THE EASY STEAM MACHINE

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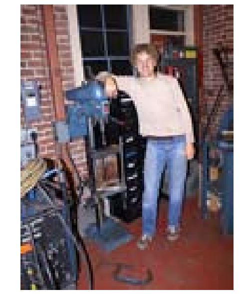
how can we change lives?

{ What is The Easy Steam Machine? }

With **The Easy Steam Machine**, rural Indonesian farmers can increase their income. The Machine provides them an efficient way to produce steam for their home essential oil distillation units. By reducing the time to produce steam from hours to just a few minutes, The Machine enables farmers to process at least 25% more biomass per day! Time is saved by (1) increasing surface area, (2) heat insulation, and (3) including a continuous water flow through system. As a $230 plug-and-play replacement for the traditional batch drum, the Easy Steam Machine ensures durable, hassle-free steam distillation.

get to know us...

{ The Team }



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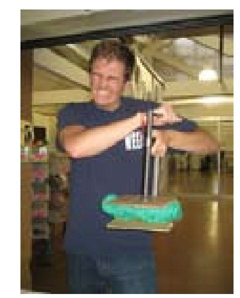
Christoph is finishing his MBA from the Stanford Graduate School of Business in June 2010. Prior to joining the GSB, he worked at the Clinton Foundation HIV/AIDS Initiative, working on reducing the price of Ready-to-Use Therapeutic Food to save the lives of more severely malnourished children. Before this one-year engagement at the Clinton Foundation, he worked as a consultant for Booz & Co in their New York office. Christoph is involved on the board of the alumni association of his undergraduate scholarship foundation. He holds an MMath in Computer Science from the University of Waterloo, and an advanced degree in Computer Science from Frankfurt University.



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Jesse is currently pursuing an MBA at Stanford Graduate School of Business and plans to attend Tulane University School of Medicine's MD program in 2010. Prior to attending business school, he worked for his family as a Production Supervisor at Guittard Chocolate Company and also served as a Research Assistant for ED&F Man Ltd, a leading commodity supply chain service firm. As a result of these professional experiences, Jesse has undertaken various operations and supply chain projects in several West African and South American countries.

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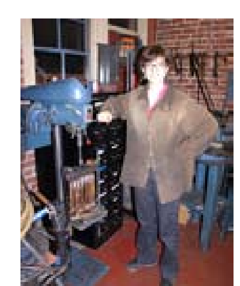
Nina is a first year Master's student in Mechanical Engineering with a focus in Mechatronics at Stanford University. She gradated with a B.S. in Engineering with a focus in Product Design from Stanford in 2009. She loves creating and enjoys participating in creative team endeavors, swing dancing, and improv theatre.



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Andi is a first year Master's student in Mechanical Engineering at Stanford University. She graduated in 2009 with a B.S. in Mechanical Engineering from Stanford. She spent a year developing renewable energy systems in Sri Lanka and developing a national expansion program for a rickshaw program in India. She loves the challenge of designing and building integrated systems. She plays piano, enjoys candy, and is passionate about engineering for the developing world.

{ Need and Opportunity }

NEED STATEMENT

Subsistence farmers in Indonesia need a way to process all of their lemongrass and patchouli into higher value essential oil. Currently, farmers leave up to twenty-five and seventy-five percent of their plant material unprocessed because their essential oil distillation device is too cumbersome and time-intensive. Given the short harvest period and the low throughput of their device, farmers must leave potential income in the field, unprocessed.

THE OPPORTUNITY

Using the traditional oil distillation device, a farmer is able to produce on average 3 kg of patchouli oil in one harvest season. He harvests lemongrass and patchouli1 three harvests in a year, which leaves him with 9 kg of patchouli oil. At the price from the local oil trader, $20 per kg, the farmer is able to earn approximately $180 from oil distillation. According to the FAO, the average subsistence farmer in Aceh is able to earn between $360 and $450 per year[2].

There are two opportunities to increase income generation: (1) improve the quality of oil produced, and (2) increase the quantity of oil produced. Indonesian Patchouli oil is well known on the world market and occupies 80-90% market share[3]. Over eighty percent of Indonesian Patchouli oil is produced in Aceh, North Sumatra and West Sumatra (see Figure 1), primarily for export markets at a value that is increasing every year. It is produced by steam distilling Patchouli leaves and is used as a raw material in perfume and cosmetic products.

Recently, the export price of Patchouli oil reached $1,000/kg, while farmers in rural Aceh still received only $20 per kilogram. Villagers in rural Aceh can not access the higher price bracket because the village-level trader does not differentiate based on quality of oil. The trader comes to the village whenever prices are low and purchases at one rate. If the farmer produces higher quality oil, there is no accessible market.

However, there is a ready market for farmers who are able to produce larger quantities of essential oil.

THE USER

Bak Saptu and Ibu Rabunia are a farming couple in their late fifties. They moved to Putri Betung village from a neighboring village and are two of the poorest residents. They own 1.5 hectares of land, where they plant a variety of crops: chili, patchouli,

1 Organic Lemongrass - A guide for small holders. Export Promotion of Organic Products From Africa. December 2005.
2 FAO/WFP Food Supply and Demand Assessment for Aceh Province and Nias Island (Indonesia). 5 May 2005. < http://www.fao.org/docrep/008/j5202e/j5202e00.HTM>.

3 Lending Model Information System for Small-Scale Enterprises. Patchouli Cultivation and Oil Industry. < http://www.bi.go.id/sipuk/en/?id=4&no=20301&idrb=41801>.

Figure 1. Map of Indonesia (dot signifies Petri Betung Villiage and circle indicates Aceh)

“I would use my additional income to increase the number of crops I’m growing. I would purchase cacao seedlings and corn. I’ve also dreamed of purchasing a small mower that I could use to remove weeds from my fields.”

lemongrass, small amounts of coffee, and candlenut. One year ago, they started using new agricultural practices as recommended by a local agricultural extension officer. This means that they use packaged seeds, mounds, and plastic foil. Each mound requires intensive preparation involving five different fertilizers. Every ten days, they hand water each of their 600 chili plants with a combination of water and fertilizer. In their old age, they find that they have little time left in the day for any other income generating activities.

However, seven years ago, they bought a traditional oil distillation device for $150. With this device, they can run four batches of lemongrass per day and two batches of patchouli, producing 0.4kg of oil per batch. Bak Saptu says that he would prioritize buying a better distillation machine over other machines because he knows that it will increase his income. He is willing to pay thirty percent more than the original price for a device that produces two times the oil in the same amount of time.

Bak Saptu’s distillation unit is old—it is rusty and leaks. He has tried to get a loan to buy replacement parts, but the oil trader, who is his only source for capital, refused the loan. ■

{ The Solution }

OUR FOCUS

In order to increase the quantity of oil output, we focused on increasing both the throughput and the yield, i.e. doing a faster job and doing a better job. The Easy Steam Machine is a replacement, plug-and-play device that fits directly into the traditional system—which makes it less expensive than purchasing an entire new device. It also lowers the barriers to adoption because farmers will feel familiar with the design and user interface.

PROBLEMS WITH TRADITIONAL SYSTEM

Figure 3 illustrates the design of the traditional system.

The 'boiler' unit consists of an oil drum stacked lengthwise on top of a hollowed earthen mound 'oven.' Water inside this 'boiler' drum is heated by the fire from the oven which eventually produces steam. A second oil drum filled with plant material (either lemongrass of patchouli) is then stacked over the top of the 'boiler' drum where holes connecting the two drums allow the stream to enter into the second drum and pass through the plant material. The hot steam then removes the oil from the plant material by breaking open the cellular walls and vaporizing the oil in a process called stripping. The steam/oil vapor is then carried out of the drum holding the plant material and channeled into a long metal pipe. This long pipe is set into a trough with flowing water to cool its walls from the outside so that the hot steam/oil vapor can condense inside the pipe. The condensed liquid is then collected and the oil/water mixture is allowed to separate so that the oil can be skimmed off of the top and sold.

There are four problems with the existing system that lower the throughput and yield:

1. Stifled fire
    - The fire pit has a limited oxygen supply. As a result, the fire is difficult to start and must be constantly tended to maintain a constant heat source. This is active time that the farmer is unable to do other tasks
2. Biomass heat loss
    - The biomass chamber is completely uninsulated. The oil often touches the cold sides of the drum and condensates back into the biomass chamber before it has a chance to be carried up and over to the collection bucket
    - The biomass chamber is often rusty and any oil caught in this chamber is unusable. As a result, the yield (kilograms of oil per batch) is lower
3. Poor water-to-fire interface
    - The surface area at the water-to-fire interface is low, which means that it takes a long time for the water to boil
    - The time it takes the system to boil is unproductive distillation time because oil is not being collected
4. High water maintenance
    - The traditional system is a batch device. The farmers must load 50 gallons of water, wait for it to boil, and then keep checking to see whether the water has run out. Because the biomass container sits directly above the water drum, there is no easy way to check the water level

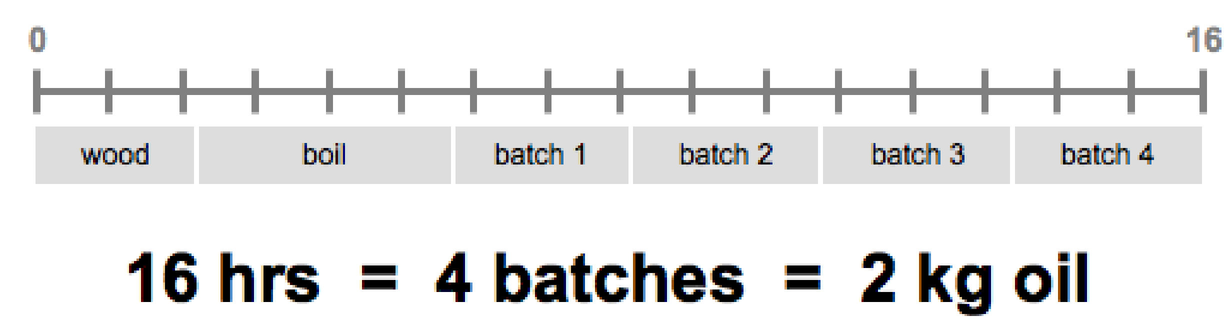


Figure 2. Operational Timeline for Traditional Unit

With this traditional device, farmers are able to process four batches of lemongrass or two batches of patchouli plant per day. They harvest lemongrass and patchouli three times per year and process as much as possible in the course of a week in preparation for Sunday market. The harvest week is filled with activity. The farmers must gather wood, boil the water, and process batches - a process which takes 16 hours per day. Figure 2 depicts the timeline. In one 16-hour work day, the farmer can process four batches of lemongrass, which produces 2kg of oil. On the Monday after market day, the villagers pick up their normal farming routine, making sure the rest of their farm does not go untended for too long. How can we increase the quantity of oil produced?

THE EASY STEAM MACHINE

The Easy Steam Machine has four main features that increase the quantity of oil produced (see Figure 4). In order to increase the yield, we designed (1) a more efficient fire and (2) biomass insulation. To increase the throughput, we designed (3) higher surface area and (4) a water flow-through system.

1. **More efficient fire**: the Easy Steam Machine fire pit is designed using the principles of the rocket stove[1]. We realized quite early that many scientists and engineers have worked on designing stoves for high efficiency and that there is limited room for further innovation. As a result, we designed an efficient fire chamber using the L-shaped rocket stove design with aerated cement insulation.
2. **Biomass insulation**: the Easy Steam Machine uses an insulated jacket that is wrapped around the biomass container to prevent oil from condensing on the walls.
3. **Higher surface area**: we increased the water to fire surface area by using a water tube design, which is the state-of-the-art for efficient boilers today. Instead of one large oil drum, the water travels through a system of small tubes that maximize surface area interface with the fire. The surface area to volume ratio in The Easy Steam Machine is 218 times more than the traditional system (see Appendix B).
4. **Water flow-through**: the Easy Steam Machine uses a water flow-through system to reduce the volume of water in contact with the heat source at any given point in time. This results in faster vaporization rates because the vaporization energy of the water is directly proportional to the mass of the water (see Appendix B). There is an external, gravity-fed reservoir that delivers water to the inner tubes to replenish the water as it turns into steam. Unlike the traditional system, it is very easy for the farmer to refill the water and know the water level at any point in time.

1 < http://en.wikipedia.org/wiki/Rocket_stove>

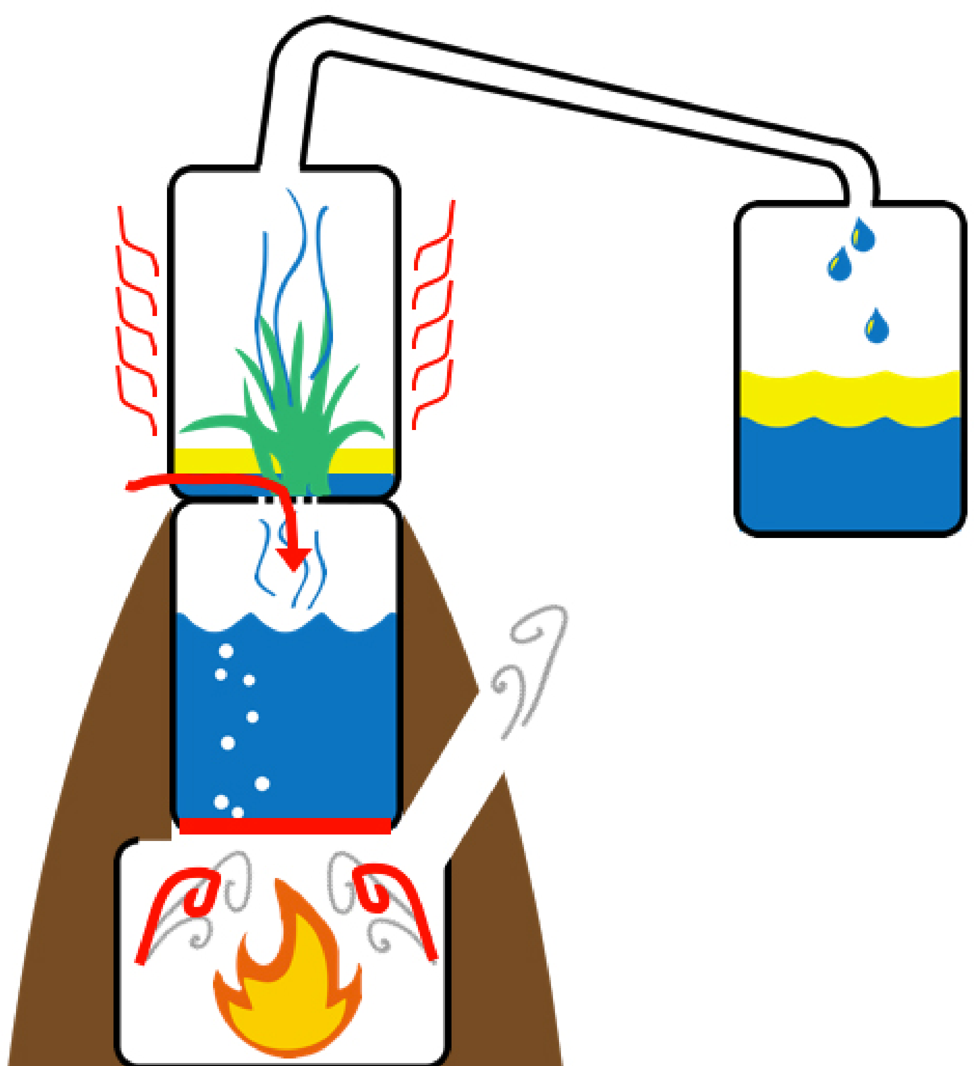


Figure 3. Inefficiencies with Traditional Distillation

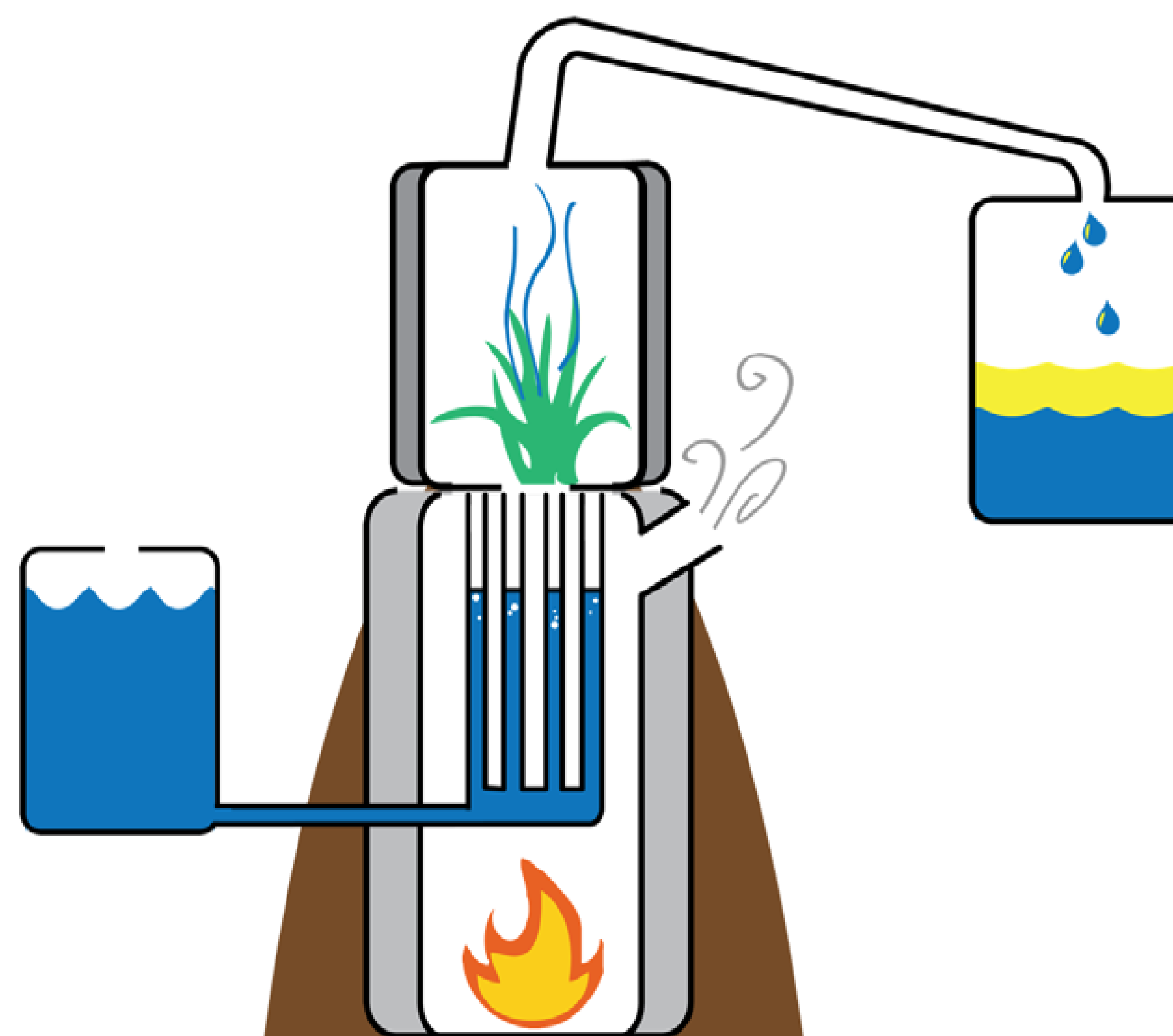


Figure 4. The Easy Steam Machine

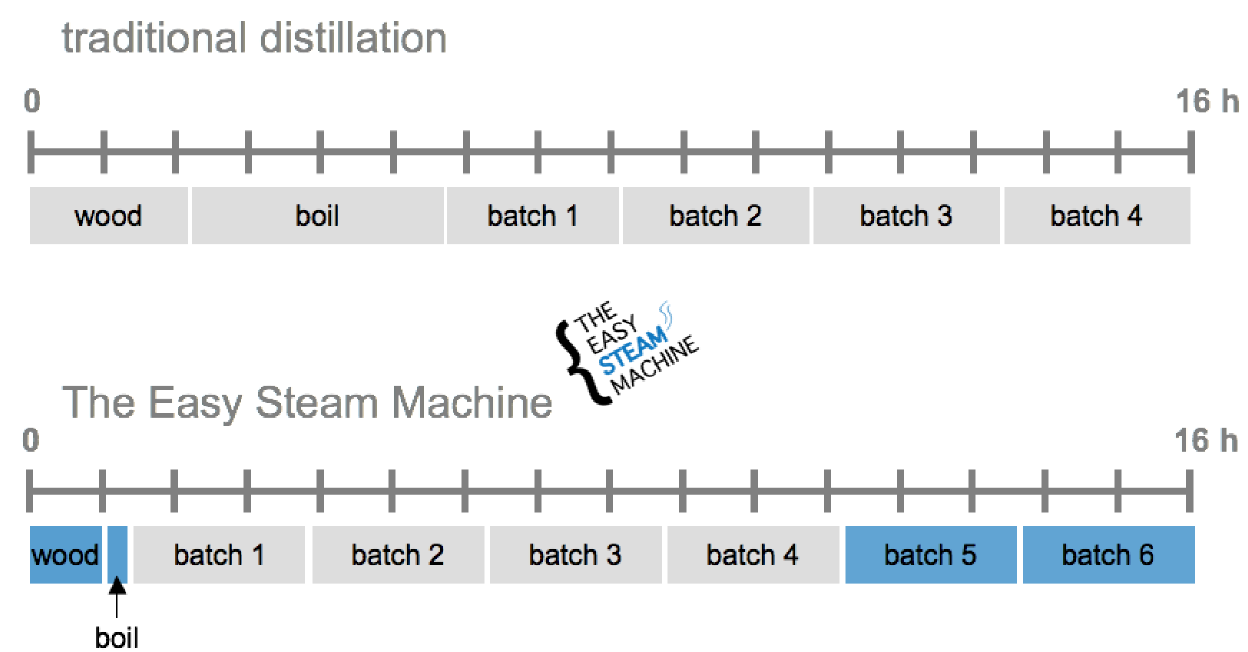


Figure 5. Operational Timeline Comparing Traditional Unit to The Easy Steam Machine

Increasing Yield

Although we have not yet run experiments to quantify the oil gains from increasing yield, we predict that insulating the fire and insulating the biomass will lower the batch time and eliminate any oil losses at the biomass container. Based on our early experience running complete oil distillation tests, we believe that across four batches, this could save the equivalent of one batch per day. In the next phase of product development, we will be building the traditional distillation system and can take direct measurements of the oil lost.

Increasing Throughput

We increased throughput (i.e. increased the number of batches per day) by (3) increasing the surface area and (4) adding a water flow-through system. In the traditional system, it takes 3-4 hours to boil the water and create steam. This is enough time to run another batch per day, which would increase daily oil production by 25%!

With both increased yield and increased throughput, we expect the farmer will be able to process two extra batches per day, as seen in Figure 5.

Pricing and Cost

Our target retail price for the Easy Steam Machine is $230. According to IBEKA, the markup between wholesale and retail is anywhere from 25 to 50% in Indonesia[2]. This means our wholesale price needs to be $150 to $180. We have outlined a preliminary bill of materials at $100 (see Appendix A).

To account for fluctuations in labor and steel prices, we have a buffer of at least $44 between material cost and wholesale price. In order to reduce costs, we removed steel from our design wherever possible, replacing it with aerated cement, rubber, and ceramic. ■

2 These percentages are based on IBEKA's targets for their new market-based product, the picohydro device, which is $1200 wholesale and $1500-1800 retail.

{ Industry Analysis }

COMPETITION

Two main competitors exist in the traditional oil distillation market: the current farm-level distillation system that oil-traders supply to farmers and IBEKA's high-tech cooperative distillation plant. These two are at the extremes of our competitive landscape regarding their respective CapEx costs and costs of operation (see Figure 6).

Traditional Distillation System

The current farm-level distillation system is purchased by farmers from the oil traders that serve as the buyers of their essential oils. The materials for the system cost $150 and are purchased on a loan advance from the oil trader who is paid back with a portion of money from the future sales of oil from the farmer. The typical packback period for such a system ranges from 3-5 harvests depending on the fluctuation in market pricing of the oil and the productivity of the farmer. The farmer installs the system on his own using the purchased materials and other widely available materials from the surrounding forest (bamboo, palm fronds etc.). Farmers continue to use this system but have several complaints about its operation and design (see Figure 3):

1. 'Boiler' drum leaks water and steam
   - Requires water additions which disrupts the steam flow when cooler water is added to the drum mid-process
   - Spilled water dowses the flame below decreasing heat and requiring more wood fuel
   - Leaking steam creates efficiency losses
2. Large quantity of wood fuel required
   - Though wood is cheap, it must be collected from the surrounding forest and carried back to the farm. As wood is taken, farmers must venture deeper and deeper into the forest to collect their wood
3. Current device rusts easily
   - The rust build-up can trap oil, cause the

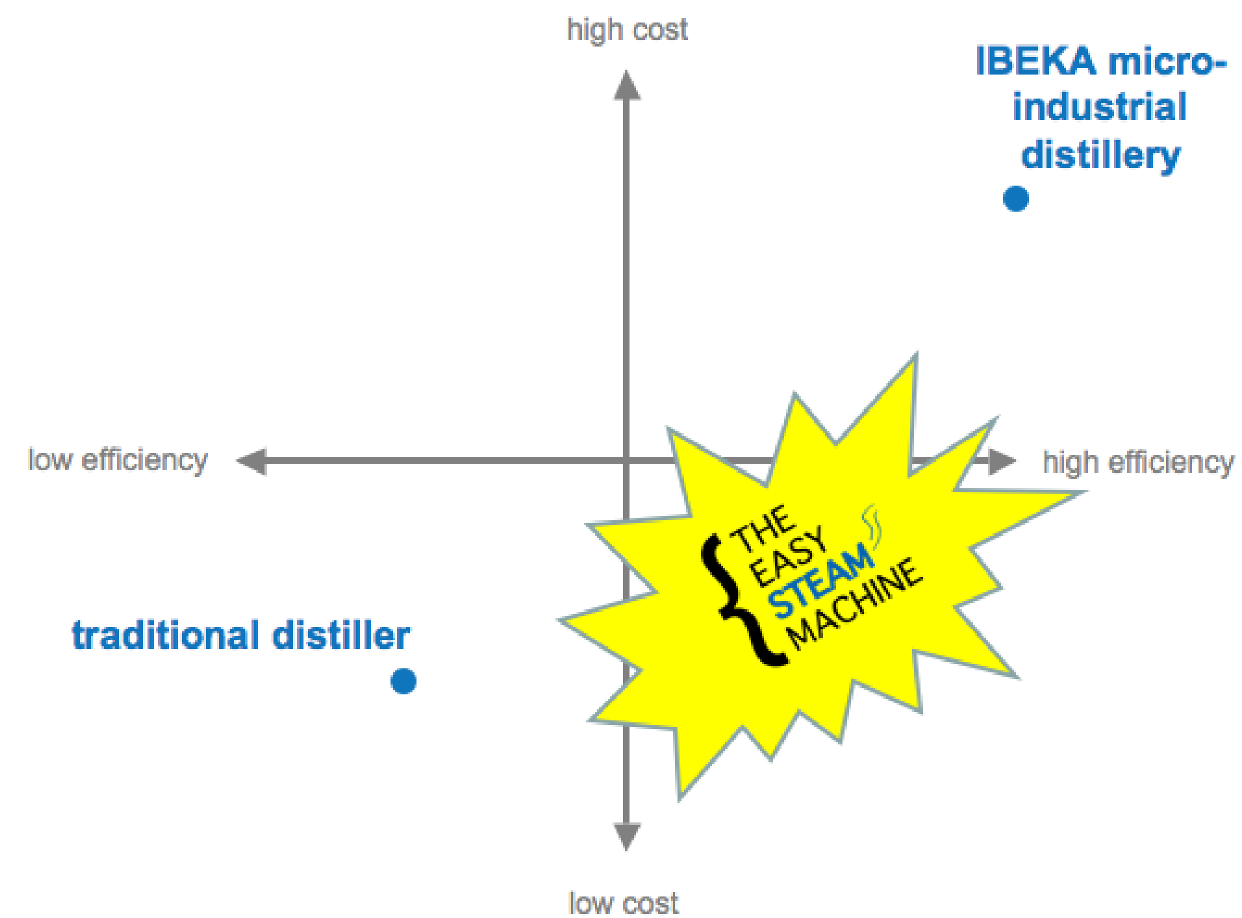


Figure 6. Market Distribution

different parts of the system to leak steam/water/oil, and prevents efficient transfer of heat by insulating metal with an oxidized coating

4. Batches of plant material too small
   - The current system requires several batches of plant material to be loaded and unloaded onto the boiler drum. This is troublesome for the farmer who must constantly cycle batches during the operation.

Though the upfront CapEx for this system represents a significant investment for the farmer, labor represents the main production limiting factor, as the costs to operate the system are low. Figure 2 illustrates the operational timeline for the farm-level distillation system. Tending to the fire, adding water and cycling batches of drums require constant attention. In addition, the start-up costs associated with bringing the water in the 'boiler' drum to boil mean that the farmer must devote an entire day to the process for his efforts to be worth the opportunity cost of not tending to other duties on the farm. However, though the time and effort to operate the system is extensive, the costs to operate the system are low. Fuel is obtained for free from the surrounding forest, water is plentiful, and both the lemongrass and patchouli crops grow extensively with little or no cultivation.

IBEKA Distillation Plant

In July 2009, IBEKA piloted a state of the art oil distillation facility in Putri Betung, Aceh as a means for farmers to collectively process and sell their essential oils. The IBEKA system costs upwards of $10,000. This high-end distiller produces 3.5kg of high-quality oil per day (3 batches of 1.5kg each), as compared with the traditional system, which produces approximately 1kg of poor-quality oil each day. However, several challenges have prevented this system from wide-scale adoption: technical hurdles, barriers to working capital, and community disagreements over operation logistics. Although IBKEA installed this system over a year ago, it is still not in operation. We believe that with the Easy Steam Machine, IBEKA can impact more farmers, more quickly, because we have lowered the barriers to adoption.

The main reason the villagers are unable to use the high-end system is technical: the boiler draws such a high initial current that the control system of the microhydro power plant is unable to keep pace and the entire mini power grid shuts down. The high-end distillation system draws nearly a quarter of the entire mini power grid capacity -- 48 out of 200kW. It also requires four male operators to run the system and, according to Puni and the women who own the distillation company, is not user-friendly.

The women owners continue to come to the facility three times a week to clean and maintain the system even though it is not in operation. They dream about the day when the system will be in full operation and already have ideas for additional design improvements:

1. Current device needs a better condenser
   - The oil outlet pipe often leaks steam, which means that the water vapor has not been sufficiently cooled and could be losing valuable oil
2. Water tank is too small
   - They need to refill the boiler in order to get through three batches of patchouli material. The women would like to be able to produce 500kg of Patchouli oil per week, for which this system is too small
3. Steam is not distributed evenly
   - When the steam leaves the boiler and enters the plant chamber, it rises upwards in a narrow column. The women owners believe that there should be a steam distributor to evenly spread the steam throughout the entire biomass

SUBSTITUTES

In reviewing the substitutes to the oil distillation/production industry, we must look to the other economic options that farmers encounter in the rural village setting. This can be done by outlining alternative investments for the distillation system CapEx costs (i.e. the investments that constitute the opportunity costs) in addition to understanding alternative uses of labor time/inputs from the farmer.

Figure 7. Cocoa Beans Monthly Price

Alternative Crops

Farmers in Aceh have demonstrated a historical willingness to change their crops according to short-term price fluctuations. Nearly all of the farmers we visited had cycled several different types of crops on their farm over the years. Whenever a particular crop exhibits high prices at the farm-gate level over a sustained period of 1-2 years, farmers will begin replacing their current hectares with the new crop. Currently, this is most noticeable with the cocoa crop, which has seen a surge in world prices since early 2008. Figure 7 shows the historical spot price for cocoa futures on the NYBOT exchange[1].

As these high world prices make their way to the farm-gate farmers have planted more of the highly profitable cocoa crop, which displaces many of their traditional crops such as patchouli and lemongrass. Though essential oils fetch high prices, with lemongrass oil averaging $8.60/kg and patchouli averaging $37.80/kg, they require a relatively high labor input in order to produce them. Though most cocoa in the world also requires a high labor input during the fermentation process, Indonesian cocoa is unfermented and, thus, is a low labor crop in comparison to lemongrass and patchouli. However, unlike cocoa which is a tree crop that requires tending and 3-5 years to reach maturity once planted, patchouli and lemongrass have the advantage of growing seasonally with little or no labor or fertilizer inputs. Thus, some farmers have expressed a reluctance to invest in cocoa due to the opportunity costs that arise from devoting their land to a crop that will require labor and inputs, yet will not yield income for 3-5 years. These factors demonstrate the risk in the oil distillation industry where commodity pricing is relevant and short-term price volatility can drive investment/planting decisions of farmers.

Sell Unprocessed Lemongrass and Patchouli

A second substitute to distilling the lemongrass and patchouli into essential oil is the simple act of selling the unprocessed crops as raw material to a distillation facility and/or to another party who plans to distill them into oil or sell them in raw form. Though it is not functioning at this point in time, IBEKA's coop distillation facility is a likely consumer of lemongrass and patchouli plant material in the future. However, this facility is limited by several factors. The first is the transportation logisitics associated with transporting the bulk and mass of raw crops to the facility. The current facility is scaled for use that exceeds the capacity of the immediate area and so, it will require farmers to transport their crops over several miles to the facility. Though this could be arranged by a

1 http://www.indexmundi.com/commodities/?commodity=cocoa-beans&months=60

coop truck that picks up the plant material from the farms and can track the weight that each farmer contributes, these specifics have yet to be solved and constitute a additional hurdle beyond the immediate problems associated with an inability to power the system.

The additional probability of the farmer selling his plant material to a third party in the village is quite low, as the volume of raw lemongrass and patchouli sold in both urban and rural markets is low, due to the plants' extensive cultivation. However, this third-party market could arise if certain individuals in the village begin specializing in essential oil production and begin purchasing the crops from their neighbors in order to serve as raw material for their distillation systems. Rather than threaten our industry, this potential market could enable the sale of a device with a high enough productivity to allow farmers to specialize.

Sell Land and Become Contract Worker

Though this substitute in not a major threat to the market landscape in Aceh, it could be a significant threat in other areas like Setu where urban expansion creates financial incentives to displace agricultural land with housing developments. Often times, farmers will have incentive to sell their land if the value has increased due to the entry of developers or if crop prices have risen steadily and thereby increased the profits you can earn from agriculture. As families grow through the generations, farm plots often get smaller and smaller as they are divided between siblings. This decreases a families ability to earn money from agriculture and they begin to look elsewhere to make a living. The trades and contract work is often an attractive alternative to agriculture for many farmers, who will sell their land and take up these jobs. This is relevant to the oil distillation market because this labor substitute could threaten to decrease the number of potential customers in locations where the agricultural way of life is being displaced. This threat should be addressed by our choices of where to sell the product (which areas of Indonesia), as we should choose locations initially where the threat of this potential substitute is the lowest.

Become an Oil Trader

An additional substitute could result from the sucAn additional substitute could result from the success of our device in creating substantial value for farmers. If the easy steam machine is able to generate the returns we project, farmers with extra money may begin to pay the oil market by purchasing oil from other still operators in their area. Those who are successful at trading oil and earning a profit could move away from oil distillation and into trading oil and loaning oil distillers money on a full time basis. Though this risk would significantly decrease if the Easy Steam Machine became the new standard of still at the farm-gate level, thereby allowing all farmers to compete equally, early adopters could gain an initial market advantage that moves them away from distilling and towards trading. Though this effect will most likely be small, it could decrease the number of long-term customers for our device. In addition, the result of having our initial customers become extremely successful could inflate expectations of the returns from our device beyond those that would be obtained if the device become the farm-gate industry standard. Decreased expectations could lead to decreased satisfaction.

BARRIERS TO ENTRY

The barriers to entry for the oil-still industry are relatively extreme in that some are very high, while others are very low. The fact that all of these barriers must be overcome means that the barriers are relatively high. This creates an attractive industry for groups involved, by limiting the number of competing groups in the space while also making it a bit risky for entrants, who must overcome these barriers to achieve success.

Distribution

One of the most significant barriers to entry is the distribution of the device in the rural market. This applies to the device's ability to access rural consumers, its ability to keep transportation costs low, in addition to its ease of transportation. As with most products in the developing world, distribution to rural consumers is extremely difficult due to poor infrastructure, increased sensitivities to inventory, and the dispersed/low-density of customers in the rural market. The oil still industry is affected by all of these factors, which constitute a major hurdle to overcome if we are to ensure a successful business model. Rural villages that grow and distill lemongrass and patchouli are dispersed throughout Indonesia. Though there are regions that tend to have higher rates of distillation and essential oil production, even these have a low density of potential customers, as only four or five stills exist in each village, and villages are an average distance of 6-8 km apart from each other in rural areas. This low density, when combined with a poor road network, requires an extensive and costly transportation network even for the most basic consumer products, let alone a large device such as an oil still. In addition, it requires the suppliers of stills to carefully manage their inventories of a unit that is a large capital investment for their customers and a that suffers from a volatile demand due to fluctuations in crop prices (i.e. if distilling is favorable given the other crop options). Due to these unfavorable conditions, the barriers to entry resulting from distribution are high in the oil still industry and must be carefully managed if our business model is to be successful.

Low Prices

Due to the fact that essential oil stills are exposed to extremely harsh working conditions, such as fire, boiling water, steam, and hot oil, they must rely on highly durable materials in order to maintain their functionality over the long-term. Current stills are constructed with steel, and though this material is a commodity product, it is also a high cost raw material product given the incomes of rural farmers. When we add the high costs of transportation resulting from a heavy material in an underdeveloped rural setting, we find that the material costs of the device can quickly add up. Due to the fact that the consumers are extremely price sensitive due to their limited access to capital or credit, this cost/durability trade-off must be carefully managed by those groups who are active in the space. Though clever design and inventory structure can reduce many of these cost issues, we find that the need to maintain low costs constitutes a significant barrier to entry for the oil distillation industry.

Manufacturing

Manufacturing shops are extremely prevalent in Indonesia and range from formal, world-class facilities in urban areas, to informal metal-workers and mechanics in rural areas. However, though the general costs for manufacturing are low and the availability of manufacturing options are high, the quality and skill level of tradesmen is the critical factor that influences the success of a manufacturing outfit. Though highly skilled tradesmen and technicians can be found, they are not as available as one would hope and are often difficult to keep in employment due to the high demand for their services. We are fortunate enough to have a partner (IBEKA) with extremely skilled mechanics and technicians who are both loyal and long-term employees of the group. Thus, though the barriers to entry that result from manufacturing are medium, we will have a significant competitive advantage in this area if we are able to partner with IBEKA.

Marketing

Unlike that majority of products that rely on traditional marketing avenues like advertizing and brand management to promote their product and increase demand, the rural Indonesian consumer products market relies heavily on word-of-mouth to achieve these marketing goals. In addition, there are no formal companies who are present in the farm level still space. As a result, traditional marketing is not largely present in the industry and customers primarily rely on tangible proof to make their choices. This conventional habit of consumers will make any market effort secondary to the actual functionality, results, and opinion that the device exhibits amongst consumers. This is not a significant barrier to entry in the industry but rather an unknown factor that emphasizes the fact that the device must deliver on its promise to increase ease of process and value to the consumer.

Supplier Power

The majority of raw materials used in the construction of stills, such as steel and concrete, are commodities and thus are subject to commodity market forces. As a result of this, though the raw materials constitute a large part of the overall cost of the device, the supplier power is extremely low in the distillation industry because the suppliers are unable to influence the market price of their materials.

Buyer Power

Buyer power is extremely low in the distillation industry because rural farmers are individuals who are not collectively negotiating large volume purchases. In addition, these customers are do not have significant access to capital or credit, and thus, are not able to willfully withhold their purchase of devices that are necessary to their livelihoods. ■

{ Prelaunch Plan }

A number of activities need to happen in order to successfully launch our product. We need to prepare for the pilot, run the pilot, and incorporate the lessons from the pilot into the product launch plan (see Figure 8).

PREPARE PILOT

In the Fall, we plan to enter the first stage of manufacturing with IBEKA by conducting prototype manufacturing and pilot test with them in Indonesia. Before venturing to IBEKA's manufacturing facilities in Indonesia, we will construct an additional prototype here at Stanford that iterates on our current design, as this will provide a signal to IBEKA of our willingness to carry the project forward and will allow us to address and resolve the current concerns they have with our latest design. At Stanford, we plan to build another high-resolution prototype that incorporates our final design ideas at full-scale for comprehensive testing. Simultaneously, we will recreate the traditional distillation system from Aceh in order to take bench-mark test data. Our goal is to produce repeatable test results that show at least 50% increased oil production in 16 hours. We will work with local Bay Area manufacturers, Airtronics and the PRL throughout the manufacturing process. This prototype will enable us have a conversation with Rizki about the logistics of manufacturing the device in Indonesia.

At the same time, we will ask IBEKA to provide deliverables to us that exhibit their willingness to create the time and space for us to build the device in their facilities and conduct user feedback surveys. Specifically, these deliverables will be the following:

1. Scheduling a dedicated employee and/or engineer to the manufacturing effort during our visit
2. Scheduling with Adi or Riski to assist in manufacturing user testing
3. Delegating a manager for the still project
4. Scheduling shop time and resources for the manufacturing effort
5. Purchasing the necessary materials for construction according to the BOM
6. Identify and secure 2-3 farmers who are willing to participate in long-term user testing with a new still design

Once these conditions are met one or two of our team will travel to Indonesia and build 2-3 stills for long-term field testing. These stills may be of the same design or they could be of different design iterations in order to collect the appropriate user and manufacturing data.

Manufacturing still prototypes with IBEKAs technicians and managers will allow us to pass on our project knowledge to them in a tangible fashion, as we will be able to walk them through the manufacturing process and explain the reasoning and story behind each design feature. This will be critical to the project hand-off, as it will allow us to bring IBEKA up to speed, and ensure that our knowledge gets transferred to the correct people on the organization (i.e. those technicians and

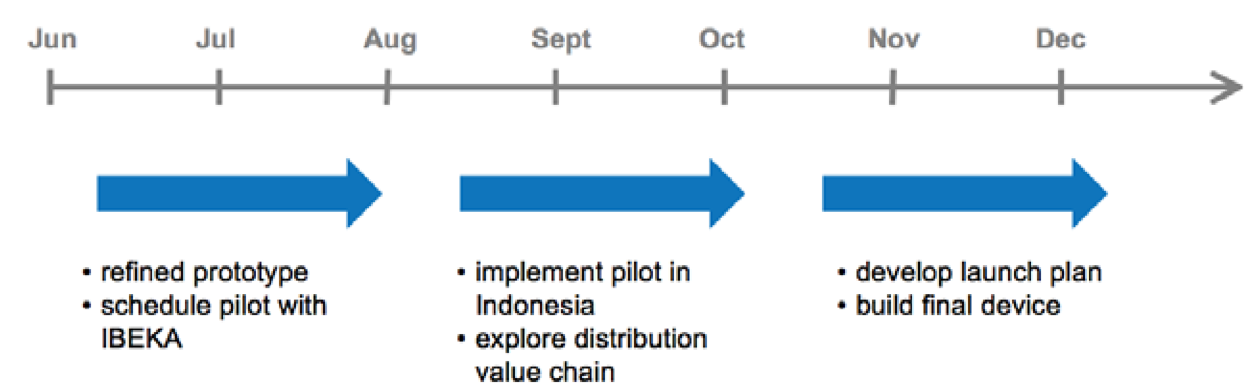


Figure 8. Next Steps

managers who will carry it forward).
After this joint prototype manufacturing process is completed and the relevant design, construction, and functionality knowledge is passed to IBEKA during the construction process, we will jointly conduct user testing in the field with the chosen farmers.

RUN PILOT

The goals for the pilot are:

- to determine the best user interface possible so it is easiest for the farmers to use our device
- to refine the device to best meet farmer needs
- to understand how to make the device truly plug and play with the existing solutions
- to get farmers excited about this new product

We consider our pilot successful when we learn about the above four points. The ideal result would be if farmers would not want to give back the pilot product! Once adequate user testing has been conducted, the design changes that enhance the usability and profitability will be incorporated into the device. However, these changes will occur with the manufacturability in mind to keep these costs low and the efficiencies high.

To run the pilot, two people from our team will travel to Indonesia to work directly with IBEKA.

In the first 10 days of the trip, we will work with Rizki to build a number of pilot devices in either Rizki's shop in Bandung or in affiliated metal shops. We will likely spend the first day discussing the prototype with Rizki, and the remainder of the time managing the manufacturing process. Our main objective here is to keep Rizki's time commitment to a minimum as he is very busy with the launch of IBEKA's first commercial product, the picohydro system.

At the same time, we will explore the existing distribution infrastructure for small and medium-scale appliances such as fridges and locally-made products. We will also finalize transportation plans for our device up to Aceh. Our third task for this Bandung period is to explore available materials in Bandung and their price points.

We have budgeted four days travel time for us and for the device, and expect both to be in the first pilot village in Aceh by the start of our third week in Indonesia. By that time, we expect local staff to have identified farmers willing to participate in the pilot and selected local distillation installation workers to help install our devices.

We anticipate 2-3 weeks filled with activities in Aceh. We have decided that it will be best to run the pilot in villages where there is no pre-existing high-end distillation system. Otherwise there will be an over-saturation of oil distillation products in the village and there will be little incentive to use the Easy Steam Machine. To plug our pilot device into the existing stills, we will work with the local distillation device installers. In addition to setup help, this will allow us to determine their capabilities in setting up and eventually servicing our steam machine. While the pilots are running, we are planning to gather user data: we want to observe a farmer using the current and the new device for a full day, to understand any benefits and shortcomings of the old device in terms of user-device interactions. This will allow us to make our final device even better before the product launch.

We will measure oil production rate, quality, and total quantity per batch and for the whole day. Through repeated observations, we will decrease the unavoidable margin of error in these observations.

Additionally, we want to explore the market in each pilot region: how many distillation devices are there, how much total plant production, and how much oil output. Here we will work with the existing agricultural extension officers such as Ibu Banon's husband in Putri Betung. Part of the market research will be a pricing analysis to determine farmer's willingness and ability to pay more for a better product. Furthermore, we are planning to

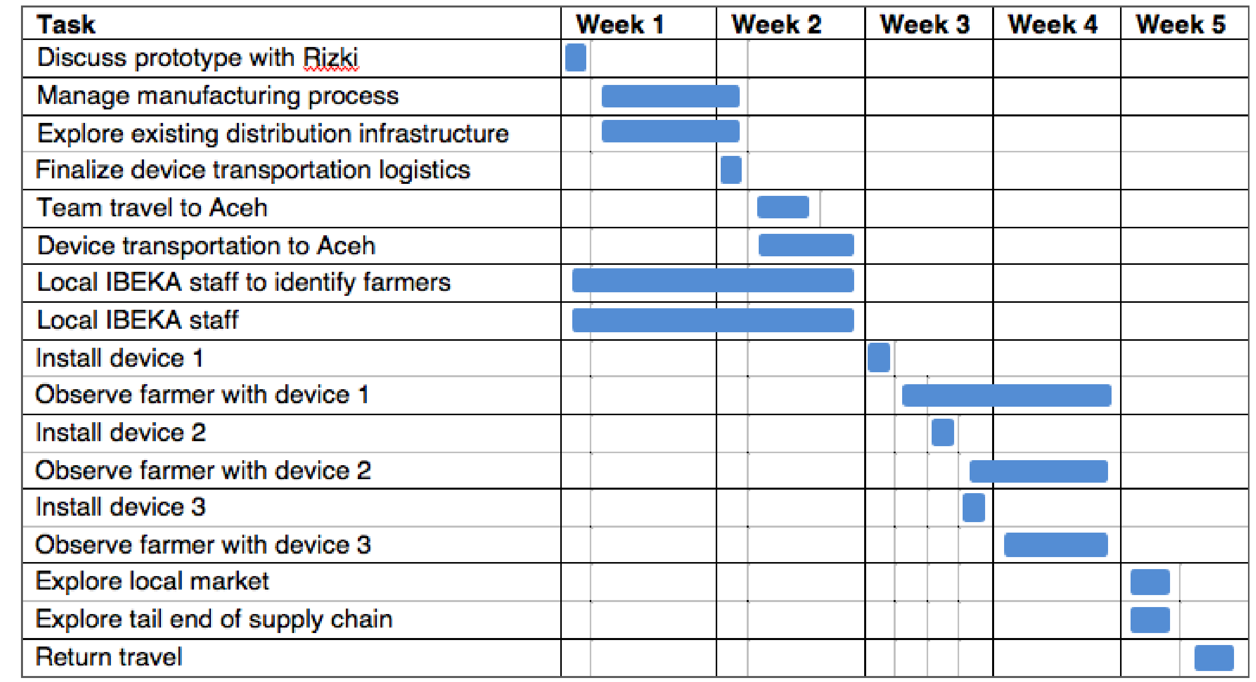


Figure 9. Gantt Chart

conduct case studies of how other brands penetrated rural Aceh.

Finally, we are planning to research the final end of the supply chain of durable equipment such as fridges and locally-made appliances that we started in Bandung. We will determine who wholesalers are, confirm margins, and determine the best partner that will support our product launch going forward.

The Gantt-chart in Figure 9 outlines the activities and our desired multi-tasking effort during the five weeks in Indonesia. ■

{ Funding Needs }

In order to get to the next level of product development, we need to build a full-scale model of The Easy Steam Machine as well as a full-scale imitation of the traditional system. Before handing our product to IBEKA, we need to prove the efficacy of our device by conducting a set of comprehensive comparative tests across both units.

This quarter, we achieved our goals of creating a device that produces instantaneous steam.

However, we would like to make sure that we can scale these features to the village requirements. We also need to test our hypothesis regarding increased yield.

Based on our product development budget from this quarter, we have laid out a proposal for our funding requirements through the pilot study. ■

FUNDING PROPOSAL

Category	Item	Cost ($)
Prototyping - Easy Steam Machine	Mild steel	500
	Aerated cement	200
	Plastic bucket reservoir	20
	Threaded caps	20
	Radiator hose	10
	Manufacturing costs	800
Prototyping - Traditional System	Steel pipe	100
	Oil drum (x3)	100
Testing	In-line flow meter	100
	High-temperature thermocouple	100
Pilot	Airfare (1 roundtrip ticket)	3000
	Contract work for implementing pilot	300
	In-country amenedies (for one month)	200
	Farmer Liability Insurance	400
Total Funds Proposed		6100

{ Operational Plan }

MANUFACTURING

Strategy

IBEKA's manufacturing team has both the quality and the bandwidth to manufacture the Easy Steam Machine. They are currently producing 3-4 microhydro systems per year and are building out the capacity to produce 100 picohydro per month. Currently, they have 20 percent downtime, which they fill with non-IBKEA contracts. They often produce spare parts for local textile factories. Rizki, IBEKA's lead engineer, is able to reverse engineer broken parts and reproduce them 70 percent cheaper than OEM because he has minimal R&D costs. Rizki's competency and experience span a broad range of products, from oil drilling machinery to dryer, to turbine blades that require complex 3-part molds. Unlike the three other micro-hydro manufacturers in Indonesia, Rizki designs his own turbines and turbine housing to fit the local context. We believe that The Easy Steam Machine would be a great contract to fill some of his shop's 20 percent downtime.

IBEKA's manufacturing capabilities constitute a major competitive advantage for our device, as we will be able to take advantage of low labor costs while ensuring that the device is constructed in a high quality environment with highly skilled mechanics. Nevertheless, due to the uncertainties around our product's business model, we plan to implement the manufacturing plan in stages while using discovery-based planning to adapt our structure to the unforeseen knowledge we will gain as we scale up. The following discussion will demonstrate direction and goals for the various manufacturing phases in order to provide a vision for our scaling process.

Low-Level Production

As we approach a finalized product launch design for the still by using the pilot tests, IBEKA will independently explore the features of small scale manufacturability in parallel. The goal of this parallel process will be to address the question: how do you make 50-100 distillation units? Critical-to-quality (CTQ) features provided by user feedback and essential parameters determined by functionality testing and measurement will serve as the focus of the manufacturing process. As a result, IBEKA will separate the design into features that require a high level of precision and a low level of precision. For those features that require high precision, they will explore jigs and fixtures to enhance the speed and quality of the manufacturing process. In addition, IBEKA will also explore the different material procurement options and may adjust the design in order to take advantage of material costing (i.e. reducing the use of some high cost materials and replacing them with lower cost materials that exhibit tolerable quality). As IBEKA refines the device design during this parallel process they may build batches of 4 or 5 stills to analyze the manufacturing process, test the ability to maintain critical specifications, and run the stills to ensure proper operation (end product quality control). Using these batch process prototypes IBEKA will be able to correct for any inefficiencies in their process and operations.

Once IBEKA has procured the necessary raw materials in bulk, and finalized the v1 design of the device by incorporating the lessons from the pilot study and the batch manufacturing prototypes, they will manufacture 50-100 of the devices in batches. The final number of stills produced during this phase will depend on the projected demand for the device using market data gathered during the pilot study. Because IBEKA will be manufacturing these stills in a shop that is also producing picohydro units, they will need to balance the production times for the two devices in order to ensure that demand is met. During this balancing process it will be important to pay attention to the trade-off between set-up costs and response time. As a highly versatile shop that produces several products and undertakes many specialized projects the set-up costs associated with readying the shop for production runs can be significant and they should be minimized. As a result, operations should be analyzed in order to determine the most efficient batch sizes for the various sizes based upon the market demand.

High Volume Production

After 50-100 units have been produced, IBEKA will be able to gather more field data on long-term use in addition to manufacturing data in order to produce a v2 design of the still. Manufacturing and user data from phase II should address the following in order to inform the phase III manufacturing process which will aim to produce 1000 still units:

1. Quality Control + Reliability: Field data should be collected on the failure points of the v1 devices and research should be conducted to determine if the manufacturing process contributed to the failures. This will allow IBEKA to establish firm QC guidelines and measurements for controlling the manufacturing process during high volume production.
2. Outsource Production or Keep In House: Once the costs and efforts of manufacturing 50-100 units are understood after phase II, IBEKA can decide to either scale its manufacturing facilities to produce 1000 units, build a dedicated factory to produce 1000 units, or outsource the work of producing 1000 units to one of its many industrial manufacturing contacts. In the event of outsourcing the production, careful attention should be paid to IP issues so that IBEKA doesn't 'teach' and manufacturer how to produce units and, in turn, create a competitor. In addition, labor quality should be tightly audited if the third-party option is explored, as there is a wide range of labor quality in Indonesia. NOTE: this decision should be undertaken before the v2 design is finalized, as the increased volume of production could create opportunities to acquire bulk commodity materials at significantly lower prices.
3. Process: Developed in parallel with the decision to outsource or keep manufacturing in-house. Using QC, process, and design data and analysis from phase II, the manufacturing process should be analyzed and adapted to a 10x increase in production volume. Investments in additional jigs and fixtures should be considered to enhance rate and adherence to specification ranges.
4. Stress/Safety Testing: An increase in the number of stills that are operational in the field means an increase in the operational and environmental parameters that they will encounter with different users. As a result, v2 stills produced in phase III must be subjected to stress tests to ensure their long-term reliability and durability. Not only is this important to maintaining product quality, it also ensures that the stills remain 'safe' under a variety of environmental conditions.

MARKETING AND PROMOTION

For farmers in Aceh, seeing is believing. Villagers pay a premium for local products that they can see produced before their eyes. In Putri Betung, farmers spend fifty percent more on their coffee just to have it locally roasted and ground: "we don't trust the imported coffee from Medan [the nearest major city], because they might mix flour into the coffee." Our marketing and promotion strategy needs to show functionality and ease of use directly to the farmers. This is where word of mouth becomes critical: IBEKA has received electrification requests from villages as far away as 100km from existing microhydro power projects. In this environment, our Easy Steam Machine can only become a well-accepted product in the marketplace if we can get farmers to spread the word.

We plan to introduce the product in areas where IBEKA is already active, but where there is no pre-existing large-scale distillation unit. IBEKA has a strong brand in those villages, and this can help us win over the initial customers required for the word of mouth campaign to take off. Even now-famous brands such as Honda for motorcycle, Kubota for agricultural machinery, and Sanyo for water pumps, started out with word of mouth penetration in Indonesia. Today, some of the brand names are used as the category name: e.g., people refer to motorcycle as "Honda" (even if it is not a Honda), or call water pumps "Sanyo" (even those of a different brand). We want to become that brand for oil steam distillation machines.

This strategy is not without risk: it relies on what we have seen during the need-finding trip and what we have heard from IBEKA. In fact, IBEKA is trying out this exact same strategy for their picohydro product, and we anticipate a lot of mutual learning.

Product

Our pilot is the first building block of this strategy. In the pilot, we will refine the product to make it as user-friendly as possible while aiming for a high daily oil production rate. We will work with local repair shops close to the demonstration villages and train technicians to repair our new devices. To that end, we will provide a warranty to the early adopters that we will fix their products should any breakdowns occur. We have built in farmer liability insurance of $400 to be able to buy the villagers a new traditional oil distillation machine should anything break on their existing system - or should they lose money in the first season.

Price

As mentioned in The Solution section above, we are targeting a $230 system. This is our aspiration, however, after refining our prototype for local production, we will need to modify the price.

Our price should not be too high to allow for a reasonable repayment timeframe and good NPV, but it also should not be too low. We learned from IBEKA that farmers in Aceh categorize products by price: cheap, mid-level, and expensive. People believe that the most expensive products are the best and they aspire to purchase these products.

Placement

We will strategically work with the early adopters in each village. They will be most likely to try a new device, and once they use it, everybody in the village and the neighboring villages will stop by. When IBEKA installed the microhydro system in Putri Betung, people came from far away villages to see the electrification in action. Even in everyday life, younger farmers drive around on their motorbikes to neighboring villages to see what others are doing and if there are any new devices or new farm practices that are successful.

This is where our device comes in: once the early adopters show it to visiting farmers from other villages, these farmers will take the word back to their home villages and some of them may also become early adopters. These early adopters will buy and use the device and so the cycle continues and spreads further and further. For these early adopters, IBEKA will have to organize installation and maintenance demonstrations. Once they have trained with the new device, they can become qualified to teach visiting farmers.

During the pilot, we are planning to assess the speed of this spread to determine how many seed villages we need in order to reach broad marketing coverage within Aceh over the next three years.

Promotion and Advertising

For our initial product promotion, we will provide free installation and free repair of manufacturing-related problems. This will help farmers feel comfortable making the investment into a new product. If IBEKA takes on the risk of repairing a few machines, it will induce even more farmers to try them out. This will be the seedling for our word of mouth advertising campaign introducing The Easy Steam Machine.

While in Indonesia, we saw few billboard advertisements within the remote villages, aside from cellphone advertisements on the sides of local shops. However, villagers often travel to Marpunge, the nearest town (30 minutes from Putri Betung) to purchase farming equipment. Here, we saw several stores with hand-written billboards announcing new products (see Figure 10). A banner introducing the new Easy Steam Machine that also advertises the store itself might be a way to convince the storeowner to broadcast the availability of our product more broadly.

During our follow-up pilot launch in Aceh, we will be able to research further how established

Figure 10. Handwritten Billboard

brands leverage promotions and advertising. Are there radio stations? Are there newspapers? Are there village broadcast systems? Do people like to use stickers on their motorbikes or other vehicles? We will explore how knowledge about new products penetrates rural Aceh. Equipped with that knowledge, we will refine our promotion and advertising strategy when we evaluate and reflect back on our pilot later this year.

SALES AND DISTRIBUTION

Currently, farmers purchase the traditional distillation system with credit from their local, village-level oil trader. The trader lends money to the farmers, the farmer purchases the oil distillation device, and pays back principal and interest to the local trader. Typically, these transactions are netted with any proceeds the farmers makes from selling essential oil. This alignment is key to financing a new device: the trader will make a good return if the farmer can generate a good return. Our device fits squarely into this scheme. It will generate higher returns for the farmer, and the farmer can use them to pay back the loan used to purchase the device. While we have this initial understanding, more research still needs to be done to fully understand how farmers purchase, construct, and find funds for their current distillation units.

The point of sale will be village shops such as the one we visited in one of the villages 30 minutes away from Putri Betung. That shop was a crop aggregator/trader, buying from village traders and selling to district-level traders in the district capital. The shop also supplied anything from chicken feed to cell phones. Some suppliers shipped products directly to the shop, while the shop keeper purchased some products on his own and transported them to his store. With the distribution infrastructure in place, this is a natural candidate to sell our machine.

Part of our market research is to determine which types of stores would stock our machine, and how their current supply chain works – either from Bandung or from another place of manufacturing, as will be determined during the pilot. The goal is for us to provide IBEKA with a list of wholesalers that would purchase the product at the point of manufacturing, and sell it using their own channels.

While our sales and distribution plan is necessarily vague given the lack of information, we will be able to leverage IBEKA's learning from their picohydro project. They will need to put in place a distribution system and will have to answer many of the same questions that we have. During the pilot, we are planning to get an update on the picohydro distribution from IBEKA.

The most difficult part of this strategy is how to transition from the pilot-level (where IBEKA or a specialized courier service transports the device to Aceh) to a wider market-based distribution (where IBEKA sells to a wholesaler at the shop gate). We will carefully track the number of units sold in each district and will recommend switching to a wholesaler/distributor based model once demand picks up beyond the early adopters.

INSTALLATION AND MAINTENANCE

Our current strategy is to manufacture a boiler retrofit for broken oil stills. Traditional units break quite often and must be repaired, often by taking another loan from the oil trader. However, many times the oil trader will refuse to give a repair loan because he feels he will not be repaid because the still has major breaks and will continue to function poorly even when some repairs are made. Though the purchase and installation costs of our retrofit will be above the cost of a traditional repair, it will incentivize the farmer by providing guaranteed returns on an investment he must make in order to continue his distillation operation and it will provide guaranteed returns to the traders who makes the loan for the retrofit. Purchase of the retrofit materials will be made at the local village shop, which carries a retrofit 'kit'. It should be noted that while the majority of the components are ready to install (i.e. the 'reverse radiator,' and water tank), the aerated cement ring will be installed in place using bags of cement/aluminum powder mix and a mould that is kept by the shopkeeper and provided free of charge. Because the items for the retrofit are heavy, more than one person will be required to install the system but this will not be a problem as rural labor in Indonesia is communal and farmers normally help each other in the fields throughout the year. Critical parameters such as the water level between the tank and the radiator or the placement of the radiator in the cement ring will be designed in an intuitive way, so as to prevent improper installation. However, as information travels fast between villages by word of mouth, we believe that the general installation knowledge will be easily available within the community after a few stills have been installed and used in the vicinity. In order to insure this proper knowledge takes hold, it will be important for IBEKA to provide proper guidance in the initial stages of product launch. Though pilot and product launch studies will reveal data about the installation process, this vision will provide our direction at this point in time.

However, the maintenance strategy of retrofitted stills is a bit different in that it will require pilot studies and data from long-term use in order to understand the maintenance needs for the device. Currently, we feel that there are plenty of informal maintenance resources in the village (informal metalworkers and builders) to service the device. However, we are unsure of what parts of the device will be high-maintenance and/or what the motivation will be to repair device failures. Indeed, our need-finding trip found some village devices like the coffee grinder in disrepair yet nobody felt that it should be repaired. The following questions will need to be answered by our pilot and product launch studies in order for us to gain a better understanding of the device maintenance:

1. Can vs. Will Maintain: What makes people want to maintain? (e.g. the coffee sheller was easy to fix but nobody fixed it)
2. How do villagers maintain other relatively complex devices like motorcycles, refrigerators etc? (How to they gain knowledge of how to do this?)
3. What parts of our device fail the most?
4. Should we supply an inventory of spare parts to ease or incentivize device maintenance?
5. What field modifications are made? (Do they decrease efficiency or make the device unsafe?)
6. Do farmers remove of essential parts for other uses that decrease efficiency or increase safety risks to operators? (i.e. insulation)

Once the answers to these questions are understood, IBEKA will have a better understanding of a maintenance strategy. As a result, it is essential for them to do proper pilot and launch planning to identify the short-term and long-term data points they will gather to inform this strategy. ■

{ Organizational and Legal Structure }

STRATEGY

Though the business law and organizational structure is less formal in Indonesia in comparison to the US, both Puni and Iskandar are high profile individuals both locally and globally their business organization should conform to the highest legal standards to maintain a positive image of their work. This presents a few challenges as IBEKA, a legally registered non-profit organization, will soon move into the for-profit consumer product space. In order to adapt their organization to this changing focus, IBEKA can look to several models of hybrid for-profit/non-profit companies in the US and adapt them to their local context. Given Puni and Iskandar's personal connections in Indonesia, they will undoubtedly be able to construct a creative legal solution to this hurdle.

The following hybrid business models and concepts could be useful in brainstorming solutions to developing a hybrid Indonesian organization:

1. Blended Value Concept[1]: This concept focuses on maximizing the value a company creates in the economic, social and environmental space. This may help IBEKA identify the social and economic values they are attempting to quantify.
2. Side-by-side Model: Here a board of directors governs a traditional 501c3 non-profit which is 100% owner of a for-profit LLC. Though LLC's are not favored by capital markets, this would not be a problem in IBEKA's case because they do not need an exit strategy. Using this model, IBEKA could create a for-profit company that produces rural consumer products and have that for-profit 100% owned by IBEKA.
3. 1-1-1 Approach: This is a for-profit business model founded by Salesforce.com whereby 1% of stock, 1% of profit, and 1% of employee time is dedicated to a non-profit cause. This goal is transparent to stockholders and thus, the market will not 'punish' the founders for destroying value with this 1-1-1 commitment. Though it is an interesting concept, it would not work well for IBEKA, as it would not fit with their business model.
4. For Benefit Models: This is a for-profit model that focuses on the social, environmental, and/or economic benefits of the products they create (i.e. 7th Generation, Patagonia etc.). This could be a great solution for IBEKA's consumer products, as they could create a wholely independent for-profit company that produces innovative, value-creating products for rural farmers.
5. B-corps[2]: This model has gain popularity in the US as a certification model of for-profit under the B Corporation organization, who audits and approves companies seeking this designation. Because it is primarily a US certification model, I do not think it will fit IBEKA's for-profit model well.
6. L3C: This is a hybrid model and designates itself as low-profit limited liability company[3] (LLC). The business is operated as for-profit but differs from for-profits that focus solely on creating monetary value by incorporating secondary values (environmental, social etc.) into its business decisions. It is an evolving model with certain benefits and drawbacks that could be explored by IBEKA. ■

1 www.blendedvalue.org

2 www.bcorporation.net

3 http://en.wikipedia.org/wiki/Limited_liability_company

{ Risk Analysis }

STRENGTHS

- IBEKA has well-established manufacturing capabilities. Rizki and Iskandar are both highly capable engineers that have demonstrated their design and manufacturing capabilities with the 40 microhydro power stations across Indonesia. Additionally, they have affiliations with a number of workshops across Indonesia that will allow them to get even complex manufacturing jobs done. We have seen anything from aerated cement to water turbines to to large, heavy-duty galvanized steel containers.
- Word of mouth marketing is a demonstrated method in Aceh. It worked with the microhydro station and Adi has already suggested that the picohydro system will use a similar approach. Additionally, IBEKA has a lot of contacts on the ground to start out the seeds for its viral campaign: the electricity co-ops and local shopkeepers in microhydro-electrified villages. These resources are available for the Easy Steam Machine as well.

Farmers are already paying a significant amount of money for the current device ($150), and our new device would have a price in the same order of magnitude ($230).

- There is credit available to farmers through local sources. This is not something we have to implement on order to roll out the product.

WEAKNESSES

- IBEKA has developed a co-op level steam distillation machine that appeals to IBEKA because it would foster the creation of more village-level co-ops. The Easy Steam Machine needs a firm commitment from IBEKA. With attention drawn away to another distillation machine with potentially overlapping customer segments, the product launch of The Easy Steam Machine might suffer.
- The key driver of the financial returns to the farmer from our device is the difference in cost between his outside option and the Easy Steam Machine. Farmers will benefit the most when they use the Easy Steam Machine to replace a failing distillation machine or when they first start oil distillation. However, we are initially targeting farmers that already have an existing device that needs a repair. We need to be careful to target farmers that have the most expensive repair.
- For the real product launch, we need to find a way to combine our Steam Machine with the existing device right at the point of sale. The current device is sold directly by the installers, but we are planning to go through the existing village shop infrastructure. We will address this issue when we meet with the traditional installers during the pilot.
- Device performance and price are tightly linked. The higher our surface area to volume ratio (see Appendix B), the more efficient steam generation and thus oil production rate. During our pilot, we need to determine how much farmers value this higher production rate and find an optimal combination of device price and production rate.

OPPORTUNITIES

- IBEKA can be a first mover in the home oil distillation space, establishing itself as the brand associated with oil distillation machines. This fits well in their desire to promote larger co-op models of oil distillers: the small machine is well suited for areas where a co-op model is not feasible. Once well established in the individual space, IBEKA can leverage its reputation to supply co-ops with a larger distillation machine to capture this additional space in the market.
- There are other opportunities for a steam generation device, for example in health applications. The Aceh government is providing more and more health centers in rural areas[1], and had just built a new center in Putri Betung when we visited. There might be an opportunity to use steam for medical device sterilization purposes. Another Extreme team showed interest in our device to produce essential oils

1 Asian Development Bank, Indonesia: Decentralized Health Services Project - Completion Report. January 2010. http://www.adb.org/Documents/PCRs/INO/34007-INO-PCR.pdf (Accessed June 6, 2010)

that can be used in hand sanitizers. There are many opportunities, and the availability of a reliable and fast steam source might even spark more entrepreneurial ideas in rural Aceh.

- Oil steam distillation is not unique to Aceh. Indonesia produces a lot of essential oils and there might be a market for our device beyond Aceh, and possibly beyond Indonesia. IBEKA could turn this product into an export product through partnerships, or license the intellectual property to other organizations either for free or for a fee. There are many interesting business model implications and IBEKA can use this device to start to brainstorm more in this direction.
- The device can promote rural development beyond the farmers themselves. Adi indicated that there might be local metal shops who could build our device. In this case, more of the value generated from the device would be captured in Aceh: both the device itself as well as the proceeds from the incremental oil sold would remain in the province and foster local economic development.

THREATS

- We have not completed product development yet. Steam boilers are non-trivial devices that come with a usability and safety risk. In the worst case, farmers will not like the new boiler because of yet unidentified usability issues. Through our pilot, we are mitigating this risk to just a few devices.
- IBEKA does not yet see the promise in our approach that we believe in. In particular, Rizki has doubts about our design and Puni has invested time, money, and emotional energy into the co-op distillation facility and its managing director, Ibu Banon. The pilot is our time to shine and come up with a final device that farmers are willing to buy, because that is what counts in the end.
- Word of mouth marketing and branding is "sticky" in it transmits both positive and negative perceptions without much of control on our end. We need to get it right the first time and deliver a device that satisfied what it promises: to be a quicker way for farmers to generate steam. We mitigate this by having repair technicians ready under our warranty program when we launch in the seed villages for the word of mouth campaigns.
- By tying our device to the IBEKA brand, we will have other products influence the Easy Steam Machine and vice versa. We need to determine how much brand overlap to permit during the initial stage of our pilot on the ground with IBEKA.
- There is third party risk: our goal is to send the product through the regular distribution channels and hand it to a wholesaler at the factory gate. If the wholesaler or the shopkeeper at the final point of sale mismanages the product, it will reflect negatively on our product in general. Additionally, using local technicians to service the device might introduce modifications that negatively impact device performance. This can also negatively impact our brand perception. We mitigate this by providing training to new "agents" who sell and service our products, at least during the initial product launch phase.
- The biggest contingency is if we are not able to travel during the summer to prepare and run the pilot with IBEKA in Aceh. We foresee two backups: Andi and Nina could travel in January 2011 after they graduate in December 2010; or we could hire Lando Wala, who already knows us and has a deep relationship with IBEKA. Lando would be able to build the pilot devices and run the pilot. We knows Aceh and followed us during our needfinding trip. ■

{ Financials }

The financial model is based on a wide range of assumptions that need to be tested during the pilot and the early stages of the product launch. At this point, two items are important:

1. The returns to the farmer, and these are independent of market penetration.
2. The project financials

Please refer to the appendices for more details on our financial model.

RETURNS TO THE FARMER

We estimate that farmers will be able to pay back the initial cost of the device (at a moderate discount rate of 30%) after 3 years when purchased as an add-on to their existing still, and after less than 1 year when used as a stand-alone system (see Figure 11).

PROJECT FINANCIALS

We estimate that IBEKA will earn a 20% return on its capital tied into the project, above any direct labor and material for the Easy Steam Machine. This will include any fixed overhead costs such as machine depreciation that IBEKA allocates to our this project. Retailers and Distributors will take approximately a 40% margin (typical value for the US, and higher than IBEKA's estimate for the pico hydro system).

Figure 12 shows the projected cost structure (we are assuming $1 = Rp10,000).

For the word of mouth campaign, we aspire to a 10x spread to new villages every year, i.e. 10 villages will hear about the new distillation machine per every village that already knows about it, up to a cap of half the villages that do not know yet. With Aceh's ~6,400 villages, this will yield almost

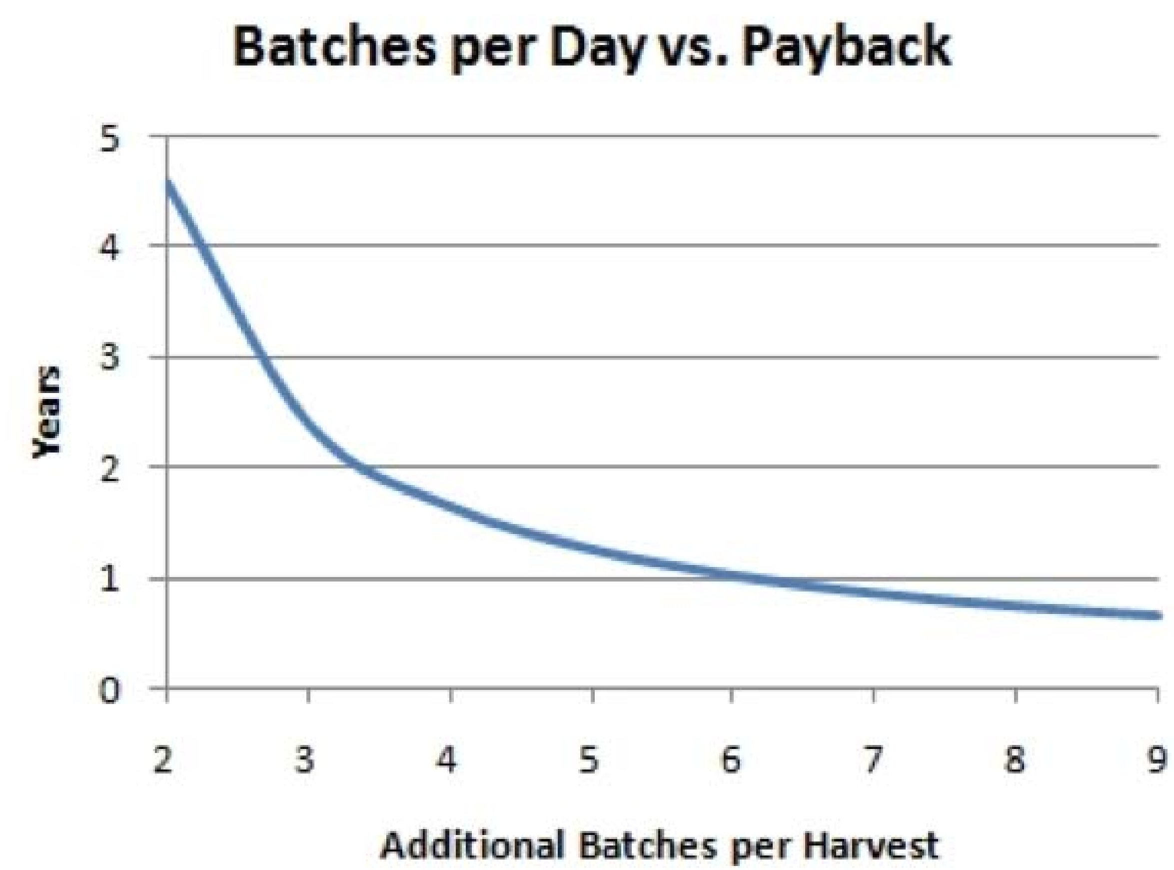


Figure 11. Payback to Farmer

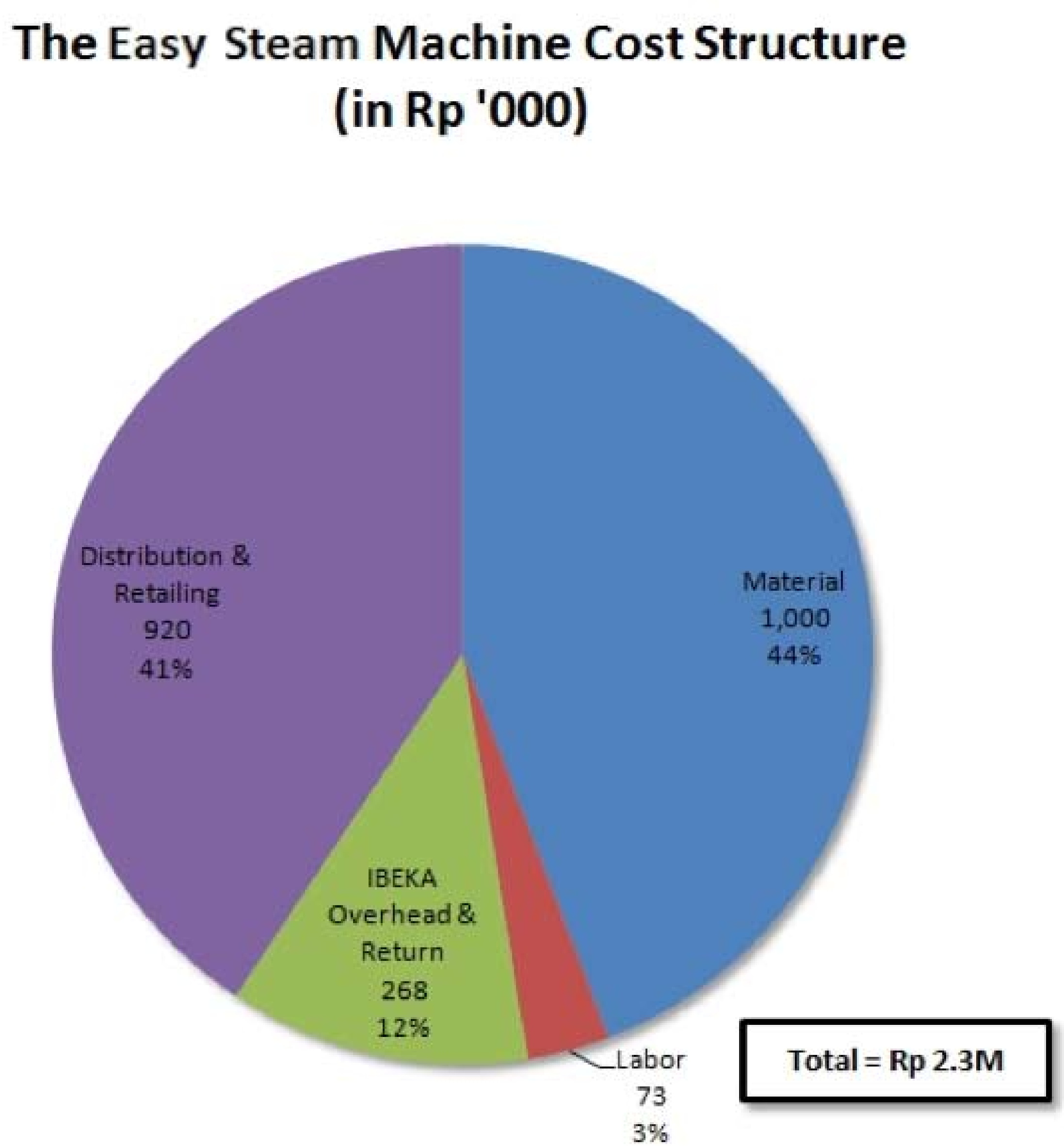


Figure 12. Cost Structure

complete market coverage by 2015. We expect that in those villages, we will be able to have at least one machine sold by 2011, reach 10% of the addressable market (machines replaced in this year) by 2012 and ultimate get to 30% by 2015. We estimate sales of almost 4,000 devices in the first 5 years of operation (see Figure 13) to a total market share of close to 25%. ■

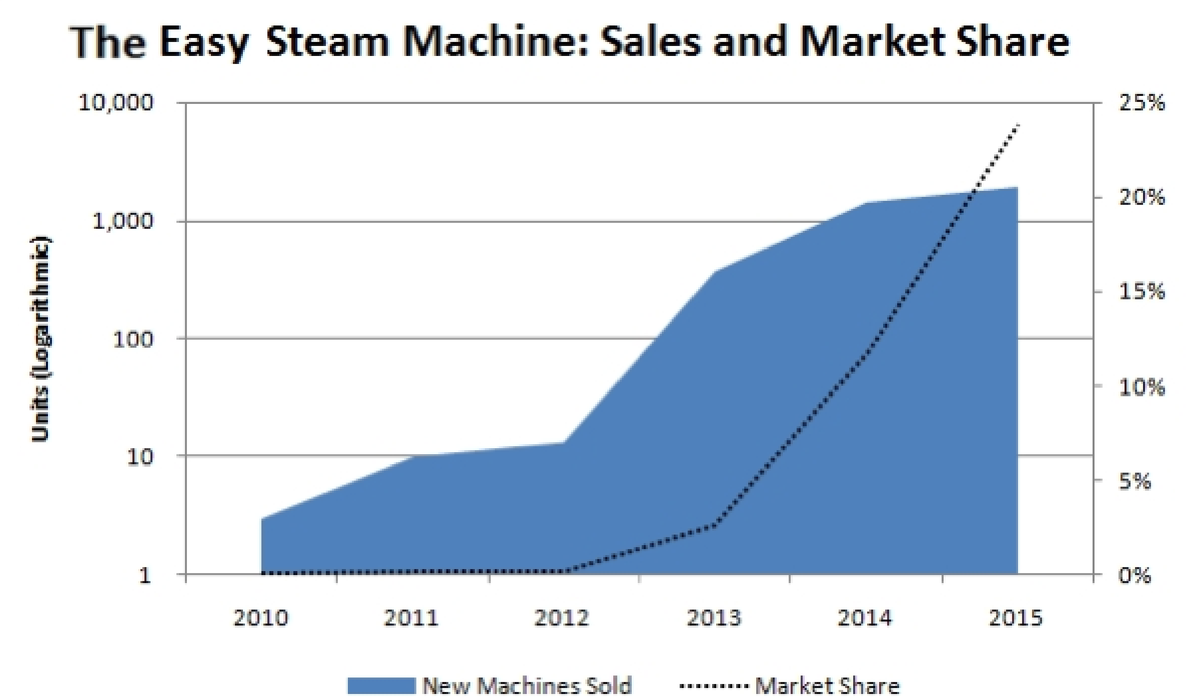
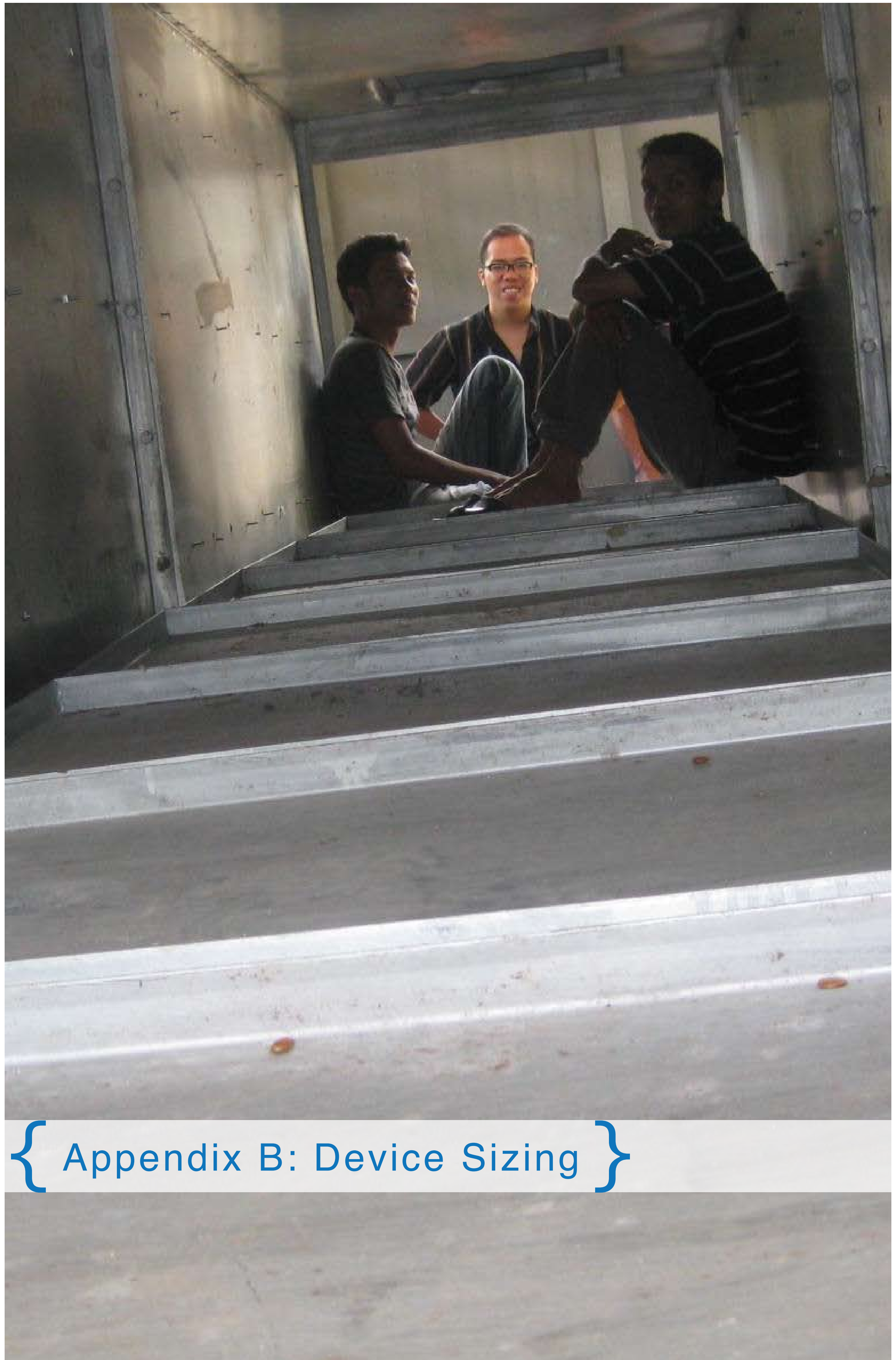


Figure 13. Sales and Market Share

Appendix A: Bill of Materials

BILL OF MATERIALS

Material	Size	Weight (kg)	Price/kg	Price
Steel Pipe	16x2' (1" dia)	24.4	1350/tonne	32
	4x10" (2" dia)	11.85	1350/tonne	16
	1x15" (3" dia)	3.7	1350/tonne	5
Threaded Caps	1x(3" dia)			3
Exhaust Pipe	2xCeramic Pipe		1350/tonne	5
Outlet Pipe (Ceramic)	3' (1" dia)	2.29		3
Aerated Cement	10 ft^3			12
Plastic Tank	20 gallon (+ stepped nozzle)			10
Car Radiator Hose				5
Insulation for Plant Container				9
Total Cost				100



{ Appendix B: Device Sizing }

OVERVIEW

	Traditional	Coil Prototype	Final Prototype	Final Device
Surface area between water and fire (in m^2)	0.5361	0.41	0.1834	1.05
Volume (in Liters)	211	1.16	0.7127	6.7647
Ratio	0.0025	0.3534	0.2573	0.1552
Ratio Relative to Traditional Device	1	141	103	62
Power (kW)	5.9	3.25	1.49	7.2
Vaporization Rate (L/Hr)	10	4.5	2	10

VAPORIZATION ENGERGY CALCULATION

Energy needed to boil water: assume we start at 20c and go to 100c, i.e. 80K temperature delta:

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

Energy needed to vaporize water from its boiling point: 2,257 kJ/kg (note: 7x the energy needed to bring it to a boil!). Total energy needed to turn water into steam: 2.6MJ/kg = 2.6MJ/L

CURRENT SYSTEM

DATA FROM THE FIELD

	Patchouli	Lemongrass
Water used per batch	120 L	60 L
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

Even assuming that the fire has a 1,000K temperature difference to the drum of water, we can only get a maximum power of:

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

This yields a steam generation rate of 9.4 L/hr for the current device. We will round up to 10 L/hr going forward.

Heated surface area to volume: 34.5in * 23 in * PI / 3 = 5,361cm^2 = 0.54m^2. Volume is 55ga = 211 L. The ratio is 5,361cm^2 / 211 L = 25.4cm^2 / L

COIL PROTOTYPE RESULTS

Surface Area

Large Coil: 0.5 in diameter, 23' length. About 22' in the fire. Total area = 0.5in * PI * 22 * 12in = 415 in^2 = 0.27 m^2

Medium Coil: 3/8 in diameter, 4" coiling with 10 coils => 4in * Pi * 10 = 125in length, say 120in in the fire. Total area = 3/8in * Pi * 120in = 141 in^2 = 0.09 m^2

Small Coil: 1/4 in diameter, 2" coiling with 10 coils => 2in * Pi * 10 = 63in length, say 60in in the fire. Total area = 3/8in * Pi * 60in = 71 in^2 = 0.05 m^2

Total surface area = 0.41 m^2

Volume

PI * r^2 * length

3.14159*(.5/2)^2*23*12+3.14159*(.38/2)^2*120 + 3.14159*(.25/2)^2*60 = 70.7in^3 = 1.159 L

Water in copper pipes, surrounded by hot gas => h = 13 W/(m^2 K) (approx)

Therefore energy transfer rate

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

Observed rate of energy transfer: produced 4.5l of steam in 1 hour. Need 2.6MJ/l of water to vaporize.

Power of the apparatus was $4.5 l \frac{l}{h} \cdot 2.6 \frac{MJ}{l} = 11.7 \frac{MJ}{h} = 3.25 kW$ power.

Using Newton's law of cooling from above, this implies:

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

The delta T is probably an understatement because we are not 100% efficient and 625K seems rather low for an intense fire.

Our prototype long-time test yielded a power of 3.25kW at a 0.4 sq m surface are, or 8.125 kW/m^2

For steel pipes, it is 11/13 of that (the heat transfer coefficient is lower): 6.875 kW/m^2

FINAL PROTOTYPE RESULTS

Surface Area
- 4 large (3/4" dia), long pipes
- 10 skinny (1/2" dia), long pipes
- 2 large (3/4" dia), short pipes
- 4*3.14159*.75*10 + 10*3.14159*.5*10 + 2*3.14159*.75*7 = 284in^2 = 0.1834m^2

Volume
- pi*r^2*length
- pi * (0.75in/2)^2*10in*4 + pi * (0.5in/2)^2*10in*10 + pi * (0.75in/2)^2*7in*2 = 43.49in^3 = .7127l

Surface area to volume ratio: 0.247 m^2 / L
- o This is 218 times the surface area to volume ratio of the traditional system

Energy: 8.125 kW/m^2 * 0.1834m^2 = 1.49 kW

Vaporization rate (using coil prototype numbers): 4.5l/hr * 1.49kW/3.25kW = 2l/hr

FINAL DEVICE

Vaporization Rate: 10 L/hr

Vaporization power (starting with 20c water): $\frac{2.6 MJ}{10 l / hr} = 26 MJ / hr = 7.2 kW$

Surface area required: $\frac{7.2 kW}{6.875 kW / m^2} = 1.05 m^2$

Using 1" pipe.

Surface area per 1' of pipe: $1" \cdot \pi \cdot 12" / \text{ft} = 12\pi \text{in}^2 / \text{ft} = 0.024 m^2 / \text{ft}$

Total pipe needed: $\frac{1.05 m^2}{0.024 m^2 / \text{ft}} = 43.8 \text{ft}$

Total volume of pipe: $(1" / 2)^2 \cdot \pi \cdot 12" \cdot 43.8 = 412.8 in^3 = 6.7646 l$

{ Appendix C: Payback Calculations }

BASELINE

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

IMPROVEMENT WITH OUR DEVICE

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

{ Appendix D: Financials }

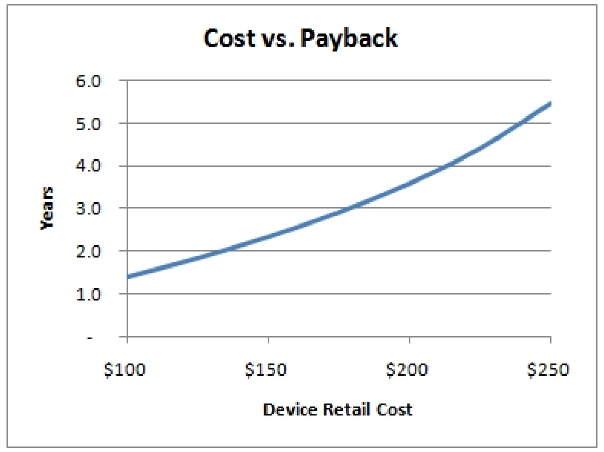
FARMER RETURNS

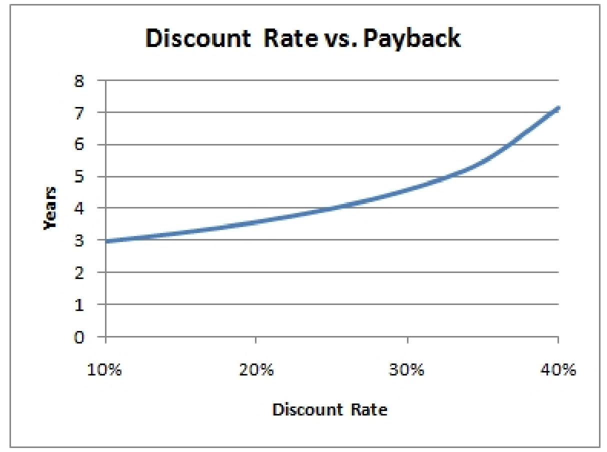
We assume a 30% discount rate for Aceh farmers. We take a $230 price for the device based on the project financials further below.

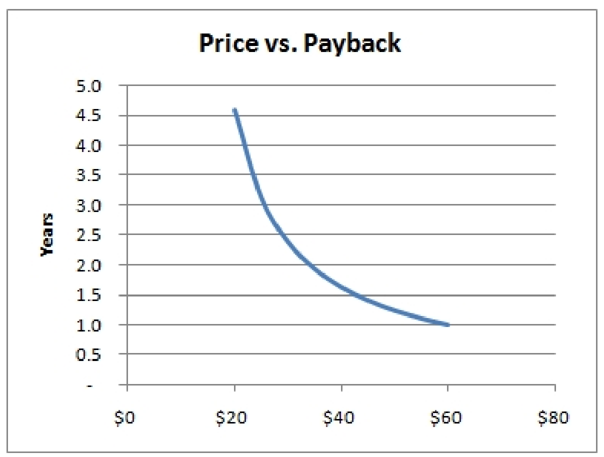
IMPROVEMENT WITH OUR DEVICE

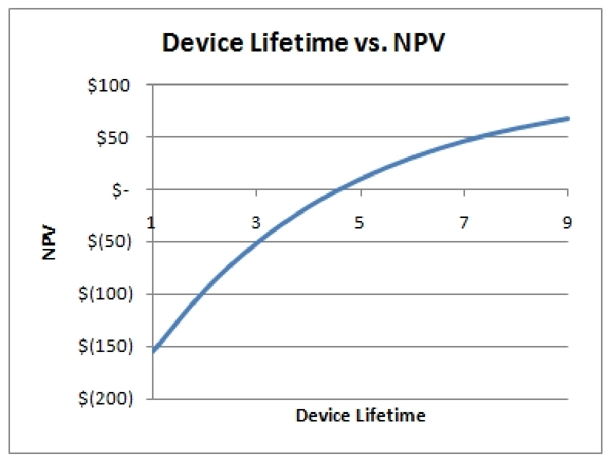
Inputs	Value	Source
Annual Discount Rate	30%	Assumption
Harvests per year	3	Need finding
Harvest-to-harvest discount	9%	
Price per kg oil	20 kg	Need finding
kg oil per batch	0.5 kg	Need finidng
Additional batches per harvest	3.0	1 per day
Additional $ per harvest	$30	
Device Cost	$230	Input
Payback period (years)	4.6	
Years	4	Input
NPV	($16.68)	

The farmer's payback period and NPV are highly dependent on the price of patchouli oil, device lifetime, and how much the device is improving the farmer's current oil output and thus income. The ideal customer is a farmer whose device has completely broken down, or a farmer who is just about to start oil distillation because the payback period is shortest when the Easy Steam Machine is purchased instead of a traditional machine, in which case the price difference of some $80 is already less than the additional annual income of an estimated $90. However, when farmers buy the machine as an add-on, the payback period is almost five years - something we are continuing to work on. The following charts show the sensitivity of the results to some of the input assumptions.









PROJECT FINANCIALS

First, we estimate the oil-producing farmer households as share of total households. We use Indonesia statistical data, assume that 50% of all exported oil is produced in Aceh, and that farmer households produce 36kg of oil (on average), which is 2kg per day with 3 days per harvest and 3 harvests per year. We end up with an estimated 15% of farmer households involved in essential oil production. We take that as our total addressable customer basis.

Inputs	Value	Source
Population Aceh	4,073	BPS
Household size Aceh	4.50	BPS
Farmer household share	47%	BPS, value of all Indonesia
Farm households	425	
Essential oil exports (MT)	4,618	Export News Indonesia, NAFED, 1(II), Feb 08
Aceh share	50%	Assumption
Farmer production (kg/yr)	36	Based on 2kg per day, 3 harvest over 3 days
# farmer HH producing (k)	64	
Farmer HH Share	15%	

Next, we make assumptions about market penetration, lifetime, and other economic parameters. The key is our village word of mouth marketing model: we assume that during a year, each villages with out Easy Steam Machine reaches 10 new villages that have not been exposed to our device yet, but we will at most reach 50% of the unserved villages.

Additionally, we assume a 40% distributor and retailer margin, plus a 20% IBEKA-internal overhead margin that each profit-oriented project needs to contribute to cover the cost of IBEKA's funds. This includes any fixed costs such as depreciation of machinery.

For the production cost, we assume 8 hours of labor plus Rp 1M of parts (see BOM above).

Inputs	Value	Source
Population growth in Aceh	1.60%	Average 2007-2009 (excluding Tsunami and civil war times)
Household size in Aceh	4.5	BPS (Indonesian Statistics Office) March 2009 socio-economic indicators
Farm household share	47%	Ibid, p. 72
Oil producing household share	15%	Separate worksheet
Machine lifetime	5	Assumption
Village spread (villages/yr)	10	Knowledge spread (nearby villages/yr)
Village spread max gap closing factor	0.5	Assumption - reach at most that fraction of non-penetrated villages
Inflation	7.75%	BPS average Bandah Aceh 2003-2008 excluding post-tsunami 2005
Material cost (Rp 000)	1,000	Target
Labor hours to manufacture	8	Assumption
Labor cost 2010 (Rp/hr)	9,172	BPS for 2009; applied inflation to reach 2010 number
Distributor & Retailer margin	40%	US Retail average
IBEKA overhead and Return	20%	Assumption
Sales price	2,300	Target

Putting it all together, we estimate that IBEKA can earn its required returns on the funds put into this project. By 2015, we expect to have reached about 1/4 of the addressable market.

INCOME STATEMENT (in Rp '000)						
Inputs	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
SALES FORECAST						
Population Aceh (K)	4433	4504	4576	4650	4724	4800
Population Growth	1.60%	1.60%	1.60%	1.60%	1.60%	1.60%
Household Size	4.5	4.5	4.5	4.5	4.5	4.5
Farm Household Share	47%	47%	47%	47%	47%	47%
Farmer Households (K)	463	471	478	486	493	501
Oil producing household share	16%	16%	16%	16%	16%	16%
Oil producing households (K)	74	75	76	78	79	80
Machine lifetime (yrs)	5	5	5	5	5	5
Machines replaced per year	14,819	15,056	15,297	15,542	15,791	16,043
Villages	6,424	6,424	6,424	6,424	6,424	6,424
Oil producing households per village	11.5	11.7	11.9	12.1	12.3	12.5
Machines replaced per village per year	2.3	2.3	2.4	2.4	2.5	2.5
New villages reached	1	10	100	1,000	2,657	1,328
Cumulaive villages reached	1	11	111	1,111	3,768	5,096
Spread			10%	15%	20%	30%
Households reached (min 1 per village)	3	13	26	403	1,852	3,818
NEW MACHINES SOLD	3	10	13	377	1,449	1,966
Market share	0.0%	0.1%	0.2%	2.6%	11.7%	23.8%
SALES PRICE	2,300	2,478	2,670	2,877	3,100	3,341
Price increase with inflation	7.75%	7.75%	7.75%	7.75%	7.75%	7.75%
Projected Revenue	6,900	24,783	35,868	1,084,029	4,492,029	6,566,442
Distributor & Retailer Margins at 40%	2,760	9,913	14,347	433,612	1,796,880	2,626,577
IBEKA REVENUE	4,140	14,870	21,521	650,417	2,695,320	2,939,865

COGS						
Materials	3,000	10,775	15,595	471,317	1,953,130	2,854,975
Material cost per unit	1,000	1,078	1,161	1,251	1,348	1,452
Price increasce with inflation	7.75%	7.75%	7.75%	7.75%	7.75%	7.75%
Labor	220	791	1,144	34,584	143,316	209,492
Labor cost / Unit	73	79	85	92	99	107
Labor Cost Growth at Inflation	7.75%	7.75%	7.75%	7.75%	7.75%	7.75%
TotaL COGS	3,220	11,566	16,739	505,901	2,096,447	3,064,467
Overhead and Returns at 20% Gross Margin	805	2,891	4,185	126,475	524,112	766,117
TOTAL EXPENSES	4,025	14,457	20,924	632,376	2,620,558	3,830,583
IBEKA EBITDA	115	412	597	18,041	74,762	109,282
% Margin	3%	3%	3%	3%	3%	3%

thank you!

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