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A CASE STUDY ON EXPLORING ENERGY USER NEEDS TOWARD DESIGN FOR BUILDING ENERGY SAVING

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ABSTRACT

In this paper, energy user needs are explored via the new user research method combining generative tools and focus group interview toward design for building energy saving. A number of needs for building energy reduction are extracted, and the needs tree is generated by classifying and structuring them. They can be classified into behavioral needs and solution needs in the highest level. The behavioral needs can further be decomposed into those in internal context and external context according to the motivations to generate them. The solution needs can be composed of those related with physical environment, regulation, and individual mindset. The E3 (economical, ecological, and experience) value framework is also introduced to classify extracted needs. When particularly considering energy users' experience values, it is demonstrated that those associated with rule (extrinsic social), reluctance/willingness (active emotional), contentment (reactive emotional), habit (intrinsic social) and knowledge (epistemic) values mostly occur. The results can provide the basis for designing and changing energy users' activities for effective provision of service for building energy saving.

Keywords: user centred design, early design phases, service design, building energy saving, energy user needs

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1 INTRODUCTION

Efficient building energy consumption has recently become a crucial issue for successfully reducing greenhouse gas emissions and saving the limited energy resources. To improve such energy consumption efficiency, in addition to technological efficiency, the energy consumption reductions by means of behavioral changes of energy users have been actively attempted (Wood & Newborough, 2007; Dietz et al., 2009; Stephenson et al., 2010). Therefore, the design approach for behavioral changes of energy users should be appropriately applied.

Recently, there has been much research on design for behavioral changes, in particular, in the area of consumption behaviors. Shove emphasized the re-specification of normal practice and the construction of services for comfort, cleanliness and convenience for environmental importance in the cases of air-conditioning, showering and frozen food, in particular (Shove, 2003). In addition, Strengers also discussed the composition, reproduction and change of everyday household practices such as bathing, laundering, house cleaning, heating and cooling for the behavioral change and demand management strategies towards carbon neutrality (Strengers, 2010). Meanwhile, Scott et al. introduced a methodology for practice-oriented design based on both discursive analysis and experimentation in everyday life in their EU Living Lab project (Scott et al., 2012). They conducted the case study on bathing to show applicability their methodology.

In this context, the proper user research methods should be applied to access tacit and latent needs of energy users, and those extracted needs can serve the basis for design for behavioral change toward efficient building energy management. There have been a number of user research methods to dig out user needs. Traditional approaches involved verbal and observational methods. The verbal methods generally focus on what people say and think. The information is delivered in words issued by people within their perception of experience. Meanwhile, the observational methods focus on what people do and use with giving just observable information (Sanders, 2002). However, there exist limitations with traditional user research methods for accessing tacit and latent needs and then user-centered methods such as make methods have been proposed. Make methods focus on what people feel, dream and imagine as well as what people say, think and do. With given toolkits, people can create what they feel, dream and imagine, and it can be analyzed to reveal deeper levels of user needs that cannot be extracted with traditional methods. In addition, it is possible to involve users in the early stage of design process with a participatory way.

When exploring energy user needs for reducing building energy consumption in this research, the user-centered methods were considered to make participants involve in the situation of building energy usage. The traditional methods were also considered at the same time to effectively dig out energy user needs for building energy reduction specifically. For the user-centered approach, the Generative Tools (GT) has been introduced. GT has been proposed to access tacit and latent needs which are not generally articulated in words and observed in behaviors (Sanders, 2001). This method has been introduced in the field of participatory design that usually focused what people make rather than what they say or do (Sanders & Williams, 2001). With this method, tacit and latent needs can be caught by analyzing what people make using toolkits comprising images, clay, papers, words, and so forth (Sanders, 2001). People make collages, layouts, plans, stories, memories reflecting their own aspirations with this method (Sanders, 2000). GT effectively enables designers to develop user-centered products and services with being inspired by stories spoken by people and tangible and visible artifacts which people make. On the other hand, for traditional approach, the Focus Group Interview (FGI) has been considered. FGI is among traditional approaches digging out the users' needs on the basis of social science background. This method is suitable for exploratory user research for a new field. In this method, six or more people sharing common interests and/or experiences come together and conduct semi-structured discussions.

In this paper, the methodology to extract and classify energy user needs in the context of building energy saving is proposed. Both user-centered (GT) and traditional (FGI) methods are combined to explore tacit and hidden energy user needs. In addition, identified low-level needs are classified and structured to extract meaningful higher level themes, and they are also mapped to E3 (economical, ecological and experience) value framework (Cho et al., 2010). It will be valuable to note the distinctive implications from the results, since designers can use them for design for behavioral change toward efficient building energy saving service with participatory way of users.

2 ENERGY USER RESEARCH METHOD

The experiences on usages of energy systems such as air conditioning, lighting and standby power systems in the office building were explored by the proposed user research method combining GT and FGI. The overview of the detailed methodological procedure of energy user research is schematically shown in Figure 1. As can be seen in Figure 1, there were two separate stages such as an individual immersion stage and a group session stage.

In the immersion stage, the workbook which was designed to sensitize participants to the research theme – energy consumption in the office building – was used. In more detail, the participants were asked to express his or her activities and feelings related to the energy consumption according to a type of space and to identify which energy systems were used in the first day. Besides, they were asked to describe energy wasting habits in the office. In the second day, they were asked to describe their own and others' activities using each energy system. In addition, the activities to waste and save energy were described by each participant, and the ideas for energy saving were finally come up with. Sample pictures for detailed tasks in the workbook during the immersion stage are given in Figure 2.

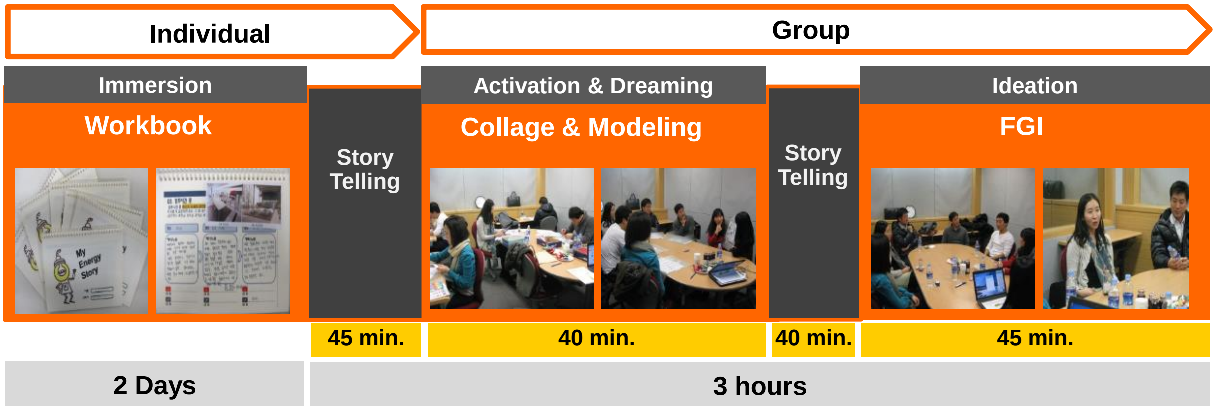


Figure 1 Schematic overview of energy user research method

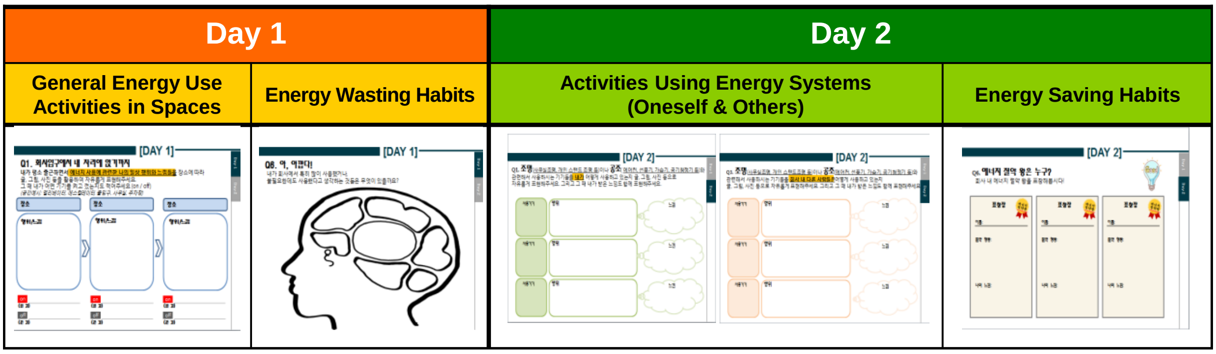
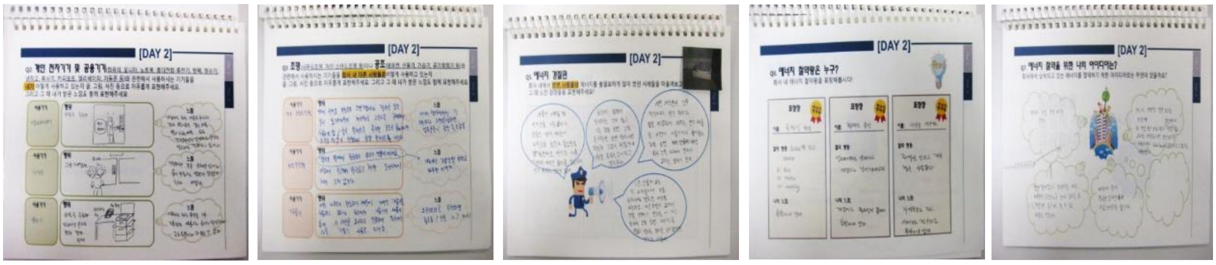


Figure 2 Sample pictures for detailed tasks during the immersion stage

Figure 3 shows the sample pictures of the results of the workbook activities. By describing individual experiences, the participants could be deeply immersed into a situation related to the energy consumption in the office building and could be triggered to think of associated needs and requirements. The representative remarks by the participants were "I turned on the light automatically although I didn't really need it", "When I was on the night work, the unnecessary lights were still turned on", "People used the air conditioning system thoughtlessly since it is a shared utility.", "People took an elevator although they went up to even 2nd and 3rd floors", and so forth. When finishing the workbook session, the participants had an individual pre-interview about their workbook activity results.

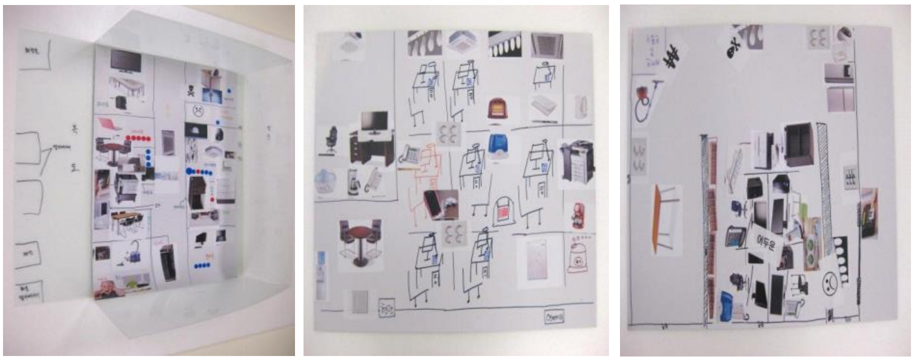
A group session stage would be followed after the individual workbook session stage. In the first step of the group session stage, they were asked to conduct collage and modeling. The tasks of collage and modeling in this research were somewhat modified from the original one. During these tasks, the participants were asked to express an as-is situation and later a to-be situation on the energy consumption in the office. More specifically, they were asked to make the as-is and to-be layouts of the office where they worked by using materials provided. The to-be layout would be better one in terms of energy saving. Figure 4 shows the sample pictures of results from the tasks of collage and modeling.

(a) Workbook activities – Day 1



(b) Workbook activities – Day 2

Figure 3 Sample pictures of workbook activities



(a) Results from collage and modeling activities – As-is

(b) Results from collage and modeling activities – To-be

Figure 4 Sample pictures of collage and modeling activities

The images and symbols which were provided for those tasks were somewhat abstract in order not to limit the participants' "free dreaming" on the current and future energy usages in the office building. After completing the collage and modeling tasks, the participants were to participate in storytelling concerning their modeling results. During the storytelling session, the following remarks were uttered by participants for the as-is case: "The layout of office was energy-inefficient.", "The lights should be always turned on since blinds blocked the windows all day.", "In the case of shared standby power, everybody didn't care.", and so on. On the other hand, those on the to-be case were as follows: "The change of individual's attitude for energy saving should be important.", "It could be advantageous to individually control lighting for energy saving.", "It would be better to encourage the usage of stairs instead of elevators.", and etc.

After completing the GT, the FGI was applied to identify the activities using energy systems under the various environments and contexts. During this session, the participants' experiences related to air conditioning system, lighting system and standby power system were discussed and shared. In addition, the interactions between their activities and energy systems were discussed while reflecting space, people, objects and time under the specific contexts. It was also conducted to generate new ideas to efficiently reduce the energy consumption. The representative remarks in the FGI phases were "People wasted energy in the office more than in home.", "The culture to reduce energy consumption in the company should be needed", "The energy saving products are needed", and so forth. The entire process was video-recorded, with some scenes captured in photos, by agreement.

3 ANALYSIS OF RESULTS AND DISCUSSIONS

The sessions of storytelling of GT and FGI ideation were transcribed, and the content analysis was conducted. Firstly, the transcripts were read several times, and the needs were extracted as many as possible. Then, the needs were classified into several issues based on their similarity and structured according to their characteristics. This classified needs structure was then used to build the needs tree, and Figure 5 shows the final needs tree for energy usage in the office building after analysis.

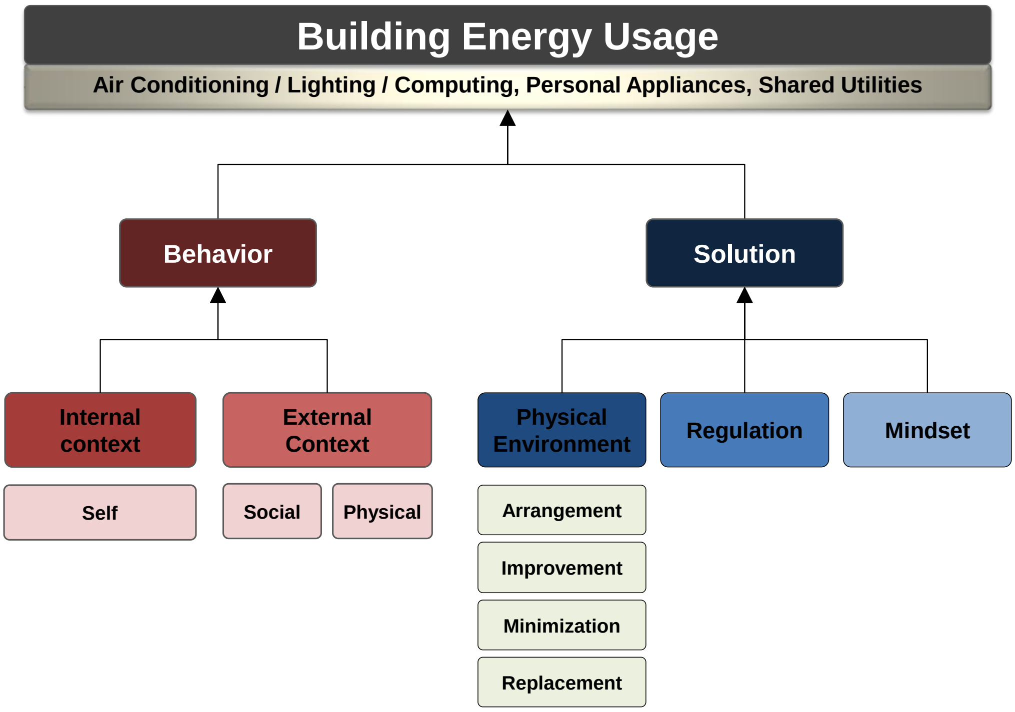


Figure 5 Needs tree for building energy usage

As can be seen in Figure 5, it was preliminarily concluded that the needs regarding building energy usage was mainly composed of those related to "behavior" and "solution". Furthermore, the needs in the category of behavior can further be related to "internal context" and "external context" in a lower level. The behavioral needs in the "internal context" were associated with individuals' arbitrary activities using energy systems based on their own motivations, habits, and so forth. On the other hand, those in the "external context" could be related to social and physical aspects. The behavioral needs in the social aspect were to be influenced by others and corporate culture and those in the physical aspect were influenced by physical surroundings.

Concerning needs associated with solution, there are three sub-categories with which needs were related such as refinements through "physical environments", "regulation" and "individuals' mindset". The solution needs related to the physical environments could further be assigned to the lower categories such as "arrangement", "improvement", "minimization" and "replacement". In other words, the solution needs for reducing energy consumption via the arrangement, improvement, minimization and replacement of energy systems and surrounding structures were addressed by the participants. The solution needs in the category of the regulation are associated with those for energy saving via policy, regulation and rule. Finally, the solution needs related to the mindset represent those for energy saving by enhancing energy users' awareness.

The sample need statements are given in Tables 1 and 2 in the cases of energy use behavior and solution, respectively. In the internal context of energy use behavior, a number of need statements were related to the habitual issues. For example, people usually activated or left energy systems without deep care. In the case of social aspect of external context, it was found that company regulations and rules issued by managing directors could dominantly influence on people's behaviors using energy systems. Meanwhile, for the physical aspect of external context, it is likely that people wanted to have surrounding energy systems to be easily controlled to satisfy their needs.

Table 1 Needs statements associated with energy use behavior

Behavior			
Internal Context	Self	Air-conditioning	-People don't turn off the heater during lunch time to maintain temperature while all of them are out of office. -The heater is turned on all day because people prefer warm environment although the temperature is too high. -The officeworkers don't care for controlling public air conditioning system since it is not related to personal expenses.
		Lighting	-People who are supposed to be on night work leave the lights on while they are out of office for dinner. -Although the office lights are bright enough for work, people usually turn on their personal desk lamp. -People usually turn on the lights while they come to work, but never adjust them until they leave.
		Standby power	-While people go out for lunch, they never turn off the computer. -While boiling water, people use an electric boiler instead of using hot water from a water purifier. -Even for the 1st and 2nd floors, people habitually take an elevator.
External Context	Social	Air-conditioning	-As the youngest, he or she usually control the air-conditioning system.
		LIghting	-In order to be complimented by boss, people turn off the lights. -Since boss asks to do, people reluctantly follow the energy saving rule of the company.
		Standby power	-It is prohibited to use individual heater to save electric power rates. -There exists a limitation to maximum number of papers for printing. -Since my boss is so tenacious, people are very good at turning off electric power.
	Physical	Air-conditioning	-Due to lack of ventilation, the air purifier is always turned on. -Due to lack of insulation, the air in the office is so cool, and people automatically turn on the heater when they come to work. -Due to heat from sun, the office temperature is above 30 degree even in winer season, and people use electric fans.
		Lighting	-The light in the bathroom is always turned off to save energy. -All switches are located at the similar position, and it is very likely to turn on the lights which we don't really need. -Because there is no personal desk lamp, all lights should be turned on even if only one person works in the night.
		Standby power	-Due to degraded performance of a microwave, it takes more time to heat frozen foods and requires more energy. -Since the heater turned on in the morning only one, people usually have lap blankets or hot pack.

Table 2 Needs statements associated with energy use solution

Solution		
Physical Environment	Arrangement	-Since the heater turned on in the morning only one, people usually have lap blankets or hot pack. -I want the switch for energy saving extension cord to be near my desk. -Since the office is directed north and cold, how about changing its direction such as south?
	Improvement	-I want to remove the door of staircase to make refreshing environment. -If there is any funny elements such as displaying calories consumed while using stair, it would be good for energy saving. -Since the side room is usually cold, the insulation and protection against wind may be needed. -If personal desk lamp is equipped, the office lighting can be turned off even while working at night. -People who sit directly below heater feel too hot and dry, and others who are far from heater feel cold.
	Minimization	-It may be necessary to minimize the number radiator in the bathroom. -The indirect lighting may not be needed, and it can be minimized. -We may be able to use one multi-purpose printer via good network system.
	Replacement	-Since the discussion tables were prepared for each cubucle, we may not need a conference room. -The switches to control heating and lighting in each room are needed. -If there is the timer at the electric outlet, the eletric power is automatically shut off although we don't turned off. -How about making the elevators to operate only for higher floors?
Regulation		-If the samrt work center gains more popularity, it would be more efficient for saving energy. -We may be able to use one multi-purpose printer via good network system. -If people who are working at night work together in one space, it would be good for energy saving. -If the energy usage pattern is included in the promotion evaluation process, people may try to save the energy voluntarily. -Since we have had the energy saving campaign more than three months, it becomes a habit to save the energy.
Mind Set		-It is troublesome to regularly following energy saving guideline. -The change of individual's attitude for energy saving is most important. -If there is a boss, people usually follow the company regulation to save energy. -In home, people usually save the energy, but they don't in company.

Concerning solution needs, as can be seen in the case of physical environment in Table 2, people tended to think of various ideas by rearranging current office layout, improving energy efficiency with addition of energy saving materials and structures, minimizing the materials related energy consumption and replacing current devices with new ones. In the case of regulation, it seemed that the campaign, rule and policy could be effective solutions to induce people's energy saving behaviors. It was also found that individuals' attitude or mindset could be very important for voluntarily and naturally conducting energy saving behaviors. It might be necessary to devise the behavioral guideline for people to more conveniently follow for saving energy, eventually resulting in the change of their mindset for efficient building energy usage.

The extracted needs were also classified according to the E3 (economical, ecological and experience) value framework (Cho et al., 2010). In the E3 value framework, economical values include cost reduction and income enhancement. Ecological values address the issues such as energy and water saving, dematerialization, reducing hazardous materials, reuse and recycling. Experience values deal with more people-oriented viewpoints including utilitarian and hedonic aspects. With the adoption of consumer value framework by Holbrook, extrinsic and intrinsic value dimension is used as the first classifier of experience value. The extrinsic experience values are composed of functional and extrinsic social ones. On the other hand, the intrinsic experience values include emotional, social, and epistemic ones, and the emotional one is further decomposed into active emotional and reactive emotional ones. Figure 6 shows the overall schematic diagram of E3 value framework, and the more detailed descriptions on experience values can be found in (Cho et al., 2010).

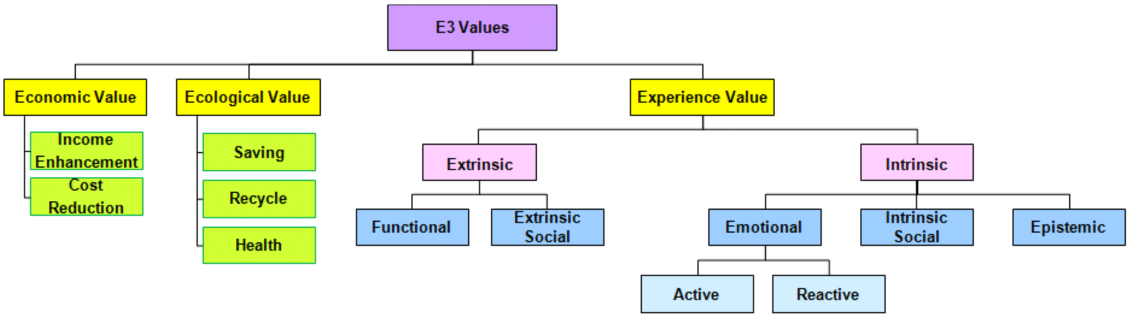


Figure 6 Schematic diagram of E3 value framework (Cho et al., 2010)

The energy users' needs extracted from the user research method were classified according to the E3 value framework, in particular, the experience values. Basically, all of the extracted needs were associated with saving of building energy and related costs, which could be translated into economic and ecological values. In addition, they were highly related to energy users' experiences and could be mapped to various experience values. In Figure 7, the values being mapped to a number of energy user needs are highlighted with a color coding. As can be seen in Figure 7, it is demonstrated that energy user needs associated with rule (extrinsic social), reluctance/willingness (active emotional), contentment (reactive emotional), habit (intrinsic social) and knowledge (epistemic) values mostly occurred. With this information, designers can target those values and improve them in the course of their design of activity and behavioral change for effectively providing a building energy saving service.

4 CONCLUSIVE REMARKS AND DISCUSSIONS

In this paper, the user research method combining generative tools and focus group interview was proposed to explore needs of energy user for building energy saving. In the energy user research, office workers participated, and three days were spent for immersion, collage, modeling, story-telling and FGI ideation activities. All activities were video-taped, and in particular, the story-telling and FGI ideation sessions were transcribed.

After analyzing the transcripts, the needs were extracted as many as possible. Then, those needs were classified and the structured, and, as a results, the needs tree for the energy usage in the office building was obtained. This needs tree was composed of "behavior" and "solution" as the highest level. The needs related to behavior were further be decomposed into those related to the internal and external contexts. The needs associated with internal context were self-oriented ones, and in the case of external context, the needs were associated with social and physical aspects in the lower level. The social needs were others-oriented ones, and the physical needs were originated from physical surroundings. On the other hand, the needs related to solution were also decomposed into those related to physical environment, regulation and mindset, respectively. In particular, the needs for physical environments could be further related to arrangement, improvement, minimization and replacement in the lower level. In addition, the extracted energy user needs were mapped to experience values in the E3 value framework. The results can provide the basis for designing and changing energy users' activities to provide efficient service for building energy saving.

More specifically, critical energy user needs could be translated into the critical elements of the energy use behavior model, which was proposed in authors' previous research (Lee et al., 2012). As can be seen in the energy use behavior model given in Figure 8, the experience values in the E3 value framework were considered to the elements of energy users' experience context.

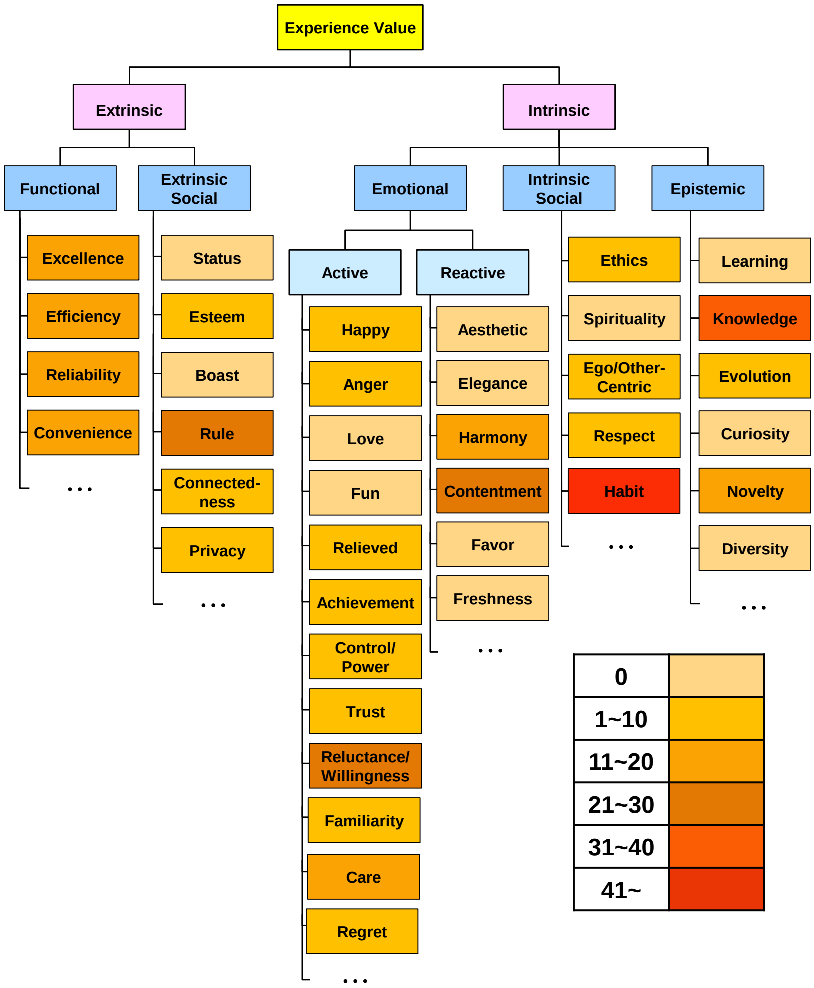


Figure 7 Experience values to which extracted energy user needs are mapped

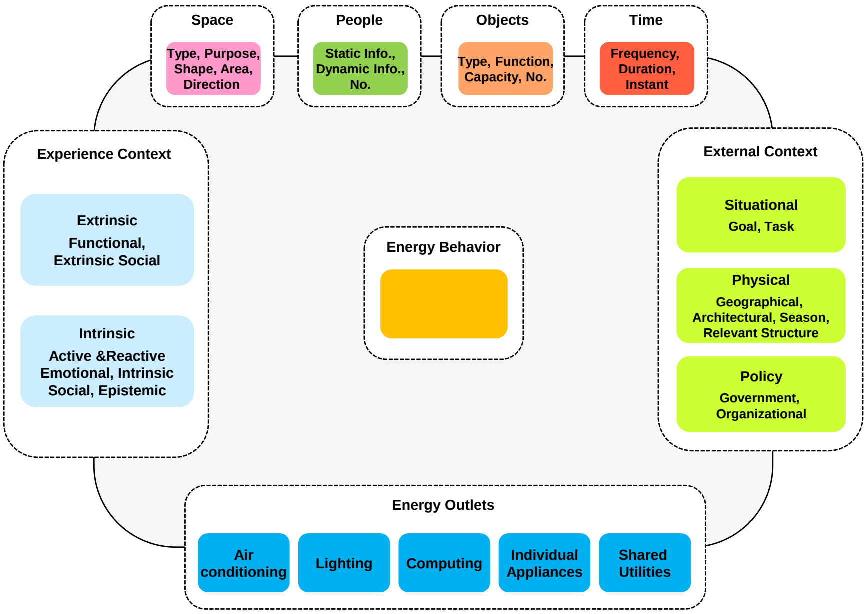


Figure 8 Schematic diagram of energy use behavior model (Lee et al., 2012)

Those elements of the experience context in the energy use behavior model could evaluate the effectiveness of designed activities or behaviors for building energy saving without significantly sacrificing, even improving energy users' experience values. Therefore, the results given in Figures 5 and 7 could be the starting points for designers to preferentially consider while conducting the design for behavioral change for the building energy saving service.

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