Sarulla Operations Ltd

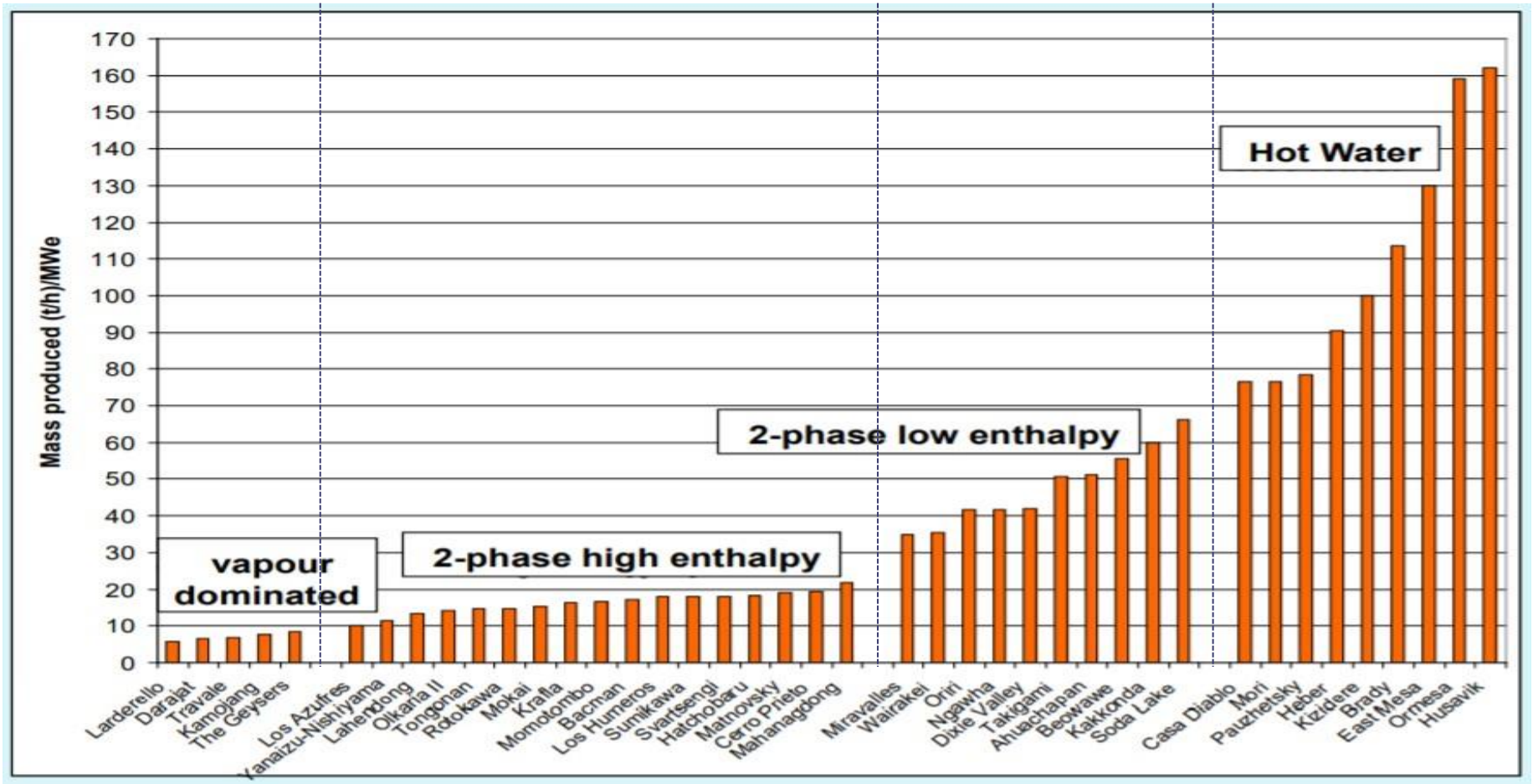
Introduction to Geothermal Production

Surabaya, 25 October 2022

Geothermal is Clean Energy with Small Surface Footprints

Types of Geothermal Systems

Mass Produced per MWe Generated



(From course material of GEOTHERM-602 Postgraduate Certificate in Geothermal Energy Technology, University of Auckland, New Zealand)

Back To Basic (1): Boiling Water

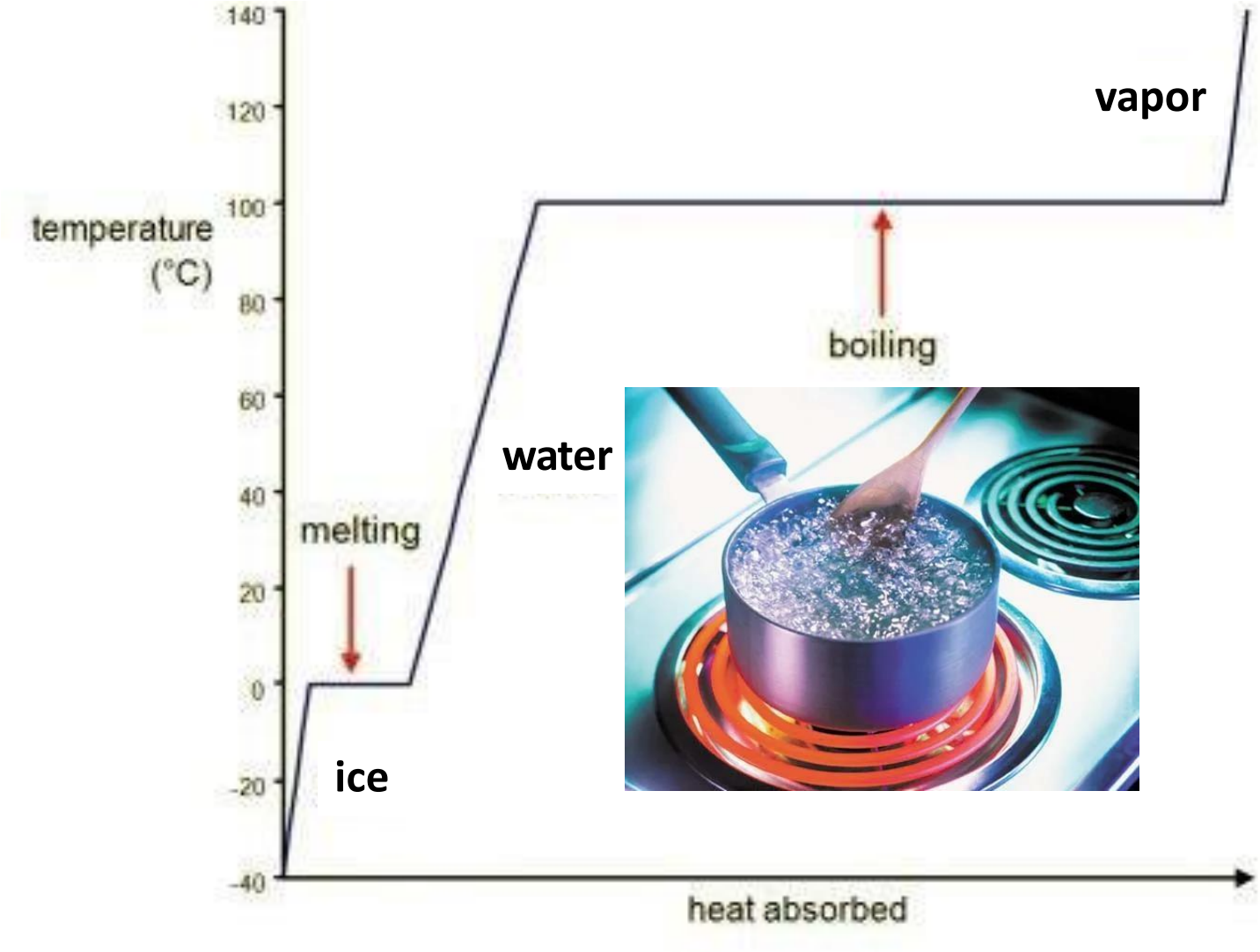


Image Source: https://www.britannica.com/science/boiling-point

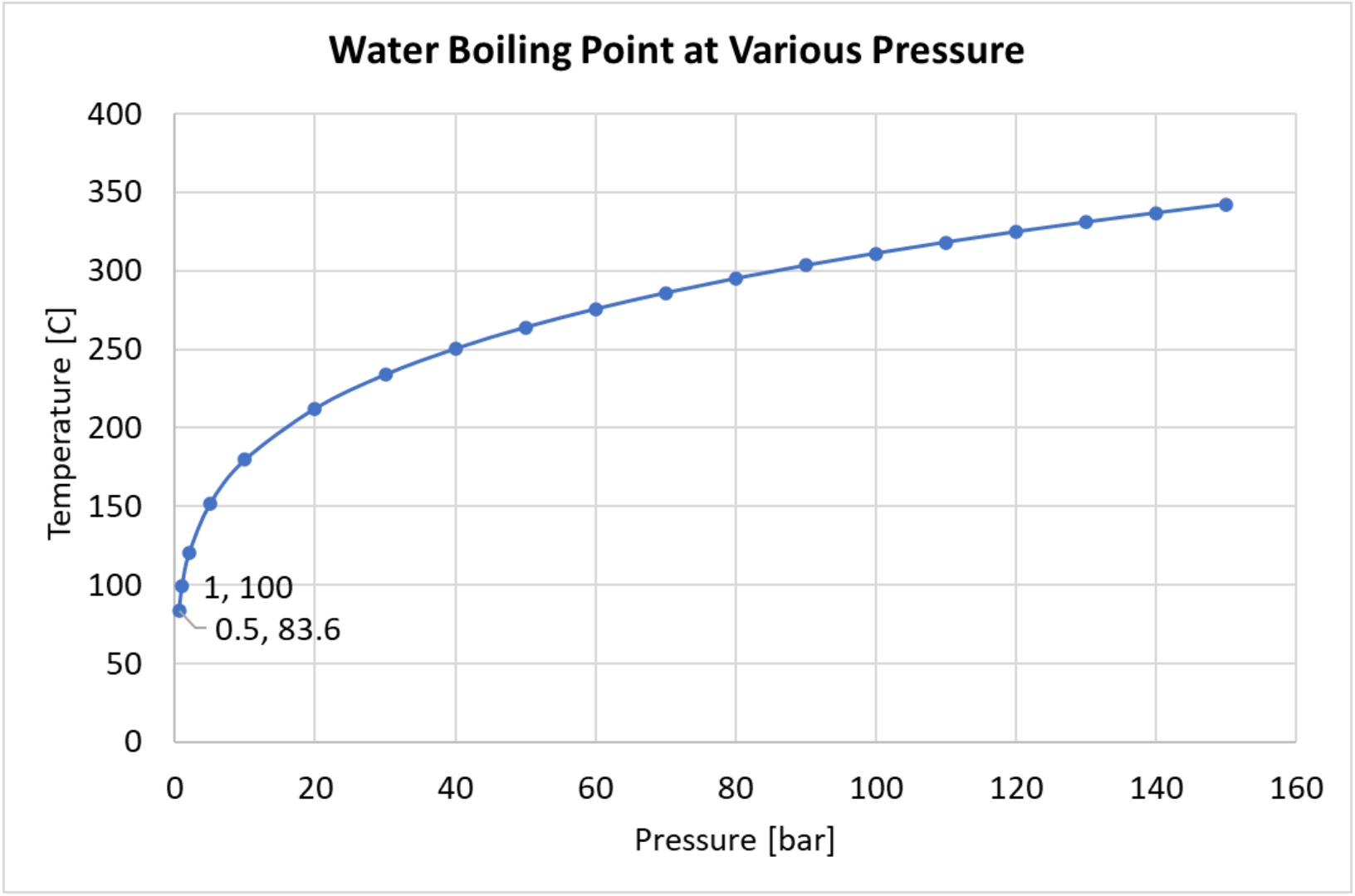
Back To Basic (1): Questions

1. What's the boiling temperature at sea level?

2. What will happen if you keep heating up boiling water? Will the temperature keep getting hotter?

3. If you're at Mahameru & trying to boil some water, which statement is correct?
   a. The water will boil at **higher temperature** than if I boil some water in Surabaya
   b. The water will boil at **exact same temperature** than if I boil some water in Surabaya
   c. The water will boil at **lower temperature** than if I boil some water in Surabaya

Back To Basic (1): Boiling Water



Back To Basic (1): Boiling Water

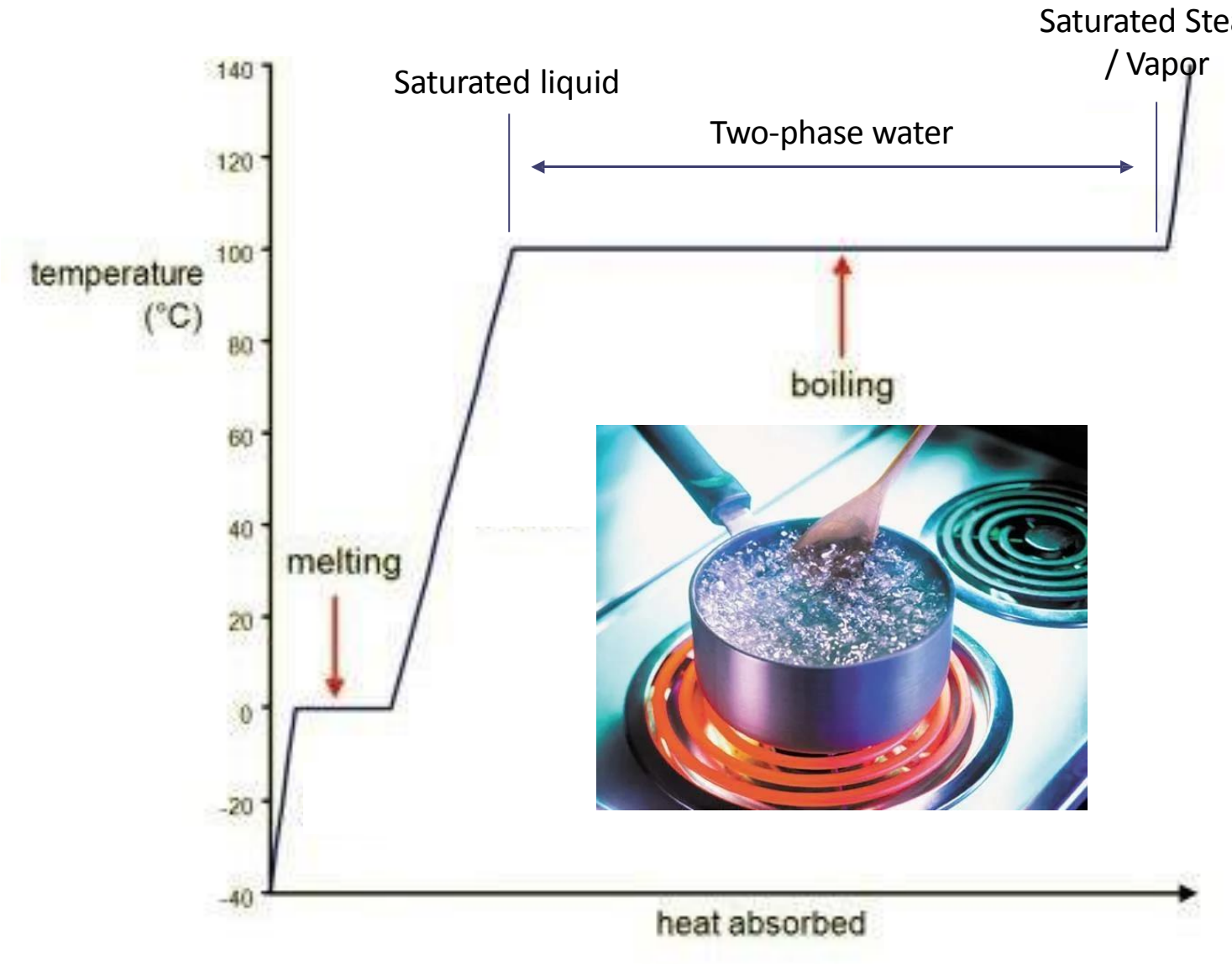


Image Source: https://www.britannica.com/science/boiling-point

Back To Basic (2): What's Specific Enthalpy

1. What's the Enthalpy?

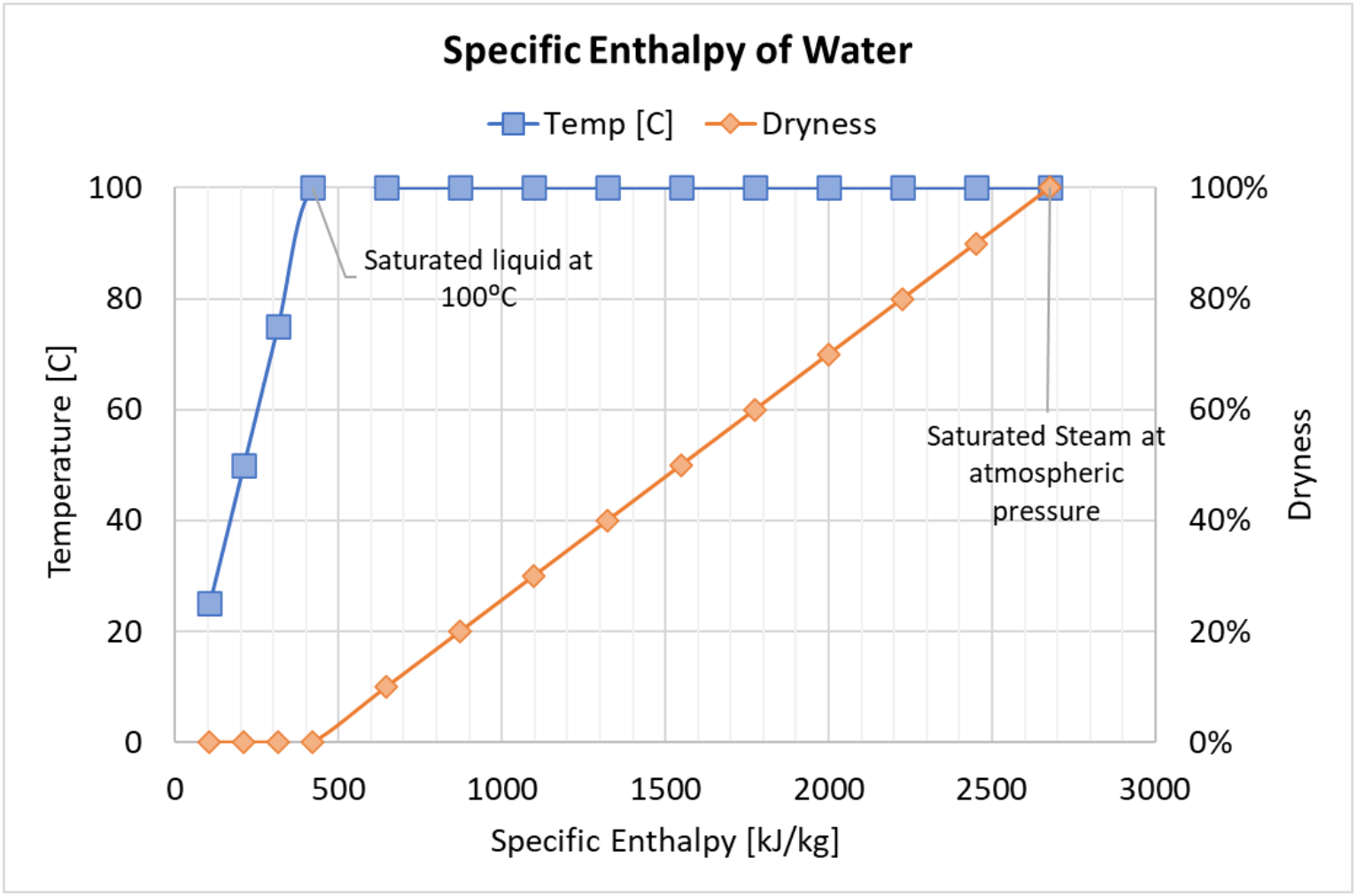
   "Heat energy content"

2. Which one has higher specific enthalpy?
   a. Water at 40^{o}C
   b. Water at 80^{o}C

3. Which one has higher specific enthalpy?
   a. Saturated water at 100^{o}C
   b. Two-phase water 100^{o}C

4. Which one has higher specific enthalpy?
   a. Two-phase water 100^{o}C
   b. Saturated steam at 100^{o}C

Back To Basic (2): What's Specific Enthalpy



Back To Basic (2): What's Specific Enthalpy

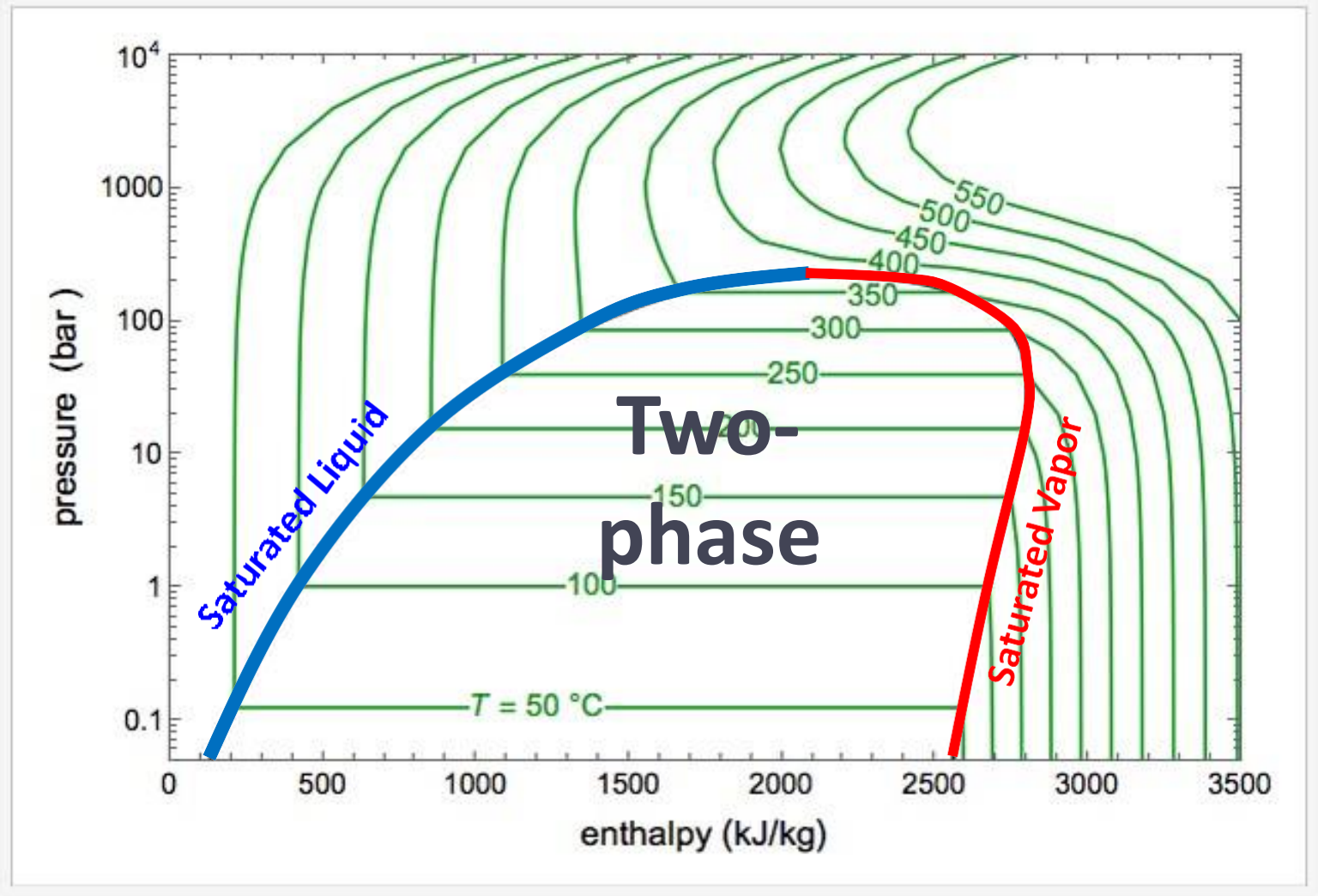


Image Source:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fdemonstrations.wolfram.com%2FPressureEnthalpyDiagramForWater%2F&psig=AOvVaw0rOk3eacXCkyRfo1Bv3Hzj&ust=1666602685824000&source=images&cd=vfe&ved=2ahUKEwjru-r5gPb6AhVY83MBHZrGDIkQjRx6BAgAEAw

Types of Geothermal Systems

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Main Categories and Heat Transfer in Geothermal System

Category		Temp (°C)	Type of Geothermal Power Plant
Two-Phase/Dry Steam Systems (high-temperature)	Low enthalpy	225 < T < 270	Single-flash
	High enthalpy	250 < T < 330	Double-flash
	Vapor-dominated	250 < T < 330	Dry-steam
Hot Water Systems (intermediate/moderate-temperature)		T < 225	Binary / Single-flash
Warm Water Systems (low-temperature)		T < 125	Basic Binary

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1. Single-Flash Steam Power Plants

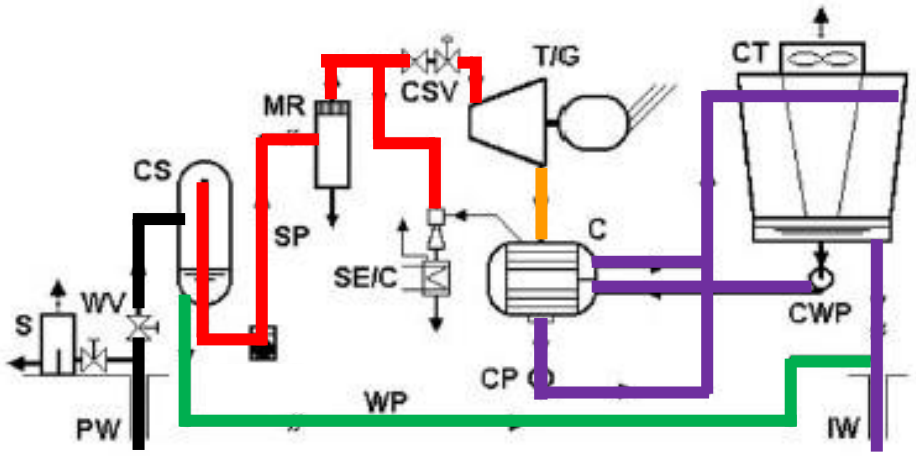

Fig. 5.6 Simplified single-flash power plant schematic [6].

DiPippo R., Geothermal Power Plant: Principles, Applications, Case Studies and Environmental Impacts

Equipment:

1. PW: **Production Well**(s)
2. IW: **Injection Well**(s)
3. WV: Wing Valve
4. S: Silencer (for flow test facility/ emergency release during power plant shut-down
5. CS: Cyclone Separator(s) / **Separator**(s)
6. MR: Moisture Remover / **Scrubber**
7. T/G: **Steam Turbine**
8. SE/C: **Steam Ejector** and/or **Vacuum Pumps**
9. C: **Condenser**
10. CT: **Cooling Tower**

Fluid Types:

1. Two-phase flow
2. Separated steam
3. Separated brine
4. Near-atmospheric steam
5. Condensate

Example of Single-Flash Geothermal Power Plants in Indonesia: Salak / Awibengkok & Wayang Windu (Star Energy), Dieng & Patuha (Geodipa), Lumut Balai, Ulubelu & Lahendong (PGE), Ulumbu & Mataloko (PLN)

1. Single-Flash Steam Power Plants: Questions

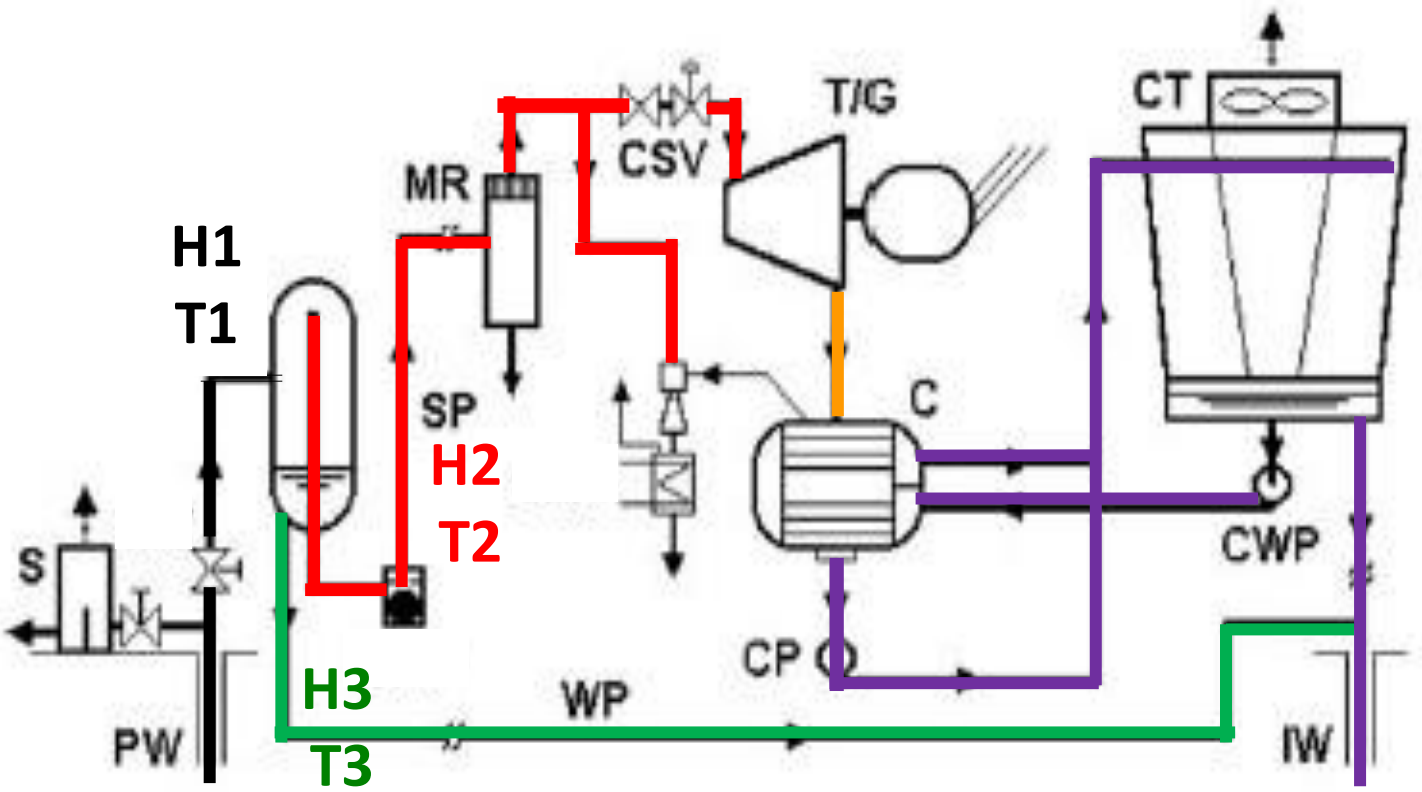

Fig. 5.6 Simplified single-flash power plant schematic [6].

1. Does H1 = H2 = H3? Explain

2. Does T1 = T2 = T3? Explain

Piping & Separators Layout

2. Double-Flash Steam Power Plants

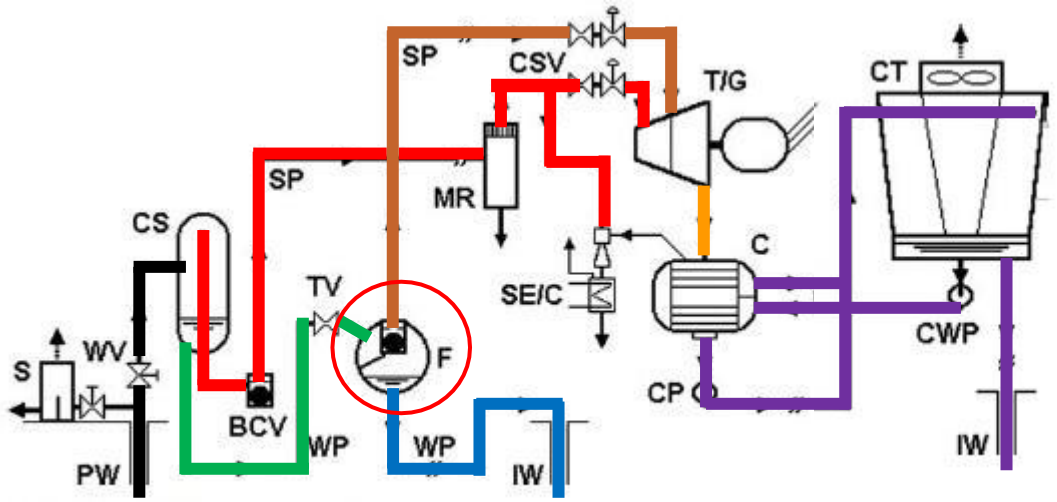

Fig. 6.6 Simplified double-flash power plant schematic [1].

DiPippo R., Geothermal Power Plant: Principles, Applications, Case Studies and Environmental Impacts

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8. SE/C: **Steam Ejector** and/or **Vacuum Pumps**
9. C: **Condenser**
10. CT: **Cooling Tower**
11. F: Flasher

Fluid Types:

1. Two-phase flow
2. High-pressure separated steam
3. High-temperature separated brine
4. **Low-pressure steam**
5. **Low-temperature separated brine**
6. Near-Atmospheric steam
7. Condensate

Example of Double-Flash Geothermal Power Plant in Indonesia: Muara Laboh (Supreme)

3. Dry-Steam Power Plants

Dry-steam Power Plants is much simpler. It's specifically designed for geothermal field with **no brine production**

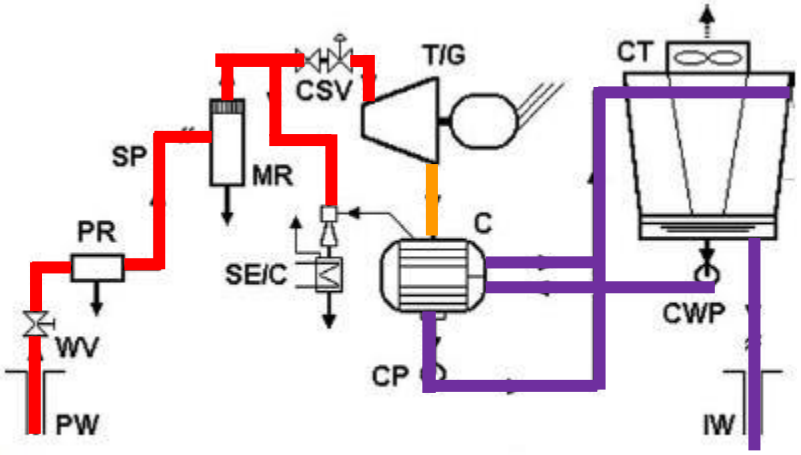

Fig. 7.10 Simplified schematic flow diagram for a dry steam plant [18].

DiPippo R., Geothermal Power Plant: Principles, Applications, Case Studies and Environmental Impacts

Equipment:

1. PW: **Production Well**(s)
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3. WV: Wing Valve
4. ~~S: Silencer (for flow test facility/ emergency release during power plant shut-down~~
5. ~~CS: Cyclone Separator(s) / **Separator**(s)~~
6. MR: Moisture Remover / **Scrubber**
7. T/G: **Steam Turbine**
8. SE/C: **Steam Ejector** and/or **Vacuum Pumps**
9. C: **Condenser**
10. CT: **Cooling Tower**
11. PR: Particulate Remover

Fluid Types:

1. Steam
2. Near-atmospheric steam
3. Condensate

Example of Dry-Steam Geothermal Power Plants in Indonesia: Darajat (Star Energy) and Kamojang & Karaha Bodas (PGE)

4. Binary Cycle Power Plants

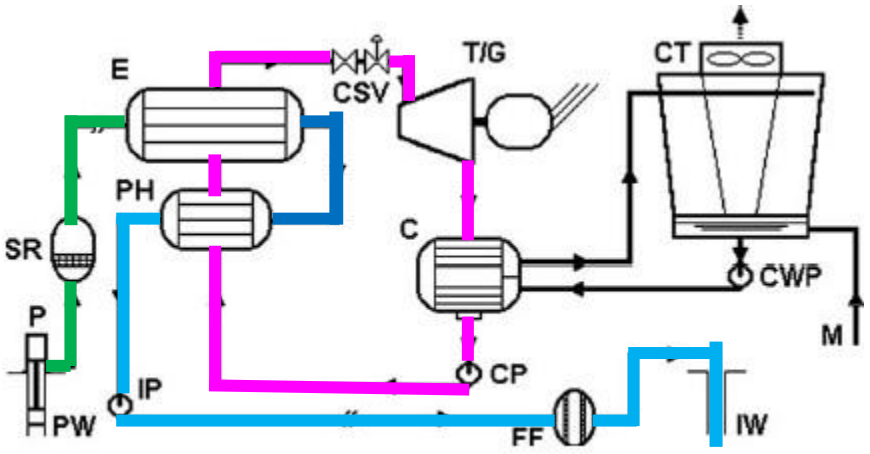


Fig. 8.1 Simplified schematic of a basic binary geothermal power plant [4].

DiPippo R., Geothermal Power Plant: Principles, Applications, Case Studies and Environmental Impacts

Equipment:

1. PW: **Production Well**(s)
2. IW: **Injection Well**(s)
3. P: Pump
4. SR: Sand Remover
5. E: Evaporator
6. PH: Preheater
7. T/G: **Steam Turbine**
8. C: **Condenser**
9. CT: **Cooling Tower**
10. FF: Final Filter

Fluid Types:

1. Hot-Brine
2. Colder Brine
3. Organic Motive fluid (liq.)

5. Combined-Cycle Power Plants (1)

Single-Flash & Binary Plan

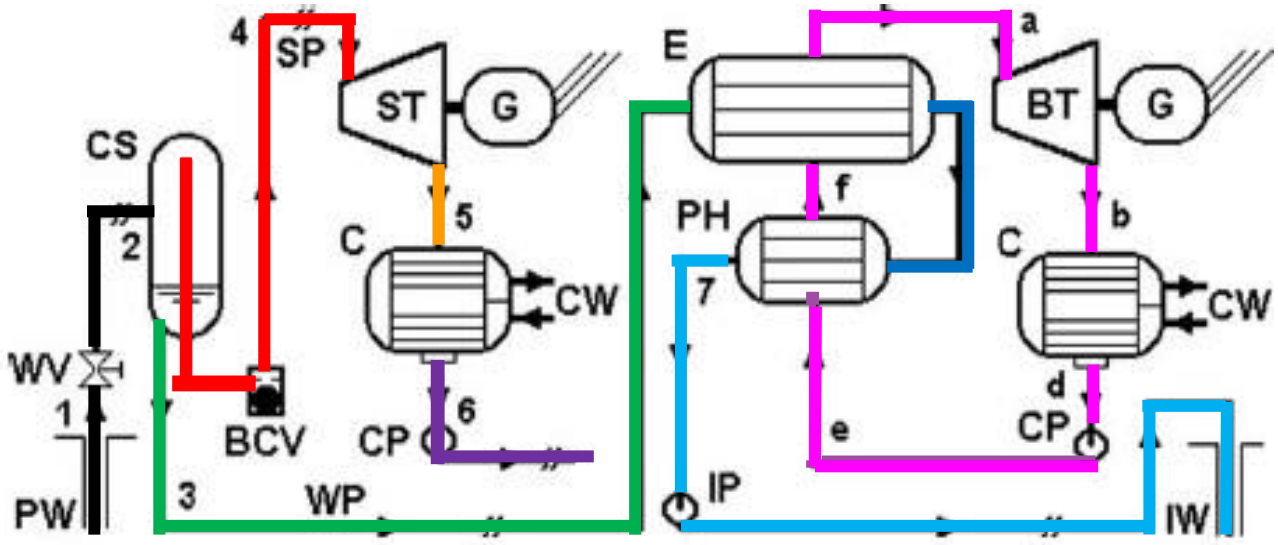


Fig. 9.7 Combined single-flash and basic binary plant; after [1].

5. Combined-Cycle Power Plants (2)

Integrated Single-flash & Binary Plants

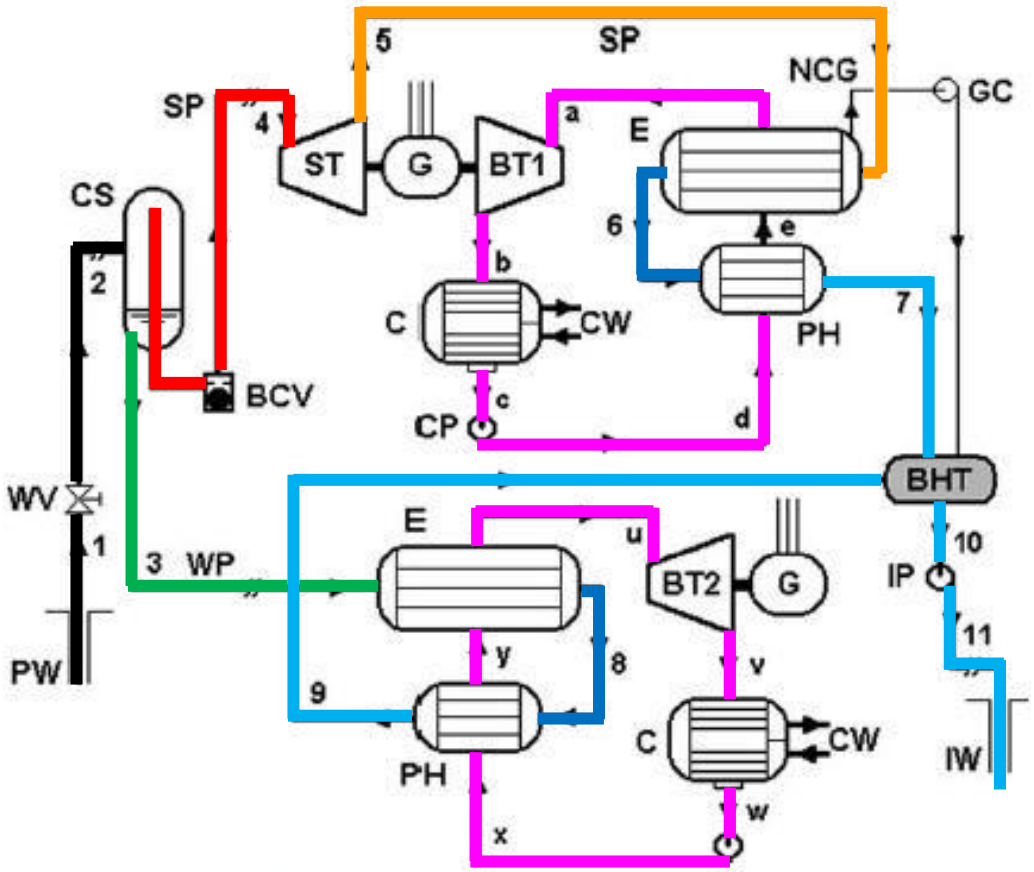
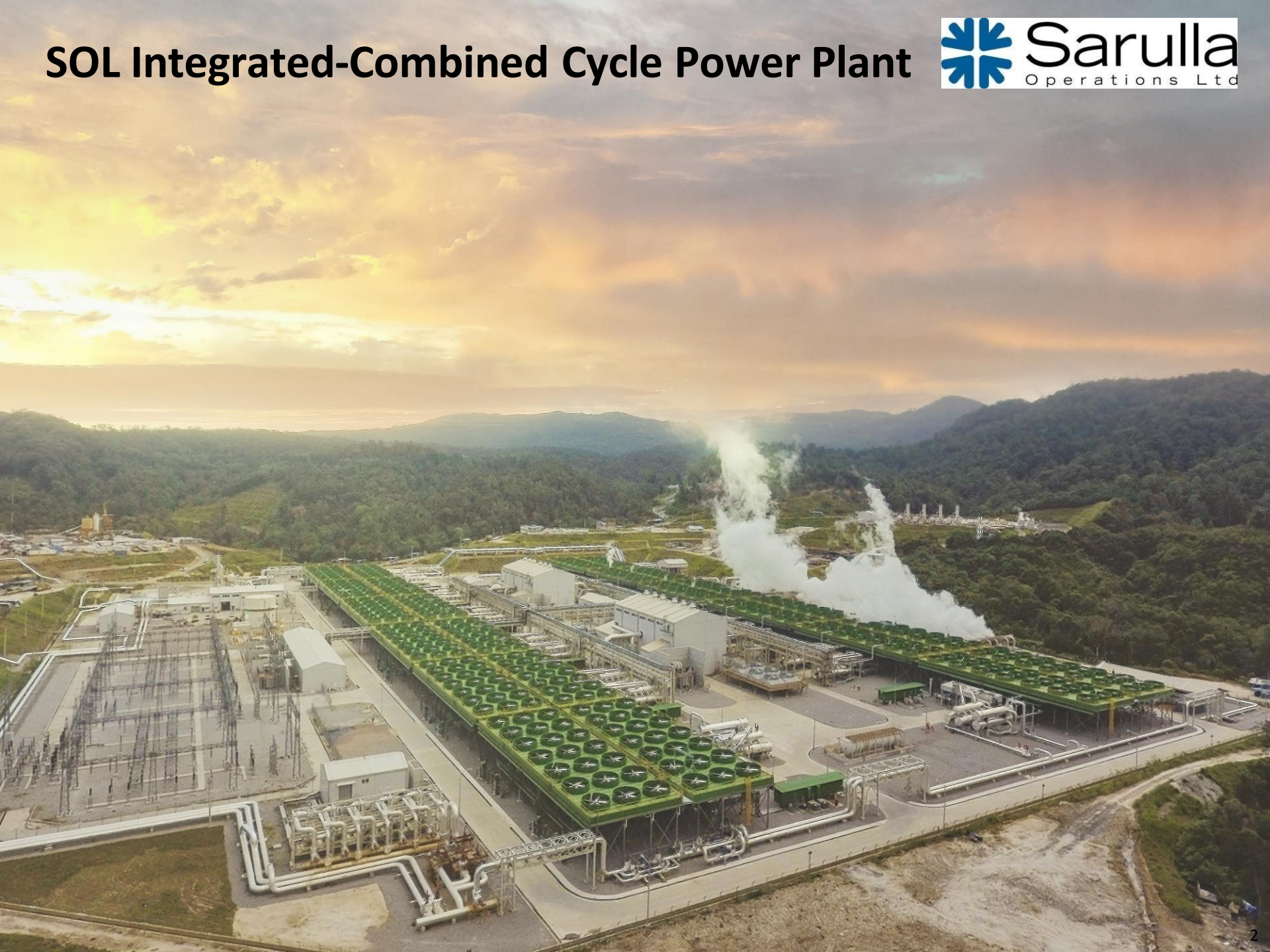


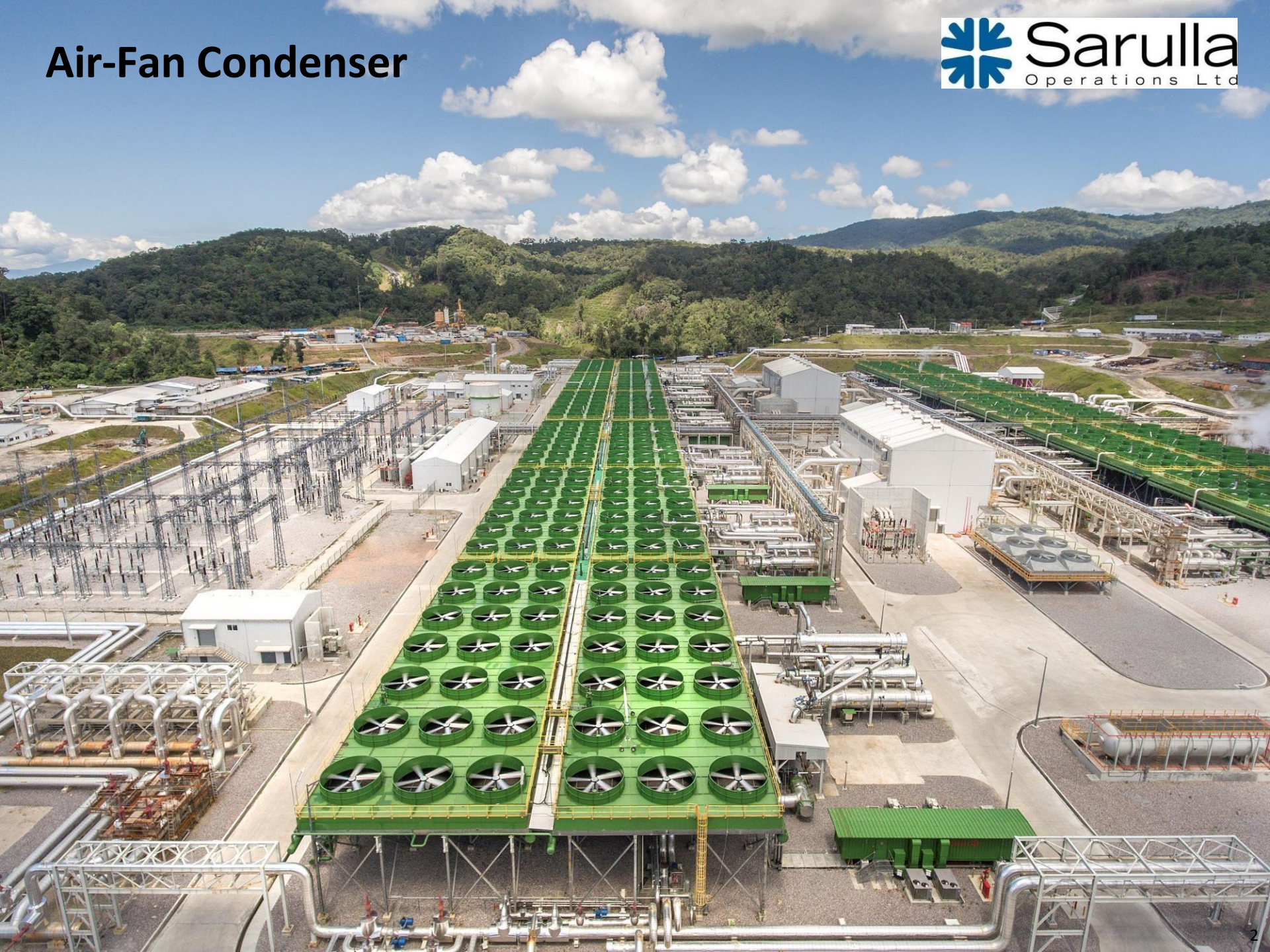
Fig. 9.9 Integrated single-flash/binary plant.

Example of Combined-Cyle Geothermal Power Plants in Indonesia: SIL & NIL (Sarulla Operations Limited) and Sorik Marapi & Sokoria (KS Orka)

SOL Integrated-Combined Cycle Power Plant



Air-Fan Condenser



Animated Combined-Cycle Power Plants

SARULLA DIGITAL ANIMATION_1.mp4


Geothermal Plant Map
https://www.thinkgeoenergy.com/map/