GREEN MINI GRID
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Ice-Making as a Productive Application in Green Mini-Grid (GMG) Systems

Practitioner Guide

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Practitioner Guide:
Ice-Making as a Productive Application in Green Mini-Grid (GMG) Systems

Written and edited by the GMG Facility Kenya

Published in December 2018 by the Green Mini Grid Facility Kenya.

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The ice-making guide is a support tool and should not be considered legal or strategic business advice. It is assumed that practitioners have:

1. Conducted technical and financial feasibility analysis specific to their company/situation.
2. Carried out adequate due diligence, including legal requirements.
3. Consulted the relevant communities to seek informed consent.

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The Green Mini Grid Facility Kenya avails funds and supports green and sustainable mini-grid electrification in Kenya. The Green Mini Grid Facility Kenya provides technical assistance, investment grants and output-based grants to catalyse investment in this sector while providing support to the Kenyan National Electrification strategy. The Green Mini Grid Facility Kenya is supported by DFID and the European Union African Infrastructure Trust Fund (EU-AITF) with the Agence Française de Développement as the implementing partner for the facility. Innovation Energie Développement (IED) is the managing entity and in partnership with I-DEV and Practical Action Consulting (PAC), is responsible for the implementation of the Facility.

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List of acronyms

AFD	Agence Française de Développement (French Development Agency)
B2B	Business to business
BMU	Beach Management Unit
BoP	Bottom of the pyramid
CAPEX	Capital expenditure
CBO	Community based organization
DFID	Department for International Development
EIA	Environmental impact assessment
EU-AITF	European Union-Africa Infrastructure Trust Fund
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GMG	Green-Mini Grid
HAACP	Hazard analysis and critical control points
hr	Hour
KEBS	Kenya Bureau of Standards
kg(s)	kilogram(s)
KPI	Key performance indicator
KSh	Kenya Shillings
kWh	Kilowatt hour
LCOE	Levelized cost of electricity
M&E	Monitoring and evaluation
MT	Metric tonnes
NEMA	National Environment Management Authority
NGO	Non-governmental organization
NPV	Net present value
PU	Productive use
PUE	Productive use of energy
SME	Small and medium enterprise
TA	Technical assistance
USD	United States Dollar
VC	Value chain
yrs	Years

Introduction

Productive uses of energy refer to the utilisation of electricity for income and employment generating activities. Productive use (PU) activities can be a catalyst to rural development and sustainable economic growth, providing opportunities for job creation, skill development, increased income, market access and reduced vulnerability. PUs can also accelerate the success of green mini-grid (GMG) projects, by increasing demand for energy and increasing household income, thereby enabling people to purchase more energy and 'climb the energy ladder'.

This guide is designed to provide support to practitioners to make effective decisions and aid in implementation of PUs. In order to catalyze economic development in a community through PUs there are many variables and complex dependencies that must be addressed by multiple stakeholders including mini-grid developers, financial institutions and small to medium enterises (SMEs). Cottage industry activities tend to be easier to set up and generate faster returns from integration with clean energy solutions, than large, capital intensive PUs that tend to need more resources and have a longer break even period. Financial viability of any PU is essential to ensure the benefits reaped by the community are sustained and to ensure mini-grid developers can effectively provide the quality and quantity of energy needed.

This guide is designed to provide support to practitioners to make effective decisions and aid in implementation of PUs.

Solar panels powering a mini-grid in a rural community

Purpose

The guide is the result of the GMG Facility Kenya's extensive work to support mini-grid developers and the mini-grid industry at large to address sector level barriers to expanding off-grid electrification, with an emphasis on increasing market access and social inclusion for bottom of the pyramid (BoP) consumers and businesses. A Sector Mapping conducted in 2017 highlighted that practitioners had a limited understanding of how productive use activities should be integrated into mini-grid planning and operations. This guide is the final product of a technical assistance (TA) project that seeks to address this barrier.

This guide aims to help practitioners assess whether ice-making for fish preservation (and other purposes) is an appropriate, beneficial and financially viable productive application, both for a community and for a mini-grid developer. It also provides guidance for practitioners on how to operationalize an ice-making PU, recognizing the complexity of doing so.

This guide is organized as a series of tools that can be applied independently or together, based on the individual needs of the practitioner, the objectives of the activity, and the participating community's circumstances. It establishes a set of best practices to be considered and is not an exhaustive list of how to integrate PUs into off-grid electrification initiatives.

Fish is highly perishable but shelf life can be extended by the use of ice.

Who should use this Guide

This guide is primarily intended to support mini-grid developers establishing a mini-grid project in a rural community. Ideally the guide should be used during the feasibility stage of development for mini-grid developers, as the tools offer important considerations that will help in the decision-making process for practitioners to ensure more accurate assessment of demand when considering sites; ultimately improving success for their business and the communities that benefit from rural electrification. However the tools are also designed to be used as a resource in areas where a mini-grid is already operating.

The guide is also relevant for other practitioners involved in rural electrification initiatives, including:

- NGOs and donors working to increase rural electrification and pilot or implement PUs
- Investors in mini-grid companies and projects in rural areas.
- Communities interested in attracting a mini-grid developer to partner on addressing electrification needs.
- Government officials and regulators setting policy on green energy development activities.
- Companies seeking to partner with mini-grid developers to establish or grow their businesses. These can include ice-making enterprises and companies involved in fisheries or aquaculture, at any level of the value chain.

This guide is organized as a series of tools that can be applied independently or together, based on the individual needs of the practitioner, the objectives of the activity, and the participating community's circumstances.

How to use the Guide

The guide includes five separate tools that can be used independently, as needed by the individual user. It is organized sequentially so that if a practitioner is starting the process from scratch, the guide will help them to follow from business case assessment (economic feasibility) to business model design, implementation and monitoring.

Where possible, examples are included to describe concepts and if appropriate, templates are provided. These are intended to be adapted by the user, depending on specific contexts.

This guide will help practitioners follow from business case assessment to business model design, implementation and monitoring.

Contents of the Guide

Tool 1:

Feasibility checklist to help determine whether a productive use application is viable within their context.

Tool 2:

Business model guidance to help identify the most appropriate business model for the productive use application. It focuses primarily on the ownership configurations, which involves partnerships with other actors. The tool also provides brief tips on effective community engagement.

Tool 3:

Technical considerations and requirements to highlight considerations for equipment conversion or reconfiguration and provide guidance on mini-grid sizing.

Tool 4:

A detailed plug-and play financial model that assesses various scenarios based on the business model options in Tool 2.

Tool 5:

Guidance on monitoring and evaluation, including suggested indicators and data collection tools and processes.

Overview of fisheries and aquaculture – the need for ice

Fish can be safely stored for up to 10-15 days at 0^0C

Demand for fish in Kenya has tripled in the last three decades and based on global and local consumer trends, the fisheries sector has high potential for economic growth. Fish is also recognized as an important input to nutritional food security. While capture fisheries makes up the largest portion of the fish sold in Kenya, significant reductions in the volumes of fish from Lake Victoria – the country's primary source of freshwater fish – have created an opportunity for the aquaculture subsector, which is developing quickly. The fishing industry contributes around 5% of Kenya's GDP and supports the livelihoods of more than half a million people. However, growth of the industry – both wild capture and fish farming – is constrained by the lack of adequate cold chains, which limits earnings for producers and discourages consumers.

Growth of the industry – both wild capture and fish farming – is constrained by the lack of adequate cold chains, which limits earnings for producers and discourages consumers.

Challenges in the fish value chain are common to fishing communities and fisheries sectors to some degree, independent of country context. Key challenges include:

a. Dependence on capture fisheries and dwindling stocks of fish.

b. Relatively high prices compared to imported fish (especially frozen fish from China).

c. Lack of negotiating power on behalf of fishers, producers and vendors over buyers.

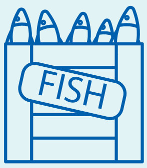
d. Lack of cooling and cold chain capacity.

Fish is highly perishable, but shelf life can be extended by controlling the environment at every step of the value chain. Predicted losses increase as handling temperatures increase, and while fish can be safely stored for up to 10-15 days at 0° C, it can deteriorate completely, making it unsafe (due to bacterial growth) after a few hours at 30°C. In Kenya, where the fish value chain is characterized by a high degree of fragmentation with a large number of loosely organized, small-scale producers, maintaining a well-integrated cold chain is a major challenge.

There is potential for mini-grid powered ice making and other forms of refrigeration to improve the entire supply chain. The availability of a reliable and affordable energy supply is a key precondition for the development of cold chains in the fisheries sector. Decentralized renewable energy from mini-grids coupled with energy-efficient equipment can help to lower the operational costs of cold chain infrastructure, thus increasing the business' economic viability and making them more attractive to investors.

Potential for cold chain improvements in capture fisheries

Value chain point	Current condition	Improved condition
Capture	Fish is caught and kept in the boat's hull without any form of cooling facility. Fishers using hooks experience higher losses from spoilage than those using nets, given the longer period of time needed to complete a viable day's catch.	Fishing boats with cool boxes with sufficient ice to keep fish cold from the moment of capture.
Collection	Aggregation points located on the beaches receive the daily catch, where it is weighed and traded between fishers and buyers. Fish is placed on the floor or on cement slabs. Lack of infrastructure, including power grids, and relatively low volumes are distinct features of fish aggregation points.	Fish weighed in cold rooms or from the ice boxes, with outside temperature exposure kept to a minimum. Collection points with hygienic surfaces and tools (e.g. scales, knives), and access to clean water.
Storage	Fish is stored on transport boats or on-land in insulated metal containers with limited ice available. This is the first point where ice or any type of cooling is introduced. Preservation is considered the responsibility of the buyers.	Fish stored in clean, sealed cooler boxes with plenty of ice or in cold rooms, freezers or other cooling appliance to keep spoilage to a minimum. Minimized storage period.
Transport	Fish is transported in vessels with large metal storage containers (if exported to Uganda, for example) or in smaller cooler boxes in boats (if destined for other Kenyan destinations). Some ice is applied but the volume used depends on factors such as fish price, ice price and ice availability.	Well insulated and refrigerated transport vehicles and containers are the best option to preserve fish. Insulated containers with ice, depending on travel distances. Melting of ice can pose contamination risk by spreading microbes.

Value chain point	Current condition	Improved condition
Distribution 	Fish is distributed through wholesale markets or channelled to pre-arranged buyers (e.g. processing factories). Cooling with ice or other means is rarely part of the distribution process, except where cold storage infrastructure exists or ice is sold on site. In some cases, local governments facilitate collective cold rooms or freezer services which customers are charged based on usage.	In tightly organized value chains there are limited numbers of distributors who collect large volumes, and distributors own bulk cold storage facilities. In value chains characterized by many distributors with small volumes, if public or shared facilities are not available, distributors carry ice boxes or adequate cooling containers.
Retail 	Street vendors and open markets are the most prevalent point of sale, where cold chain facilities or equipment are rarely available and fish is stored in open, unrefrigerated containers. In larger cities, fish is also sold at supermarkets where it is displayed in refrigerated units or sold frozen. Fried, smoked or salted fish is also widely consumed. These are often the second-grade fish that was rejected at the point of aggregation, usually for lack of freshness but also due to size.	Fish is kept under consistently cold conditions, avoiding fluctuations in temperature. At a minimum, ice is used to maintain coolness. Ideally, marketplaces have refrigerated display cases and other hygiene and food safety infrastructure (e.g. clean water). Standards for traceability are established and enforced. These help retailers to demand improved product quality, trickling throughout the supply chain.

Potential for cold chain improvements in aquaculture

Aquaculture is a relatively new industry in terms of commercial activity and is characterised by two types of producers in Kenya:

1. Small and medium size companies producing up to 1,000 MT of tilapia per year, grown in freshwater cages in Lake Victoria.

2. Micro-scale farmers and enterprises fish farming in-land by means of earthen ponds, primarily, but also above ground tanks and some cages in rivers.

The value chain differs in several ways but an integrated and reliable cold chain can also contribute significantly to improving the quality and marketability of farmed fish, especially in a few critical points along the value chain. The steps not included below are the same as those steps outlined in the fisheries value chain above.

Value chain point	Current condition	Improved condition
Inputs	Fingerlings are either produced on-farm or purchased from hatcheries. These are normally transported in bags with oxygenated water.	Depending on the travel distances, ice is utilized to keep the environment around the bags cool.
Harvest	Fish harvests can be controlled by timing the production cycle and harvesting depending on customer demand. For farms in remote locations, ice is difficult and expensive to come by.	As with capture fisheries, ice is provided to maintain the cold chain from the point of harvest. Especially important given the lack of nearby water (as in the lake) which can help keep fish alive after harvest.
Transport	Some aquaculture companies have their own adequate transport or hire refrigerated trucks for distribution to the various market locations. Smaller enterprises and small-scale pond farmers transport fish in bicycle, motorbike or car to market.	In the absence of refrigeration, ice boxes or insulated containers are standard for transportation of fresh fish.

Case Study: Developer X in Lake Victoria

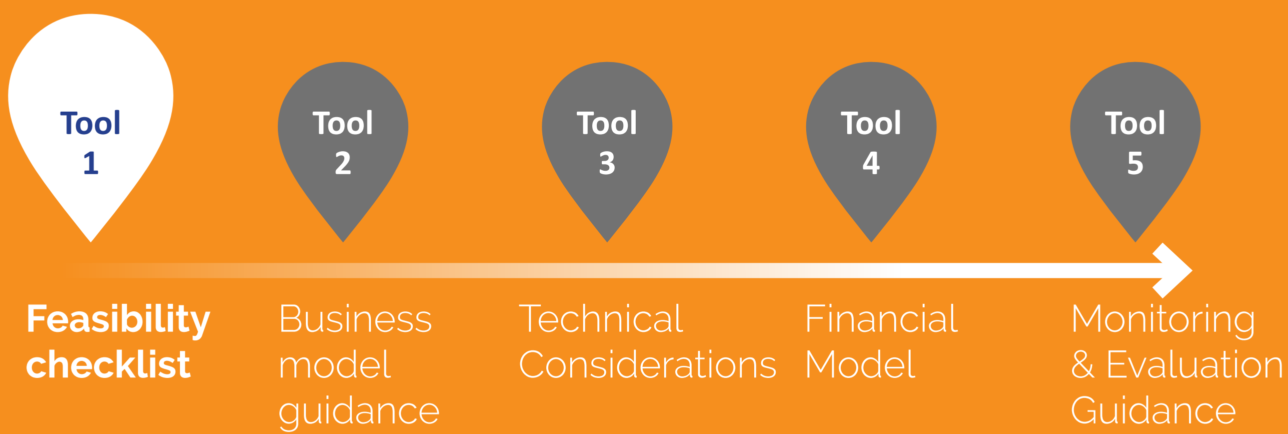
The Kenya Lake Region is one of the most densely populated, with over 10 million people or about 25% of the country's population. It encompasses 10 counties making up the Lake Victoria Basin, and is also a critical resource for bordering neighbors Uganda and Tanzania. In addition to the economic and nutritional contribution of the fisheries sector, it provides livelihoods for millions.

Ringiti is a rocky island on the border with Uganda, where the population of 4,000 people lives from the fishing activities on the Lake. Without access to electricity, the island's growth potential remains limited. By bringing solar power to Ringiti, Developer X intends to change that. The original design of the mini-grid provides DC power supply with a midday load of around 6 kW and an evening peak around 21 kW.

Developer X has identified ice-making as a potential opportunity given the community's dependency on fisheries and the current absence of cold storage and ice plants on the chosen island sites. This means that fish spoils quickly, impacting the leverage that fishers have when negotiating prices with buyers. Similarly, traders' own costs increase since they have to purchase ice, which can only be accessed off-island. This lowers their margins and limits their ability to offer better prices.

Learning about the fish value chain helped Developer X understand the needs of the community and where to intervene.

Tool 1: Feasibility checklist



Purpose

At the early stages of mini-grid development, mini-grid developers conduct in-depth feasibility studies that include demand assessments, cost/benefit analyses, environmental impact assessments, community consultations, and a host of other studies and diagnostics needed to assess business viability and ensure compliance. However, these assessments rarely allow for a meaningful consideration of opportunities to integrate productive uses of energy and the feasibility of various PUs.

This tool is designed to help practitioners who have identified ice-making as a potential opportunity in a particular context to understand the financial and socio-economic potential of an ice-making PU integrated with a mini-grid. The checklist highlights questions to be answered, key data points to be collected and unit economics needed for the success of an ice-making business. It will enable practitioners to make an informed decision on whether to proceed further with an ice-making PU.

The checklist can be used by those contemplating developing new mini-grid sites as well as those evaluating PU opportunities in existing sites. It is designed to be used as a first step decision tool before investing extensive time, money and effort in setting up an ice-making PU.

Feasibility Checklist

Consult communities to confirm interest

Organized community consultations using convening methods such as barazas, focus group discussions or village level meetings are a way to ascertain whether residents are interested in having ice making facilities in their community. The community's input can be useful to gauge the need for ice and to identify the primary uses of ice (e.g. fish preservation, cold drinks, medicine storage). This toolkit is focused on ice-making as an application for fish preservation. Engaging community members to hear their views on their energy needs, gauge support levels for the mini-grid and assess demand for the PU, and doing so from the outset, will help prevent conflict and complexities that could contribute to the failure of the project.

Mobilizing participation is best done by engaging with community leaders. Examples of key discussion points include:

- Ask community members (men, women and youth) to explain what their understanding of productive uses of electricity is. Ask the community to explain the reasons why it is important to promote productive uses of electricity.
- Discuss with the community what productive activities are generally undertaken by men, women and youth in the community, and the types of energy used; and whether their productivity can be improved if electricity was accessible.
- Discuss with the community other new productive activities that they could undertake if electricity was available nearby. This will provide insights into community perspectives without influence from the mini-grid developer's preference. If ice-making and the need for ice is highly rated then the PU will be addressing an existing community need. If not, then community uptake of the services might be problematic.

The GMG Facility has several resources to assist with this community engagement, including the community engagement section in Tool 2 and the Facility's Manual of Procedure, Guidelines to improve the social and economic impact of GMG projects (July 2017) which includes considerations on social and gender inclusion and mainstreaming in design, development and management of proposed interventions- enhancing communities' participation in decision making and supporting economic opportunities for communities.

Conduct value chain(s) analysis

Ice has multiple uses, therefore, it is critical to understand the value that ice can bring to different end users. One strong market is the commercial fish industry since, as shown in Section B, ice can be used in every step of the supply chain and can have significant impact in reducing post-harvest losses. Although it may not be necessary to conduct a comprehensive value chain analysis, at a minimum it is important to know how the value chain operates and the ways in which the availability of electricity will optimize that operation in order to understand whether ice-making is a viable and beneficial opportunity.

> This tool is designed to help practitioners who have identified ice-making as a potential opportunity in a particular context to understand the financial and socio-economic potential of an ice-making PU integrated with a mini-grid.

Start by mapping the value chain points and actors using a simple value chain map as shown below. The purpose of this is to forecast, where possible, if there is untapped demand potential at different points in the value chain. Reviewing the value chain will help to identify whether particular inefficiencies need to be addressed before introduction of an ice plant can improve operation. For example, ice is bulky and melts quickly, therefore, insulated ice boxes or storage cases should be available for transport.

Key Steps in Value Chain Analyses

1. Identify value chain to analyse
2. Map out different stages of the chain and how they link to one another
3. Identify actors involved at each stage and their roles
4. Describe the support environment that facilitates business development and operations
5. Indicate existing opportunities that would foster business growth
6. Highlight constraints in the chain that will impact on capacity utilization and explore solutions

Assess the market potential

For each phase of the supply chain, determine current practices in relation to ice purchases.

Key questions to ask if ice is available:

- Who is purchasing ice?

  Ideally, all actors along the value chain will utilize the ice, including fishers, traders, transporters and retailers.

  - Data points required: primary uses, minimum daily sales.

- How much ice do they use daily or weekly?

  This will determine total current usage.

  - Minimum daily production required will depend on the sales of fish and will vary according to season. Calculate a per annum average.

- Where do they purchase ice?

  If already available within a reasonable distance, consider the cost of travel and transport (especially if by boat). This may be offset by an operation closer to the buyers and will assist in assessing the optimal price point for the ice.

- How much does it cost?

  Current price is a good starting point, although may not demonstrate potential demand, especially if the cost is higher than potential customers are willing to pay. Consider the impact on profit margins in fish sales, including using ice and other inputs (e.g. ice boxes).

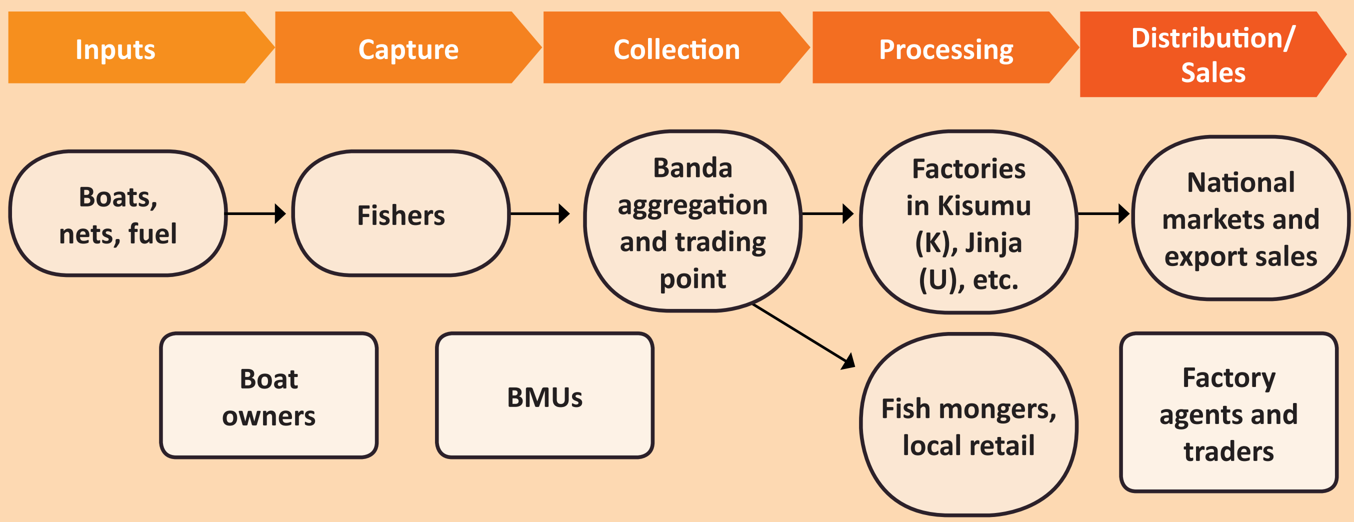


Figure 1: Fishing value chain examples

- Price for ice in Kenya ranges from US$0.08 to US$0.11 per kg, depending on multiple factors, including production costs, location and competition.

Key questions to ask if ice is not available locally and for those who are not using ice (even if available):

- How much fish is captured or harvested per day or week?

  Estimated total catch or harvest is an indicator of the potential market size. Consider the seasonality of capture fisheries and use an average number for the year to calculate quantities.

  - In temperatures above 30°, 3.4kg of ice are needed to chill 10kg of fish.

- If ice is available, why do some people choose not to purchase ice?

  - There could be several reasons for this, besides price. For example, in some fishing communities, the cold chain begins at the aggregation point and traders are seen as responsible for purchasing ice or other cold storage means. This information may reveal an opportunity to provide training to the fishers on cold chain applications and management.

What is the potential market growth? Look at the national, regional and global trends using historical data. Is the demand for fish increasing? Are sales going up? In addition to quantitative data from government and other sources, interviews with people in the business are good sources of qualitative information.

Determine competitiveness

Factors such as price, quality and consistency will determine competitiveness of fish production, which will directly impact ice sales. What are the factors that could increase the cost of production? For example, are fish stocks declining? If so, this could have an impact on the demand for ice in the future.

Data points to be captured:

- annual increase in consumer demand for fish
- current fish production
- current prices for fish
- current price for ice
- quantity of ice being used (usage rate based on volume)
- number of potential users.

Consider incentive programs and other forms of potential subsidy. For example, does the government prioritize fishing as an economic activity? Are there tax breaks and other forms of incentive for those investing in the industry? Find out if there is a development project in the area that could provide support to start up the project – financial or in-kind.

Evaluate current and necessary expertise

Assess whether external expertise will be needed to set up and maintain an ice-making business. Lack of skills for ice-making, training, water testing, appliance engineering, and other related services may be identified. If external sourcing is needed, are there potential partners? If not, can the business absorb the cost of additional staff to cover the skills gaps? Tool 2 contains further information on potential partnerships.

Compare electricity costs

If there is already an ice plant on site, being powered by a diesel generator, compare an ice-making operation with current/other sources of energy. In areas where diesel-powered facilities exist, the costs of conversion will affect the ability of the ice plant operator to switch from diesel power to the min-grid. Refer to Tool 3 for technical considerations and Tool 4 for a plug and play financial modelling tool, where various scenarios can be tested against multiple assumptions. Convincing an entrepreneur to convert an existing plant may require more than a financial argument. Incentives such as introductory tariff and other offers can be effective.

Identify other potential uses

Identify the potential to diversify the use of ice at the relevant location. For example, in the absence of refrigerators and electric freezers, ice can provide a temporary substitute for meat, milk, drinks, and medicine storage. Purchasers may include local shop owners, schools or health facilities. These can serve as additional customers but are unlikely to require the volumes of ice necessary to sustain an ice-making operation on their own.

> To gauge potential market growth, look at the national, regional and global trends using historical data

Assess legal and regulatory requirements

Management and operation of an ice plant

Water permit should be acquired: Section 36 of the Water Act requires issuance of a permit for any use of water from a water resource unless it is for domestic use.

Single Business Permit should be obtained: The County Government Act No. 17 of 2012 mandates county governments to enact by-laws that provide for the levying of Single Business Permit Fees and issuance of Single Business Permits.

Business should be registered: Section 4 of the Registration of Business Names Act requires that every individual or corporation having a place of business in Kenya that does not use its names must be registered. Unless the ice-making business is being conducted by the ice plant owner in his/her own name, that business must be registered.

Construction of the ice plant

The construction of the ice plant will require approvals from various regulators.

Under the Physical Planning Act no. 6 of 1996, the county government is mandated to regulate developments within the county. Section 30 of Physical Planning Act requires that any person who is carrying out developments within a county shall obtain development permissions. Construction of an ice plant would require development approval by the county government.

The National Environmental Management Authority manages the environmental effects of ne developments in line with the National Environmental Management Act. Before the construction of ice plant, the owner requires an Environmental and Social Impact Assessment (ESIA) licence.

Construction must also be registered by the National Construction Authority (NCA) under the National Construction Authority Act.

Health Safety and Health Regulations

In order to comply with hygiene standards, the Occupational Safety and Health Act, Public Health Act and the Food, Drugs and Chemical Substances Act should be reviewed. The Occupational Safety and Health Act provides for application of registration of the premises. The Public Health Act ensures that the public is protected by ensuring that any production premises are maintained in good hygienic conditions and the handlers of food properly certified. The Food, Drugs and Chemical Substances Act regulates the product by ensuring that there is no adulteration.

Kenya Bureau of Standards (KEBS) is the regulatory body tasked with ensuring that goods and services produced in Kenya or imported meet set minimum standards. Section 10 of the Standards Act No 7 of 2004 provides that every commodity being manufactured or processed has to have certified the standards set out by KEBS. Therefore, ice produced by any ice plant must meet the standards issued by KEBS and be approved.

Confirm compatability

- If there is an existing ice plant, can the equipment be powered by the mini-grid?
- Does the mini-grid design consider the energy requirements of the ice-making equipment?

  If the equipment requires a three-phase set up, consider whether the mini-grid can either accommodate for that or can be upgraded in the future. More detail on compatibility is contained within Tool 3 (Technical Considerations).

Ascertain suitability of site

- If there is no existing ice plant, can land be accessed?
- Does the site meet the requirements of the regulators?

Is there access to fresh and clean water? If the fishing villages are near the sea, fresh water access may be a problem, subsequently raising the costs of the ice-making operation and potentially making it non-viable. Beware that local management of water resources is not creating conflict that could be exacerbated by the addition of the PU application.

Determine how far the mini-grid site is from the existing ice plant or proposed new premises. The shorter the distance of the ice plant from the mini-grid site, the lower the cost of power distribution and less power lost in distribution. If the ice plant already exists and the mini-grid is already in place, is the existing operator willing to relocate closer to the mini-grid site? What are the cost implications of relocating and who will cover the cost – ice plant owner or mini-grid developer?

Financial feasibility assessment

At the feasibility stage, a high-level financial assessment should be performed to inform a go/no-go decision on the productive use activity. The objective of this initial feasibility assessment should be to determine whether the product of the PU activity can be offered on terms that are competitive or better than prevailing options.

In the case of the ice-making PU, this can be done by comparing the expected unit production cost of the ice to prevailing market price in the mini-grid community.

The key inputs needed to perform this calculation are as follows:

- **Expected unit production cost:** specifications of ice-making plant including cost, useful life, production capacity per hour and power rating
- **Prevailing market price of ice**

With these inputs, the unit production cost can be estimated using the calculator shown in the table below.

Beware that local management of water resources is not creating conflict that could be exacerbated by the addition of the PU application.

Ref.	Category	Units	Calculation
Ice Production Estimate			
(a)	Ice-plant Useful life	yrs	Input
(b)	Ice-plant Operating Hours	hrs	Input
(c)	Lifetime Operating Hours	hrs/day	(a) x (b) x 365 days
(d)	Production Capacity	kgs/hr	Input
(e)	Lifetime Production	kgs	(c) x (d)
Fixed Cost			
(f)	Machine Cost	$	Input
(g)	Fixed Cost	$/kg	(f) / (e)
Variable Cost			
(h)	Expected energy Tariff	$/kWh	Input
(i)	Ice-plant Power Rating	kW	Input
(j)	Lifetime Energy Consumption	kWh	(i) x (c)
(k)	Lifetime Energy Cost	$	(h) x (j)
(l)	Variable Cost	$/kg	(e) x (k)
Output			
(m)	Unit Production Cost	$/kg	(g) + (l)
(n)	Prevailing Market Price	$/kg	

Table 1: PU Financial Feasibility Calculator

There are two key analyses that can be performed using the calculator:

- Comparative Analysis: calculate unit production cost based on estimate of Expected Tariff and Ice-Plant Operating Hours (a measure of demand)
- Break-even Analysis: goal-seek for Expected Tariff or Ice-Plant Operating Hours (a measure of demand) that results in a unit production cost that is equal to prevailing market price

The Comparative Analysis can be performed if the user has high-confidence in the Expected Tariff or ice-plant operating hours. If the user would like to assess the break-even Tariff or ice-plant operating hours at which the ice-making plant would be feasible from an economic standpoint then the break-even analysis should be performed.

Review capital requirements and availability

Understanding the capital investment needed for undertaking an ice-making enterprise is an important consideration at this stage. This is dependant on the viewpoint of the stakeholder. For a mini-grid developer, the capital investment includes the cost of upgrading the system including generation and distribution infrastructure. For the owner of the ice plant, the primary costs are related to the purchase or conversion of the ice-making equipment. Key considerations in estimating cost should be the power rating of the ice-making plant which in turn should be informed by expected market demand and capacity utilization. Mini-grid developers and owners of the ice plant should also assess the availability of financing options at this stage.

Case Study – Feasibility Checklist

In the case of Developer X in Kenya, following the items in the checklist resulted in a decision to pursue ice making as high potential PU in at least one of their pre-selected sites. Using the checklist enabled the developer to identify areas where further review or attention was needed.

Consult the relevant communities

- Fishing was identified as the primary means of economic activity in the village.
- Community expressed interest in ice making, given the absence of ice or other forms of cooling.
- Differences identified between village leaders and at least one banda regarding ownership. These will need to be addressed and resolved.

Conduct value chain(s) analysis

- Value chain analysis showed important points related to the potential for ice:
- Increasing competition (including imports), signalling that quality will be key.
- Aquaculture's market share is growing, as capture stocks decrease.
- Cold chain investments are considered the role of the traders, hence some training of other value chain actors may be required.

Determine competitiveness

- Sale price of US$ 10 per bag of ice reflects the currently monopolistic nature of the enterprise and provides potential opportunities for new entrants.

Compare electricity costs

- When compared with diesel operation, overall costs of production decrease.

Assess the market potential

- Review of sales statistics, prices and consumption data revealed high demand for fish, with an upward trend.
- Ice is already purchased, when available, in a nearby village.
- Ice operators confirm unmet market demand due to lack of electricity.

Evaluate current and necessary expertise

- Identified lack of expertise in fish production and marketing. Requested technical assistance from the GMG Facility for value chain analysis.
- Recognized limited knowledge of ice making. Pursuing partnership with commercial ice making operator.

Identify other potential uses

- Community survey highlighted other potential users, including restaurants and bars.
- Drinking water lacking; opportunity to integrate water sales into the ice making operation.

Confirm compatibility

- Current infrastructure on site will require upgrading to 3-phase power to accommodate the ice making equipment.
- Company planned upgrades in phase 2 of operations, which may need to be anticipated to pursue ice making as a PU. Additional financial feasibility may be required.

If grid is planned as 3-phase from the beginning, additional costs and marginal and high compatibility is ensured

Assess legal requirements

- ESIA Licence NCA Certificate
- Tariff Approval
- Development Approvals from the county Government
- Registration of the premises under OSHA Act
- Permits under Food, Drugs and Chemical Substances Act and Public Health Act.
- Certification of the products by KEBS

Ascertain suitability of site

- Installed infrastructure within acceptable distance to beach aggregation points.
- Site located near fresh water source.
- Will need to purify water for ice making, in order to meet regulatory requirement.

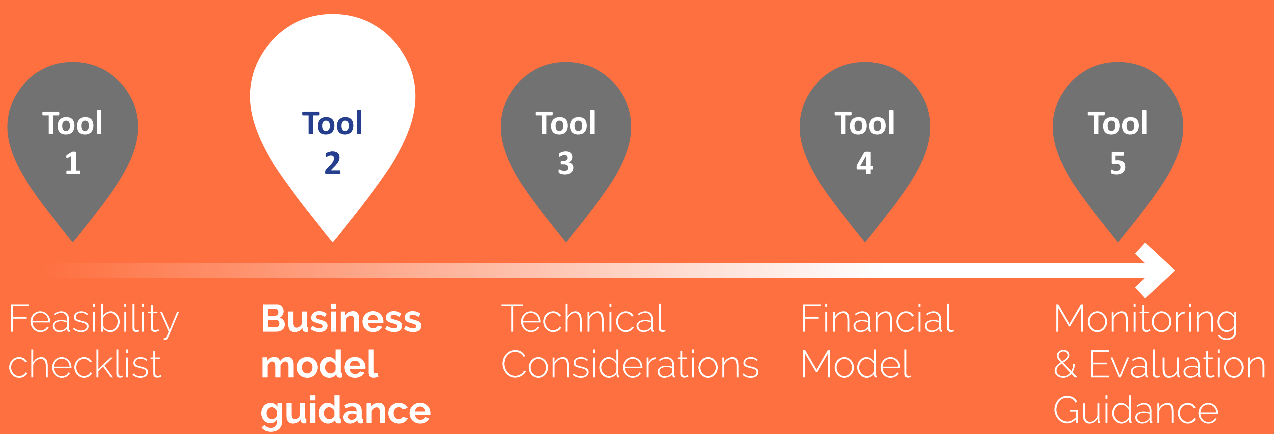
Review capital requirements and availability

- Potential partner already owns ice making equipment. Financing to be sought for costs of start up, transport of equipment to site, installation to mini-grid.
- Additional CAPEX needed to add water purification implements to the equipment.

Financial feasibility assessment

- The break-even analysis indicated that as long as Developer X could offer a Tariff that was below 0.84 $/kWh, the unit production cost of a mini-grid tied ice making plant would remain competitive with the prevailing retail market price of ice in the mini-grid community

Tool 2: Business model guidance



Purpose

Having completed the feasibility checklist in Tool 1 and determined that ice making is a viable and valuable addition to the value chain, the next step is to decide how best to support its implementation and integration into the mini-grid. It is expected that in addition to fish preservation, consistent access to ice can support the emergence of other businesses and improve community services. Providing ice for food preservation, medical facilities, and entertainment establishments, for example, could improve the economic standing and quality of life of a community.

Tool 2 is designed to help practitioners identify the most appropriate business model to integrate ice-making into a mini-grid. If the business model is not appropriate for the conditions and objectives of the mini-grid developer, ice plant owner and the community, the chances of success will be hampered.

There are multiple business models for ice-making in a fishing community. The ones presented here are the most common and readily implemented, but this list is not exhaustive and others may be more appropriate in a given context.

The value chain analysis completed during the feasibility assessment will help with understanding gaps in the value chain at each site. The value chain process also helps to determine if there is excess market demand for ice that will be met by expanding or increasing ice output through capacity upgrades of the ice making equipment.

This tool is designed to help practitioners identify the most appropriate business model to integrate ice-making into a mini-grid.

Common factors and minimum requirements

Regardless of which business model is best suited to the needs and objectives of the enterprise owner or individual community, there are several common elements that will need to be in place prior to integrating the ice-making PU:

1. Community demand and buy-in: since the enterprise will depend on members of the community as customers, it is essential that community demand is confirmed.

2. A credible and reliable partner: an entrepreneur, company, community group or organization interested in establishing and operating the ice making enterprise.

3. Financing: by the mini-grid developer, self-financing from the ice plant owner, an independent financial institution, investor or development partner (e.g. donor, NGO).

4. Ice-making equipment compatible with mini-grid power output. Ideally, the equipment should be energy efficient. (Refer to technical considerations in Tool 3).

5. Convenient location of ice plant and mini-grid: a site to establish the ice plant, preferably convenient to those purchasing the ice (e.g. at the aggregation point or market) and close to mini-grid.

In addition to these common factors, each business model will vary depending on the answer to three main questions:

1. Is there an ice-making facility currently at the site?

2. Is there a potential partner (commercial or non-profit)?

3. Does the community have the capacity and interest in operating an ice-making facility?

Which Ownership Model to Choose

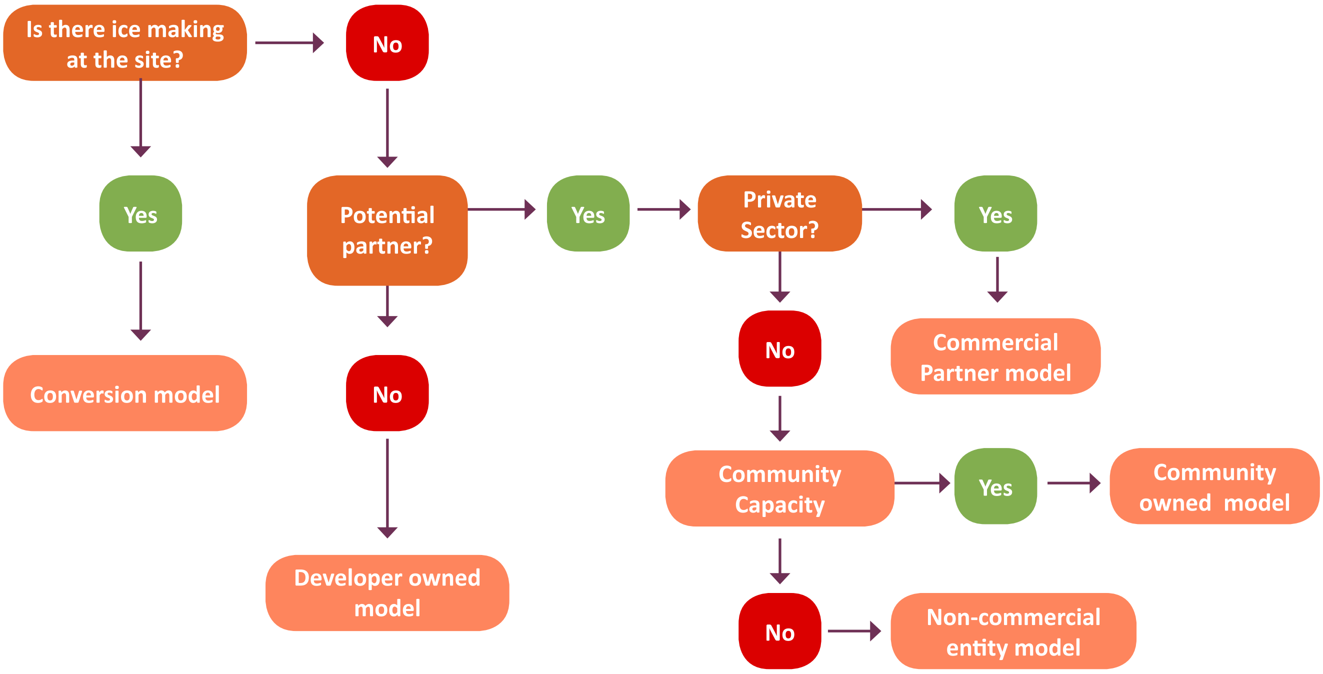


Figure 2: Decision map to determine appropriate business model

If an existing ice making operation is at the site

Conversion model

If the feasibility analysis indicates that ice is already available through an existing enterprise at the mini-grid site, there may be the option to convert the current ice-making equipment from diesel generator powered to mini-grid electricity. The conversion model increases electricity demand for the mini-grid developer, and can also reduce energy costs for the ice plant owner. The success of integrating a more efficient ice plant using this business model will depend on several factors outlined below.

Specific considerations:

1. **Business interest.** Willingness of the existing ice plant owner to integrate into the mini-grid system. This may depend on the cost effectiveness of conversion for the ice plant owner, which may be measured by savings on diesel vs. mini-grid electricity.

2. **Access to finance.** There may be costs of converting equipment and any necessary upgrades that may require external financing.

3. **Appropriate technology.** The conversion model is predicated on the ability to convert existing equipment to allow for mini-grid integration. An evaluation of the machinery should reveal any challenges and provide an opportunity to estimate conversion costs.

4. **Business analysis.** Since the viability of this conversion model depends on the ice-making operation being successful, the ice plant should be carefully assessed.

5. **Site selection.** Distance of the ice plant from the mini-grid site with consideration of demand from households and other businesses.

6. **Mini-grid design.** Capacity of the mini-grid infrastructure to generate single or 3-phase power, depending on the ice making equipment specifications.

7. **Mini-grid capacity.** Capacity of the mini-grid generation plan to generate sufficient power.

If there is no ice making operation at the site

It is likely that the community does not already have an ice-making enterprise and hence there is an opportunity to introduce one. The four ownership models set out below - community owned, developer owned, commercial partner and non-commercial partner ownership models - provide options for how to integrate ice-making into the mini-grid.

Before selecting any partner, thorough due diligence should be conducted. A contractual relationship should be put in place that includes mediation measures for conflict resolution. Several basic practices can help forge strong partnerships:

1. Set out clear expectations and define roles and responsibilities.
2. Consult, engage and be transparent.
3. Share successes and failures.
4. Don't blame and be willing to accept responsibility.
5. Whether the partner is a multinational company or a CBO, act as equals.

Community owned model

The community owned model assumes that an existing community-based entity – an entrepreneur, community group, or association (CBO) – is interested in establishing a new ice production enterprise. This model suggests that the mini-grid developer works closely with the community-based entity to help set up the ice plant and advise on equipment compatibility and energy needs that will be provided by the mini-grid.

Advantages/disadvantages of this model:

- For the mini-grid developer: increases demand on the mini-grid, co-planning with the community produces shared interest. At the same time, may need to provide additional support, including management training and access to finance.
- For the community: ownership of the enterprise increases value and provides revenue. Financial risk of committing to debt payments and ongoing operational expenses.

Specific considerations:

- **Partner selection.** As with any investment, selecting the right entrepreneur organization to work with is important, especially if financing is involved. Pre-determining minimum criteria to help in this decision will remove the temptation to rush to make a less than ideal decision. For example, the entrepreneur/CBO should:
    - Be known to and trusted by the community
    - Have experience in a related business, preferably social enterprise.
    - Be registered as a legal entity or be willing to formalize an existing entity.
    - Have a clean financial record and means to repay the equipment loan.
    - Demonstrated experience/interest in contributing to the community's improvement.
- **Ownership transition.** In the case where the mini-grid developer or other advisory party (e.g. NGO) assists the entrepreneur or CBO by establishing and managing the operation in the start-up phase, a clear ownership transition plan should be agreed and documented. In addition to repayment terms for the capital financing, other factors to consider include profit sharing, valuation and governance before and after the transition.
- **Client relationship.** It is critical to clarify responsibility of all stakeholders through a legally binding contract, since involving multiple players can cause confusion about roles and responsibilities. For example, if an NGO is providing capacity support to the community group, cooperative, or fishers banda, there is opportunity to skirt accountability when problems arise.
- **Community capacity.** If the selected entity is a CBO, community association, self-help group or similar, it is likely that they will need to receive support in governance, management and other capacity strengthening areas. Since these types of groups tend to change leadership often, the more established the group, the less potential problems with continuity, commitment and compliance with agreed terms.

Commercial partner model

Another option in the case where ice is not already available in the fishing community is to partner with a commercial ice production company or related business to bring the activity to the community. An existing aquaculture or fisheries company could be a suitable partner, since they will benefit from producing ice for their own operations and also offer the product to others in the community.

Advantages/disadvantages of this model:

- For the mini-grid developer: increases demand on the mini-grid, and if the partner is an aquaculture company seasonality is no constraint since there is demand for ice all year round. But mini-grid developer does not fully control their customer base and accuracy of demand predictions depends on the partner's projections being fully realised.

- For the community: meets a local need with no community investment requirement, but carries risks of crowding out a potential locally owned enterprise.

Specific considerations:

1. **Access to households.** If partnering with an aquaculture/fisheries company who would own the ice plant, the location of the company's operation should be near a village that generates sufficient demand from households and businesses in addition to the electricity demand from the ice plant. Otherwise, the company will reap benefits from energy access for their ice operation as a stand alone system and the community will not benefit from the integration of the mini-grid in the remote site.

2. **B2B service provision.** As an important customer of the mini-grid developer, the ice production owner may expect a package of technical support or after sale service. Since this may require equipment specialist expertise, if not already contemplated within the business model of the mini-grid developer, any extra expense and resourcing for this will need to be allocated.

3. **Diversion from households.** Although the commercial entity may provide consistent and increased electricity usage for the mini-grid developer, there is a risk of diverting power from other customers, especially individual households. To reduce the risk of overreliance on a single client, the mini-grid developer should seek to connect a diversified client pool, including households and small businesses. Conducting accurate demand assessments will ensure that the mini-grid is sized correctly.

4. **Overload risk.** Industrial use, although desirable in terms of capacity utilization by the mini-grid developer, also has the potential to exceed generation, especially if the PU client is a seasonal or growing business. If the demand on a mini-grid exceeds supply capacity, this will result in a network collapse (black-out), and will therefore need a manual reset. Overload is not an option, and proper design of supply capacity should therefore be sought. See technical considerations in Tool 3.

Non-commercial entity model (government or NGO)

The non-commercial entity model involves the mini-grid developer working with an NGO or other non-commercial entity, such as the government, to set up and operate an ice-making facility to serve the needs of the community.

In many rural communities in Kenya and elsewhere, NGOs and other local support organizations (e.g. faith-based organizations) work regularly with residents on a variety of development initiatives. Their rapport with and knowledge of communities and their energy requirements can be leveraged and assist mini-grid developers to gather more accurate data to inform feasibility studies and collaborate on social inclusive development strategies. NGOs can also be instrumental in training community members, developing appropriate community governance/ management structures for PU applications, providing tools and equipment, and even facilitating financing.

In Kenya, as in other countries, the government invests in commercial activities, including ice-making, cold storage and other infrastructure intended to support a specific industry. In areas where the fisheries sector is important, most of the town markets are built by local governments, though few include cold chain equipment (usually freezers). Involving the government in a mini-grid project targeting ice-making as a PU could be a way to get the enterprise up and running quickly.

Advantages/disadvantages of this model:

- For the mini-grid developer: increases demand on the mini-grid and provides a long-term PU client with project costs potentially offset by the development partner. If a government partner, this may give added legitimacy to the enterprise. But mini-grid developer does not fully control their customer base and accuracy of demand predictions depends on the partner's projections being fully realised. There is also the risk of non-payment or closure by cash strapped government entities / non-sustainable donor programs, and commercial experience of the partner may be limited which could give rise to operational challenges. This can be mitigated through provision of capacity building and outlining roles/expectations clearly from the beginning.

- For the community: meets a local need with no community investment requirement and partner can potentially also provide broader livelihoods support through complementary programs/interventions. But carries risks of crowding out a potential locally owned enterprise and of the ice plant closing if dependent on donor funding (can be mitigated by strategic planning and agreeing an exit strategy in advance).

Specific considerations:

1. **Shared value.** When dealing with another for-profit company, mini-grid developers may often find common ground and familiarity with matters of business procedures. A non-commercial entity may have a different approach, determine value based on divergent criteria or take a more collective method to decision making. Knowledge sharing and trust building can minimize conflict arising from these differences.

2. **Government interference.** Striking a partnership with the government may give added legitimacy to the project, help to unblock bureaucratic delays and reduce risk to the mni-grid developer. Dealing with government can also present challenges in establishing boundaries, delineating clear roles and achieving transparency and accountability.

3. **Monopoly risk.** Helping to establish a commercial enterprise in a community can have the unintended consequence of creating a monopoly and "crowding out" others who could start similar businesses, but did not receive support. When the operator is a government entity, this risk is potentially higher, given the powers of government through policy and practice. For example, while a commercial player can enter the market and compete for customers through pricing or differentiation strategies, if the operator is also the entity responsible for approving business licences and other necessary requirements, this will result in an unfair business environment. Consequently, the government entity can maintain a monopoly position through unfair competition.

Developer owned model

There may be cases where the mini-grid developer may choose to establish the ice plant as a separate line of business. In this case, both the mini-grid utility and the ice plant are owned and operated by the same party, at least initially. For some mini-grid developers, this model may be temporary and provide a catalyst to provide energy to a poor community, with initial demand coming from the ice plant it could be the best way to enable the mini-grid's minimum operational capacity upon commissioning.

Advantages/disadvantages of this model:

- For the mini-grid developer: creates an additional revenue stream, while increasing demand on the mini-grid and giving the mini-grid developer full control over their customer base. Can contribute to improving community relations by demonstrating commitment and market confidence. But is also outside the scope of the mini-grid developer's expertise, and capital costs to establish the ice plant (if borne by the mini-grid developer) may be oppressively high.

- For the community: meets a local need with no community investment requirement. But carries risks of crowding out a potential locally owned enterprise, and of creating dependence on the mini-grid developer for essential services.

Specific considerations:

1. **Legal complexities.** There is no legal limitation on the mini-grid developer on whether or not they can operate other businesses including ice-making. However, whether they can run other businesses depends on their Articles and Memorandum of Association. Most mini-grid developers want to isolate the business of power from any other businesses in order to ring fence it from externalities.

2. **Proof of concept.** Setting up ice plant directly allows the developer to collect data about sales and profitability, which will be useful for future planning of the mini-grid operation. Additionally, where ice making is not already available, attracting potential entrepreneurs and investors to set up a new ice plant can prove more challenging than transferring an existing business.

3. **Financing.** Although a lower cost option to testing the market for ice making, this business model involves setting up an ice plant from scratch, which will require financing, adding to the already high capital costs of setting up the mini-grid infrastructure.

Financing terms

In the event that the machinery and facilities will need to be pre-financed, there are range of financing options:

a. Direct mini-grid developer finance. This involves potentially risking company capital to support an external (and unrelated) business. It can also present an opportunity to co-invest or buy equity in another potentially profitable activity. Decisions regarding terms of payment, guarantee or collateral and other contractual issues will need to be clearly outlined. In Kenya, financing in the form of a loan may have regulatory ramifications, which should be understood before embarking on any financing activity.

b. Third-party financing. Working with a bank, financial institution, or commercial investor to finance the enterprise can present the least risk for the ice plant owner. However, this may not always be an available option, especially with a start-up business, and interest rates may be prohibitively high. Working with the ice plant owner to develop a realistic business plan and presenting the project together can help widen the pool of interested financiers. The most typical financing product offered by a commercial financial institution is asset finance. The main advantage it offers over traditional finance products is that the asset being financed can be used as collateral. This means that businesses do not need to guarantee all of their business and/or personal assets to secure financing. Financial institutions use their existing lending policies and procedures, and standard loan terms, in extending credit facilities for PU equipment. Figure below shows the typical financing terms that are offered for PUs.

Loan Amount Range (KSH)	Tenure	Interest Rate	Deposit	Collateral
10,000 – 100,000	<12	13% + Processing Fee + Credit Life Insurance	30%	Mortgage & registration of equipment Credit guarantee
101,000 – 300,000	<24	13% + Processing Fee + Credit Life Insurance	30%	Mortgage & registration of equipment Credit guarantee
>300,001	<36	13% + Processing Fee + Credit Life Insurance	30%	Mortgage & registration of equipment Any formal collateral

Table 2: Typical financing terms that are offered for PUs

c. Development partner support. For enterprises that seek to achieve community impact by providing a service that improves economic activity, there may be opportunities to attract an impact investor or development funding. Often, funds available can be in the form of soft loans with favourable repayment terms or even grants. Close engagement with the community is essential, as is a well-developed justification for how the community members will directly benefit.

Partner roles and potential alliances

Rural electrification projects often involve many actors, from mini-grid developers and community leaders, to government and financiers. When establishing PU activities, there may be others involved, including commercial companies, entrepreneurs, community groups and NGOs. Identifying and analyzing the project's stakeholders is essential to identify, influence and manage potential supporters and partners, as well as those who may oppose the project.

Non-Government Organizations (NGOs)

Often, the capacity of a community is not in line with the skillset needed to establish businesses that are made possible by the introduction of electricity. Building capacity in the community can help bridge this gap and ultimately boost the demand for commercial services. Since this is normally outside the scope or capability of the mini-grid developer or an ice plant owner, a partnership with a third-party such as an NGO could be beneficial. For example, training fishers and traders on the importance of maintaining a cold chain can improve their business and increase demand for ice. Cross-training on the benefits of ice to support other livelihood activities can leverage the emergence of micro-businesses to increase families' ability to pay for products and services. NGOs also often support community members with low-cost tools, such as ice boxes, to improve their businesses.

Government officials

Whether extension officers from the Fisheries Department, cooperative or social services, government agents are based in the communities and can be extremely helpful in convening, informing and educating members of the community on behalf of the ice plant owner and mini-grid developer. There can also be challenges with time availability, skills and competencies, and costs, given the lack of resources from the public sector. For example, government agents often require transport to move among communities and facilitation fees to attend community meetings or public events organized by the company. Transparency in these transactions should be maintained at all times. A clear code of ethics should also be adopted and all company staff trained.

Beach Management Units (BMU)

Many fishers in Kenya are organized into bandas and BMUs. Therefore, these are ideal organizations to engage in any ice-making activity. Training and awareness raising may be needed among BMU members to inform them of their responsibilities regarding food safety, fish quality and the potential profitability of adherence to an uninterrupted cold chain. Many BMUs have facilities for aggregation, where ice making and other forms of cold store can be located. Some bandas and BMUs expressed interest in operating an ice production plant.

Aquaculture and fisheries companies

As well as being potential customers for the mini-grid developer, fisheries and aquaculture companies can purchase fish caught or farmed by fishing communities, providing them with a reliable market for their product. Aquaculture companies can also experiment with helping smaller fish farmers to access markets by integrating them into their company's supply chain. Both these options create an increased demand for ice, and hence electricity from the mini-grid. The better a mini-grid developer knows the value chain and their part within it, the easier it will be to integrate.

Local banking agents

Financial institutions, such as Equity Bank, Cooperative Bank, and other national and local institutions can play an important role, not only in financing the ice-making enterprise. For example, providing micro-loans to fishers to improve their catch or improve their fish farm can indirectly boost the demand for ice. Moreover, many banking agents also provide financial literacy, credit management and other financial trainings, which build local capacity of community members.

Rural electrification projects often involve many actors, from mini-grid developers and community leaders, to government and financiers.

Community engagement

Both mini-grid developers and communities benefit from increased access to electric power. However, for many mini-grid developers, especially those entering new villages, islands and towns to offer their electrification services, it can be challenging to gather information, navigate bureaucracy, and decipher unwritten norms. Equally, some communities may have negative experiences from previous projects and will be initially sceptical and resistant to new activities.

To ensure the success of the PU activity and the mini-grid, it is best to engage the community from the beginning and draft a Community Inclusion Strategy, to define a set of community best practices so that as the company's presence in the community increases and new people join the project, there are clear guidelines already set out. This will also help in attracting and managing customers after the mini-grid infrastructure is running and businesses and households are connected. Therefore, engagement with the community is not only good practice but good for business.

While it is essential to garner the support of key individuals, including the village chief, BMU, banda and church leaders (where relevant), other business owners and local government officials, mini-grid developers should avoid inadvertently contributing to social exclusion. The practitioner should work with the community to correctly identify their genuine representatives but do not bypass engaging with the community members themselves.

Fishing and aquaculture communities are faced with a variety of socio-economic challenges. Some are intrinsic to their characteristics, including geography (especially remote islands), while others are external, such as fish market dynamics and the price of fuel. Women are particularly at risk, even though they play an important role in the fisheries and aquaculture industry by gathering and drying omena (small fish) and by marketing fish (fresh and cooked) directly to consumers. Different cultures assign different social norms, attitudes and roles to women and men that translate into different tasks within the household, in their communities, and in economic activities. These differences also affect the opportunities that women and men have in all spheres of life, including opportunities that access to energy offers. In order to ensure that these differences are put into consideration when planning and implementing an ice-making PU, the developer is encouraged to use a gender lens throughout the entire process, from design to implementation to operations & maintenance.

Other challenges faced by fishing communities include an ageing population and migration of young people in search of employment, low education and skills including business and marketing, limited access to resources to establish complementary or unrelated enterprises, and a lack of technical skills in fish farming as an alternative to the decreasing capture fisheries.

Generally, community members will be more receptive to ice-making and complementary activities if they feel part of the decision-making processes. It helps to outline the broad opportunities and benefits to the community at large, including employment and income-earning opportunities, both for consumers as well as for those directly employed in operating the equipment.

Best practices

Best practice dictates that community engagement should be systematically integrated into the core business activities of power development projects, especially those that involve land and infrastructure. Special attention to environmental, social and governance issues is particularly relevant in African rural communities because there is often overlap between social, business and work activities. In many communities, informal relationships are key to business success.

Below are tips to effectively engage with fishing and aquaculture communities in authentic, fair and transparent ways during the entire project cycle.

Fishing and aquaculture communities are faced with a variety of socio-economic challenges. Women are particularly at risk, even though they play important roles such as gathering and drying *omena* and marketing fish.

Effectively engaging with communities

DO	DON'T
• Involve all members of the community and listen to their ideas and feedback.	• Arrange meetings at times and in places that are difficult for women to access.
• Conduct separate meetings for women to be able to speak freely.	• Use separate meetings for women to exclude them from participating in broader community meetings with men.
• Communicate the vision for the project and lay out plans clearly and openly.	• Assume that a few representatives will accurately transmit your message to the wider community.
• Adhere to national laws and regulations regarding public participation (see Legal section).	• Raise expectations and make promises that are not achievable within the financial realities of the project.
• Establish an internal community engagement team and feedback mechanisms.	• Stop community engagement efforts after the project is established. Ongoing communication is part of improved management.
• Use techniques including public barazas, key informant interviews, roundtable meetings, focus group discussions.	• Leave verbal agreements to interpretation. Best to document all community meetings and negotiations, and rely on legal contracts for critical and potentially sensitive issues, such as land leases.

Equipment sourcing

Equipment supply is a key challenge for PU financing for mini-grids. To be successfully deployed, PU equipment needs to meet many parameters:

- Accessible for purchase in or near mini-grid communities, many of which are remote rural areas
- Affordable, both in terms of upfront capital expenditures and on-going operating expenditures
- Quality vetted – durable and reliable over time, and often under harsh conditions
- Compatible with mini-grid technical specifications
- Supported by a warranty and after sales service
- Creditworthy suppliers able to receive large asset finance transactions directly

Case Study Tool 2: Ice making commerce

Introduction

Developer X has sites in several lakeside villages and island communities. Their power demand assessment found that current household use would be insufficient for the mini-grid to be commercially viable in the short term. To compensate, Developer X needs additional PU activities that would also utilize their mini-grids. The primary economic activity in the area is fishing and there are several aquaculture farms as well, all needing ice to preserve fish. Therefore, ice making showed high PU potential.

After completing the steps in the feasibility checklist (Tool 1), the viability of ice-making as a PU was confirmed and Developer X decided to pursue this opportunity as a pilot in one island community. Should this prove to be successful and profitable, the company intends to expand it to other sites, with the potential addition of cold store.

Deciding on the ownership model

Using Tool 2, Developer X decided on an ownership model that fits the company's objectives, financial conditions, current commitments and future plans. Starting with the decision map (below), two models were possible:

1. Partnership with a commercial entity
2. Community based model

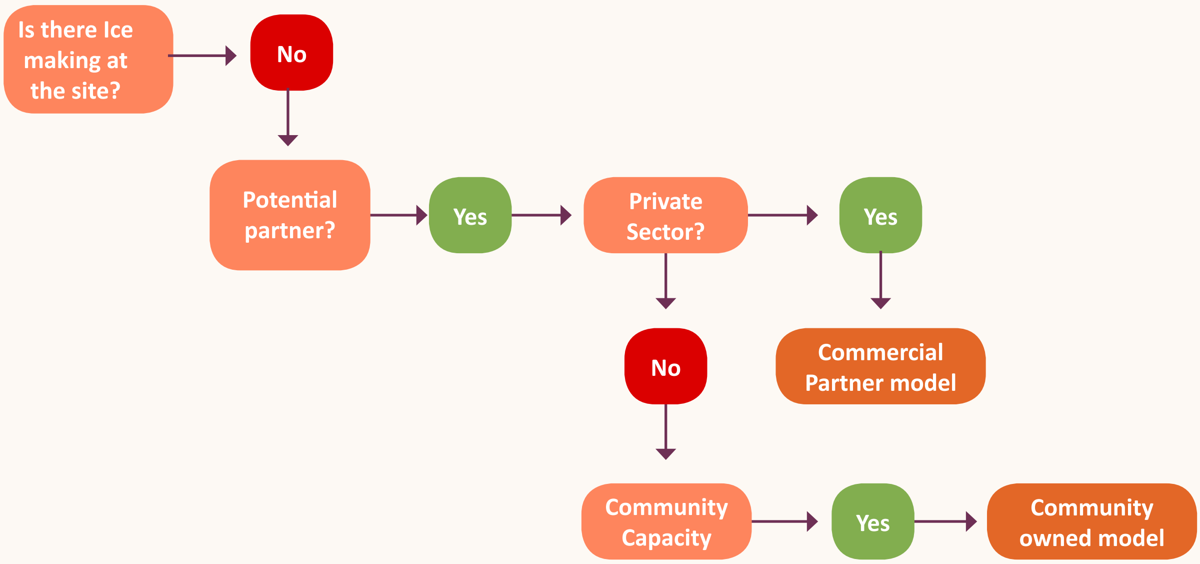


Figure 3: Decision map for determining ownership model

Rating the options

In order to decide which model would be most suitable, Developer X reviewed the advantages and disadvantages of the models, as outlined in Tool 2, and created a rating system to evaluate the two options. Developer X identified a specific commercial partner ("Company X"), an aquaculture company, to deploy the ice-making PU activity on an island community and worked through the rating system with this specific company in mind.

Assessment criteria	Community operated model*	Commercial partner model*
Expertise	2	4
Pre-existing relationship	5	5
Understanding of local market dynamics	0	3
Scaling potential	1	4
Community consultation	3	4
Total	**11**	**20**

*Rating 0-5, with 0 indicating no previous experience/capacity or alignment, and 5 reflecting proven success in this area/ strong alignment.

Table 3: Rating system for determining ownership model

This rating was based on the following considerations:

- Expertise: As Developer X is primarily a project development company, they had a strong preference for a third party to own and operate the ice-making PU.
- Pre-existing relationship: Developer X had previously installed a commercial and industrial scale solar PV system for Company X on an adjoining island and is therefore familiar with the management team and operations.
- Understanding of local market dynamics: Company X is intimately familiar with market dynamics, key actors, gaps and opportunities on the island community where the mini-grid is located.
- Proximity to mini-grid site: Company X's aquaculture farming operations are located on an adjoining island to the mini-grid site which would allow management to efficiently oversee the day-to-day operations of the ice plant.
- Scaling potential: Company X has the long term growth strategy to create a 'hub and spoke' model in which it can provide ice and cold storage to a network of islands. This scaling plan is well aligned with Developer X's planned portfolio of mini-grid sites and therefore presents an opportunity to scale the model beyond one island community, if successful.
- Community consultations: Community based organizations on the island community which are known as Beach Management Units ("BMU") indicated their preference for Company X to own and operate the PU activity. The BMUs have a limited mandate and resources and did not want to take on the financing risk associated with setting up the enterprise

As a result of this assessment Developer X decided that the commercial partner model was more appropriate and had greater potential. By partnering with a company to set up an ice plant on the island, Developer X will help enable fishers and buyers to access a critical input, adding to the economic power of the island and potentially increasing the overall demand for electricity from the mini-grid.

Mitigation measures

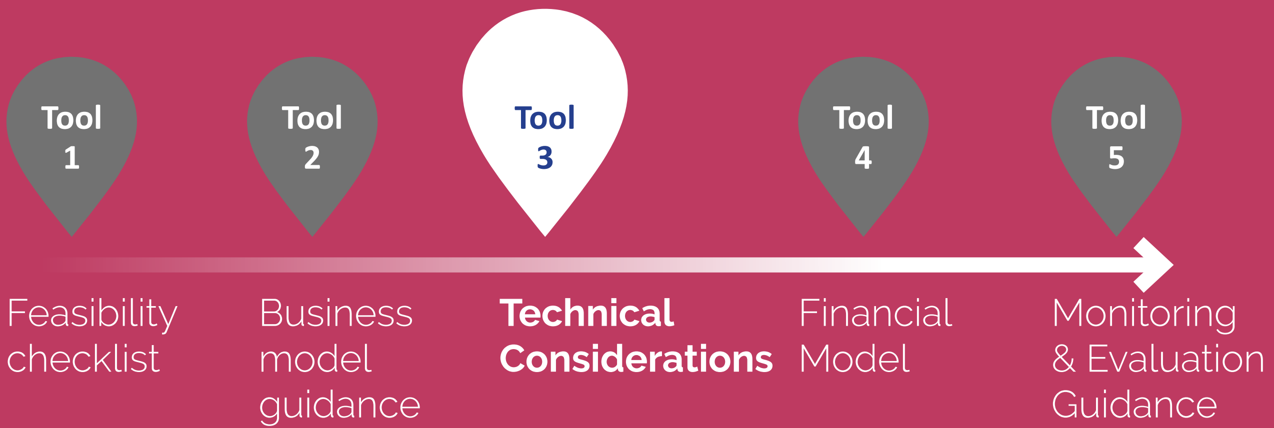
As with any new investment, risk is inevitable. Anticipating these before starting the project and putting in place mitigating measures will increase the chances for success for Developer X. Using Tool 2 Developer X identified the following risks and mitigation strategies.

Risk	Mitigation
Relying too heavily on a single enterprise increases risk to the mini-grid developer.	In addition to the PU, Developer X has projected 200 household connections.
The limited choice of enterprising partner could increase risk to the mini-grid developer, especially if the partner is not aligned with the mini-grid developer's objectives.	Developer X is familiar with the commercial partner, having worked with the company previously. They enlisted TA from the GMG Facility Kenya to conduct due diligence. A legal contract will be drafted, including mediation measures for conflict resolution.

Seasonality of fisheries industry makes accurate estimates difficult.	Developer X used the financial model template (Tool 4) to conduct sensitivity analysis and included ranges in financial projections to allow for fluctuations.
Potential diversion of electric power from households and micro-businesses in favour of larger PU.	Developer X has a target of 200 households and more in a second phase, with planned upgrades to the mini-grid infrastructure.
When the partner is an aquaculture company, access to households can be compromised if not within proximity of the mini-grid.	Company X has agreed to establish a separate ice-making plant, which will serve 100% community customers and not the aquaculture farm.

Table 4: Risk and mitigation strategies identified for Developer X

Tool 3: Technical Considerations



Purpose

This tool provides technical considerations around integrating an ice-making PU with a mini-grid. Sections 1-3 of this tool provide more general guidance around the technical considerations of PUs, with a particular focus on:

- the different types of grids and what needs to be done at the level of the mini-grid or the level of the ice plant to ensure compatibility
- how the mini-grid can best provide sufficient power to meet the demand of the ice plant at all times

Technical Feasibility Checklist

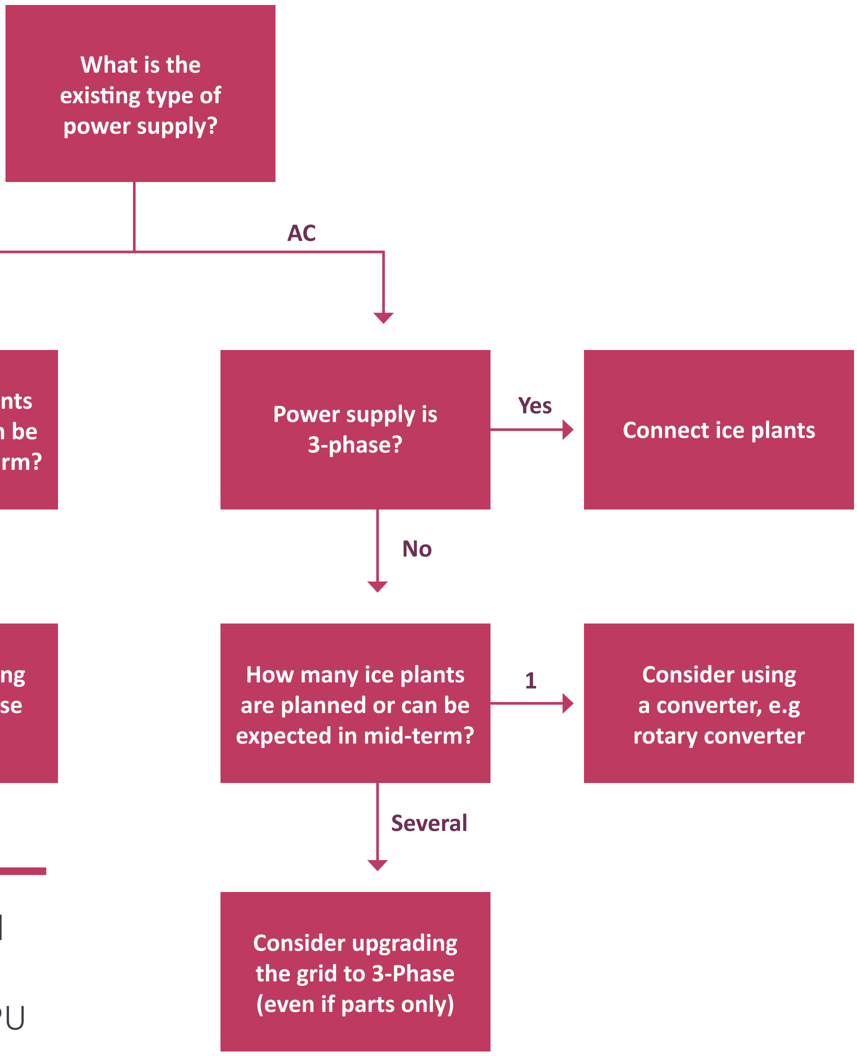
It is recommended that the owner of the business seeks advice from the minigrid developer to confirm that the equipment or technical solution sought are compatible and efficient for the entrepreneur.

Is the mini-grid compatible with the type of power needed for the ice plant?

Middle size commercial ice-making units will typically range from 5kW to 20kW. They all run on AC power and while the smaller ones will run on single phase (typically below 6 kW), larger units will run on 3-phase.

The decision process is as follows, assuming the ice-making equipment requires 3-Phase AC power.

Figure 4: Decision process of ice making equipment compatibility with the mini grid



This tool provides technical considerations around integrating an ice-making PU with a mini-grid.

One should always bear in mind that the most compatible grid network is a 3-phase AC grid. A 3-phase AC grid will become necessary sooner or later as the overall demand increases or if the main grid is interconnected.

One should always bear in mind, that a DC grid can carry less power and less far than an AC grid. If there is a high demand at the end of a long distance (more than a few hundred meters), a DC grid will not be technically feasible because it will cause too much voltage drop through the line.

Retrofit of a single-phase AC grid to 3-phase AC

If mini-grids are operational and are based on a thermal power source such as diesel generators, it is certain that they are operating on AC. A developer may therefore need to think about upgrading the grid to a 3-phase grid.

Single-phase power is delivered through single cables whereas three cables are needed for 3-phase. Therefore, if one wishes to upgrade a grid from single to 3-phase, a retrofit of the complete overhead cabling will be necessary, unless 3-phase cabling was deployed from the beginning, while planning ahead. A 3-phase retrofit can also be done to parts only of a minigrid.

Re-cabling is not necessarily very costly if the same poles can be used to carry the cables, and it is in fact a frequent activity as the power demand increases in villages or towns. If a system is upgraded from single to 3-phase, no upgrade or retrofit needs to be done at the grid connections of the consumers, since 1 single phase can be taken at any point to connect their house or business.

Retrofit of DC grid to AC

If mini-grids are operated on DC power, retrofitting to an AC grid is more complex for the following reasons:

- It must include new cabling and power conversion units
- Connections to users, and therefore user's internal cabling, must also be adapted

In the case of a retrofit, the DC part of the grid should be confined to power production and storage only whereas the AC part of the grid should be used for power supply and consumption: this is the most typical and optimised way of production / storage / supply and consumption of power.

Using individual Converters

If a grid retrofit is not an option because of the incremental cost, or because it is not expected that more than one PU will be connected, it is possible to use converters.

There are ways to convert any type of power to other types, although some conversions are not common. The following points shows the conversion possibilities from the most common to the least common:

- **DC to AC (single or 3-phase):** this can be done using regular inverters. These can either be battery inverters, i.e connected to a single voltage source, or solar inverters which are adapted to the changing voltages of solar panels

- **AC single phase to AC 3-phase:** this can be done using rotary phase converters of variable Frequency Drives (RFD). However more reliability can be obtained directly from a 3-phase source (typically a diesel generator)

A few cost examples for converters are shown below

- 20 kW rotary phase converter ~ 5,000 USD
- 20 kW three phase battery inverter ~10,000 USD

What technical options are available to provide incremental power?

In order to supply enough capacity to account for the ice plant, the options are to either:

- increase the solar array / battery storage or supply an additional diesel generator.

If the PU load is high and / or punctual, the cheapest option will be to install a diesel generator to provide incremental peak power. Although this is not a green option, it can be a solution for short-term increments, until the demand load is sufficient to justify additional infrastructure.

Power delivered by a thermal source such as diesel generators is completely dispatchable, which implies that this source delivers the exact power which is needed by the consumers, obviously up to the maximum power of the generators. Therefore, when planning a conventional mini-grid powered by a generator, the peak load determines the power of the generator to be installed and the rest of the load is automatically supplied.

To bridge the gap between power demand and solar power supply, one can either implement:

- a diesel generator: low in CAPEX but high in OPEX
- a battery bank: high in CAPEX but low in OPEX

The decision path for an ice-making PU is shown below in dark grey. Other types of PU activities could follow the light grey path depending on their consumption patterns.

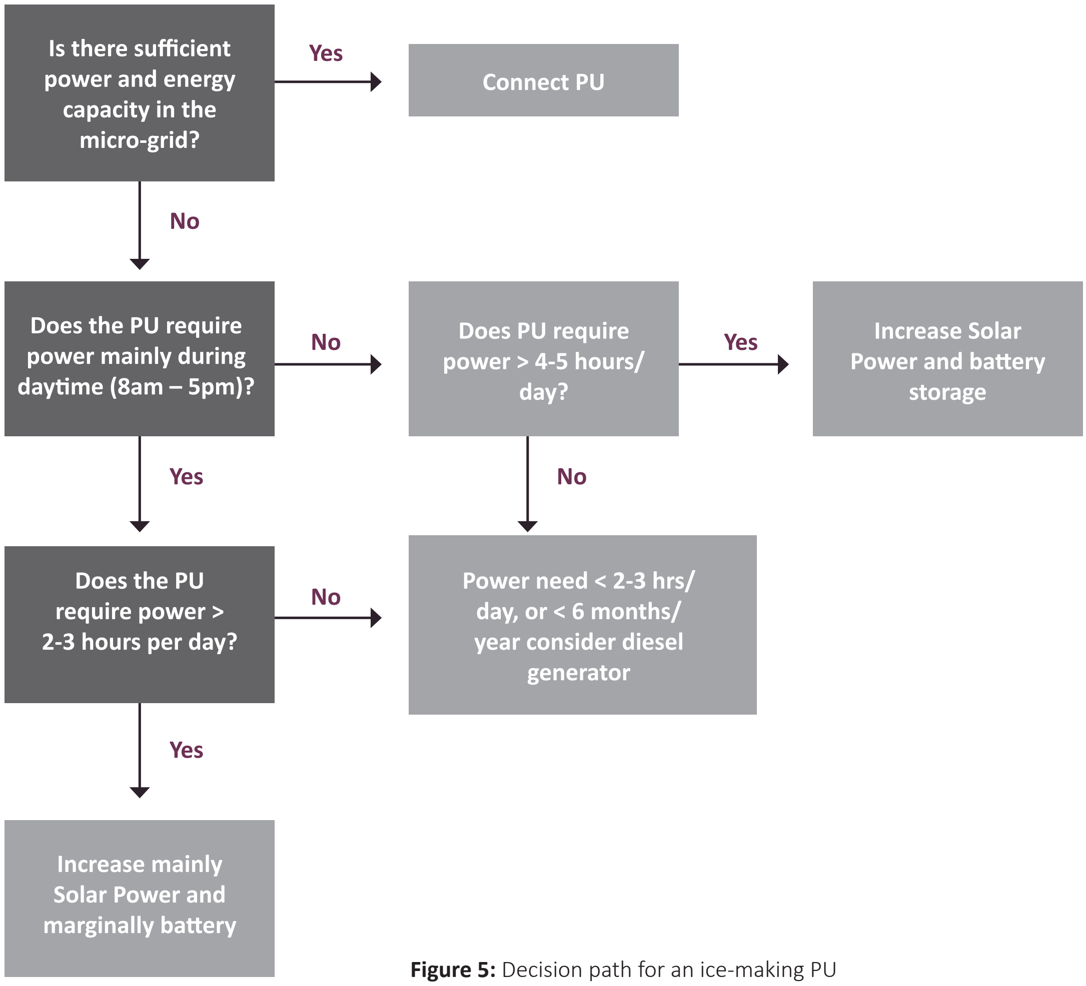


Figure 5: Decision path for an ice-making PU

Punctual vs long energy demand

A solar system provides about 5 full load hours per day: a 20kW solar system will therefore provide on average 100 kWh per day. Since the cost of kWh is mainly determined by the investment costs, the system will not be viable if the 20 kW demand is only during 1 or 2 hours.

On the other hand, the cost of kWh from a diesel generator is principally determined by the operational costs (cost of diesel). Therefore a diesel generator running 1 hour per day will cost 5 times less than one operating 5 hours a day. A diesel generator is therefore optimum for short term incremental energy.

Since the ice making activity requires power for at least half of the day, an additional solar capacity is prefered.

Daytime vs night time energy demand

Solar power is a non-dispatchable source: it does not follow the demand, but rather the solar resource. Most of the solar energy is available when the sun is high, between 10am and 2pm, and there is therefore a mismatch between the maximum supply at midday and the maximum demand in the evening. The production of a 150kW solar system is shown below.

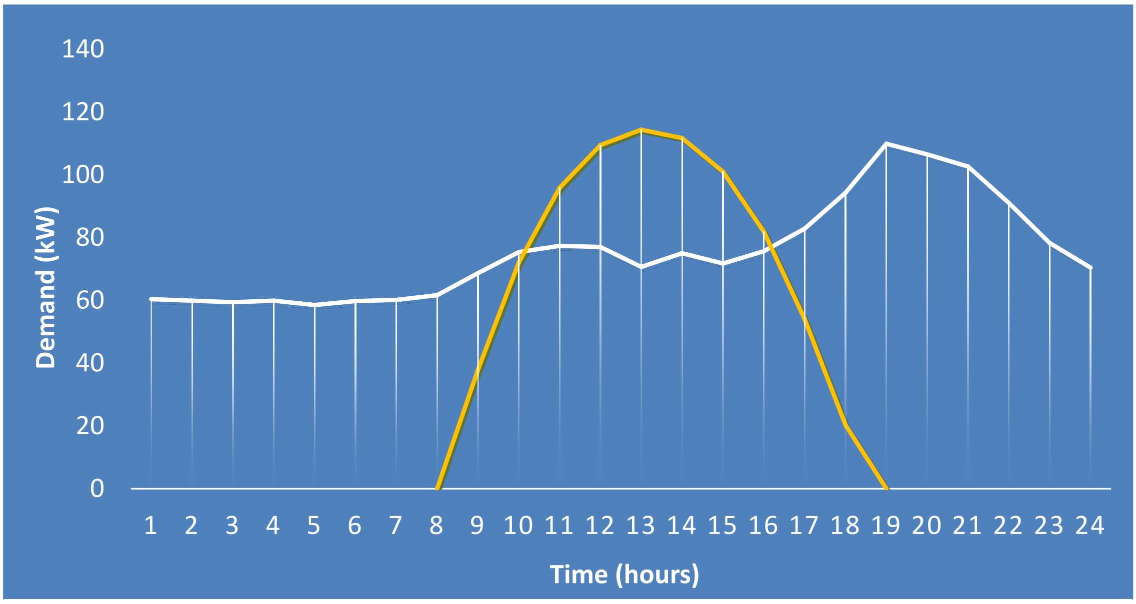


Figure 6: Typical load curve for a small town and production of a PV plant

Since most of the solar energy is available during daytime, even in case of increased demand during the day, a mismatch between demand and supply is not commonly seen during sunlight hours. However, if most of the energy is used during the daytime, the batteries may not be sufficiently charged to cover the evening peak.

The easiest technical way to control the consumption patterns of customers is to use meters which can limit:

- power (expressed in kW): only a certain number of appliances can be used simultaneously and
- energy (expressed in kWh): appliances can be used only a certain duration, until a kWh limit set by the provider.

With the use of smart meters, these parameters can be set remotely and can vary throughout the day or the week.

Again, the easiest way to ensure there will always be sufficient energy in the evening peak, even if the batteries are unloaded is to provide a back-up diesel generator.

A battery bank does not generate energy: it displaces energy stored in times of excess production to time of excess demand. The addition of battery therefore requires incremental solar power in order to account for sufficient energy.

- If the demand of the PU is during daytime hours, there is a good match between demand and supply and therefore a large battery will be needed.
- If the demand of the PU is during evening or night, the energy produced during the day will need to be displaced to the demand time: a large battery bank will be needed.

In the case of ice-making, there is a good match between high power and energy demand, and a use principally during daytime. An increase of solar power is therefore most appropriate only with a minor increment of battery storage.

Case Study: Ice-making Conversion Model for Developer X

Let us assume Developer X has identified a potential entrepreneur wishing to start an ice-making business.

On the mini-grid of Developer X, the daily consumption before the ice plant is around 200 kWh. The ice plant will therefore more than double the overall consumption of the village.

Currently, Developer X's mini-grid has a rated capacity of 15 kW so it will not be able to run the plant. The size of the solar generator will therefore more or less have to double in order to cover the energy demand of the ice plant.

Grid upgrade cost calculation example

If the grid has to be upgraded from DC to 3 phase AC, one should account for about 26,000 USD, on the distribution only, in order to upgrade a 3km single-phase grid to a 3-phase grid as broken down below.

Item	Price
Equipment	
2 x single-phase inverters (if compatible) or 1 x 3-phase inverter	$10,000.00
Electrical equipment at generation (LV Panel)	$5,000.00
Recabling grid into 3-Phase (assuming 3 km)	$3,000.00
Other cabling at consumers level	$3,000.00
Installation	
Mechanical / Electrical installation	$5,000.00
Grand total	**$26,000.00**

Table 5: Grid upgrade cost calculation

Incremental power supply cost calculation example

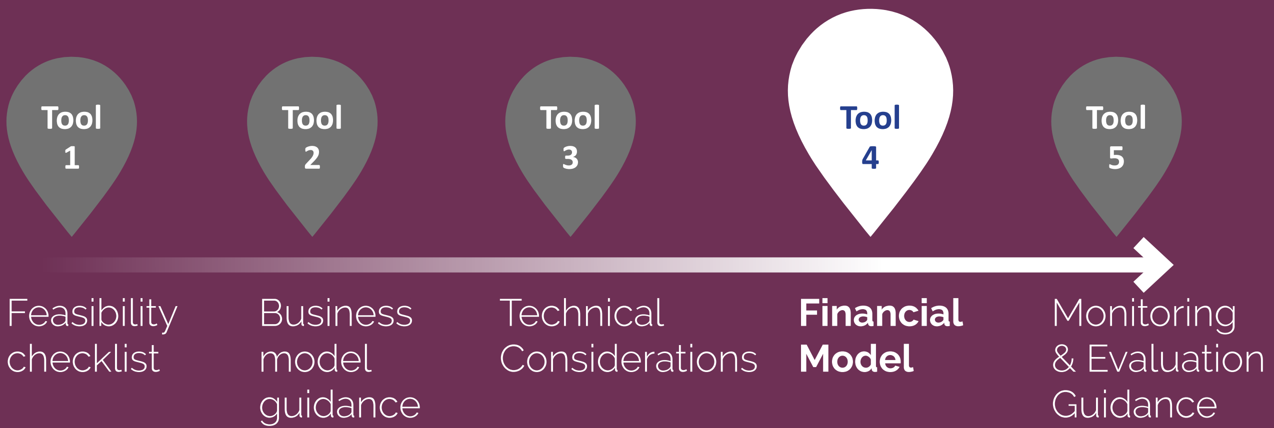
Since the PU requires energy over a long period of time (12 hours per day), it is justified to increase the solar power in order to provide that power. A cost calculation example is presented below.

Item to provide incremental power with Solar	Price
Equipment	
PV Panels and equipment 20kW	$30,000.00
Inverters 20kW	$15,000.00
Batteries 80 kWh	$30,000.00
Other cabling at consumers level	$3,000.00
Mechanical / Electrical installation	$5,000.00
Grand total	**$83,000.00**

Table 6: Incremental power supply cost calculation

‘All costs/prices reflect typical averages, based on experience in the region in similar sized projects’.

Tool 4: Financial Model



Purpose

The purpose of Tool 4 is to assist mini-grid developers and owners of the ice plant such as aquaculture /fisheries companies and CBOs to determine the financial feasibility of ice-making for fish preservation as a PU activity.

Tool 4 is best viewed and understood in its original Microsoft Excel Workbook Format (www.gmgfacilitykenya.org) The tool provides a general overview as well as detailed user instructions and guidance throughout. This written section of the guide should be used as high level reference only to understanding the intent, design and potential applications of Tool 4.

The Financial Model is built from the perspective of both the mini-grid developer and the ice plant owner, with the understanding that the ice-making plant must deliver positive returns to both parties to be a financially feasible enterprise.

Mini-grid Developer's View

The mini-grid developer has to consider the overall economic impact of upgrading the mini-grid system to accommodate the ice plant. This is best reflected in the Levelized Cost of Energy (LCOE) calculation, which is a measure that reflects the overall cost to the mini-grid developer for each unit (expressed in kilowatt hours) of energy produced from the mini-grid system. LCOE is expressed in the following formula:

LCOE = (Capital Expenditures + Present Value of Lifetime Operating Expenditures) / (Lifetime Energy Production)

Furthermore, to evaluate project economics, the mini-grid developer should consider typical investment metrics such as internal rate of return (IRR) and payback period.

The model calculates the LCOE under two default scenarios. The 'Base Case' scenario calculates the LCOE for a mini-grid system without an ice-making plant. Whereas the 'Upgrade Case' scenario calculates the LCOE incorporating the additional investment and energy production to accommodate an ice-making plant.

A decreasing LCOE between the two scenarios is an indication of the positive marginal benefit of adding an ice-making plant to the economics of the mini-grid system. Furthermore, it is noted that the LCOE (with a profit margin for the mini-grid developer) becomes the basis for the Tariff that is paid by the end-user. As such, a decreasing LCOE results in lower electricity bills and therefore cost savings and increased financial returns for the ice plant owner.

This analysis can be performed in the Mini-grid Developer's View Worksheet of the excel model and is organized as follows:

Reference	Calculation
1	LCOE Analysis
2	Key Investment Metrics
3	Cash Flow Analysis
4	Assumptions and Calculations
4.1	Capital Expenditures
4.2	Operating Expenditures
4.3	Energy Production

Table 7: Organisation of online excel worksheets (Developers view)

This tool assists mini-grid developers and owners of the ice plant to determine the financial feasibility of ice-making for fish preservation as a PU activity.

Ice Plant Owner's View

The ice plant owner has to consider the investment, cash flow generation profile and perform sensitivity analysis of key value drivers in assessing the economic viability of the PU activity. The key investment metrics to be assessed are the IRR, net present value (NPV) and payback period.

The model allows the user to build a detailed cash flow forecast, which provides the basis for the calculation of the investment metrics. The cash flow forecast is developed using key financial, commercial and market assumptions related to the operations of the productive use activity.

For a given set of inputs, if the IRR is greater than the cost of capital, NPV is positive, and payback period is within an acceptable range, the ice plant owner should proceed with the project.

The model allows the user to build a detailed cash flow forecast, which provides the basis for the calculation of the investment metrics.

The ice plant owner should assess the impact of changes in key variables such as the retail price for the product or the electricity tariff. The model facilitates this analysis through a sensitivity analysis calculator that shows the impact on the NPV based on changes to the assumed values for key variables..

The model has two default scenarios. The 'Conversion Scenario' refers to the case where the ice plant owner owns/operates an ice-making plant already and is looking to either convert it from diesel to electric or transport it to the mini-grid site from another location. The 'New Enterprise Scenario' refers to the case where an ice plant owner intends to build and operate a new ice-making plant at the mini-grid site.

These analyses can be performed in the Ice Plant Owner's View Worksheet of the excel model and is organized as follows:

Reference	Calculation
1	Key Investment Metrics
2	NPV Sensitivity Analysis
3	Cash Flow Analysis
4	Assumptions and Calculations
4.1	Ice Sales
4.2	Energy Consumption / Ice Production
4.3	Operations & Maintenance (O&M)
4.4	Depreciation
4.5	Interest and Principal Loan Repayments

Table 8: Organisation of online excel worksheets (Ice plant owners view)

Case Study (Developer X and Company X)

The financial model template has been used by Developer X and a commercial partner, Company X, to understand the financial viability of upgrading an existing mini-grid on a Lake Victoria Island to accomodate a new ice plant.

Prior to using the model, both Developer X and Company X agreed to set specifications for proposed ice-making equipment that would be used as the basis for the analysis.

Developer X used the 'Mini-grid Developer View' worksheet to understand the economic impact of integrating the ice-making equipment on its existing mini-grid system by calculating the LCOE (Category 1), Tariff (Category 1) and investment metrics (Category 2) under the 'Base Case' and 'Upgrade Case' Scenarios. To perform this analysis, Developer X estimated the key inputs associated with upgrading the system including system size (Category 4.3), energy production (Category 4.3), operating expense (Category 4.2) and capital expenditures (Category 4.1).

Company X used the 'Ice Plant Owner' worksheet to calculate the return on investment (Category 1) associated with the purchase, installation and operation of a new ice making plant with the agreed upon specifications. The calculations were performed assuming 'New Enterprise' scenario.

Mini-grid Developer View Results

The table below demonstrates the key output of the 'Mini-grid Developer View' worksheet for Developer X. It is noted that the LCOE decreases significantly between the two scenarios indicating the marginal benefit of adding an ice-making plant is greater than the costs associated with upgrading mini-grid system. In mathematical terms, this is due to the magnitude of increase in total energy production being greater than the associated increase in capital and operating expenditures over the lifetime of the mini-grid system. Another significant factor contributing to the lower LCOE is the underutilization of the system in the Base Case due to lower than expected demand. As such, the investment and required increase in system size in the Upgrade Case is lower than would be needed if the existing system were operating at higher utilization.

Furthermore, as the profit margins to the mini-grid developer are assumed to remain the same under both scenarios, the lower LCOE would support a lower electricity Tariff that can be passed on the ice plant owner and other residential and commercial end-users connected to Developer X's mini-grid system.

	Units	Base Case	Upgrade Case
System Size	kW	20	75
Capital Expenditures	$	176,336	415,860
Present Value of Operating Expense	$	51,564	166,179
Total Energy Production	kWh	439,691	1,612,560
LCOE	**$/kWh**	**0.52**	**0.36**
Profit Margin	%	66%	66%
Tarff	**$/kWh**	**$0.86**	**$0.60**

Table 9: Mini grid developer view worksheet for developer X

Ice Plant Owner View Results

The table below demonstrates the key input and output values for Developer X using the worksheet 'Ice Plant Owner View'. The analysis indicated that for a 14.3kW ice-making plant with a production capacity of 3000 kgs / day and approximately 20 hours of usage over 10 year period, the ice plant owner can expect a positive NPV and IRR and should therefore proceed with the investment.

Key Input	Units	New Enterprise
Ice-making Plant Power Rating	kW	14.3
Production Capacity	kgs /day	3000
Utilization	hrs/day	20
Useful life	Years	10
Unit Retail Price	$	0.10
Tariff	$/kWh	0.60

Key Output	Units	New Enterprise
Total Investment	$	40,000
IRR	%	209%
NPV	$	63,401
Payback Period	Years	1.73 years
Annual Production	kgs	300,000
Energy Consumption	kWh	102,960

Table 10: Ice Plant Owner's view for Developer X

The resultant NPV is highly sensitive to changes in two key input variables (i) Tariff (ii) Unit Retail Price. The analysis indicated a negative NPV result in the following combinations of values

Ice Price (($/kg)	0.08	0.10	0.12	0.14	0.16	0.18
Tariff ($/kWh)	>0.6	>0.8	>1.0	>1.1	>1.3	>1.5

Table 11: Analysis of resultant NPV

It should be noted that the cost of power supplied by a diesel generator is lower (0.40 $/kWh) than the prevailing mini-grid tariff. While the mini-grid tariff may be higher than equivalent diesel cost, the PU activity may still be profitable and therefore additional factors need to be taken into consideration:

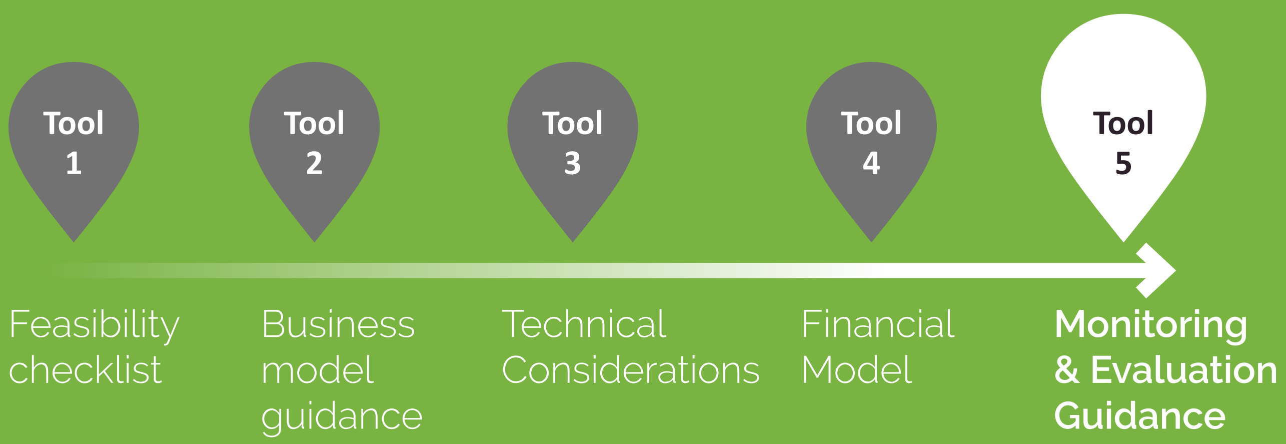
- Reliability: An electric grid may be more reliable in the long-term with fewer outages than diesel-gen set which needs frequent maintenance and exposes the ice plant owner to fuel supply delays / shortages
- Cost savings: For a new enterprise, connecting to the grid can provide upfront cost savings on diesel generation equipment or stand-alone solar PV system
- Operations & maintenance: The operations and maintenance costs of the power supply are borne by the mini-grid developer
- Value-add services: The mini-grid developer needs to ascertain whether they have the capacity to offer the value add services such as capacity building, financing and/or access to inputs/markets to incentivize integration of existing ice-making activities with the mini-grid
- Mission-based motivation: Some PU owners may have a personal preference for selecting a generation source that is eco-friendly.

Mini-grid developers seeking to improve PU load as part of their installed mini-grids can pursue a range of catalytic strategies to encourage ice plant owners to connect to the grid in the first instance including:

- Facilitate access to appropriate financing for the capital expenditure required to purchase an ice plant, by linking with financial institutions or provide credit guarantees to facilitate lending
- Make tariff subsidies to be more competitive with diesel

In many instances, a combination of the above strategies will likely be the most effective for supporting an ice plant owner, however with different combinations and relative emphasis based on the need of the ice plant owner and capacity of the mini-grid developer.

Tool 5: Monitoring & Evaluation Guidance



Purpose

Introducing ice-making into a fishing community can have a number of impacts, in particular income creation for fishers through reduced post-harvest losses and storage of excess catch. However these impacts cannot be assumed to happen; they need to be validated. In addition there may be unexpected outcomes or impacts from introducing ice-making facilities into a community and these also need to be understood.

The purpose of this tool is to provide guidance on how to undertake monitoring and evaluation (M&E) on an ice-making business in a fishing community, introduced as a productive activity attached to a mini-grid. The focus of this tool is on the social impacts of the ice-making business rather than the impact on energy demand / mini-grid profitability, as it is assumed this is tracked using existing business indicators.

Why is M&E important?

This tool should be integrated into a wider M&E strategy that monitors and assesses the impact of the mini-grid as a whole. Having an M&E strategy in place enables accurate and reliable data to be collected and analysed into useful insights, which can enable effective decision-making. It demonstrates accountability to customers, partners and if relevant donors – it is also important for donors to assess the social return on investment. Finally, M&E allows for lessons learnt to be communicated, and ideally shared across the sector to improve quality and innovation in mini-grid business models.

For broader guidance on developing an M&E strategy please see the M&E toolkit developed for mini-grid practitioners by University of Strathclyde, Practical Action and Carbon Trust (2018). https://pureportal.strath.ac.uk/en/persons/aran-eales/publications/

The purpose of this tool is to provide guidance on how to undertake monitoring and evaluation (M&E) on an ice-making business in a fishing community, introduced as a productive activity attached to a mini-grid.

Steps in developing M&E framework

Step 1. Decide what to measure and develop a Theory of Change

A theory of change is a useful tool to think through how and why a desired change is expected to happen in a particular context. A theory of change generally includes four levels:

1. Impact level: What impact(s) do we wish to achieve?
2. Outcome level: What conditions are needed to achieve this(these) impact(s)?
3. Output level: What outputs are needed to achieve these outcomes?
4. Activity level: What activities must be undertaken to achieve these outputs?

Having a theory of change in place provides a clearer picture of desired outcomes/impacts and therefore what should be measured as part of an M&E strategy. Not every possible outcome/impact needs to be measured (nor is this possible), so the theory of change should reflect the social impact priorities of the community, mini-grid developer and partners.

The theory of change should not be static one-off tool but a 'living document' that can be refined as understanding of an intervention's impact increases.

A sample theory of change for Developer X for an ice-making business is outlined in Figure 7.

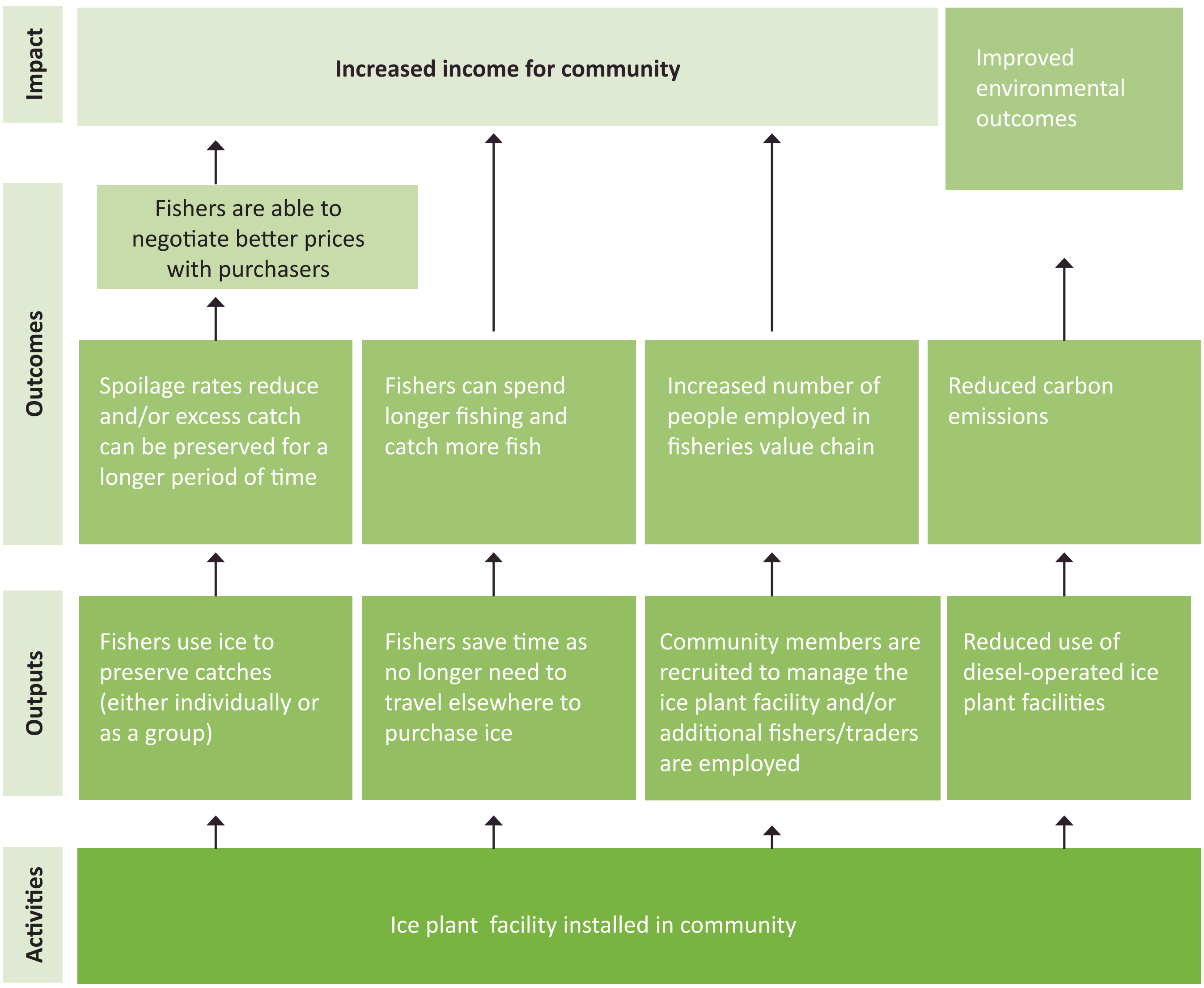


Figure 7: Theory of change

Note this theory of change does not include the outcomes and impacts that may occur due to the emergence of other businesses that take advantage of the ice plant, such as a cool drinks business which may provide additional income for local shop owners. If these are actively desired outcomes they should be included in the theory of change.

Step 2. Develop indicators

Once a theory of change has been developed, the next step is to design indicators. These are used to track and quantify progress of activities linked to outputs, outcomes and impact.

Below is a menu of indicators that can be used to assess outcomes and impacts of an ice-making business. Practitioners can select indicators depending on the context as well as the priorities established in the theory of change, and adapt and expand indicators as needed to create a tailored M&E approach. The closer the indicators are aligned to company-wide Key performance Indicators (KPIs), the easier they will be to track and the more useful they will be.

Outcome/impact to measure	Indicator	Notes
Reduced spoilage – note these indicators are easiest to measure at the beach level rather than the individual fisher/ trader level.	Reduction in % of reject fish	Important to focus on % not quantity since that will vary depending on the quantity of fish caught.
	Reduction in % of low grade fish	This is important to measure since often very low quality fish can be sold locally (and therefore does not classify as 'reject fish'). Note this indicator refers to quality and not fish size, which is often the basis of pricing.
	Reduction in % of fish value loss	This represents the loss in income expressed as percentage of total potential income. It gives a measure of how the lost income compares with the maximum income that would have been obtained if all the fish was kept in the highest grade, and therefore fetched the best price.
Increased incomes of fishers/traders – note these indicators are easiest to measure at the beach level rather than the individual fisher/ trader level.	Increase in % of high grade fish	As fish quality improves with increased usage of ice, existing markets can be grown and better markets (eg export markets) can be accessed which have premium prices. Note this indicator refers to quality and not fish size.
	% increase in revenue for fishers/ traders from fish sales	Measured either by individual fishers or total daily fish income to BMUs.
Increased employment opportunities.	% increase in people involved in fish business	Through tracking number of additional fishers/traders and staff employed to manage the ice plant.
	% increase in number of ice users	While not directly measuring employment opportunities, this indicator is helpful to understand the capacity of business both in ice selling and fish trade.
Reduced carbon emissions and improved environmental outcomes.	Estimated tons of greenhouse gas emissions avoided through use of renewable energy instead of diesel.	Calculation based on litres of diesel consumed before and after ice-making plant was installed (either because original plant was diesel operated or because previously fishers depended on a separate diesel-operated facility).

Table 12: Indicators that can be used to asesss outcomes and impact of an ice making business

Attribution can be difficult with a number of these indicators as there are many factors beyond the introduction of ice that can contribute to the desired outcomes/impacts. However by collecting data against a variety of indicators the attribution link is strengthened.

Being aware of unintended consequences

It is possible that setting up an ice plant has unintended negative consequences. For example:

- it might draw customers away from a nearby ice plant and therefore affect the income and livelihood of those plant owners/operators.
- reduced quantities of 'reject' fish may mean that community members who sell or buy these locally for fried/smoked fish may have less business or have to pay higher prices
- the increased ability to store fish may mean larger catches which could contribute to overfishing
- increased incomes might attract more fishers to the area, which could reduce fish caught per fisher and therefore reduce community income (or offset any income gains from higher prices) or result in overfishing

While it is not possible to set up mechanisms to track these unknown factors in advance, having a robust M&E strategy should mean that there are communication channels and relationships in place to help identify and mitigate any emerging issues. Data collection should ensure people are being asked 'open' questions, not just specific questions designed to track pre-defined indicators: this will give space for responders to articulate any concerns/issues they may have which might not otherwise be captured.

Step 3. Develop tools and process to collect data

Data collection should as far as possible be integrated into existing processes and customer interactions.

Data collection methods

To collect data against the above indicators, the most likely data collection methods are the following:

1. Monitoring basic fish quantity and quality data, either indirectly through reviewing BMU logs if they have captured this information or through direct data collection.
2. Surveys of fishers/traders (to capture income levels, ice usage patterns and fish pricing and to supplement data around fish quality/quantity)
3. Monitoring of data from ice plant (to capture quantity of ice produced, number of ice users)

Data collection should be participatory and done in collaboration with BMUs and other relevant community stakeholders.

Timing of data collection

Data should be collected at regular intervals (eg. quarterly, 6-monthly or annually) to track progress against indicators, with baseline data collection occurring before the installation of the ice plant.

However since fisheries are subject to significant seasonal variations, data taken at a particular time of year might not be comparable to a different season and therefore the timing of data collection should reflect the conditions at the time of the baseline survey and subsequent data collection periods.

Data collection tools

Sample tools for surveys and data monitoring are in Figures 7 and 8.

- Name of site
- Name / job of respondent
- On average how long do you store fish before purchased?
- On average what quantity of fish do you catch/purchase? (kg)
- Indicate the quality of each grade caught/purchased (kgs of each grade)
- What price do you get for each grade? (Ksh/kg)
- On average what quantity of fish you catch is rejected? (kg)
- Do you use ice? (y/n)
- How much do you pay for ice? (ksh/kg)
- How much ice do you use per day? (kg)
- What ice quantity to fish ratio is used? (kg)

Figure 7 - Sample survey for fishers/traders

Landing Beach: ___________________________ **Month:** ___________________________

		Quantity of Fish Landed (Kg)				Price (Ksh/Kg)			
Day	Date	Total Quantity	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C	Total Income
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Note that for this table grading criteria is by quality and not size

Figure 8: Sample data monitoring sheet

Tips on effective surveying

Enumerators need to be able to speak the local language and understand local culture and context. Gaining community trust is essential to ensure accurate information. It is also important to consider having enumerators of both sexes to enable male and female members of the community to feel comfortable.

Consideration should be given to avoiding survey bias when designing the questions. Survey bias can occur by phrasing questions to elicit either a positive or negative reaction from the respondent, often termed 'leading questions'. The key is to keep the phrasing as neutral as possible.

Consideration should be given to sampling strategies. The purpose of sampling is to select individuals for interviews from the total population in the target region in a way that is governed by chance (or at least by clear, transparent purposive sampling), not by the researcher's or enumerator's choice/bias. The resulting randomness of sample selection is important for guaranteeing representativeness of the collected data. It is not always possible to have random samples and where this is the case purposive sampling is another option. Ultimately what is most important is to be transparent and clear about the sampling methodology used and associated constraints, and therefore any disclaimers on conclusions made.

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