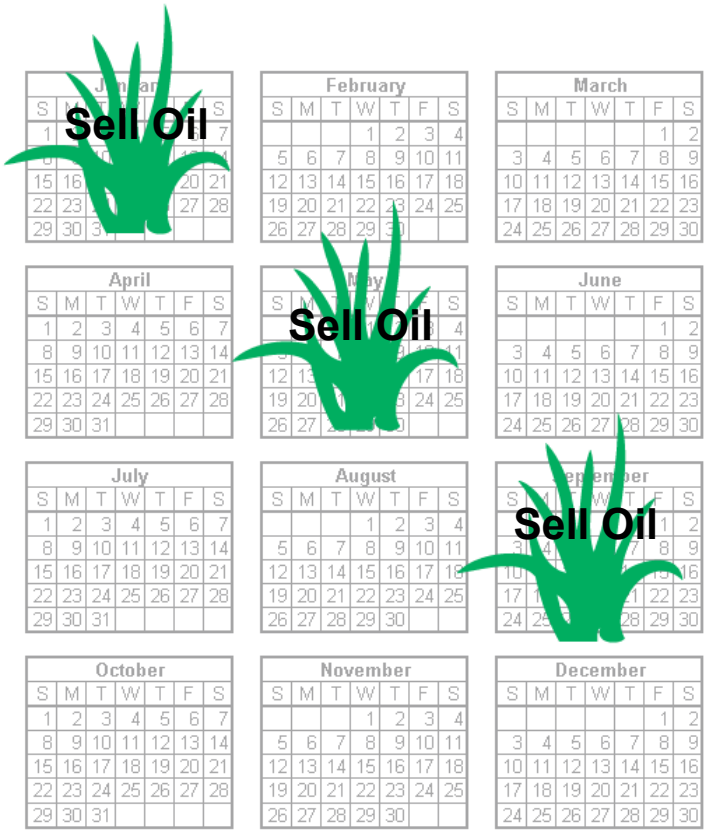
the d.Stillers present

Pak Sadu & Ibu Rabunia

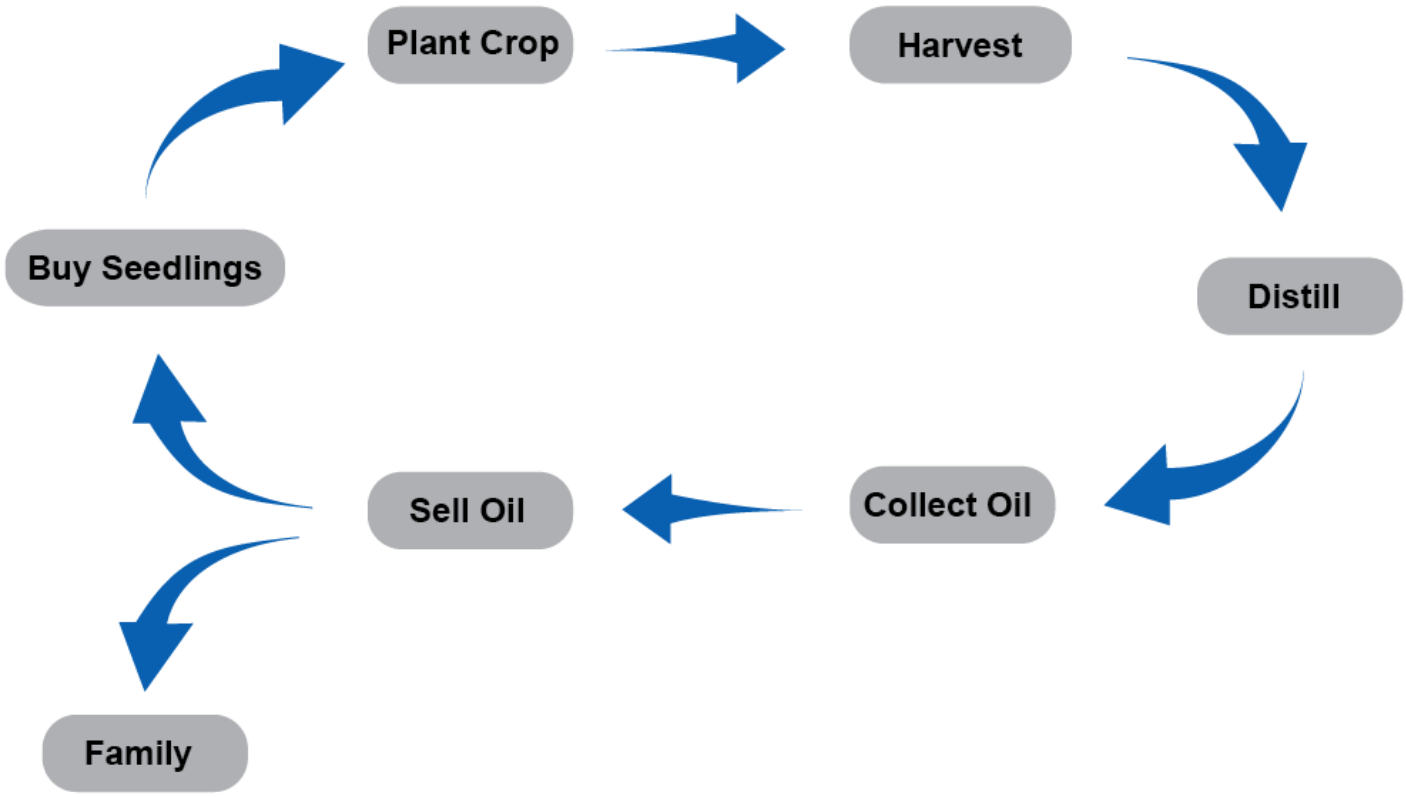


Weeklong Process

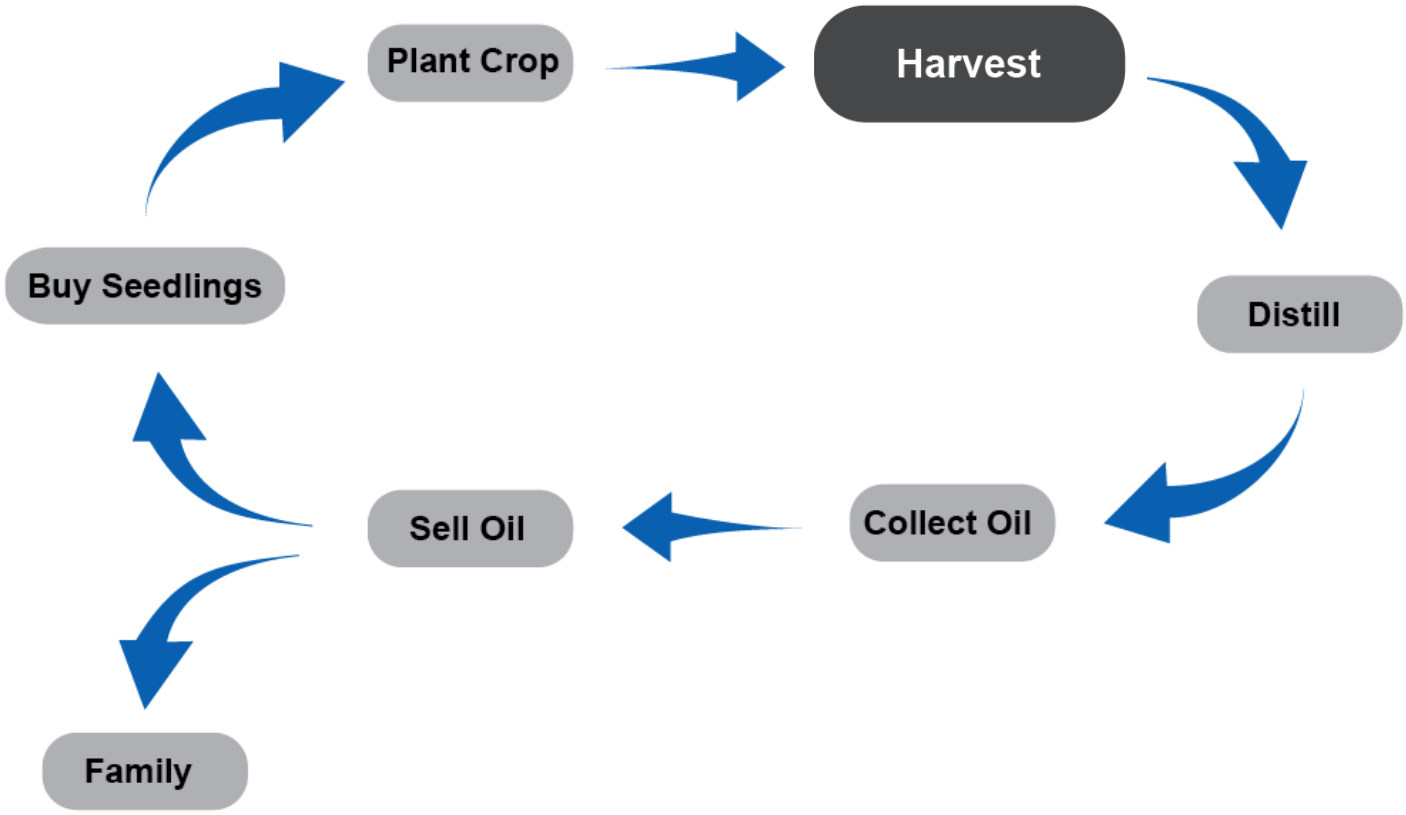
Market Day

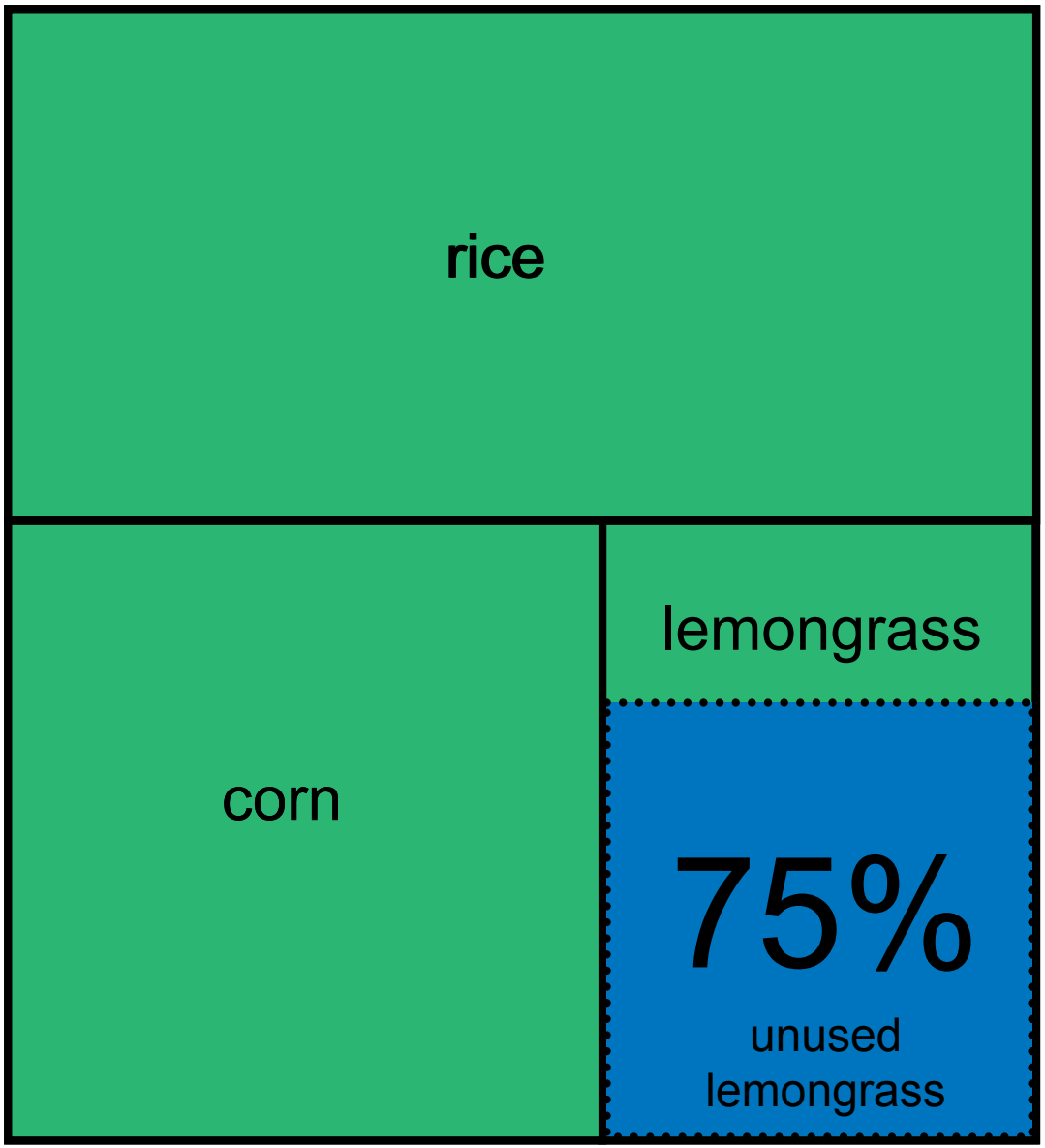
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday

Processing Cycle

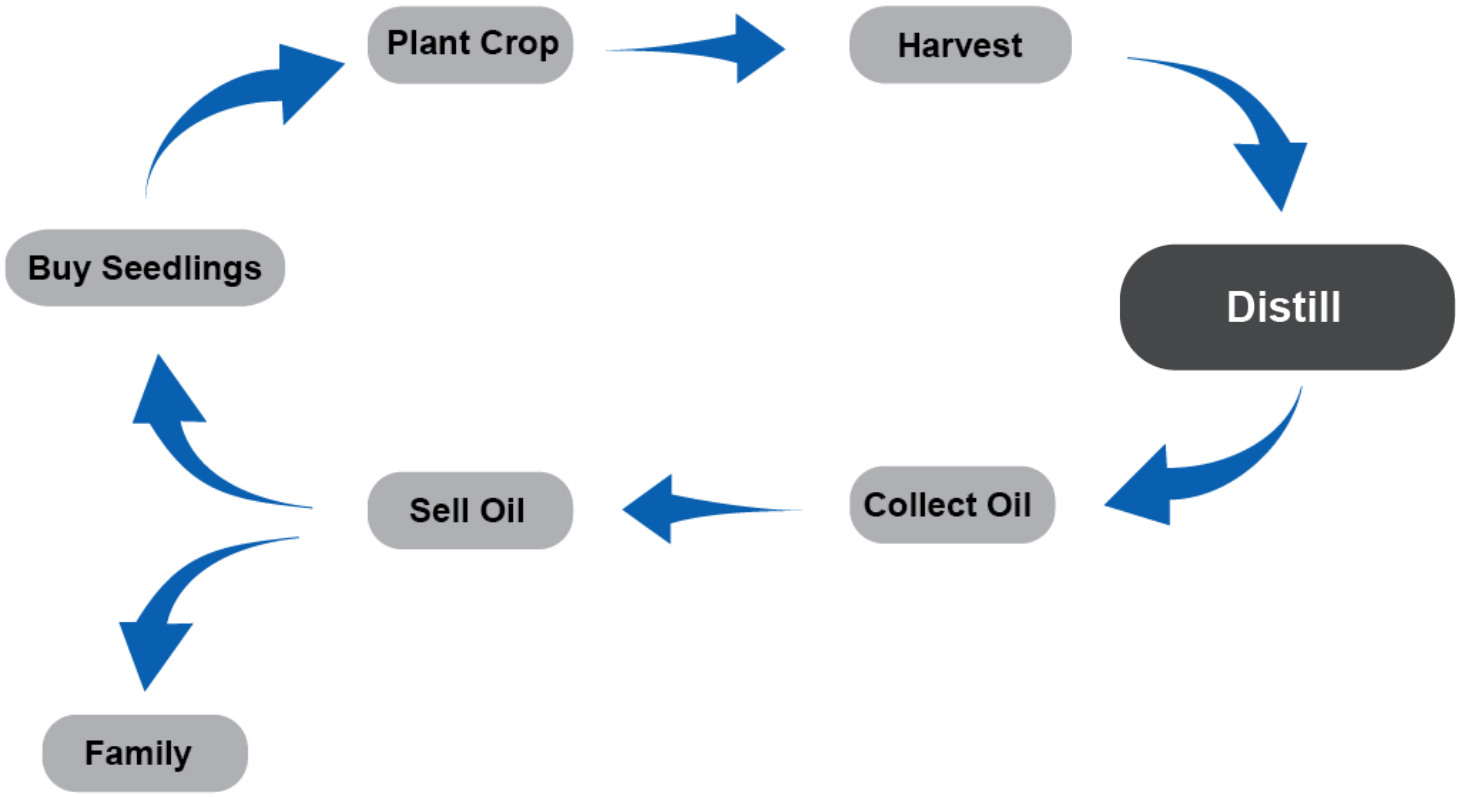


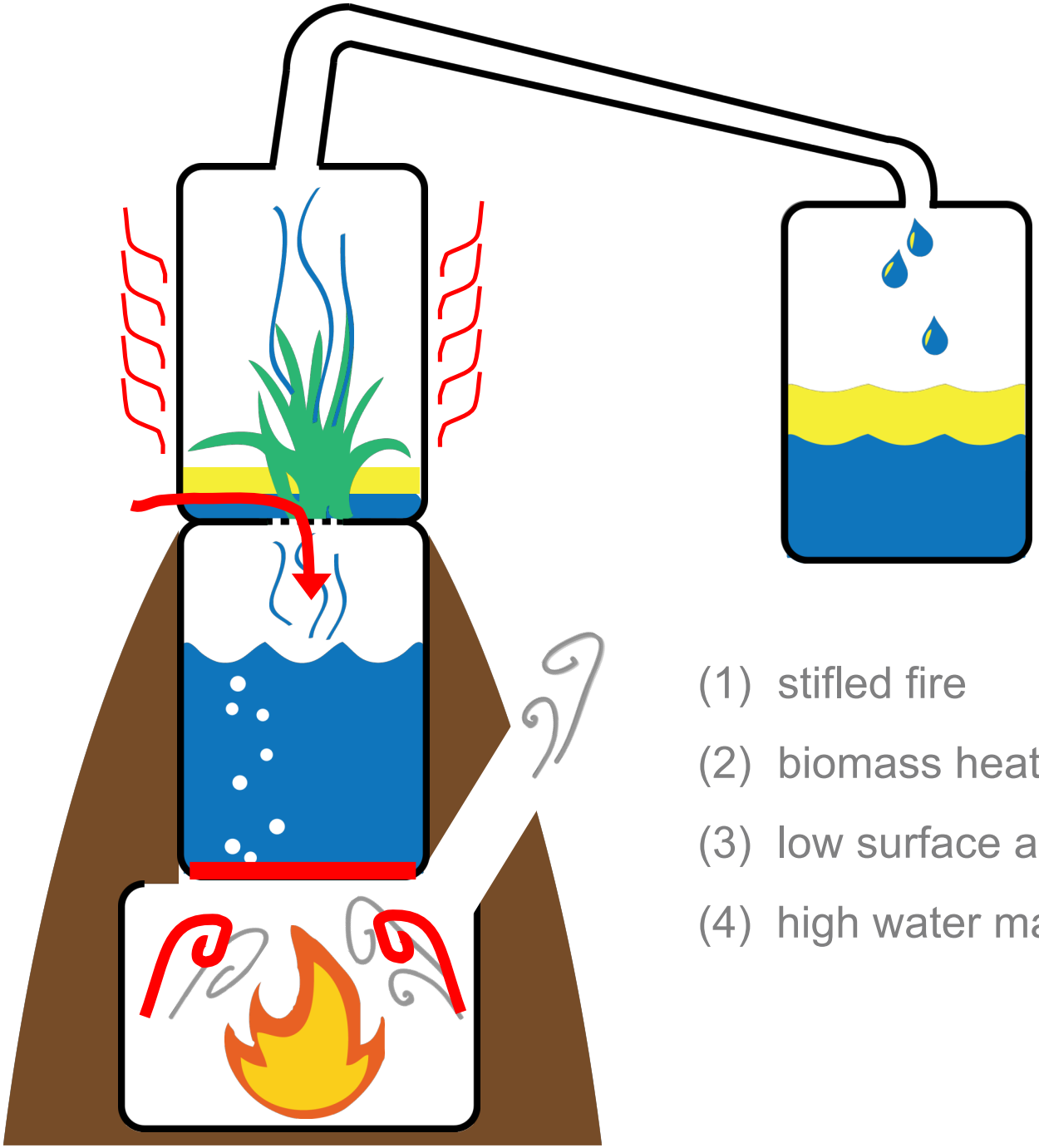
Processing Cycle




rice
corn
lemongrass
75%
unused
lemongrass

Processing Cycle





(1) stifled fire

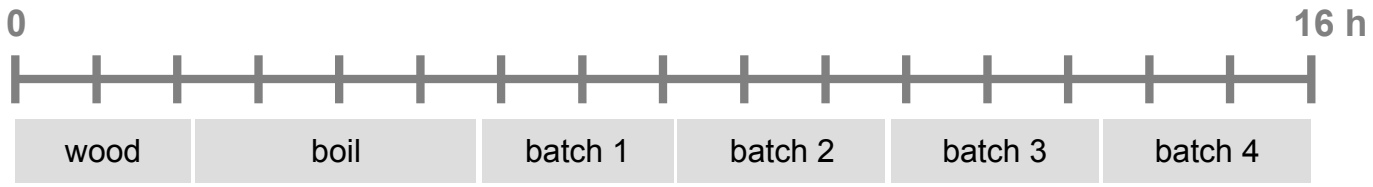
(2) biomass heat loss

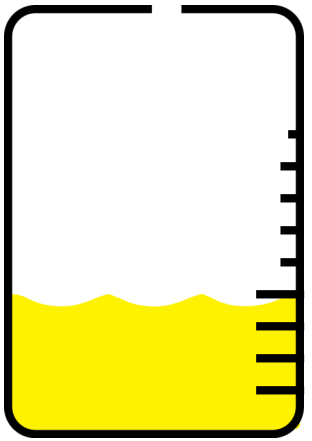
(3) low surface area

(4) high water maintenance

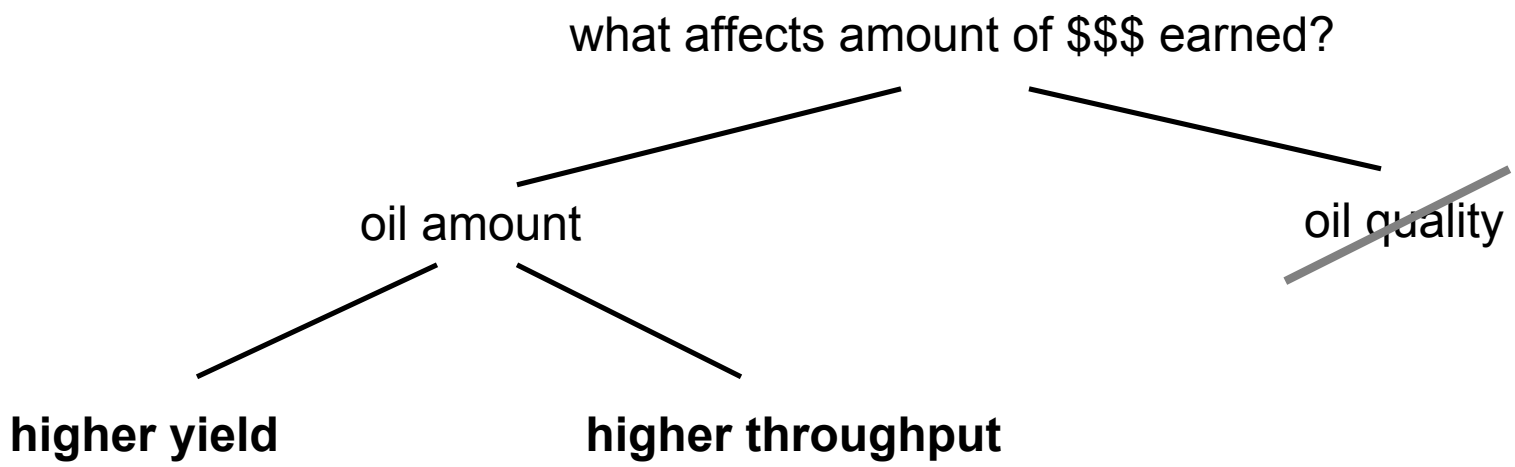
gather **wood** → **boil** water → lemongrass **batch**

traditional distillation





16 hrs = 4 batches = 2 kg oil


what affects amount of $$$ earned?
oil amount
oil quality
higher yield
higher throughput

higher yield

aka doing a BETTER job

(1) efficient fire

(2) biomass insulation

higher throughput

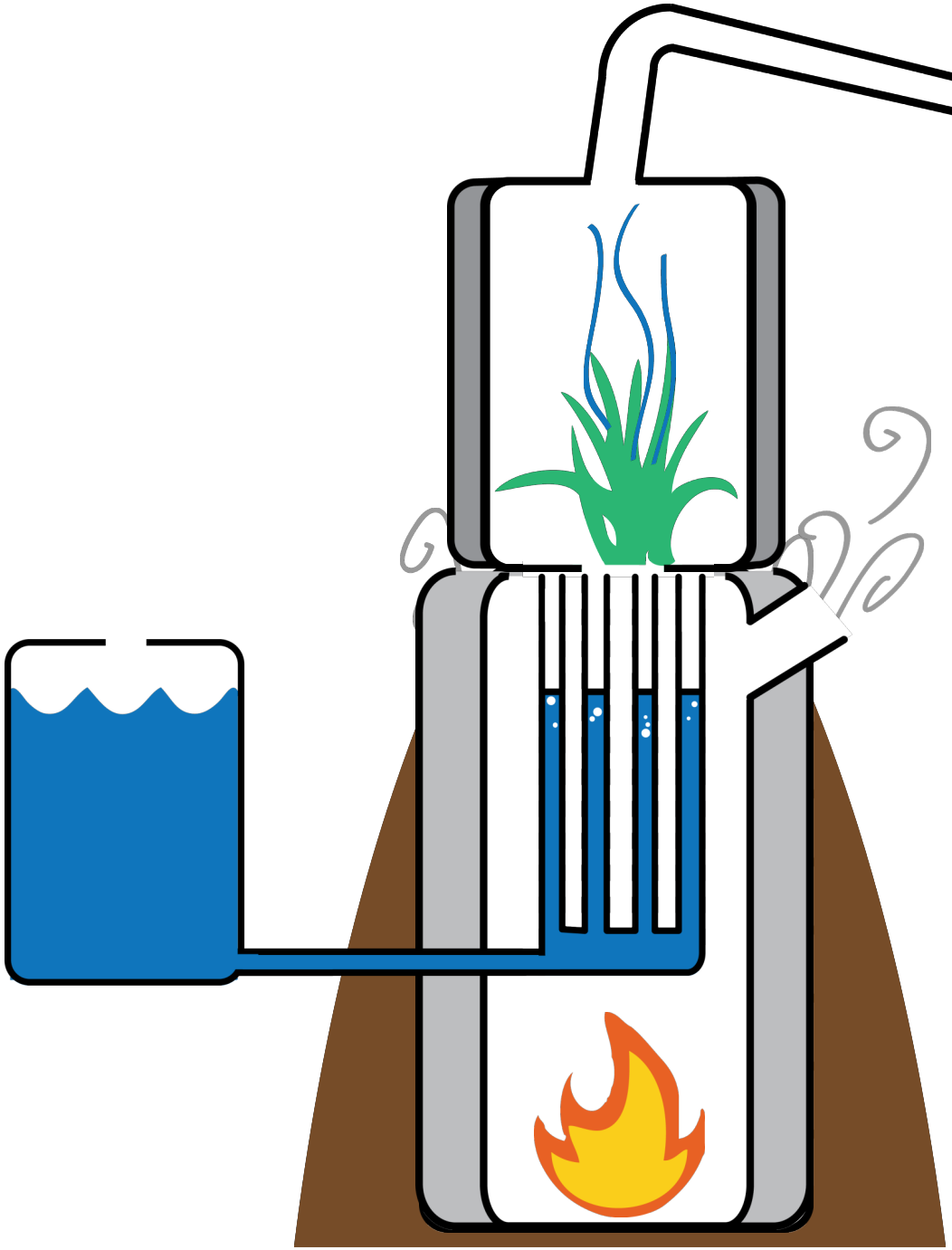
aka doing a FASTER job

(3) more surface area

(4) water flow-through

THE
EASY
STEAM
MACHINE

VIDEO



(1) efficient fire

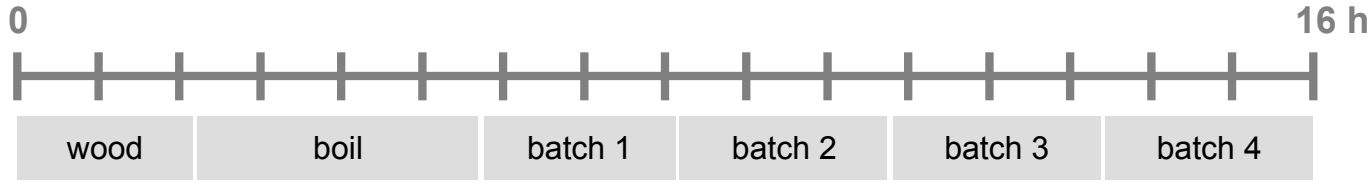
(2) biomass insulation

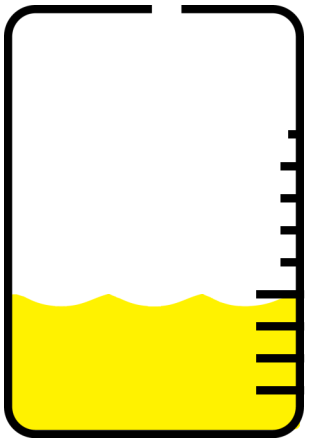
(3) more surface area

(4) water flow-through

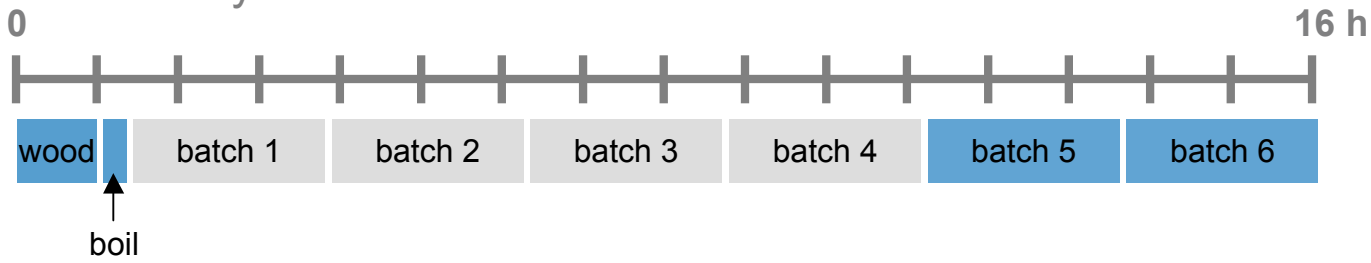
gather **wood** → **boil** water → lemongrass **batch**

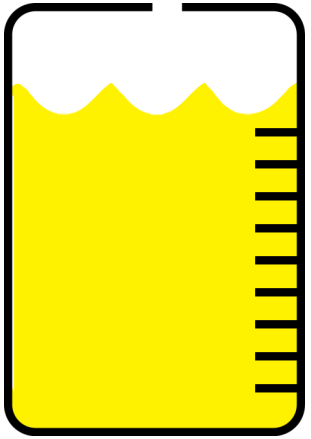
traditional distillation





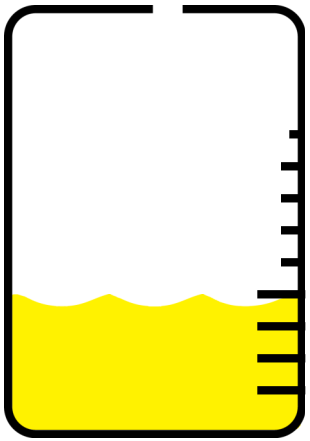
The Easy Steam Machine





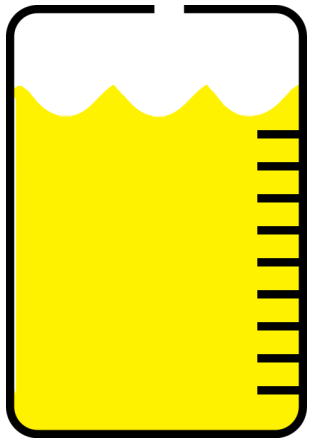
lemongrass payback

traditional distillation



18 kg/yr x $8/kg = $144/yr

The Easy Steam Machine



27 kg/yr x $8/kg = $216/yr

Distillation income increased by 50%

I'd buy more seedlings
…cacao
…chili

Pak Sadu & Ibu Rabunia

how do we get

to Indonesia's farmers ?

IBEKA

People
Centered
Economic &
Business
Development

Puni

Social Change

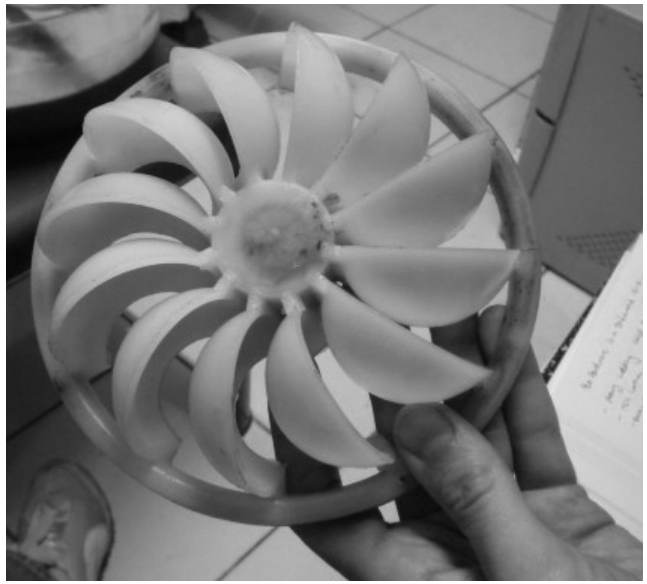
Iskander

Technology

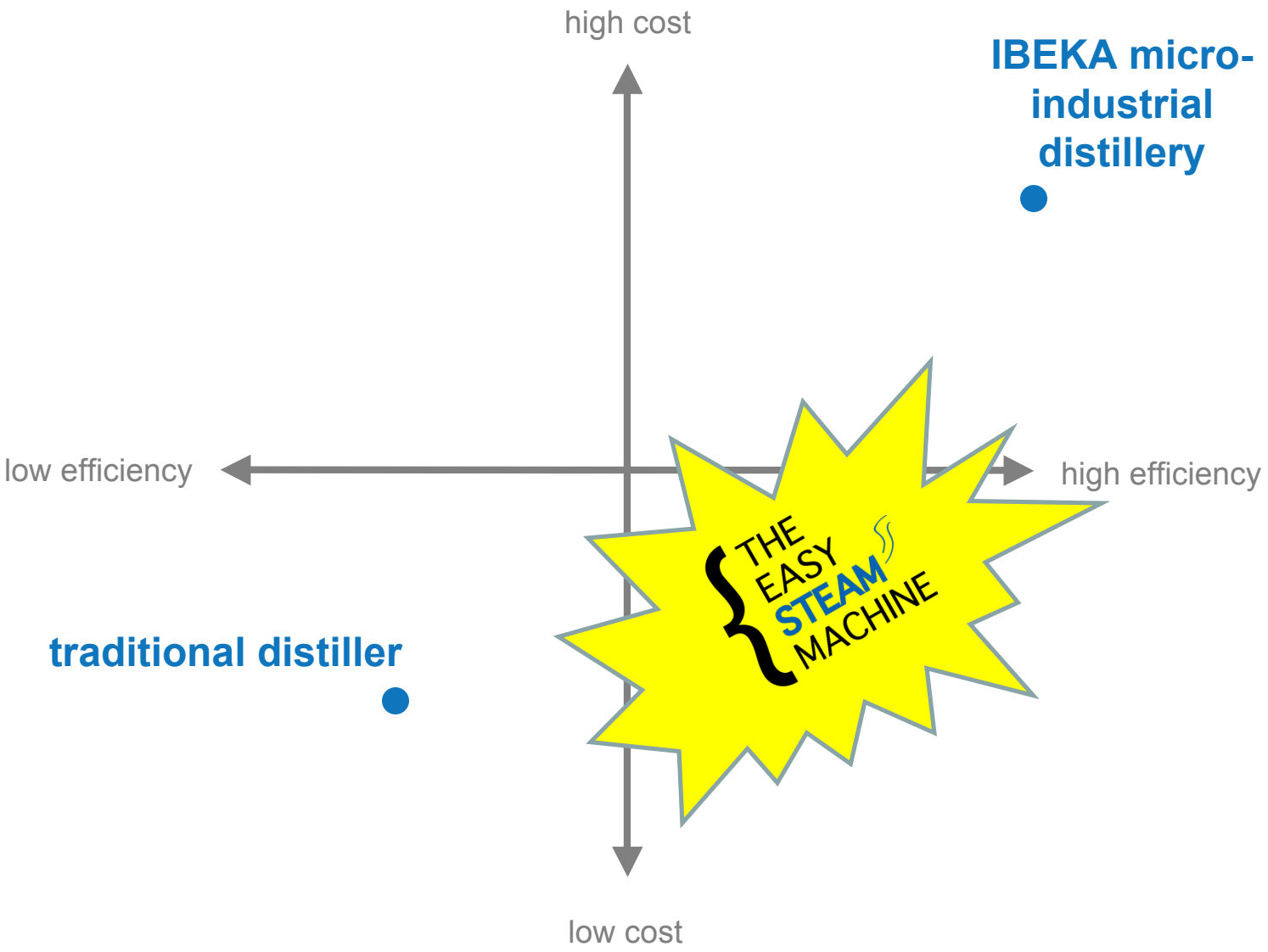
A: market based **IBEKA products**
that alleviate poverty

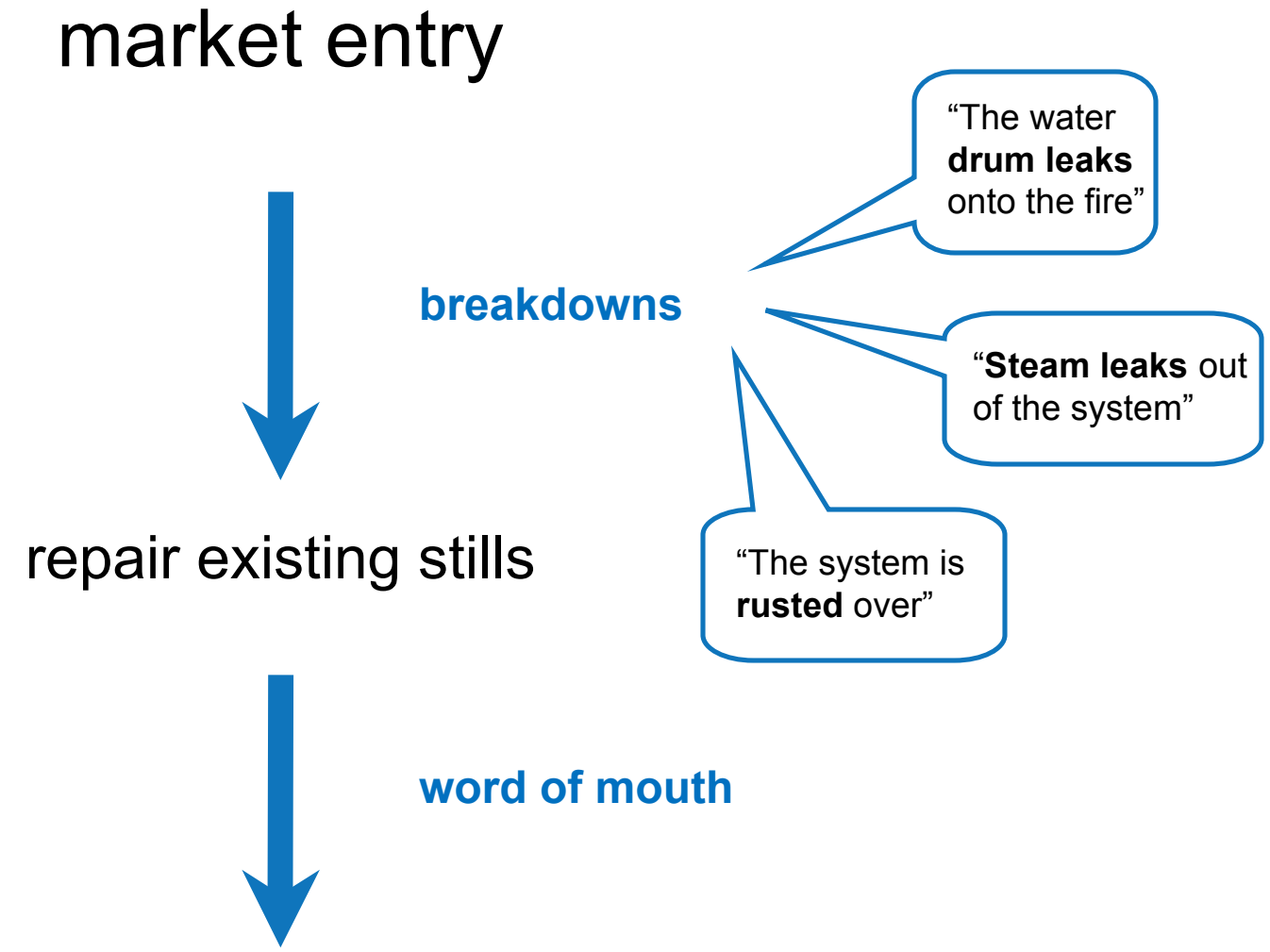
A: IBEKA Pico-hydro System

{



A:
THE EASY STEAM MACHINE
IBEKA


high cost
IBEKA micro-industrial distillery
low efficiency
high efficiency
THE EASY STEAM MACHINE
traditional distiller
low cost

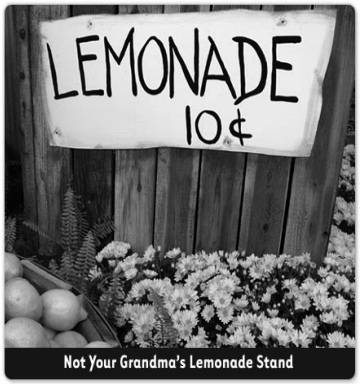

market entry
breakdowns
"The water **drum leaks** onto the fire"
"**Steam leaks** out of the system"
"The system is **rusted** over"
repair existing stills
word of mouth
new still installations

how does IBEKA get

to Indonesia's farmers ?

Manufacturing

- IBEKA
- existing pico hydro mfg capability



Marketing

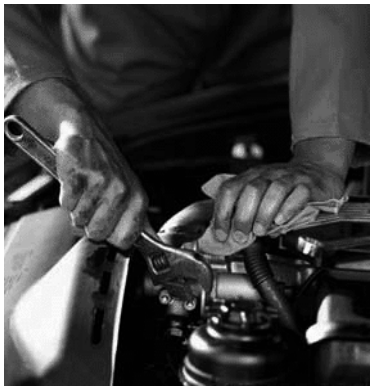
- word of mouth
- distillation entrepreneurs
- IBEKA brand

Sales

- existing town shops
- financing through village traders

Distribution

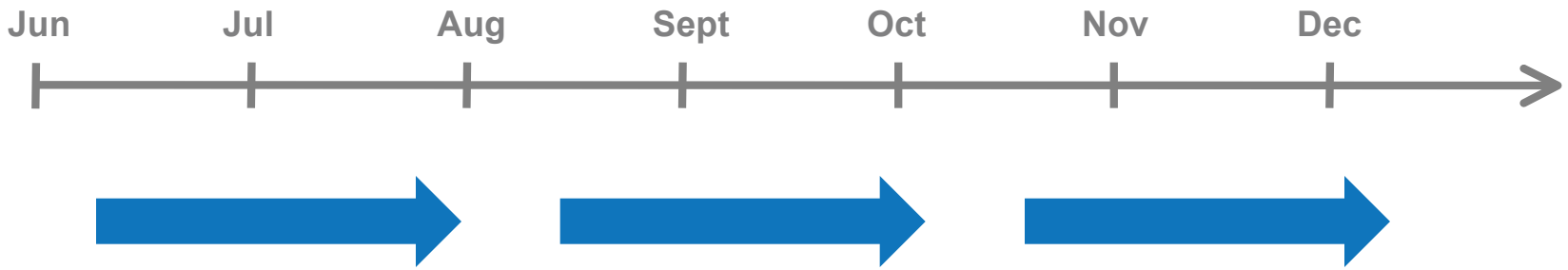
- wholesalers
- existing infrastructure
- IBEKA's pico hydro value chain



Maintenance

- local motorbike repair shops
- installers of current system

Next Steps



- refined prototype
- schedule pilot with IBEKA

- implement pilot in Indonesia
- explore distribution value chain

- develop launch plan
- build final device

questions?

Bill of Materials

Material	Size	Weight	Price/kg	Price
Steel Pipe	16x2’ (1” dia)	24.4kg	1350/tonne	$32
	4x10” (2” dia)	11.85kg	1350/tonne	$16
	1x15” (3” dia)	3.7kg	1350/tonne	$5
Threaded Caps	1x (3” dia)			$3
Exhaust Pipe	2 x Ceramic Pipe		1350/tonne	$5
Outlet Pipe (Ceramic)	3’ (1” dia)	2.29kg		$3
Aerated Cement	10 ft^3			$12
Plastic Tank	20 gallon (+ stepped nozzle)			$10
Car Radiator Hose				$5
			Total	$91

Water vaporization energy

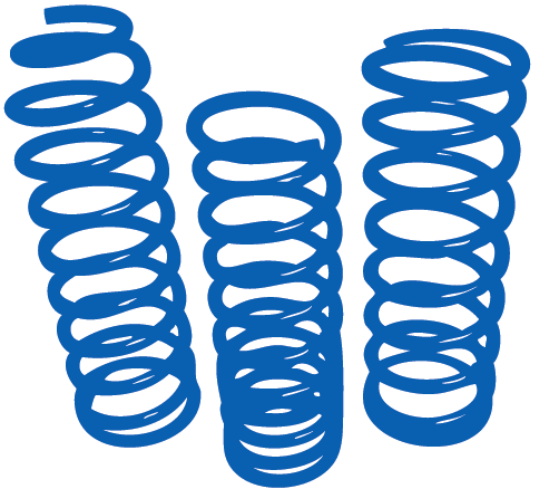
Assume 20°C water temperature, 100°C boiling point (at sea level)

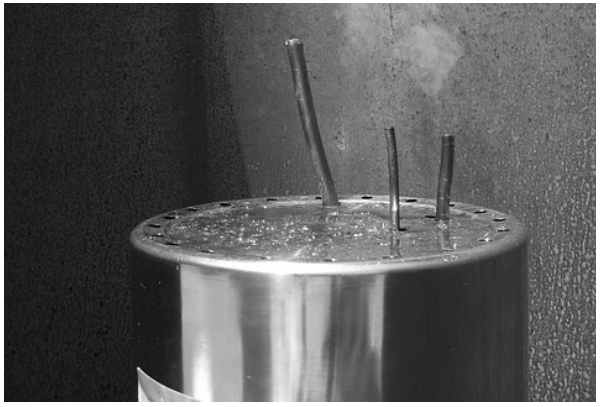
Total energy to vaporize = boiling energy + phase change energy

Boiling energy: $q_{boil} = c_{water} * \Delta_T * m_{water} = 4.186 \frac{kJ}{kg \cdot K} \cdot 80 K = 335 \frac{kJ}{kg}$

Phase change: 2,257 kJ/kg

Total energy: 335 kJ/kg + 2,257 kJ/kg = 2.6 MJ/kg
1l water to steam in 1 hour: 7.2 kW





Coil Prototype Results

Surface area: 0.4 m^2

Energy transfer: Newton's Law of Cooling

For copper pipes, heat transfer coefficient is ~13 W/(m^2 K)

$$\frac{dQ}{dt} = h \cdot A \cdot \Delta T = 13 \frac{W}{m^2 \cdot K} \cdot 0.4 m^2 \cdot \Delta T = 5.2 \frac{W}{K} \cdot \Delta T$$

Steam rate: 4.5l water evaporated per hour

Power:

$$4.5 l \frac{l}{h} \cdot 2.6 \frac{MJ}{l} = 11.7 \frac{MJ}{h} = 3.25 kW$$

This implies

$$\Delta T = 3.25 \frac{kW}{5.2 W / K} = 625 K$$

Material-power ratio:

$8.125 \frac{kW}{m^2}$ for copper, $6.875 \frac{kW}{m^2}$ for steel

Current System Calculation

	Patchouli	Lemongrass
Water used per batch	120l	60l
Time	6 hrs	4 hrs
Vaporization rate	20 l/hr	15 l/hr
Vaporization power (assuming boiling water)	45 MJ/hr = 12.5 kW	34 MJ/hr = 9.4 kW

Realistic energy transfer is just 6 kW for 10l steam generation.

$$\frac{dQ}{dt} = h \cdot A \cdot \Delta T = 11 \frac{W}{m^2 K} \cdot 0.54 m^2 \cdot \Delta T = 5.9 kW$$

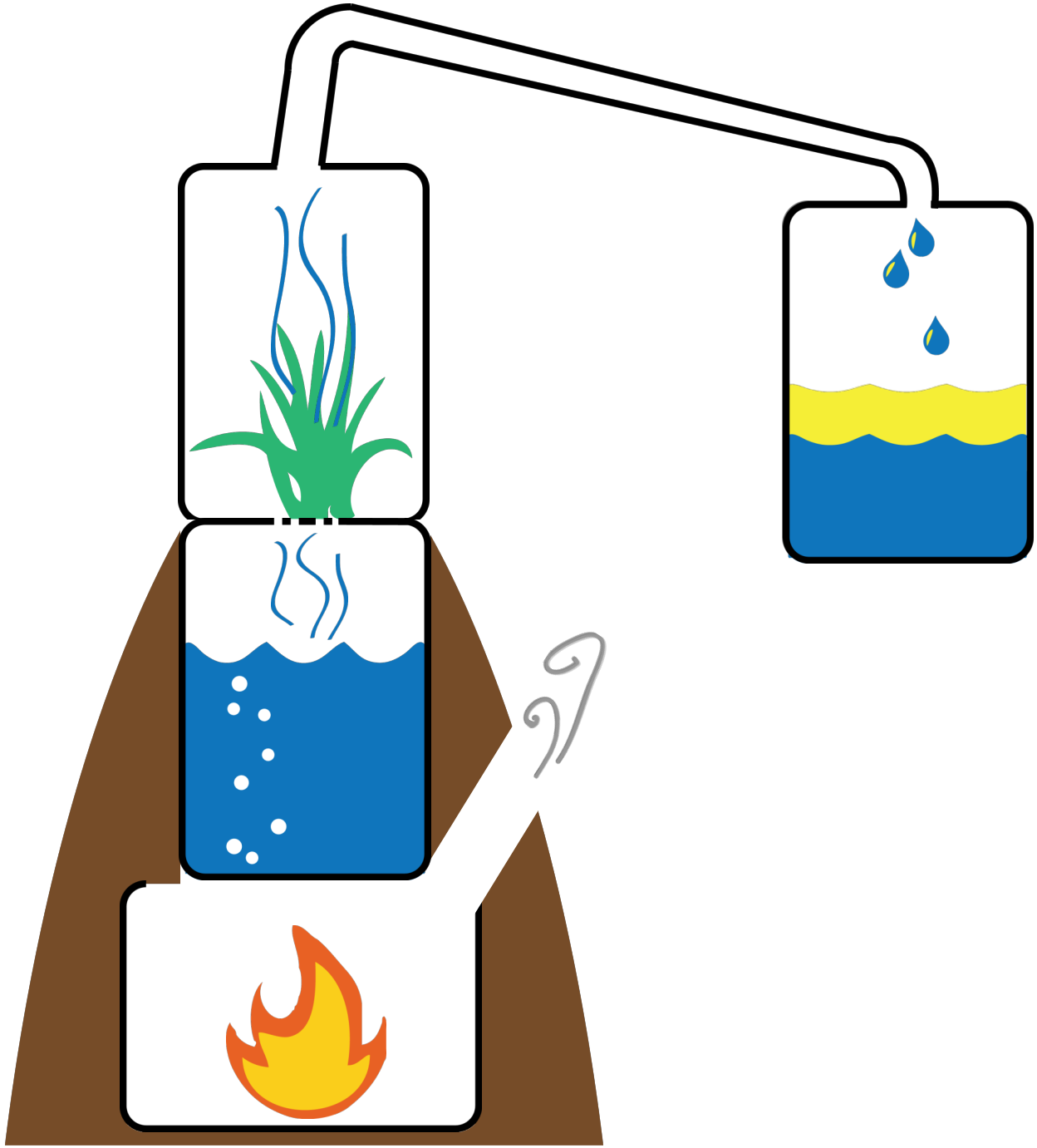
Note that water is boiling already and using steel, so just 2.3MJ/kg.

Final Device Sizing

Vaporization rate	10 L/hr
Vaporization power (assuming 20c water)	$\frac{2.6MJ}{10l/hr} = 26MJ/hr = 7.2kW$
Surface area	$\frac{7.2kW}{6.875kW/m^2} = 1.05m^2$
Amount of 1” pipe required	$1” \cdot \pi \cdot 12”/\text{ft} = 12\pi \text{in}^2/\text{ft} = 0.024m^2/\text{ft}$ $\frac{1.05m^2}{0.024m^2/\text{ft}} = 43.8\text{ft}$

We will undersize for the pilot and adjust upwards as needed.

Payback Calculation

Baseline		
	Patchouli	**Lemongrass**
Harvests per year	3	3
Days per harvest	3	3
Batches per day	2	4
Batches per harvest	6	12
Input per batch	20kg	60kg
Oil yield per batch	0.5kg	0.5kg
Market price	$30/kg	$8/kg
Revenue per batch	$15	$4
Revenue per harvest	$90	$48
Revenue per year	$270	$144

Improvement		
	Patchouli	**Lemongrass**
Harvests per year	3	3
Days per harvest	3	3
Additional batches per day	1	2
Additional batches per harvest	3	6
Input per batch	20kg	60kg
Oil yield per batch	0.5kg	0.5kg
Market price	$30/kg	$8/kg
Revenue per batch	$15	$4
Additional revenue per harvest	$45	$24
Additional revenue per year	$135	$72