Renewable Energy Solutions: A ROLE FOR KENYA'S TEA INDUSTRY IN RURAL ELECTRIFICATION

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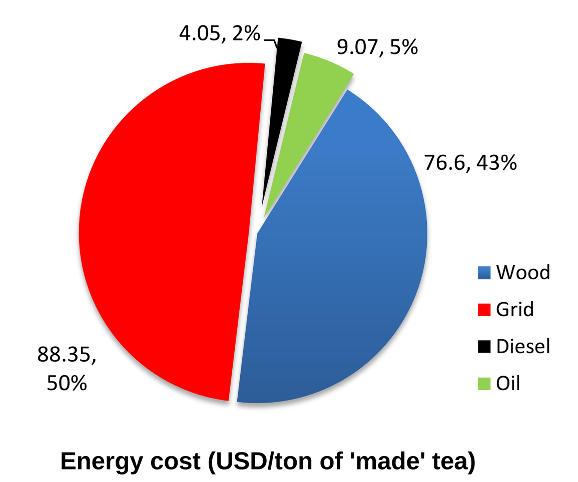
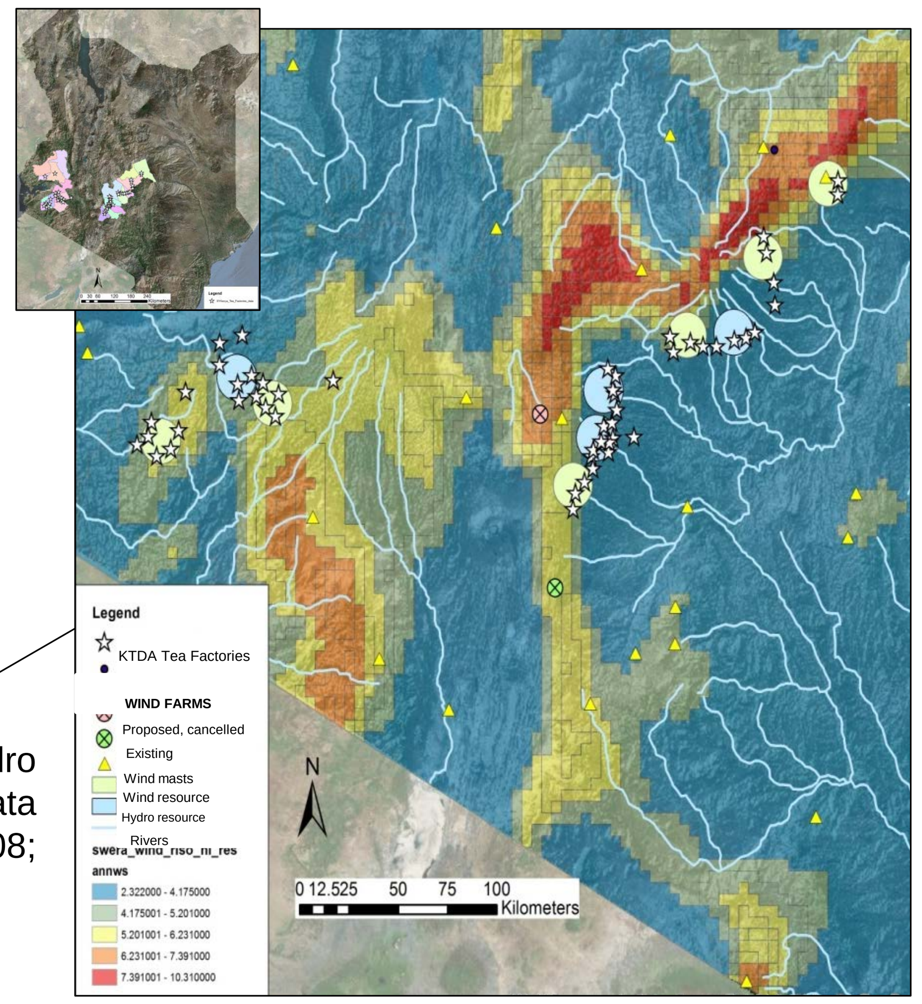
Introduction

- Rural Africa is energy-poor and national electrification schemes place a financial burden on the state. Can renewable energy projects, managed and operated by the rural private sector, play a role in local electrification?
- This study examines whether Kenyan tea factories, with state support, can act as facilitators and demand anchors for small rural energy schemes.
- Different tariffing structures are explored to see if these can encourage rural consumer participation, and support equitability and project viability.

Grid electricity contributes significantly to KTDA tea factories costs (IED, 2008)





Potential for wind (yellow/red=high) and hydro (rivers) power in tea-growing regions (Data from: WRI, 2007; IED, 2008; RisoeDTU, 2008; Nordman, 2014; IRENA, 2015; KTDA, 2017).

Research Questions

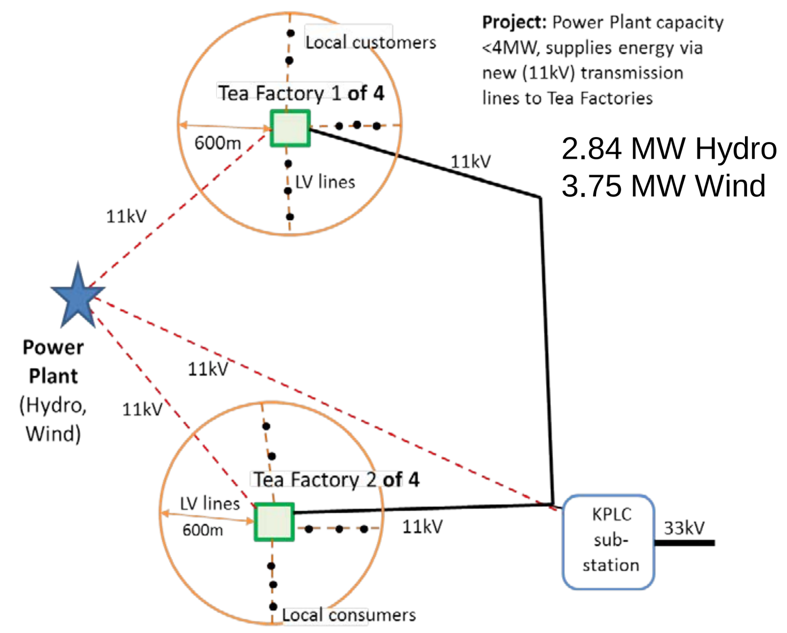
1. Can small wind/hydropower **supply tea factories** with **low cost** electricity?
2. Could these plants deliver **low cost** electricity to local **rural consumers**? Does including **rural consumers benefit** overall **project economics**?
3. Does the Kenyan **feed-in-tariff** (FiT) **support investment** in small RE?
4. Can **changes** in **cost allocation** lead to **fairer, more equitable** electricity **pricing** within the small rural electrification scheme?

Methodology and Model Design

- Input parameters and assumptions from the literature, where possible.
- Consumers: 4 tea factories, 800 domestic & 100 small businesses.
- Wind & hydropower projects assessed using cost-benefit financial models.
- Break-even (average cost) **electricity price** for plants is **key decision criterion**.
- Present value of savings found for tea factories and rural consumers.
- Sensitivity analysis on base case (Scenario 1).
- Different cost allocation rules calculated using a simple demand-supply model.
- Sensitivity analysis on prices in VBA.

Modelled Business Case

SCENARIOS EXAMINED	National grid connection	Consumers included
Scenario 1 (base case)	Grid connected (FiT)	Tea factories, rural consumers
Scenario 2	Grid connected (FiT)	Tea factories
Scenario 3	Stand-alone (No FiT)	Tea factories
Scenario 4	Stand-alone (No FiT)	Tea factories, rural consumers



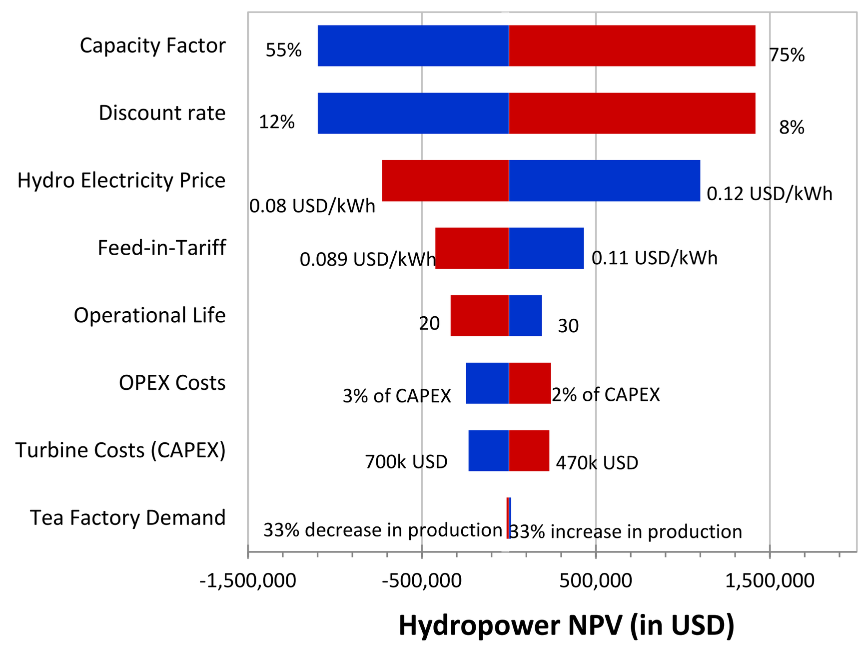
Main Results

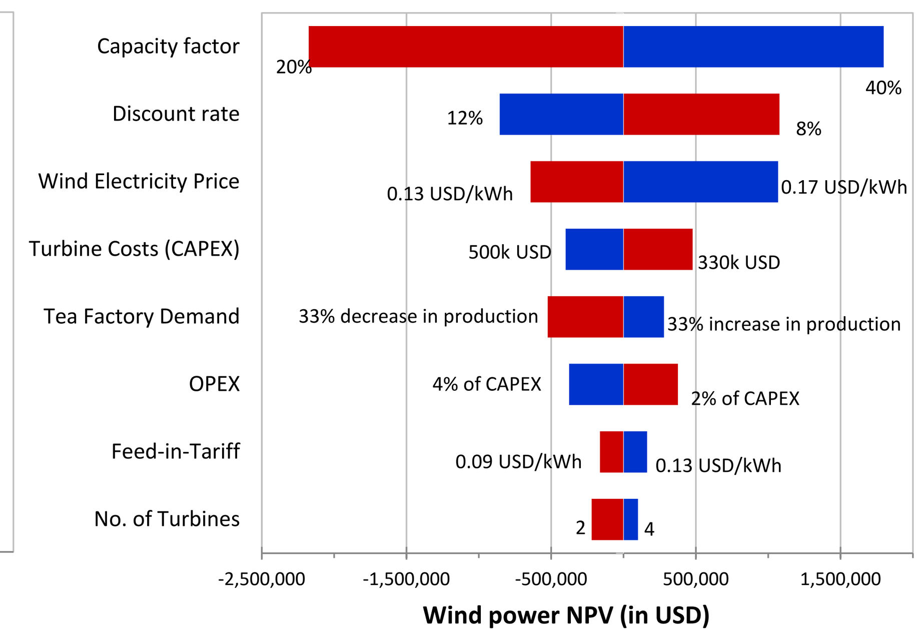
- **Grid connection & export** of surplus electricity **is key** to financial viability.
- **Hydro FiT is sufficient** without supplying excessive rent under base assumptions. *Project break-even price and hydro Fit are similar*.
- **Wind FiT is not sufficient** to provide full cost recovery under base assumptions. *Project break-even price is higher than the wind FiT.*
- **Project** economics **benefits** from **rural consumer** participation. *Tea factory savings increase when rural consumers are included.*
- **On-grid hydropower** provides **lower cost** electricity than on-grid wind or the national grid. *All consumers benefit from hydropower, but wind price is too high for domestic consumers - **exploration of cost allocation.***

	HYDRO		*WIND*	
SCENARIO 1	PV Savings per Tea Factory	1,176,944 USD	PV Savings per Tea Factory	409,706 USD
(Base case)	<u>PV Savings for Rural Consumers</u>		<u>PV Savings for Rural Consumers</u>	
	Domestic: *(per household)*	95 USD*	Domestic: *(per household)*	**-74 USD***
	Small Business: *(per property)*	1,365 USD*	Small Business: *(per property)*	635 USD*
SCENARIO 2	PV Savings per Tea Factory	1,176,101 USD	PV Savings per Tea Factory	378,762 USD
SCENARIO 3	PV Savings per Tea Factory	***- 348,468 USD***	PV Savings per Tea Factory	***-24,943 USD***
SCENARIO 4	PV Savings per Tea Factory	***-186,266 USD***	PV Savings per Tea Factory	104,997 USD
	<u>PV Savings for Rural Consumers</u>		<u>PV Savings for Rural Consumers</u>	
	Domestic: *(per household)*	***-232 USD****	Domestic: *(per household)*	***-144 USD*****
	Small Business: *(per property)*	199 USD*	Small Business: *(per property)*	387 USD**

**Includes 69 USD saving from Year 0 connection fee compared to the KPLC connection charge*
***At estimated cost per kWh - insufficient electricity generated by Year 20 to supply to all rural consumers*

Base Case Sensitivity: Project Risks





Cost Allocation

What tariff structure should be applied to the mini-grid? Three simple 'end member' pricing options explored.

	Cost Allocation	*Rationale*
Option 1 *(After base case)*	Tea factories and rural consumers share IPP and MV line costs. Rural consumers also pay surcharge for LV grid.	High cost 'end member' for rural consumers. All consumers contribute to the infrastructure they use, according to consumption.
Option 2	Costs of IPP, MV and LV lines shared between tea factories and rural consumers.	All consumers contribute to all infrastructure, according to consumption. Tea factories partially subsidize LV grid.
Option 3	Tea factories pay for IPP and MV line costs. Rural consumers pay only the surcharge for LV grid.	Low cost 'end member' for rural consumers. Tea factories subsidize rural consumers. Rural consumers pay to access the electricity – a marginal cost of connecting the mini-grid.
Pay FiT and excess	Rural consumers pay FiT and cover the costs of the LV lines. Tea factories pay 'break-even' price for IPP and MV lines.	Tea factories (as shareholders in IPP project) make same saving as under Scenario 2.

Results

- All consumers treated **equally** in Option 1 (base case). **Wind** power is **too expensive** for domestic consumers. *Rent transferred from rural consumers to tea factories.*
- **Most equitable** solution (Option 3) **benefits all** consumers, but tea factory savings are lower (than Option 1). *Rent transferred from tea factories to rural consumers.*
- ***Ownership issues***: Tea factories are **shareholders** in power plant & may want to **take advantage** of rural consumers. *When rural consumers pay FiT, plus mini-grid surcharge, tea factories make same savings as selling to the national grid without rural electrification scheme.*

	HYDRO		*WIND*	
1. After Base Case	PV Savings for Tea Factory	1,176,944 USD	PV Savings for Tea Factory	409,706 USD
	<u>PV Savings for Rural Consumers</u>		<u>PV Savings for Rural Consumers</u>	
	Domestic: *(per household)*	95 USD*	Domestic: *(per household)*	**-74 USD***
	Small Business: *(per property)*	1,365 USD*	Small Business: *(per property)*	635 USD*
2. Share all costs	PV Savings for Tea Factory	1,153,468 USD	PV Savings for Tea Factory	400,028 USD
	<u>PV Savings for Rural Consumers</u>		<u>PV Savings for Rural Consumers</u>	
	Domestic: *per household)*	163 USD*	Domestic: *(per household)*	**-4 USD***
	Small Business: *(per property)*	1,607 USD*	Small Business: *(per property)*	887 USD*
3. Rural pay only excess	PV Savings for Tea Factory	1,095,088 USD	PV Savings for Tea Factory	303,576 USD
	<u>PV Savings for Rural Consumers</u>		<u>PV Savings for Rural Consumers</u>	
	Domestic: *(per household)*	446 USD*	Domestic: *(per household)*	400 USD*
	Small Business: *(per property)*	2,619 USD*	Small Business: *(per property)*	2,329 USD*
Pay FiT and excess	*PV Savings for Tea Factory*	*1,176,101 USD*	*PV Savings for Tea Factory*	*378,762 USD*
	<u>PV Savings for Rural Consumers</u>		*<u>PV Savings for Rural Consumers</u>*	
	Domestic: (per household)	*98 USD**	*Domestic: (per household)*	*56 USD**
	Small Business: (per property)	*1,377 USD**	*Small Business: (per property)*	*1,099 USD**

**includes 69 USD saving from Year 0 connection fee compared to the KPLC connection charge*

Policy Recommendations

- Kenyan **Government** should **review** FiT policy, in particular the **small wind FiT**.
- **Regulators** have an important **role** to play in mini-grid **tariff determination** and standardization to **encourage efficient, fair and equitable cost allocation** and prevent ownership issues influencing pricing.

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