Value Chain Energy Mapping

BACKGROUND

A lot of energy is needed to feed the world's population. 30% of the energy used worldwide goes into the production and processing of food from field to table. The vast majority of it comes from fossil fuels, being responsible for over 20% of global greenhouse gas emissions (FAO, 2016). Furthermore postharvest losses in developing countries as a result of poor harvesting, transportation and storage systems are 40% of total production (FAO, 2011a). This does not only affect local economies, but also results in undernourishment. Limited access to electricity is a major impediment to rural development and affected 22.5% of the global rural population in 2016 (World Bank, 2019). In Europe more than 75% of food goes through a cold chain at some point. A 2015 World Health Organization report concluded that 600 million people – almost 1 in 10 worldwide – fall ill after eating contaminated food and 420,000 die every year. The consequences of food loss are far beyond hunger, farmer poverty and inflated food prices. Post-harvest food loss occupies a land area almost twice the size of Australia, consumes 250km3 of water per year, three times the volume of Lake Geneva; and emits 3.3 billion tonnes of CO_2, making it the third biggest emitter after the US and China[i].

The world's population continues to grow, and with it the need for food and for energy to produce it. At the same time millions of farmers and processors in developing countries and emerging economies lack access to modern and clean energy technologies. Energy limitations in turn prevent the deployment of production and processing technologies that could rapidly improve agricultural productivity, increase value addition and reduce post-harvest losses (FAO & USAID 2015).

- Irrigated crops for instance ensure far higher (on average double) and reliable yields than rain-fed crops. Irrigation allows for additional harvest per year, too (FAO, 2011b). Solar pumping for irrigation in turn has significantly lower operating expenses than diesel pumping.
- The shelf-life of most vegetables increases dramatically when their storage temperature is reduced from 30°C to 10°C ambient (FAO & USAID, 2015). An autonomous solar system might be a more viable investment than a grid connection plagued with frequent power outages
- Wood consumption for boilers in a processing facility leads the deforestation and greenhouse gas emissions. Optimizing the boiler system to improve insulation and capture process heat or switching to biogas or crop waste combustion could reduce reliance on wood fuel.

OBJECTIVE

An Energy Mapping approach was developed based on the ValueLinks[ii] Methodology. The objective is to allow development practitioners to obtain an overview of what forms of energy for which processes are utilized during each value chain step. This overview enables an understanding of energy access, energy intensity and the potential for energy-related interventions.

DESCRIPTION OF METHOD

This method allows you to quickly map the state of the art of an agricultural value chain from an energy point of view. You identify what type of energy is used for which activity or process. In addition, you detect energy sources in the value chain. Based on this information you will be able to assess options for making the value chain energy smart through introducing renewable technologies and/or energy efficiency measures.

PROCESS STEPS

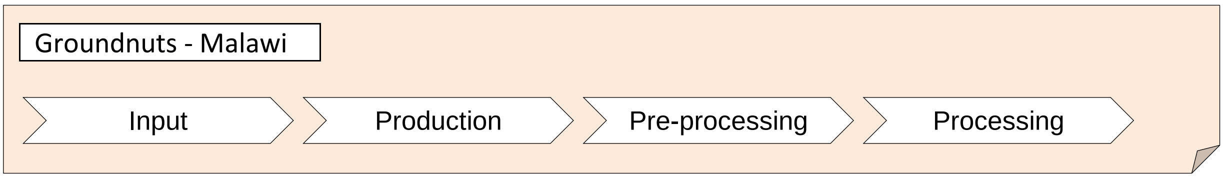
I: Map the current situation

1. **Identify a value chain** (VC)
   Clarify which value chain is being assessed (rice, poultry, fruits, dairy, etc) and what is the geographic focus (national, regional, provincial, individual case, etc.).

   Groundnuts – Malawi

2. **Identify relevant VC step** (e.g. Input, production, transport, pre-processing, storage, value-added processing, transport and logistics, marketing and distribution, end user).

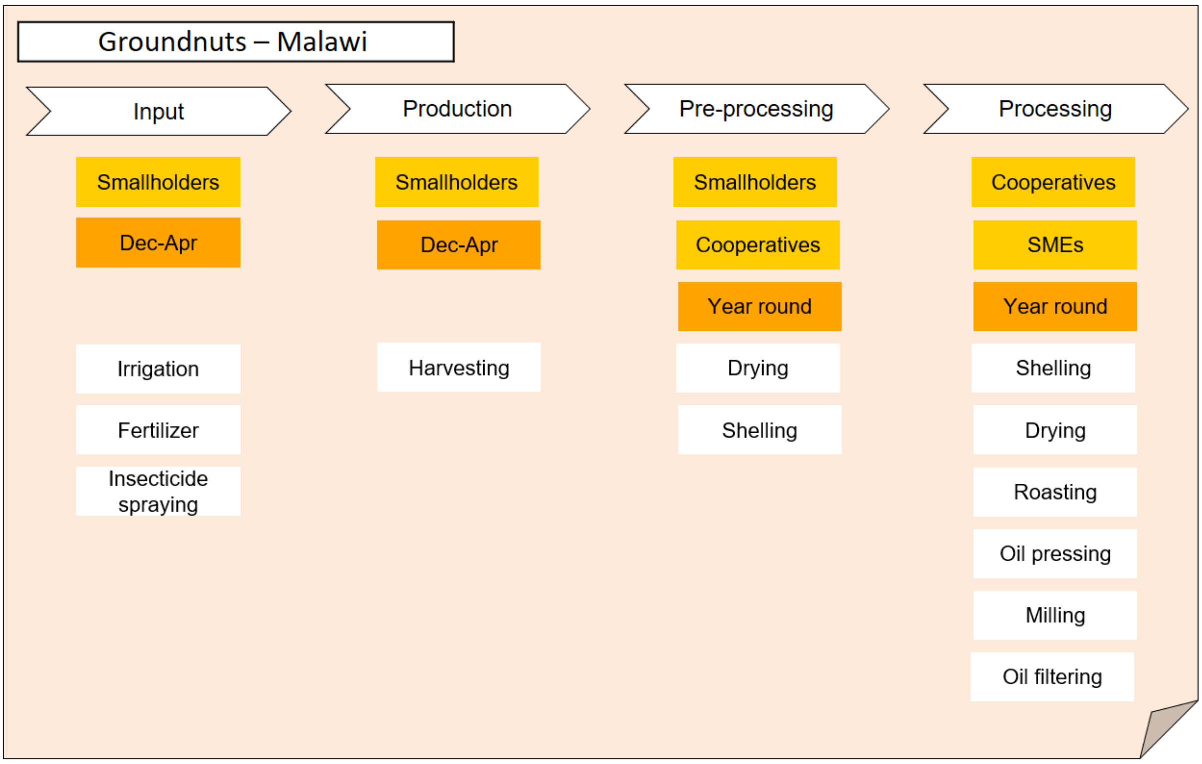
    a. Each VC step is one column
    b. Document VC step on a --> white, arrow shaped card: 



3. **Identify activities** happening at each VC step.
Review the work effort required at each value step with specific emphasis on technology deployed.

    List these activities in sequence in order to illustrate the work steps.

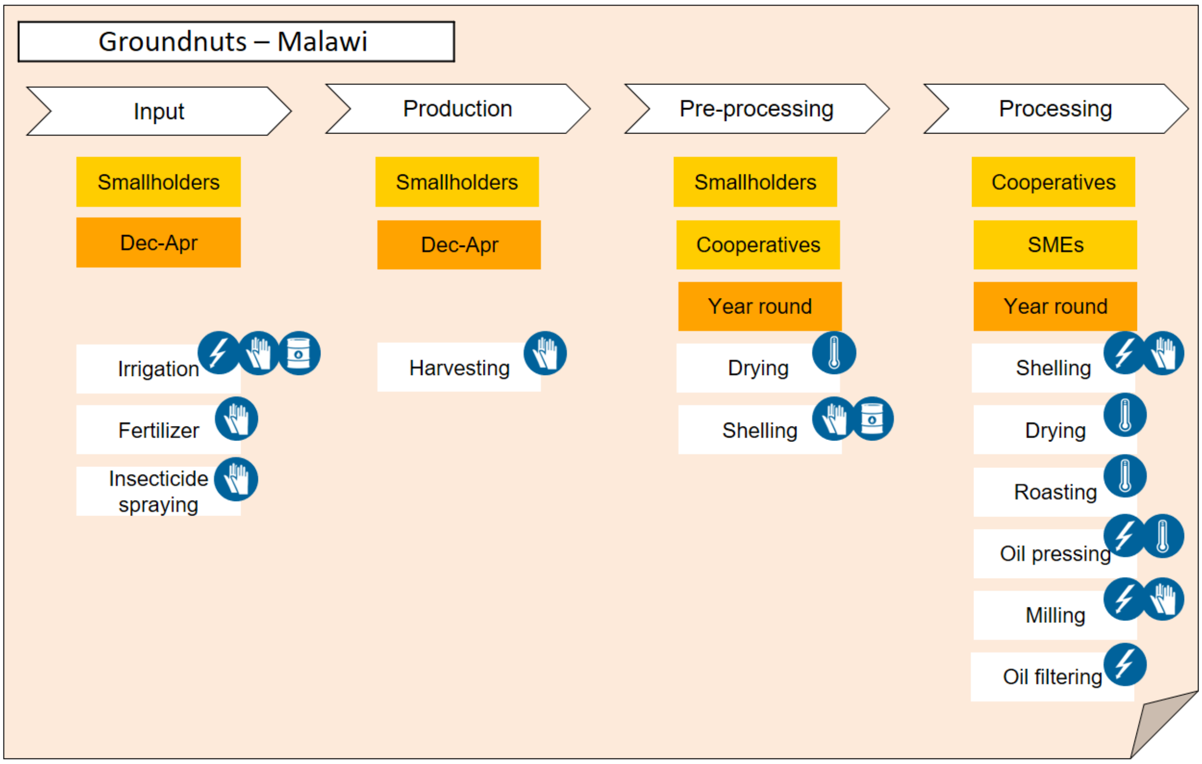
    a. who is doing the activities in each step (e.g. farmer, cooperative, trader, small processor) --> rectangular yellow card.
    Note: where certain activities in a step are outsourced to service providers or performed by other specialists, note this next to the activity
    b. When does each activity take place? (e.g. every day, in Sept after harvest) --> rectangular orange card
    c. each activity (e.g. irrigation, tillage, grinding, packaging) and device or method (e.g. irriga-tion: diesel pump; shelling: electric dehuller, drying: direct sun on floor --> rectangular white card



Groundnuts – Malawi
Input
Production
Pre-processing
Processing
Smallholders
Dec-Apr
Irrigation
Fertilizer
Insecticide spraying
Smallholders
Dec-Apr
Harvesting
Smallholders
Cooperatives
Year round
Drying
Shelling
Cooperatives
SMEs
Year round
Shelling
Drying
Roasting
Oil pressing
Milling
Oil filtering

4. **Determine type(s) of energy** that is directly used at each activity (electricity, heat, manual, fuel) with blue circles by using icons as below

Note: depending on the resolution of the assessment you might need to use multiple cards



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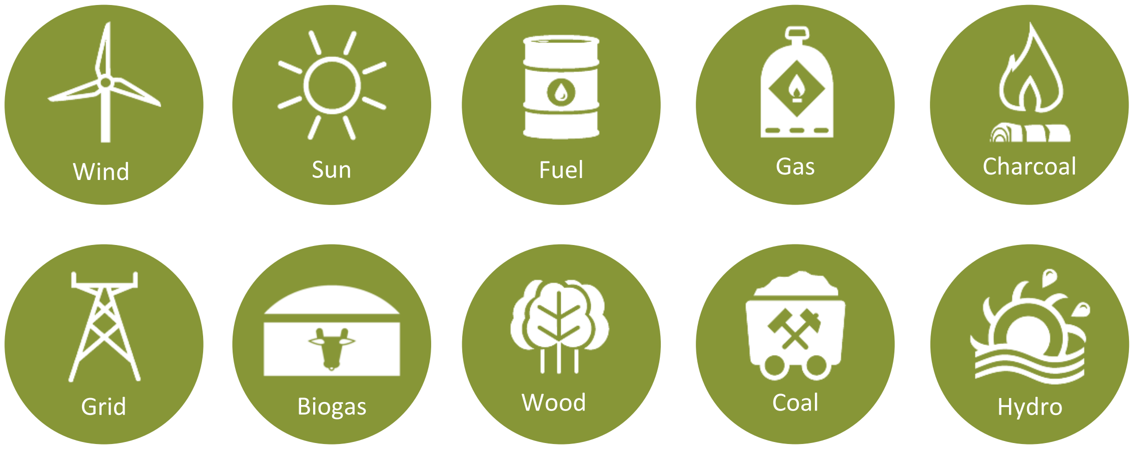
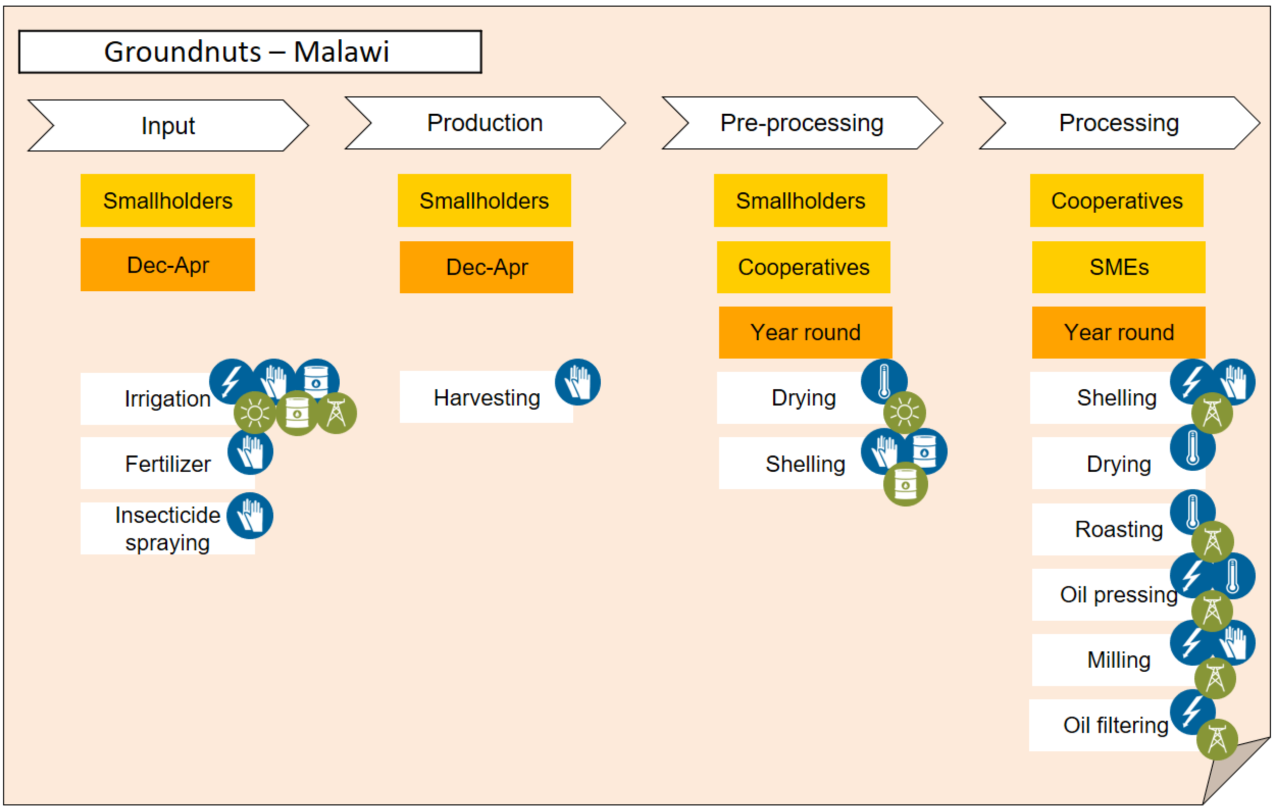
5. **Determine energy source:** Put icons (or words) on green circles which source the energy is from [iii]



Note: depending on the resolution of the assessment you might need to use multiple cards)



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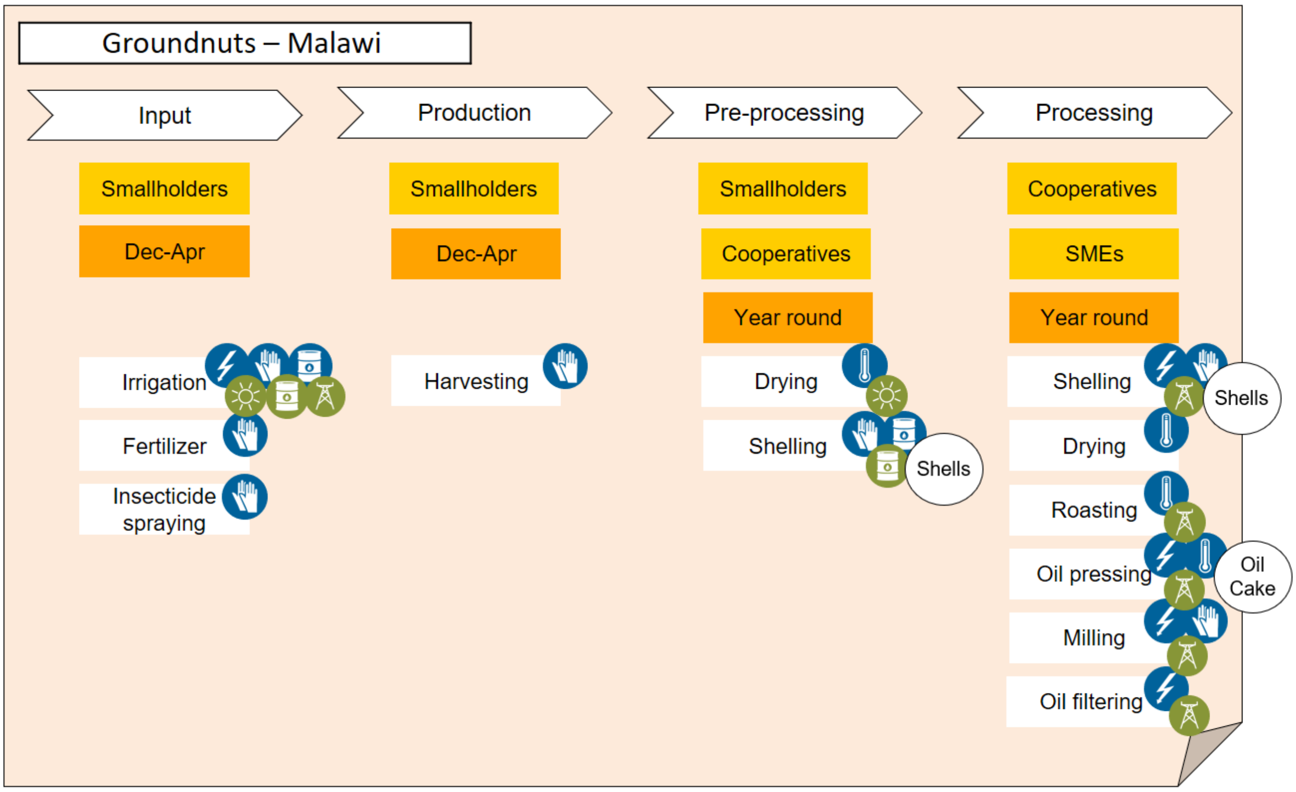
6. Is there an untapped energy source as a result of production (e.g. biomass, biogas, process heat) --> use white circles to indicate!



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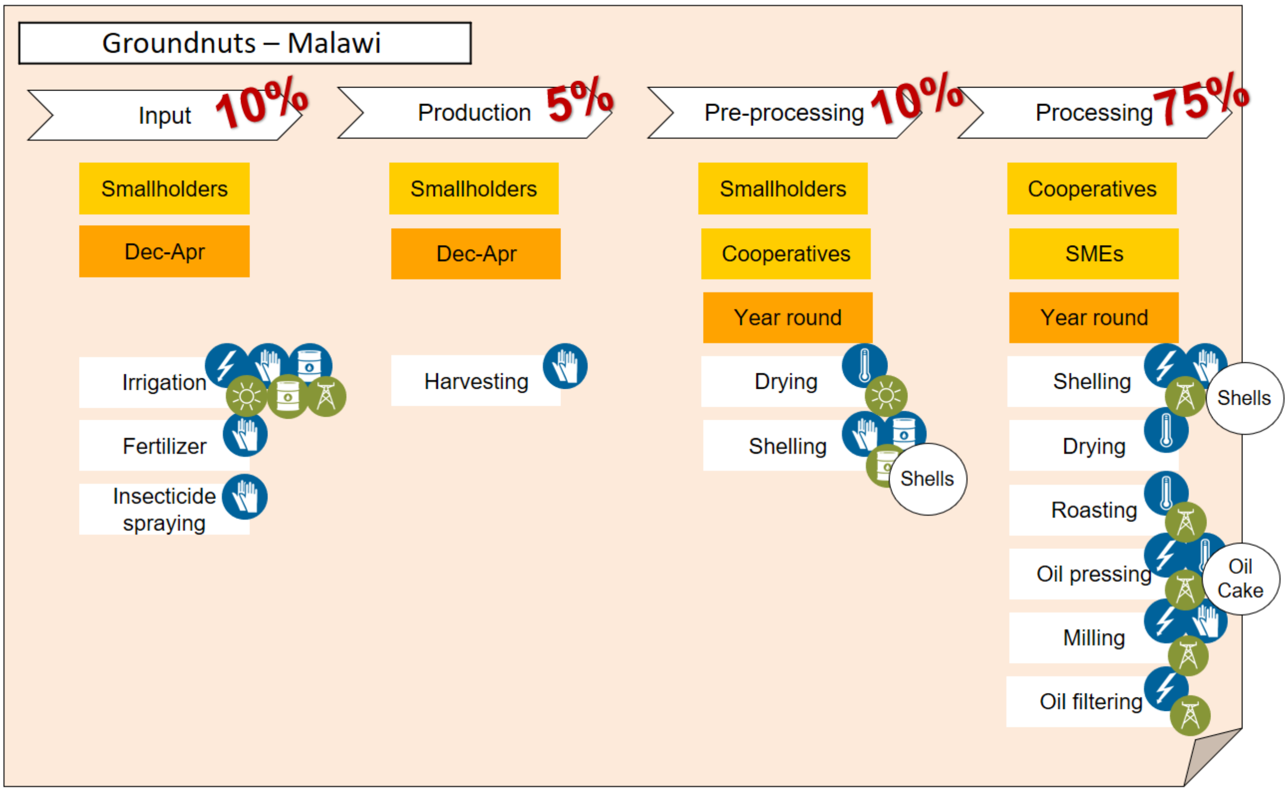
7. Do an estimate: how is the energy demand (%) distributed across **VC steps**? This estimate serves only to indicate levels of energy intensity across the value chain. Assuming that 100% of energy is used across the value chain, what percentage proportion is used at each VC step?



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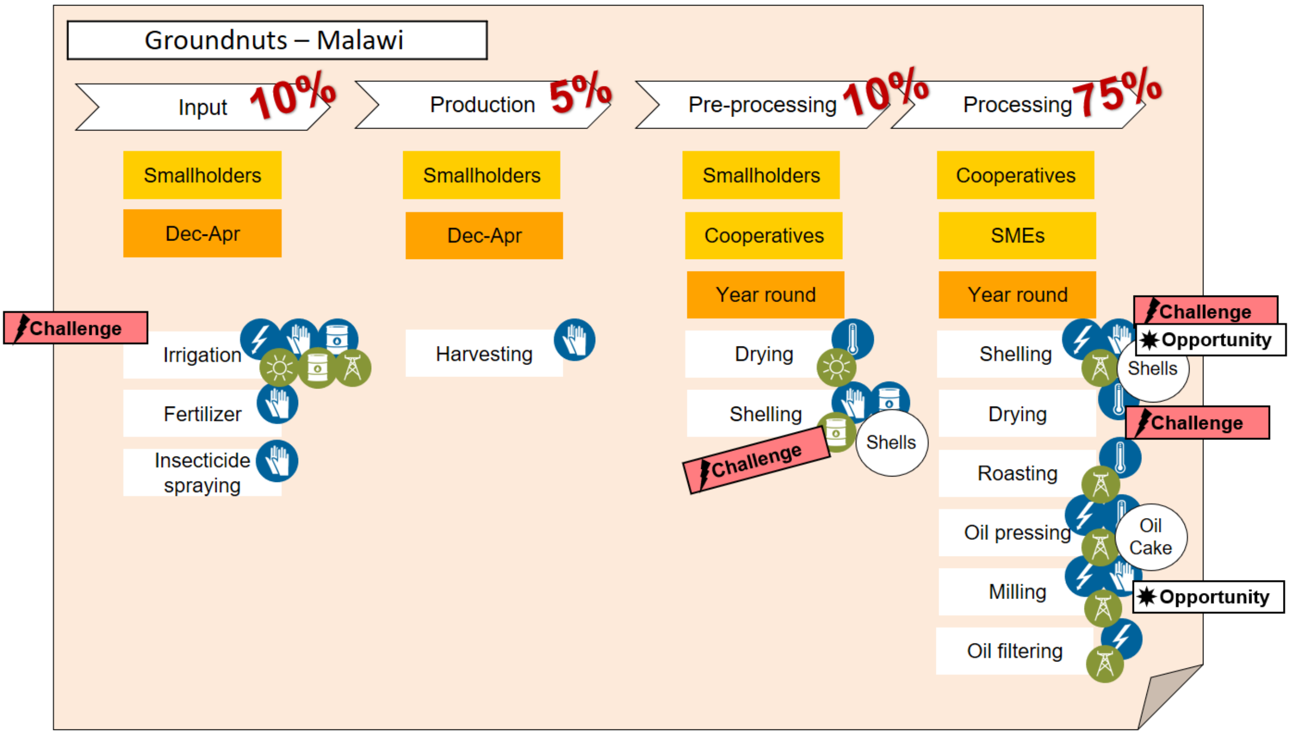
II: Barrier and opportunity analysis of the mapped VC

Use [Challenge] to document key constraints/challenges for the VC from an energy point of view (e.g. energy reliability factor, development stage of technology, prices, input/output ratios, production rates…)

Use this card to indicate opportunities along the VC: [Opportunity]



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III: Data refinement

This step is for an advanced, more detailed analysis. It allows for assessing technical complexities, productivity rates and financial viabilities of alternatives. Values are added to the color cards and may include:

a) **Input/output ratio**: the amount of raw material required to operate a machine and the respective output of a value added product. Example: x kg of fruit (input) to produce y liters of undiluted fruit juice (output).
b) **Input and output costs**: Cost of a quantity of raw material and value of the resulting value added product. Example: $/kg of fruit to produce fruit juice at a value of $/liter
c) **Appliance energy demand**: Amount of energy an appliance requires to operate, usually measured in kilowatts (kW) or horse power (HP). The technical specifications are usually displayed on the equipment. Example: a cassava grinder requires 3 HP (conversion: 1 HP = 0.746 kW) to operate
d) **Appliance energy consumption**: Amount of energy an appliance would use over time. This is determined by the daily, weekly or monthly average operating times and measured in kilowatthours (kWh) or horse power hours (HPhrs). Example: a 3 HP cassava grinder operates for three hours daily, five days per week and four days per month (3hrs x 5 days x 4 weeks = 60hrs per month), thus consuming 180 HPhrs (60hrs x 3HP)
e) **Appliance cost**: The cost for procuring equipment or estimated value
f) **Appliance operating costs**: The cost of operating an appliance over time. This monetary value combines for instance annual fuel expenditures and repair and replacement costs
g) **Appliance space requirement**: estimated in m^2 or similar area units this shows the physical footprint of an appliance. This would also include the energy infrastructure necessary to operate an appliance. Example: a 3kW solar water pump would require a solar panel area of about $20m^2$

V: Reflect on your VC – develop a future scenario

These questions might be of help

- SWOT: What are the VCs' weaknesses, strengths, opportunities and threats from an energy point of view?
- What do you want to improve for whom? (e.g. productivity, reduce food losses, improve quality, less GHG, more income, etc)?
- Are there quick wins/low hanging fruits?
- Who is lacking what? Who offers what?
- How to best tackle the needs/constraints and opportunities? (e.g. technology, capacity, awareness, frame conditions, capital, etc)?
- With whom do you have to get engaged to improve the VC?
- Where RE or EE can come into play?

ANNEX

Description of Icons

Icon	Description
ELECTRICITY	Electrically-operated appliances connected to an electrical power source like the grid, a solar system or diesel generator. Electricity is used to operate electric motors for numerous applications such as grinding, milling, pumping, dehulling. **Note**: if electricity is used to produce heat (an inefficient process), this icon does not apply
MANUAL	Manually operated appliances. These may include hand or treadle pumps, manual grinding or pounding, using a crank or winder to rotate a machine or basic shelling by hand. This would also include animal traction or animal-powered mechanization such as plows and threshing, but also animal-drawn carts for transportation.
FUEL	Liquid fuel powered appliances using an internal combustion engine. This includes tractors and power-take-off (PTO) appliances, appliances operated via a V-belt, drive belt or pulley system connected to a stationary engine. **Note**: if liquid fuel is used to produce electricity to power electric appliances, or simply burnt to produce heat, this icon does not apply.
HEAT	Appliances that require a direct heat source to operate. This includes boilers operated with wood fuel or fuel oil. Appliances may also be use electricity for heating as is used for smaller boilers, steam irons, hot presses or extrusion processes.
WIND	Energy harnessed from wind. This includes electrical wind turbines and chargers for electricity generation and mechanical wind systems like piston-type wind pumps. Icon applies to small stand-alone units or isolated mini-grids.
SUN	Energy harnessed from the Sun. This includes electrical photovoltaic (PV) systems (mono-crystalline, ply-crystalline, thin film) for electricity generation and solar thermal systems, like solar water heaters, concentrated solar power (trough, parabolic dish or linear fresnel reflectors), solar dryers. Icon applies to small stand-alone units or isolated mini-grids.
COAL	Energy from fossilized coal. Coal (lignite, anthracite) as a combustion fuel for boilers, smelters and other heating systems. Usually extracted through mining and requires minimal refinement processes.
GAS	Energy from fossilized natural gas. This includes butane, propane, liquefied petroleum gas (LPG). Usually extracted through venting and associated with oil fields. Requires purification and refinement.
CHARCOAL	Energy from charred wood fuel. Charcoal is produced through oxygen starved combustion (slow pyrolysis) of wood in kilns, which removes moisture and volatiles. Charcoal burns at higher temperatures and gives off less smoke than burning wood directly. Production is mostly local and charcoal is widely available.
FUEL	Energy from fossilized oil. Oil and petroleum derivatives. This would include Diesel, petrol, gasoline, aviation gas, heavy fuel oil. Usually extracted through deep well pumping and requires several refinement processes.

HYDRO

Energy harnessed from flowing water. Water is channeled across a turbine, which turns a generator to produce electricity. Small run-of-the-river systems are typically used for smaller loads and village electrification, while large hydroelectric dams produce electricity for the national grid

Note: This icon applies to mini-grid or captive load applications (power generation directly by end user). In the case of a grid connected hydropower supplying power to the national grid, this icon does not apply

GRID

Electrical energy from a national or regional utility. Electricity is produced from a mix of generation options and transferred over transmission and distribution lines to industrial, commercial and residential clients. Electricity consumption is usually metered and regularly invoiced by the utility. **Note**: this icon does not apply to island systems, isolated mini-grids or captive loads (power generation directly by end user)

BIOGAS

Energy from organic waste products. Primary form is methane gas produced due to fermentation of organic materials. Gas can be ignited directly for cooking or boiling applications or used in an internal combustion engine to drive a generator to produce electricity.

WOOD

Energy released during the combustion of wood fuel or crop residue (e.g. rice husks). This also includes wood gasification through pyrolysis. Wood fuel can be ignited directly for drying, cooking, boiling or smoking applications or combusted in a gasification chamber to produce wood gas (for subsequent burning in an internal combustion engine to drive an electric generator)

References

FAO (2002): Crops and Drop. Making the Best Use of Water for Agriculture. Rome. Online available via http://www.fao.org/3/Y3918E/y3918e00.htm#TopOfPage

FAO (2011a): Global food losses and food waste – Extent, causes and prevention. Rome. Online available via http://www.fao.org/3/mb060e/mb060e.pdf (last accessed 18.03.2019)

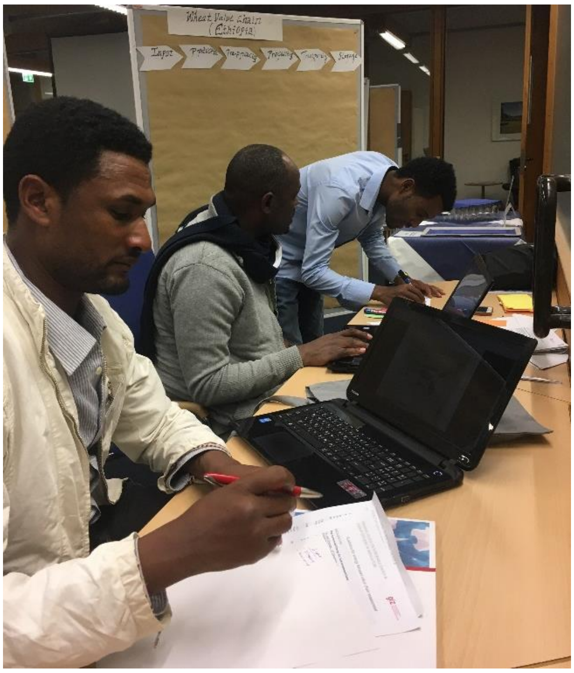
FAO (2011b): Save and grow – a policy maker's guide to the sustainable intensification of smallholder crop production. Plant Production and Protection Division, Food and Agricultural Organization of the United Nations, Rome.

FAO (2016): The state of food and agriculture: Climate change, Agriculture and food security. Rome. Online available via http://www.fao.org/3/a-i6030e.pdf (last accessed 18.03.2019)

FAO & USAID (2015): Opportunities for Agri-Food Chains to become Energy Smart. Rome. Online available via https://poweringag.org/sites/default/files/Opportunities_for_AgriFood_Chains_to_Become_Energy_Smart_19oct16.pdf

World Bank (2019): Access to electricity, rural (% of rural population); World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program; available online at https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?year_high_desc=false (last accessed18.03.2019)

Examples of Mapped Value Chains and the Mapping Process



i http://www.ccacoalition.org/en/blog/cooling-all-%E2%80%93-18th-sustainable-development-goal
ii http://valuelinks.org

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[iii] For FUEL a ***D*** can be added for Diesel, ***P*** for Petrol or similar