, Electrical Engineering)

Bachelor of Engineering (2005-2009)

(Institut Teknologi Sepuluh November, Electrical Engineer)

Subholding Power & NRE Prepare for Energy Transition…

Pertamina New Organization : Based on Letter of Decree: 18/C00000/2020-S0 dated June, 12 2020



Company Profile

PERTAMINA

100%

Indonesia

PERTAMINA

Sub-Holdings :

Power & NRE — PERTAMINA POWER INDONESIA

Subsidiary — PERTAMINA GEOTHERMAL ENERGY

Afiliasi — JAWA SATU POWER

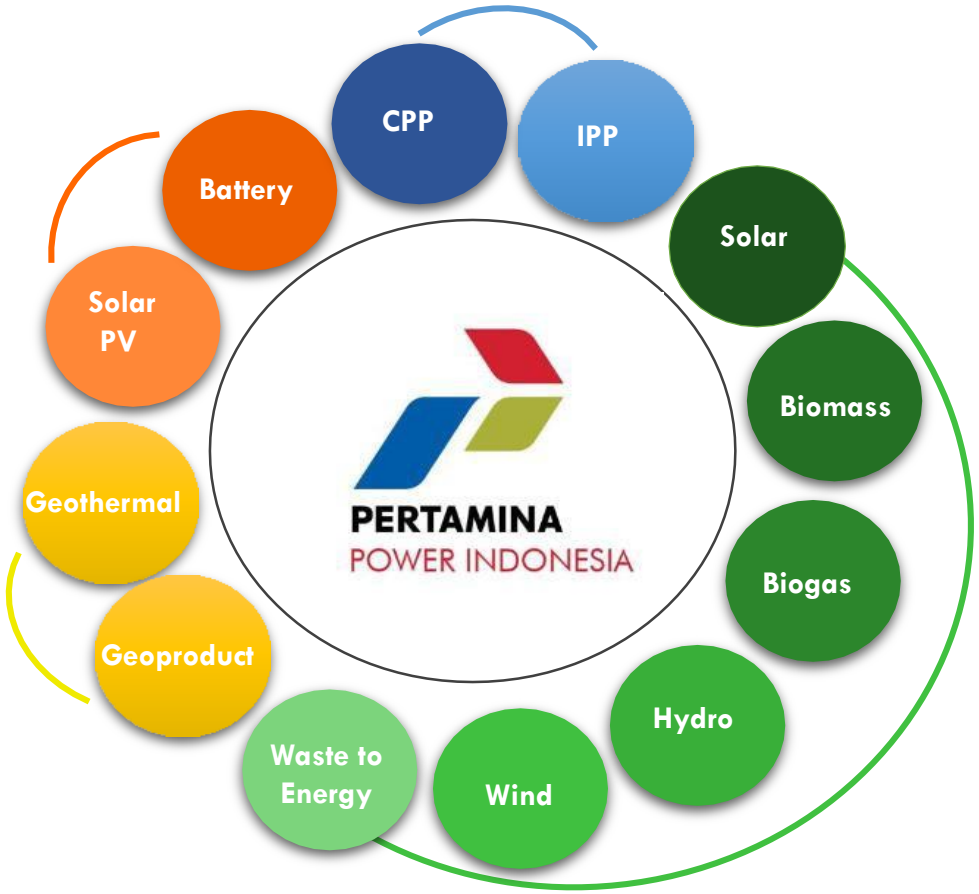
JAWA SATU REGAS

Vision

To become Indonesia's Green Energy Champion towards achieving net zero in 2060

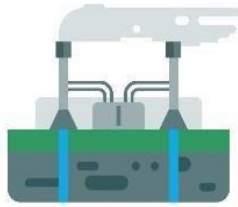
Mission

Leading Pertamina's energy transition via development of carbon solutions, new renewable energy, and building the future businesses in energy sector



Business Line

Gas to Power



Geothermal

Manufacturer

New Renewable Energy

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The Journey towards Energy Transition Through Innovative Clean Energy

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PLTBg Pagar Merbau **1 MW** (O&M)

Seeulawah (Expl)

PLTBg Sei Mangke **2,4 MW**
PLTS Sei Mangke **2 MW**

Ulubelu **220 MW**

PLTS Badak **4 MW**

Lahendong **120 MW**

PLTBg Kwala Sawit **1 MW** (O&M)

Sibayak **12 MW**

PLTS Dumai **2 MW**

Sarulla **330 MW**

Sungai Penuh **55 MW**

Hululais (Dev) **2x55 MW**

Cibeureum Parabakti **377 MW**

Darajat **271 MW**

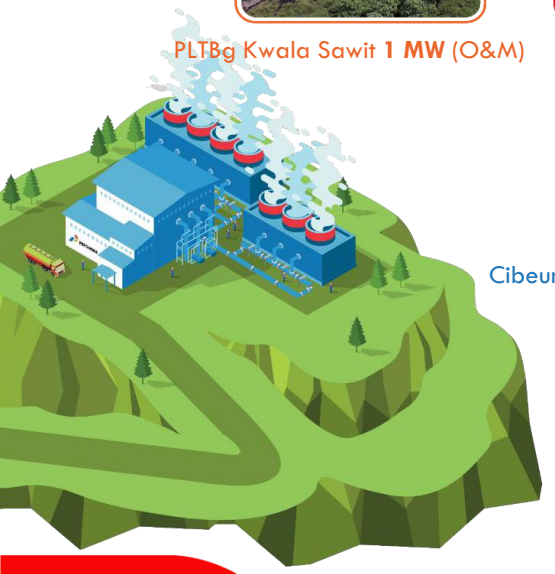
Lumut Balai **1x55 MW**
Lumut Balai **2x55 MW** (Dev)

PLTS PTPR (Jabodetabek, Jateng, Jatim) **0,39 MW**

Pengalengan **227 MW**

Gn. Lawu (Expl) - Relinquishment Process to Goverment

Bedugul



Karaha **30 MW**

Kamojang **235 MW**

PLTS Cilacap **1,4 MW**

IPP Jawa Satu **1760 MW** (Construct)

JV PPI : **40%**
Marubeni : **40%**
Sojitz : **20%**

- PGE Own Operation (**672 MW**)
- PGE Exp&Dev Project (**495 MW**)
- PGE – JOC (**1.205 MW**)
- PPI Operation & Dev(**1174,15 MW**)

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Power & NRE Business Group

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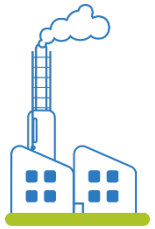
PT Pertamina (Persero) has established a Power & NRE Subholding (PNRE SH) of which the operation is handled by PPI and PGE to manage Power and New & Renewables Energy (NRE) including geothermal business activities. PNRE SH is expected to ensure business excellence along the value chain of new & renewable energy, geothermal, and low carbon solutions, including increasing productivity through reliable & efficien operation, and accelerating business and capability development in the partnership and financing to maintain the sustainability of energy business in the present and the future.



Low Carbon Solutions

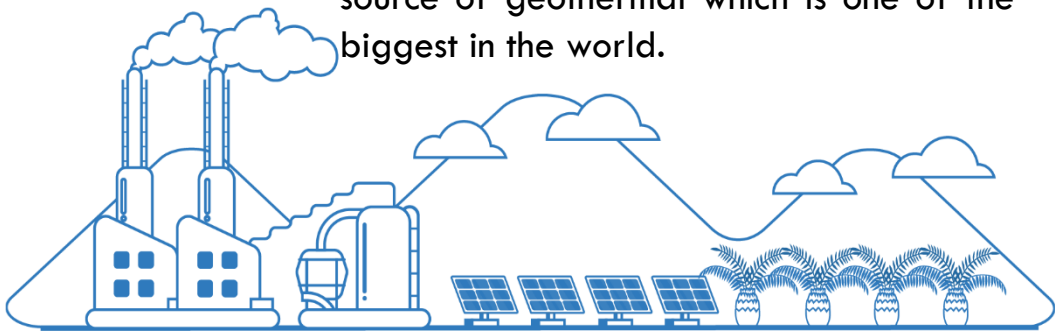
Gas Fired Power Plant uses natural gas to produce clean energy with the lowest carbon emission amongst other fossil fuel resources. Currently we are developing an IPP Jawa-1 project which integrates the gas facilities into a power plant project, consisting of 1.760 MW Combine Cycle Gas Turbine (CCGT), the FSRU, the gas pipeline that connects the CCGT and the FSRU, and the transmission lines that connect the Power Plant with interconnection points.

New & Renewable Energy

Pertamina Subholding Power & NRE carried out various initiatives related to the development of Renewable Energy, including the installation of Solar PV as a solar module-based renewable energy power plant and Biomass/Gas power plant in various regions in Indonesia.

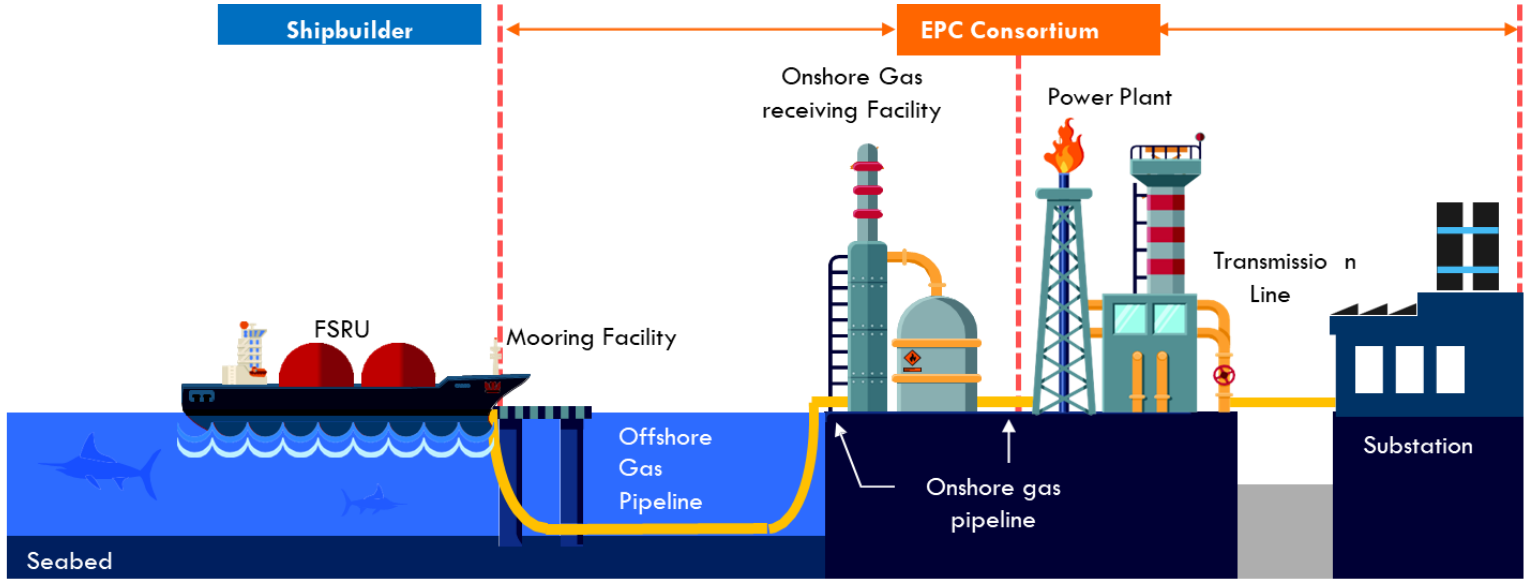
Geothermal

Through Pertamina Geothermal Energy, we already have 672 MW installed capacity of geothermal power plant in various locations in Indonesia. Geothermal is one of the cleanest sources of energy, where Indonesia has 24 GW potential source of geothermal which is one of the biggest in the world.



IPP Jawa-1 - Gas to Power Project

The first integrated power plant in Asia and the largest in Southeast Asia that combines the LNG business (FSRU) and IPP business (PLTGU/Combined-Cycle Gas Turbine)



Type of Plant	Combined Cycle Gas Turbine 1760 MW FSRU 170,000 m^3 with capacity of 400 mmscfd
COD	Q2 2022
Location	Cilamaya, West Java, Indonesia

Scheme	BOOT IPP & FSRU
Off-taker	PLN (national power utility)
PPA Term	25 years
Total investment	USD 1.8 billion
Consortium	Pertamina (Leader) Marubeni (Co-Leader) Sojitz (Member)

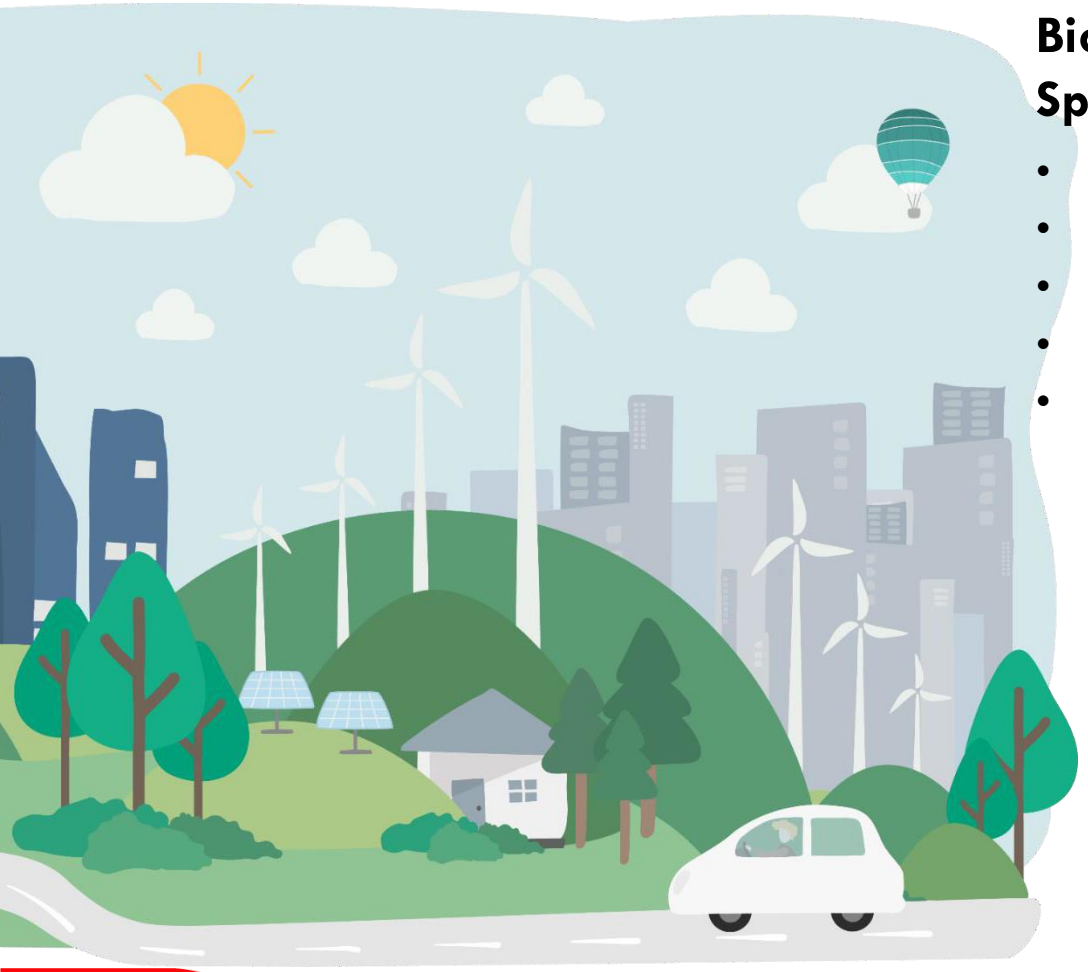
Pertamina Power Indonesia Committed to Maximize Renewable Energy Development

Solar PV Plant – Badak, Kalimantan Timur 4 MW

- Installed Capacity **4 MWp**
- Annual Electricity Generation **3.1 GWH**
- Annual GHG Reduction* **123.2 tCO2e**
- Design Facility **>25 years**
- Capacity Factor* **15.4%**

** Estimate Average*

Pertamina Power Indonesia Aim Sustainable Energy Business and Special Economic Zone Developments



Biogas Plant – Sei Mangkei, North Sumatera, Special Economics Zone 2.4 MW

- Installed Capacity **2.4 MW**
- Annual Electricity Generation **11.32 GWH**
- Annual GHG Reduction* **11,288 tCO2e**
- Design Facility **>20 years**
- Capacity Factor* **90%**

** Estimate Average*

Pertamina Power Indonesia Seeks Collaboration With Partners To Develop Renewable Project

- Installed Capacity **2x1 MW**
- Annual Electricity Generation **12.6 GWH**
- Annual GHG Reduction* **10,787 tCO2e**
- Design Facility **>20 years**
- Capacity Factor* **90%**

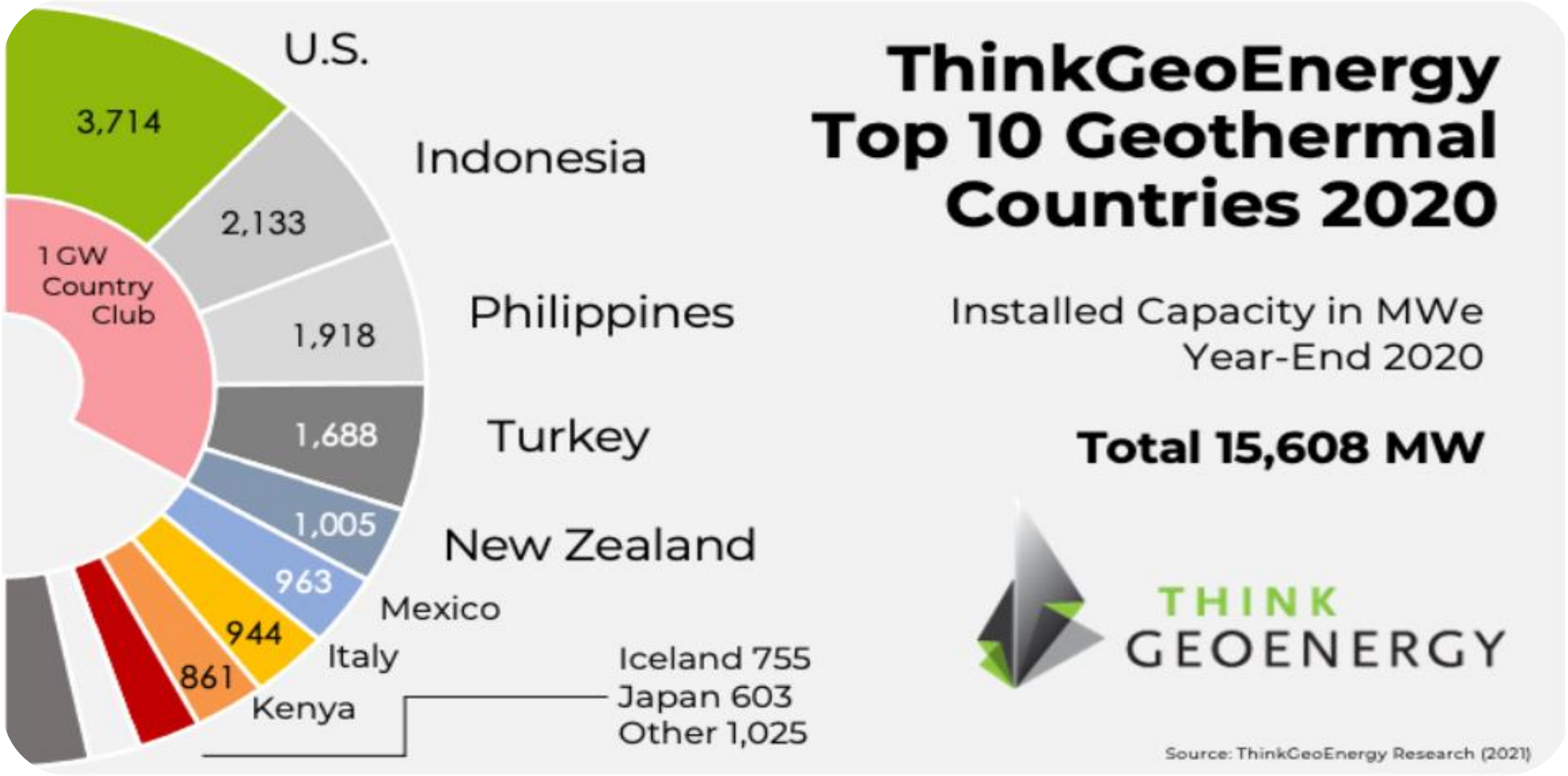
** Estimate Average*

Biogas Plant
Kwala Sawit 1 MW

Biogas Plant
Pagar Merbau 1 MW

Overview

World Largest Total Installed Capacity - 2020



Overview

Geothermal Power Plant in Indonesia

Geothermal Power Plant - its Positioning, Developers and Location

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PLTP in Indonesia - Positioning

1. Geothermal Installed Capacity **2.133 MW**
2. % Geothermal Installed vs Potential Resources **8,9%** **(2.132 MW VS ± 24 GW*)**
3. % Geothermal Installed vs Country Total Installed **3%** **(2.132 MW VS ± 70 GW**)**

* Geological Agency MEMR (Dec 2019)

** MEMR (Nov 2020)

PLTP in Indonesia and its Developer

Developed by PGE — 672 MW

1. Kamojang (235 MW)
2. Lahendong (120 MW)
3. Sibayak (12 MW)
4. Ulubelu (220 MW)
5. Karaha (30 MW)
6. Lumut Balai (55 MW)

Developed by JOC PGE — 1.205 MW

1. Wayang Windu (227 MW) - SE
2. Darajat (271 MW) - SE
3. Gn. Salak (377 MW) - SE
4. Sarulla (330 MW) - SOL

Developed by Others — 256 MW

1. Patuha (55 MW) - GDE
2. Dieng (60 MW) - GDE
3. Ulumbu (10 MW) - PLN
4. Mataloko (3 MW) - PLN
5. Muara Laboh (85 MW) - Supreme
6. Sorik Merapi (42,3 MW) - SMGP

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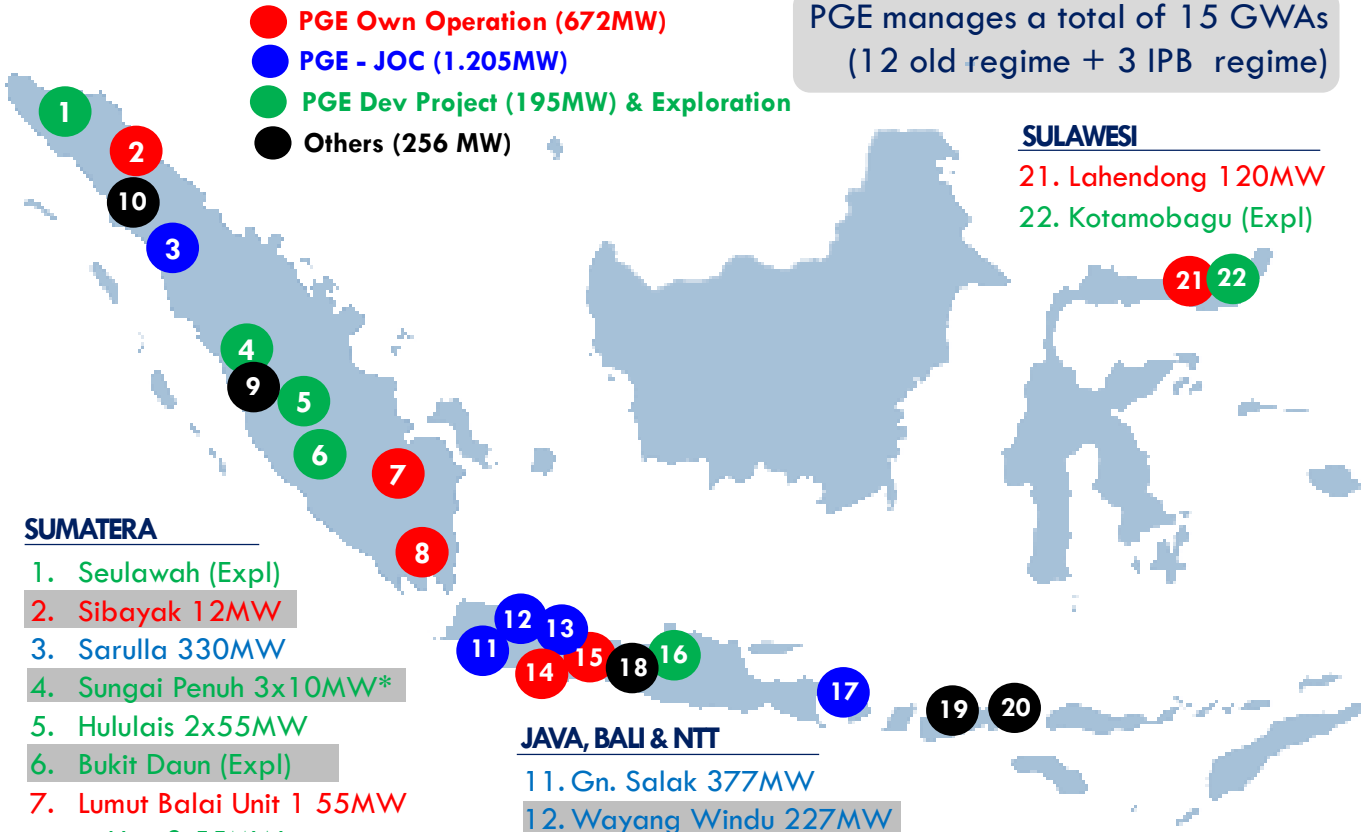
PLTP in Indonesia's Geothermal Working Area (GWA)

PGE manages a total of 15 GWAs (12 old regime + 3 IPB regime)



SUMATERA

1. Seulawah (Expl)
2. Sibayak 12MW
3. Sarulla 330MW
4. Sungai Penuh 3x10MW*
5. Hululais 2x55MW
6. Bukit Daun (Expl)
7. Lumut Balai Unit 1 55MW + Unit 2 55MW
8. Ulubelu 220MW
9. Muaralaboh 85MW
10. Sorik Merapi 43MW

**FID 55MW*

SULAWESI

21. Lahendong 120MW
22. Kotamobagu (Expl)

JAVA, BALI & NTT

11. Gn. Salak 377MW
12. Wayang Windu 227MW
13. Darajat 271MW
14. Kamojang 235MW
15. Karaha 30MW
16. Gh. Lawu (Expl)
17. Bedugul
18. Dieng 60MW & Patuha 55MW
19. Ulumbu 10MW
20. Mataloko 2,5MW

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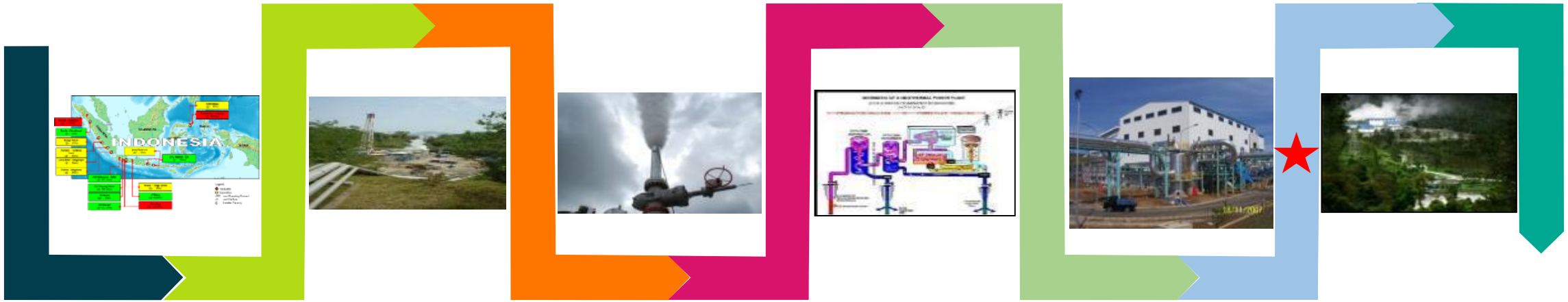
Project Sustainability Sample - Geothermal



2-3 Years

3-5 Years

>30 Years

Hundreds million USD cost

Cent by cent sales

Important role : maintenance planning and evaluation

- Should be efficient
- No mistakes

PGE Geothermal Plant

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KAMOJANG

ULUBELU

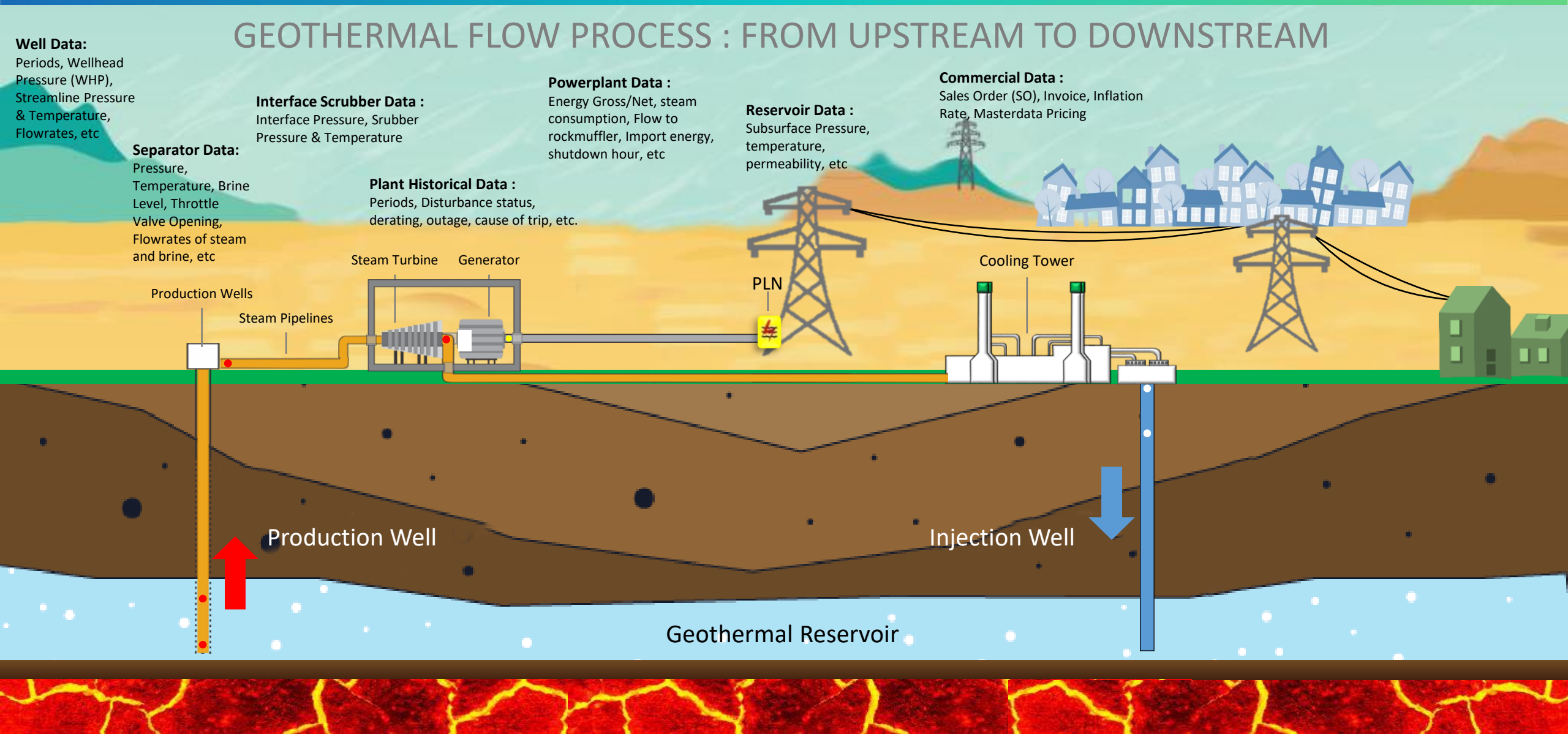
LAHENDONG

KARAHA BODAS

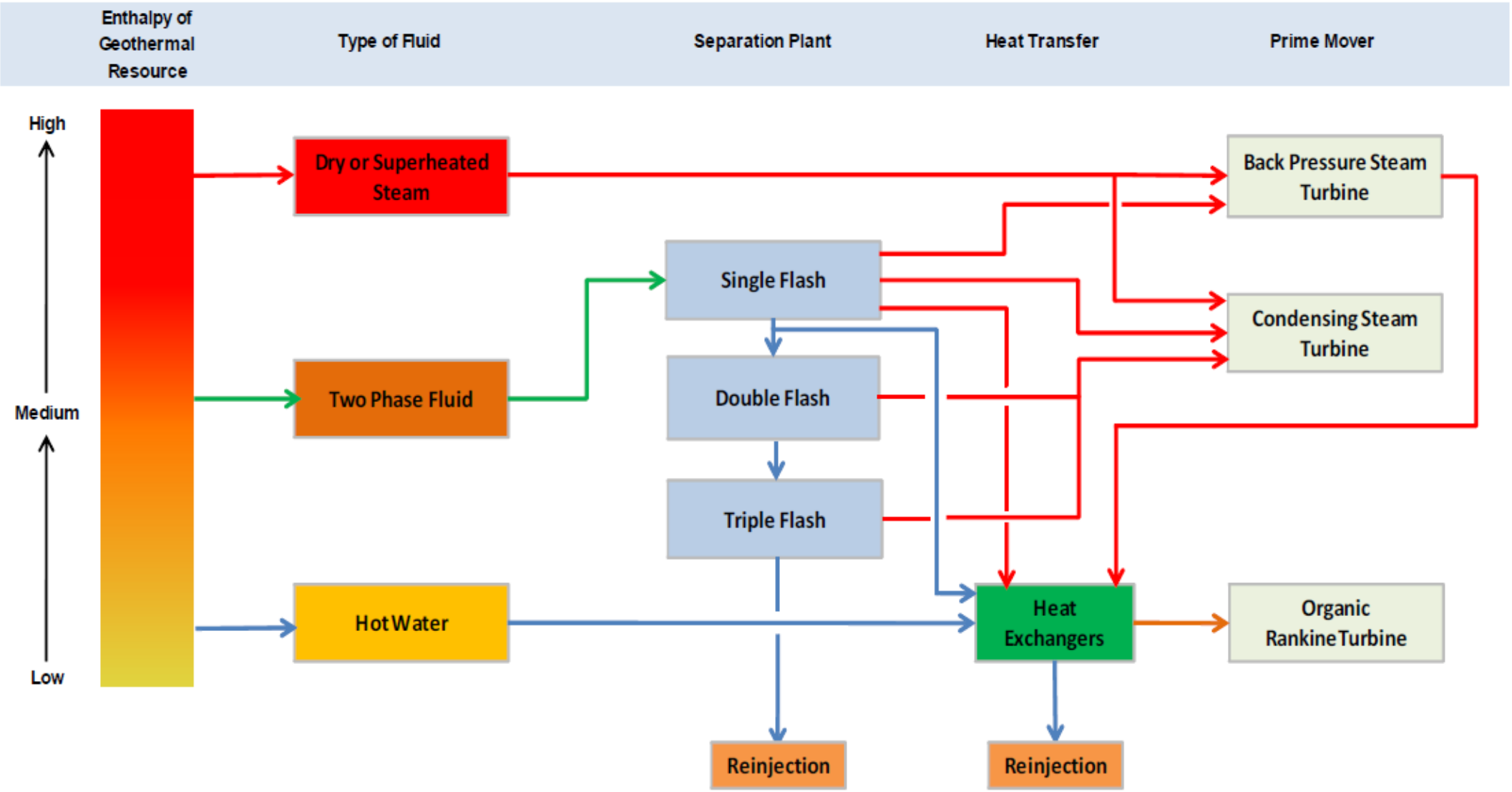
LUMUT BALAI

Indonesia is the **World-Second Largets** Country of Having Current Installed Capacity

GEOTHERMAL FLOW PROCESS : FROM UPSTREAM TO DOWNSTREAM



GENERAL PROCESS FLOW DIAGRAM OF GEOTHERMAL PLANT



INTEGRATED GEOTHERMAL PLANT EQUIPMENT

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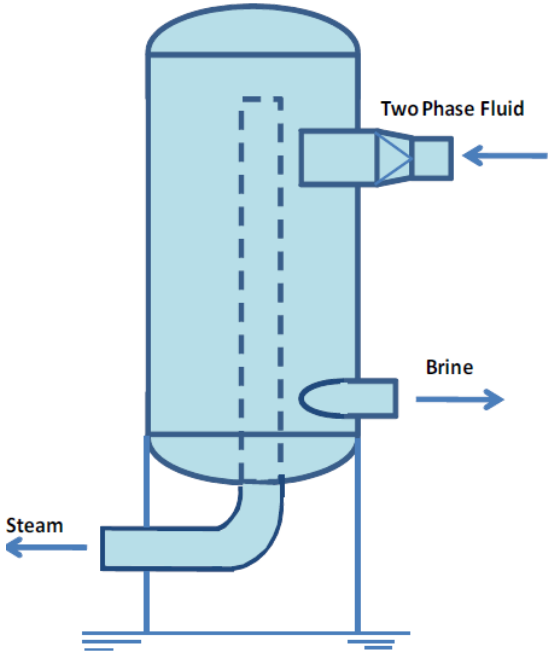
Geothermal Well

Kamojang, Well KMJ-56

PIPELINES

Two-phase pipelines in Wayang Windu

INTEGRATED GEOTHERMAL PLANT EQUIPMENT



Separator

Scrubber

INTEGRATED GEOTHERMAL PLANT EQUIPMENT

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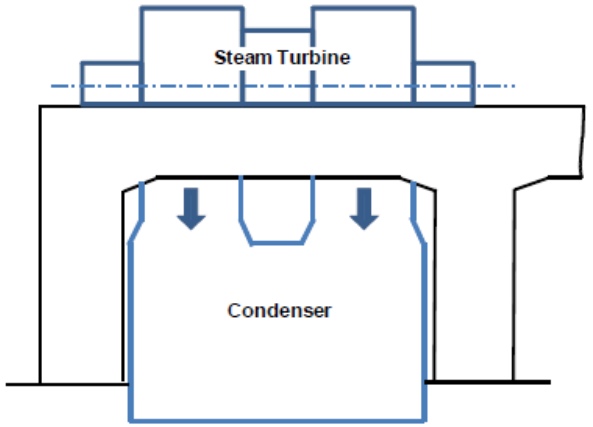
Rock Muffler

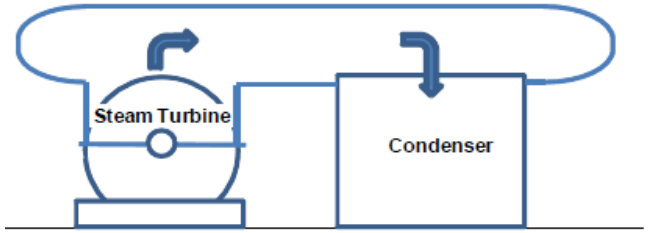
Steam Turbine

135 MW of Nga Awa Purua Geothermal Plant, New Zealand

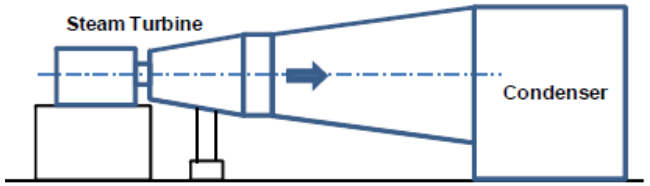
Condenser



Bottom Exhaust



Top Exhaust



Axial Exhaust

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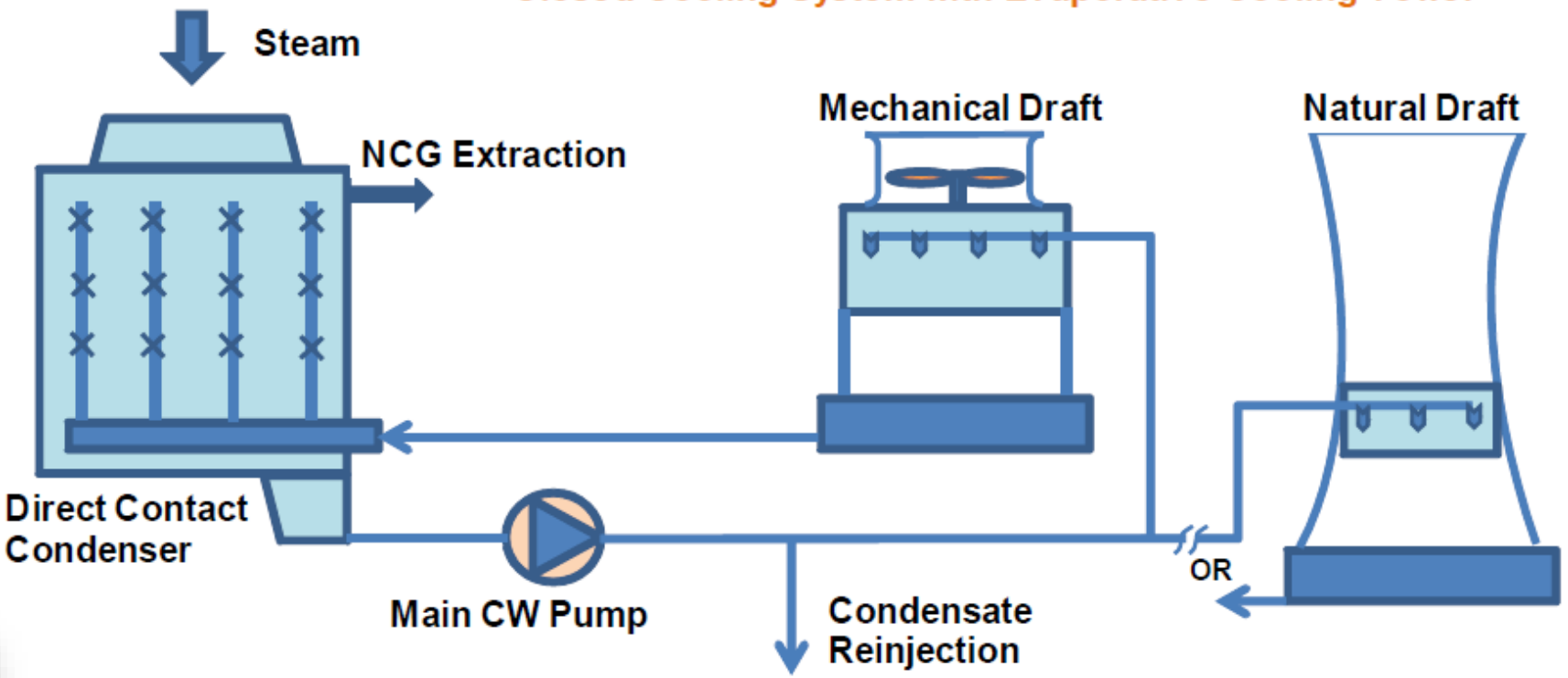
Cooling System

1. Hot Well Pump
2. Liquid Ring Vacump Pump
3. Auxiliary Cooling Water Pump
4. Other Pumps
5. Gas Ejector
6. Cooling Tower



INTEGRATED GEOTHERMAL PLANT EQUIPMENT

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Generator

INTEGRATED GEOTHERMAL PLANT EQUIPMENT

Transformers

Switchyard

Other electrical, Instrument & Control, and Safety equipment

1. Protection System
2. Motor Control Centre
3. Distributed Control System
4. Fire System
5. others

DIRECT / UNCONVENTIONAL UTILIZATION

Beyond Energy

Optimalization of Geothermal Energy

Geothermal Direct-use and Mineral Extraction for product diversification

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1 Brines to Power

- **500 kW in Lahendong Area**
- Operation cost saving (house load substitution)
- Supporting beyond programs that require electricity supply
- Expansion of a low temp energy utility

2 Hydrogen

- **100 kg/day in Ulubelu Area**
- Green hydrogen production through water electrolysis (H_2O)
- Plan to be marketed to refineries/ chemical plants or as raw material for making green methanol

3 H_2S Removal & CO_2 Liquefaction

- Reducing H_2S & CO_2 emission
- Dry Ice production

4 CO_2 Methanol

- Reducing CO_2 emission
- As a fuel mixture (Pertamina's A20 program) or for export markets

5 Agrobusiness

- Commercialization of agro resources (cloves, coffee, flowers, mushrooms, vegetables, livestock and essential oil production)
- Optimization of low temp energy (steam/brine) and CO_2, as well as economic empowerment of the surrounding community

6 Geothermal Tourism

- Utilization of high tourism potential in the Lahendong field
- Development of tourist objects with the concept of geothermal parks (hot springs, manifestation tours, and geothermal education)

7 Silica Extraction

- Production of high quality silica from an extraction plant with a capacity of 7,000 tons/year in Hululais field

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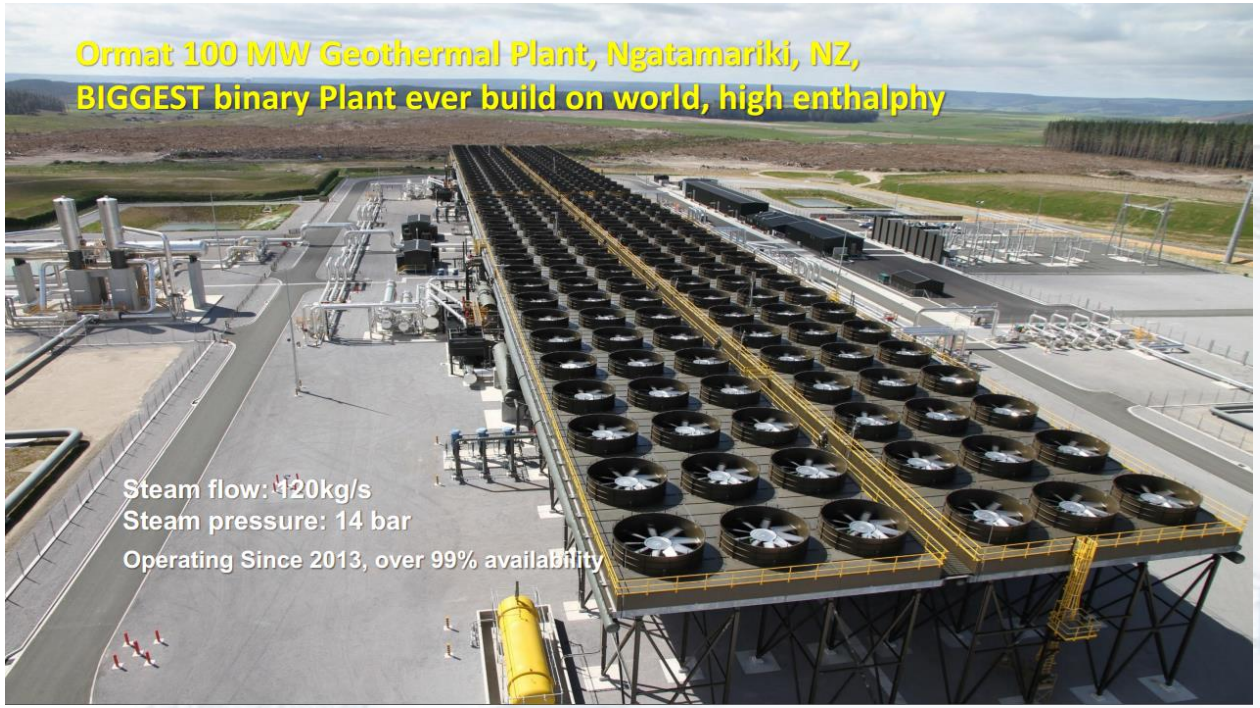
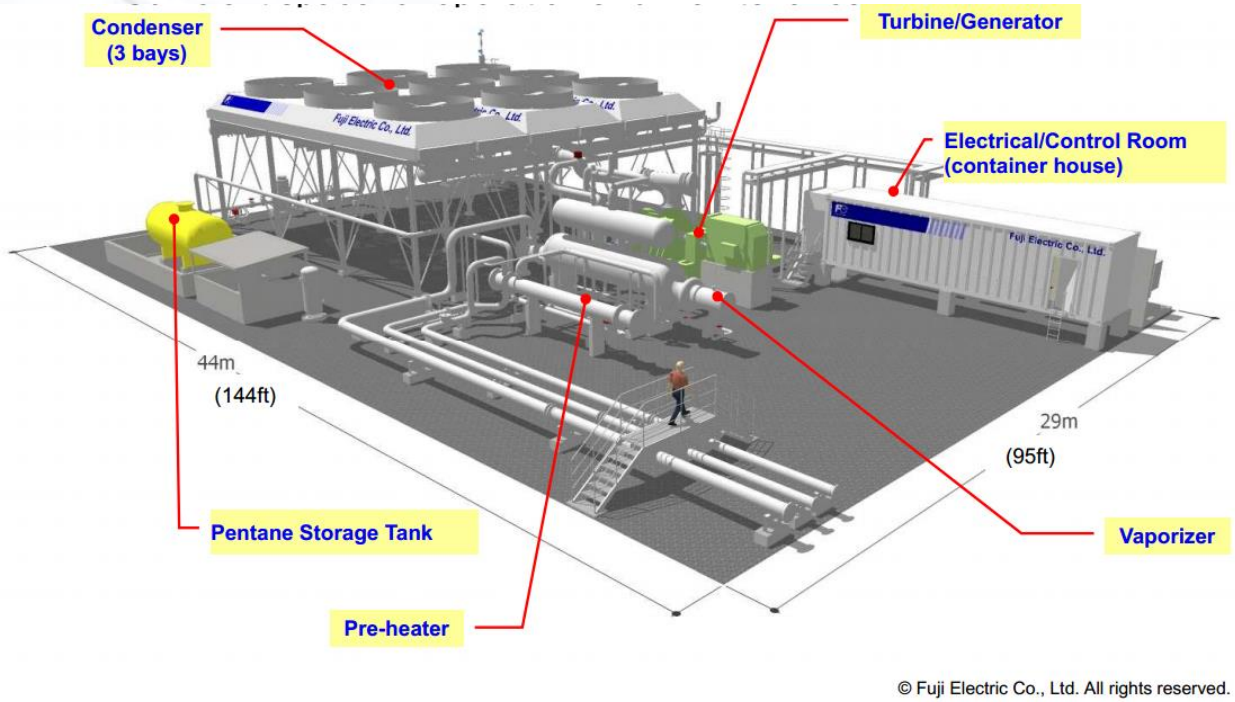
Brines to Power / ORC Plant

PERTAMINA GEOTHERMAL ENERGY

ORMAT



FUJI



2MW Single Pressure with Air Cooled Condenser

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BANGGA BUATAN INDONESIA

Brines to Power / ORC Plant

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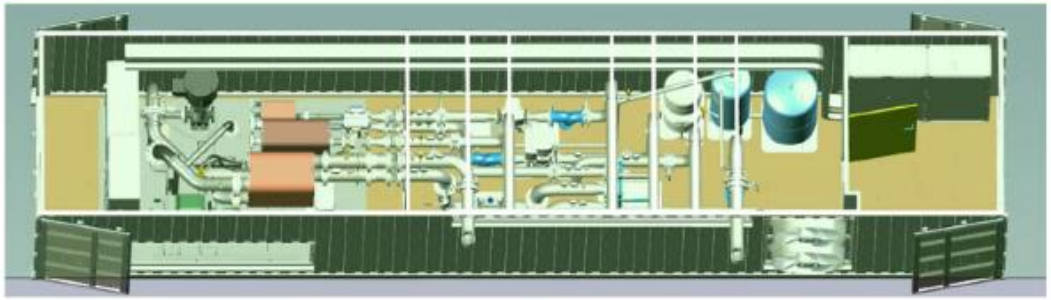
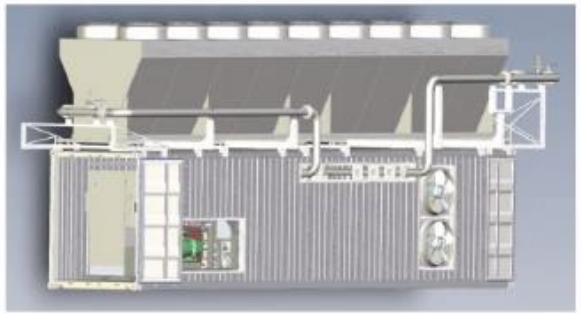
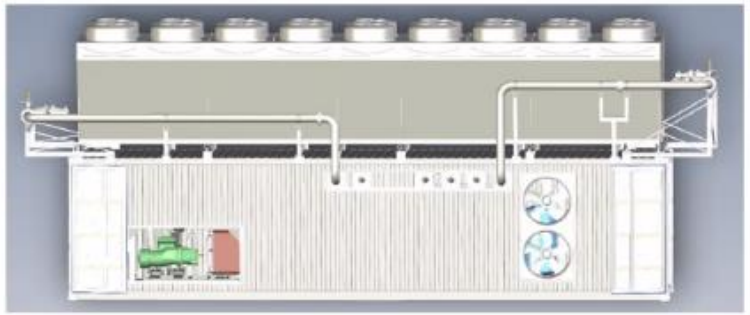
PERTAMINA GEOTHERMAL ENERGY
EXAMPLE SOLUTION

ElectraTherm
BY BITZER GROUP







Bitzer

RECENT INSTALLATION - ROTTENBURG GERMANY

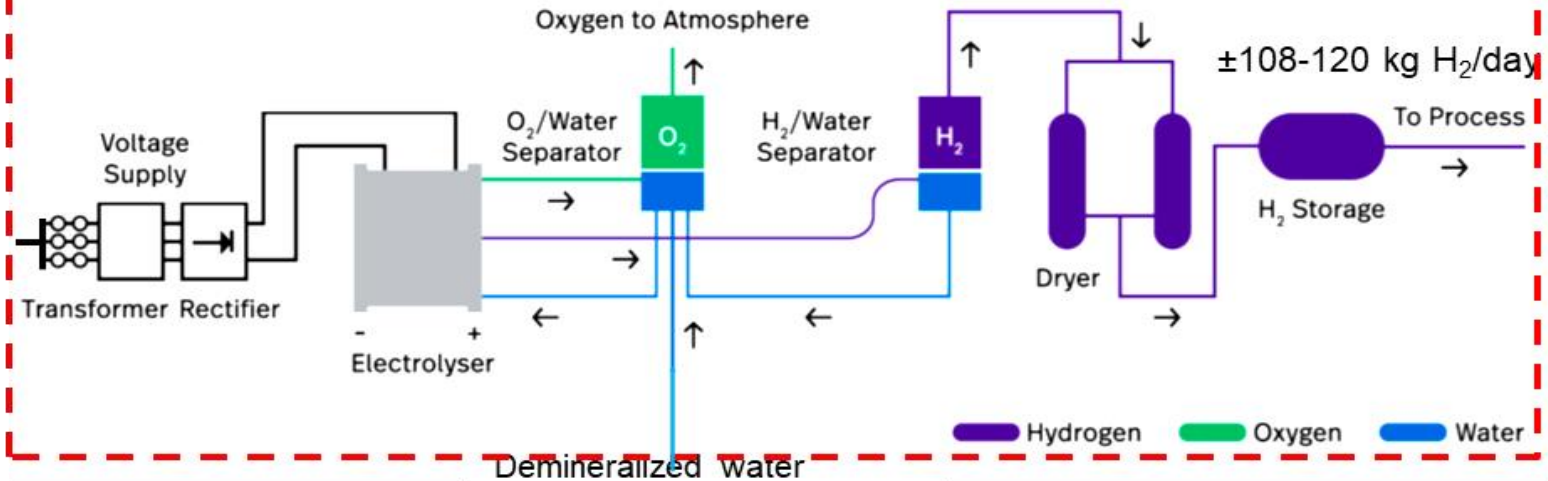
ElectraTherm
BY BITZER GROUP

Bitzer

Green Hydrogen Pilot Plant

Electrical source (±300 kW) is tapped from existing own-used aux. trafo of Geothermal Power Plant (Ulubelu Unit-3)

A simplified PFD/schematic diagram is modified from NEL presentation



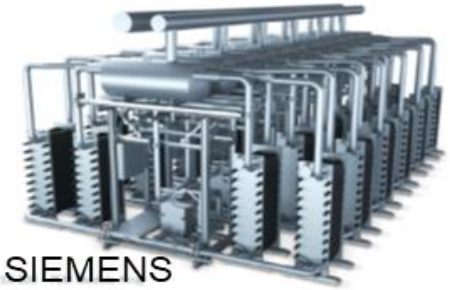
Demineralized water (±1300 litre/day)
Fresh water (±2600 litre/day)

Compressor (H_2 is compressed up to ±200 barg)

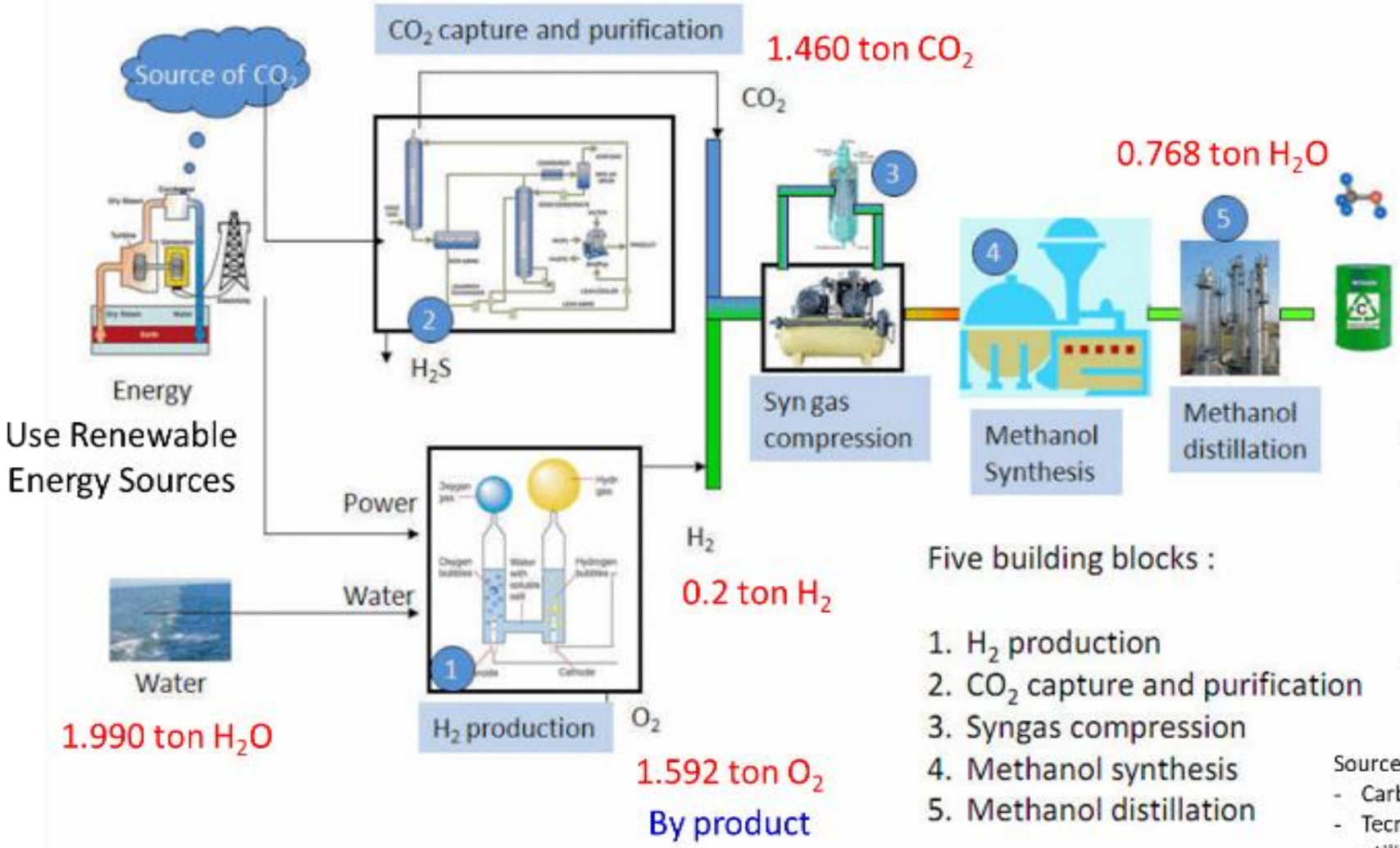
Hydrogen Tube Trucks

Customer candidate (off taker): RU III (Plaju). H_2 will be used for feeding in polypropylene plant or others.

Examples of electrolysers:



CO_2 to Methanol



Five building blocks :

1. H_2 production
2. CO_2 capture and purification
3. Syngas compression
4. Methanol synthesis
5. Methanol distillation

Utilities consumption & others:

- ✓ Electricity = 11.5 MWh / ton methanol
- ✓ Cooling water = 92.26 ton H_2O / ton methanol
- ✓ Final Net CO_2 **savings** = 1.28 ton CO_2 / ton methanol

Sources :

- Carbon Recycling International company presentation
- Tecno economic and environmental evaluation of CO_2 utilization for fuel production, 2016

Implementasi CO2 Plant

CO_2 to Methanol Pilot Plant
~300t/year

CO_2 to Methanol Commercial Plant
~4000t/year

What is methanol used for?

H_2S Removal - CO_2 Liquefaction

BIOPROSES H_2S REMOVAL

Proses

1. Penyerapan H_2S dengan larutan alkali
2. Regenerasi alkali sulfida dengan aktivitas mikroba lokal

Keunggulan

1. Menggunakan mikroba lokal
2. Menghasilkan produk samping organik sulfur → dimanfaatkan untuk pertanian
3. Konsumsi chemical rendah → hanya untuk make-up

Absorber : $H_2S + NaOH \dashrightarrow NaHS + H_2O$

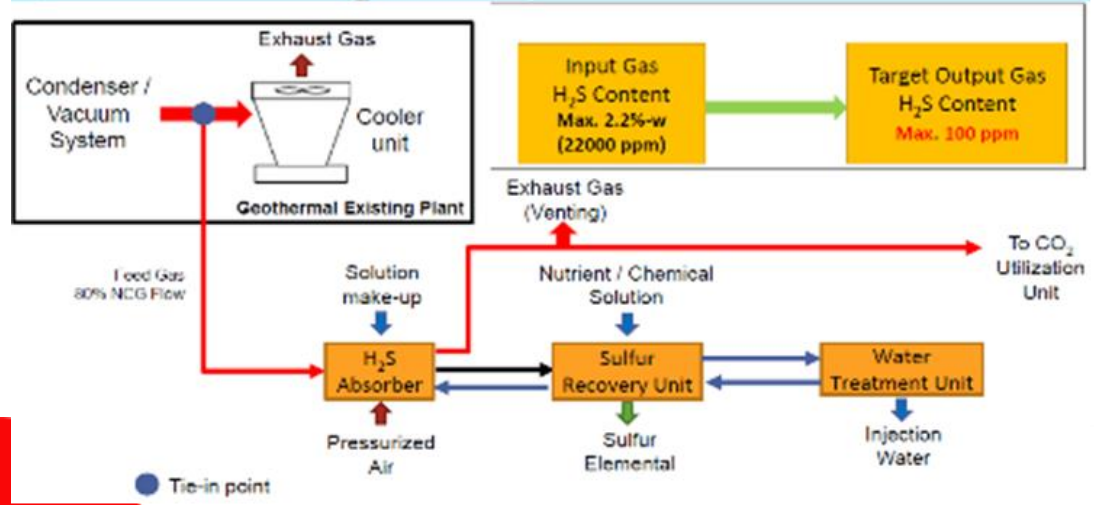
Bioreactor : $NaHS \dashrightarrow NaOH + S^o$ (Microba)

CO_2 LIQUEFACTION

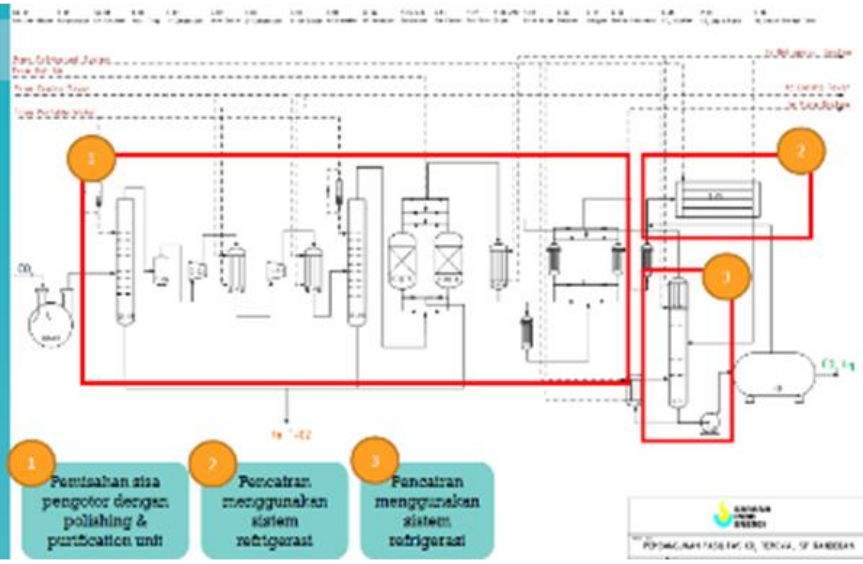
Proses

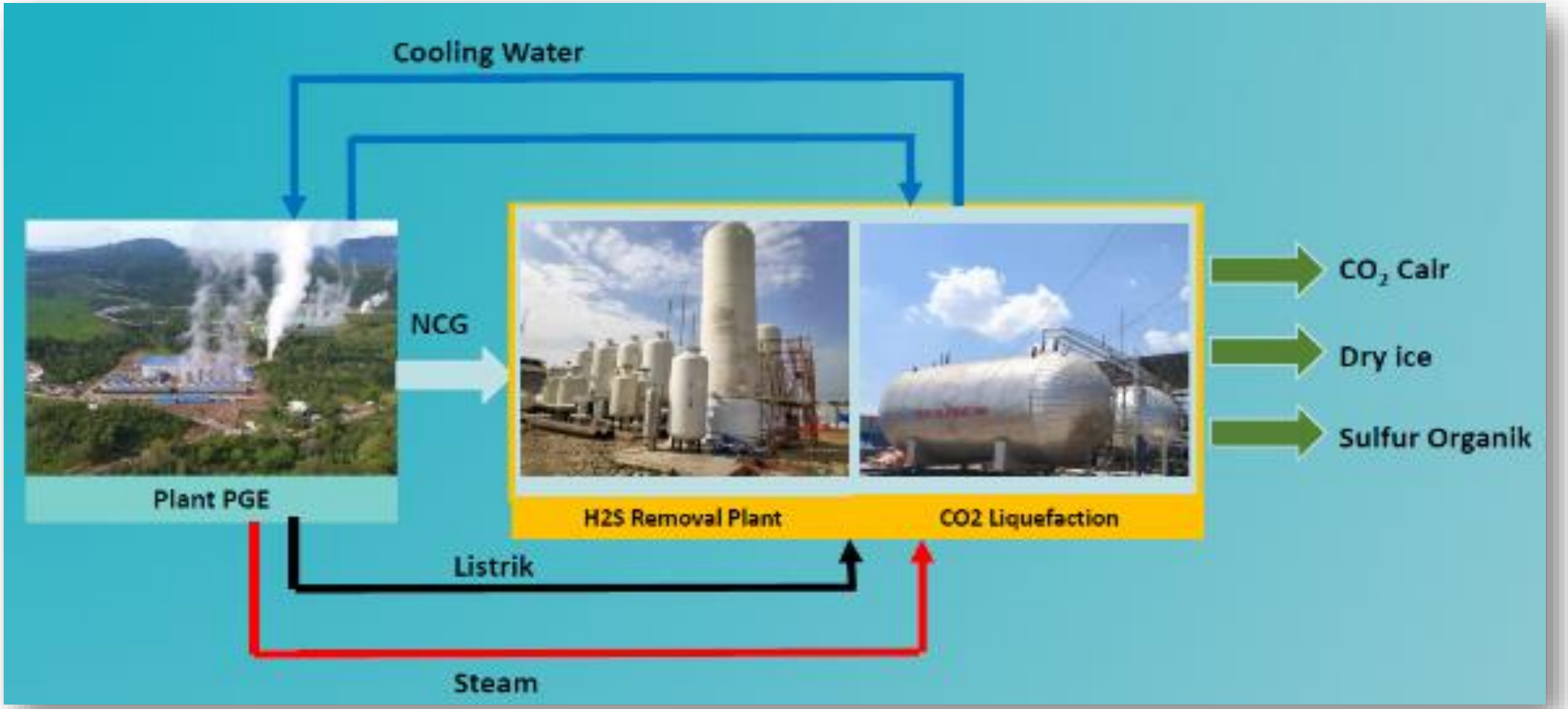
1. Pemisahan sisa pengotor dengan polishing & purification unit
2. Pencairan menggunakan sistem refrigerasi
3. Pemisahan akhir menggunakan distilasi
4. Sebagian CO_2 diubah menjadi dry ice

DESIGN BIOPROCESS H_2S REMOVAL



TAHAP 2 CO_2 LIQUEFACTION





Installed Capacity:

- H2S *Removal Plant*: 1,8 MMSCFD
- CO2 *Liquid Plant*: 40 ton/*day*
- *Dry Ice Plant*: 8-16 ton/*day*

Product Quality:

- CO2 *Food Grade* SNI

Biaya Investasi Terdiri Dari:

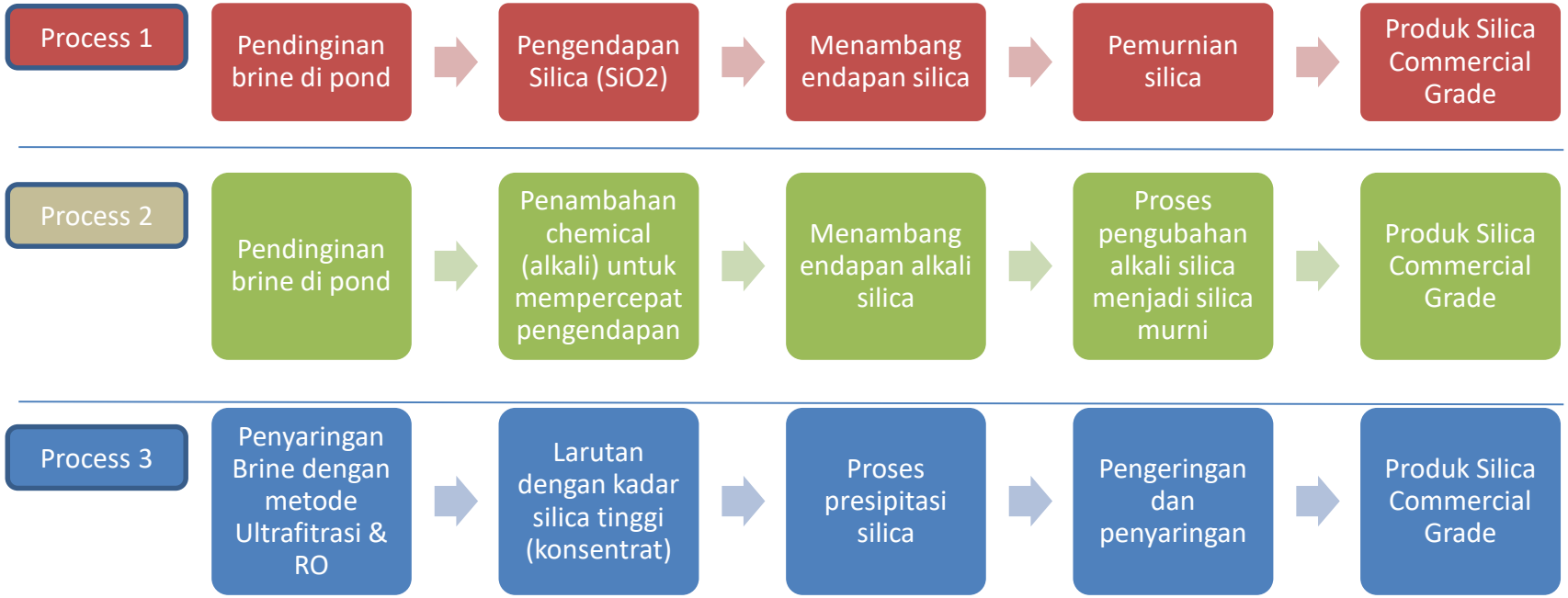
- *Pre project or Capitalized cost*
- *Engineering Cost*
- *Purchasing and Installation Cost*
- *Storage and Transportation Equipment Cost*
- *Start Up Cost*
- *Life Time 20 years*

SILICA (SiO_2) EXTRACTION

PERTAMINA

Technology Background

Dari study literature terdapat 3 pendekatan process yang bisa digunakan untuk proses ekstraksi silica dari lapangan geothermal yaitu:



Project Pathway

Process	Risiko Utama
Pemurnian Endapan Silica	Kegagalan pilot plant, Biaya investasi tinggi, Terganggunya operasional karena suplai bahan baku yang intermittent
Ekstraksi Endapan Alkali Silia	Kegagalan study, kegagalan pilot plant
Ekstraksi silica dari brine	Ketergantungan dengan vendor luar negri, kegagalan di proses kerjasama, dapat menganggu operasi utama lapangan geothermal

Optimalisasi Source PGE - Geotourism Lahendong

Hot Brine

Geopark/Hot Pool
& Water Treatment

Cold Brine

Hot Brine

Binary Plant

Electricity

Cluster LHD-05
Pompa Injeksi, dll

Sumur Reinjeksi

Cold Brine

GEOTHERMAL TOURISM

Geothermal Bungalow/Hotel

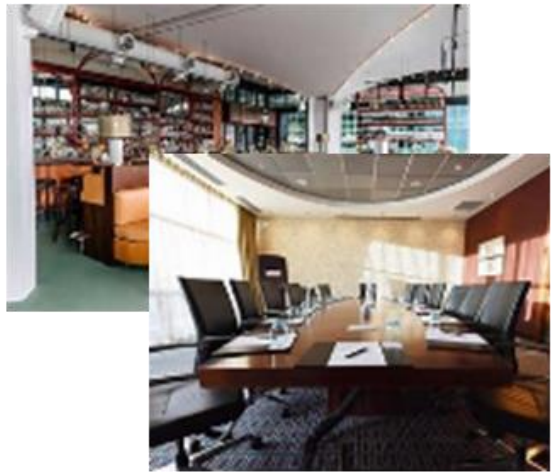
Geothermal Water Park

Geothermal Manifestation Tour

Binary PP Education

Outbond

Geothermal Education



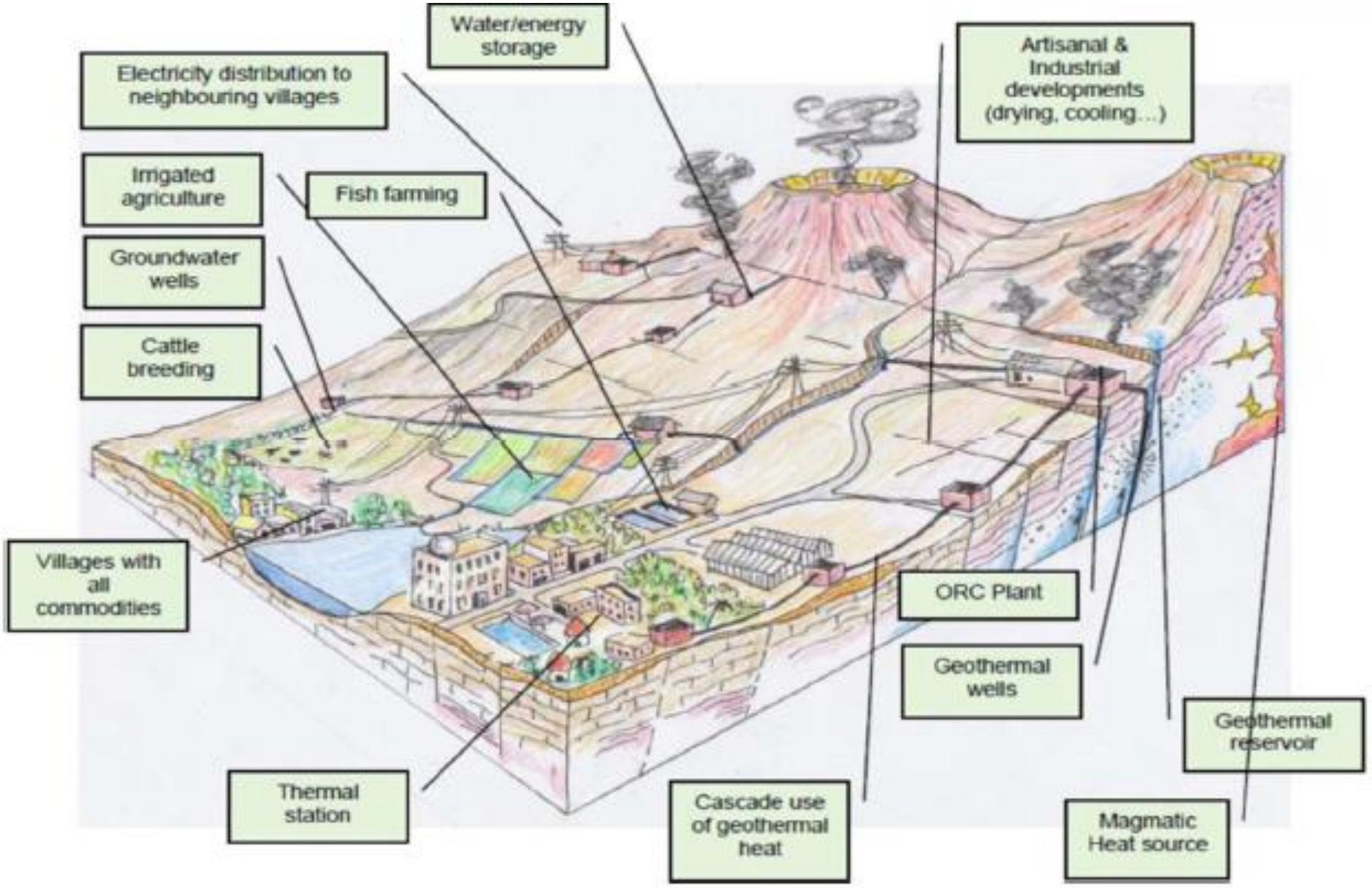
Caffe & Restaurant

Meeting Room

Photo Spot

Lokasi Potensi Geotourism Area Lahendong

AGROBISNIS


Water/energy storage
Electricity distribution to neighbouring villages
Artisanal & Industrial developments (drying, cooling…)
Irrigated agriculture
Fish farming
Groundwater wells
Cattle breeding
Villages with all commodities
ORC Plant
Geothermal wells
Geothermal reservoir
Thermal station
Cascade use of geothermal heat
Magmatic Heat source

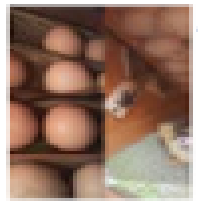
AGROBISNIS

Implementasi direct use di bidang agribisnis yang telah dilaksanakan PGE :

Proses	Keterangan
Proses pengeringan (drying)	gula aren, kopi, cengkeh, kopra, vanili
Penyulingan minyak esensial	minyak bunga krisan
Farming	Budidaya jamur merang
Peternakan	Penetasan telor ayam

Pabrik pengeringan gula aren Masarang

Penyulingan minyak esensial dari bunga krisan



Alat penetasan telur ayam (monitoring melalui mobile phone)

THANKYOU

Green Energy for Future