BEFS
Bioenergy and Food Security Projects

Introduction to Bioenergy: Opportunities and Risks and the Policy Process

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Outline

☞ **Bioenergy and Food Security**

- Introduction and interlinkages

☞ **Bioenergy policy**

- Development of sustainable, food secure bioenergy sector
- FAO's BEFS Approach

☞ **Sustainable Bioenergy Assessment**

- BEFS Rapid Appraisal Tool: Case study Malawi

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Bioenergy

……is all energy derived from biofuels,
which are fuels derived from biomass.

Biomass

……materials of recent biological origin
including plant materials and animal waste.

Biofuels and bioenergy

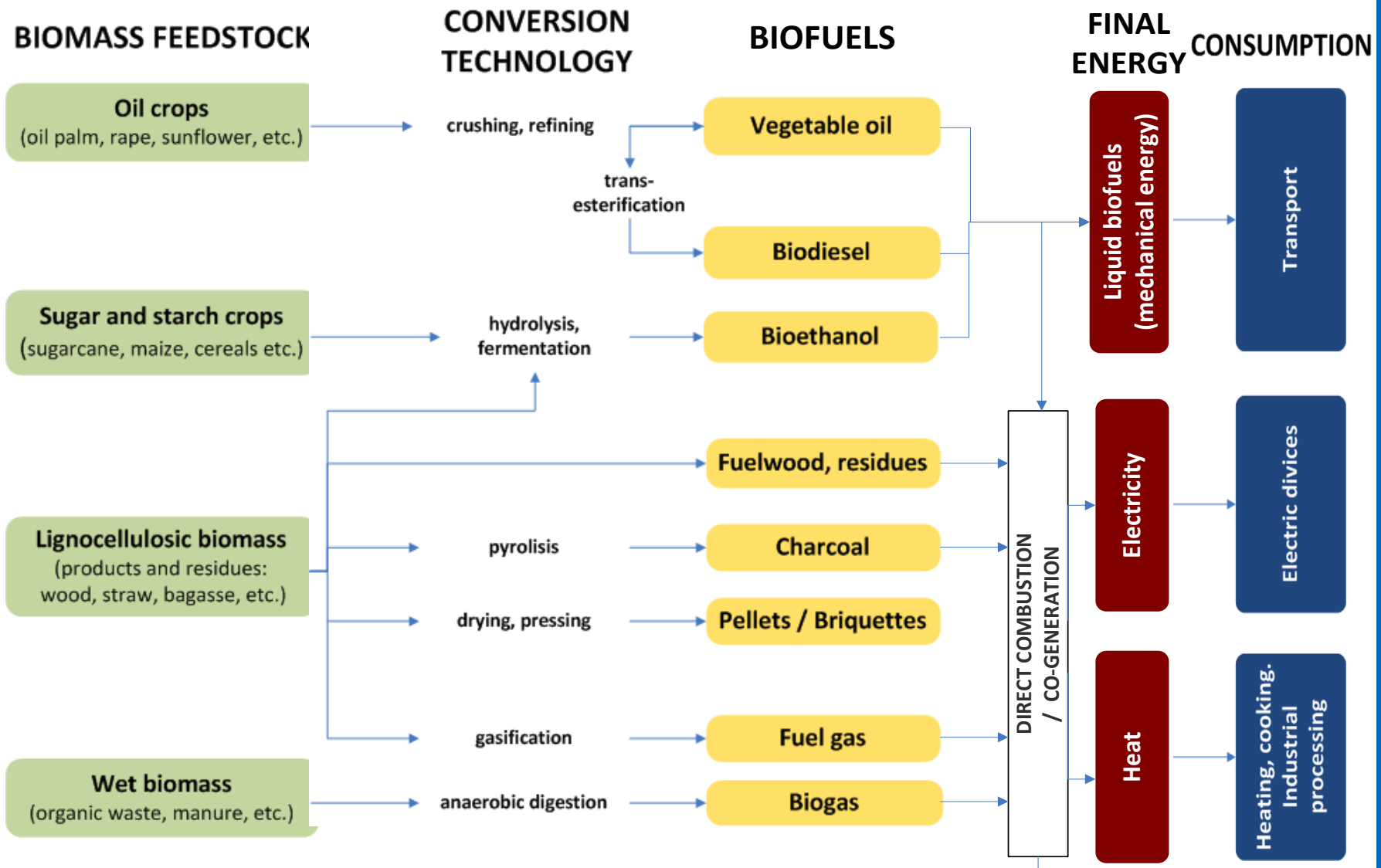
FEEDSTOCK

Woodfuel and woody residues, crop residues, livestock residues, crops, food processing residues

Solid Biofuels	Gaseous Biofuels	Liquid Biofuels
		
Firewood, charcoal, briquettes	Biogas, syngas (gasification)	Bioethanol, biodiesel and straight vegetable oil

Heating and Cooking | Electricity | Transport

From bioenergy feedstock to final energy use

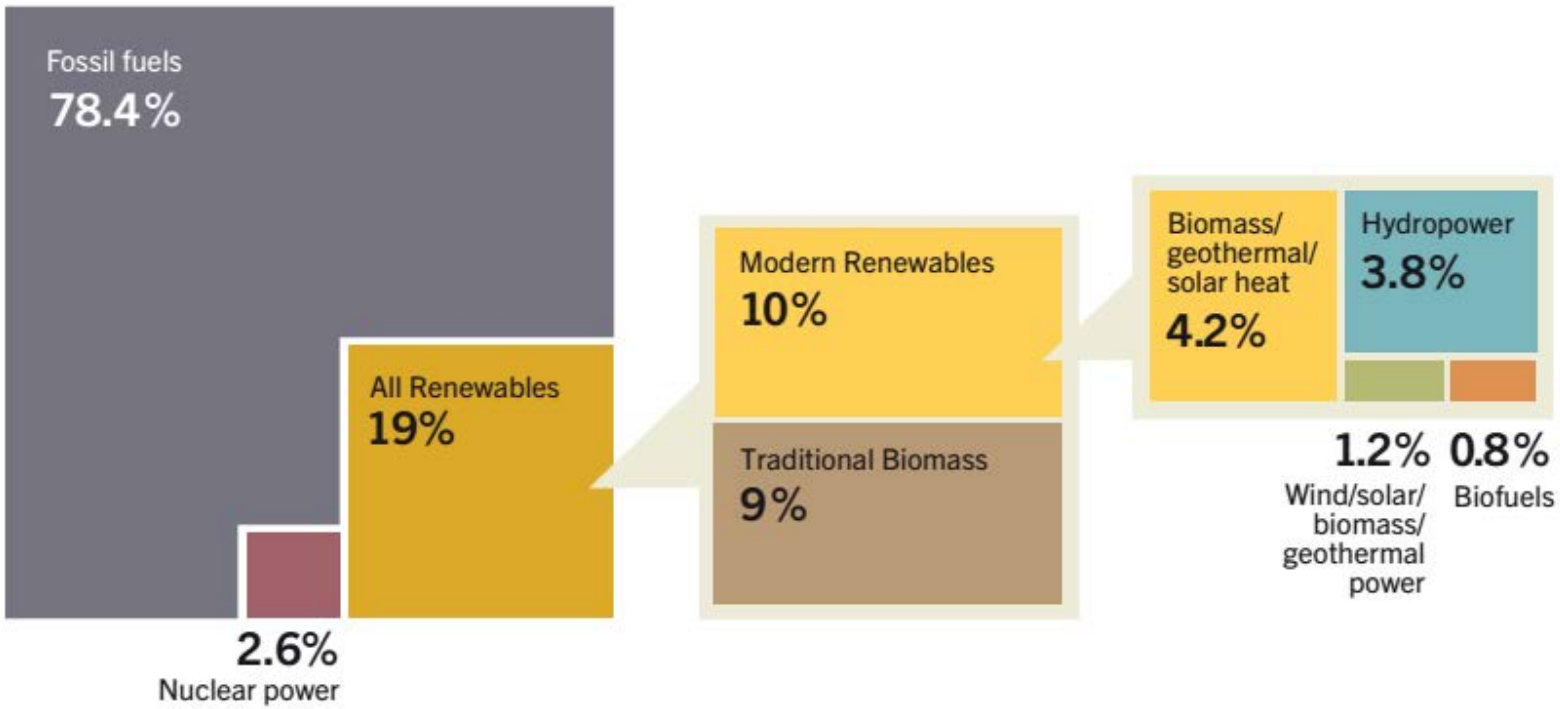


Biofuel	Energy end-user			
	Households	Community level	Industry & services	Transport
Vegetable oil (SVO)	Cooking, machinery, electricity	Electricity generation	Machinery, electricity	X
Biodiesel	Machinery, electricity		Machinery, electricity	X
Ethanol	Cooking (ethanol gel)			X
Fuelwood, residues	Cooking, heating	Electricity/heat	Electricity/heat	
Charcoal	Cooking, heating		Industrial processing	
Pellets	Heating	Electricity/heat	Electricity/heat	
Briquettes	Cooking, heating			
Fuel gas			Electricity/heat	
Biogas	Cooking, lightning	Electricity, electricity/heat	Electricity/heat	

Developing countries	Developed countries	All

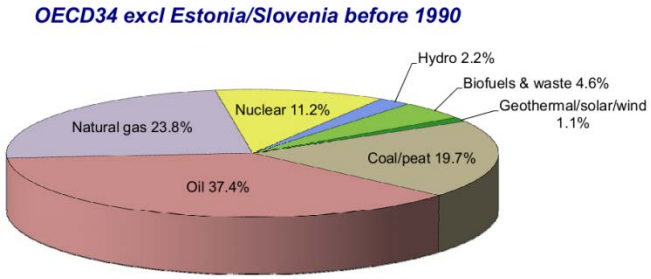
Role of bioenergy in Total Primary Energy Supply

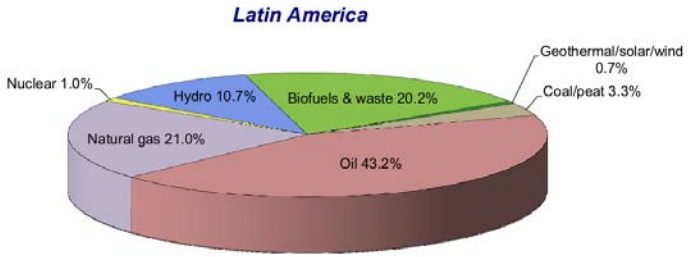
Figure 1. Estimated Renewable Energy Share of Global Final Energy Consumption, 2012

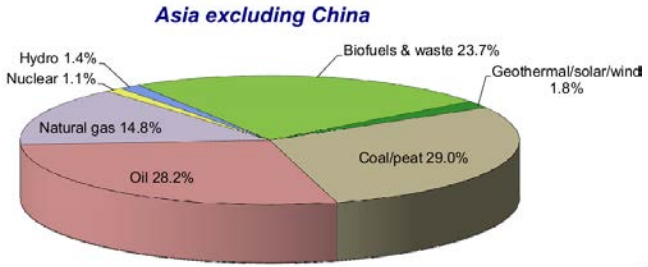


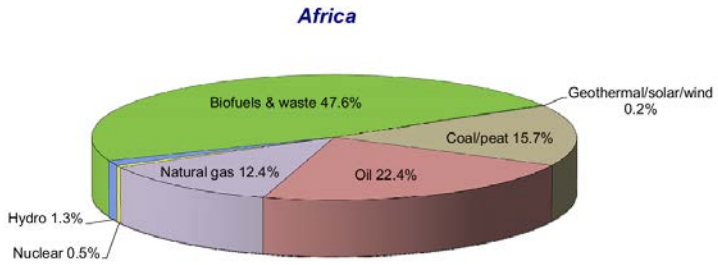
REN21: Renewables 2014 Global Status report

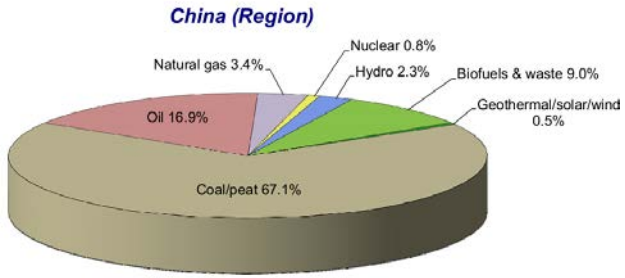
The importance of bioenergy in TPES across regions in 2009











Share in TPES	OECD34	Latin America	Asia (exc.China)	China	Africa
Biofuels and waste	4.6%	20.2%	23.7%	9.0%	47.6%

Food Security

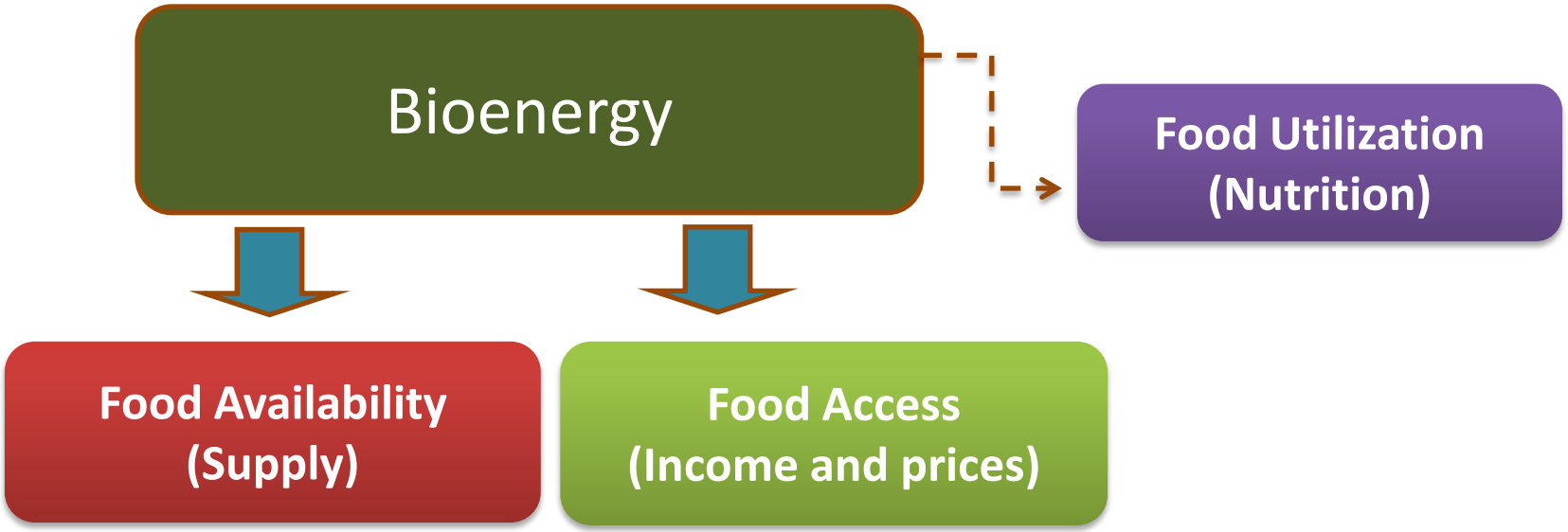
….exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

1996 World Food Summit held in Rome

☞ the 4 dimensions of food security

- ✓ AVAILABILITY - Physical AVAILABILITY of food
- ✓ ACCESS - Economic and physical ACCESS to food
- ✓ UTILIZATION - Food UTILIZATION
- ✓ STABILITY - STABILITY of the dimensions

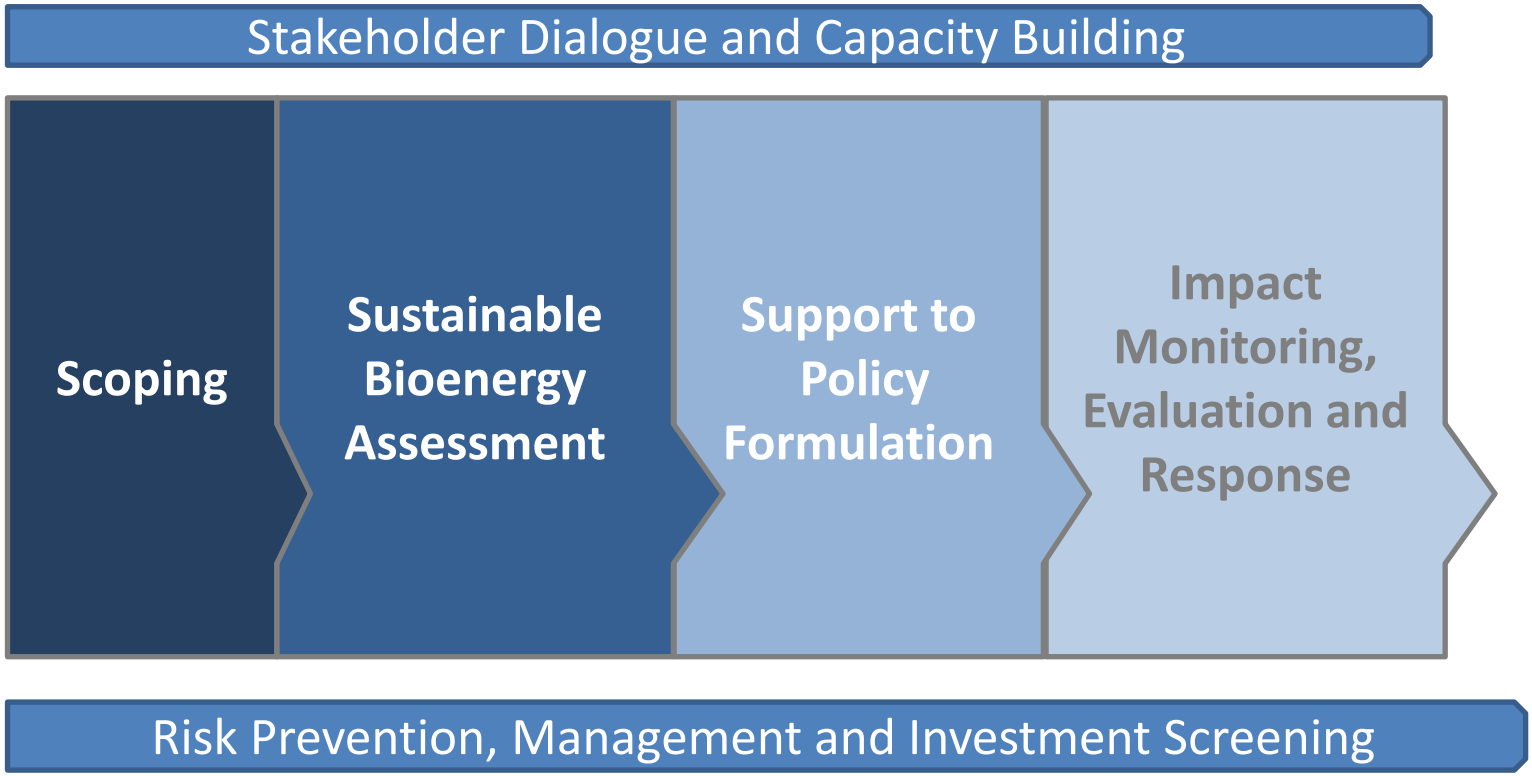
Linkages: Bioenergy and Food Security



Environmental sustainability, social acceptability, and economic viability of the bioenergy sector "setup"

FAO's Bioenergy and Food Security (BEFS) Approach

- Six areas of support



development of sustainable, food secure, bioenergy sector

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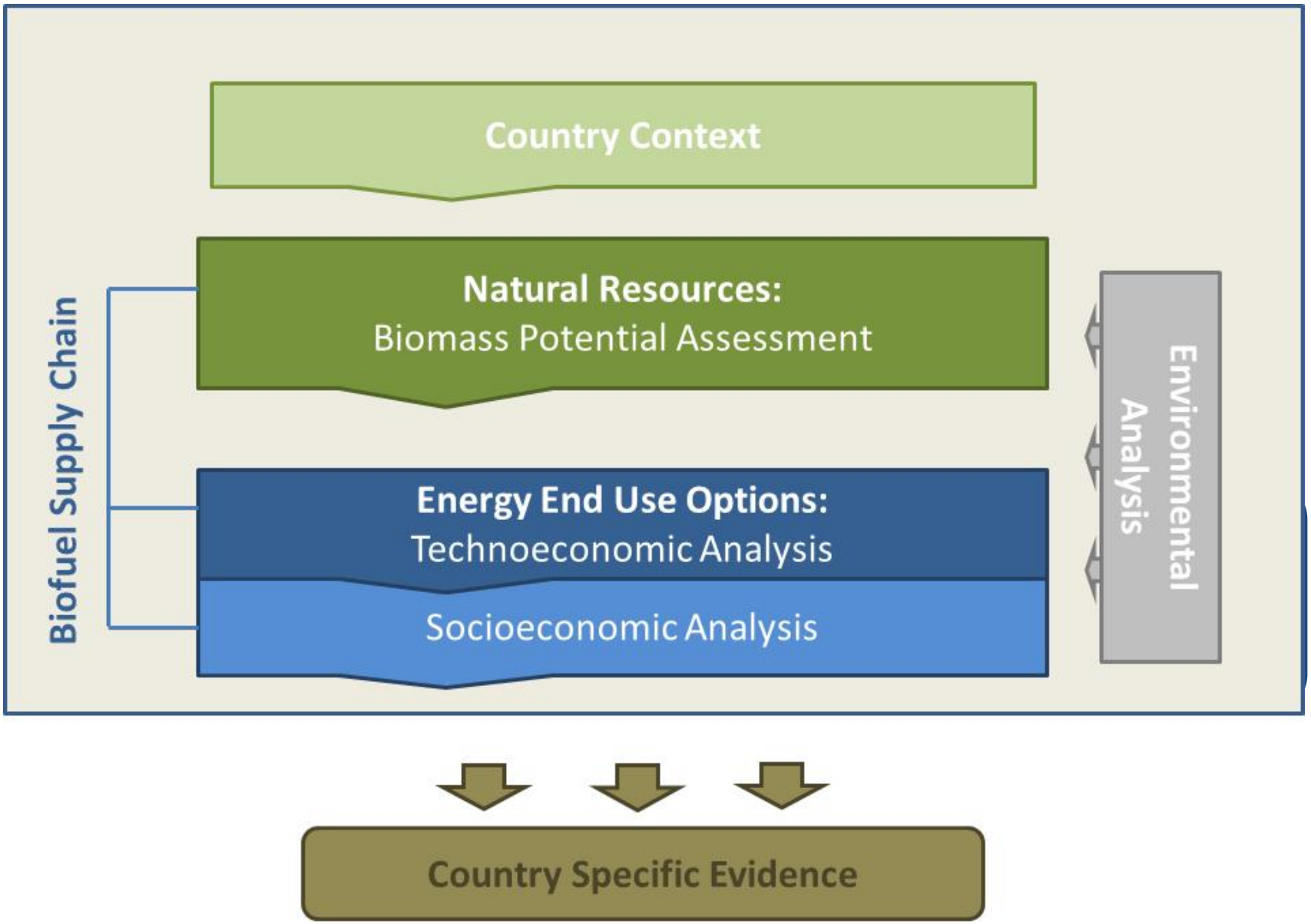
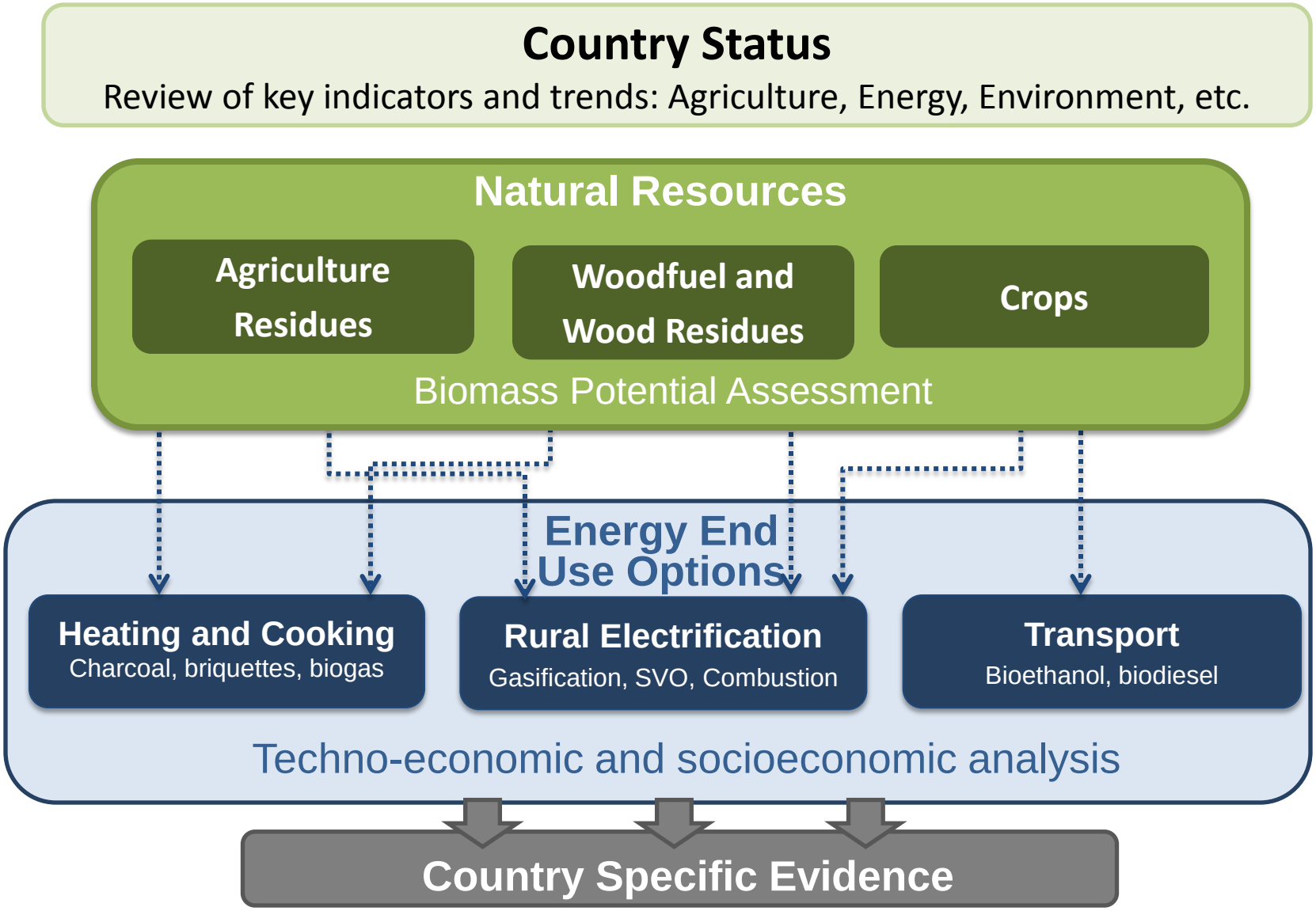

Country Context
Natural Resources:
Biomass Potential Assessment
Energy End Use Options:
Technoeconomic Analysis
Socioeconomic Analysis
Biofuel Supply Chain
Environmental Analysis
Country Specific Evidence

BEFS Rapid Appraisal

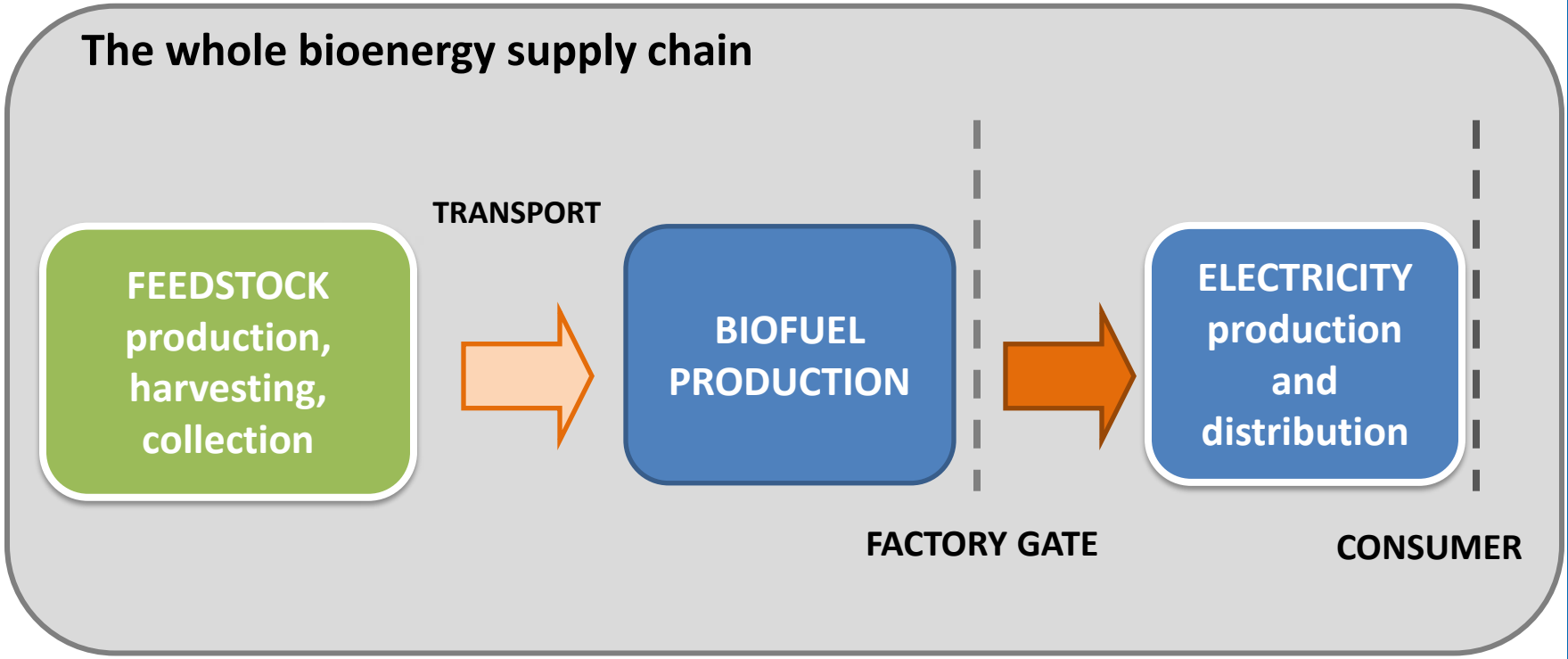
- **Characteristics:**
  - ***Excel* based** set of tools
  - globally applicable, national (subnational) level assessment
  - implementable in a relatively short time
  - can be used with limited user defined data, default values are provided as an option
  - analysis can focus on country needs
  - allows to limit the scope of detailed analysis

- **Limitations:**
  - Accuracy of results depend on the accuracy of the data
    - Default data, user defined data
  - Further detailed analysis would be required for actual policy formulation, so this is the initial step. A sub-national level BEFS RA could be an option.

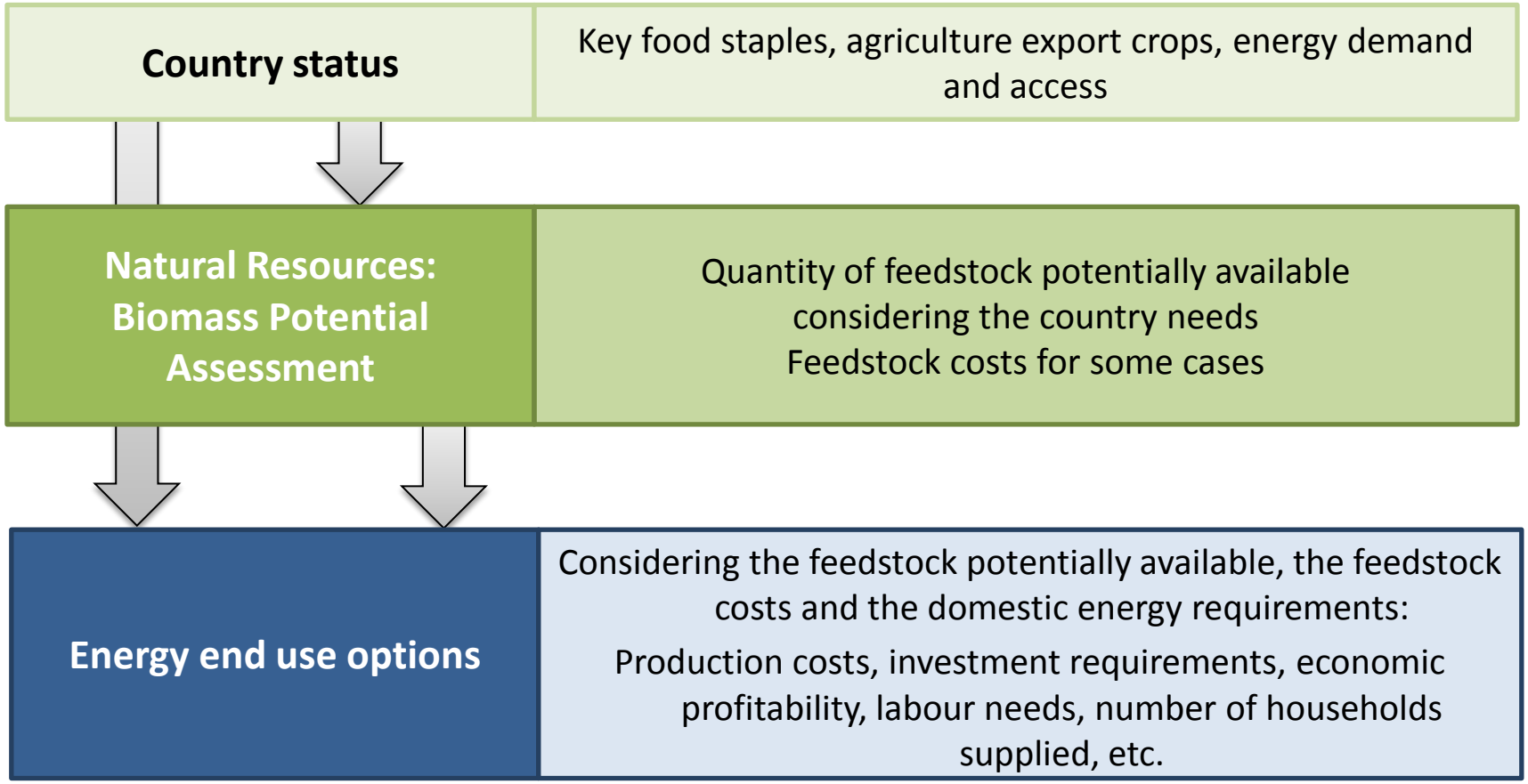
Structure


Country Status
Review of key indicators and trends: Agriculture, Energy, Environment, etc.
Natural Resources
Agriculture Residues
Woodfuel and Wood Residues
Crops
Biomass Potential Assessment
Energy End Use Options
Heating and Cooking
Charcoal, briquettes, biogas
Rural Electrification
Gasification, SVO, Combustion
Transport
Bioethanol, biodiesel
Techno-economic and socioeconomic analysis
Country Specific Evidence

Boundaries of the analysis



Outputs and interlinkages between modules



Results of BEFS RA

….can assist policy makers / technical officers in

- **Outlining the country** energy, agriculture and food security context
- **Outlining the sustainable bioenergy options** of interest
- **Obtaining initial estimates** of which sustainable bioenergy supply chains are **viable** in the country
- **Identifying options of interest that require more in-depth analysis** and planning e.g. more detailed BEFS analysis

How does the appraisal account for food security and sustainability?

- **Food Security**
  - Identify key food staples in the country
  - Strive for feedstock production that is additional to current uses
  - Consider options for income generation, employment and potential tradeoffs (feedstock level, processing level)
- **Sustainable use of natural resources**
  - intensification of agricultural production as preferred option
  - forestland and protected areas excluded
  - current/planned uses of residues excluded
  - importance of residues for soil fertility and structure considered
- **Economic and social sustainability**
  - competitiveness
  - financial viability
  - outgrowers' inclusion

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BEFS RA Case study:

Rural electrification options in Malawi

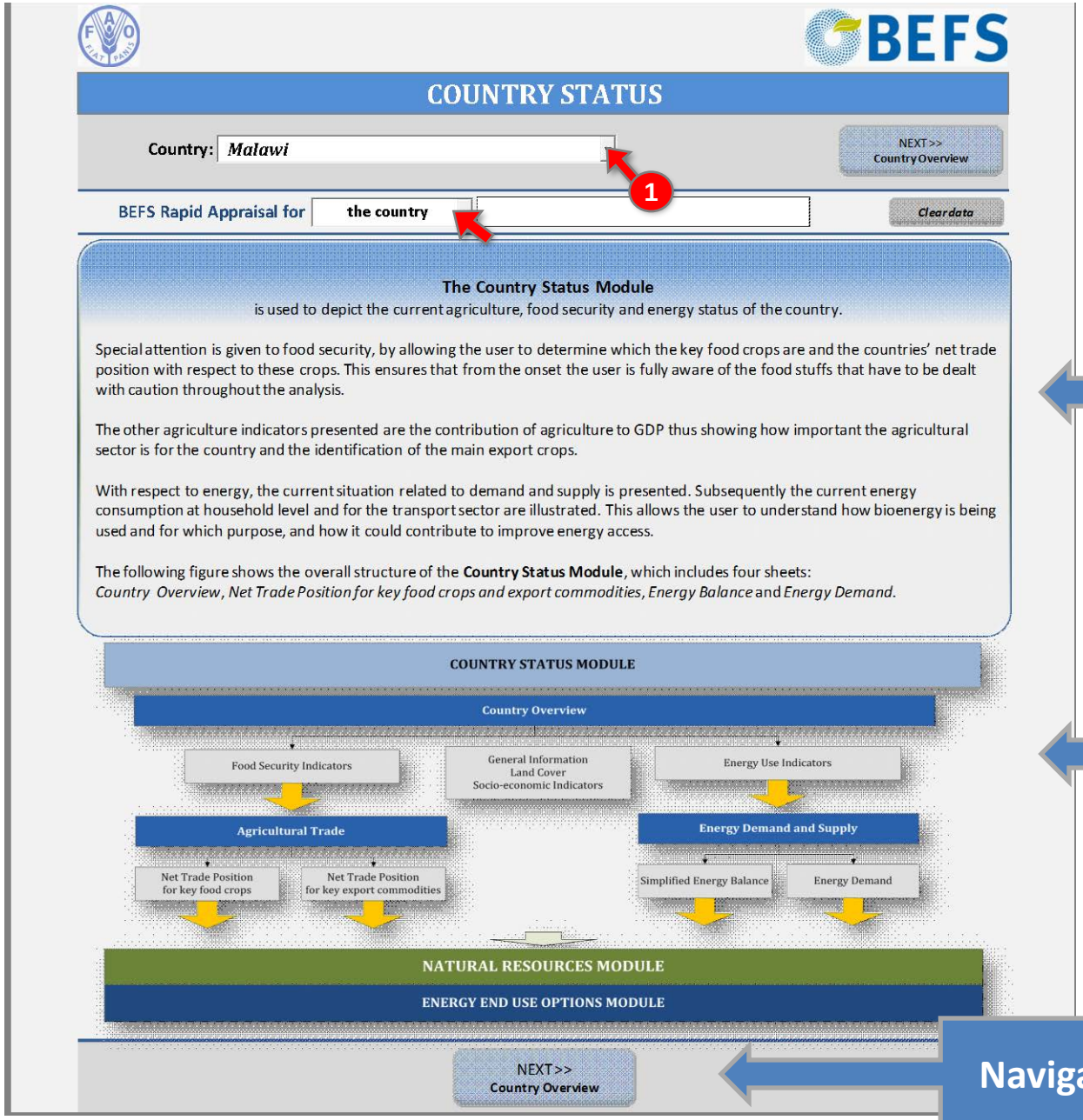
Introduction to the case study: The flow of BEFS Rapid Appraisal for Malawi

- **Country context**
  - Country status tool
    - ⇒ Level of food security
    - ⇒ Energy needs and priorities

- **Bioenergy feedstock options**
  - NR Module
    - ⇒Which type of feedstock is available
    - ⇒How much is available

- **Technology pathway**
  - Energy End Use Options Module
    - ⇒Which options are viable
    - ⇒Which options are preferable

Opening the .xlsm file and Introduction



Introduction

Structure

Navigation buttons

COUNTRY OVERVIEW

COUNTRY: Malawi

<< BACK
Start

NEXT >>
Net Trade Position for key food crops

BEFS Rapid Appraisal for the country

Enter data into white cells | Grey cells are calculated

POPULATION

Parameter (unit)	Value	Year	User-defined value	Year
Total population (1000 inhab)	15,381	2011		
Rural population (%)	80%			
Urban population (%)	20%			
Population density (inhab/km^2)	163.1			
Source:	*FAO, 2013: FAOSTAT*			

SOCIO-ECONOMIC INDICATORS

Parameter (unit)	Value	Year	User-defined value	Year
GDP per capita (current US$)	363.64	2011		
GDP/capita, PPP (current int. $)	889.74	2011		
GDP/capita, PPP (const. 2005, int. $)	784.97	2011		
Agriculture, value added (% of GDP)	30.17	2011		
Source:	*The World Bank, 2013: WDI*			

LAND COVER / LAND USE

Parameter	1000 ha	% of land area	Year	User-defined value	Year
Country area	11,848		2011		
Land area	9,428	100%	2011		
Agricultural area	5,580	59.19%	2011		
Arable land	3,600	38.18%	2011		
Permanent crops	130	1.38%	2011		
Forest area	3,204	33.98%	2011		
Source:	*FAO, 2013: FAOSTAT*				

FOOD SECURITY AND ENERGY USE

Parameter (unit)	Value	Year	User-defined value	Year
Undernourished population (%)	23.1	2011		
Poverty headcount ratio at national poverty line (% of pop.)	50.7	2010		
Energy use (kg of oil eq. per capita)	0.0	2010		
Electricity consumption (kWh/capita)	0.0	2010		
Access to electricity (% of population)	8.70	2010		
Source:	*The World Bank, 2013: WDI*			

FOOD SUPPLY AND KEY FOOD SECURITY CROPS

Rank	Food commodity	Food supply (kcal/capita/day)	Share in total food supply
1	Maize	1,158	50.0%
2	Potato	195	8.4%
3	Cassava	135	5.8%
	Subtotal	1,488	64.2%
	Total food supply	2,318	100%
Source:	*Food balance sheet, FAOSTAT*	*Year:*	2009

AGRICULTURAL TRADE - KEY CASH CROPS

Rank	Trade commodity	Export quantity (t)	Export value (1000 US$)	Export unit value (US$/t)	Share in total value of exports
1	Tobacco	144,676	874,904	6,047	69.6%
2	Tea	49,999	120,787	2,416	9.6%
3	Coffee	901	5,271	5,850	0.4%
	Subtotal		1,000,962		80%
	Total value of export of agricultural commodities		1,256,639		
Source:	*FAOSTAT, Trade*		Year:	2009	

Malawi: Energy balance

Sector	Energy demand by fuel (TJ/year)				
	Biomass	Petroleum	Electricity (hydro, thermal)	Coal	*Total (%)*
Households	127,394	672	1,798	5	*83.4%*
Industry	9,664	3,130	2,010	3,481	*11.7%*
Transport	270	5,640	35	15	*3.8%*
Service	452	558	477	174	*1.1%*
Total (%)	*88.5%*	*6.4%*	*2.8%*	*2.4%*	

Source: Malawi BEST (2009)

- Biomass is the most important energy source
  - fuelwood, charcoal and crop residues
- Households use the largest share of energy

Malawi Country Status - Summary

- Population: 15.3 million, 80% rural
  50% below national poverty line
- Agriculture/GDP 30% of GDP
- Access to electricity 8.7% of total population
  2% of rural population

- **Main staple crops (% of daily calorie intake)**
  - Maize (50%), Potato (8.4%), Cassava (5.8%)
- **Main export crops (% of agri. Exports)**
  - Tobacco (69%), Tea (9.6%), Coffee (0.4%)

- Agricultural production
  - Mainly small-holders (tobacco outgrowers)
  - Subsistance farming
- Energy supply
  - traditional biomass
  - does not meet the demand (imports)

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Malawi Case Study: the flow of BEFS Rapid Appraisal for Malawi

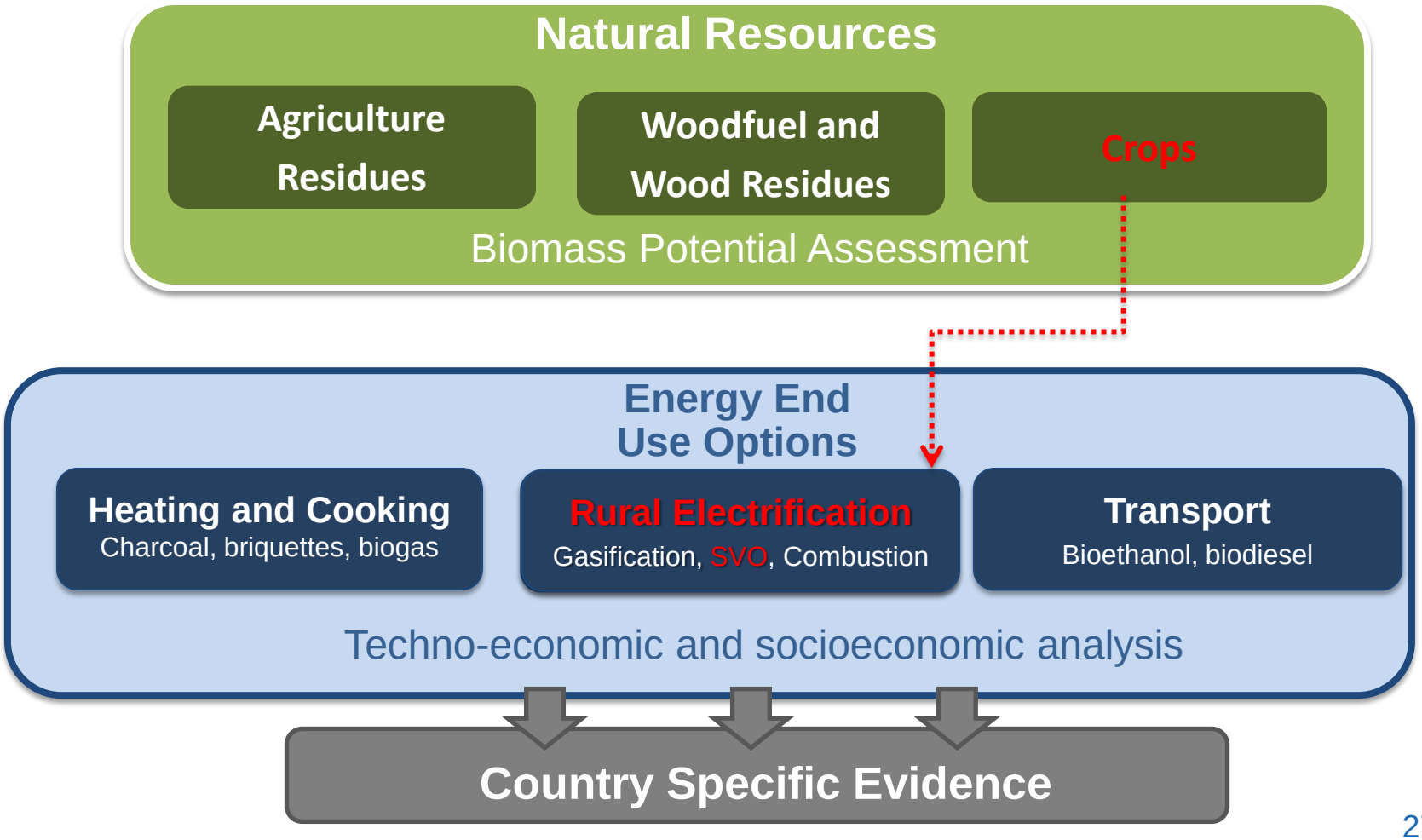
- Country context
  - **Energy needs and priorities**
  - ⇒ **Rural electrification is one of the priorities**

- **Energy End Use Options: Rural electrification**
  - **SVO** and gasification**,** combustion

- **Feedstock options**
  - Oilseed crops: **sunflower** and **soybean**

Structure

Country Status
Review of key indicators and trends: Agriculture, Energy, Environment, etc.



CROP PRODUCTION

COUNTRY: *Malawi*

<< BACK
Crops Component

NEXT>>
Net Trade Position for the selected crops

BEFS Rapid Appraisal for the country

The Crop production tool
is used to assess the potential for additional production of crops that can be used as feedstock for liquid biofuels: **straight vegetable oil, biodiesel and ethanol.**

Feestock for production of straight vegetable oil and biodiesel include oilseed crops:
coconut, jatropha, oil palm, rapeseed, soybean and sunflower.

Feestock for production of ethanol include sugar and starchy crops:
barley, cassava, maize, sugarbeet, sugarcane, sorghum and wheat.

Up to four crops can be analysed at the same time, irrespective of the biofuel type.

Select the crops (crop 1 - crop 4) you want to analyse from the dropdown lists below:

Crop 1	*Crop 2*	*Crop 3*	*Crop 4*
Sunflower	Soybean	Select a crop	Select a crop

Clear selection

NEXT>>
Net Trade Position for the selected crops

The following options for additional production of the selected crops can be analysed:

Intensification - increase in annual production due to an increase in crop yields achieved through: improvements in agricultural practices and/or increases in the use of inputs (e.g. fertilisers, pesticides, machinery).

Change of crops - replacement of a crop currently grown on a defined land area with a different crop.

Extensification - increase in annual production due to an increase in the production area i.e. expansion of arable land.

Select the option you want to analyse:

NEXT>>
INTENSIFICATION

NEXT>>
CHANGE OF CROPS

NEXT>>
EXTENSIFICATION

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INTENSIFICATION

<< BACK
Crops Component

NEXT >>
Select an option for additional production

Enter data into white cells | Grey cells are calculated

Calculations

Parameter	Unit	Crop 1 Sunflower	Crop 2 Soybean	Crop 3 Select a crop	Crop 4 Select a crop
		Current production			
Current yield	t/ha	0.83	0.94		
No. of harvests/year		1.0	1.0		
Annual production	t/year	7,902	73,978		
Total production area	ha	9,520	78,700	0	0
		Intensified production (Potential production on the same area with increased yields)			
Input level	Select	Intermediate	Intermediate	Input level	Input level
Intensified yield	t/ha	1.73	2.12		
No. of harvests/year		1	1		
Potential production	t/year	16,470	166,844	0	0
Total production area	ha	9,520	78,700	0	0
		Planned production for non-bioenergy purposes (food, feed, export, etc.)			
Planned production	t/year	8,000	75,000		
Area of production	ha	4,624	35,377	0	0

Current production
(FAOSTAT, ag. statistics)

Intensified production
(AEZ – potential yields)

Non-bioenergy needs
(food, feed, export…)

the tool

Potential production for bioenergy

		Sunflower	Soybean	Select a crop	Select a crop
Potential production	t/year	8,470	91,844	0	0
Area of production	ha	4,896	43,323	0	0

Clear data

Results from NR Module
Crops

- **Crops – available for bioenergy**

	sunflower	*soybean*
Intensification (t/year)	8,470	91,844
Change of crops (t/year)	54,942	
Extensification: possibility for expansion of arable land unclear at this level of analysis		
TOTAL (t/year)	**63,412**	**91,844**
Allocated for SVO (t/year)	**31,706**	**45,922**
Allocated for biodiesel (t/year)	31,706	45,922

Energy End Use Options Module

BEFS Bioenergy and Food Security Project

RAPID APPRAISAL TOOL FOR RURAL ELECTRIFICATION-SVO

SVO and Rural Electrification Description | Data Entry Sheets | NEXT >> Energy Demand

Disclaimer

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DATA ENTRY SHEET FOR SVO + RURAL ELECTRIFICATION

<<BACK Start Sheet | Load Default Values | Clear Data | SVO+Electrification Process Description | Energy Demand Sheet

Use white cells to input data | Grey cells are used for calculations

	Feedstock 1	Feedstock 2	Feedstock 3	Feedstock 4
Feedstock	Sunflower	Soybeans	Please Select	Please Select
Feedstock Potential (t/year)	31,706	45,922		
Feedstock Yield (t/ha)	1.73	2.12		
Oil Content (%)	53%	21%		
Feedstock Price (USD/t)	$ 300	$ 380		
Feedstock storage cost (USD/t)	$ 55.00	$ 55.00		
	Storage Calculator 1	Storage Calculator 2	Storage Calculator 3	Storage Calculator 4

Production Cost 1 | Production Cost 2 | Production Cost 3 | Production Cost 4

Electricity Price Definition

Select a method to define the price of electricity: Method 1

Method 1	Units	
Comparative Production Cost of Electricity	$ 0.79 USD/kWh Electricity Price Calculator	Method 1: Use a calculator to define the price of electricity generator using a diesel generator based system.

General Inputs

Labors		Units			Units
Unskilled Worker	$ 0.16	USD/person-h	Skilled Worker	$ 0.89	USD/person-h
Utilities		Units			
Diesel	$ 1.90	USD/Liter	==>Required to start up the engine		
Transportation cost		Units			
Transportation cost of feedstock	$ 0.54	USD/t/km	==>Feedstock (collection point to oil extraction plant)		
Other costs		Units			Units
General and Administrative (%)	8%		Maintenance Cost (%)	20%	
Plant Overhead (%)	30%		Miscellaneous Cost (%)	10%	
Financial parameters		Units	Investment Cost Update		
Discount rate	25%				
Loan ratio	80%		Plant Cost Index during 6/2014	160.00	
Loan interest rate	17%		http://base.intratec.us/home/ic-index		
Loan term (year)	15	year			

NEXT >> Summary of Results Comparative | NEXT >> Summary of Results by Feedstock

Feedstock availability (NR module)

Feedstock price and storage costs (national market)

Costs of alternative energy supply (electricity from diesel generator)

Other inputs (labour, utilities, transportation,…)

Financial parameters (discount rate, loan ratio, interest rate…)

Results

For 3 capacity levels: 10kW, 40 kW, 100 kW

- **Techno-economic results**
  - Potential number of plants
  - Area required for feedstock supply
  - Total investment
  - Production costs and comparison with alternative el.source
  - Share of production costs (feedstock, transport, labor)

- **Socio-economic results**
  - Number of jobs created
  - Number of households supplied
- **Financial analysis results**
  - Net Present Value
  - Internal Rate of Return

NEXT >>
Summary of Results Comparative

NEXT >>
Summary of Results by Feedstock

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SUMMARY OF RESULTS OF SVO + RURAL ELECTRIFICATION COMPARATIVE

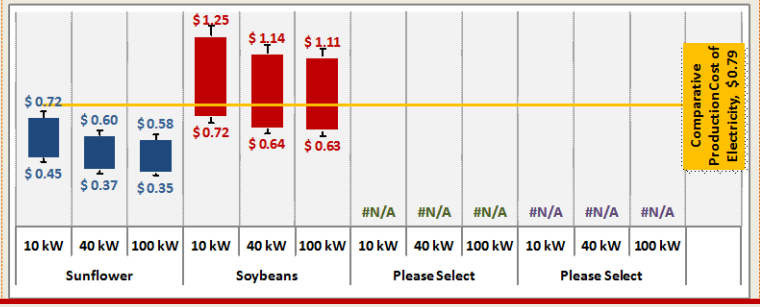
Feedstocks Selection

Sunflower | Soybeans | Please Select | Please Select

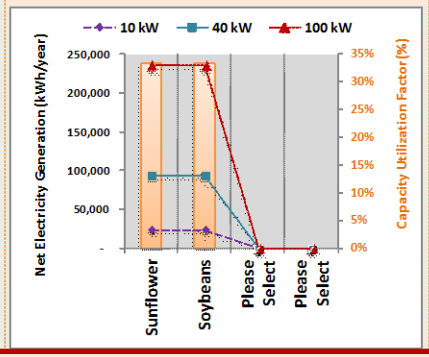
Techno-Economic Results

Comparison of average production costs (USD/kWh)

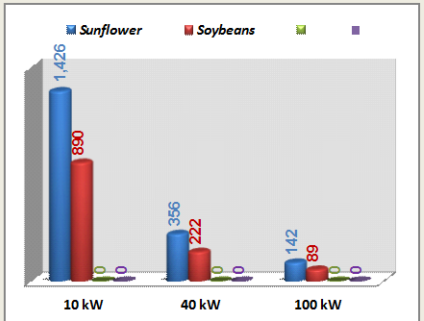
Include revenue from meal coproducts



Net Electricity Generation vs. Capacity Utilization Factor (%)

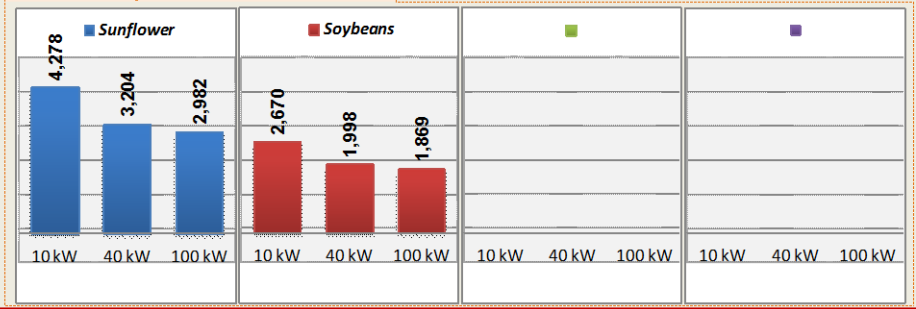


Potential number of plants

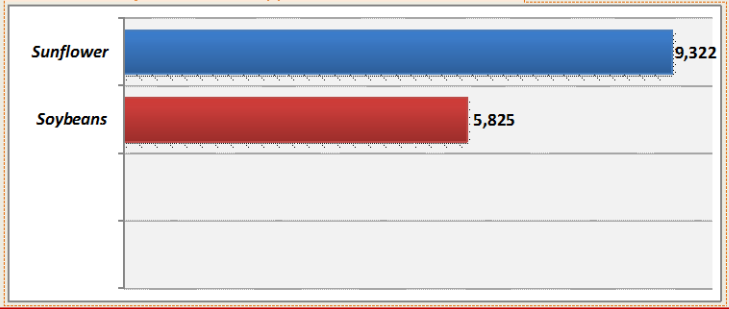


Socio-Economic Results

Total Number of Jobs Created

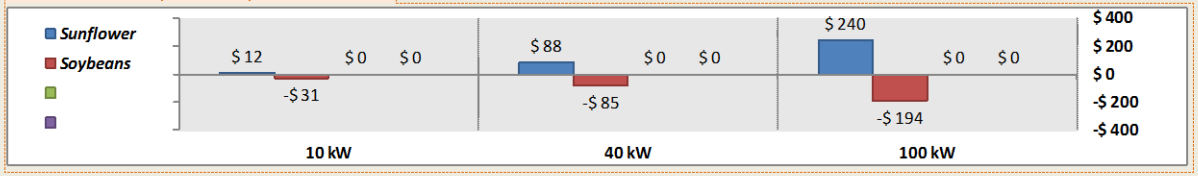


Total Number of Households Supplied



Financial Analysis Results

Net Present Value (1000 USD)



Internal Rate of Return (%)

	10 kW	40 kW	100 kW
Sunflower	196%	389%	437%
Soybeans	Not feasible	Not feasible	Not feasible

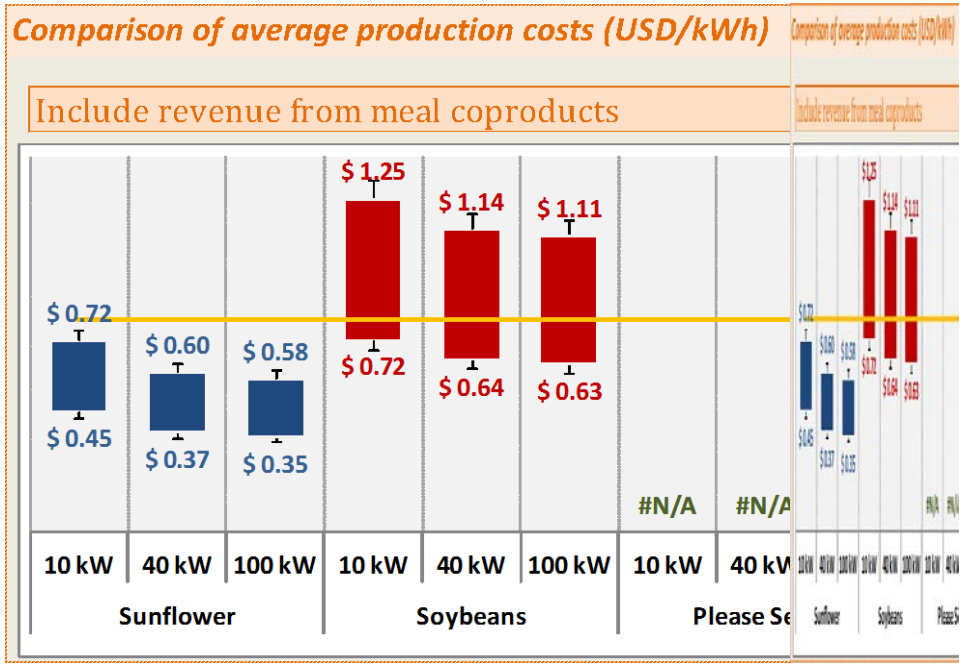
Techno-economic

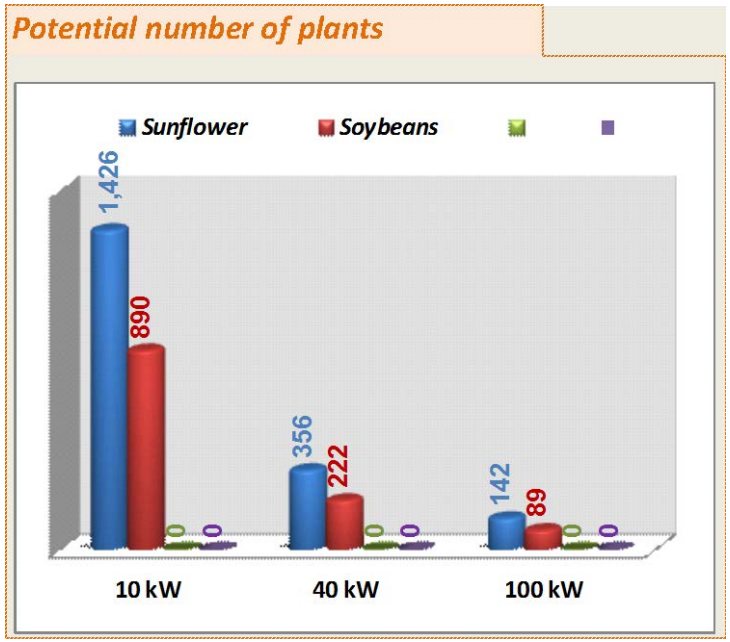
Socio-economic

Financial

BEFS

Techno-economic results



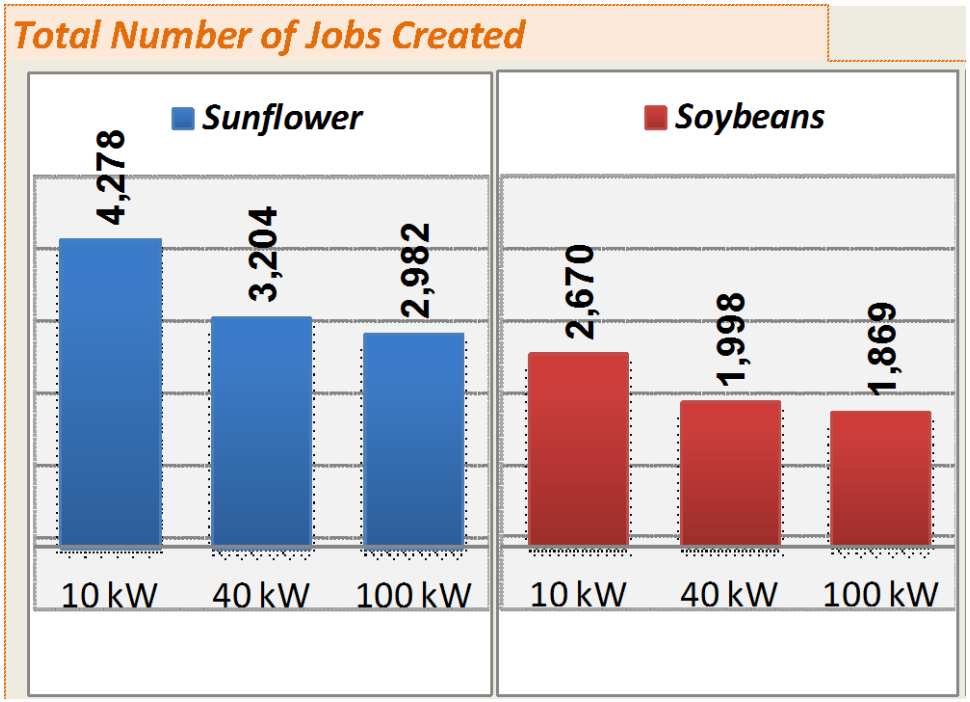


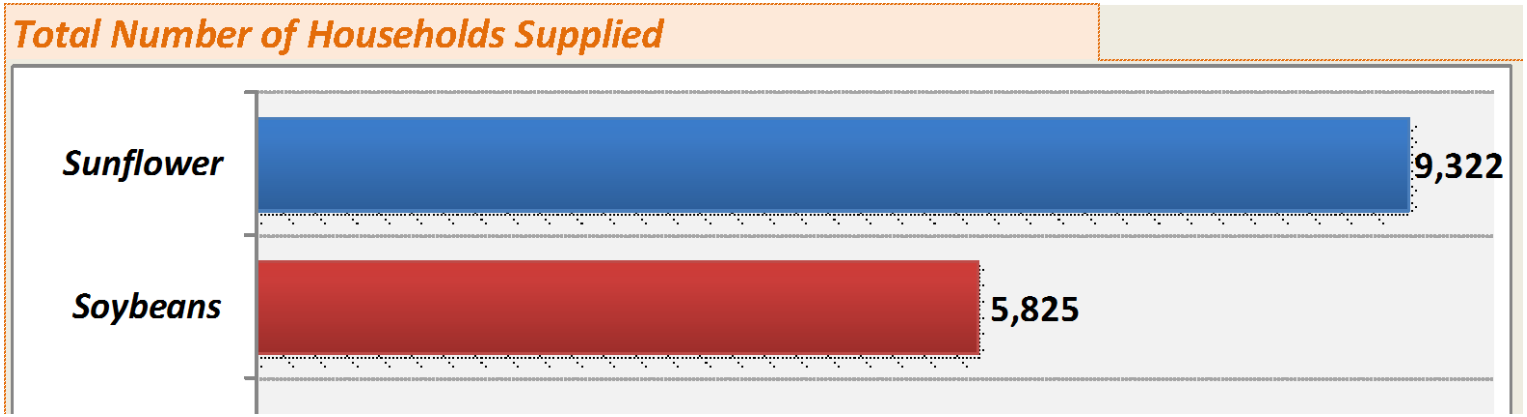
Comparative alternative

- 100 kW diesel generator
- Placed at the consumption site – no investment in the distribution network

- 3 capacity levels: 10kW, 40kW, 100kW
- based on the feedstock available for bioenergy – calculated in the Crops tool

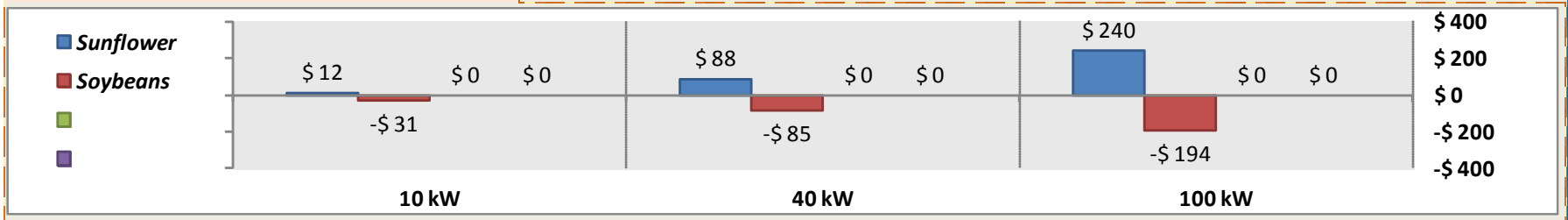
Socio-economic results





Results of financial analysis

Net Present Value (1000 USD)



Internal Rate of Return (%)

	10 kW	40 kW	100 kW
Sunflower	196%	389%	437%
Soybeans	Not feasible	Not feasible	Not feasible

Summary of results
- Comparison among feedstock-

Feedstock		Feedstock availability (kW installed capacity)	Households supplied	Jobs created	Financially viable	Competitive with diesel generator
Soybean		8,900	5,825	1,869-2,670	-	-/+
Sunflower		14,260	9,322	2,982-4,278	+	+

NEXT >>
Summary of Results by Feedstock

Summary of results for sunflower

Capacity	Total investment (USD)	Possible number of plants	Area required for feedstock supply	Households supplied	Jobs created	Financially viable	Competitive with diesel generator
10 kW	8,990	1,426	13 (ha)	7	3	+	+
40 kW	30,429	356	52 (ha)	26	9	++	+
100 kW	73,307	142	129 (ha)	65	21	+++	+

SUMMARY OF RESULTS OF SVO+RURAL ELECTRIFICATION FROM SUNFLOWER

<< BACK Data Entry Needs | Production Cost 1 | Production Cost 2 | Production Cost 3 | Production Cost 4 | Energy Demand Sheet | NEXT >> Summary of Results Comparative

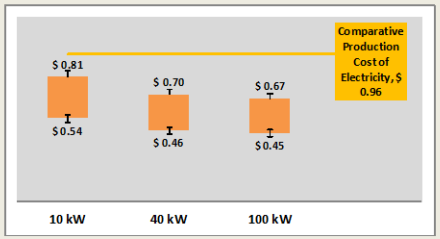
Select a biomass residue to see the summary results: Sunflower

Create a PDF report

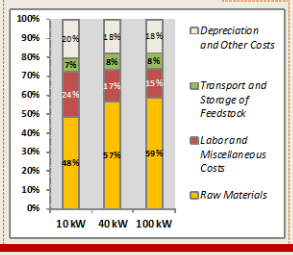
Production Cost and Investment Results

Include revenue from meal coproducts

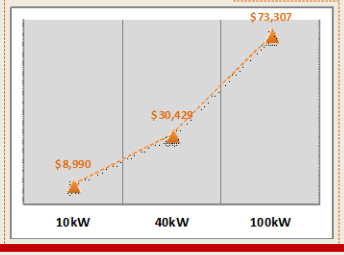
Range of total Production Cost + Distribution (USD/kWh)



Share of Production Cost (%)



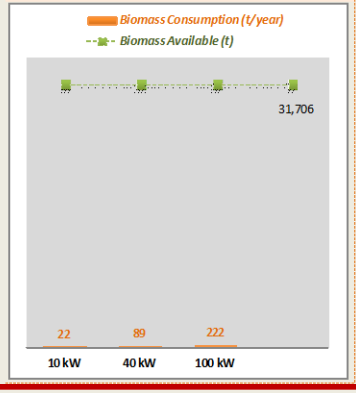
Total Investment (USD)



Investment and production costs

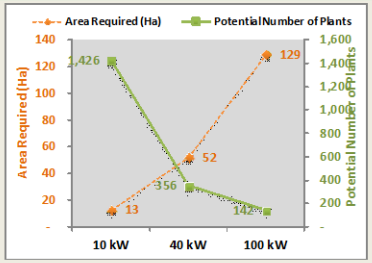
Technical and Operating Results

Feedstock Consumption per plant

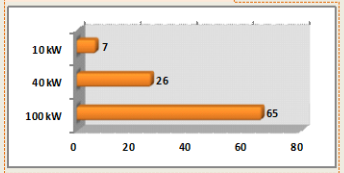


Area Required vs. Potential Number of Plants

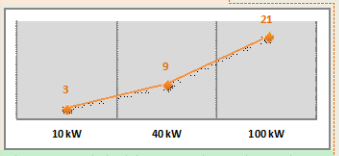
The maximum number of plants potentially available for 10 kW size is 1426
The maximum number of plants potentially available for 40 kW size is 356
The maximum number of plants potentially available for 100 kW size is 142



Households Potentially Supplied



Potential Job Creation

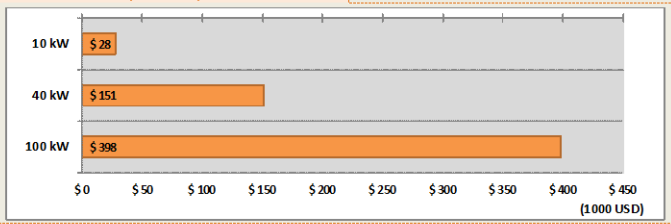


Job creation includes labor required to produce and distribute electricity only. Biomass collection is excluded

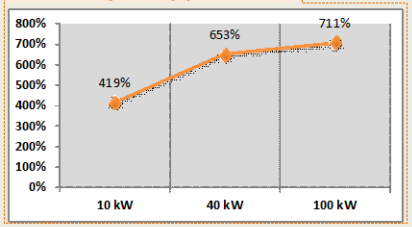
Technical and operating results

Financial Analysis Results

Net Present Value (1000USD)



Internal Rate of Return (%)

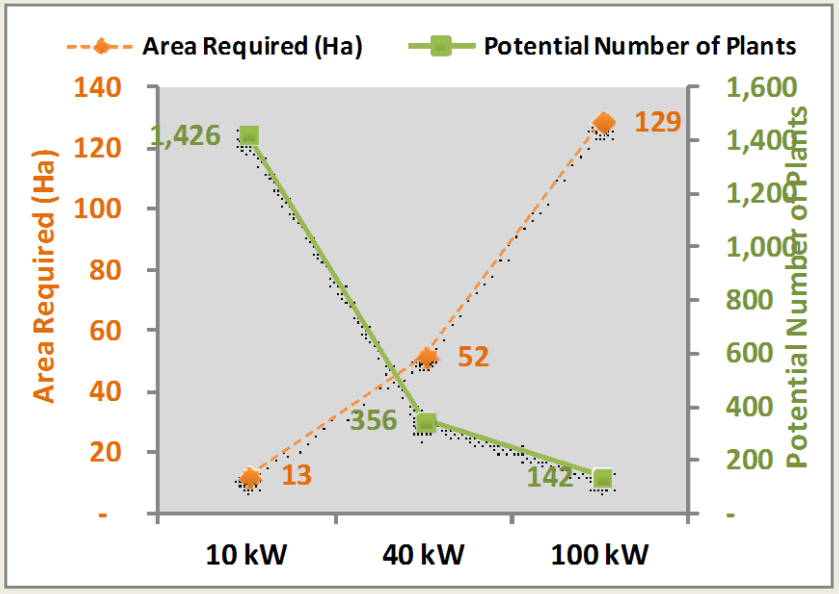


Financial

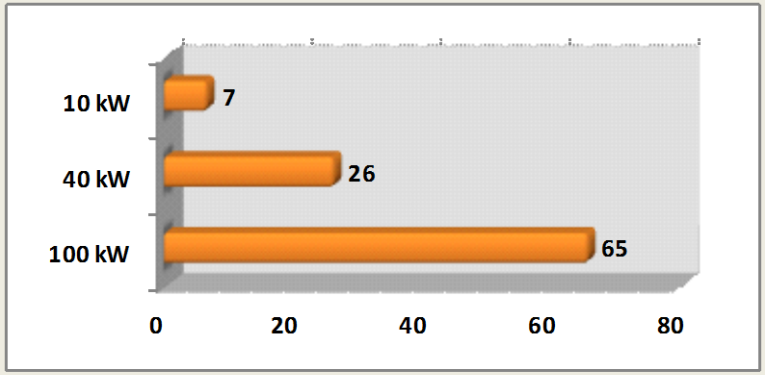
Results for SVO from sunflower

Area Required vs. Potential Number of Plants

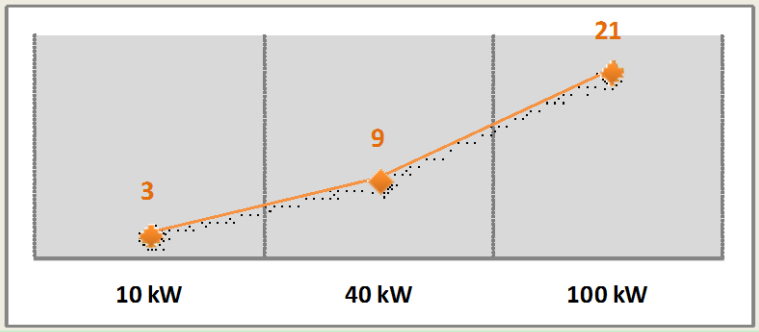
The maximum number of plants potentially available for 10 kW size is 1426
The maximum number of plants potentially available for 40 kW size is 356
The maximum number of plants potentially available for 100 kW size is 142



Households Potentially Supplied

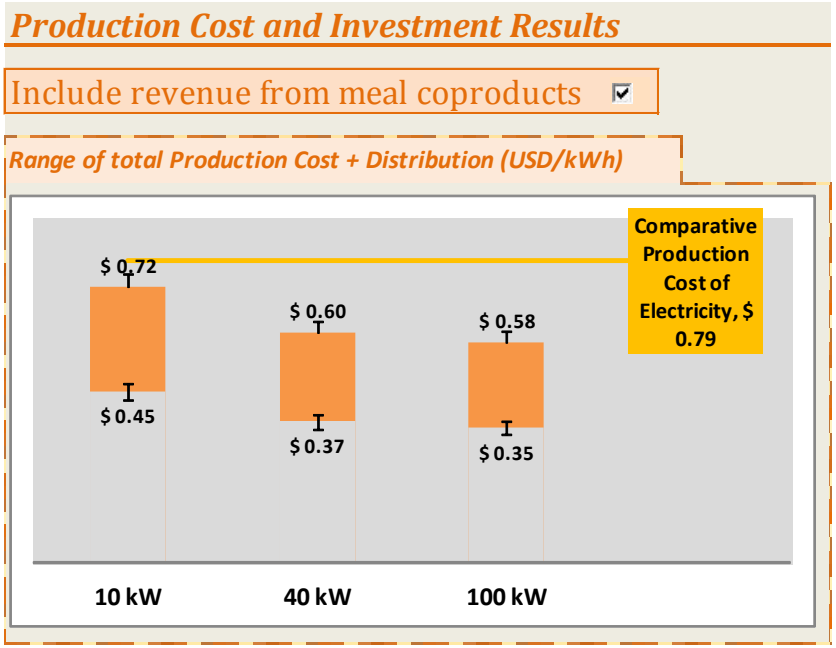


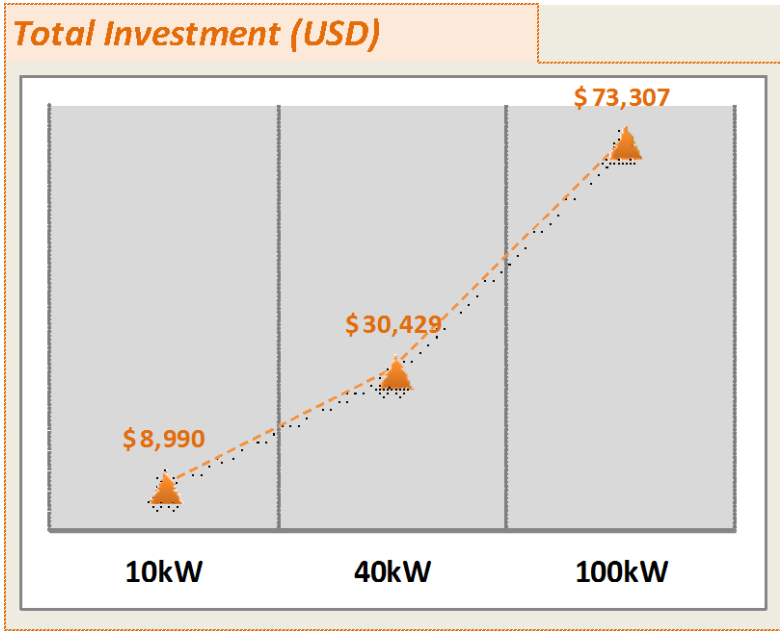
Potential Job Creation



Job creation includes labor required to produce and distribute electricity only. Biomass collection is excluded

Results of financial analysis for sunflower





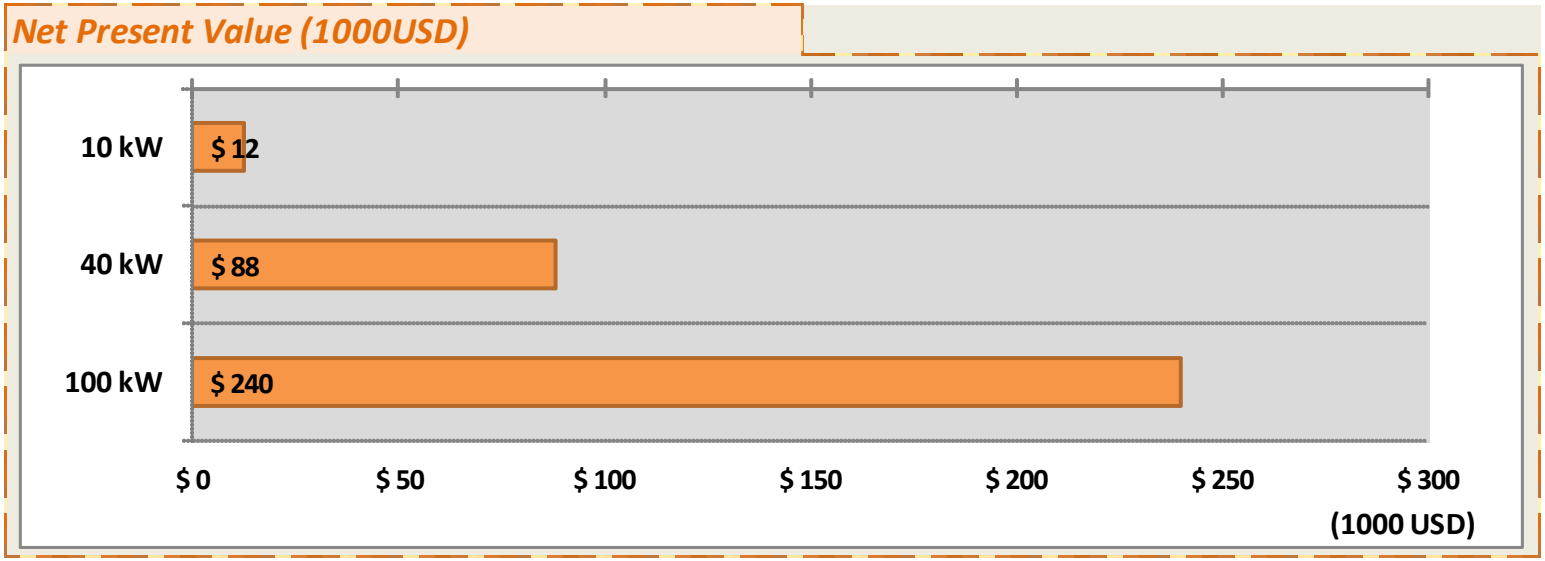
Comparative alternative

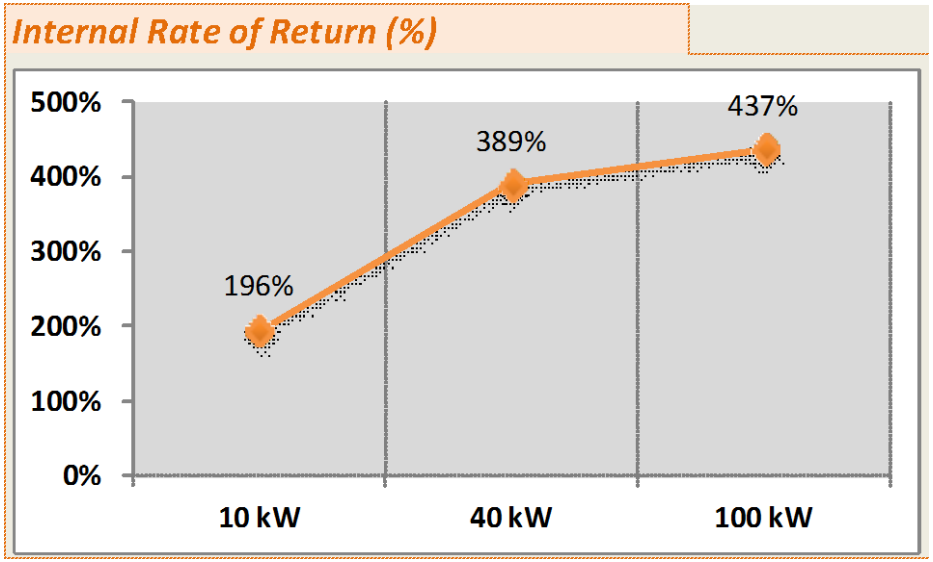
- 100 kW diesel generator
- Placed at the consumption site – no investment in the distribution network

Total investment - sunflower

- SVO generator and distribution network

Results of financial analysis for sunflower





Summary

Concluding remarks

- Understand the context, needs, constraints and investigate, **based** on the local **evidence**, potential viable solutions

- Central role for **smallholder inclusion** to ensure targeting poverty reduction

- **What bioenergy option** against which energy need, considering a **broader energy mix**

- **Integration is key**: Integrate food and energy systems

Questions?

- How would you use BEFS RA tools in the implementation of your programmes and projects?

All tools and manuals are available from:

http://www.fao.org/energy/befs/rapid-appraisal/en/

BEFS

Bioenergy and Food Security Projects

Thank you for your attention!

http://www.fao.org/energy/befs/en/

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