

# International Conference on Understanding Sustainable Energy Solutions (USES)

## Energy Efficient Rural Food Processing Utilising Renewable Energy to Improve Rural Livelihoods RE4Food Project

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# Postharvest losses in sub- Saharan Africa



- **Poor harvest facilities**
- **Very limited opportunities to preserve food products**
- **Inadequate storage facilities**
- **Poor or no cooling facilities**
- **Poor infrastructure and therefore no access to markets**



# Sustainable solution to reduce losses



- Decentralised, distributed food processing close to production
- Supported by distributed renewable energy
- Create opportunities for rural livelihoods
- Not only reducing food loss but adding value to food products and increase rural incomes

# RE4Food Project

**EPSRC/DFID/DECC (£745K)**  
**Mar 2013 – June 2017**





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## **RE4Food Partnership**

- **Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya**
- **Practical Action Consulting (PAC), Kenya/UK**
- **Kwame Nkrumah University of Science and Technology (KNUST), Ghana**
- **NJALA University, Sierra Leone**
- **Environmental Foundation for Africa (EFA), Sierra Leone**
- **Stellenbosch University, South Africa**
- **Kessel University, Germany**
- **Newcastle University, UK**



# RE4Food R&D programme



- Evaluate and assess food chains
- Identify current rural food processing & renewable energy use
- Explore innovative post-harvest food processing using renewable energy
- Capacity building - stakeholder engagement, dissemination & knowledge transfer



# RE4Food R&D programme

## 1<sup>st</sup> RE4Food Stakeholders Workshop, Ghana

Developing a common understanding of the problems related to post harvest handling at a rural level and sharing of research knowledge and potential solutions

Additional stakeholders: TEC, Ministry of Food and Agriculture (MoFA), renewable energy technologies companies, NGOs, research institutes, agri-tech public/private sector and international organisations.



# RE4Food R&D programme

## **2<sup>nd</sup> RE4Food Stakeholders Workshop, Sierra Leone**

Mapping out reasons for the post-harvest fish losses.

Additional stakeholders: Fishing communities of Goderich and Tombo

## **3<sup>rd</sup> RE4Food Stakeholders Workshop, Ghana**

Further discussion to understand activity and difficulties in rural communities; identify solutions

Additional stakeholders: Research institutions, food processing companies, traders, farmers and other government agencies

# RE4Food R&D programme



## 4<sup>th</sup> RE4Food Stakeholders Workshop (Kenya)

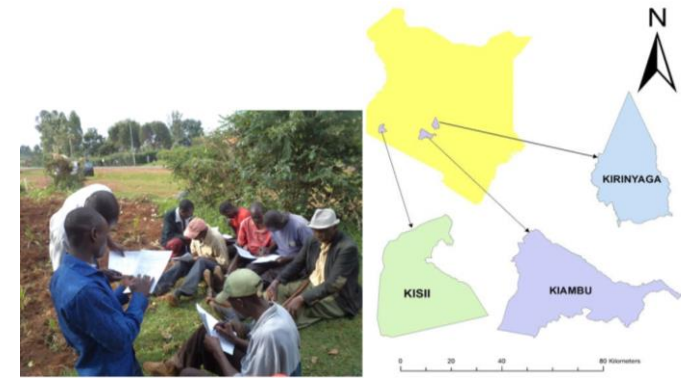
Gathered post-harvest food chain and processing data and information related to solutions proposed to better understand possible interventions.

Additional stakeholders: Kenya National Domestic Biogas Programme (KENFAP), BIMAS Ltd, KWFT – DTM, MoEP, MoALF, SoMCoDI and SCODE.



## Case study: Baseline information on vegetable processing and potential Renewable Energy Use (Kenya)

- **Case study:** 249 respondents were interviewed from 3 counties: Kisii (103), Kiambu (107) and Kirinyaga (39)
- **Goal:** Provide factual baseline information on the aspects and impacts surrounding the processing of high-moisture-content vegetable production and the extent and potential of renewable energy use by Kenyan farmers.
- **Harvest type by counties:** Kirinyaga and Kiambu: producing mainly exotic vegetables such as tomatoes, kales and cabbages; and Kisii produces mostly indigenous vegetables like amaranth, black nightshade and spider plant.
- **Post harvest losses:** harvesting (24.5-8.6%), on-farm sorting (36.2-20.2%), transportation (16.4-5.3%), market (20.7-5.1%) and value addition activities (21.9-12.7%)
- **Current practise for preserving vegetables:** use of shade (73% average respondents), use of sacks in the open (20% average respondents), and cold rooms hired from HCDA (3% average respondents).
- **Main challenges:** poor infrastructure, low prices, lack of market, surplus produce, high taxation, poor storage, exploitation and lack of capital.
- **Suggested interventions and solutions:** training, ready market, technology for value addition and production, quality seeds, affordable capital and good infrastructure.



County	Kisii n =103	Kiambu n =107	Kirinyaga n =39
Activity	Percent		
Rearing animals	96.1	91.6	89.7
Cereal food crops	100.0	51.4	97.4
Farming root crops	59.2	82.2	61.5
Farming pulses	89.3	23.4	74.4
Farming fruits	98.1	15.0	97.4
Farming vegetables	99.0	89.7	71.8
Salaried job	1.9	1.9	2.6
Casual/ non-salaried	54.4	60.7	46.2

*In the table: n = size of sample*

## Case study: Identifying activities in markets that have potential of influencing food losses (Kenya)

**Case study:** 187 traders in 14 markets located in Kirinyaga, Kiambu, Kisii and Kakamega

**Goal:** To identify the activities in the marketing value chain that have potential of influencing food losses, assess magnitudes of critical loss causing factors, identify the specific technologies, evaluate the magnitude of losses and energy inputs as well as potential of using various forms of renewable energy sources.

### Results:

- Most traders in Kiambu, Kirinyaga and Kakamega buy their vegetables direct from farmers while those in Kisii get their stock from intermediaries (middlemen). The results also show that there is lack of organized marketing systems by traders;
- Modes of transporting vegetables from the source to the market are predominantly motor cycles, vehicles, bicycles and draught animals;
- Most traders sell their produce in the open sun or under makeshift shaded structures, resulting to high post-harvest losses due to moisture loss, contamination from dust and animal droppings. This leads to quality and weight loss, hence, returns that the trader expects is likely to drop especially if the vegetables do not sell immediately.
- The proportion of damaged vegetables thrown away after value addition ranges from 0-20%.

**Conclusion:** There is need for RE4Food project to develop innovative, affordable, effective and efficient technologies (e.g., for drying and cooling) that can enhance shelf-life of vegetables. This intervention could result to not only reduce post-harvest losses but also increase market prices of the produce thus improving the traders' livelihoods

*Reference: Energy Efficient Rural Food Processing Utilising Renewable Energy to Improve Rural Livelihoods in Kenya*



# Case Study Food Losses at farms and potential integration of renewable energy services (Kenya)

**Case study:** 211 farmers in Kirinyaga, Kiambu, Kisii and Kakamega

**Goal:** To identify the activities in the production value chain that have potential of influencing food losses, assess magnitudes of critical loss causing factors, identify the specific technologies, evaluate the magnitude of losses and evaluate the energy inputs and potential of using various forms of renewable energy sources

## Results:

- Type of vegetables grown:

Region	Counties	Proportion of farmers growing the vegetables (%)			
		Kales	Tomatoes	Cabbage	Indigenous
Central	Kiambu	62.0	0.0	42.0	0.0
	Kirinyaga	7.8	100.0	0.0	3.9
Western	Kakamega	9.4	9.4	1.9	100.0
	Kisii	7.0	0.0	3.5	94.7
	$\chi^2$ -value	67.32	187.77	60.92	191.92
	df	3	3	3	3
	p-value	0	0	0	0



- Major source of losses during harvesting:

County	Bruising	Immature	Over mature	Cutting	Colour	Withering	Pest damage
					change		
Percent							
Kakamega	18.0	54.5	13.0	16.1	15.4	23.5	27.3
Kiambu	20.0	18.2	50.6	35.5	52.3	35.3	26.7
Kirinyaga	44.0	18.2	24.7	6.5	20.0	10.3	30.0
Kisii	18.0	9.1	11.7	41.9	12.3	30.9	16.0
Total	100	100	100	100	100	100	100

## Case study: Effects of practices of maize farmers and traders on the contamination of maize (Ghana)

- **Case study:** 150 farmers from maize farming communities across 10 cluster zones and 30 traders were randomly selected from each market
- **Introduction:** High degrees of aflatoxin in food render the food unsafe for human consumption. The disposal of such foods also constitutes an economic loss in food production.
- **Goal:** The study was to investigate management practices employed at the market level and on farms by maize traders and smallholder farmers, respectively, and their impact on aflatoxin contamination.
- **Results:**
- **Farmers and traders practices contributing to contamination:**
  - Use of farmer-saved seed stock as planting material;
  - Delayed harvesting,
  - Heaping harvested maize cobs on the field;
  - Planting by broadcasting method,
  - Use of hand dipping and teeth cracking method to determine dryness of maize,
  - Use of wooden stalls with no proper ventilation for maize storage at market centres and temporal storage in the open using tarpaulin resulting in heat build-up and moisture re-absorption.

Parameter	Farm	Ejura market	Agbobloshie market
Moisture content (%)	<13	12.5 – 13.4	13.1 – 16.6
Weevil infestation	Absent	Low	High
Presence of mould	No	Yes	Yes
Aflatoxins present	Yes	Yes	Yes
Level of aflatoxins	<LOD	>LOD	>LOD

LOD= limit of detection (G2, G1= 1.5 ng/g; B2, B1= 0.8 ng/g).



Reference: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1021.7554&rep=rep1&type=pdf>

# Case study: Comparative analysis of traditional fish drier and solar dryer (Sierra Leone)

**Case study:** Interviews with key stakeholders in the artisanal fishing industry including fishermen, fish processors, fish and wood traders in two major fishing communities, Goderich and Tombo in Sierra Leone, and experiment using traditional fish drier and solar dryer.

**Goal:** Compare fish processed through the use of traditional fish smoking using wood and those dried using renewable energy (solar dryer) in terms of taste, texture, color, flavor and hardness. In addition, we measured the amount of energy utilized to produce a given quantity of dried fish, and finally conducted an economic valuation of resources used in fish processing

## Results:

- Solar drier took longer time to dry and not economically feasible
- Customers prefers traditional smoked fish over solar dryer

**Table 1: Operations of a traditional banda**

Fresh fish weight (kg)	Dry weight (kg)	Dry weight (%)	Weight loss	Weight of wood	Water loss per kg of wood used
153	80	52%	73	75	0.97
77	40	52%	37	38	0.97
32	13	41%	17	20	0.85

**Table 2: Operation of the solar dryer**

Fish species	Fresh weight (kg)	Dry weight (kg)	Dry weight (%)	Final colour	Duration in the dryer
Herring	3.9	1.1	28%	silver	5 days
Herring	1.9	0.9	47%	silver	4 days



Left: traditional banda, Right: solar dryer

# RE4Food R&D

## Hybrid solar-biomass grain drying facility



**Maize drying  
facility located  
in a farmers  
market in Ghana**

# RE4Food R&D

## Hybrid solar-biomass vegetable drying facility in Kenya



# RE4Food R&D

## Charcoal evaporative cooler and packing facility for fruit and vegetables in Kenya

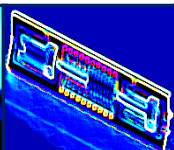
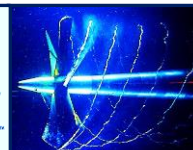
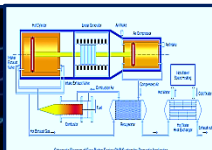
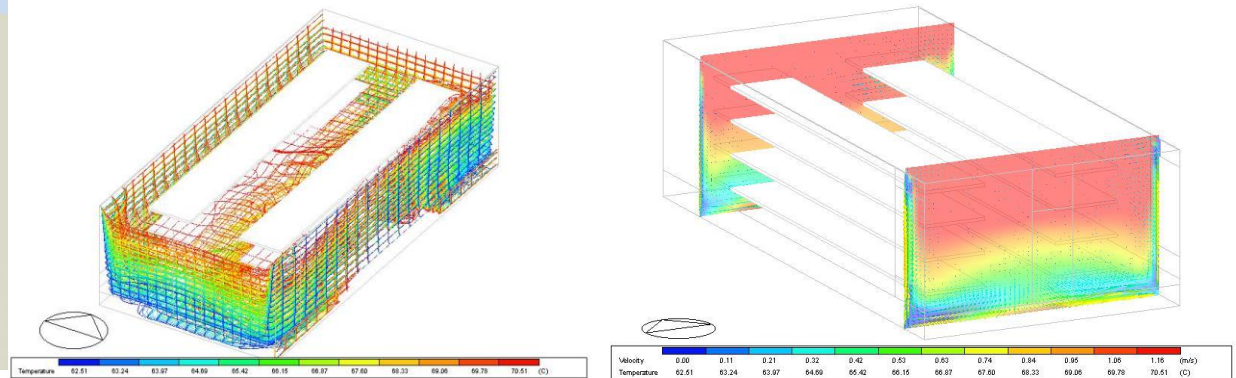
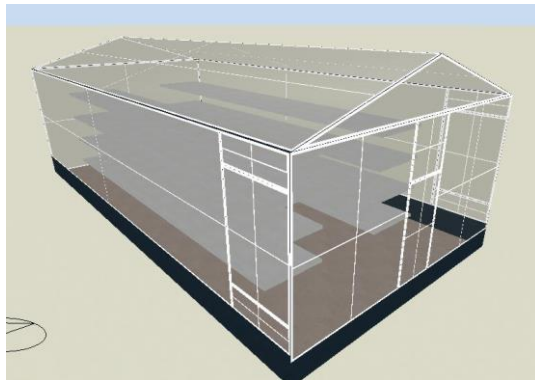
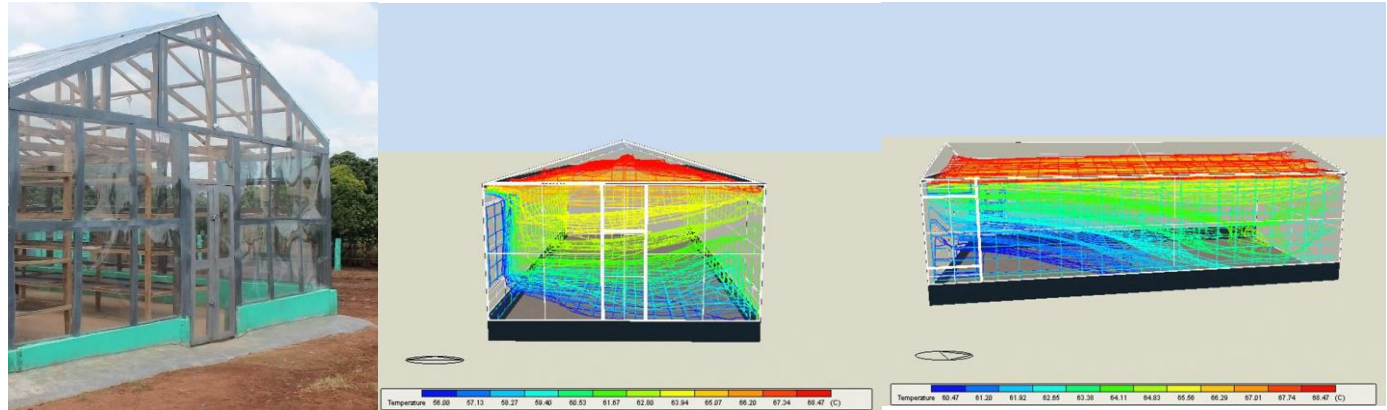


# Publications

- Kallon A, Lebbie A, Sturm B, Garnett T, Wadsworth R (2017) Comparative studies of fish smoking and solar drying in the Sierra Leone artisanal fishing industry. *Journal of Stored Products and Postharvest Research*, 8 (3), 40-48 DOI: 10.5897/JSPPR2016.0217
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- Ndirangu, SN,. Kanali CL, Mutwiwa UN, Kituu GM (2016). Model for Renewable Energy Based Agroprocessing Technology Transfer. *Proceedings of Sustainable Research and Innovation Conference*, [S.I.], p. 304-317, July 2016. ISSN 2079-6226. Available at:  
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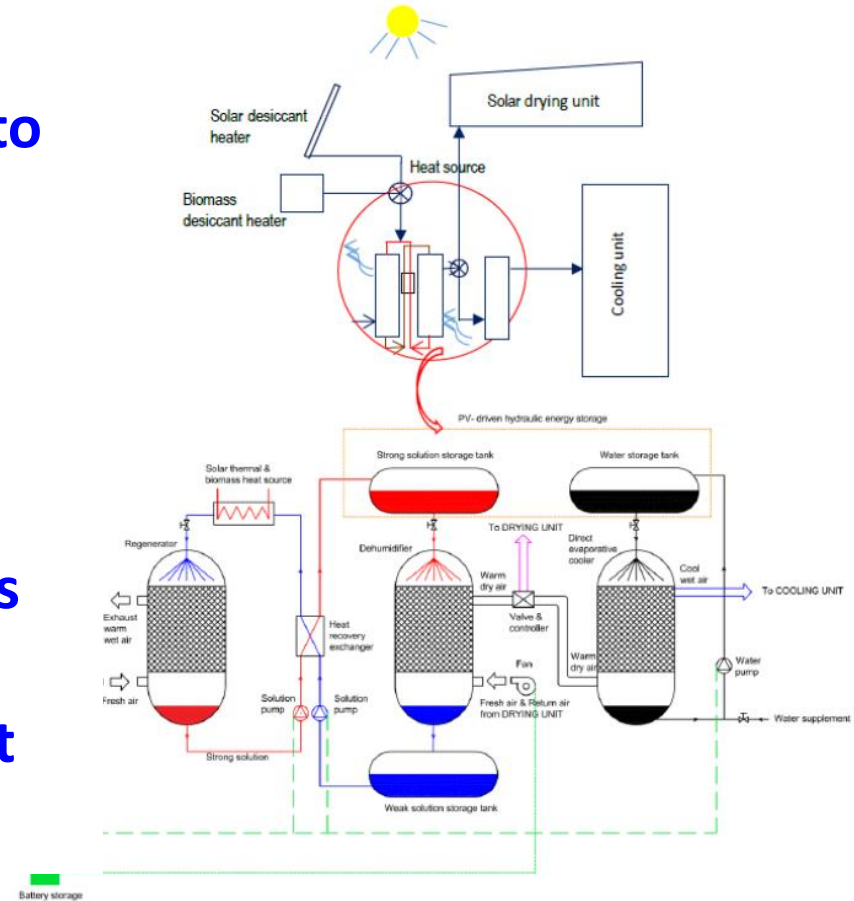
# Further research and development

Computational  
fluid dynamics  
(CFD) enabled  
optimisation of  
a hybrid solar  
dryer



# Further research and development

- Enhanced agricultural product drying and cooling infrastructure to maximise the use of renewable energy through the integrating thermo-chemical energy storage
- Innovate UK project to integrate plastic PV surfaces and hybrid energy storage to existing facilities
- District cooling networks
- Following up on impact on current interventions



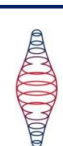


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