# The influence of market availability on the adoption rates of sustainable energy technologies in Kakuma refugee camps

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## Abstract

Market availability is a key feature in a business. It helps in designing the product or service that meets the needs of consumers, and setting competitive, profitable and affordable prices. Adoption of sustainable energy technologies can therefore be best discussed in the lens of supply and demand. One of the bases for unwillingness to adopt sustainable energy is the fear of unreliability in supply. On the demand side, adoption of energy technologies will depend on satisfying what the customers are asking for and not necessarily what the suppliers imagines. The purpose of this study was to investigate the influence of supply and demand factors on the adoption rates of sustainable energy technologies in Kakuma refugee camps. The study adopted concurrent descriptive cross sectional and correlation research designs. Both simple random and purposive sampling methods were used to sample respondents. A quantitative tool was administered on 286 refugee respondents, two focus group discussions were held, 29 key informant interviews were conducted while 10 observations were made. Data was analyzed using SPSS by applying both descriptive and inferential statistical procedures. The study findings revealed that the predictor variables identified as supply and demand factors, had a significant positive influence on adoption rates of sustainable technology. The study concludes that market availability factors have a role on adoption rates of sustainable energy technologies as indicated by the value $\beta 1 = 0.113$, $t = 3.782$, $p<0.05$ and $\beta 2 = 0.790$, $t = 26.333$, $p<0.05$ UNHCR and humanitarian agencies should develop a gendered database on SE requirements in camps that is based on consumer preferences as a guide to planning and management of humanitarian energy aid.

***Keywords:*** *Adoption rate, markets, supply, demand, sustainable energy technologies, Kakuma refugee camps, cooking, lighting.*

## Introduction

A significant requirement to the successful adoption of sustainable energy technology is a stable market (Lahn and Grafham, 2016). One such market is the humanitarian settings hosting refugees. This market although huge has in general limited access to sustainable solutions. Most refugees depend on insufficient humanitarian agency handouts of 'in-kind' firewood or have to travel long distances to collect firewood in the latter case, exposing themselves to the risk of attack and/or sparking conflict with host communities (UNHCR, 2016). In many cases refugee households' unwillingness to adopt renewable energy is due to fear of unreliability of supply. This forms one of the bases for failure to adopt renewable energy technologies in refugee camps (Rosenbaum et al., 2015). In most cases firms selling fuel such as ethanol or biomass pellets are faced with the challenge that the products are still relatively new to the market. Currently in Kenya, most renewable energy technology is available although market penetration is notably low and existence of these technologies is rarely known by potential users (Mwakubo et al., 2007).

## Demand for energy services

There are a number of ways to describe energy demand and access. Energy demand can be categorized by the energy services needed for lighting, cooking or heating as well as by the consumer group (Rosenbaum, et al., 2015). The energy services needed by each consumer group such as households, small business enterprises and communities vary widely but include electricity, thermal energy, and liquid and gaseous fuels (Sampa, 2007). The preferences and priorities of different groups and communities in refugee camps are important factors in determining which energy choices are appropriate, especially at the household level. In addition, actual energy use in a household varies depending on the local environment, local availability of energy, local livelihoods, camp organization and local incomes. In such environments, energy needs are mainly described in terms of energy for cooking, lighting and operating electronic equipment.

Consumer demand for renewable sustainable energy increases as consumers become active in life. Today, consumers increasingly have positive attitudes towards renewable energy. This seems to be making long-term impact on energy markets, by promoting the transition to a green energy market. The increasing market attractiveness of renewable energy, due to positive signs on the demand side, encourages firms involved in the renewable energy technology and product sectors to develop strategies for capturing the market and profit potential. In Kakuma I camp for example, more than one-third expressed a willingness to pay for quality household solar products, indicating a potential customer base of 5,000 families and a market worth some $300,000' (Corbyn & Vianello, 2018). In Kakuma, a market for solar home systems based on PAYGO and leasing models is emerging.

**Supply of sustainable energy technologies**

In order to meet the consumer demands companies are working to establish feed stock supply chains and last-mile distribution routes (Lahn and Grafham, 2016). As such, some of these companies do not view Kakuma as 'low-hanging fruit' and would rather concentrate their efforts on Nairobi or other urban centres where the price of charcoal is much higher and the market less remote (Simon, 2016).

In addition, a lot of companies offering alternative fuels, such as briquettes and ethanol, are small, early-stage firms, not operating at a scale or making profits. Such companies may be interested in the opportunity presented by new markets but lack their own funds to invest. They would, according to Rosenbaum, et al., (2015), need financial and operational support to scale up their business in displacement settings such as refugee camps

Other factors that make sustainable energy technologies less competitive or unavailable in the markets include lack of successful sustainable energy business models that can be replicated to help turn small-scale projects into commercial businesses and meet market demands effectively and efficiently. There are opportunities to leverage existing displacement-setting markets, as was highlighted by several proposals for the concession in Kakuma. Fuel and stove distribution can be handled through new or existing retail outlets and sales agents (Rosenbaum, et al., 2015).

**Unmet energy needs**

The electricity for camp management comes from inefficiently maintained diesel generators, which have high running costs (Morales, 2017). This means energy needs of millions of displaced and refugee people are being met inadequately (GIZ, 2017) and inefficiently (Bailey, Lahn & Grafham, 2017), and not through the most effective or carbon-efficient interventions (Bensch, 2016).

In Kakuma, firewood is part of the emergency supplies given to refugees for domestic fuel needs. Currently, getting adequate supplies for the sprawling camp is proving to be an up-hill task for the humanitarian agencies. Fuel scarcity drives refugees into clearing of available vegetation, burning plastics or selling part of their food rations for firewood. Women and girls risk their lives venturing into bushes for firewood collection and are at

times victims to sexual assaults, snake bites, scorpion stings, arrests and abductions while foraging in bushes for fuel.

On the sustainable energy solution supply, deficiency of market analysis has in many cases hampered the uptake of product development (Wanjiru and Ochieng, 2013). As shown by poor market understanding regarding stakeholder mapping, technology mapping and promotional schemes, high costs of products often lead to market stagnation further discouraging the technology uptake. Appropriate energy technologies properly delivered offer opportunities for improving conditions in humanitarian settings.

Market availability and intervening factors under market conditions in a humanitarian setting are a recent phenomena and have scantly been studied on their relationship with the adoption of sustainable energy technology. This study addressed this knowledge gap by conducting a mixed research design from a consumer behavior perspective by considering both independent and intervening variables in order to heighten the knowledge of adoption rates of sustainable energy technology, thus the study examination of the influence of market availability on the adoption rates of sustainable energy technologies in Kakuma refugee camps.

**Research Design**

This research adopted concurrent descriptive cross sectional and correlation research designs. The choice of this research method was primarily to collect qualitative data to illustrate quantitative findings. This enabled the researcher to collect both quantitative and qualitative data that focused on generating detailed information regarding the key aspects.

**Study Population**

According to UNHCR (2019), as of August, 2019 Kakuma refugee camps had 191,500 refugees. 1000 of them who were trained by SNV on sustainable energy in Kakuma formed the study population. Further, the population included zonal leaders in the camps, lead persons drawn from UNCHR implementing agencies and sustainable energy market organizations.

**Sampling Strategy and Sample Size**

The current study employed simple random sampling technique to sample refugees in Kakuma refugee camps. Purposive sampling was used to select UNHCR implementing partners. In choosing the sample for FGDs, and observation, census was used. The Slovins statistical formula was employed to obtain the study sample size as follows.

$$n = \frac{N}{1 + N(e)^2}$$

Where; n= sample size, N=Population, e = level of precision

n=1000 / (1+1000 $(0.05)^2$) = 286 respondents

For focus group discussions, census technique was used since the population of interest was smaller. However for interview, 29 lead persons drawn from 42 implementing partners operating in Kakuma were selected. This represents 69 % of the population.

**Data Collection Instruments and Procedure**

The quantitative tool employed was a structured questionnaire that was applied to 286 refugee respondents. The qualitative tools employed were interview and FGD guides and an observation check list. The instruments were pre-tested in a pilot study at Kalobeyi due to its similarity with camps, to check for their reliability and validity.

For open-ended questionnaires the respondents were required to use their own words to answer questions, whereas in closed-ended questionnaires pre-written response categories were provided. The questionnaires were

administered using 'drop-and-pick' method. This provided convenience and efficiency in the process of data gathering.

For key informant interviews, purposive sampling was used to identify respondents through consultation with SNVs in the camps. Only the UNHCR implementing partners whose role were within the interest of the study were chosen for the interview. An interview schedule was used, and before the interview, the interviewer gained a rapport with the respondent. The respondents answered identical questions at individual level to maintain confidentiality and to control bias among the respondents.

Focus Group Discussions (FGD) were used to explore their ideas on ownership and adoption of sustainable cooking and lighting technologies. The topics for discussion were modeled from the research questions, questionnaires and interview schedule. Two FGD were carried out comprising 7 and 6 zonal leaders respectively.

Observation was used to explore the SE technologies in the Kakuma market place. The SE market organization list was provided by the SNV, which is in charge of the energy cluster in Kakuma camps. All the organizations were visited, observation on their technologies made and photographs taken.

Secondary data was used to supplement the primary data collected and identify critical grey areas the study sought to fill. The sources of data reviewed included journals, publications, online reports and statistics from the government ministries such as energy and donor agencies working in Kakuma refugee camp. The secondary data was useful in corroboration of the study findings.

**Data analysis**

Data was analyzed using Statistical Package for Social Science (version 25) by applying both descriptive and inferential statistical procedures. Descriptive results were presented in tables. Quantitative information was analyzed through statistical procedures. Pearson's correlation analyses was used to explore the association among market determinants of adoption rates of SET and SET adoption rates. The regression model was tested on how well it fits the data. Fischer distribution test was applied. It was used to test the significance of the overall model at a 5 percent confidence level. The p-value for the F-statistic was applied in determining the robustness of the model. The conclusion was based on the basis of p-value. The statistical significance of the coefficients were determined using the t-statistic. The t-test was used to establish if the correlation coefficient were significantly different from zero, and, hence whether there is evidence of relationship between the two variables. To test the hypotheses, multiple regression model was used. The significance of the regression model was determined using analysis of variance (ANOVA). The significance of each independent variable was also tested. The significance of coefficients were determined using the t-test.

The statistical package for social sciences, SPSS (version 25.0) was used for data analysis.

The regression model used was as follows:

$$Y=\alpha + \beta_1 X_1 + \beta_2 X_2 + e \qquad \text{Equation 3.1}$$

Where:

**Y** is weight for adoption rates of SET

**$\alpha$** is regression constant

**$\beta_1$- $\beta_2$** are regression coefficients

$\mathbf{X_1}$ is weight for supply factors

$\mathbf{X_2}$ is weight for demand factors

**e** is stochastic term

Hypothesis were tested at 95% confidence level ($\alpha = 0.05$). A two tailed test were carried out.

## Results and Discussion

### Descriptive Analysis

### Supply of Sustainable Energy

The mean and standard deviation of the findings on the supply factors influencing the adoption rates of sustainable energy technologies is shown in table 1.

**Table 1: Sustainable Energy Supply**

| | Mean | Std. Deviation |
|---|---|---|
| | Statistic | Statistic |
| The current supply of sustainable energy in the camp is unreliable, that is, bioethanol stoves are available while ethanol is inaccessible | 4.13 | 1.034 |
| The sustainable energy solutions require knowledge to operate and maintain which is lacking among the refugees | 4.55 | 1.241 |
| The suppliers do not ensure hands on trial before purchase of sustainable energy solutions | 4.62 | .911 |
| Sustainable energy solutions in the refugee camp are not provided with user manuals | 4.61 | 1.083 |
| The sustainable energy solutions in the refugee camp do not have after sales service guarantees | 4.30 | 1.342 |
| There is easy accessibility of sustainable energy through available drop points within the refugee camps | 2.94 | .997 |

### Reliability of Supply

The current supply of sustainable energy in the camp is unreliable, as indicated by a mean of 4.13 (SD = 1.034). It was observed that wood fuel and charcoal were the main sources of cooking fuel in the camps. Wood fuel was the most preferred because it is promoted by UNHCR and its partner agencies. As a result, families are supplied with firewood on regular basis from wood distribution centres spread throughout the camps. However, during FGD most households complained that they were only provided with a few pieces of firewood on these occasions, which could barely make three meals. According to the FGD the main reasons for reliance on wood and charcoal among the refugees included their low cost (37.1%), lack of alternatives (32.1%), readily available (19.3%) and their being non-polluting to the environment (11.4%) - particularly for charcoal.

According to Corbyn and Vianello, (2018) a survey conducted in Kakuma 1 in 2016 show that 78% of households rely on unreliable energy from unregulated suppliers. A UNHCR (2019) study show that out of 340 households issued with energy saving stoves that use pellets, only 40 % continue to use them after the first year due to unreliability of pellet fuel. FGD respondents concurred with the findings that there were high levels of unreliability informed by very regular interference, with blackouts happening multiple times in a day.

According to UNHCR (2019), energy supply in Kakuma is affected by the high investment cost and unreliable transmission and distribution infrastructure. Approximately 5% of the household's access diesel generated electricity from unregulated service providers. The diesel mini-grid market is highly territorial, with different suppliers in each quarter of the camp operating as monopolies. The quarters are largely separated by ethnicity, creating a divide between groups over supply provision. One Somali electricity supplier explained;

> *'The South Sudan supplier did not have the capacity to supply to the South Sudanese businesses, so that is why I stepped in. But I cannot connect a South Sudanese household that is not my territory. I would be in trouble! And if any guy connects anyone on my side, I will call the police on him'.*

Another distributor of energy within the refugee camp said;

> *Within the Kakuma Camp commercial zones, power is charged against number of fridges or by number of bulbs. At the household level, it is charged against apparatus such as number of television sets, radios or bulbs et cetera. Power costs range from Kshs. 500 to Kshs. 5000 depending on the number of appliances used in the house or businesses.*

Grid reliability challenges are much more severe in dispersed rural areas than in urban centers. This is because investment in urban infrastructure far exceeds that of isolated and lower income rural areas The difference between rural and urban unreliable-grid estimates in Kenya exceeds 30 percentage points (IFC, 2018)

A majority of off-grid and unreliable-grid households rely on dirty and expensive fuels to address and supplement their basic energy needs (International Energy Agency, 2017a). While regional and rural-urban variations exist, most households end up paying a prohibitively high premium and must choose from a common basket of energy sources to cover their basic needs. These include kerosene, candles, and increasingly dry-cell battery torches for lower levels of service, and diesel generators (UNCDF, 2017). Majority of the refugee result to using firewood when sustainable energy fuels are unavailable.

Several spots for selling bioethanol stoves and fuels had very low stock levels. This is largely due to limited distribution channels where only one supplier provides ethanol from Siaya County. This shrinks the addressable market for SET such that even if products are affordable they may not be physically available. In addition, distribution costs, when passed on to consumers, affect affordability especially for customers living away from population centers who are not easily reached through existing distribution networks and infrastructure. As manufacturers and distributors are unable to pass these additional costs on to customers, they prefer to limit stocks further shrinking the addressable market once distribution costs is priced in.

**Knowledge to operate and maintain**

Lack of knowledge to operate and maintain sustainable energy technologies affects the adoption rates as indicated by a mean of 4.55 (SD = 1.241). It was observed that refugees adopted technologies that they had knowledge about. SET suppliers do not ensure hands on trial before purchase of sustainable energy solutions as indicated by a mean of 4.62 (SD = 0.911). This affect the adoption rates of SET due to difficulty of use and undemonstrated benefits of the technology.

Lack of user manuals and after sale services affected the adoption rates of sustainable energy technologies in the camps as depicted by means of 4.61 (SD = 1.08) and 4.30 (SD = 1.342) respectively. Availability of

technical assistance in the proximity of the end users is a key factor in countering the effects of market spoilage. Market Spoilage occurs due to the presence of substandard products in the market. Availability of competent technicians for trouble-shooting, repair and maintenance of the SET within the camps increases the trust of the consumers. Due to innovations in SET products that targets refugees, it is essential to develop local maintenance capacity in camps. Nevertheless, the low buying power makes the notion of setting up service centers in the camps unsustainable.

## Distribution channels

That adoption rates were limited by inadequate distribution channels as indicated by a mean of 2.94 (SD = 0.997). However, it was observed that charcoal that has widespread dealership and accessible virtually everywhere, is widely used.

### Demand for Sustainable Energy

The findings on the influence of demand on adoption rates of sustainable energy technology in the refugee camps is shown in table 2.

**Table 2: Sustainable Energy Demand**

| | Mean | Std. Deviation |
|---|---|---|
| | Statistic | Statistic |
| I prefer to adopt sustainable energy within the refugee camp over other energies which are costly as it enables me to save money | 4.59 | .873 |
| I use sustainable energy for cooking within refugee camp since it is efficient, that is, saves fuel | 4.02 | .965 |
| I use sustainable energy for lighting systems within the refugee camp since it is convenient | 4.56 | 1.255 |
| I use sustainable energy for operating household electronics systems within the refugee camp | 4.47 | .886 |
| The aesthetics that accompanies sustainable energy solutions motivates me to purchase and adopt those solutions | 4.39 | 1.123 |
| I prefer to use sustainable energy as the solution to healthy environment within the refugee camps | 4.35 | 1.199 |

## Cost and energy saving

Demand for SET is driven by the need to save money as most respondents prefer to adopt sustainable energy over other energies, which are costly as it enables them to save money as indicated by a mean of 4.59 (SD = 0.873). Equally the drive to save fuel influences the demand of SET as most respondents agreed that they use sustainable energy for cooking since it saves fuel as indicated by a mean of 4.56 (SD = 1.255). A survey of 231 households in Kakuma I camp found that, roughly 25% of residents cook on a ‘three-stone fires’, while 66% cook on rudimentary wood or charcoal stoves. Only 31% of households use kerosene for lighting compared to 36% that use electric batteries. One reason for the relatively low use of kerosene may be that Kenya has removed subsidies for this fuel, raising the cost making many households shift to solar lighting.

## Convenience in operating electronics

Sustainable energy is used because of its convenience in lighting and operating household electronics systems as shown by a mean of 4.56 (SD = 1.255) and 4.47 ( SD = 0.886) respectively. A study by Mwaniki (2016) established that nearly 85% of households in Kakuma refugee camp own a mobile phone, and many use mobile money as a method of savings – indicating high potential for mobile-based energy access demands.

**Aesthetics and safe environment**

Aesthetics that accompanies sustainable energy solutions motivates them to purchase and adopt those solutions as shown by a mean of 4.39 (SD = 1.123). In addition, sustainable energy was preferred as the solution to healthy environment within the refugee camps as indicated by a mean of 4.35 (SD = 1.199). Smoke inhalation in poorly ventilated cooking areas presents a health risk to refugee and internally displaced households. The implications of the high reliance on wood fuel are dire, particularly on both internal and external air pollution, as well as on the destruction of forest resources in the area. The Lancet Respiratory Medicine Commission estimates that indoor air pollution in low and middle-income countries accounts for around 3.5–4 million deaths every year.

Women and girls face the risk of sexual and gender-based violence by venturing outside camps in search of firewood. UNHCR reports show that in 63 % of households in Chad family members have experienced problems when collecting firewood. These problems consist of physical or verbal aggression, theft of property, rape or attempted rape, injury or confiscation of firewood. Médecins Sans Frontières (MSF) reported treating nearly 500 Darfur women and girls in Sudan who were raped within a five-month period in 2004–05. The rapes took place during trips outside the camps to collect firewood or water.

The fact that firewood collection outside camps is illegal in many countries, further encourages exploitation of the vulnerable and under-reporting of assaults. Providing renewable energy cook stoves and lighting equipment will help reduce violence against women and girls. One FGD participant emotionally said that;

> *Our mothers and daughters have each experienced sexual and/or physical attacks while collecting firewood in the bush this calls for the urgent removal of this risk by providing the camp households with renewable energy solutions.*

Houses and children are not spared either as an informant mentioned that;

> *'House fires, kids' burns and hospitalization of individuals with severe burns are common in Kakuma refugee camp, especially during the dry season when the area is dry and there are strong winds'*

**Multivariate Analyses**

**Relationship between Market availability and Adoption Rates of SET**

Table 3. presents Pearson's correlation of market availability of sustainable energy and its integration in refugee camps.

**Table 3: Relationship between Market Availability and SE integration**

| | | Energy supply | Energy demand | Adoption rates of SET |
|---|---|---|---|---|
| Energy supply | Pearson Correlation | 1 | | |
| | Sig. (2-tailed) | | | |
| | N | 274 | | |
| Energy demand | Pearson Correlation | .322** | 1 | |
| | Sig. (2-tailed) | .000 | | |
| | N | 274 | 274 | |
| Adoption rates of SET | Pearson Correlation | .368** | .726** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 274 | 274 | 274 |

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation analysis found a weak positive correlation between energy supply and sustainable energy integration (r=0.368, P<0.001). The correlation between demand for sustainable energy and sustainable energy integration correlation is supported (r=0.726, P<0.001). This implies that an increase in demand and supply of sustainable energy would lead to an increase in the sustainable energy integration in refugee camps.

## Model summary

**Table 4. Market availability and sustainable energy Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .874[a] | .0.764 | .0.754 | 2.004 |

a. Predictors: (Constant), Energy demand, Energy supply

In the regression analysis conducted shown in table 4, the goodness of fit for the regression between market availability and SE integration was significant, F(2,272) = 313.614, P<0.001, $R^2$ = 0.764. $R^2$ squared of 0.764 indicates that 76.4% of the variations in SE integration is explained by the variations in market availability as measured by demand and supply. This implies that 23.6% of the unexplained variations in SE integration is accounted for by the other variables outside the study scope.

## ANOVA

**Table 5: Market Availability and Sustainable Energy Integration Model Validity**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 3459.165 | 2 | 1729.583 | 313.614 | .000[b] |
| | Residual | 1500.013 | 272 | 5.515 | | |
| | Total | 4959.178 | 274 | | | |

a. Dependent Variable: Sustainable energy integration

b. Predictors: (Constant), Energy demand, Energy supply

The ANOVA test conducted as presented in table 5 showed that the overall model was significance indicated by an F statistic of 313.614 at P<0.001.

## Significance of coefficients

**Table 6. Market Availability and Sustainable Energy Integration Regression Weights**

| | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| Model | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | 3.680 | .823 | | 4.470 | .000 |
| | Energy supply | .122 | .032 | .113 | 3.782 | .000 |
| | Energy demand | .849 | .032 | .790 | 26.333 | .000 |

a. Dependent Variable: Sustainable energy integration b.

Regression analysis (table 6) on the supply and demand coefficients show that supply and demand factors uniquely contributes significantly to sustainable energy adoption rates (P<0.001). This imply that one positive unit change in energy supply would lead to a change in SE integration at the rate of 0.122. Likewise, one positive unit change in energy demand would lead to a change in SE integration at the rate of 0.849. The predicted value of adoption rates of SET when all other variables are 0 is 3.680.The fitted equation is as shown below;

$$Y = 3.680 + 0.122X_1 + 0.849X_{2+} \text{Ɛ}$$

The current supply of bio-ethanol stoves is unreliable, while ethanol is inaccessible. Market dealers of SE solutions do not offer hands on trial prior to making a sell to refugees. In other cases, dealers of SE solutions do not provide user manuals to refugee buyers so as to enable them utilize the technology without hardships. It was observed that the market dealers of SE solutions have little of SE technologies to meet the demand of the market thus triggering high price for the scarce commodity. Surprisingly, according to UNHCR implementing partners, the market of sustainable energy solutions is efficient and that it significantly influences adoption of sustainable energy by refugees only that, some of the SE technologies on offer are costly and cannot be sustained by refugees.

## Conclusion

This study has found conclusive evidence that supply and demand factors contributes significantly to adoption rates of sustainable energy technologies. This imply that one positive unit change in a supply or demand factors would lead to a change in adoption rate of sustainable energy technology. This implies that with concerted and unified efforts to change the behavior of consumers, and improve the supply chain the sustainable energy technologies can be adopted easily especially when the intervening supply and demand issues are identified. Donors and humanitarian agencies should therefore invest in successful SE business models and sensitization programs in order to take advantage of available markets for sustainable energy technologies.

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