



Federal Ministry
for Economic Affairs
and Energy



Storage Solutions in Developing Countries

A Case Study on the Market Potential for Battery Storage in Tanzania

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Energy supply in Tanzania

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Battery storage technologies

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Fields of application for battery storage

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Market potential & Outlook



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Energy supply in Tanzania

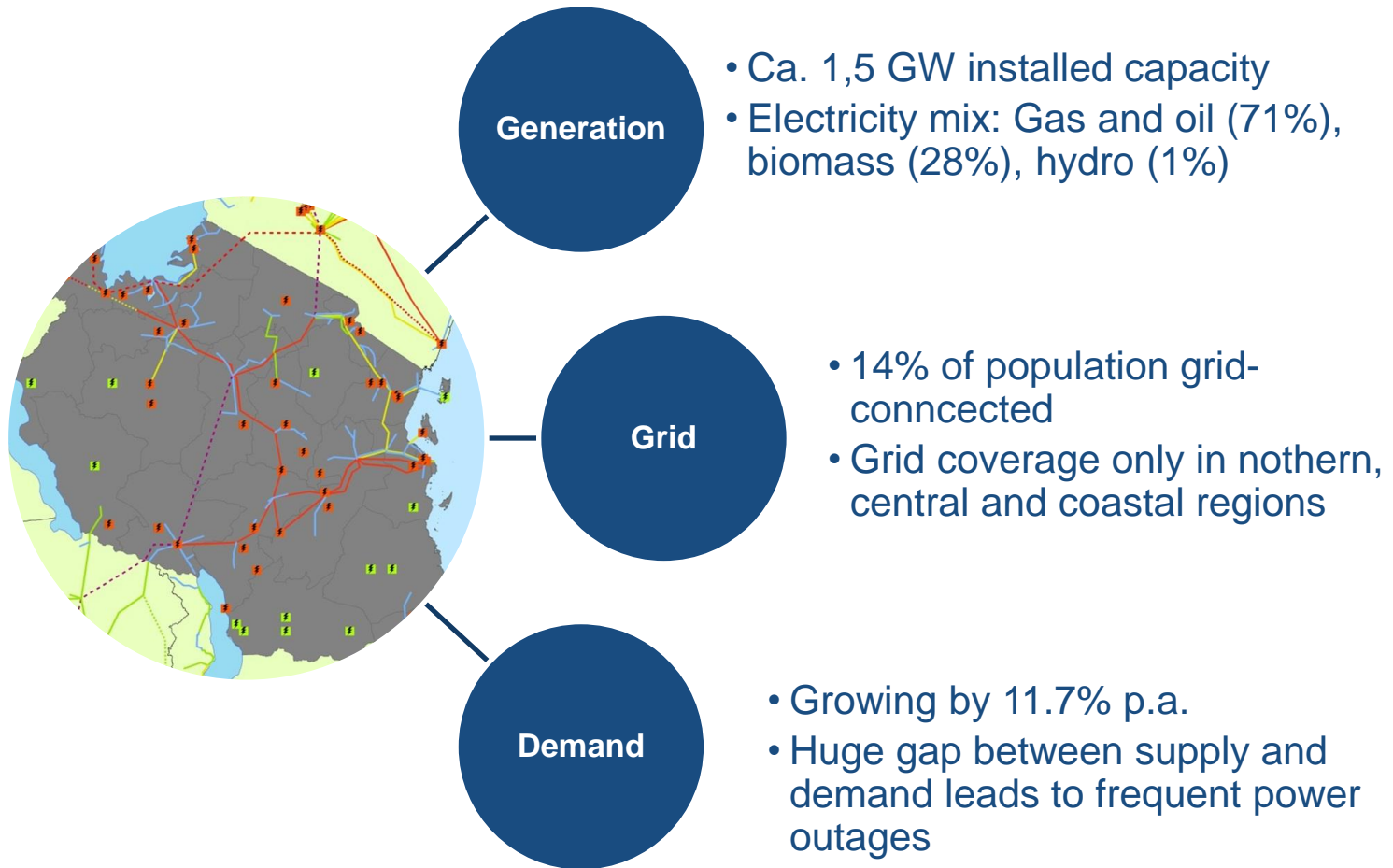
Status Quo in Tanzania



- **Frequent power outages:** 3-10 times per month for 3-5 hours
- Power capacity insufficient to meet a steadily **increasing demand**
- Unreliable power supply is stated as one out of three **largest obstacles for doing business** in Tanzania
- Industry suffers production downtimes and needs to backup with **expensive diesel** power generation



Energy supply in Tanzania



Energy supply in Tanzania

Back-up power supply:

- Diesel generators most commonly used back-up power source (>54% of companies)
- High Diesel prices up to 1.20 Euro/liter



High costs for diesel power generation
30-43 ct/kWh
vs.
National Grid price
3-12 ct/kWh



Analysis of the cost competitiveness of storage technologies for back-up power supply

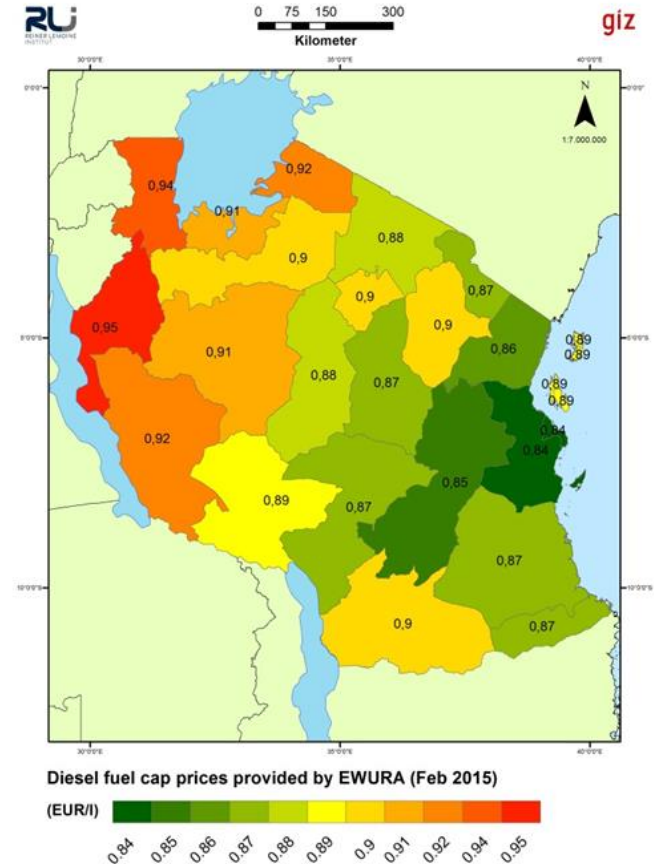


Figure: Regional diesel cap prices

Source: Own illustration according to EWURA (2015) and Szabo et al. (2011)

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Facilitator

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Battery storage technologies

Comparison of technical characteristics of lead-acid and lithium-ion batteries

Technical parameter	Lead-acid batteries (VRLA)	Lithium-ion batteries
Energy density (Wh/kg)	20 – 45	100 – 200
Power density (W/kg)	100 – 200	200 – 4000
Lifetime (years)	3 – 10	10 – 15
Cycles (at 100 % DoD)	200 – 470	3000 - 5000
Max. depth of discharge	~ 50 %	~ 80 %
Self-discharge (at 20° C)	< 5 % per month	< 5 % per month
Roundtrip efficiency	60 – 85 %	90-95 %
Capital expenditures ₂₀₁₃ (EUR/kWh)	250 - 500	800 - 1600

- Cost advantage and maturity
- Applicable for regularly occurring long-lasting outages
- Lighter and longer lifetime
- Suitable for frequent outages and weak grid stability

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Fields of application for battery storage



Residential sector: households, villages



Commercial sector: Service, agriculture, small industries



Tourism sector: grid-connected hotels, small lodges



Telecom sector: grid-connected and off-grid towers



Health care and administration: hospitals and public buildings



Fields of application for battery storage

An excel tool was developed to assess the **economic attractiveness** of lead-acid and lithium-ion batteries

Input parameters:

- Electricity consumption
- Load curve (evening/ midday peak)
- Frequency and duration of power outages
- Battery type and profile

Results:

- Economic comparison of lead-acid batteries, lithium-ion batteries, and diesel genset
- Project cost debt-financed/ equity-financed
- Energy demand curve and power outages
- Sensitivity analysis: diesel fuel price, interest rate, battery CAPEX

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Market potential & Outlook



Commercial sector: Service, agriculture, small industries

- Unreliable electricity supply major **obstacle for business**
- **High diesel fuel costs and low interest rates** are most favourable for cost-effectiveness of batteries
- **Lithium-ion batteries** suitable for customers with **frequent outages** and a weak grid stability,
- **Lead-acid batteries** can be applied for regularly occurring **long-lasting outages**

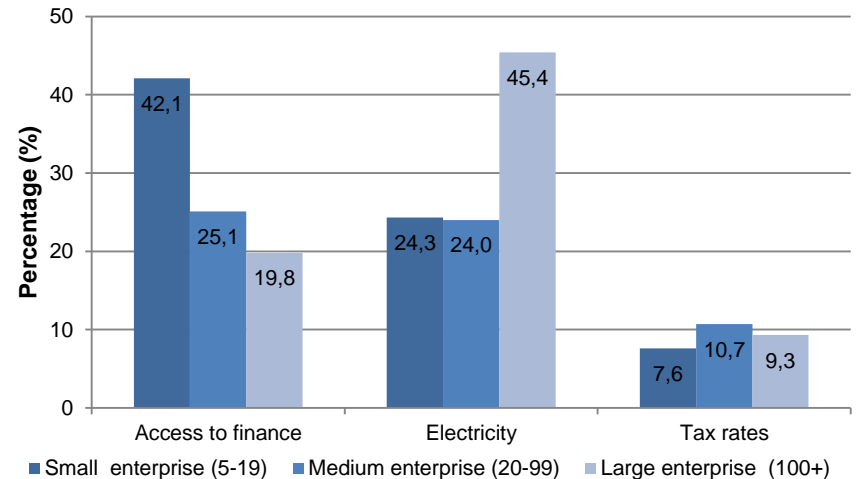


Figure: Three biggest obstacles for doing business in Tanzania (Number of employees in brackets)

Source: World Bank (2013)

Market potential & Outlook



Commercial sector: Service, agriculture, small industries

- A coffee farm selected as case study
- Stable demand of around **135 kW per hour** due to constant use of energy intensive machinery (water pumping)
- Blackouts occur daily between 5 and 7pm

Conservative assumptions:

- Grid power costs 0.1 EUR/kWh
- Diesel fuel costs 1 EUR/l
- Interest rate of 15 % is applied
- No solar PV capacity installed

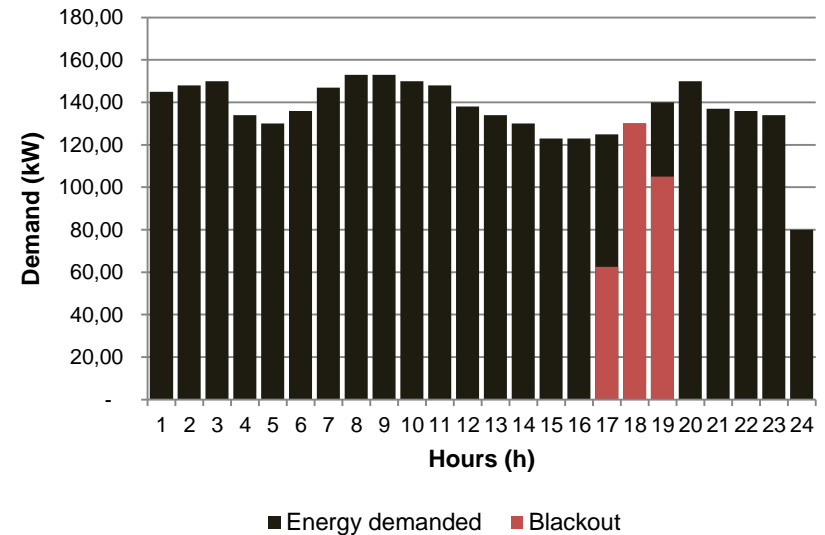


Figure : Load profile and power outages for agricultural company case study



Source: Own illustration – load profile was made available by OneShore Energy GmbH

Market potential & Outlook



Commercial sector: Service, agriculture, small industries

- Approx. **9% electricity losses** due to power outages
- Necessary **storage capacities** to compensate blackouts: **456 kWh Li-ion, 238 kWh L/A** and **210 kW diesel generator**

Battery back-up systems				Diesel generator		
	Lead-acid	Lithium-ion				
Parameter	Value	Value	Unit	Parameter	Value	Unit
Installed capacity	455.9	238.4	kWh	Installed capacity	210.0	kW
Installed power	152.0	238.4	kW			
Total Investment	159,581.0	238,427.4	EUR	Total Investment	63,000.0	EUR
Annual CAPEX	35,562.6	43,985.3	EUR	Annual CAPEX	10,774.1	EUR
Annual OPEX fix	3,191.6	2,384.3	EUR	Annual OPEX fix	210.0	EUR
Annual OPEX var.	0.0	0.0	EUR	Annual OPEX var.	5,120.0	EUR
Annual charging costs	12,641.9	11,346.2	EUR	Annual fuel costs	40,959.8	EUR
Total annual costs	51,396.2	57,715.7	EUR	Total annual costs	57,063.8	EUR
Annuity factor	0.22	0.18		Annuity factor	0.17	
LCOE battery back-up energy	0.50	0.56	EUR/kWh	LCOE diesel back-up energy	0.56	EUR/kWh

Market potential & Outlook



Tourism sector: grid-connected hotels, small lodges

- Contribution to Tanzanian **GDP: 12,1%**
- Average hotels consume between **500 and 1,500 kWh per day**
- Almost all hotels have back-up power generation facilities or are solely operating on diesel generators
- Large potential for storage systems



Case study resort – assumptions:

- Daily Consumption 1 MWh
- Grid power costs 0.1 EUR/kWh
- Diesel fuel costs 1.20 EUR/l (remote lodge)
- Interest rate of 8 % is applied (access to international capital market)
- Solar PV system with a peak capacity of 35 kWp

Market potential & Outlook



Tourism sector: grid-connected hotels, small lodges

Battery storage systems				Diesel generator		
	Lead-acid battery	Lithium-ion battery				
Parameter	Value	Value	Unit	Parameter	Value	Unit
Installed capacity	208.5	69.5	kWh	Installed capacity	104.3	kW
Installed power	69.5	69.5	kW			
Total Investment	72,991.7	69,515.9	EUR	Total Investment	31,282.1	EUR
Annual CAPEX	16,266.2	12,824.3	EUR	Annual CAPEX	5,349.8	EUR
Annual OPEX fix	1,459.8	695.2	EUR	Annual OPEX fix	104.3	EUR
Annual OPEX var.	0.0	0.0	EUR	Annual OPEX var.	2,833.4	EUR
Annual charging costs	5,950.4	5,340.5	EUR	Annual fuel costs	23,761.5	EUR
				Annual fuel consumed	19,801.3	litre/a
Total annual costs	23,676.5	18,860.0	EUR	Total annual costs	32,049.0	EUR
Annuity factor	0.22	0.18		Annuity factor	0.17	
LCOE battery back-up energy	0.42	0.33	EUR/kWh	LCOE diesel back-up energy	0.57	EUR/kWh



Market potential & Outlook



Telecom sector: grid-connected and off-grid towers

- **4,600 telecom towers** in Tanzania with annual **growth rate of 19% p.a.**
 - Two thirds grid-connected and one third off-grid
 - The **majority of towers** face power **outages** for more than **6 hours per day**
 - High costs for purchase and transport of diesel
- Telecom towers bear a **high market potential for batteries** due to regular blackouts as well as high costs for energy costs back-up power supply

On-Grid: Energy costs

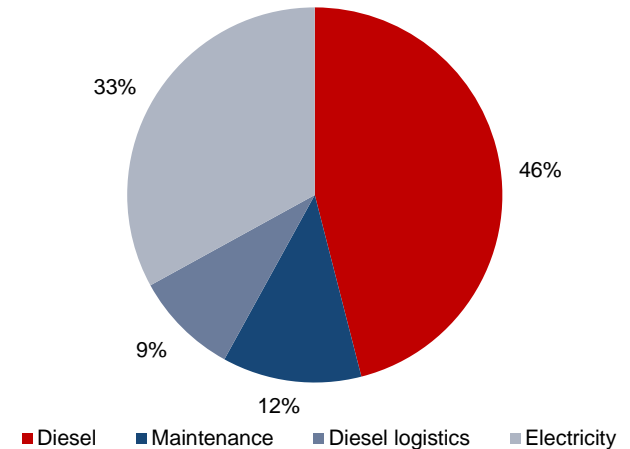


Figure: Electricity supply costs for on-grid and off-grid operating telecom towers

Source: GSMA (2015c)

Market potential & Outlook



Health care and administration: hospitals and public buildings

- Reliable electricity supply essential for health infrastructure
 - **Largely underdeveloped** health system; in remote areas health care is provided by small dispensaries or health centres
 - Only **50% of all health facilities** are provided with access to **electricity** and 30 % with access to reliable electricity supply (power outages less than 2 hours)
- Back-up energy supply for health care required

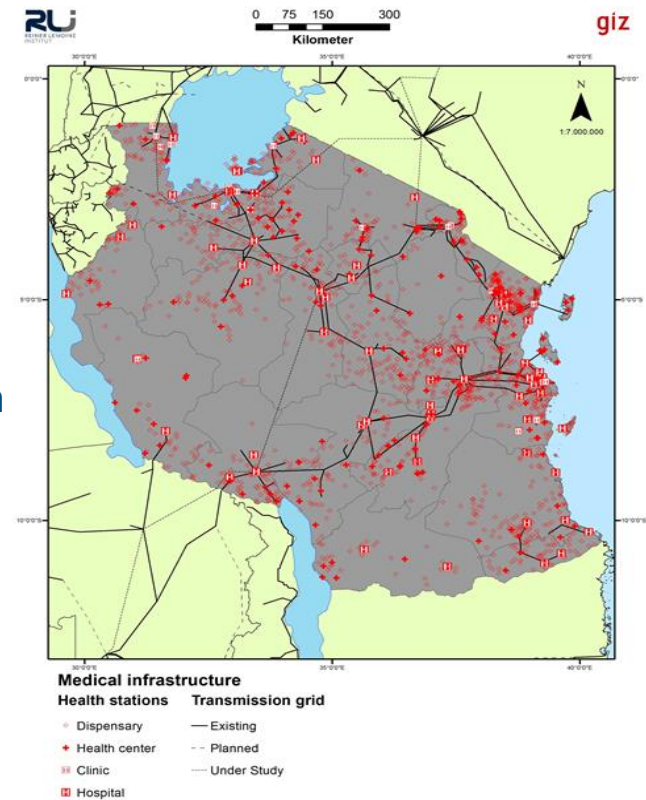
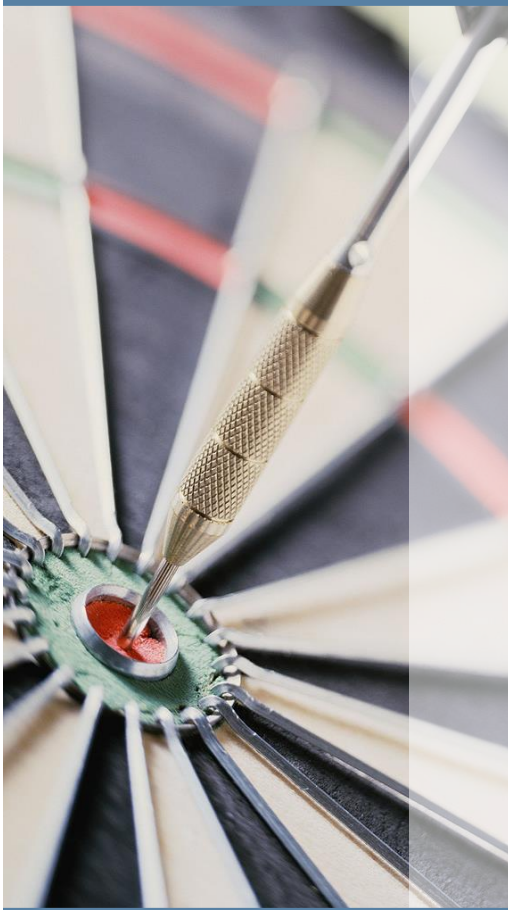


Figure: Health care infrastructure in Tanzania

Source: National electrification prospectus (REA 2014)

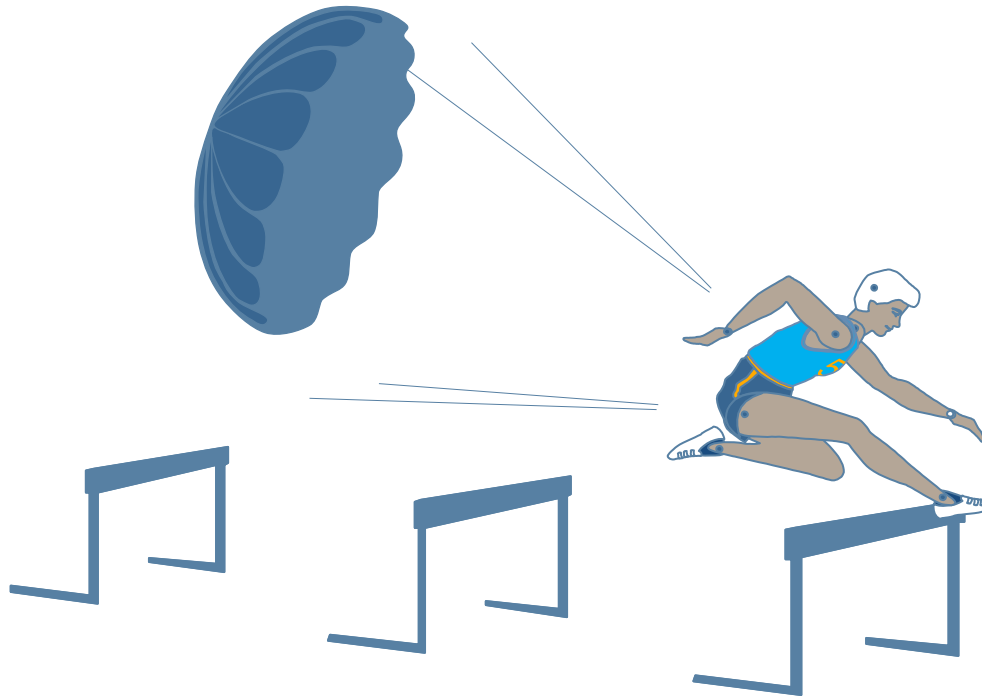
Market potential & Outlook



- Most attractive: **off-grid and weak grid** regions
- **Tourism sector** and **commercial sector** most promising
- **Lithium-ion batteries** most suitable for occurrence of **highly fluctuating power outages** which require quick charging and discharging reactions
- **Lead-acid batteries** are attractive for **longer steady back-up power supply** (less cost per kWh storage capacity)
- The **combination of battery systems with PVs** further reduces back-up power costs
- The most influencing factors on the **economic viability** of battery systems for on-grid back-up power supply are the applied **interest rate** and the local **diesel price**

Market potential & Outlook

How to overcome the hurdles for market entry?



Market potential & Outlook

Challenges

Technical

- Missing quality standards for battery products
- Technical know-how of local distributors



Financial

- Difficult access to local or international financing
- High upfront investments
- Short term price sensitivity of end-customer
- Import taxes on batteries



Projects

- Missing pilot projects for new technologies
- High consulting and marketing effort
- Diverse customer structure
- Price sensitivity of customers
- Strong internat. competition with low cost products



Approach

- Introduction of standards
- Training of local distributors and electricians

- International financing programs and guarantees
- Micro-financing for small projects
- Education on economic advantages of batteries
- Combination of RE products and batteries to save import taxes

- „Centralized“ project development
- Collaborative pilot projects

Thank you for your attention!

Contact:

Stefanie Werler

Project Development Programme (PDP)
renewables – made in Germany initiative

E: stefanie.werler@giz.de

T: 030-338424-389



For further information and to download the full study visit :

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