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Taming the Renewables: Actors' Innovation in Improving the Utilisation of Biogas for Daily Use in Agricultural Setting

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ABSTRACT: Biogas development in Indonesia has reached a large number of users since 2009 and the technology has had a successful adoption rate at the local level. However, the ways that users develop and adopt innovation with regards to this useful technology has been under-researched. This study aims to address the innovations being undertaken by biogas users; these innovations are a decentralising process of technical knowledge that is based on users' interpretations of pre-existing social and cultural values they experience in everyday life. Through innovation, users can demonstrate a greater sense of ownership, which leads to them feeling more able to integrate the biogas into their lives, including its incorporation into agricultural activities at home. The main recommendation drawn from this research is that users' ideas and knowledge, as well as the social-cultural values underlying their everyday lives, should be taken into account in order to ensure successful construction processes and that they be understood as co-shaping elements that will enable a smooth immersion of the users and the technology.

Keywords: biogas, technological innovation, knowledge, everyday lives.

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1. Introduction

Energy supplies for rural communities are crucial. One feasible way of making energy sources readily available for rural communities is by decentralizing the supplies, which can be achieved by making use of local resources that are abundantly available, such as animal manure for biogas. As emphasized in the Renewable Energy Market Assessment Report on Indonesia (U.S Department of Commerce 2010), the Government of Indonesia mandates the optimizing of livestock-led alternative energy forms like biogas to enable sustainable livelihoods, particularly in rural areas. In accordance with this policy, if local communities can reap the benefits of this type of by-product, the utilization rate of alternative energy in Indonesia could increase from 4.3% to 17% in 2025. Then, Indonesia should be able to prevent an energy crisis in Asia (Contributing to poverty Alleviation through Regional Energy Planning in Indonesia (CAREPI) 2009). In support of this plan, the Dutch-headquartered non-profit organisation, SNV (Netherlands Development Organisation), in collaboration with the Indonesia Ministry of Energy and Minerals, established a biogas program in Indonesia called 'Biogas Biru' in 2009; the aim of this program is to provide the rural community with wider accessibility to the use of biogas.

By 2012, 8,000 biogas installations had been successfully constructed under the 'Biogas Biru Program' in eight selected provinces, including Yogyakarta, West Java, East Java, Central Java, East Nusa Tenggara, West Nusa Tenggara, Bali and Sulawesi. In order to promote the associated activities, the SNV assigned a local non-government organisation (NGO) and provincial cooperatives for partnering purposes in order to reach prospective users. This organisation was tasked as the Construction Partners

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Organization (CPO). Basically, the successful implementation of biogas in the household is determined by the 'socio-technical interaction' between the household users and the agencies who are engaged in the construction phase, as flawless practice in the daily routine can be achieved so long as it is aligned to socio-cultural practices, as well as the technical proficiency of the users. Previous studies revealed that the failure of biogas development projects in the developing countries is mainly due to the incompetence of experts in handling the cultural concerns of the local users, and their inadequacy of knowledge in how to take the users' pre-existing habits and cultural characteristics into account during the transitional period of biogas use – moving from gas cook stoves to biogas (Akinbami, IIlori, Oyebisi, Akinwumi & Adeoti 2001; Pathak, Bhatia, Mohanty & Gupta 2009). This study concentrates on the conversion of livestock by-products as alternative energy form by extracting the methane gas for household cooking and aims to discern how innovations are undertaken by the biogas users to improve their acceptance of the technology in their everyday life. Therefore, this study has been undertaken to respond to the following question: *How do innovations undertaken by household biogas users improve the function of the technology in order to be incorporated in their daily life experiences?*

2. Theoretical Insights

Biogas technology is an engineering product, but it also contains social components that can be ascertained from the users' experiences and everyday lives. This study provides an analysis of this issue using a sociological understanding of technology and associates it with current practices in the development of biogas technology in Indonesia. Secondly, Social Construction of Technology (SCOT) is applied to investigate the ways which innovations emerge out of users' social interpretation, which is based on pre-existing farming or agricultural-related activities.

2.1 Towards Sociology of Technology and Development

The biogas implementation of the 'Biogas Biru Program' that has been carried out since 2009 has a distinctive feature when it comes to the adoption of technology. It is characterised by the prospective user's independence in choosing the type of reactors according to their household needs. This demonstrates that the users have a high degree of control over the technology and have a high level of knowledge of it. This study addresses new examples of the development of the biogas technology, which uses a modernisation approach. In the modernisation approach, a technical expert utilises their superior knowledge throughout the planning and implementation stages of the technology and relates to the users as merely passive groups. The modernisation approach comes from the notion that development is the transformation of traditional societies to modern ones, and is characterised by advanced technology and material prosperity (Carrier & Miller 1999).

Technological development, particularly in developing countries, is much affected by the mainstream ideology of the development agencies who view themselves as being actors who bring prosperity to targeted countries (Wilhite 2008; Winther 2008). The main premise of such development models is the paralysis of the social power of a community in order to advance the exploitation of that community. The technology experts during that period were provided with a "low contextual understanding of local setting as well as the culture in which technology is implemented" (Crewe 1997). Until recently, experts and *developmentalists* who implemented technology in the developing countries believed that the societies within which they operated had been endowed with frailty by God. Hence, they construed themselves to have monopoly on the truth for development and believed that scientific discourse which lies under Western science is perceived as objective truth (Crewe 1999). Hence, technological development in the global South is problematic, because local communities have been undermined for decades by the attitudes of the West (Crewe 1997).

The *developmentalist* ideology as described above is still implicit in the implementation of technologies and, in some instances, has made its deficits clear to the public. In 2009, before this study commenced, the CPO staff noticed that over 200 biogas installations/digesters under the development scheme of Indonesia Ministry of Energy and Minerals were in place for the local communities. The installations occupied home space. Unfortunately, the installations had broken down and the household users no longer benefitted from them due to technical difficulties. No technical repairs had been organised to tackle the problems. Even worse, the relevant authorities had not obtained informed consents from the local users during the construction phase. The prospective local users of the technology had not been adequately assessed and/or provided with information about the benefits of the technology, including the technical features. From this, we can assume that the experts had deemed themselves to be superior with regards to the development and had rendered the local communities as the victims of the technology. Hobart criticises the nature of the problem of underdevelopment and its solutions are defined by reference to this world-ordering knowledge used by the engineers as they do not incorporate the users' culture and social values into technological products (Hobart

1993, Bijker 1996)). When assessing household technology prior to its introduction, the felt needs of the users and other contextual problems associated with the depth of understanding on the technical knowledge of the technology should be addressed (Winther 2008).

The arrival of biogas technology in households provides epistemological gaps for research to understand the interplay and association between people and the cooking technology that will be used in the households. By embracing this theoretical perspective, the roles of users in innovation can be equally heard and represented, because, as explained by Shove, Guy and Wilhite (1998), infrastructural choices in energy technology use are critical issues that must be examined.

2.2 Social Construction of Technology as Roots of Innovation

The theorisation above has addressed the problematic sides of technological development critically. It has also shed a light on the significance of presenting users' innovation in the domain of the technology study. In addition to it, the following theoretical approach, Social Construction of Technology, will bring us some insights into the innovation as creativity that users undertake to handle the technology.

SCOT (Social Construction of Technology) emerges as a theory to oppose technological dominance that had endured for a long time, which the roles of society in using their ingenuity are taken aside. This theory, called 'Technological Determinism', informs a neglect to all social dimensions in the society, including the community's culture. One of the notions about this theory, which invited criticism by many, is that it claims that the change in the technology is the most important factor for social transformation in society (Mackenzie & Wajcman 2004). As criticism to this theory and to provide evidence that technology is not the main contributor to the transformation, we need to give opportunities for users' innovation to be heard in a research because all users have creativity and pre-existing knowledge that allow them to try out the technology. As asserted by Lie and Sørensen (1996), users play very significant roles in making negotiations and this process would determine the sustainability of the technology they use.

The main understanding of SCOT is based on a perspective in that societal members have roles to shape the existing science and technology. Following this perspective, society is situated as an active agent for the utilisation of technology. The SCOT approach has been used since 1980 amongst European technological studies. It has two concepts: the first is 'interpretative flexibility' and the second is 'technological frame'. Interpretative flexibility denotes that each of the social groups who are associated with the technology can perceive different meanings on the same technological artefact that they adopt. Herein this notion, the "social variables" (Mackenzie & Wajcman 2002) in the discussion of technology become sociological because it considers the use of technology is much affected by intrinsic identity, situating in the knowledge, norms, belief and even the 'user's interpretation about the technology. Further, the relations between users and the technology are a "seamless web" (Fugslang 2001). The technological frame is a concept being used for making sense of how actors frame technology according to their social category of membership in a certain social group in the society. On the other hand, a specific culture can be an enabling and constraining variable that shapes continued use of a technological artefact.

Interpretative flexibility describes the ability of users in discerning the meaning of the artefacts for their lives. Interpretative flexibility affirms that the changes of the technology or the artefacts are not fixed, always interactively evolved, and remodelled at the implementation stage. To clarify this, Wajcman (2004) defines interpretative flexibility as "capacity embodied in the group of users or people engaged in a technology and such understanding is varied one another and in further stage user could make alternative meaning and deployment of technology".

It is obvious that different groups can have alternative meanings, demonstrating 'heterogeneity' characteristics, which users may resurface and discern distinctive meanings. Further, heterogeneity based on Volti (2001) is translated as particular actors who are involved and engaged in the utilisation of technology, and they will deliberately choose and further develop new forms in the use of the technology based on the needs, desires and intentions. In relation to it, experiences hence become the basis of distinguishing the conceptualisation of artefacts in itself (Flichy 2008).

2.3 On Innovation

Innovation performed by users as continuation of interpretative flexibility gains significance because users are actors that are inseparable in the regime of socio-technical. Several studies under the rubric of social construction of technology confirms, users are the core and main source of innovation and such acts are thought to be ways of overcoming the limit of the artefacts (Rohracher 2003). As integral parts of sustainable use of artefacts, users are viewed as important resource persons of innovation where it incorporates the expectation, social practices and even institution. Based on this perspective, artefacts of technology and users themselves are central to create engagement. The co-learning space generated by innovation is explained further by Rohracher (2003, 2009) that mutual learning processes of designers and users can happen in a larger scale revolving in the regimes of technologies. Subsequently, products of innovation can be sustained by roles, responsibility and perception of the users (Geels 2004).

In the context of biogas technology, where the artefact is placed in a specific setting of agricultural society, local knowledge and experiences are two entities that are embedded in the everyday lives conceived by the household users. As Escobar (1999) maintains, local agricultural knowledge should be taken into consideration, in the context of innovation, as "context-specific improvisational" rather than indigenous knowledge. Departing from this thought, innovation is an effort that is undertaken by the users to adapt with their geographical locations. Experimentation on the artefacts as a pathway of local modelling emerged through use and this can become practice (Escobar 1999). Speaking on local practices, cultural value is intricate but the innovation can hardly be kept away from it. In this manner, cultural values can, through local practices, order the objects, and configure the experience and behaviours of the users.

In the case of biogas construction, an agency who plays roles in the construction process is Construction Partner Organization represented by the AWFFDFM as Non-Government Organization (NGO). This organisation provides assistance with their institutional competencies of gaining trustworthiness and mobilising public support to advance the innovation. Given the importance of recognising the ability of this organisation, Rohracher (2009) endorses this idea by addressing that negotiating standards, enrolling, and aligning supply-side, and demand-side actors, communicating with the public and building trust for the respective products is instrumental in making users' innovation less conflicting and acceptable for certain groups.

3. Methodology

This research aims at exploring the social phase of appropriation of biogas technology in rural households. The main focus of the research is on the houses which demonstrated modifications on the infrastructures of biogas installation (i.e manometer, mixer, gas pipeline). Based on the observation, it was found that three houses had particular modifications in their reactor so the narrative interviews with three male users who were routinely using and managing the biogas for household needs. The research took place in Sri Hardono village in June 2011, located in Pundong District Bantul Regency Yogyakarta Province. In this village, there were 15 biogas users and the construction project was managed by a farming organisation, namely Serikat Petani Indonesia (Indonesian Farming Association), who was entrusted by HIVOS Indonesia as construction agency.

In investigating how the technological artefacts successfully go through the life of users, this research also should present how the 'meaning' is produced by the users that allows the functionality of this technology to be accepted by the family members. A qualitative approach is then chosen because it provides the researcher with the capability of understanding the experience of individuals in a socially nuanced context. The household as the focus of this study is important because it is a social space where human relations and lived experience are co-shaped (Berker *et al*. 2005; Livingstone 2003). Lived experience is characterised by individual attitudes that are responsive to particular situations in certain social contexts. Given this importance, the research applied a 'Personal Construct' approach to revealing the individual experience of obtaining biogas technology and how this technology is incorporated into the household space.

As an introduction, the 'Personal Construct' term emanates from phenomenology, which "construes the everyday life world as reality in which an individual can engage himself and which he can change the whole he operates in it by means of his animate organisms"(Schutz & Luckmann, 1973 cited in Bakardjieva 2006) to figure out how they live everyday life. In practice, applying personal construct is useful for this study. During fieldwork it was done by, as explained by Berker *et al*. (2005), allowing participants or family members to share the experiences of the use of technology. Besides that, an ethnographic interview was also used by requesting the participant to tell their stories about relevant historical facts when biogas technology came into their community and what social and infrastructural resources they mobilised during construction process (Brockington & Sullivan 2003). 'Meaning-making' is an extent that this research wants to present and it is emblematic on the technology. In support of presenting what biogas technology meant to the users, the present study also addresses some cultural findings that reflect the situations in the household before and after biogas technology came into their home. As advised by McCarthy and Wright (2004), we must attempt to put what culture and language have crystallized from the past together with what we feel, wish and think about our present point in life.

Participant observation also gave me flexibility in documenting the infrastructural space of the household. The social space here is meant as locations in the household that have been modified in the aftermath of biogas technology adoption in the household. Inspired by the study of family space as presented by Winther (2008), social space may take form, for instance, in the modification of the physical interior in dining rooms and kitchen as response to the arrival of technology. In so doing, I toured the kitchens, cowshed, became involved in farming activity and photographed the user's activity. Throughout my fieldwork users were not hesitant to permit me coming through to their homes. They even felt appreciated and valued. Photographing the artefact was helpful to aid me with certain abilities in figuring out the meaning of altered artefacts. It also deepened my understanding and knowledge with physical changes of the infrastructures due to realignment of routines, and consumption practices. All of the research activities enabled me to discern the conception about socio-technical interfaces in the use of biogas technology and obtain particular evidence about the "shift of family ethnoscape" (Wilhite 2008) like the changing of the dining room and the reposition of the kitchenette after some months. The interviews and observational data were analysed thematically according to the innovation products. All of the data were contextually analysed by incorporating other social practices that effect the use of biogas.

4. Result and Discussion

4.1 Innovation 1: Integrating the Cowshed with Mixer

In the biogas construction, users have the liberty to modify their biogas installation according to their needs. Although CPO staff advises them to locate the mixer and biogas plant at the backside of the house, the biogas users have a choice not to do so, so they are not constrained to implement and practice their own ideas. One of the daily activities that most users perform to maintain the hygiene of the cowshed is removing the dung every early morning. As the cleaning is quite laborious, the user shall find ways to ease this routine by connecting the cowshed with feeding biogas reactors. The aims are to save time and be more convenient. Such innovation is able to support users with effectiveness in using the biogas. One particular innovation that users have on their biogas is making a pipeline that links the inlet to the cowshed. Compared to conventional inlets, the integrated ones do not require the users to collect the dung manually. By shovelling the dung just in seconds and putting it into the mixer quickly, the users can save time. To the users, innovation is regarded as a manifestation of advancing their technological mastery so that the biogas technology can be synchronised with their social customs and habits. For the user who looks after cows, they could feed in the biogas reactor with the blend of water and dung while cleaning the cowshed. Therefore, double burden is lessened.

Below is the illustration (Fig. 1) of the integrated system between cowshed and mixer of biogas. As seen, the user develops a manhole through a pipeline from the cowshed's surface linking to the mixer. When the cleaning is over, the users are not needed to put the dung into the bucket, which is time-consuming and wasting. Instead, they only pour it with the water and then shovel it forward to the mixer (Fig. 2). Throughout observation it was found noticed three household users implemented those integrated cowsheds. There are benefits resulting from this cowshed modification. First, they can have healthier cows because they would not live in a contaminated shed which may attract viruses. The women also benefit from such an innovation. One of the biogas user's wives who has the task of feeding the biogas reactor with slurry feels that the innovation makes her task easier and is really time-saving because she just rotates the handle of the mixer and flows the slurry through into the biogas plant.

Figure 1. The user showing me his integrated inlet. The model of the mixer is kept as it is but he made it with lower surface to adapt with upper position of the cowshed. The mixture of cow-dung and water go through to the lower channel of the mixer. In such a way he can maintain hygiene of himself and clean the cowshed(Source: author)

Figure 2. A user shoving the cow-dung into the inlet and then adding it with water to make it more aqueous. (Source: author)

4.2 Innovation 2: Modifying Biogas Cook Stove Installation

Modifying the gas volume measurement tool, termed as 'manometer' is part of the innovation which is helpful for household users and makes it easier for them to get an update about the availability of methane gas inside the digester (Fig. 4). This type of innovation is learned through the training provided by technical staff and informational meetings with neighbours who have installed the digester.

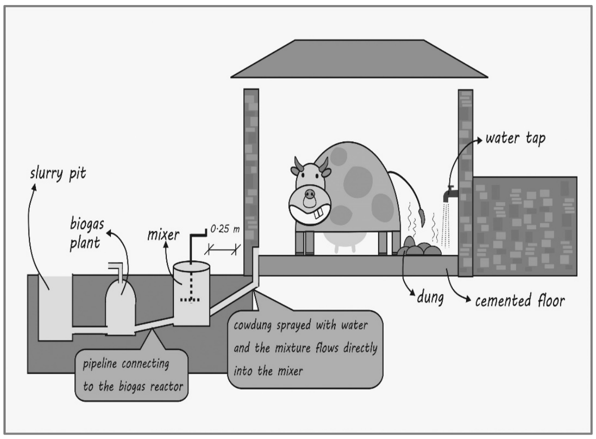

Figure 3. The model of the mixer is kept as it is but he made it with lower surface to adapt with upper position of the cowshed. The mixture of cow dung and water go through to the lower channel of the mixer. In such a way he can maintain hygiene of himself and clean the cowshed. (Source: author)

Pre-existing social practices of local community also shapes the innovation. As the community members are predominantly Moslems, they regularly hold collective Koran chanting every week in one of the homes where there is a biogas user. Considering food and drinks being served are in large portions or voluminous, cooking on one biogas stove is not sufficient. Therefore, they install another biogas cook stove to make the cooking quicker; for example, one stove is for boiling water for tea making and the other is for preparing the dishes.

The family consumption also affects this innovation. The food served for all family members is various but as the family have decided on having biogas they should find ways to adjust with this eating routine. In addition, an extra biogas cook stove is installed and to share the gas they use branched pipelines so that the gas volume can be distributed equally. This innovation also involves aesthetic re-designing of the kitchen with coated ceramic flooring (Fig. 4- *left*). Aesthetic values are considered by the users as social motivation for this innovative process. A respondent said: "I would feel embarrassed if the kitchen is not decorated with ceramic flooring because when the entire family of my daughter-in-law visits this house, they would look down on me once they sight my filthy kitchen". From this statement we can see that adjusting the infrastructure of biogas technology is as conformity to social norms. Another aesthetic value that users uphold is about the social definition of cleanliness and tidiness, which is not linked to a formal hygiene. It implies that the intention of altering the technological artefact and home-space is influenced by judgment of others, which may be conceptualised as social construction.

Figure 4. A household put the gas pipeline and manometer at outdoor kitchen in their first five months use of biogas (photo taken in June 2011). (*Right*). The same household has set ceramics flooring and walling for the kitchen and install two biogas cook stoves for cooking (photo taken in July 2012).

4.3 Innovation 3: Experimenting Quills

Incorporating biogas into the daily lives of users may differ from one home to another. Some are determined by their former experience dealing with organic waste. We can see this from the example of a user who runs a private business as a chicken meat trader. Every day more than 10 kg of quills are stocked up as he slaughters more than 15 hens before he distributes it to the traditional markets nearby. His experimentation of mixing the quills with bio-slurry begins since he finds no specific dumpsite to recycle the quills.

His experimentation then becomes advanced as he realises that his corn farming requires more inexpensive fertilisers. He tells the story that his late father has taught him of the methods of making organic fertiliser by mixing the cow dung with soil and covering them with leaves. Three days' retention is needed to enable the organic bacteria to decompose it until the organic fertiliser is ready for use. He then applies such a method for the corn farming. Firstly, upon morning, he puts the chicken manure and covers it with soil. The following day he observes a flame of gas being evaporated from the mixture, and eventually the smell of sulfuric odour comes out. Assuming it is a useful substance, he then makes further experimentation by sprinkling it to his 0.25 hectare of farm. Within a month he finds the soil becomes fertile and the leaves of the corn grew increasingly.

Though he had a lack of information to understand what it was, he concluded that the mixer was useful for fertilising the soil because, according to his agricultural understanding, an organic substance containing sulfuric odor can be utilised for soil improvement. He again comes up with another idea about re-use of quills. Similarly, he applies his experiment with cow-dung. Six months before adopting biogas, he puts two kg of quills on a banana leaf and covers it with soil, which is mixed with dried dung. Waiting for three days, he hence notices warm evaporation comes out of it. The final conclusion he made was that the blend of dung and soil was instrumental to decompose the quills. After this process he applies a similar method to his biogas by blending the quills with dung and water in the mixer before feeding it into the biogas plant. According to his previous experience, he discovers that the quills can accelerate the decomposition process in the biogas reactor and the outcome can be seen within four days afterwards. During his experimentation, the manometer installed in the kitchen displayed that the gas output measure was extremely higher, touching the high level of 60 cm (100 cm is the highest). Successfully undertaking such experimentation, he then continually put the method into weekly practice.

Since his experimentation is considered a novel effort, it is possibly risky to the biogas itself because it could obstruct the slurry pipeline in the biogas reactor. Regarding this matter, CPO staff advised him not to do it intensively. However, he did not want to restrict this user, considering that the quills can be useful for organic fertiliser, which is ecologically friendly (Interview 30.07.2011). On a different occasion, CPO staff revealed to the researcher that this user's understanding on the function of quills in stimulating a 'methanogenesis' process is a manifestation of cognitive construction of his own experiences. Moreover, a CPO staff member also came up with an appreciative opinion during interview: "every household might have distinctive way as to how incorporate biogas into their live, like what he did, no big deal with that as long as it can be controlled and the user knows the limitation" (Interview 01.08.2011). CPO acts as the handful extension of the 'technology designer' because they acquire engineering knowledge to determine the successful implementation of construction processes. In this sense, as mentioned by this user, it sheds a light that experimentation of this user is actually aligned with what the designer has expected for the compatibility of the technology itself to the social experience of the users.

These users' experiences inform us with beneficial lessons about how appropriation of biogas is linked to the users' experience in dealing with everyday waste that has become their long-endured concerns. Furthermore, new applied technology for some users might not be easy to use. When it comes to the technical knowledge, 'self-customised experimentation' appears suitable for the users to fit in their social habitus.

This study has revealed three main innovations that biogas users undertake to improve the functionality of the appliances and lift up the acceptance to the everyday life of the users. It is noteworthy that biogas users' innovation in this study could not be categorised as a 'trial and errors' process as ever noted by mainstream diffusion of technology theorists (i.e Rogers 2003). Furthermore, ideas for innovation stem from pre-existing knowledges that are associated with and integral to agricultural experiences of farming (Escobar 1999, Pathak et al 2009).

The findings above also reveal that innovation is not a neutral practice and it is aligned to Bijker's (1996) ideas in that it cannot be separated from consumption practices that have been engrained as habitus in the everyday lives of the users. It also apparent that the consumption practices are very much cultural as it is retained in the community by large. In other words, the findings reinforce an assertion that energy consumption in the household cannot be confined to cultural practices of the society. This study is a significant 'alert' to engineers working on technological implementation that innovation is an embedded process and can be at work within the values, experiences, ideas and norms. What engineers should note before initiating a development of technology into a new community is that the technology creates negotiating space between cultural values and the infrastructure (Winther & Wilhite 2015).

5. Conclusion

Innovation is an equal space where there are no clear boundaries between users and technical experts in partaking in the stages of developing the artefacts and all of these are contributions to allow new innovations to be launched continuously. Independency on the operation of the technology is the primary outcome that may bring to light the user's capability of retaining its sustainability. For instance, in the biogas development, should the upcoming setbacks occur, those users can repair the reactor by themselves and find alternative pathways to reverse the persisting problem. Therefore, knowledge transfer as an inherent process in the society can foster independency and self-reliance (Driesen & Popp 2010, Akrich 1992). Theoretically, through this study it can be additionally argued that the diffusion of appropriate technology is no longer under the ownership of engineers or the producers of the technology but it decentralises on the users. This affirmation is in lieu with Mautz's (2015) finding on the application of renewable energy in Germany: "Innovations emerge in local contexts, often supported by non-professional who simultaneously acts as developers and users of an innovation" .

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