ENERGY OPPORTUNITIES FOR AGRICULTURAL SYSTEMS AND FOOD SECURITY PROJECT

ASSESSING THE FEASIBILITY OF RENEWABLE ENERGY & ENERGY EFFICIENCY FOR VALUE CHAIN PARTNERS

Technical Brief #4

Introduction

Solar energy from the sun can be captured to Field Energy is a critical and often neglected component of value chain development. On-farm mechanization, value addition processing, and supply chain improvements like cold chain expansion all hinge on the availability of affordable power sources. Rapidly expanding innovation in renewables (e.g. solar, thermal) and energy efficiency (e.g. waste heat recovery systems, variable-frequency drives) are providing novel and increasingly cost competitive energy opportunities to support these kinds of value chain upgrading. When appropriately designed and priced, productive energy solutions can also support inclusion through expanding the geographic footprint of rural supply chains and helping small and mid-size businesses remain competitive.

At the same time, the history of foreign aid is littered with donor-funded mills, cold storage facilities, and other value chain investments that sit idle, often in part because energy and other recurring costs were prohibitive, equipment was incompatible with local energy supply, or unconsidered gender and social dynamics affected uptake and use of the investment.

This brief provides value chain and market system development specialists with the basic tools and resources to integrate analysis of energy opportunities—particularly modeling costs and payback periods for RE or EE investments—into their design and implementation work. We present a six-step process that helps practitioners to:

- Rapidly identify energy constraints to market opportunities in a target value chain (steps 1 and 2);
- Identify energy demand needs by value chain partners and comparative energy supply options (steps 3 and 4);
- Assess the feasibility of these energy opportunities for firm investment (step 5)
- Recognize key gender and social considerations that could impact uptake, use, and benefit (integrated into all steps); and
- Design interventions to catalyze those opportunities for more broad-based, sustained impact (step 6).

> This brief is the last of four practical guides developed by the **Energy Opportunities for Agricultural Systems and Food Security Project** (E4AS). Funded by USAID's Africa Bureau with field work in Senegal and Kenya, E4AS is implemented by Green Powered Technology in partnership with ACDI/VOCA. The objective of E4AS is to expand and focus information related to how renewable energy (RE) and energy efficiency (EE) can strengthen post-harvest value chains and reduce loss in sub-Saharan Africa, while also contributing to low emission development strategies (LEDS) and incorporating gender-aware strategies. Visit www.agrilinks.org/post/clean-energy-productive-use-post-harvest-value-chains-integrated-literature-review-field-work to access additional briefs and an integrated literature review with field work findings.

1 This document was produced for the United States Agency for International Development (USAID) by Dan White, Kevin Boylan, Jenn Williamson and Anna Garloch of ACDI/VOCA for Green Powered Technology, LLC under the USAID Energy Opportunities for Agriculture and Food Security Project (Contract Number AID-OAA-C-17-00112).

Guide

Below we provide a 6-step process to integrate energy opportunities into value chain and market system analysis and program design. Each step also includes an example case study in blue text boxes to show that step in action. In summary:

STEP 1: Map the Value Chain System & Target Pathways for Change → **STEP 2**: Identify Energy Constraints to Opportunities → **STEP 3**: Determine Energy Demand by Partners → **STEP 4**: Determine Energy Supply: On and Off-Grid Energy Availability and Cost → **STEP 5**: Model Returns (Feasibility) to Investment → **STEP 6**: Design Systemic, Sustainable Interventions to Catalyze on Opportunities

STEP 1: Map the Value Chain System and Target Pathways for Change

It is standard practice for market development practitioners to develop value chain system maps (especially as part of broader system analyses) that include key functions and actors such as: input supply, production activities, assembly/processing, packaging, transport, retail, export (if applicable), end consumer; along with support services (such as finance). Good visualizations and analysis reflect various market segments, overlay trade volumes, and consider how relationship/power dynamics, growth trends, and major enabling environment factors within these chain segments affect how the value chain is structured. In particular, look out for how these factors combine to create new market opportunities. For basics on how to map a value chain system, and use this to identify the best opportunities to target in order to affect positive change, see USAID's guidance on the Value Chain Wiki[1].

STEP 1 IN ACTION:

You are part of a team of value chain specialists starting up implementation on a new activity in Kenya with the goal of strengthening horticulture value chains to reduce poverty for those engaged in agriculture. You and your team map the horticulture system and its value chains (e.g. tomato, avocado, etc), identifying market opportunities as you go. Through interviews with stakeholders and reviewing trends in market data, you have identified growing and unmet demand for processed tomato products, including products requiring dried tomatoes, as well as strong relationships between this opportunity and its impact on both your target beneficiaries and positive market behaviors in the horticulture system overall.

You and your team decide to dig deeper into the potential for processed tomatoes as a pathway to strengthen the horticulture market

Note! This guide assumes the primary entry point into a market system is an agricultural value chain (e.g. dairy, tomatoes, maize); this guide helps you understand where energy is a constraint within that value chain, explore a range of options to address it, and calculate feasibility for investment in those options. However, development practitioners may also consider treating energy as a value chain system in and of itself, in addition to focusing on a specific agricultural system. Steps 1 and 2 will give you insight as to how significant energy is to transforming inclusive growth, and therefore help you prioritize how much resources you spend in treating energy as an interrelated system and set of value chains itself. Doing this would involve a different, more robust set of considerations than are focused on in this guide.

[1] www.marketlinks.org/good-practice-center/value-chain-wiki/value-chain-mapping-process

STEP 2: Overlay an Energy Lens: Identify Energy Constraints to Opportunities

Using the value chain system map and identified opportunities from Step 1 as a filter, identify where energy is used for the market opportunity-related points along the chain. This will involve a mix of consultations with teams involved in the VC system mapping as well as incorporating energy-specific questions into field surveys normally part of value chain analysis or other market research (see text box below for survey tips). For example, the adjacent figure, from Powering Agriculture's[2] '*Opportunities for Agri-Food Chains to Become Energy Smart*'[3], shows basic energy uses in the vegetables supply chain from the farm through retail. As shown, it is helpful to disaggregate energy needs by their use: heating, cooling, electricity, or moving materials from one place to another. This will enable you to match opportunities to technologies in steps 3—5 below. At this phase it is not critical that you have extremely detailed documentation on energy uses; you will only need those for points in the value chain where you will drill down for further cost estimation, as outlined in steps 3—5 below.

As part of this process, ask the firm or farm what their energy access is like—do they get power from the grid, or their own off-grid source, like solar PV or a diesel generator? What energy challenges do they have? For further examples, see text box below on field survey tips.

FIGURE 5.8. Vegetable products value chain.

FIELD SURVEY TIPS: Identifying Energy Use by Value Chain Actors or Functions

Identifying energy use types and intensity can easily be integrated into value chain analysis or any other interview opportunity with beneficiaries. This information will provide inputs into Step 3.

- When visiting farms or firms, ask them to walk you through their process from when materials/inputs arrive to when they leave. Note steps that:
- Require machinery or other electrical devices (e.g. hammer mills or other processing equipment). Ask if you can record the make and model number of the equipment. Most manufacturers will have energy load profiles for their equipment available on request.
- Require product temperature changes (e.g. cooling or heating points for milk). Make sure to note total volumes that go through these processes, and total temperature changes (entry temperature, target chill/heating temperature, etc.).
- Require the pumping or conveyance of water, air or other medium.
- Involve substantial manual labor. Try to note the mechanical energy needs—i.e. what is the labor doing? Moving bags of rice from truck beds to a warehouse? Sorting vegetables by grade? Packaging yogurt? Record the number of people needed in these roles, and the distances/ volumes or other magnitudes of work required.
- Note the products, processes, or technologies currently used for these steps.
- Ask firms or individuals to share recent electrical bills. Some firms will know their recurring energy costs off the top of their head, but it is always better to get a copy of a bill or other summary in writing.
- Ask about any energy challenges: Do they have blackouts? Do their energy bills seem to fluctuate wildly, even when their energy use remains stable? Any challenges related to access or price will be helpful in evaluating alternative energy options later.

[2] https://poweringag.org
[3] www.fao.org/3/a-i5125e.pdf

Apply a gender and social inclusion lens:

Consider and document gender and social gaps or differences in use, access, and agency.[4] Due to gaps in access to resources and lower levels of decision-making power, women, youth, and other members of marginalized groups tend to have: less access to technologies (including energy opportunities); less ability to upgrade to these technologies; greater reluctance to invest; and greater risks when they do. It is important to assess not just financial gaps (i.e., who pays, who can pay, and how much they can pay), but also gender and social norms, including which group has access to energy, what kind of energy, and how this is different. For one example of such risks, such as marginalization in enterprise as access to energy increases, see the Senegal Case Study in the E4AS Integrated Literature Review and Field Work Report[5].

Of course there can also be gender-specific positive benefits, which are equally important to understand and incorporate into design; for example, installing solar powered coolers on motor bikes expands access to cold storage to more smallholder milk producers who cannot travel to a central collection point, often a unique constraint for women.

STEP 2 IN ACTION:

Now that you have identified processed tomatoes as a key market opportunity, drill down further to get a clear sense of the range of energy uses, constraints, and opportunities to upgrade processes with renewable energy (RE) or energy efficient (EE) options.

One of the firms you interviewed during value chain mapping in step 1, The Tomato Fresh Company, mentioned that they are interested in developing a new product line, and have asked for help to determine its feasibility. Tomato Fresh currently creates ketchup and canned tomato preserves, but have reached capacity for their cold storage and processing line. They are interested in developing a new product line for dried tomatoes as a way to convert more tomatoes when market prices are low into a shelf stable, low volume product.

You work with Tomato Fresh to develop a list of all of their energy needs, from when tomatoes arrive at their facility through packaging and sale, which you list out as below. They also note that they have frequent blackouts, 2-3 times a week, and feel like their electricity is expensive.

Here is the list of energy uses at each phase in their production process—where relevant, you note where women or men complete tasks, as this will be helpful later on in anticipating potential gendered effects of changes to production processes:

Produce intake:

- Manual labor to move produce from trucks to storage sheds (mostly done by men)

Storage:

- Electricity for cold storage coolers
- Washing, grading, sorting:
- Electric to run spray pumps and produce conveyor belts
- Manual labor to grade and sort produce (mostly completed by women)
- Processing:
- Electric for tomato juice extractors, pulpers, preheaters, conveyance pumps
- Heating for pasteurization
- Packaging:
- Electric for conveyor belts
- Manual labor for final packaging and labeling (mostly completed by women)

You are most interested in the heat energy requirements for the tomato drying process, which you will delve deeper into under step 3.

[4] *AgriProFocus Gender in Value Chains Toolkit (2014) has a section on gender sensitive value chain analysis. https://agriprofocus.com/toolkit. USAID's Promoting Equitable Opportunities for Women in Agricultural Value Chain Analysis (2009) also includes guidance on gender sensitive value chain analysis. https://pdf.usaid.gov/pdf_docs/pnaeb644.pdf*

[5] *Available at www.agrilinks.org/post/clean-energy-productive-use-post-harvest-value-chains-integrated-literature-review-field-work*

Step 3: Determine total energy demand for value chain partners

Based on the energy constraints identified in Step 2, plot energy use over time by developing a rough load profile[6] for the processes or technologies in the value chain that are targeted for improvement.

To do this, first determine the total energy demand of the new equipment or process. Energy requirements should be available from the manufacturer for known/existing technology or machinery in watts per hour (or convertible equivalent). This can be used to determine total energy demand by multiplying by the operational duration needed to reach a set production goal.

STEP 3 IN ACTION:

Tomato Fresh has a production target to dry 400MT of tomatoes each year in 10MT batches. They have found a commercial dehydrator model with a 100kg per hour capacity, and will purchase 10 of them to give them a total production capacity of 1MT per hour.

However, as you determined during step 2, one of the key issues holding back Tomato Fresh's competitiveness are issues with electricity. They experience blackouts 2-3 times per week, and note that energy is one of their largest monthly expenses. A food safety specialist noted that this may be a problem for their new drying operation: If the power were to go out while tomatoes were insufficiently dry, they could spoil in the dryers, leading to wasted product at best, or poisoned customers at worst. Tomato Fresh wants your help to figure out two things:

1. What will their energy costs be for their new dried tomato processing line using the current, on-grid power supply?
2. What would it cost to replace their on-grid energy with an off-grid solar photovoltaic array?

To answer these questions, you need to first estimate their energy demand in this Step 3, then determine the cost with their current supply versus a renewable alternative. (You'll do this in Step 4).

Calculating energy demand first requires multiplying the kilowatts used by one machine per MT processed x number of machines. Tomato Fresh has sent photos of the electrical information plate on the dehydrator. The red box to the right gives you the total wattage—this is the total energy draw for the machine. They bought 10 machines—so multiply by 10—which gives 12,000 watts, or 12 kilowatts (KW) of total power needed per MT processed.

Model G2369
240V ~50Hz
1,200W

Recall that Tomato Fresh is planning to process 400MT in year, and want to process 10MT per 10 hour working day, so have decided to buy ten 100kg/hr units. Tomato Fresh will be running the units for 10 hour days, 40 days a year to process the full 400MT. So total KWH needed per year are 12KW X 10 hrs/day X 40 days/year = 4,800 KWH per year. This is their energy demand.

[6] *A load profile is a table, chart, or graph that plots energy use over time—this is the industry standard method for capturing total energy requirements over a given period of time.*

Step 4: Determine availability and costs of energy supply options

For On-grid scenarios: Determining the extent of access to energy grids (i.e. 'on-grid') is important because it will significantly affect the financial and technical feasibility of energy-intensive investments. A good place to start is the World Bank's Africa Electricity Transmission and Distribution Grid Map[7], which includes a map explorer tool[8] showing current and planned grid access across the continent. For areas outside Africa, the Global Energy Network Institute maintains a repository of national and regional distribution maps[9], of varying detail, quality, and currency. Any digital source should be cross-referenced with the national electrical utility company, who would be the most up to date authority on current and planned grid access. In addition to geographic coverage maps, most national utilities maintain publicly available rate schedules that provide cost per KWH (kilowatt hour[10]) at different voltages.

Whether these schedules are available or not, it is still critical to verify actual energy costs from market actors on the ground. USAID or other donor projects may be a good source for general commercial energy costs, but to the extent possible costs should be validated with actuals. The Survey Tips text box under Step 2 provides a helpful starting point to gather firm-specific information of this nature. These costs will be a critical input in Step 4 and 5 below.

For Off-grid scenarios: Identifying off-grid oppor-

7 https://energydata.info/dataset/africa-electricity-transmission-and-distribution-2017

STEP 4 IN ACTION:

Step 4a: Determine on-grid energy costs: The next step is to ask Tomato Fresh for their last year's energy bills. Looking at their bills, they've paid an average of $0.15 USD/KWH. So we multiply 4,800KWH X $0.15 USD = $720 USD/year estimated energy costs.

These costs assume that energy costs remain stable, and do not yet account for additional costs from blackouts. Based on their previous year's blackouts, you work with Tomato Fresh to estimate that 20% of their 40 days processing tomatoes would be interrupted by blackouts, resulting in a loss of 10%, or 4MT of purchased tomatoes, annually. On average, they are paying $100 USD per MT for processing tomatoes, meaning blackout losses would most likely add $400 per year in costs to their operations. This brings total estimated on-grid costs to $720 + $400 = $1,120 per year.

Step 4b: Determine off-grid solar PV costs: What would solar PV cost instead? Tomato Fresh will need to decide if they want battery storage to be able to use solar energy at night, or if they are fine with just using electricity when they sun is out. Given that they are only operating the dehydrators during daylight hours, they opt to forego battery storage and just use the dehydrators when the sun is out.

How large of a solar PV array does Tomato Fresh need? Go back to step 1 above: remember that each unit requires 1,200 watts of power. So when all 10 dehydrators are running, they will need 12,000 watts (or 12KW) of power, which means they will need solar panels that collectively generate at least 12KW of power. So if each panel generated 270W, you would need at least 45 panels in the array.

You work with Tomato Fresh to get three quotes from solar PV service providers for a 12KW array, including the solar panels and all necessary inverters and other equipment. All three quotes come back at roughly the same price. This brings total estimated off-grid costs to $12,000 USD for 12KW array; within 10 years, the system would pay for itself compared to on-grid costs.

In looking at both of these options, you conduct desk research and ask some of the female employees at Tomato Fresh about their energy constraints at home, and note that if the off-grid arrays were structured as mini-grids that could supply surrounding homes, they could have positive effects on replacing firewood fetching for cooking and light at night. This could reduce women's time poverty and increase their and their family's safety and health.

8 http://africagrid.energydata.info

9 www.geni.org/globalenergy/library/national_energy_grid/index.shtml

10 *Kilowatt hours are the standard unit used to measure energy consumption. Guidance on determining KWH rates for specific equipment and processes are laid out under step 3 below.*

tunities requires a more traditional sector mapping exercise. The best place to start is to identify local off-grid technology distributors and design-build firms. Other sources of potential innovative technologies include:

USAID's Powering Agriculture Program, which maintains a database[11] of emerging renewable energy technology providers with focus on USAID target markets.

The International Renewable Energy Agency (IRENA) maintains a public GIS database[12] showing wind and solar feasibility in different localities around the world.

In most of the world, diesel generators are the most common and default off-grid energy source. Generator and fuel costs can be determined by speaking with local service providers in the target region/districts.

Once the cost per KWH for energy is determined, it can be multiplied by the total energy demand (Step 3). This will be needed to model returns in Step 5 and ultimately determine the feasibility of the upgrading technology.

Apply a gender and social inclusion lens:

Consider whether on-grid or off-grid opportunities are more easily or less easily accessible to women, youth, and members of marginalized groups. In addition to comparing costs and determining whether these groups have the resources and information necessary to connect to these energy sources, assess whether there are other factors that may promote or deter access. This may include:

- Does the local service provider assess and include women or marginalized groups when advertising or educating about their services?
- Do they have local representatives that are female?
- Are there policies or procedures that make accessing these services challenging for women, youth, or marginalized groups (i.e., Can women sign a legal contract in this context? Is collateral required? Is a bank account required? Are there any legal or policy requirements, such as tax incentives or requirements, that they need to be informed about)?

[11] https://poweringag.org/innovators
[12] www.irena.org/documentdownloads/publications/ga_booklet_web.pdf

Step 5: Model Returns (Feasibility) of Energy Investment

Combine the load profile information from Step 3 with the cost data collected in Step 4 to model the financial feasibility of the proposed technology upgrade opportunity. In doing this, it is necessary to identify gaps between energy demand needs and energy supply.

There are many metrics to do this, but one of the most common is internal rate of return (IRR[13]), a way to evaluate different uses of cash at any given point of time against one another. There are many good resources that can walk you through how to calculate IRR so we will not go through them here, but instead will simply give the final values.

Note: For the purpose of identifying opportunities to integrate renewable energy technologies into a market systems or value chain strengthening programs, it is sufficient to use the information resources and process laid out in this brief. However, we stress the importance of consulting with qualified electrical engineers and other specialists as relevant before advising firms on or subsidizing investment in actual equipment purchases. There are many nuances, safety, financial, and other technical considerations too varied to cover in this brief that should be addressed as part of any energy investment.

STEP 5 IN ACTION:

We can simply add up how long it would take for Tomato Fresh to recoup its solar PV investment through electrical bill savings and avoiding wasted produce, which would be about 10.7 years. Since the solar PV system comes with a 20 year warranty and expected lifespan of 30 years, this would make it a very good investment.

However, the different cost structures of renewable energy sources and legacy technologies require a different set of calculations. For solar PV or wind, all of your costs are up front, whereas for grid power, or diesel-powered generators costs are spread out over time.

Using the internal rate of return (IRR) referenced above, we can evaluate the best use of cash for Tomato Fresh: are the electrical savings worth it, or should they invest it in another line of business?

If we take the above numbers, we would assume that in Year 1 Tomato Fresh spends $12,000 on a solar PV system, which would save them $1,120 a year over the next 20 years (while the system is fully under warranty). The IRR in this scenario would be 6.52%. In other words, this would be equivalent to investing the $12,000 in the stock market, and getting an average return of 6.52% per year for 20 years straight; all in all a good investment.

Step 6: Design Systemic, Sustainable Interventions to Catalyze on Identified Opportunities

This brief provides a practical roadmap to understand energy constraints, costs, and opportunities for partners involved in core agricultural value chain functions (e.g. processors, producers, transporters). This is an important piece of information for design. However, to act on this information and design appropriate interventions requires a much broader view of the agriculture and energy systems. Many good programmatic investments fail to have any sustainable, scalable impact because the interventions were in the wrong place to leverage broad-based impact; root causes weren't considered and targeted and thus only short term 'band-aids' get applied; or critical relationships and partnerships fall apart once the project ended. With this in mind, this step provides some basic tips to consider as programs move into the intervention design phase, within the broader context of a value chain development or market systems approach.

The most foundational best practice involves understanding the broader system of actors, forces, norms, and networks that shape incentives, behaviors, and patterns[14]. Systems thinking helps us 'zoom

[13] *For example, see step by step guides at www.mathsisfun.com/money/internal-rate-return.html, www.accountingtools.com/articles/how-to-calculate-the-internal-rate-of-return.html, or www.investopedia.com/ask/answers/022615/what-formula-calculating-internal-rate-return-irr-excel.asp.*

[14] *For one take on systems thinking within a development context, see USAID's "5Rs Framework in the Program Cycle" at https://usaidlearninglab.org/sites/default/files/resource/files/5rs_techncial_note_ver_2_1_final.pdf. Oxfam also has a helpful video accessible at www.youtube.com/watch?v=WfyWgp95kgA*

out' to understand other systems and forces that influence the core outcome we want to see (e.g. increased uptake of energy solution X by small firms in region Y of value chain Z), and then 'zoom in' to more deeply understand the root causes that drive key behaviors and changes we are targeting (not only by individual firms or consumers but also at the system-wide level).

In designing a programmatic response to identified energy opportunities, we must consider the broader ecosystem and other dynamics that influence behaviors, rate of uptake, and more. For example, the best way to address these constraints and support these opportunities will not necessarily involve direct engagement with the core value chain firm (i.e. the end user of a technology). The best 'bang for buck'—or the leverage point for truly sustainable, system-wide impact—may actually lie in support to a totally separate group of actors, or in tackling an underlying norm that shapes behavior across the system.

For example, to help firms increase uptake of solar PV technologies for small scale dairy cool chain, our programmatic response may actually focus on strengthening industry groups to pressure the government to reduce tariffs or subsidies on the materials that go into engineering and manufacturing that product locally. Or, we may support energy firms to conduct more tailored market research so they can better design, price, market and service their products to rural clients. Or, we may informally partner with various media platforms to amplify the voices of businesses who have successfully adopted solar PV, encouraging others to copy or crowd in a behavior. Or, we may work with financial institutions or impact investors to co-create and pilot tailored, bundled alternative financing options that reduces the upfront cost consumers pay and therefore nurtures more widespread uptake. Our response will depend on the insights from our systems analysis, which helps us uncover the real reasons (or 'root causes') driving negative or positive outcomes, and the best leverage points for change.

Here are some additional considerations which draw from market systems approach best practice:

- identify opportunities to co-create and co-own interventions with partners
- embrace a phased test—reflect—adapt timeline that allows models and assumptions to evolve, and for partners to take increasing ownership and investment roles
- in co-creating, be cognizant of embracing diverse perspectives through diverse representation—see the Gender & Social Inclusion box below)
- be sensitive to distorting market incentives and price thresholds through large program subsidies or 'brokering', at both the firm and customer levels;
- use grant funds in more systemic ways—don't just jump to giving a series of in-kind grants to individual businesses so they can upgrade a technology. Consider other types of market facilitation support: funding market research or willingness to pay surveys, sponsoring pay for performance competitions/contests with product suppliers, financers, and/or service providers; supporting vocational development programs to address local service provision skills and service models; buying-down risk of investment or innovation by financers by using grant funds as first-loss capita/guarantee funds; etc
- build networks amongst key industry actors and foster meaningful, repeated collaboration
- as noted under Step 1, consider treating energy as a value chain system in and of itself, given its relative importance to overall market system transformation and inclusive growth
- don't work in isolation! There are many collaborators and partners innovating in the energy-agriculture nexus space.

STEP 6 IN ACTION:

Recall in Step 5 you identified that a solar PV array would be a good addition to Tomato Fresh's new tomato drying operation. At this point, many projects would simply give Tomato Fresh a grant to go out and purchase a solar array. And while this would be good for Tomato Fresh, and potentially good for their neighbors, its impact probably ends there. What will the next firm do?

So, you and your team take a different approach. You aim to ask 'why' a bit more, pushing deeper, to help uncover the underlying reasons at a systems level—not just the level of 2-3 actors—behind why uptake of solar PV is so low, even though the payback period makes business sense. You go out and identify the major solar equipment suppliers in Kenya and interview them about their business constraints. They highlight that even though selling to a customer like Tomato Fresh clearly makes good business sense, Tomato Fresh doesn't have the cash up front to pay for the solar pv system, and there are limited financing options out there for these sized firms. You interview financing firms to understand the reasons for this and discover there is limited information flows between tomato processors, clean and renewable energy providers, and investors—as well as poor incentives for finance staff to innovate. You combine this with the social and gender analyses on your project, which highlighted that women tended to congregate in smaller, more cash-strapped businesses and don't always have title to land and assets needed for collateral—further complicating access to large upfront cash investments, although energy-fueled enterprise growth would disproportionately benefit the primarily female workforce.

You and your team then sit down and, together with investors, processors, and service provider—co-design some pilot interventions, which you'll refine and scale up as you discover what works and how committed partners are. This includes:

1. Identifying a set of impact investors interested in renewable energy opportunities, working with them and the solar PV suppliers to bundle Tomato Fresh's venture with several similar upgrade opportunities. The larger investment amount of these opportunities combined makes the investment worth it for investors, and solves Tomato Fresh's financing challenge. Through media and business networks, you support dissemination of learning from this model, building competitive pressure, perceptions of risk, and capacity for others to adapt it.

2. Facilitating investor visits to build direct relationships with solar PVs and end user processors, identifying a champion to host a feedback session

3. Support a joint advocacy effort by the horticulture industry and renewable energy providers to pressure the government to reduce tariffs or subsidies on the materials that go into engineering and manufacturing of solar PV technologies—to reduce the end customer cost.

4. Provide a small subsidy to a vocational school to train equal numbers of women and men in solar PV installation and maintenance, with training delivered by solar PV firms for quality control

5. Conduct a business feasibility assessment that helps set a modest pricing structure for neighboring homes to access the solar PV after working hours at Tomato Fresh and the other firms, decreasing women's time burdens for boiling water and enhancing social capital through enabling easier communication with family elsewhere.

As a result of these new business lines, the solar PV business develops a new dedicated sales and installation unit targeting small-scale agribusinesses—a new business line for them—and the increased information flows and pilot investments attract interest from other investors and entrepreneurs, amplifying the messages of the advocacy efforts. As a result of this approach, you and your team have successfully leveraged donor resources to in efficient, less distortionary ways that address deeper constraints at the systems level to sustainably expand access to energy, support the horticulture sector, and increase employment and decrease time poverty for women. This approach enhances the likelihood that development outcomes are broad-based and sustained.

Apply a gender and social inclusion lens:

- Ensure women's and youth participation in designing the activity—consultation and participation in identifying what is needed, what are the challenges and what are the potential solutions are the keys to designing inclusive and sustainable interventions.
- Facilitate women's and youth engagement in solutions that are attractive to market actors—support market research, sensitize market actors on the value of this approach and build their capacity, help them understand the business case for engaging women and youth in order to promote sustainable interventions.
- Assess gender and social factors such as time burdens, control over income, leadership, access to resources, and decision-making in value chain and energy assessments. These dynamics can both inhibit participation and benefit from energy upgrades so this information should factor into intervention selection and design. Meanwhile, increased access to and participation in energy upgrade activities can have positive or negative impact on these empowerment factors, so it is important to monitor, evaluation and respond to changes during implementation.
- Engage men and community leaders to understand the negative impacts of gender inequality and to promote female engagement and benefit from energy upgrades.
- Be informed—three of many resources include[15]:
  - Intervention Guide for the Women's Empowerment in Agriculture Index (WEAI): Practitioners' Guide to Selecting and Designing WEAI Interventions
  - Women's Economic Empowerment Briefs on Engaging Men and Women's Engagement Beyond Production

See the Step 6 in Action box for the Tomato Fresh case application. For more reflections on programmatic and policy implications of increasing CE and RE opportunities, see the full E4Ag integrated literature review and field work report, available at www.agrilinks.org/post/clean-energy-productive-use-post-harvest-value-chains-integrated-literature-review-field-work.

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[15] *www.agrilinks.org/sites/default/files/resource/files/WEAI%20Intervention_Guide_Final%208.2016.pdf; and www.marketlinks.org/library/womens-economic-empowerment-briefs-suite-0*