LEVERAGING THE POTENTIAL OF WOMEN MICROENTREPRENEURS IN DELIVERING CLEAN ENERGY SOLUTIONS:

THE WONDER WOMEN EASTERN INDONESIA PROGRAM

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FINDING WHAT WORKS

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Abstract

While Indonesia's development indices have improved in the past years, they do not fully represent the realities of last mile communities who lack access to energy for daily cooking and lighting. Kopernik's Wonder Women program has been reducing energy poverty through increased access to clean energy sources in eastern Indonesia over the past 4 years. Kopernik adopted a market-based approach by identifying and sourcing affordable technologies (biomass stoves, solar lights, water filters), and recruiting and training women micro entrepreneurs, or "Wonder Women", to sell these technologies in their communities.

A gender perspective is fundamental to the program because provision and use of conventional fuels (e.g. woodfire, kerosene) traditionally fall within the women's domain. As such, women hold considerable weight in the purchase decision of these appliances. Wonder Women thrive in peer-to-peer selling, especially in rural markets where economic decisions are largely based on personal bonds and mutual trust.

Between 2014-2017, 25,620 technologies were sold by 488 women. Impact was measured through household surveys with 400 customers. In three years, technology adoption has resulted in an estimated US$ 1.9 million in fuel expenditure savings for users. Factoring in profit generated by Wonder Women, the value of reduced carbon emissions, and the program cost, we estimate the program to result in US$1.6 in returns for every US$1 invested. Insights and best practices discovered through rapid experimentation and how the program can be scaled up in collaboration with the public and private sectors are discussed.

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Introduction

In the last decade, the percentage of the Indonesian population living under national poverty line has dropped six percent to 10.6% in 2017,[1] on track to fulfill the government target of reducing it to a single digit in 2018. In June 2017, the national rate of electrification, regarded as a key determinant of economic development, reached 92.8%.[2] In ensuring universal access to clean cooking, in almost ten years the percentage of Indonesian households with liquid petroleum gas (LPG), considered the most clean-burning fuel for cooking, as the main cooking fuel has burgeoned from 10.6% in 2007 to 72.4% in 2016.[3] Yet while these numbers reflect highly on Indonesia's progress against its development goals, the disparity between areas in the archipelagic state remains. Economic development is mostly centered on the main islands, Java and Bali, where almost 60% of the Indonesian population resides.

Percentage of the population living under the national poverty line remains more than double the national average at 21.9% in East Nusa Tenggara (Nusa Tenggara Timur, NTT), 25.1% in Papua, and 27.6% in West Papua.[4] Access to electricity only reached 59.2% and 48.7% of households in NTT and Papua respectively. In areas where electricity is available, connection can be unreliable with frequent outages. Furthermore, despite the significant progress in

[1] "Percentage of population living under national poverty lines by province," Statistics Indonesia, accessed June 1, 2018, https://www.bps.go.id/.
[2] "Electrification ratio in Indonesia," Ministry of Energy and Mineral Resources, June 2017, https://www.esdm.go.id/.
[3] "Households by province and main cooking fuel in 2001, 2007-2016", Statistics Indonesia, November 14, 2017, https://www.bps.go.id/.
[4] Ministry of Energy and Mineral Resources, 2017.

conversion to LPG, in NTT, the percentage of the population with access to LPG for daily cooking only increased 0.04% between 2007 and 2016. Kerosene use increased by 8.6%, while the majority of households (77.6%) in the province rely on firewood for daily cooking, the highest of all provinces. As such, not only energy poverty is common, it is alleviated at a slower rate in Eastern Indonesian provinces.

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Energy security on a macro level is commonly evaluated by considering the four A's: Availability, Accessibility, Affordability, and Acceptability of energy sources.[5] When assessing the impacts of zero and limited access to energy in eastern Indonesia, we observed the same four A's as affecting individual energy users, to different extents and with variability between areas. Taking into consideration the four A's, the following section describes the impacts of energy poverty for two basic purposes, lighting and cooking.

- Energy for lighting. As of 2017, 1,025 villages in NTT remain unelectrified,[6] an issue of *availability*. The cost of connecting one's village to the nearest grid can be prohibitive *(affordability)*, and even for urban and periurban areas that lie on the electricity grid, electricity supply cannot fulfill the demand, resulting in frequent outages *(accessibility)*.

- Energy for cooking. In eastern Indonesia, access to kerosene is limited and often requires villagers to travel long distances *(accessibility)*. Relative to the abundant firewood, kerosene is also financially prohibitive *(affordability)*. Despite a large-scale government program for converting more conventional fuels to LPG, access to LPG in most of NTT remains nonexistent *(availability)*. Kopernik's interviews and news coverage of the conversion program revealed that fear of gas leak and explosion is also preventing urban and rural communities in Indonesia from converting to LPG,[7] an issue of *acceptability*.

Impacts of energy poverty on health. Most households with no access or unreliable access to electricity for lighting rely on candles and "pelita", or simple kerosene lamps, which have been proven to be costly, hazardous, and harmful for the human health. Households without access to improved stoves rely on firewood as their main cooking fuel, typically in a three-stone-fire or traditional clay stove. These methods release toxic smoke and black carbon as byproducts of an incomplete combustion. The household members involved in cooking, typically women and consequently their young children, are exposed to the smoke for long durations because they have to tend to the fire at all times. Kerosene lighting and open fire cooking contribute to the problem of indoor household air pollution, a major health risk estimated to cause 45,000 premature deaths in Indonesia every year.[8]

Figure 1. Traditional kitchen in Lembata, East Flores. Photo: Kopernik

[5] *A quest for energy security in the 21st century* (Tokyo: Asia Pacific Energy Research Centre, 2007), http://aperc.ieej.or.jp/.
[6] *Kompas.com*, "1.205 Desa di NTT Belum Teraliri Listrik," January 10, 2017, https://ekonomi.kompas.com/.
[7] Aurora Leony, "Switch to gas an explosive issue for Indonesia's poor," *The Age*, October 19, 2007, https://www.theage.com.au/.
[8] Yabei Zhang and Yun Wu, *Indonesia - Health impacts of indoor air pollution: at-a-glance*. (Washington, DC: World Bank, 2012). http://documents.worldbank.org/.

Impacts of energy poverty on women. In rural communities, cooking and managing household chores typically fall in the women's domain. Women bear the brunt of daily provision and use of conventional fuels. This includes the necessity to travel long distances to gather water, firewood, and kerosene. Cooking with an open fire can take several hours in a day; to prepare food, drinking water, and animal feed. Women are thus disproportionately affected not only by the health hazards posed by the use of conventional fuels, but also by opportunity costs in terms of lost income and productivity. Despite this fact, across rural communities there is a lack of female representation in discussions on energy access. Gender mainstreaming in energy solutions is more than a health and productivity issue, it is also one of equality. Examining country-level data, O'Dell et al. showed that, while gender inequality is heavily correlated with national poverty levels, the stronger indicator of gender equality is the proportion of a country's population that has access to electricity— the greater the access, the greater the gender equality— regardless of the poverty level.[9]

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Energy poverty has clear, well-documented links to economic poverty. Increased access to electricity in Indonesia has been associated with a decrease in poverty rate.[10] Reliable access to clean energy determines a family's progress out of poverty by way of increased productivity, health, and climate change resilience.

The Wonder Women Eastern Indonesia (WWEI) program

Accelerating development in laggard provinces is a priority of the current administration. Yet changes are gradual and require a collaboration between the government, private sector, and civil society. Whereas the government focuses on large-scale infrastructures and subsidy programs, Kopernik focuses on household-level solutions in the "last mile", areas typically reached last by such large-scale developments. Kopernik recognized the high potential of simple, low-cost clean energy technologies available in the global market, but with little to no market mechanism of reaching customers who need them most. Looking at the impacts of energy poverty on women, Kopernik also saw the pressing need for integrating gender perspectives into clean energy solutions.

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In taking this role, Kopernik, supported by ENERGIA, the International Network on Gender and Sustainable Energy, and with funding from the Finnish, Norwegian and Swedish governments, started the WWEI program in September 2014. The program also received funding from USAID, Australian Department of Foreign Affairs' MAMPU program, Ford Foundation, and Plan International Indonesia. The program's long-term aim is to provide women and men with an equal and equitable access to and control over sustainable energy services as an essential right to development. This is achieved by first increasing energy access and services to consumers in Indonesia's remote communities, and second narrowing the gender gap in energy provision, use, and decision-making at household and community levels.

The Kopernik approach. Kopernik envisions a world where disadvantaged people living in the last mile can realize their full potential and enjoy a dignified life, free of poverty.
Kopernik contributes to this vision by finding what works to reduce poverty through experimentation with potential solutions and collaboration with various partners. Experimentations at Kopernik is based on the belief that finding effective solutions to reduce poverty requires systematic efforts, risk-taking, trials and errors. By breaking down the process into rapid, lean, small-scale experiments, Kopernik is able to identify potential solutions and risks, and tackle problems more quickly. In larger-scale programs such as the WWEI, Kopernik ran small experiments to obtain evidence that helped refine the Wonder Women program strategy. We discuss the insights from these experiments in the later sections.

[9] Kathleen O'Dell, Sophia Peters and Kate Wharton, "Women, energy, and economic empowerment," *Deloitte Insights*, last modified September 18, 2014, https://www2.deloitte.com/.
[10] Fabby Tumiwa and Henriette Imelda, *Laporan kemiskinan energi* (Jakarta: Institute for Essential Services Reform, 2011), 14, http://iesr.or.id/.

The Wonder Women. Women and gender perspectives are central to Kopernik programs for several reasons. First is the reality that energy poverty disproportionately affects women, especially in rural, last mile settings. Second, not only does integrating women perspective promote welfare, it is also a way to tap into a greater sales potential as women hold considerable weight in the purchasing decisions of household appliances.[11]

Figure 2. Kristina Bukan conducting a "tech fair". Photo: Kopernik

The WWEI program recruits and trains “Wonder Women,” or “Ibu Inspirasi” in Indonesian, to become clean energy technology agents in their communities. Wonder Women receive training in technology use and maintenance, sales and marketing, after-sales service, bookkeeping, and public speaking. They are also trained to hold technology demonstrations, called “tech fairs,” to introduce the technologies to their potential customers. Kopernik subsidizes recruitment and training, and finances upfront costs, shipping, and marketing of the technologies. Wonder Women sell the technologies at the wholesale price plus a small margin to the last mile customers. Ongoing mentoring helps them to develop new skills and grow their businesses, often by enlisting other women and men as “downlines,” thus creating economic opportunities for other community members. The Wonder Women’s development in the program, progressing from a personal sphere to the household and community spheres, is mapped onto an “Empowerment Journey”.

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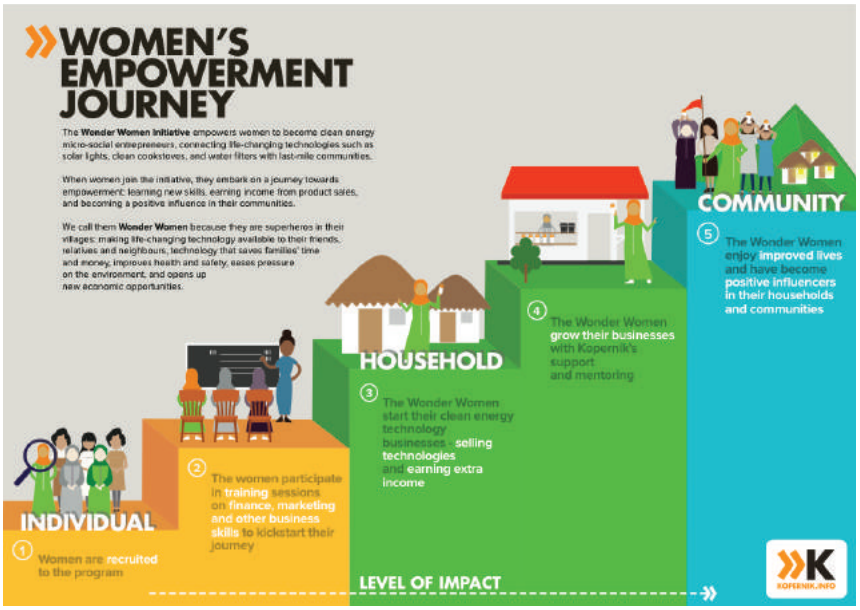

Figure 3. Kopernik Women's Empowerment Journey

[11] This is confirmed by Kopernik sales data that approximately 60% of technology purchase decision makers are female.

Between 2014 and 2017, Kopernik worked with 488 Wonder Women in 25 districts of East Nusa Tenggara (NTT) and West Nusa Tenggara (NTB) to distribute 25,620 technologies. The WWEI is one of several Kopernik programs that contributed to the distribution of 55,280 clean-energy technologies across Indonesia during the same period.[12]

Wonder Women thrive in peer-to-peer selling, especially in rural markets where economic decisions are largely based on social capitals: personal bonds and mutual trust. As expected, successful Wonder Women leverage their personal and professional circles to reach an extensive market. Women entrepreneurs gain credibility among customers from addressing first hand the energy challenges in their own household. From an empowerment and advocacy perspective, the Wonder Women inspire their communities through what they achieve: earning money to support their families, gaining skills and knowledge, and building confidence in their ability to succeed as business owners. By making women a visible part of the energy poverty solution, Kopernik hopes to encourage more women representation in energy policy conversations on the village, regional, and national levels.

Clean energy technologies. Kopernik sourced several types of clean energy technologies for distribution in the program. These technologies replace more expensive, unsustainable, and hazardous conventional energy sources, and save the users money and time. Brief descriptions of each type is provided below.

	Biomass stove. The improved biomass stove uses a thermal gasification mechanism. It burns firewood, wood shavings, coconut husks, corn cobs, or charcoal into combustible gas. This gas then ignites a clean, controlled flame, facilitating a smoke-free and fuel-efficient cooking. Manufactured in East Java, the standard size is sold at Rp 350,000.
	Ceramic water filter. The filter provides an easy and cheaper alternative to boiling or chlorinating water. It consists of two containers with ceramic filter candle(s) in the middle. The filter is made of ceramic that is impregnated with silver, and an activated carbon core. It filters particles and microorganisms, kills bacteria and fungi, removes harmful chemicals, and improves taste. The containers are made of food grade plastic. The water filter is sold at a retail price of Rp 190,000 to Rp 570,000 depending on size.
	Solar light and solar home system. LED lights that operate on batteries chargeable with a small, photovoltaic panel. A solar home system powers three to four LED light bulbs for the entire house, and comes with a larger photovoltaic panel that is placed on the roof. Setting the panel under the sun for a whole day provides a household with up to eight hours of bright, clean lighting. Some models can also be used to charge mobile phones. The lights are impact and weather resistant. A solar light is sold at a retail price of Rp 120,000 to Rp 532,000 depending on the type, and a solar home system sells at an average retail price of Rp 1,500,000.

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[12] For the current impact analysis, we are only including data collected for, and extrapolating the impact to, the WWEI program.

Partnerships. Collaboration with the development, public, and private sectors are core to Kopernik's work. We describe some examples of successful partnerships throughout the program below:

- With the government. In 2016, Kopernik working with TNP2K, Lazismu, and Besipae assisted the Ministry of Energy and Mineral Resources in piloting a distribution program called "Indonesia Terang". The solar home system distribution reached 230 off-grid households with low socioeconomic status in TTS, West Timor. Wonder Women and Kopernik staff provided knowledge on the product, installation, maintenance, and after-sales service.

Figure 4. Kopernik staff introducing the solar home system. Photo: TNP2K

- With other NPOs. The Youth Change Agent (YCA) project is a collaboration of Kopernik, Plan International Indonesia, and Ankara credit union. It aimed to provide young adults in Lembata, especially women, with skills and economic opportunities. Agents who remain active after the program completion continue to be nurtured alongside the Wonder Women.

- With the private sector. Kopernik worked with various companies to provide water filters in schools in Indonesia. Wonder Women hold an important role in running clean water campaigns, giving maintenance instructions, and providing after sales service. These events provide them with an opportunity to promote other technologies and expand their market, but ultimately they expressed great satisfaction from simply being able to help community schools provide safe drinking water to the students.

- With the civil society. Kopernik launched the Indonesian Women for Energy (#IDWomen4Energy) campaign in 2015. It aimed to engage decision makers to improve energy policies and programs, and raise awareness among the general public about women's role in expanding energy access. Through the three-year #IDWomen4Energy campaign, Kopernik engaged up to 200,000 people, reached more than one million through social media channels, and up to ten million through media coverage.

Impact assessment frameworks

Kopernik evaluates the program's contribution towards poverty reduction with two impact assessment frameworks. Each framework serves as a simple overview of the theory of change, and contains indicators from which survey items are derived.

The first maps the program's impact on the empowerment of the Wonder Women. It recognizes three spheres at which positive socioeconomic changes are expected: individual, household, and community spheres. Within each, Kopernik identified indicators in which the Wonder Women are expected to demonstrate change, as a result of participation in the program. As the impact moves away from the personal sphere to the household and community spheres, Kopernik acknowledges the lesser certainty in the program's attribution towards the desired impact. Instead, the program is positioned as one of the many different factors that contribute towards the impact.

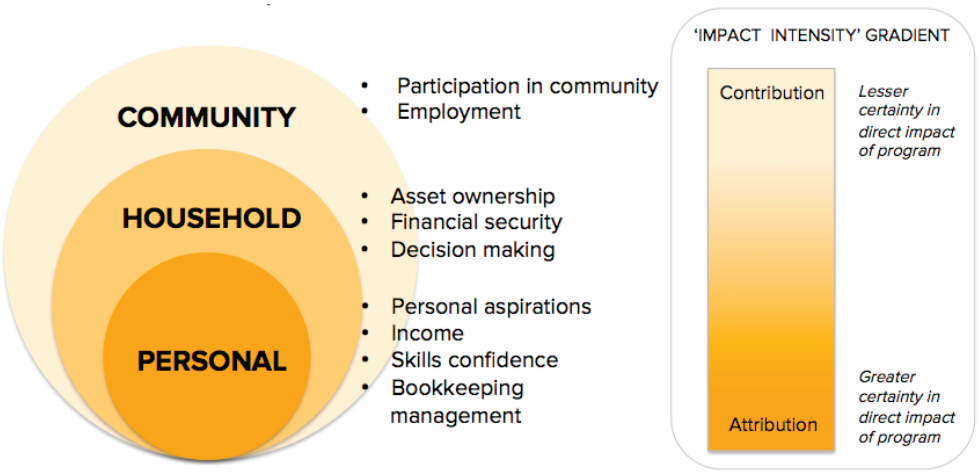

Figure 5. Kopernik Wonder Women Framework

The second framework maps the impact of the technology in the user households, with the expectation that product adoption leads to the desired impact in poverty reduction and environmental preservation. Adoption is indicated by the customer's satisfaction towards the product, usage frequency, and realization of fuel efficiency. Poverty reduction is measured by savings in fuel expenditure, time savings, and self-reported indicators of health and productivity improvements as a result of using the technologies. Finally, environmental preservation is measured by the reduction in carbon emissions as a result of switching from conventional fuels to clean, renewable energy.

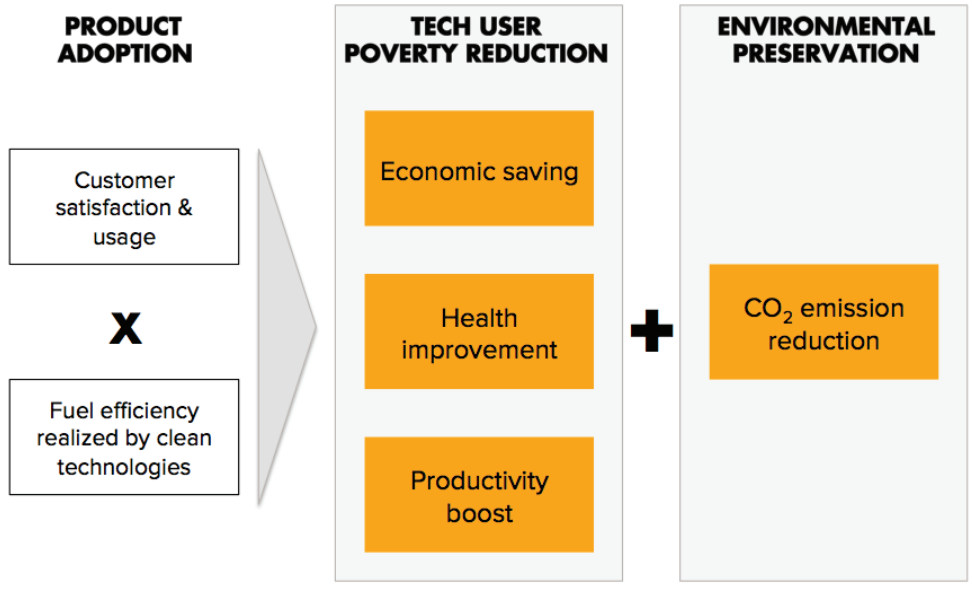

Figure 6. Kopernik Technology Assessment Framework

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Impact assessment methodology

Technology users. From 2015 until 2017, the monitoring and evaluation team conducted interviews with 405 technology user households in nineteen districts in NTT and NTB. Recent sales receipts were randomized to obtain sample households. The sample size in each district closely follows the proportion of sales in that district. Close to 20% of all surveys were conducted in East Flores, the area which saw the highest sales overall in the program. Kopernik conducted baseline surveys within one month of purchase, and follow-up surveys at approximately six months of technology usage. Distribution of respondents is shown below.

Figure 7. Distribution of technology user samples

From 2015 until 2017, Kopernik team conducted interviews with 405 technology user households in nineteen districts and surveyed 152 randomly sampled control group households across NTT and NTB, to evaluate the program results in comparison with regular households in the same area.

Kopernik also surveyed 152 randomly sampled control group households across NTT and NTB, to evaluate the program results in comparison with regular households in the same area. Follow-up measurements were taken approximately six months after the baseline measurements.

Wonder Women. Kopernik recorded transaction data of 488 Wonder Women, local partners, and other independent agents who have participated in the program. Impact assessment of the Wonder Women consists of a set of face-to-face surveys with independent Wonder Women.[13] Baseline survey for Wonder Women was conducted shortly after recruitment. A randomized subset was included in follow-up assessments throughout the program. The follow-up survey is done after six months of participation, and is repeated annually. Wonder Women who quit the program went through an exit interview, in which we examined the reasons for quitting and gather feedback for the program. Kopernik collected 287 baseline data, 109 first-year, 42 second-year, and 18 third-year follow-up data, and 51 exit interview data. Participation in any of the assessments is voluntary and sampled Wonder Women can cease participation anytime.

Carbon emissions reduction. We used technology-specific methods to calculate carbon emissions reduced by the distributed technologies. These methods are CDM-UNFCCC for cookstoves[14] and water filters,[15] and GOGLA[16] for solar lighting technologies. As much as possible, calculations are customized with Kopernik's primary data on technology usage frequency and fuel replacement. This is done to obtain a carbon emissions figure that most closely reflects the actual technology usage in eastern Indonesia. Finally, carbon value per ton of CO2 is based on the average of several trading prices for carbon in December 2017. Important to note is that Kopernik does not currently engage in any carbon emissions trading scheme or market.

[13] Wonder Women who were not recruited as members of a partner organization or cooperatives.
[14] CDM - UNFCCC, "AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass, version 8.0," 2016.
[15] CDM - UNFCCC, "MS III.AV: Low greenhouse gas emitting safe drinking water production systems, version 04.0," 2015.
[16] Global Off-Grid Lighting Association, "Standardised impact metrics for the off-grid energy sector version 1.0", Global Off-Grid Lighting Association, 2015. https://www.sun-connect-news.org/.

Program impact

Economic impacts on Wonder Women. Most Wonder Women have at least one primary occupation upon joining the program. On average, Wonder Women who were randomly sampled in our assessment (n=115) earn a monthly personal income of Rp 1,207,485 (US$ 90.79) at baseline. Wonder Women had different level of activity by the time of our final assessment,[17] which resulted in a different level of economic impact. We split the analysis based on level of activity and program type to account for this difference. Surveyed Wonder Women who remained active until the end of the third year (n=37), received an average monthly profit margin of Rp 300,093 or US$22.56, adding a 21% increase from their baseline monthly personal income.

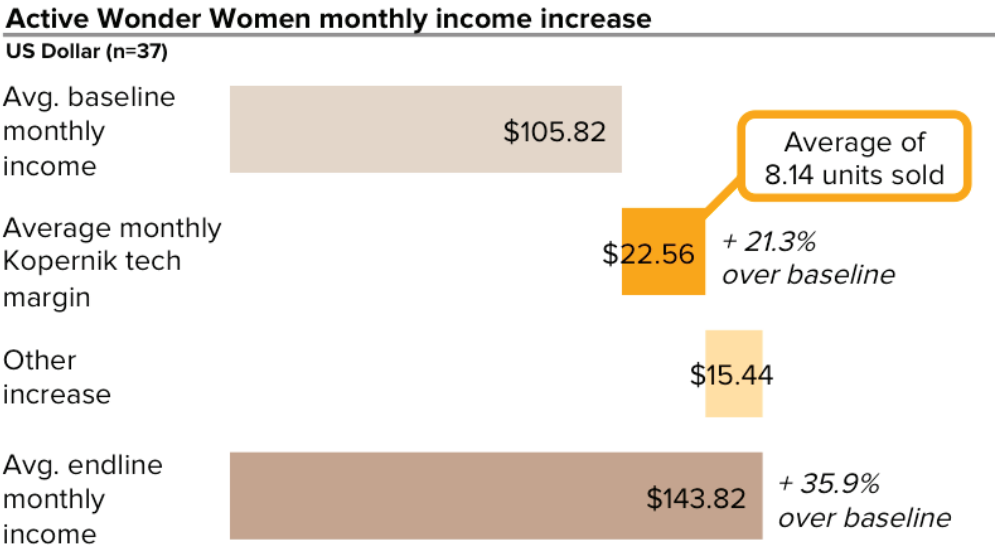

Chart 1. Active Wonder Women monthly income increase

This impact is lower for female agents from the YCA program, who earned on average Rp 145,494 (US$ 10.94) per month, and lowest for inactive and exiting Wonder Women, who earned a monthly profit margin of Rp 79,970 (US$ 6.01).

Wonder Women have the freedom to set their own retail price, but Kopernik periodically issues and disseminates a list of suggested retail prices. The income from technology business calculation is therefore an estimation based on the profit margin in the suggested retail price,[18] not actual profits received by the Wonder Women. Sales receipts suggest that most Wonder Women follow Kopernik's suggested retail price exclusive of delivery fee, therefore we expect the actual profit margin to be similar to that in our calculation.

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Figure 8. Emiliana Kopa conducts technology fairs in Bena after dark to demonstrate the benefits of the solar lamps. Photo: Kopernik

[17] Kopernik defines "active" as having at least one sales transaction in the past three months.
[18] Wonder Women have the freedom to set their own retail price, but Kopernik periodically issues and disseminates a list of suggested retail prices to control for unhealthy price competitions.

In addition to the profit from technology sales, active Wonder Women experience an average increase of Rp 205,302 (US$15.44) in monthly income from their primary occupation.

Looking at economic impact overall, WWEI program transaction data shows that all Wonder Women generated Rp 993,310,500 (US$74,685) in profit margins throughout 2014-2017, a direct economic impact fully attributable to the WWEI program.

The program's economic impact shows that all Wonder Women generated Rp 993,310,500 (US$74,685) in profit margins throughout 2014-2017.

Non-economic impacts on Wonder Women. Capturing non-economic impacts of the program on the Wonder Women is more challenging than economic ones. For this reason, Kopernik collects qualitative in addition to quantitative data, and tracks the same indicators over time. One of the indicators being reflected upon is on aspirations fulfilled: 85% of Wonder Women felt that they fulfilled an aspiration to improve the lives of the community through technologies, and 78% fulfilled their aspiration of gaining an additional income. Wonder Women also report on how much they have improved on several key skills since joining. Upon recruitment, the majority of Wonder Women had some experience in sales and marketing. However, for 78% of them, Kopernik trainings are their first formal training on sales, marketing, and basic financial skills. The overwhelming majority of sampled Wonder Women reported an improvement in confidence and skills, with 29% and 40% reporting significant increase in public speaking comfort and sales comfort respectively.

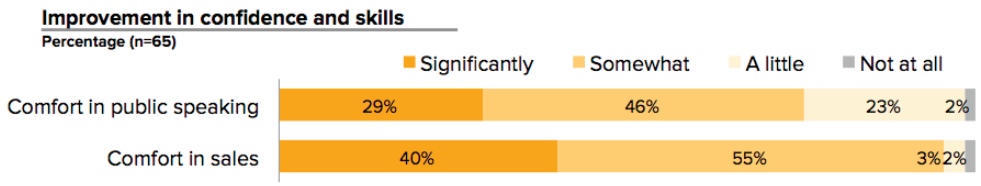

Chart 2. Improvement in confidence and skills

Economic impact on technology users. Economic impact on the technology users is measured by how much fuel expenditure is reduced or eliminated through the use of the clean energy technologies in the user households.[19] To demonstrate how we calculate impact on the technology users for each technology type, we take the analysis on solar lights fuel and expenditure as an example.

Figure 9. Rofina Surat charges her solar lights under the sun. Photo: Kopernik

At baseline assessment, we list all lighting sources used in the household. This includes kerosene lamps, electricity, candles, generator, and other sources such as petromax, flashlights with batteries, and rechargeable lights. We record how much fuel is used with each lighting source each month, fuel unit cost, and the resulting monthly expenditure.

[19] We gathered anecdotal evidence of increase in productivity and income as a direct result of technology use in income-generating activities, but we do not extend the analysis to include those economic impacts.

Approximately six months later, at follow-up assessment, we record which of the old lighting sources are still being used, and the same usage indicators as at baseline.

- Conventional source usage rate. Assessment of 142 solar light user households shows that 70% use kerosene lamps, 64% use electricity, and 51% use candles as alternative sources of lighting at baseline level. Adoption of the solar lights resulted in discontinued use of kerosene lights in 44%, and candles in 36% of these households. Changes in lighting sources usage rate are displayed in the following chart.

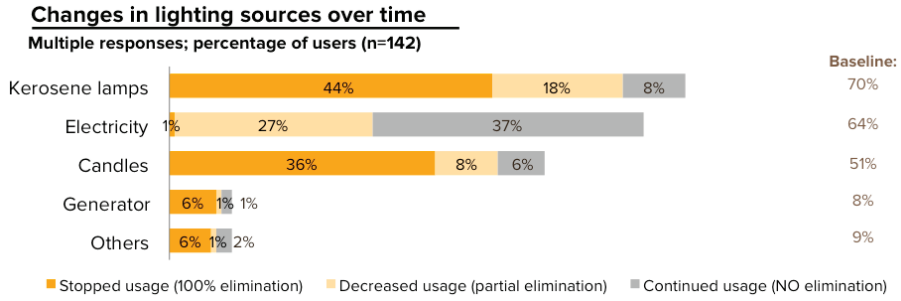

Chart 3. Changes in lighting sources over time

- Fossil fuel savings. We obtained figures of average fuel savings by type only for users who use that particular fuel, e.g. average kerosene use for kerosene users.[20] From this figure and the usage rate of each fuel, we derived the annual average fuel reduction per unit of solar light, consisting of fuel saving figures averaged out to the entire sample. These figures describe the fuel savings of an average solar light user in the program, regardless of his or her specific fuel use. To obtain program-wide savings, we multiplied the annual average fuel reduction per unit by number of technology units sold between 2014-2017. The fuel reduction estimates for solar lights are provided below.

Fuel reduction estimates

Average (n=142)

Survey reduction data			Extrapolated to all tech users	
TYPE OF FUEL	ANNUAL AVERAGE FUEL REDUCTION PER UNIT	X	TECH UNITS	= EST. TOTAL REDUCTION
Kerosene	29.01 litres			352,782.3 litres
Batteries	1.67 batteries		11,230 units	18,754 batteries
Candles	142.46 candles			1,599,826 candles
Diesel	13.52 litres			151,830 litres

Table 1. Solar lights fuel reduction estimates

[20] This calculation does not take into account changes in electricity use in kilowatt hours.

- Expenditure savings. In the baseline and follow-up assessments, we asked respondents how much one unit of fuel costs in their area, and whether the price has changed in the six months between assessments. These figures are used to calculate annual fuel cost savings estimates, per unit of technology and extrapolated to all solar lights sold in the entire program. The fuel cost savings estimates for solar lights are provided below.

Fuel cost savings estimates

Average (n=142)

	Survey reduction data		Extrapolated to all tech users		
TYPE OF SOURCE	ANNUAL AVERAGE ECONOMIC SAVING PER UNIT	X	TECH UNITS	=	EST. TOTAL SAVINGS
Kerosene	$12.57				$141,164
Batteries	$0.59				$6,648
Candles	$10.42		11,230 units		$116,982
Electricity	-$0.13				-$1,458
Generator (diesel)	$7.15				$80,297
					$343,633

Table 2. Solar lights expenditure savings estimates

This calculation is done for all four types of technologies: solar lights, water filters, biomass cookstoves, and solar home systems. Special considerations were taken to exclude users who used a combination of solar lights and solar home system, or biomass stove and water filter from the sample pool, to isolate the impact of individual technologies and avoid double counting.[21] Taking into account years elapsed since technology distribution, the total impact of the technology distribution between 2014-2017, in terms of fuel savings, economic savings, and carbon emission reductions is as follows.

	Fuel savings		Economics savings	Carbon emission reductions (tCO_2/year)
Y1	Firewood **806** tonnes Kerosene **173,314** litres LPG **39.73** tonnes	Batteries **3,574** units Candles **123,629** units Diesel **23,879** litres	$302,208	2,490
Y2	Firewood **2,421** tonnes Kerosene **743,789** litres LPG **53.43** tonnes	Batteries **10,078** units Candles **969,685** units Diesel **83,348** litres	$749,674	5,294
Y3	Firewood **4,335** tonnes Kerosene **879,716** litres LPG **48.90** tonnes	Batteries **18,754** units Candles **1,804,166** units Diesel **169,142** litres	$881,461	12,041
TOTAL	Firewood **7,562** tonnes Kerosene **1,796,819** litres LPG **142** tonnes	Batteries **32,406** units Candles **2,897,490** units Diesel **276,369** litres	**$1,933,343**	**19,825**

Table 3. Total impact of technologies distributed 2014-2017

[21] E.g. a household surveyed for using a biomass stove might use significantly less firewood because they started using a water filter and hence stopped boiling water, in addition to reducing firewood use with the biomass stove.

Non-economic impact on technology users. In addition to fuel and expenditure savings, we take self-reported measures of increase in productivity and health. A majority of sampled technology users reported increase in productivity and perceived life improvement, and reduced health and safety risks. In the case of solar lights, more than 50% of respondents reported significant reduction in exposure to smoke, fire hazard, and risk of injuries as a result of using the technologies. Unlike the case with kerosene lamps, users with children feel at ease leaving the solar lights by their children's bed at night. From a health perspective, 34% of all surveyed users reported at least one alleviated health symptoms, the most prevalent being breathing problems and eye irritation. The lights are used by an average of 1.59 study users per household. In many areas with frequent outages, the solar lights are used to assist religious ceremonies and health emergencies. They are also anecdotally found to be useful in catching fish.

Impact on the environment. Because the use of these clean energy technologies helps to reduce or eliminate the use of fossil fuels in the user households, distribution of all technologies contributes to the reduction in carbon emissions that get released to the atmosphere. We estimated that clean energy technologies distributed in the WWEI program since 2014 have contributed to the reduction of 18,439 tonnes CO2 emissions by the end of 2017.

Net economic benefit of the WWEI program. The collective net economic benefits, taking into consideration fuel expenditure savings, margins earned by Wonder Women, the value of CO2 reduction, and program cost amount to $839,070 over three years. This means that for every $1 invested, the program generated $1.6 in economic returns. This figure only accounts for economic benefits and does not monetize the many social, environmental, and human capital benefits this program generated.

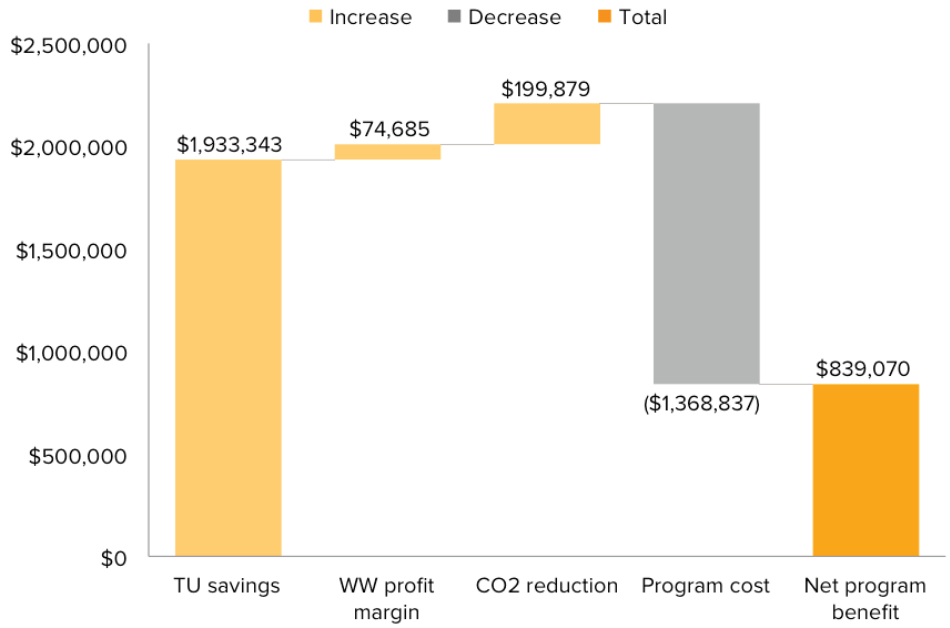

Chart 4. Net economic benefit of the Wonder Women Eastern Indonesia program 2014-2017

Insights and best practices

Maximizing performance of the Wonder Women. Kopernik identified characteristics that top-performing Wonder Women share. First is mobility: Wonder Women with access to a motorbike sell double the amount of technology compared to those without.[22] Second, contrary to expectations, experience in sales and business ownership do not ensure a higher success rate. Instead, a background in social services that provides women with a broader network of potential customers is more common among high-performing Wonder Women.[23] Finally, successful Wonder Women often involve their husband in the business, although this sometimes led the husband to take over, resulting in a high financial but low empowerment impact.[24] Kopernik incorporated insights into recruitment, training, and mentoring strategies, and shared findings with peer organizations. Kopernik's analysis on mobility, for example, inspired the organization Solar Sister with operations in Uganda, Tanzania, and Nigeria to conduct a similar analysis with their data, which yielded a similar result.

Figure 10. Margaretha Subekti introduced technologies on a boat in West Manggarai. Photo: Kopernik

Kopernik also test which incentives and campaigns are most effective to increase sales. In 2017, Kopernik ran two different sales campaigns: a local newspaper advertisement, directing readers to a selling point, and a competition with different levels of incentives in which the top-selling Wonder Women could win a motorbike. In terms of relative return on investment, for every $1 invested, sales-based incentives to Wonder Women returned $5.80 in sales, versus $2.60 returned by newspaper advertisement.[25] Wonder Women seems to be more effective in generating sales in the last mile than printed advertisement.

Generating demand and access to financing. Kopernik identified "technology fairs" as one of the most effective methods to promote the technologies in the community, as it gives the Wonder Women a chance to explain, answer questions, and demonstrate the technologies to a large number of people simultaneously, thus saving time and leveraging social influence. Tech fairs also provide an opportunity to Wonder Women to improve their confidence and public speaking skills. Key factors to successful technology fairs are timing, crowd size, and support from the local government. Tech fairs are more successful when done during the harvest season, when customers, especially farmers, have cash on hand. Just the right amount of people in attendance, about ten to twelve, is crucial as too many will make the fair disengaging, but too few results in lower energy and few interactions. Finally, getting a village chief, government official, or other influential figures to attend the technology fair is key to successful buy-in from the community.

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[22] Toshihiro Nakamura, "Sales agent performance doubles with access to motorbikes," *Kopernik Insights*, August 30, 2016, https://kopernik.info/.
[23] Toshihiro Nakamura, "Business experience is not necessarily the key to becoming a high performing sales agent," *Kopernik Insights*, September 28, 2016, https://kopernik.info/.
[24] Anna Baranova, "Better sales performance achieved when spouses get involved, but not too much," *Kopernik Insights*, April 12, 2017, https://kopernik.info/.
[25] Anna Baranova, "Sales-Based incentives offer higher return on investment than advertising," *Kopernik Insights*, October 25, 2017, https://kopernik.info/.

The majority of Kopernik customers are in the lowest income bracket. Approximately 31% are farmers, and 42% earn below US$99 in household income per month. Lowering financial barriers is crucial, and involves not only setting appropriate prices but also offering flexible payment options. Looking at payment preference data, we found that financing was critical across all price points, even for low-cost products. To purchase small solar lights which cost Rp 100,000-200,000 (US$ 7.00-15.00) about one third of customers opt for paying in installments. Once the cost of the technology exceeded Rp 400,000 (US$30.00), access to credit became a necessity with as many as two-thirds of customers needing to pay in installments to finance their purchase.[26] We identified the high potential of working with microfinance institutions and the Village Fund/"Dana Desa" to help ease the burden of financing the technologies.

Digital data collection in the last mile. Rough terrain and sparse connectivity are some of the biggest barriers facing Kopernik's work in the last mile. This is a challenge for the Kopernik M&E team; as enumerators have to obtain a representative sample of users, in terms of sample size and geographical spread, and provide reliable data with a fast turnaround for analysis and reporting. Since the beginning of the program, we used paperless, digital data collection tools to collect all M&E data. These tools proved to be integral in improving Kopernik's data quality and collection efficiency.

Conclusion and way forward

The Wonder Women Eastern Indonesia program, an initiative to expand energy access in the last mile by creating micro-business opportunities for women, has demonstrated the model's ability to generate a net economic gain, realized through a combination of fuel savings, income generation, and value of CO2 emissions reduction. The evidence has also shown it to be successful in increasing the skills and confidence of women entrepreneurs, and improving health and quality of life of the technology users. Factoring in these and other social, environmental and human capital benefits, would yield an even greater return on investment showing the model's effective contribution towards alleviating poverty, empowering women, and increasing energy access.

This initiative to expand energy access in the last mile by creating micro-business opportunities for women has demonstrated the model's ability to generate a net economic gain, realized through a combination of fuel savings, income generation, and value of CO2 emissions reduction.

The model has its limitations. Reaching last mile areas is difficult and costly, and consumers have high sensitivity to price. The current profitability of the distribution is insufficient to cover the full scope of the program, yet it is only by reaching these areas that the program yields the highest social and environmental impact. In order to maximize the economic and social impacts a mixed-model approach is needed. While technology sales can help create a market for the product, earn profit for the women micro-entrepreneurs, and generate some funding for program operations, additional funding is necessary to cover the comprehensive non-income-generating social impact activities such as training, mentoring, user education, as well as to keep the cost of the technologies affordable to the low-income population.

Through a continuous collaboration with the government, private sector, and civil society partners, as well as investment of philanthropic funds, this model can be scaled up to further its impact. Kopernik's partnerships so far enabled the program to expand the clean energy access to reach more people, fund skill-building and empowerment of women, invest in demand generation, and reduce the administrative cost of operating the program in remote locations. In the future phases, Kopernik aims to continue seeking donor funding, expanding its network of local partners including micro-lending organizations, non-profits, and government, and continue advancing the program's mission of connecting simple, low-cost clean energy technologies with the last mile communities to reduce poverty and improve lives.

[26] Anna Baranova, "Better sales performance achieved when spouses get involved, but not too much," *Kopernik Insights*, April 12, 2017, https://kopernik.info/.

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