# Feasibility study on GHP systems in tropical Asia from the experimental data of Thailand and Indonesia

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**Contents;**

1. **Case Study of Thailand**
   - **Experiment of 4 locations, Stable Underground, High Efficiency**
2. **Case Study of Indonesia**
   - **Very Low Cost System by Shallow Piping, by Indonesia**
3. **Future Plan**
4. **Conclusions**

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*__19 October 2014 at AIST Fukushima__*

# Case Study of Thailand

(1) First trial of GHP in tropical country (Oct. 2006 at Kamphangphet).
(2) Four different locations with different systems.
(3) Final operation at Chulalongkorn Univ. (Bangkok) is feasible.



**Three locations: Too big system for cooling one room (Base Pw High).**

**Chulalongkorn Univ.: Inverter type high efficiency unit.**

(4) Underground temperature not increase 2 years operation (KP data).
(5) Efficiency increase is 54% (33%?) for Chlalongkorn Univ. case.
(6) Two factors control efficiency;
  (a) Temperature gap between atmosphere and underground.
  (b) Difference of cooling efficiency between heat exchanger (GHP) and fan (AC).

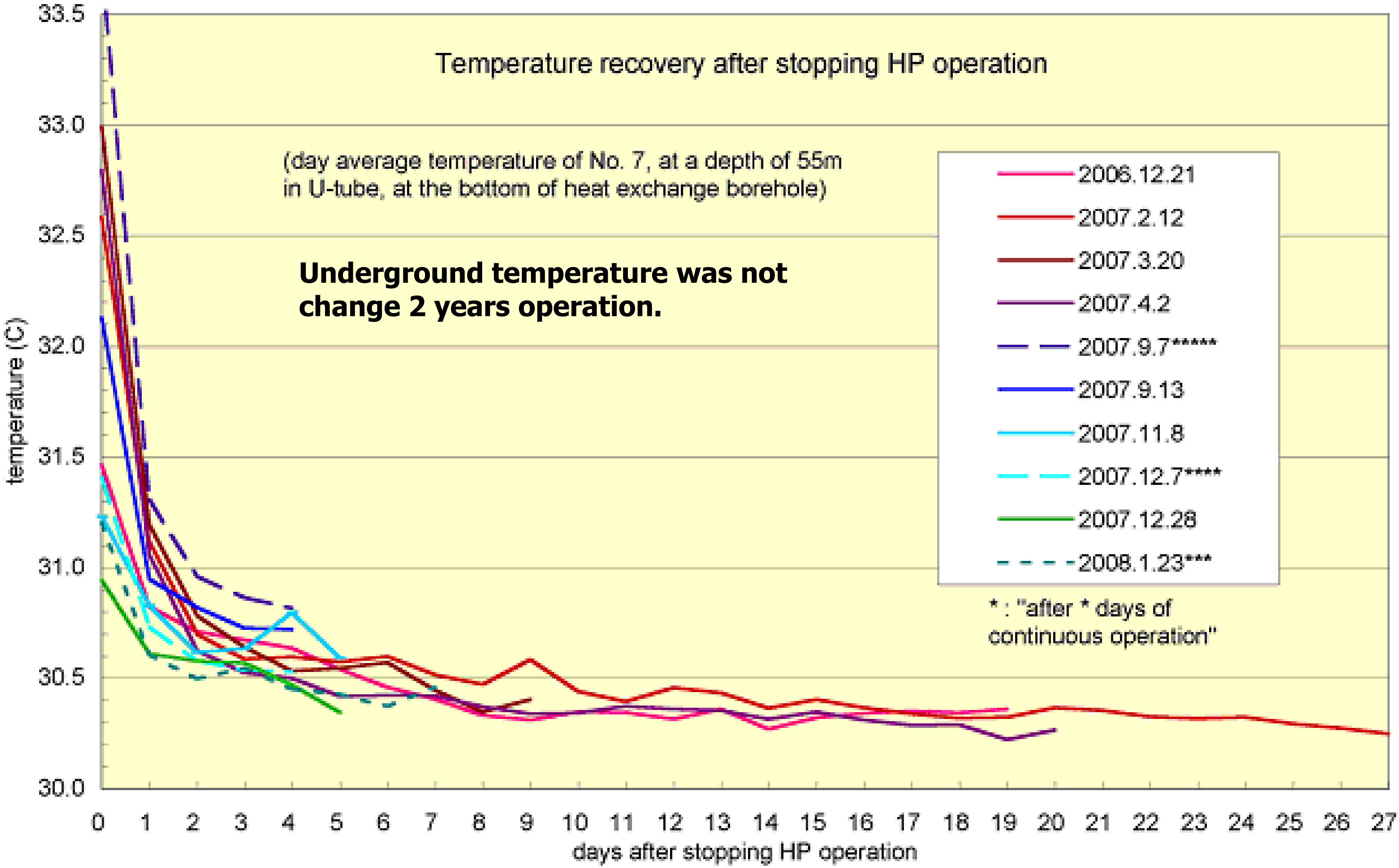
# First Trial at Kamphaengphet (Oct. 2006-Mar. 2008)

DGR Office at Kamphaengphet

GHP and Water Circulation System


Room for Cooling (Cool Water Circulation and Fan Coil Unit)

Double U-tubing in 56m Depth Well.




Yasukawa et al.(2009)

(4th Location)

# New Experiment at Chulalongkorn University (Start from May 2014)

Second Presidential Office
(Right Hand Side is for Drilling)

Second Floor for Experiment
(Room Size: 2.8mX4.7m)

# Drilling and Pipe Setting

Drilling for 50m

Just after 2 Drillings/Pipings

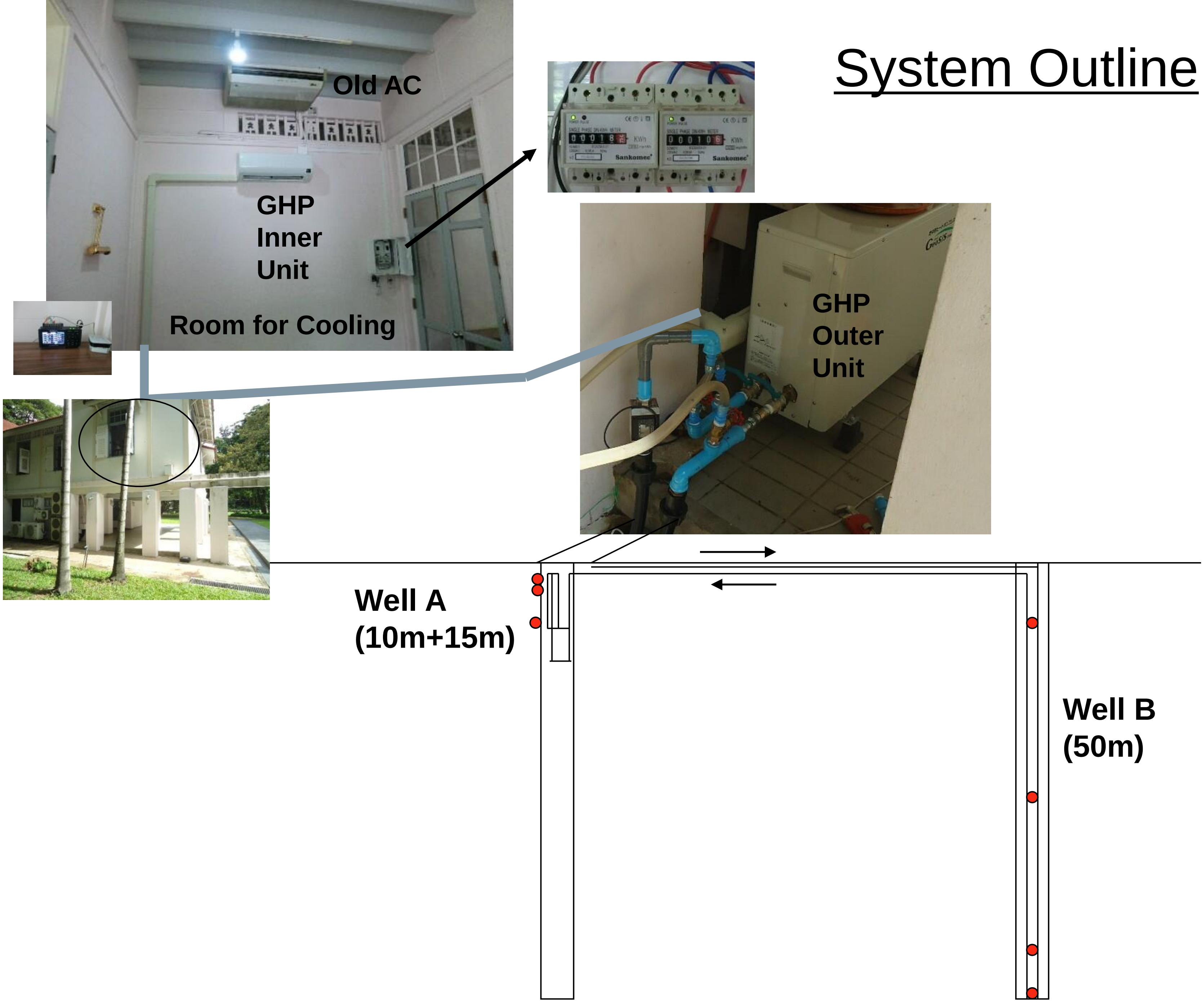
Recover Now (July 2014)

Mud Flow by Drilling

Cuttings Check for Geology

PE Pipe Setting to 50m Depth (100m length)

# System Outline



# Cooling Operation of GHP and Old Air Conditioner (August 2014)

| Date | Meter (KWh) 10:00-16:00 | | Power (W/h) | Ch.1 Room Temp. (°C) | | Ch.2 Outside Temp.(°C) | | Ch.3 GHP Flow In (°C) | | Ch.4 GHP Flow Out (°C) | | Ch.6 Well A 8 m (°C) | | Ch.7 Well B 10 m (°C) | | Ch.8 Well A 3 m (°C) | | Ch.9 Well A 1.5 m (°C) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Stop | | Start | Stop | Start | Stop | Start | Stop | Start | Stop | Start | Stop | Start | Stop | Start | Stop | Start | Stop |
| 2014.8.4 | 18.85 | 20.13 | 213 | 28.0 | 26.7 | 28.5 | 29.6 | 27.5 | 31.0 | 28.1 | 32.7 | 29.9 | 30.3 | 31.6 | 31.9 | 29.2 | 31.7 | 29.3 | 30.9 |
| *2014.8.6* | *11.00* | *14.69* | *615* | *28.5* | *25.5* | *28.7* | *29.9* | | | | | | | | | | | | |
| 2014.8.7 | 20.13 | 21.89 | 293 | 28.9 | 25.6 | 28.9 | 29.3 | 28.5 | 32.2 | 28.9 | 33.5 | 30.0 | 30.4 | 32.3 | 32.7 | 29.2 | 30.9 | 29.3 | 31.4 |
| *2014.8.8* | *14.69* | *18.69* | *667* | *28.6* | *25.5* | *29.4* | *29.8* | | | | | | | | | | | | |
| *2014.8.14* | *18.69* | *22.9* | *702* | *29.3* | *25.5* | *29.8* | *30.4* | | | | | | | | | | | | |
| 2014.8.19 | 23.93 | 26.47 | 423 | 30.3 | 26.2 | 30.8 | 30.4 | 29.9 | 33.0 | 30.6 | 34.4 | 29.9 | 30.7 | 33.8 | 34.3 | 29.2 | 31.6 | 29.3 | 31.1 |
| *2014.8.20* | *22.9* | *27.07* | *695* | *28.3* | *25.9* | *28.5* | *30.5* | | | | | | | | | | | | |
| 2014.8.26 | 26.47 | 28.61 | 357 | 29.1 | 25.9 | 29.4 | 31.3 | 28.7 | 33.1 | 29.3 | 34.5 | 29.9 | 30.6 | 34.7 | 34.2 | 29.2 | 31.3 | 29.4 | 30.8 |
| *2014.8.27* | *27.07* | *30.51* | *573* | *27.8* | *25.2* | *27.9* | *30.2* | | | | | | | | | | | | |
| 2014.8.28 | 28.61 | 29.83 | 203 | 27.3 | 25.8 | 27.7 | 29.7 | 26.9 | 31.4 | 27.5 | 32.7 | 30.1 | 30.4 | 33.5 | 33.9 | 29.3 | 30.5 | 29.5 | 30.3 |

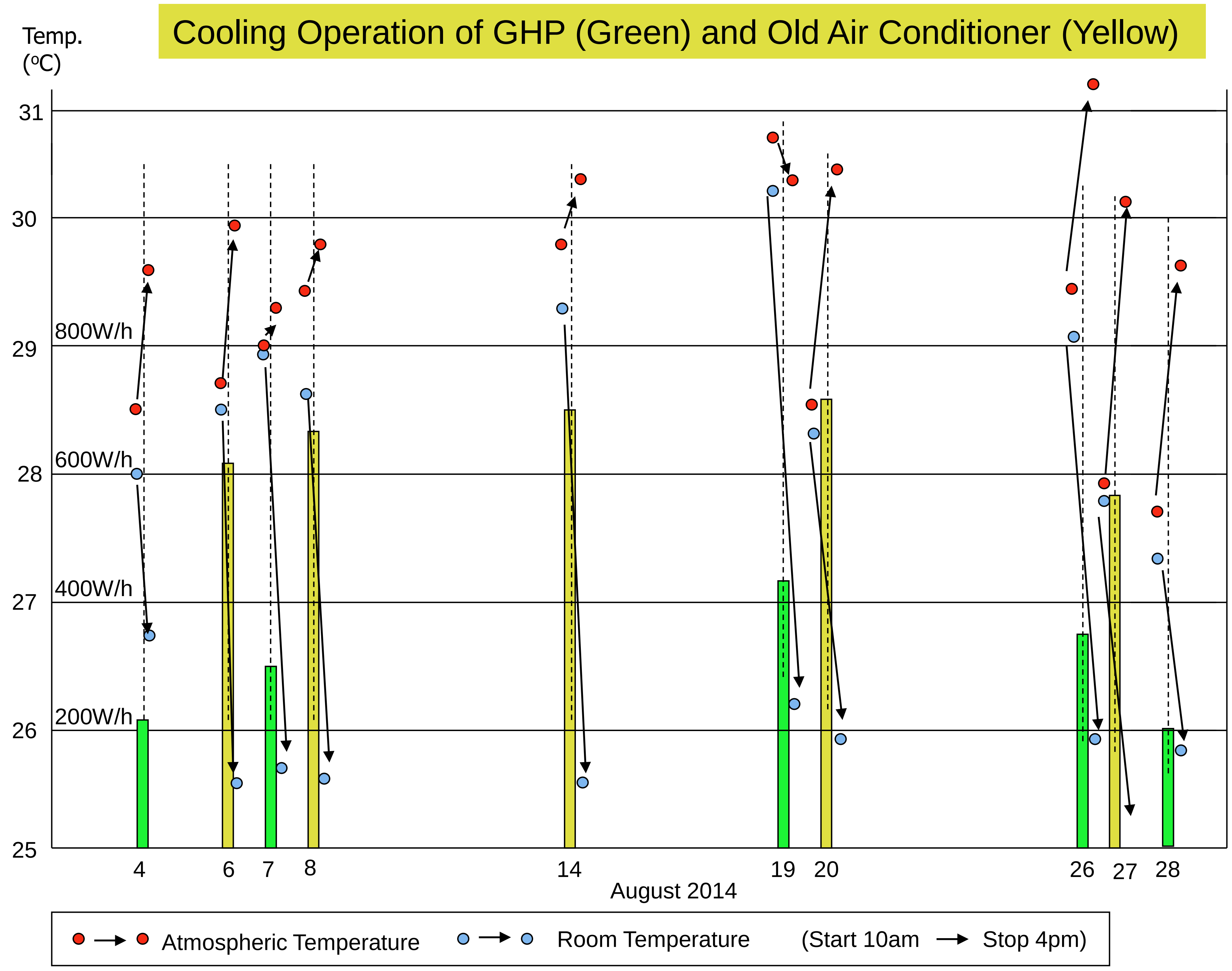
**Yellow Italic is Data of Old Air Conditioner**

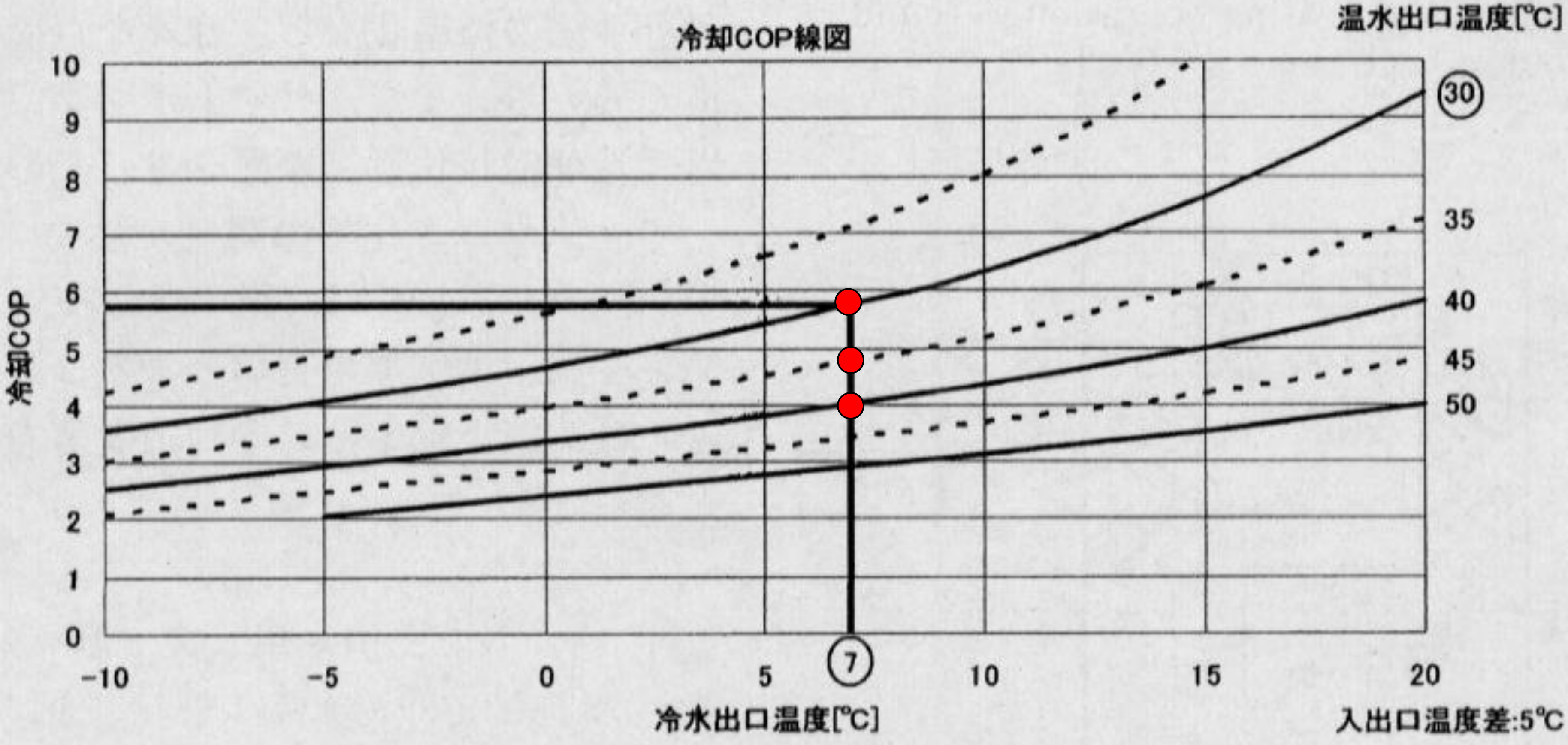
**(1) Ratio of Average Power Consumption : (213+293+423+357+203)/(615+667+702+695+573)=0.458***
**(Save 54%)**

**(2) Underground Heat Exchange Rate : 1.42°Cx25 L/min.=35500cal/min.=2473W (2473/150m=16.5W/m)**

**(3) COP: 2473Wx0.7?(Heat Exchange Efficency)/297.8W=5.8**

*** Correct old AC efficiency: 1489/(3252x0.68)=0.673 (Save 33%)**


Cooling Operation of GHP (Green) and Old Air Conditioner (Yellow)
Temp.
(ºC)
31
30
29
28
27
26
25
800W/h
600W/h
400W/h
200W/h
4
6
7
8
14
19
20
26
27
28
August 2014
Atmospheric Temperature
Room Temperature
(Start 10am
Stop 4pm)



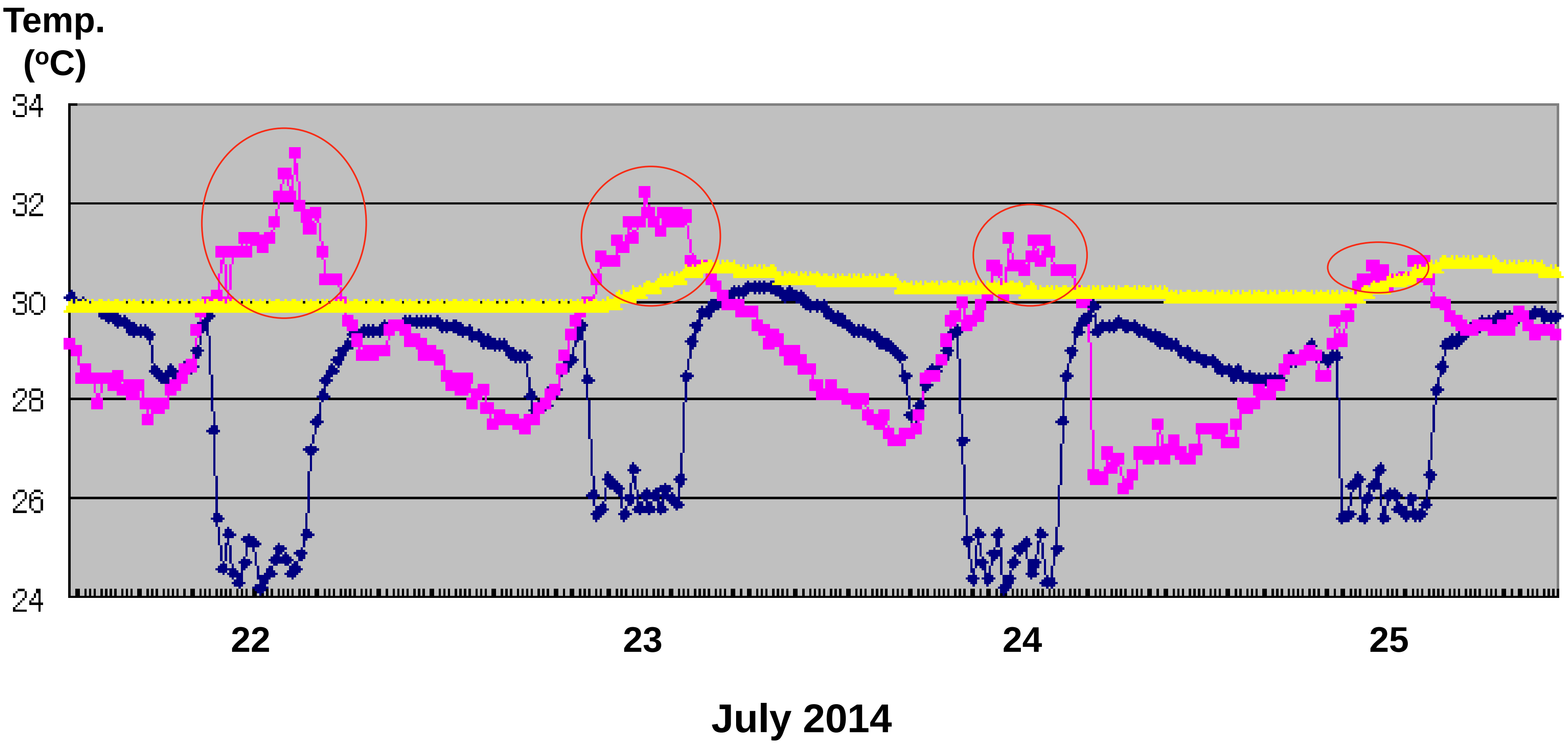

*Efficiency Increase Rate*

*Air Temp: 35℃、Underground Temp: 30℃　(5.8-4.8)/4.8=0.21*

*Air Temp:40℃、Underground Temp: 30℃　(5.8-4.0)/4.0=0.45*

*<u>* Temperature gap is two factors (Air/Underground and Cooling rate)</u>*

# Temperature Gap between Underground and Atmosphere （Bangkok)



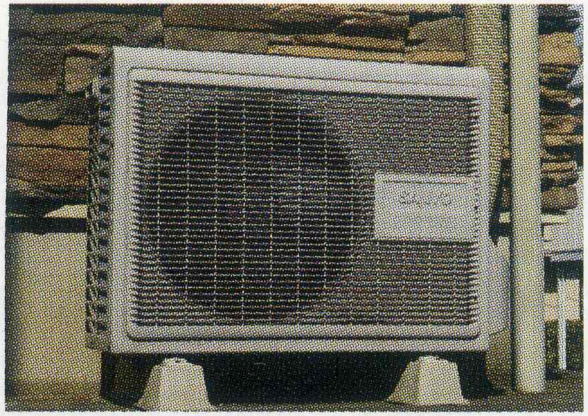
# Compare Cooling Efficiency between Fan and Heat Exchanger

## Normal Air Conditioner

**Compressor out cooled by Fan (Atmospheric Air)**

## Geo-Heat Pump System

**Compressor out cooled by Heat Exchanger (Underground Circulating Water)**



Ex. Tem. Compressor Out : 45$^{o}$C

Temp. Fan Cooling Out : <u>38$^{o}$C</u>

Temp. Compressor Out : 45$^{o}$C

Tem. Hex Out : <u>33$^{o}$C</u>

*** Even Underground Temperature High, GHP System get High Efficiency (This Phenomenon is estimated Data from Dr. Sasada-Personal Com.) .**

Project supported by
JSPS KAKENHI

# Case Study of Indonesia

(1) Experimental site is Bandung Institute of Technology (ITB).

(2) Sallow horizontal piping (1m-1.5m Depth, 200m Long).

(3) Modify normal AC (Cooling Fan to Heat Exchanger).

(4) Almost all parts from Indonesia (Technique also).

(5) Very low system cost (around 900US$).

(6) Energy shortage is about 25%.

(7) No underground temperature change is observed for over 2 years operation.

# Make Underground Piping

Make a trench of 25m length 1.5m depth by 2 days work of 5 peoples

Slinky-coil  Type Piping dept at 1.5m with 100m length

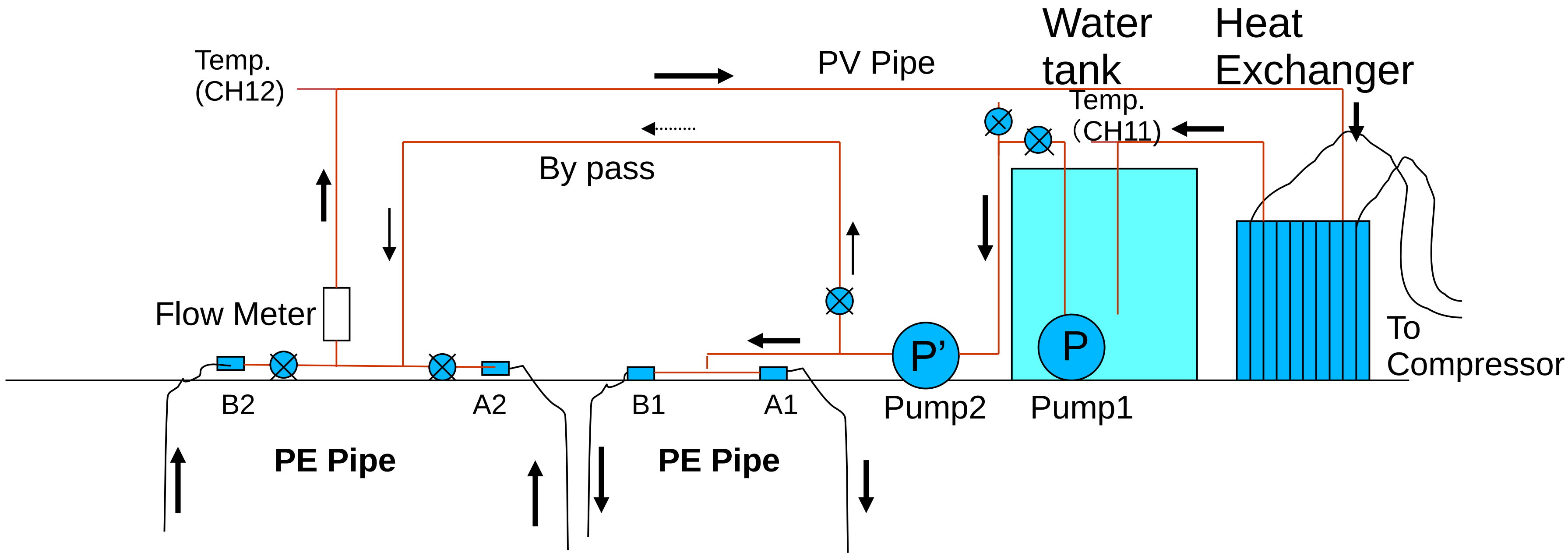
Another 100m piping at 1m depth

# Modify for Normal Air Condition Machine


Air Cooling Part is Put into Water of Underground Circulation (Late change to Heat Exchanger)

Room Facility is not Change

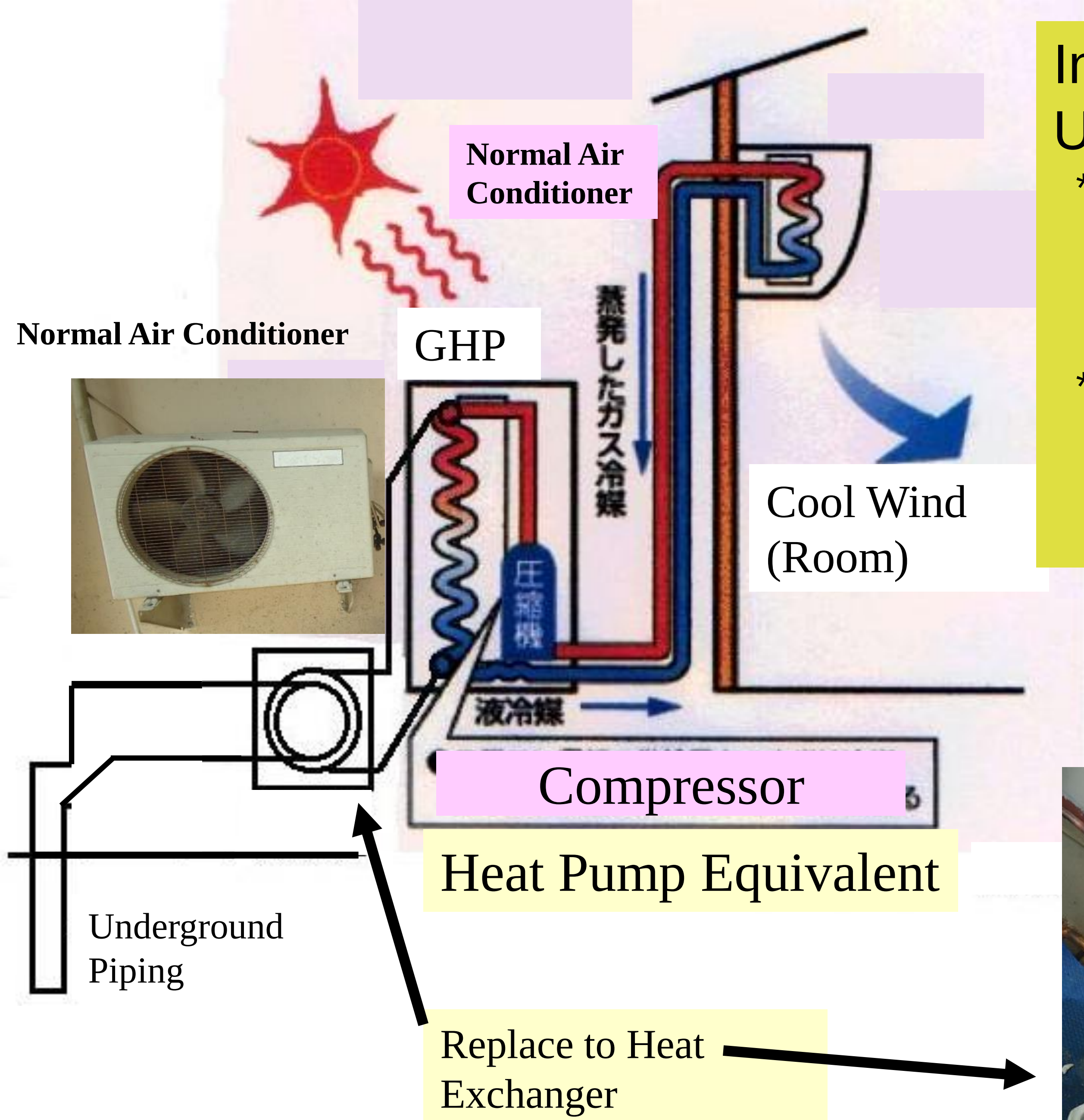
# Outline of Surface Piping



## Increase Efficiency by Use of Heat Exchanger

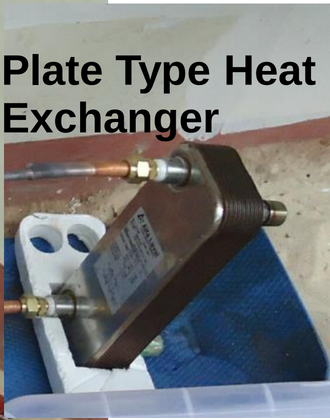
*Fan Cooling of Normal Air Conditioner: Low Cooling Efficiency.

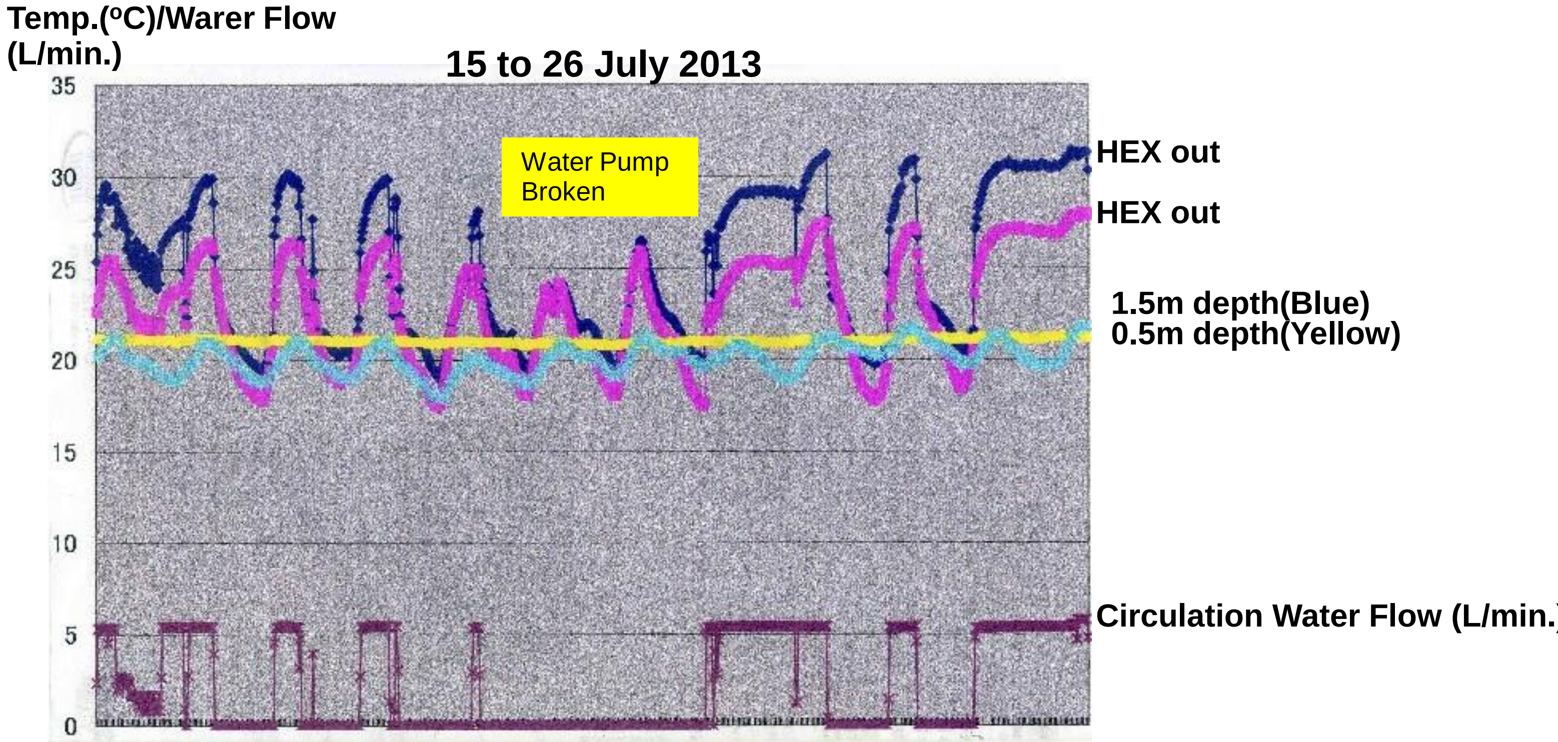
*Heat Exchange Cooling of GHP: High Cooling Efficiency (up to 5°C? lower than fan cooling)

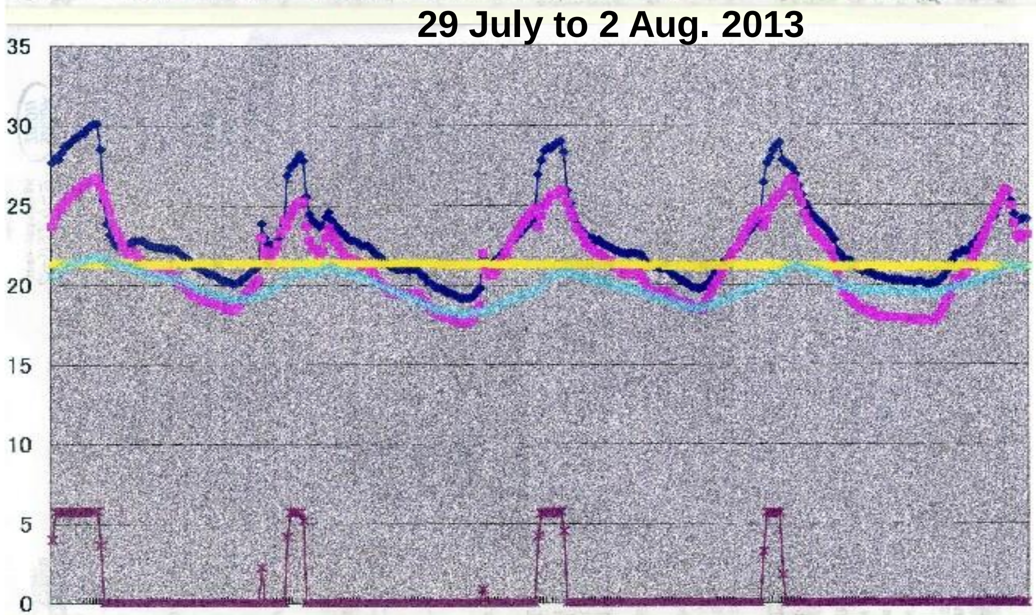



**<u>* Only change piping line of outer unit</u>**

# Cooling by Heat Exchanger




## Efficiency of GHP System

| 29 May 2013 (9:15-15:15) | 30 May 2013 (9:55-15:25) |
|---|---|
| A(GHP) 3.98kWh<br>B(Conv) 5.35kWh | A(GHP) 3.38kWh<br>B(Conv) 4.52kWh |
| **Efficiency A/B=0.74** | **Efficiency A/B=0.75** |

# Temperature and Water Flow Rate of Cooling Operation

# Basic Cost for System

**Trench（25x0.8x1.5m）　:Rp2,500,000 (21,500yen）**

**PE Pipe（200m）　:Rp1,200,000（10,320yen）**

**Circulation Pump（GFus) :Rp1,120,000（ 9,630yen）**

**Water Pool（150L)　:Rp 279,800（ 2,410yen）**

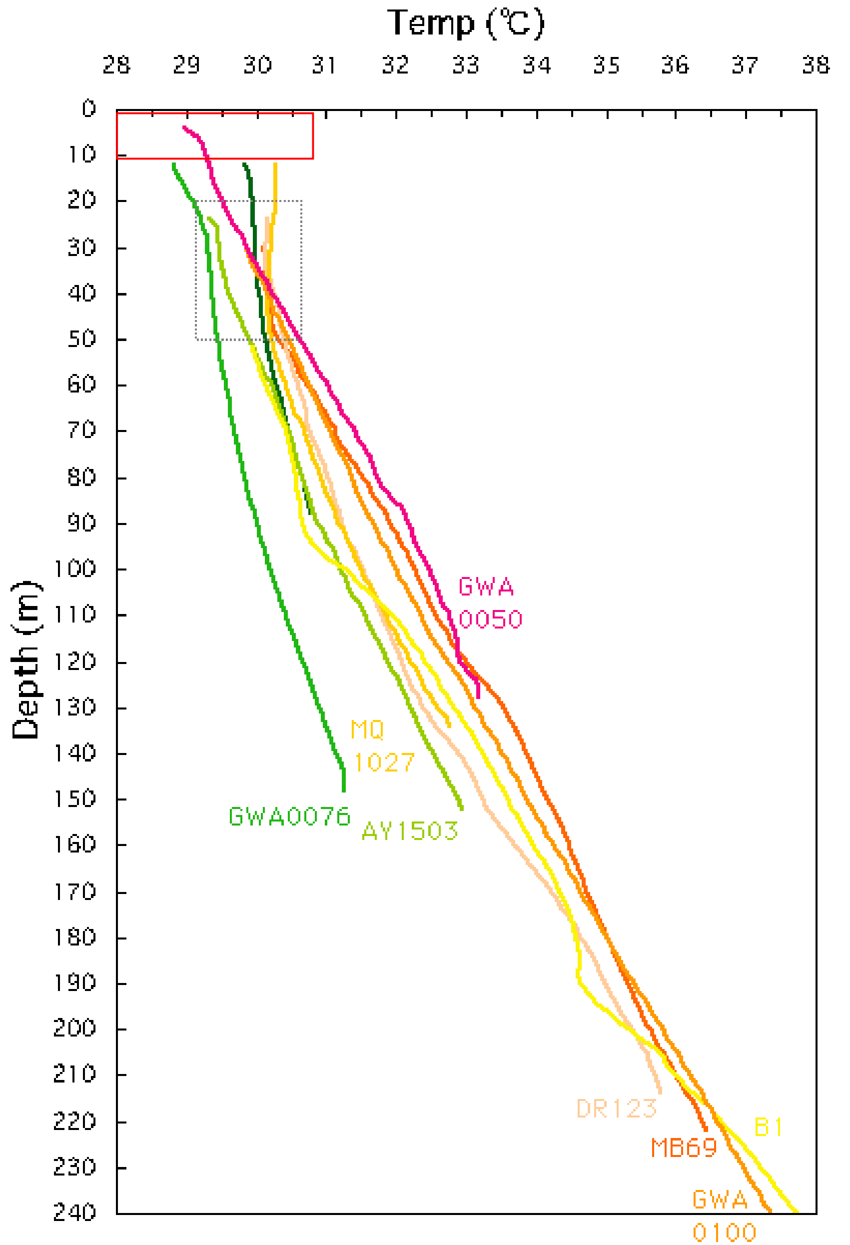
**Piping Parts　:Rp 500,000（ 4,300yen）**

**Heat Exchanger　40,000yen**

**Total (1,000Rp=8.6yen）　88,160yen （Ca.900US$)**

***Exclude AC and Instruments for Measurement (for Experiment)**

# Cost and Efficiency




***Underground Temperatures near Bangkok, Thailand***

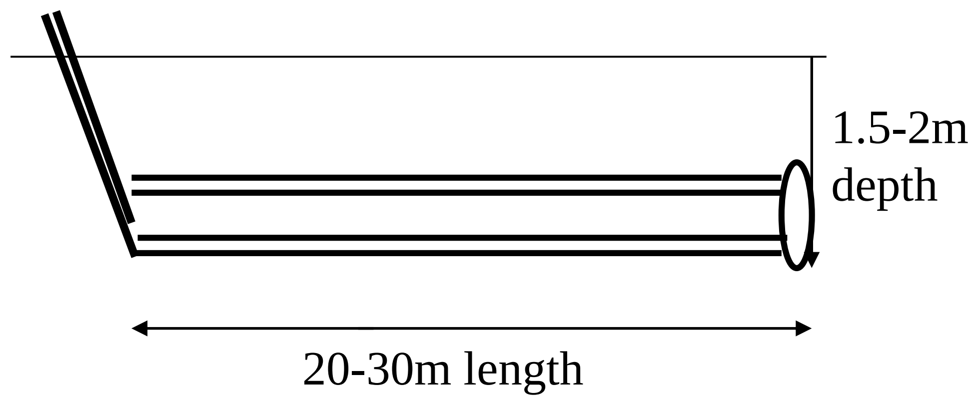
* Underground Temperatures are Low in Shallow Depth (We need low temperature).

*In Tropical Area, Horizontal Piping System has adventages both Cost and Performance (Water level is another factor).

Uchida et al. (2009)

# Try to piping by narrow trench system for keep environment

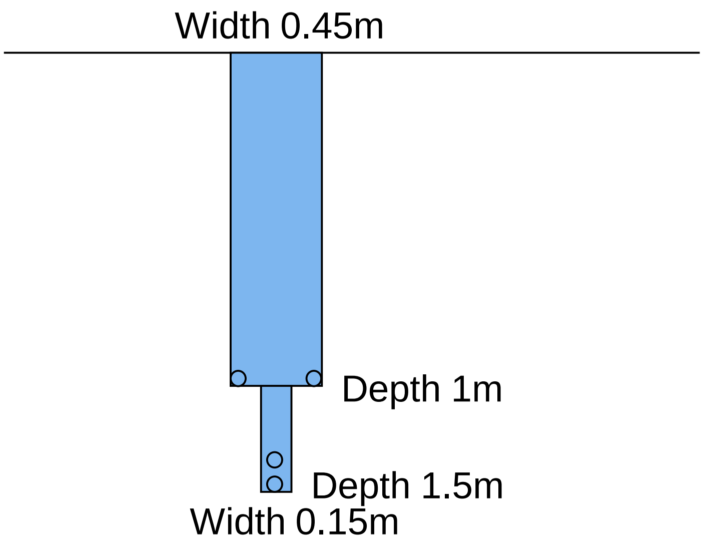
**Dump soil damage the plants (Case of ITB, Indonesia)**

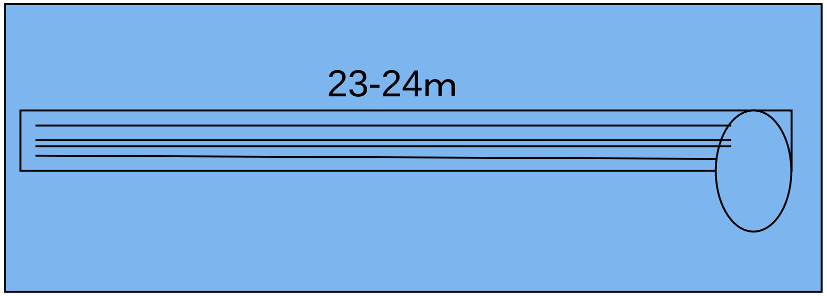



# Narrow Trench Piping （UPN Univ. Jogjakarta, Indonesia)

Narrow Trench reduces Construction Power and Damp Soil.

**One Unit is 100m Length (2 Depth Piping)**




One Unit is 100m Length Piping (Equivalent to 25-50m Drilling).

# Conclusions

1. GHP system give the efficiency up (30-50%?) even tropical countries. (Not only temperature gap but for cooling efficiency by heat exchanger).
2. GHP efficiency comes not only from temperature gap between air and underground but from heat exchanger cooling by GHP.
3. Underground temperature is stable for long term operation (Kamphaengphet case)
4. Shallow piping system is recommended for small scale GHP system of tropical countries.
5. GHP system cost is very low by use of parts and techniques of own countries.