GEOCAP
The Geothermal Capacity Building Program Indonesia-Netherlands

ONE DAY WORKSHOP

6th April
08.00-16.00 WIB

Ruang Chevron
Gedung Dekanat Fakultas
Teknik Universitas Indonesia
Kampus Baru UI, Depok,
Jawa Barat

Direct Use of Low-Enthalpy Geothermal Sources:
Feasibility Study & Project Financing in Agriculture, Industry and Small Scale Power Generation

Feasibility Study of Geothermal Waste Heat Utilization for Agriculture Processes in West Java

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Outline

- Technical Assessment
- Economical Assessment
- Proposed Project Structure

Potential Candidates from Quick Scan

Based on the potential market, there are 25 potential market consisting of:

- **Tea drying for tea industry** there are 5 locations. → Kertamanah Unit is the most potential candidate because of the distance that is closest to the source of waste heat.
- **Vetiver oil refinery** there are 2 locations but only one adjacent to geothermal sources. Its location close to Kamojang. → H. Ede Refinery
- **Beverage and soft drinks**, there are 7 locations. → 4 potential candidates (cluster industry) which are located quite close to the source (PT. Yakult Indonesia, PT. Djojonegoro, PT. Indofood Asahi, PT. Indolakto)

TECHNICAL ASSESSMENTS

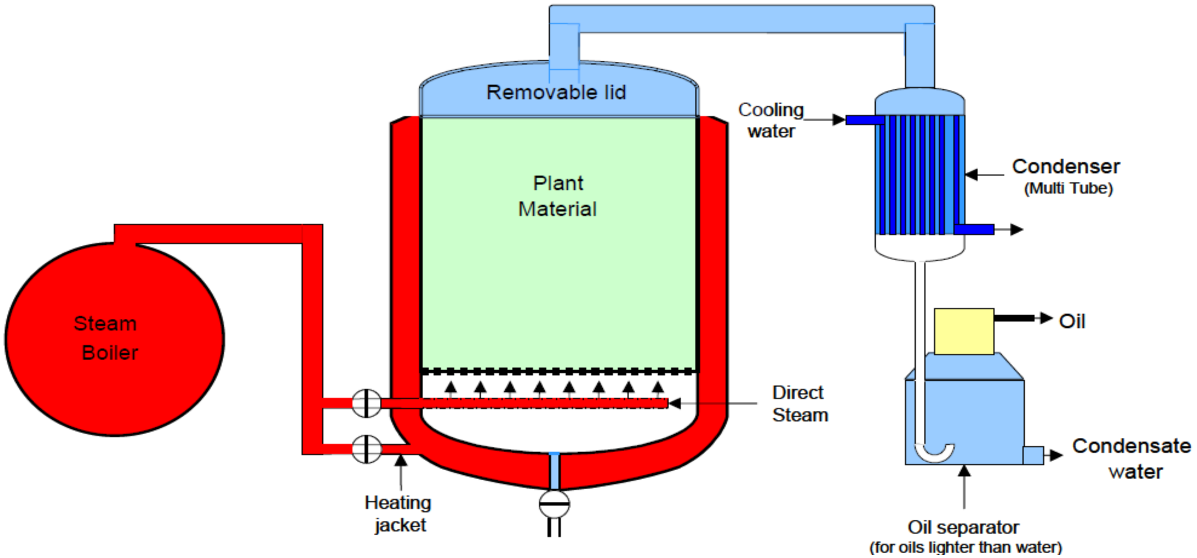
Vetiver Oil Refining

User overview

H. Ede Vetiver Oil Refinery located at district Samarang, Garut Regency West Java

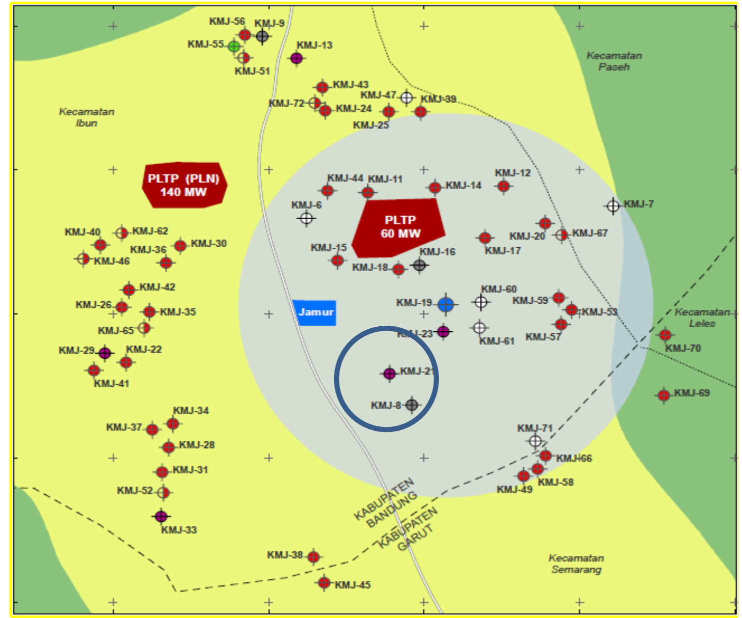
It operates traditional steam distillation at pressure of 6 bar, temperature of about 158° C, and 12 hours operation. Distillation kettle is capable of processing the grass ~ 2 tons for each batch, and produces ~ 6 kg of vetiver oil.

Main Equipments

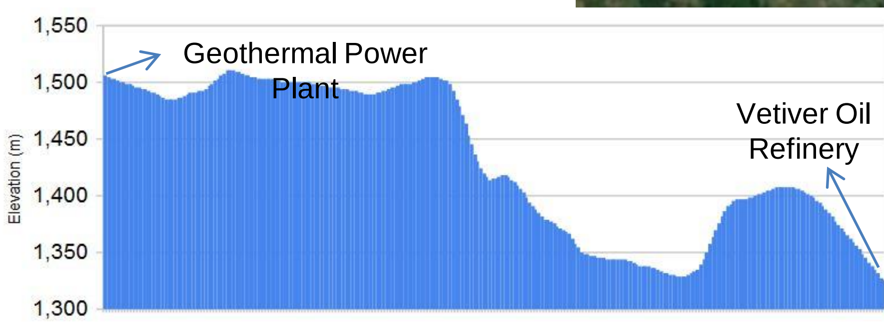


Steam Pipeline Route

The estimated distance is
~ 6 km

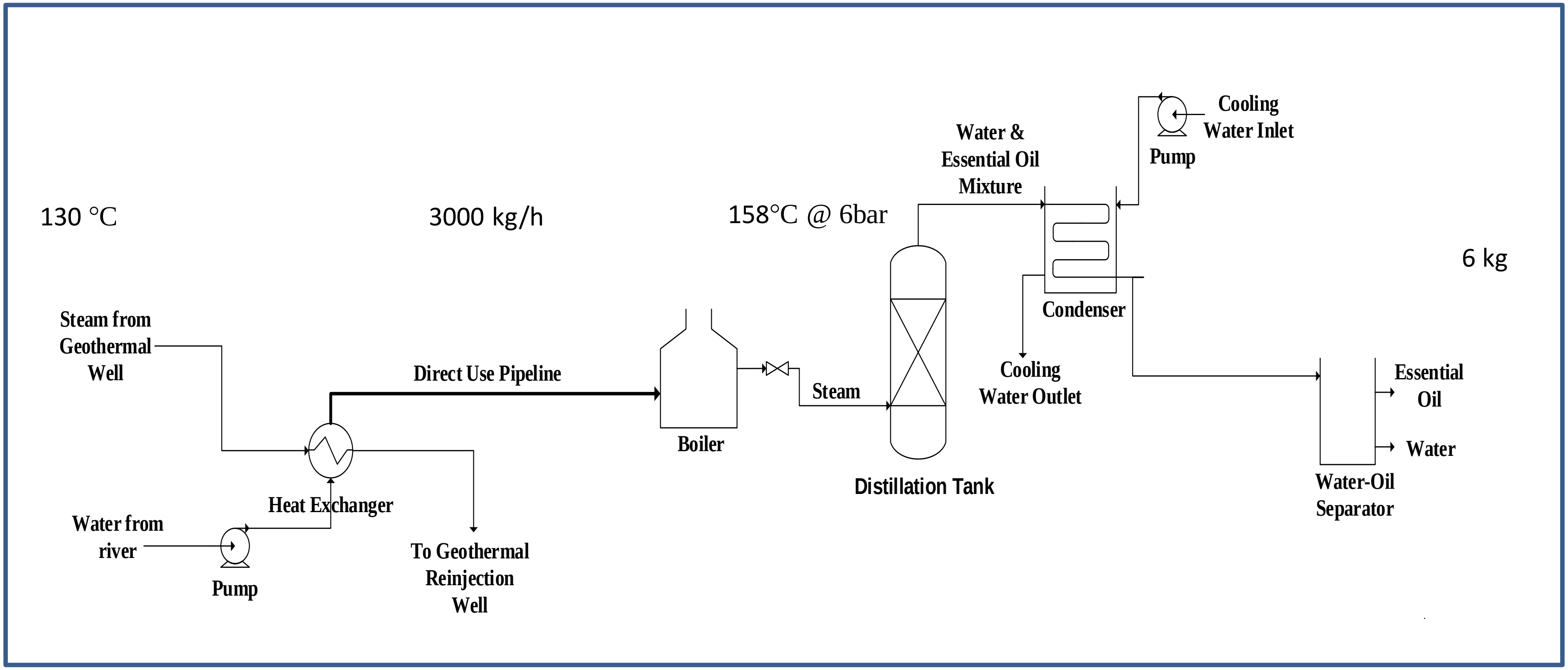


Geothermal PP, PGE Kamojang



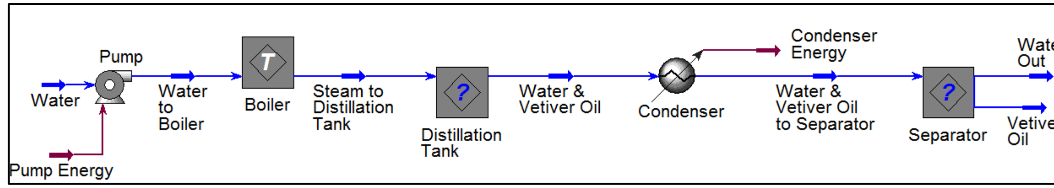
- There is a problem in temperature level of Kamojang waste heat
- Heat source directly from abandon well or monitoring well

Process Flow Diagram

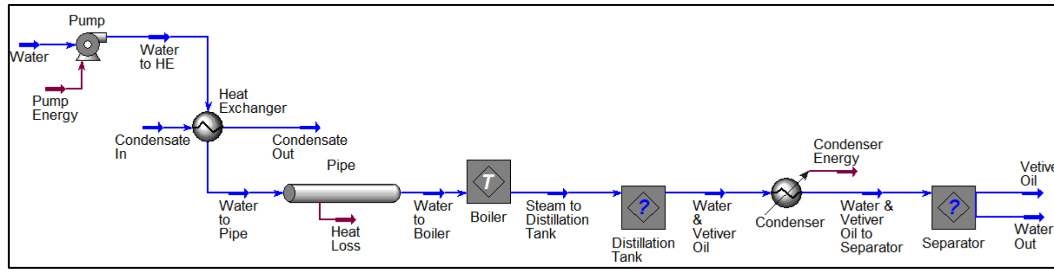


Source Steam Scenarios

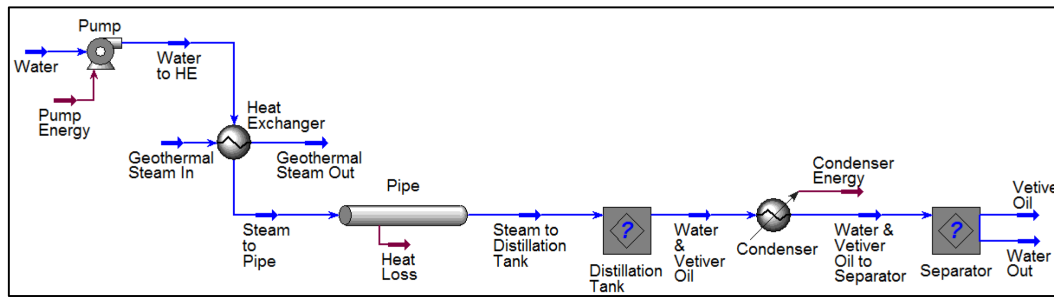
BaU (Boiler) Scheme



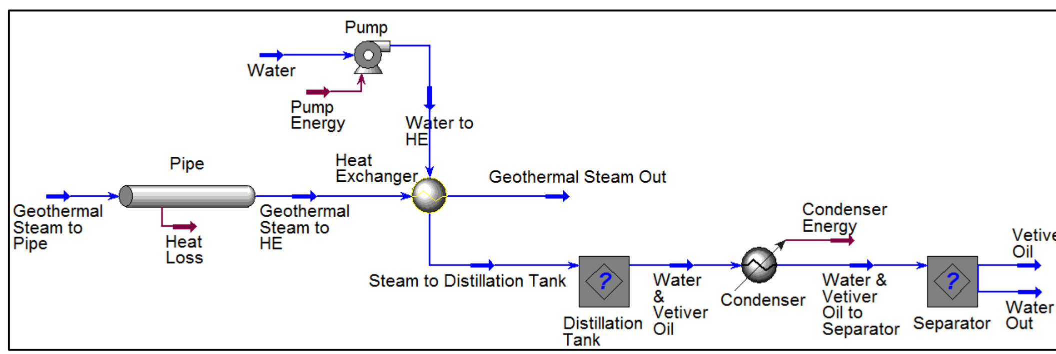
Condensate + Boiler Scheme



Geothermal Steam Scheme 1



Geothermal Steam Scheme 2

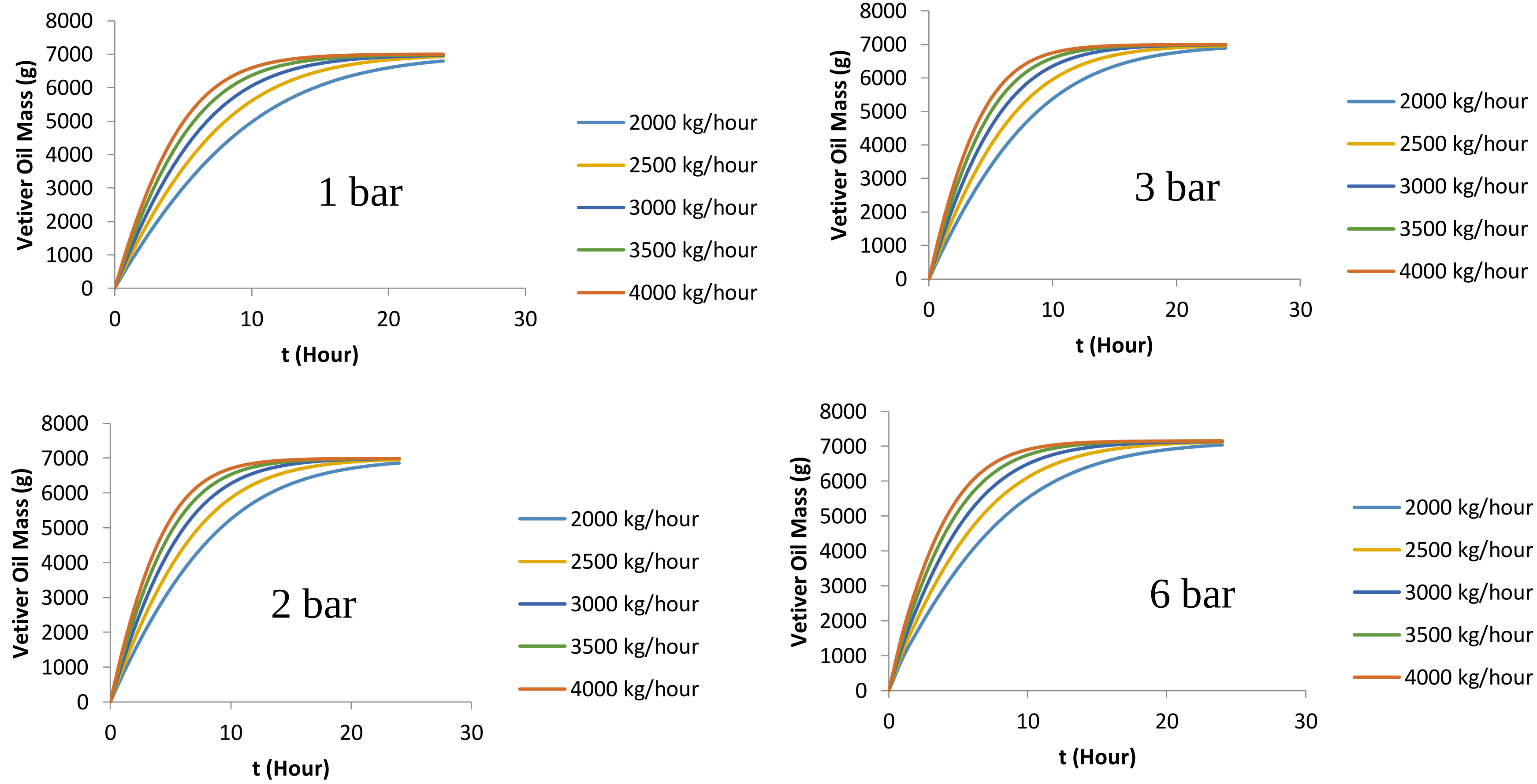


Steam Distillation Modelling

$$\theta = \frac{N_i}{S_i}\left[\frac{\pi}{EP} \times \left(\ln \frac{X_f}{X_s}\right) + \left(\frac{\pi}{EP} - 1\right)\left(X_f - X_s\right)\right]$$

where
S_i = Steam flow rate (mole/hour)
X_f = Mole of feed per mole of inert
θ = Distillation time (hour)
X_s = Mole of residue per mole of inert
N_i = mole of inert (mole)
P = Vapor pressure of volatile (mmHg)
π = Pressure of system (mmHg)
E = Vaporization efficiency

Influence of steam rate and pressure on distillation performance

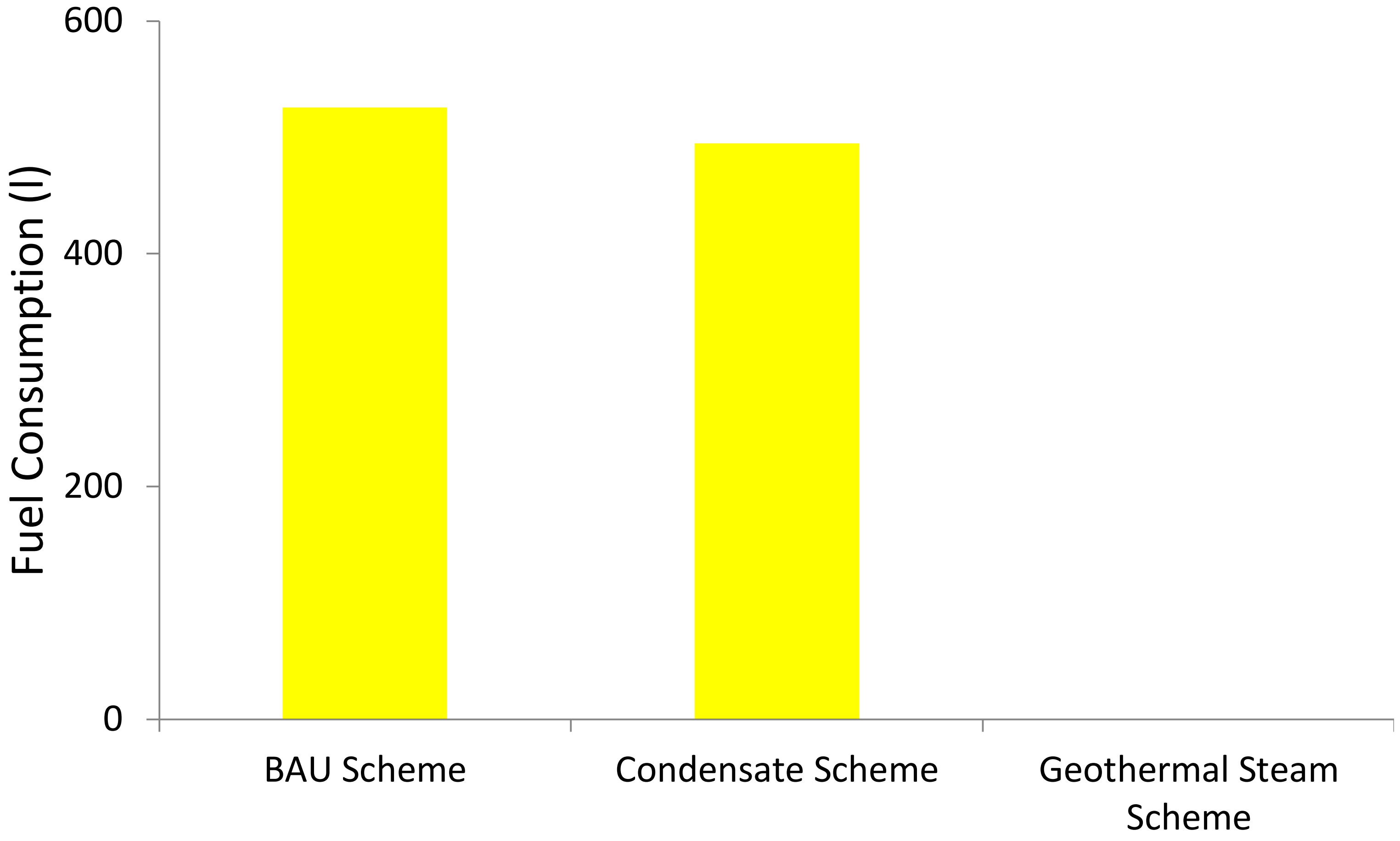


GEO CAP

Simulation Result

Parameter	BAU Scheme	6 bar Simulation	Proposed Operating Condition
Pressure	6 bar	6 bar	3 bar
Temperature	160°C	160°C	130°C
Steam flow rate	2500 kg/hour	2500 kg/hour	3000 kg/hour
Time	12 hours	12 hours	14 hours
Vetiver oil obtained	6 kg	6.5 kg	6.8 kg

Comparison of fuel consumption



Tea Drying

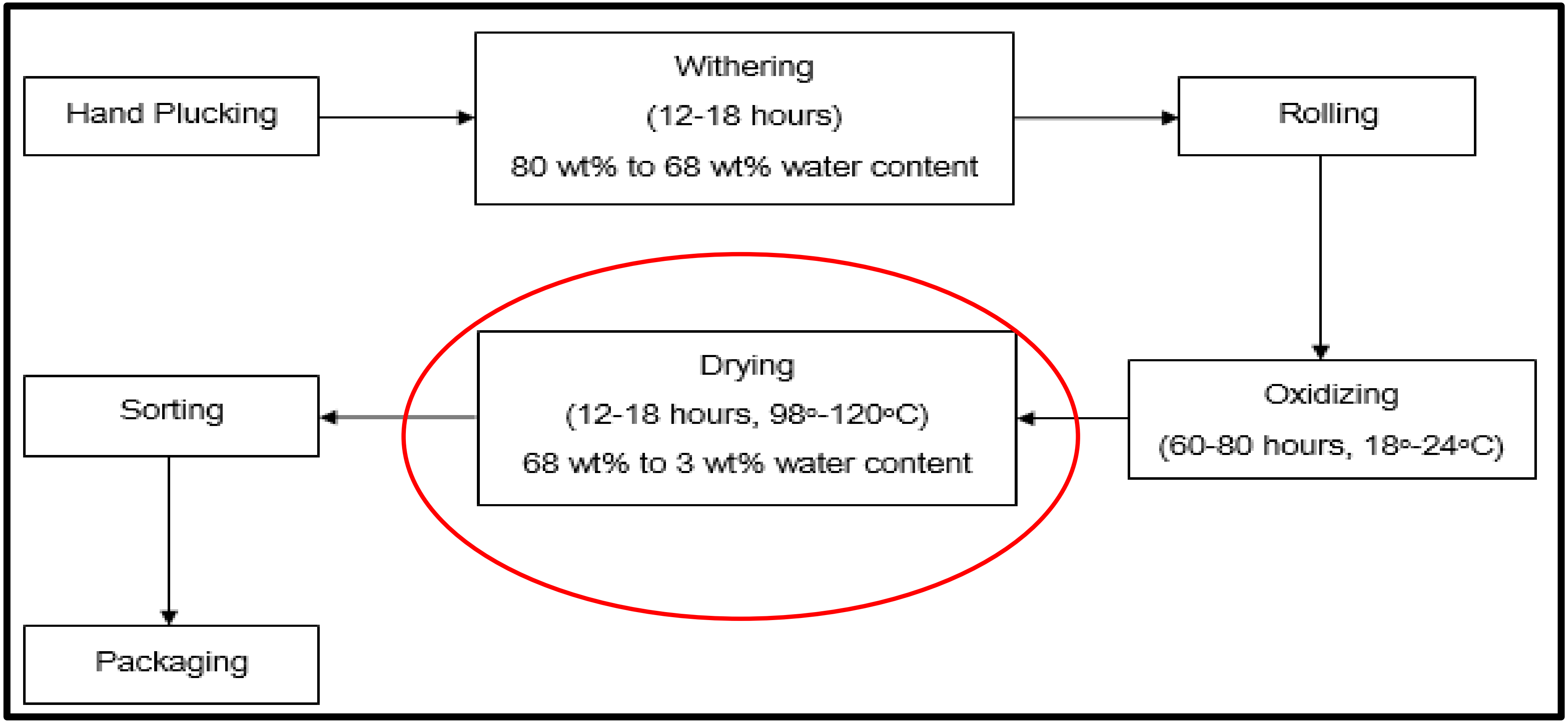
User Overview

Kertamanah tea processing located Pangalengan Bandung

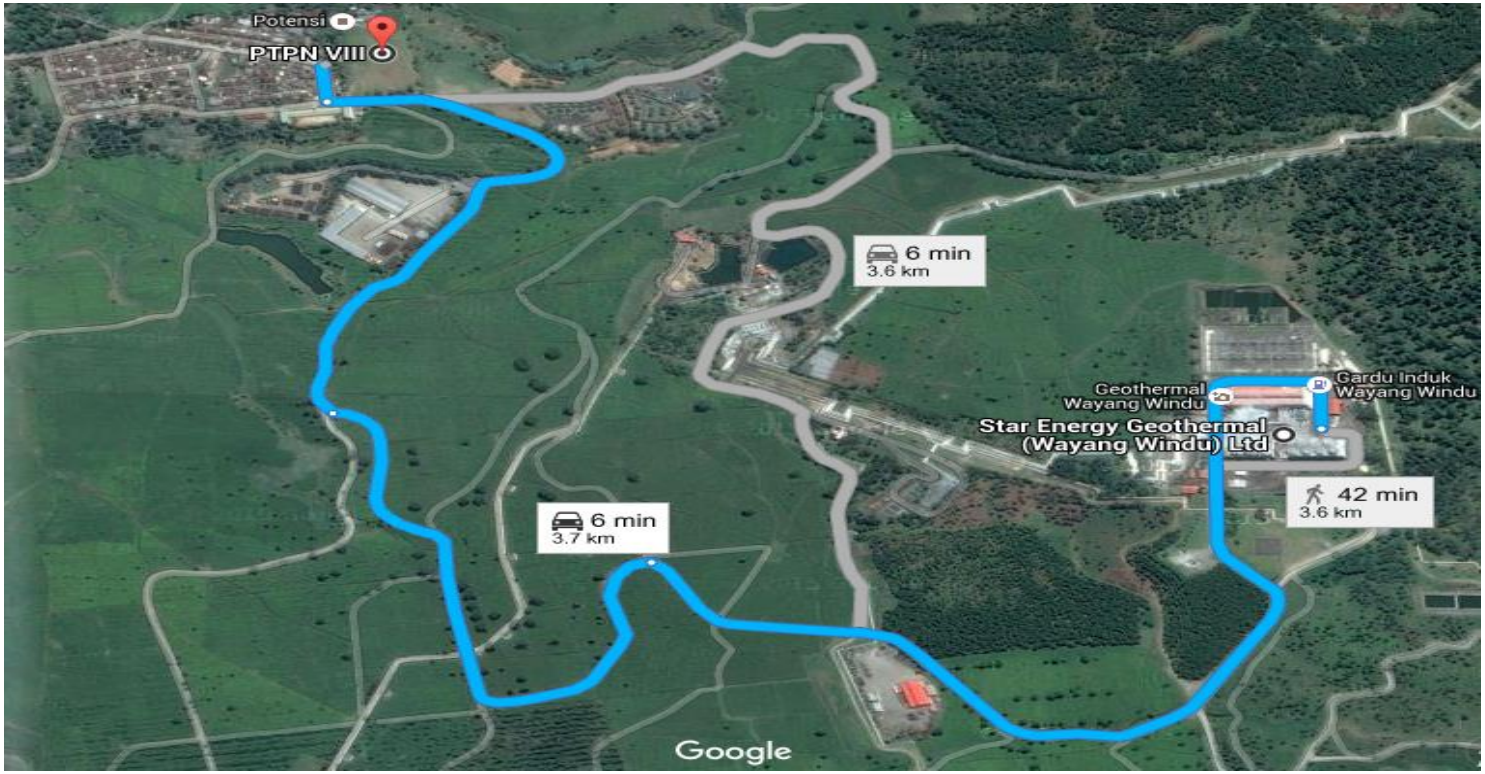
It produces high quality tea and has two concurrent rolling methods in one factory, i.e. CTC and orthodox methods. This plantation operates under management of PTPN VIII.

Tea processing capacity is 50 tons wet top-picked tea leaves per day, equivalent to 4.5 tons dry tea per day.

Tea processing

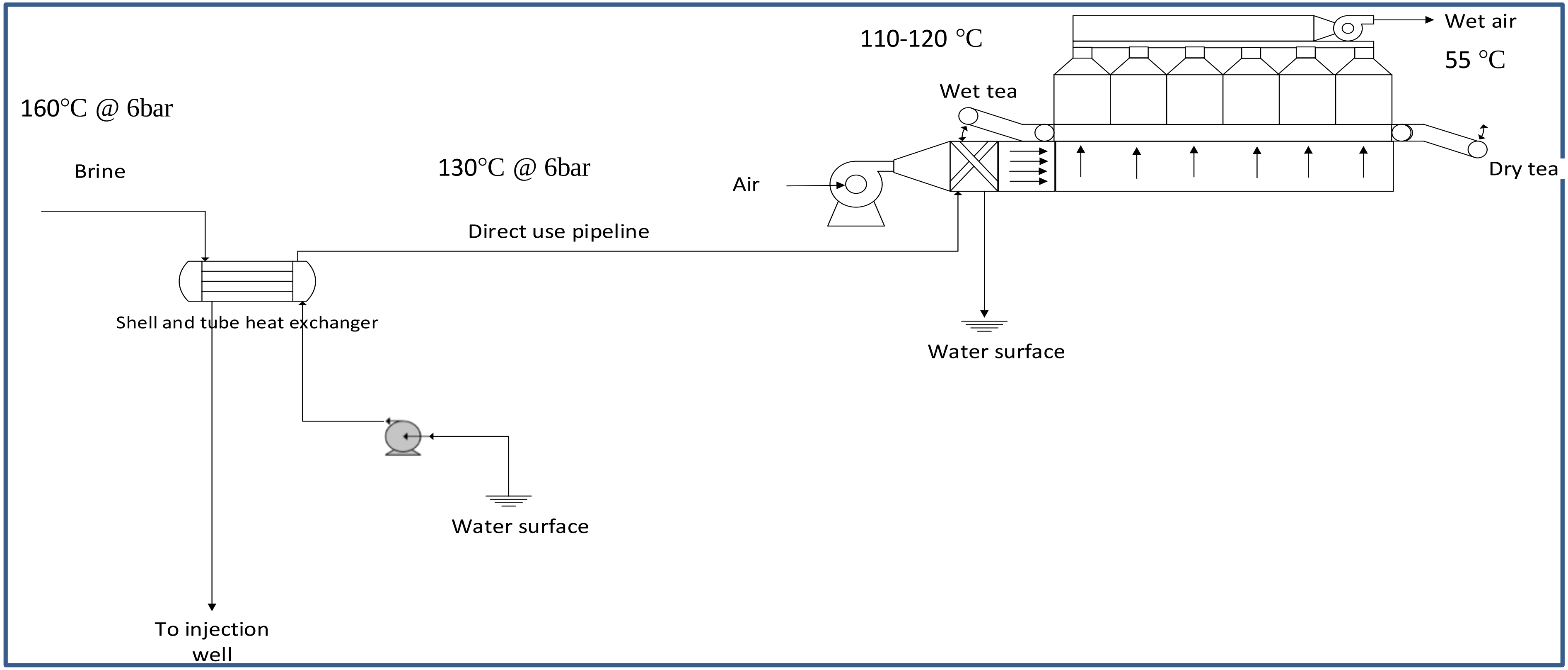


Steam Pipeline Route

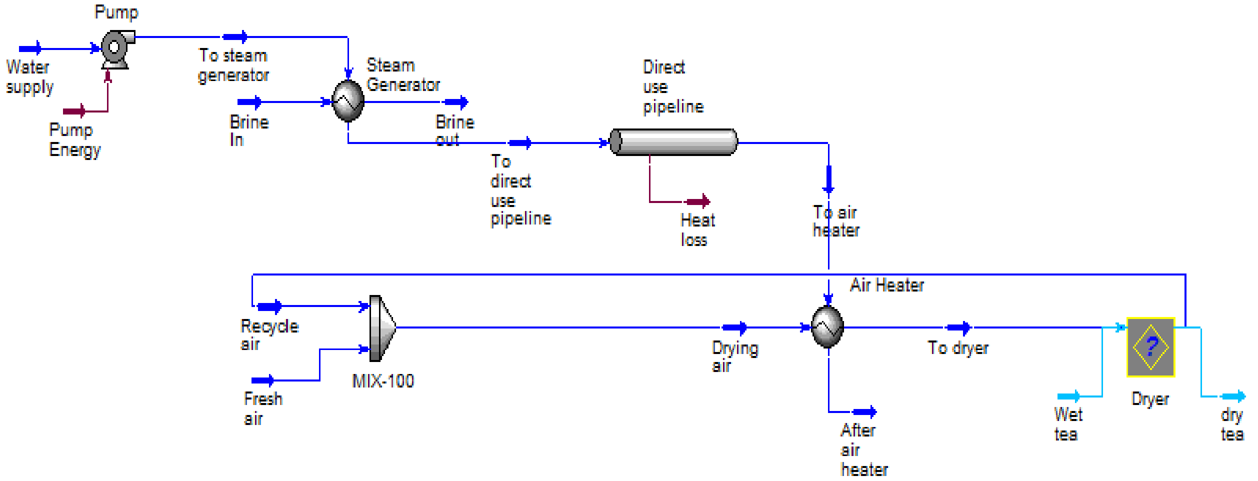


The estimated pipilene distance is about 2 km or 3.7 km via main road from Geothermal PP Star Energy Wayang Windu to Tea Processing

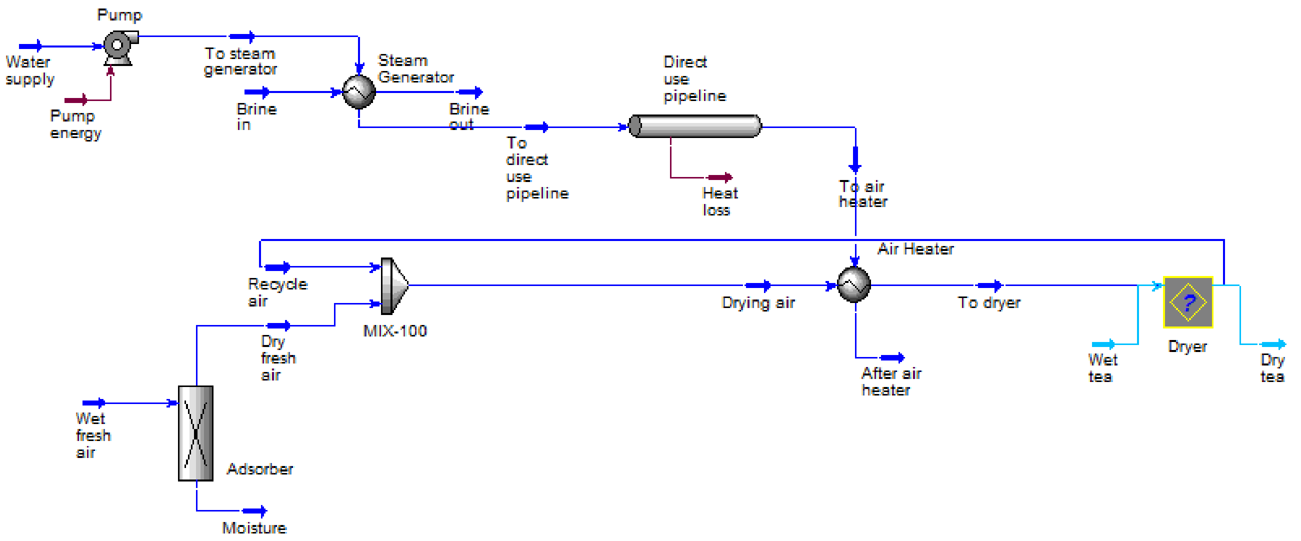
Process Flow Diagram



Simulation Schemes



without adsorber

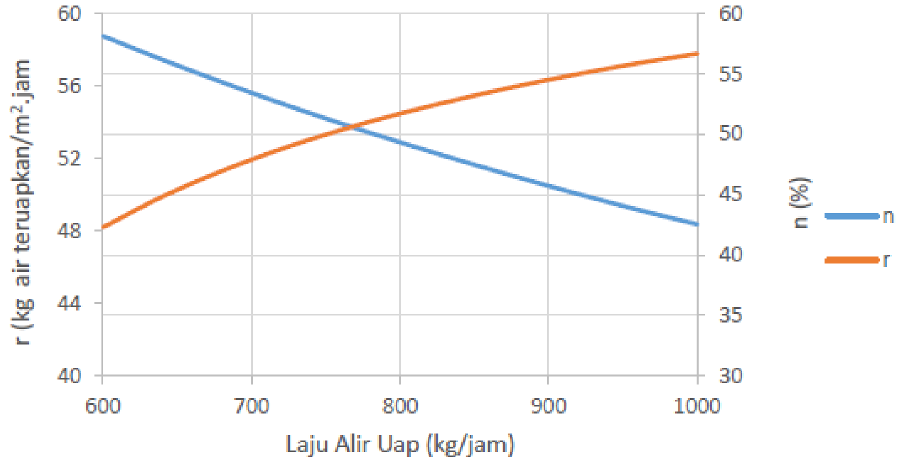


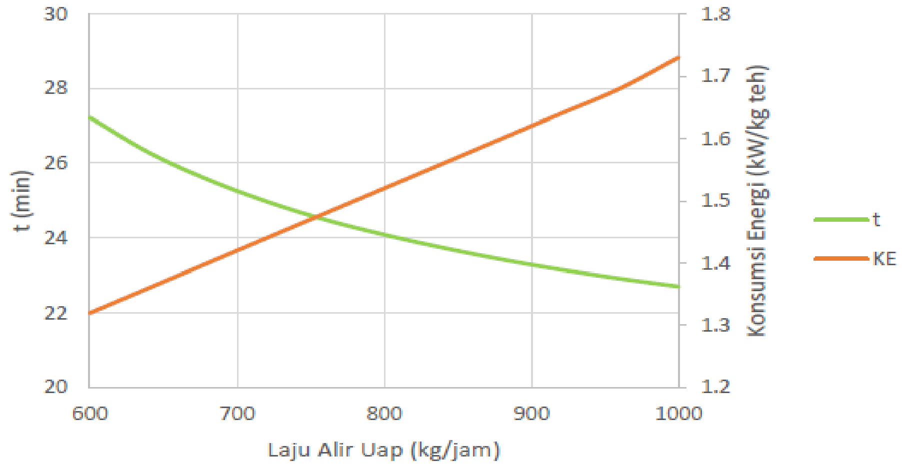
with adsorber

Equations of drying processess

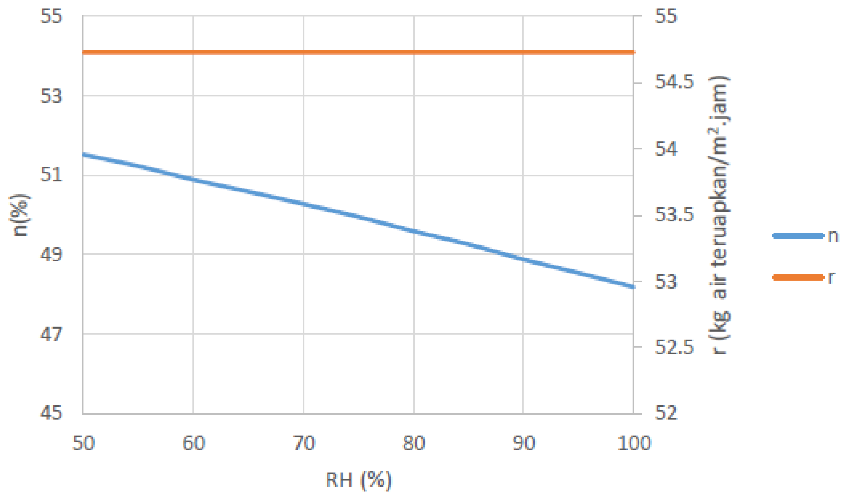
Psychometric Equations	
$P_s = \exp(A - B/(C + T))$	(1)
$Y = \mathrm{m}a_w P_s/(P - a_w P_s)$	(2)
Drying Kinetics	
$X^* = (\, a_w X_m ck)/((1 - ka_w)(1 + cka_w - ka_w))$	(3)
$t = (\ln(X - X^*)\,/(\,X_0 - X^*)/(-k))$	(4)
Mass Balance	
$W = F(X_0 - X)$	(5)
$F_a = W/(X_0 - X)$	(6)
Heat Energy	
$Q_{we} = F(X_0 - X)(\Delta H_0 - (C_{PL} - C_{PV})T)$	(7)
$Q_{sh} = F(C_{PS} + C_{PL}X_0)(T - T_0)$	(8)
$Q_{ah} = F_a(C_{PA} + C_{PV}Y_0)(T - T_0)$	(9)
$Q = Q_{we+}Q_{sh} + Q_{ah}$	(10)
Dryer Specifications	
$M = tF(1 + X_0)$	(11)
$H = M/(1 - \varepsilon)\rho_s$	(12)
$A = H/Z_o$	(13)
$L = A/D$	(14)
$v_b = L/t$	(15)
$E_b = eL(1 + X_0)F$	(16)
Dryer Performances	
$n = Q_{we}/Q$	(17)
$r = W/A$	(18)
$SE = Q/F$	(19)
Fan Spesifications	
$\Delta P = f_{we}Z_0V^2$	(20)
$F_f = \rho_a VDL$	(21)

Influence of steam rate on drying rate and energy efficiency

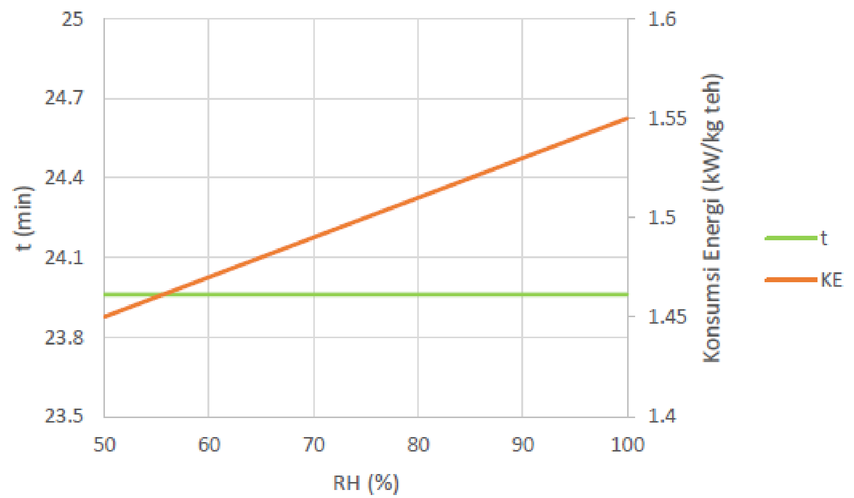




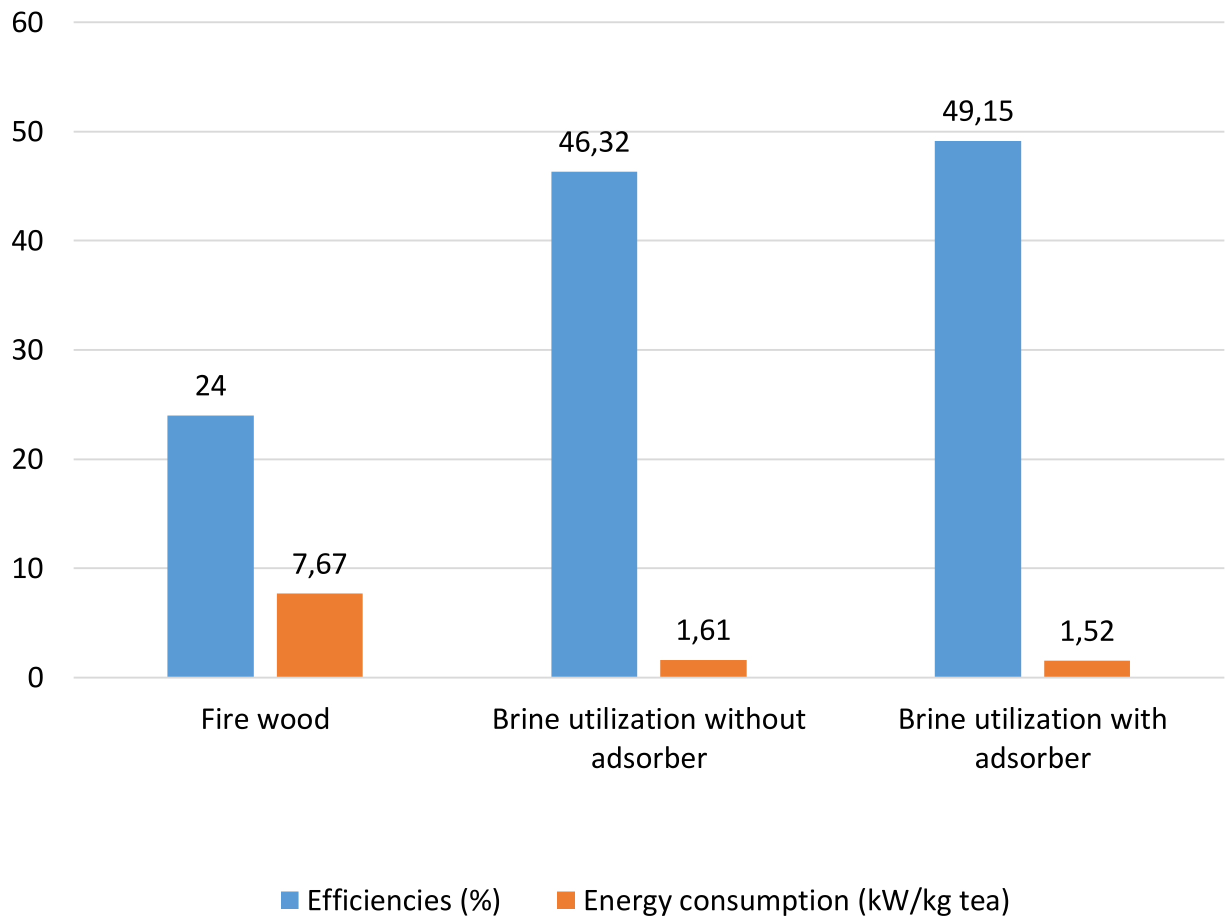
Influence of RH on drying rate and energy efficiency



(a)



Comparison of drying performances



ECONOMICAL ASSESSMENTS

Financing Scheme

Scheme 1 : Capital is earned from the bank loan as much as 100% of total capital cost. The interest rate on this loan is set at 10% which is common used in Indonesia banks. Meanwhile, the tax component used in the calculation is income tax which amounts 25%.

Scheme 2 : The source of capital is the same as scheme 1. However, the tax component used in the calculation is adjusted to the regulation of Finance Ministry (PMK No. 21/PMK.011/2010). Under the regulation, government provides income tax facility for activities exploiting renewable energy sources in the form of net income reduction as much as 30% of the total capital cost which is charged for 6 years (5% per year).

Scheme 3 : Total capital cost of the poject is charged to the producer (waste heat provider), which means that the capital is obtained from the producer as much as 100% of total capital cost as a form of CSR funds without interest rate. The tax component used in the calculation is income tax which amounts 25%.

Scheme 4 : Capital is obtained from international institutions that provide funding in the form of green funds for renewable energy. projects The example of institution as is International Finance Corporation (IFC). The Loans can be obtained from IFC are limited to 25% of the total “greenfield” project cost up to maximum of $ 100 million. The interest rate on the loan is 0.75% (LIBOR). Tax component used in the calculation is the same as the previous schemes

Vetiver Oil Refining

Capital & Operational Expenditure

Component	CAPEX ($)		
	Condensate Scheme	Geothermal Steam Scheme 1	Geothermal Steam Scheme 2
Total of process equipments Cost	1,614,111	2,622,162	1,613,272
Pipe ROW (Right of Way)[1]	124,220	262,216	161,327
Contingency and constructor fees[2]	166,253	270,083	166,167
Startup cost[3]	27,432	44,564	27,418
Working capital [4]	37,124	60,309	37,105
Total of Capital Expenditure	**1,969,140**	**3,259,334**	**2,005,289**

~ Rp 26.5 M **~Rp 44 M** **~Rp 27 M**

Scheme	Total of O&M ($)
Condensate	40,106
Geothermal Steam 1	65,187
Geothermal Steam 2	40,106

The operational and maintenance expenditure is amounted as much as 2% of the total of capital cost.

Profitability Analysis

NPV

Financing Scheme	Condensate Scheme	Geothermal Scheme 1	Geothermal Scheme 2
1	-$ 2,701,837	-$ 4,215,549	-$ 2,484,212
2	-$ 2,701,837	-$ 4,215,549	-$ 2,484,212
3	-$ 216,390	-$ 162,062	$ 9,676
4	-$ 2,632,636	-$ 4,101,008	-$ 2,407,109

IRR

Financing Scheme	Condensate Scheme	Geothermal Scheme 1	Geothermal Scheme 2
1	N/A*	N/A*	-27.24%
2			-27.24%
3			20%
4			-26.80%

PBP

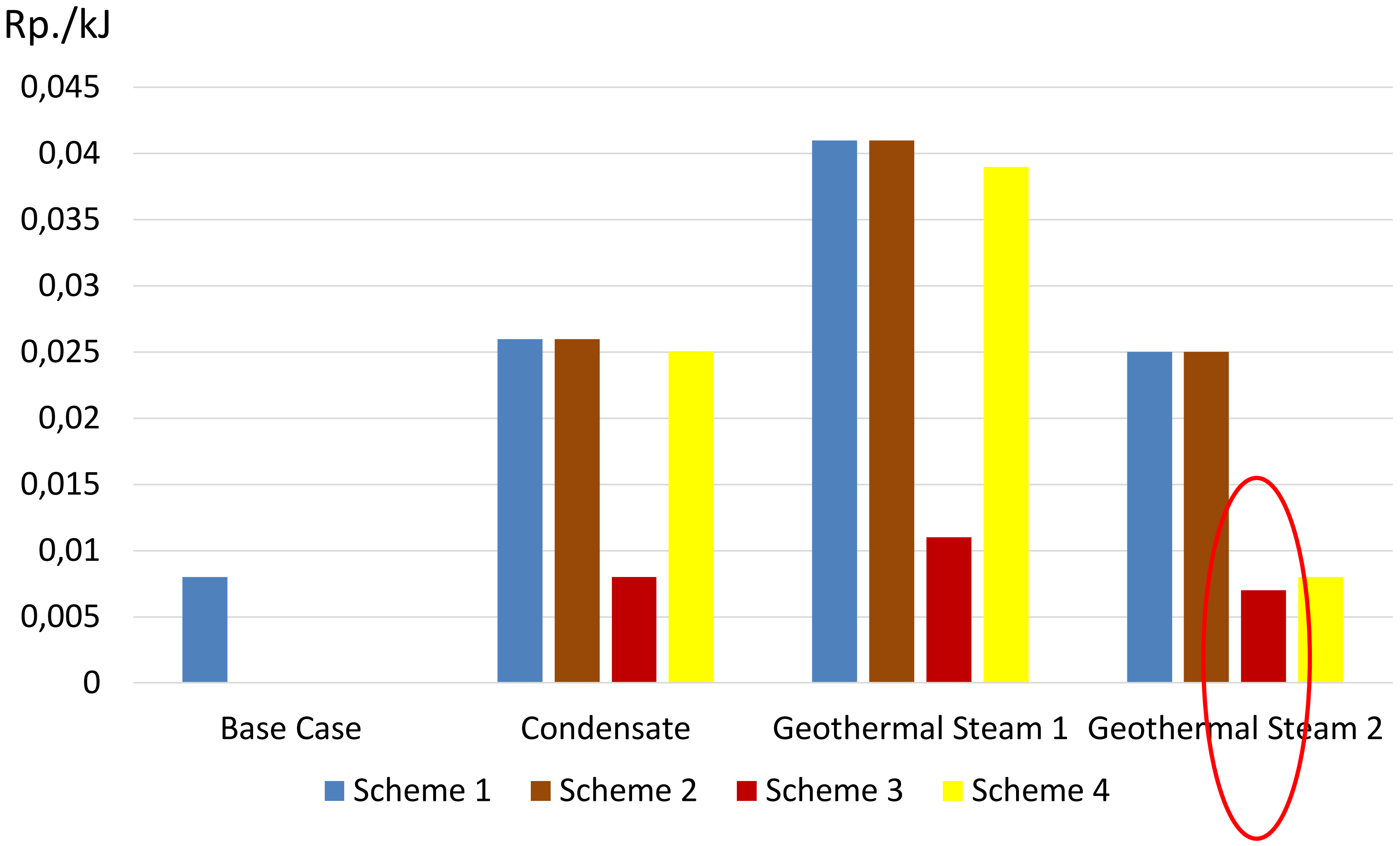
Financing Scheme	Condensate Scheme	Geothermal Scheme 1	Geothermal Scheme 2
1	N/A*	N/A*	>15 years
2			>15 years
3			5 years
4			>15 years

Revenue : Energy Saving

(Existing energy cost – Waste Heat Geoth. Cost)

*N/A means that IRR and PBP can not be calculated because of the negative cash flow in every years

Energy Cost Comparison



Conclusion – Vetiver Oil

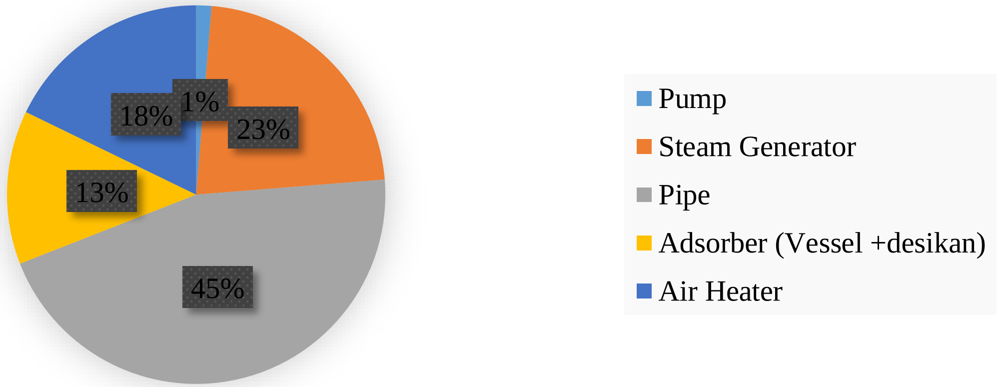
- Geothermal waste heat is feasible to used for vetiver oil production as the capital cost for infrastructure is financed by the gothermal plant through CSR →Scheme 3.
- Due to on-off utilization of steam (load factor <), needs to find other users →Cascading

Tea Drying

Capital & Operational Expenditure

Component	Cost ($)
Total process equipment cost[1)]	729,250
Right of way (ROW)[2)]	33,060
Contingency & contractor fee[3)]	137,220
Startup fee[4)]	18,000
Working capital[5)]	45,880
Total capital cost	963,410

~Rp 13 M

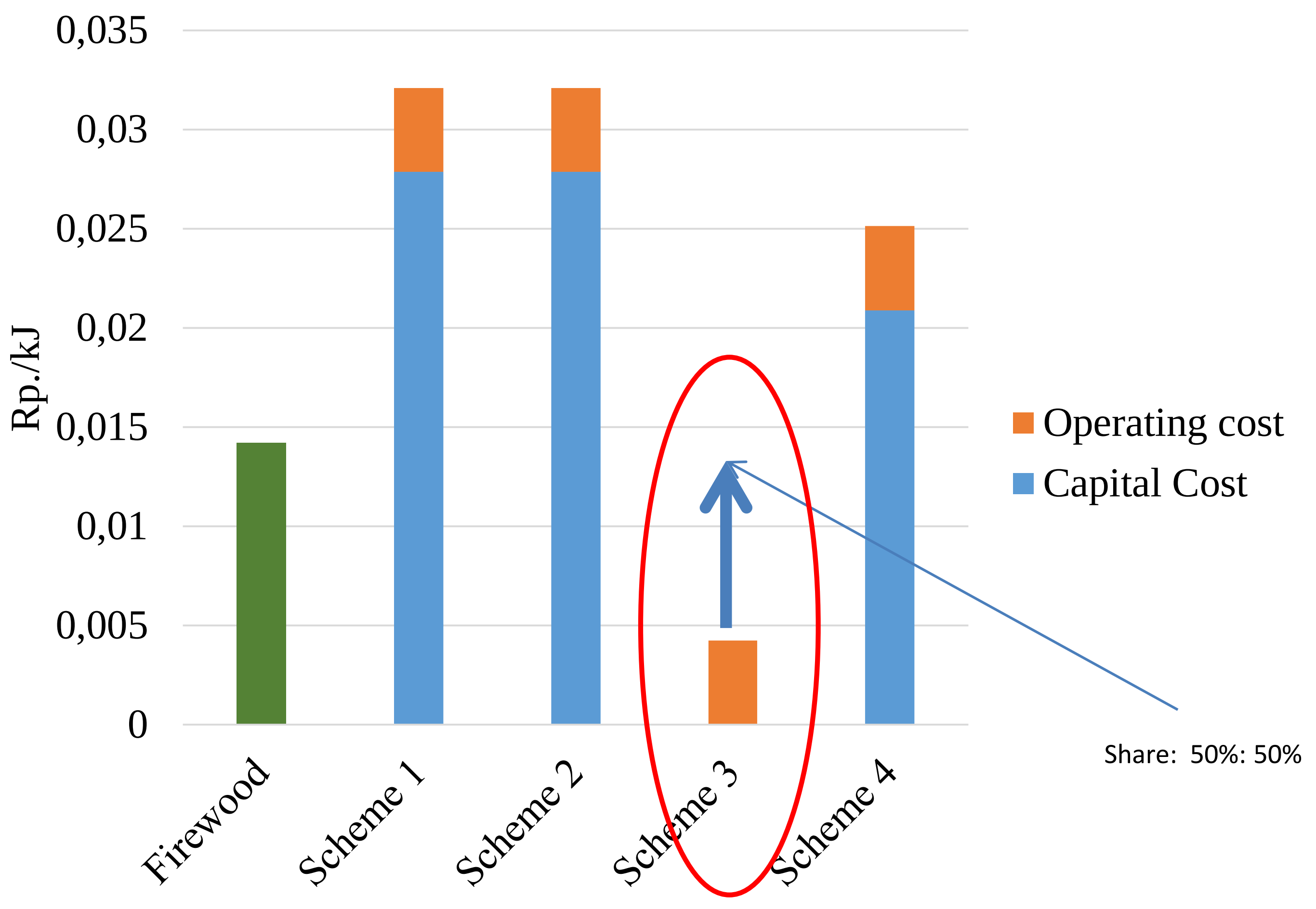


The operational expenditure is amounted as much as 2% of the total of capital cost. The operational and maintenance expenditure for this investment is $19,268.00 per year

Profitability Analysis

Scheme	NPV ($)	IRR	PBP (years)
1	(426,660.91)	-8.30%	18.50
2	(405,470.36)	-7.77%	17.78
3	506,074.18	342.19%	0
4	(365,576.54)	-7.99%	13.47

Energy Cost Comparison

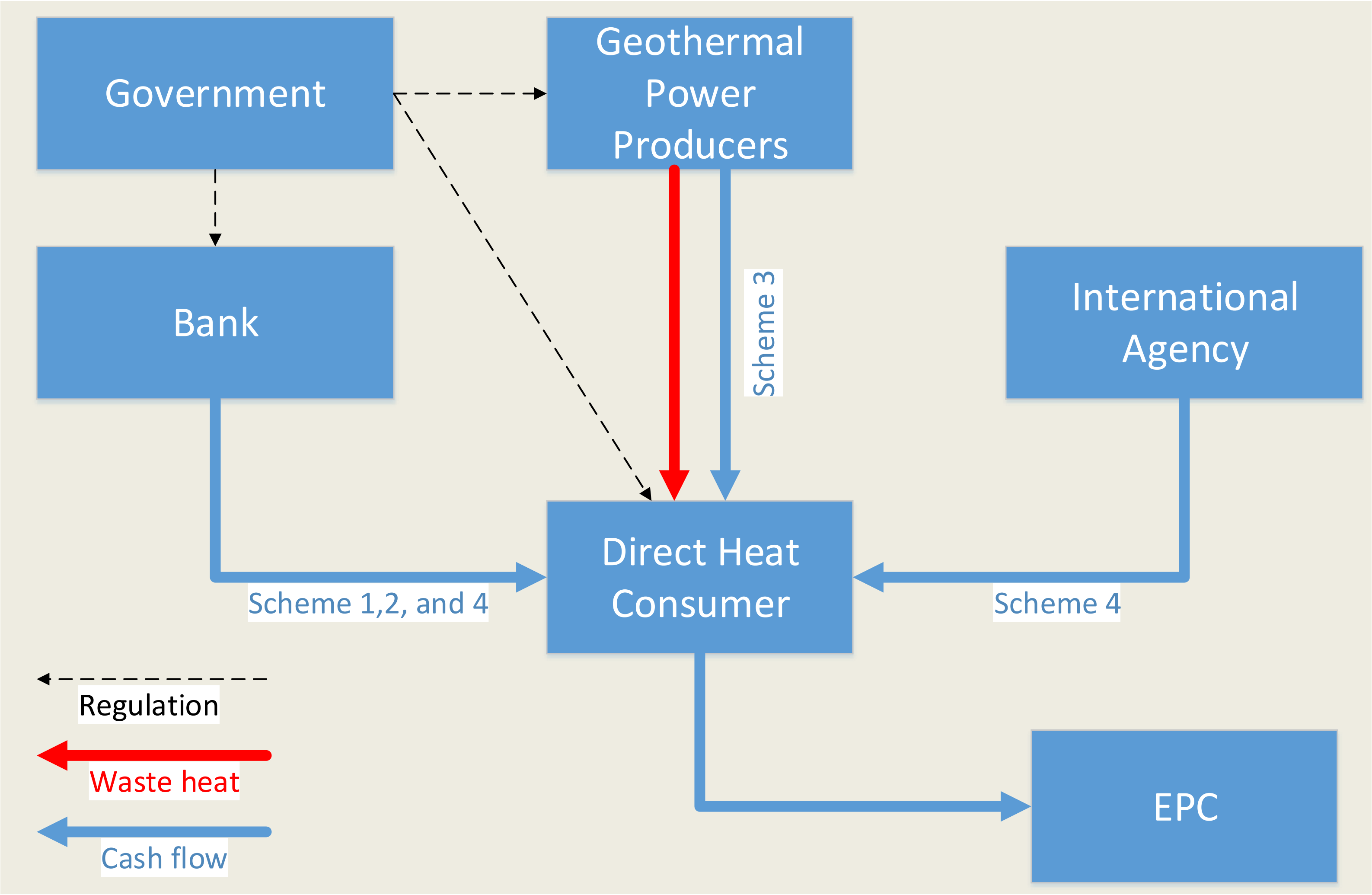


Conclusion – Tea Drying

- The scheme 3 when all the capital costs are borne by the Geothermal Power Plant producers is feasible which have lower energy costs than firewood
- There are posibilities to increase the role of user's investment
- Sustainability of firewood?

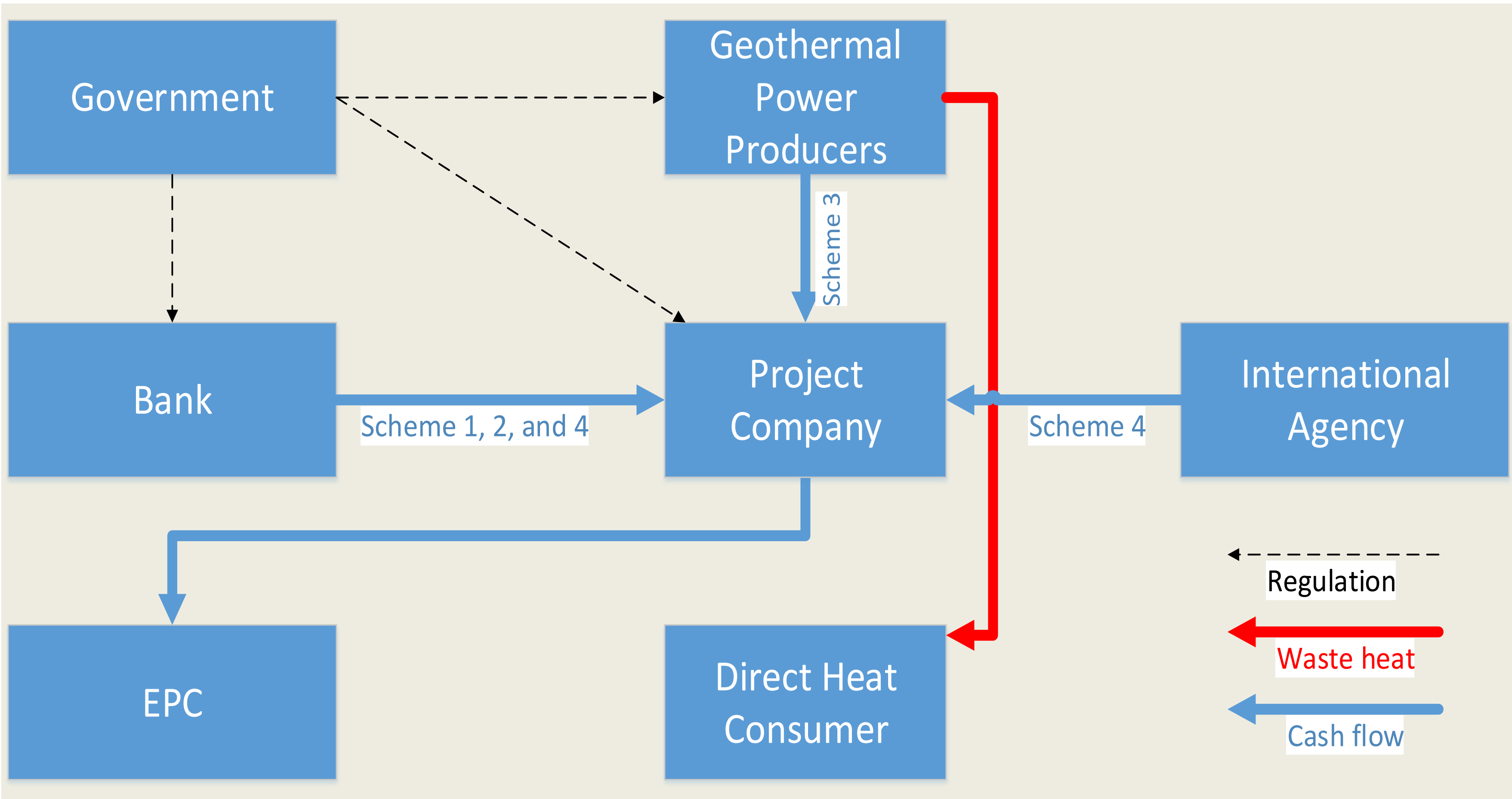
Proposed Project Structure

EPC scheme



Government
Geothermal Power Producers
Bank
Scheme 3
International Agency
Direct Heat Consumer
Scheme 1,2, and 4
Scheme 4
Regulation
Waste heat
Cash flow
EPC

SPC scheme


Government
Geothermal Power Producers
Scheme 3
Bank
Project Company
International Agency
Scheme 1, 2, and 4
Scheme 4
EPC
Direct Heat Consumer
Regulation
Waste heat
Cash flow

The Main Barriers

- Low energy prices (fossil)
- The society knowledge of the utilization of geothermal direct use optimally to local industry is not deep enough
- Uncertainty policy regarding the status of ground water with geothermal brine for industrial purpose.
- There is a willingness from user to use geothermal heat source, on the condition that the investment cost is from other parties.
- Funds from the government is limited to the direct use of geothermal. Mostly funds for geothermal electricity.
- Mostly, CSR of geothermal PP for social activities.
- There is no fiscal policy from the government such as incentives especially for geothermal direct use.

Way to success

- In spite of other benefits that a direct used geothermal system offers, such as reduced CO_2 emissions, energy efficiency (saving), waste to energy, and sustainability. The barrier of market development (implementation) can be overcome by offering incentives, grants, renewable energy tax.
- Definitely more supportive governmental policies, stakeholders and efforts are needed to speed up the development of geothermal resources for direct use.
- How to show the way saving large of energy and money while "direct-use" geothermal resources?.

Thank you