International Journal of Research and Technology in Electrical Industry

journal homepage: ijrtei.sbu.ac.ir

Shahid Beheshti University

Comparing the BAENERGY Mobile App, Iran's Experience with Using Gamification in the Power Grid, with Similar Global Apps

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ARTICLE INFO

Article history:
Received: 02 November 2024
Revised: 25 December 2024
Accepted: 25 December 2024

Keywords:
Smart City
Energy Efficiency
Demand Management
Gamification
Serious Game
Sustainable Consumption
Behaviour Change

ABSTRACT

Modern cities increasingly rely on efficient electrical distribution. In recent years, efforts have focused on developing integrated infrastructures that include resilient power systems, renewable energy generation, secure communication, and real-time energy pricing. This integrated system, known as the smart grid, forms the backbone of smart cities. In essence, consumers play a significant role in smart grids, as their energy use accounts for a considerable proportion of overall demand. As a result, utility companies, government agencies, and environmentally conscious organizations aim to reduce and alter energy consumption patterns to achieve peak load reduction, load smoothing, and carbon emission reduction. In this survey paper, we provide an overview of approaches that engage smart grid consumers through mobile applications to achieve energy efficiency, primarily by providing them with information, motivation, and recommendations. We focus on discussing both recent research project outputs and commercial products, examining various design aspects, such as game mechanics, motivation techniques, and target audiences. Furthermore, we aim to share Iran's experience with gamification in the smart grid by introducing the "BAENERGY" application.

1. Introduction

As per data from the United Nations Population Division, the World Bank estimated that approximately 4.27 billion people resided in urban areas in 2020, which represents more than 55% of the world's population. It is anticipated that by 2050, the urban population will grow by an additional 2.4 billion people, bringing the total urban population to approximately 6.67 billion (United Nations Environment, 2018; United Nations, 2015). With city growth, new challenges such as traffic congestion, waste management, pollution, and parking allocation arise, highlighting the need to adapt cities to current and future needs [1, 2].

The introduction of technology significantly impacts the cultural, social, and civil activities and service delivery of cities, adding new functions to urban

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http://dx.doi.org/10.48308/ijrtei.2024.237438.1061

management structures to enhance the lives of citizens. It is important to focus on the smart city by considering its six main components: Smart Governance, Smart Economy, Smart People, Smart Environment, Smart Living, and Smart Mobility. A smart city, in essence, is a sustainable and connected urban community that leverages the power of Industry 4.0 technology and collaborative governance to solve pressing urban issues, enhance quality of life for residents, and promote economic, social, and environmental sustainability [3, 4]. The concept of a smart city was introduced in the 1990s as a way to emphasize the vital role of communication between Information and Communication Technologies (ICT) and modern urban infrastructure. The California Institute for Smart Communities was one of the first institutions to delve into the realm of designing cities to implement information technologies, with the aim of transforming communities into smart and sustainable urban centers. The term "smart city" has various definitions used by different groups of experts and governments [5]. In short, a smart city uses information and communication technology in various forms—from information systems to interactive infrastructure—to provide advanced services, enhance citizens' quality of life, and manage resources sustainably. A smart city is a socio-technical system of interconnected and autonomous subsystems that redefine relationships using technologies like artificial intelligence, the Internet of Things, cloud computing, and blockchain. Social institutions address aspects of urban life such as good governance, citizen empowerment, services and infrastructure, quality of life, education, dynamic economy, sustainability, environmental protection, and resilience against risks [6].

Modern cities increasingly rely on the stability and efficacy of their electrical distribution infrastructure. In the last few years, considerable resources have been allocated to the development of an integrated infrastructure comprising a resilient power distribution system, the deployment of distributed generation devices that utilize renewable energy sources (such as photovoltaic panels and wind turbines), a secure and dependable communication system, and real-time energy pricing policies. This integrated infrastructure is known as the smart grid, which serves as the foundation for the smart city [7].

There are several benefits of adopting a demand response paradigm, including:

- Savings on electricity bills for both engaged and non-engaged users.
- Increased grid reliability and stability, enhancing customer satisfaction.
- Improved market performance and more options for managing electricity costs.
- Enhanced system security.

For effective implementation of demand response algorithms, advanced control and measurement devices, including communication tools and synchro-phasors, are essential to ensure accurate monitoring and seamless coordination between the various components of the smart grid. ICT plays a crucial role in enabling smart grid infrastructure through hardware, software control, and data utilization. [2], [8, 9].

One of the solutions for managing electricity demand and encouraging consumers to use electricity wisely and optimally is designing systems based on gamification in the smart grid. Gamification refers to a technique that applies game-like elements, such as points, rewards, and leaderboards, to a non-game setting. The goal is to make the experience more engaging and enjoyable for the user, leading to increased motivation and participation. The objective of employing gamification in the context of smart grids is to capitalize on users' natural inclination towards gaming and apply it to a practical setting, with the aim of accomplishing specific goals. To achieve this, game mechanics are employed to boost the motivation of users to adjust their behavior, thereby facilitating the attainment of pre-defined objectives [10].

In energy grids, gamification offers a viable solution to tackle issues such as peak demand and associated infrastructure costs. By developing captivating experiences for consumers, energy companies can stimulate energy conservation, reducing the need for costly infrastructure upgrades. While the potential applications are numerous, each concept requires meticulous design to ensure effectiveness. Overall, gamification presents a promising approach to increase citizens' engagement with measures aimed at enhancing the safety and security of smart city infrastructures [11]. Therefore, it can be said that gamification is a suitable technique for the realization of "smart people" as one of the six main components of a smart city.

In this study, we intend to review the global experiences of using gamification in the power grid. Then we analyze and compare the features of "BAENERGY" application as Iran's experience of using gamification in the power grid with similar applications. Therefore, in summary, the primary research questions are as follows:

In the literature, gamified mobile apps with energy efficiency goals have been used for what audiences in the power grid?

What gamification elements do mobile apps employ to engage and motivate their audience?

What unique gamification features does the BAENERGY app possess compared to similar applications, and how successful has it been in accomplishing its objectives?

What advantages can be gained by combining gamification techniques with smart grid technology?

2. Literature and Research Review

The European Union has set ambitious energy policy targets for 2030, which include a 40% reduction in greenhouse gas emissions, increasing the share of renewable energy sources to 27%, and saving 27% of energy compared to historical trends. To achieve these targets, the EU has explicitly identified empowering consumers, as key stakeholders in the energy market, as a crucial strategic objective [12]. To meet these targets, Europe needs to modernize its energy grids and make them smarter. This includes improving energy consumption information, increasing consumer awareness, and transforming the traditional energy grids into smart grids that can support two-way flows of electricity and information. Mobile applications, in tandem with smart home and Internet of Things (IoT) infrastructures, have the potential to serve as a vital catalyst for this energy market transformation. The enhanced computational capabilities of mobile devices, coupled with advancements in mobile app design and development, have resulted in widespread adoption by the general population. Therefore, the proliferation of smartphones, combined with the ubiquity of mobile apps, provide a compelling platform to interact with smart grid consumers [13]. Smart metering systems represent a pivotal component in the evolution of energy grids into smart grids, serving as an essential tool for monitoring grid performance and energy usage. While smart meters provide the necessary infrastructure for energy management services, the impact of their deployment on residential customer behavior remains uncertain. Existing studies have underscored the crucial role of customer engagement in the success of smart grids. Therefore, it is essential to identify the necessary drivers of customer behavior change to achieve active participation and engagement in the energy system. Motivation techniques from the rapidly emerging field of gamification hold great promise in accomplishing this objective [12], [14, 15]. A lot of research has been done in the field of using gamification to modify the energy consumption pattern. For example:

Silva et al. conducted research that aimed to leverage gamification in the promotion of proactive behaviors in intelligent environments. By analyzing sensor data to assess energy efficiency in different rooms and utilizing a context-based engine to generate personalized recommendations, they endeavored to incentivize user engagement in energy conservation efforts. Gamification elements like points, levels, achievements, and leaderboards were used to foster competition. The study found that gamification stimulated user competitiveness, enhancing determination and proactive behavior toward energy sustainability [16].

In their research, Simon et al. dedicated their efforts to the development of a pervasive game with three key attributes: unobtrusiveness, cooperation, and privacy. The primary objective of this endeavor was to create a game that could be seamlessly integrated into daily life, promoting cooperation among users while safeguarding their privacy. The game provided feedback on user performance without needing active participation, setting goals and quests to earn points. The findings indicated that the cooperative aspect was the primary driver of the experiment's success [17].

Wemyss et al.'s research highlights that raising collective awareness is crucial for encouraging sustainable energy consumption behaviors. They emphasize feedback systems and social connectivity as essential for engaging participants. Their study, involving a mobile service with game design, explored both competitive and cooperative approaches. They concluded that, without other incentives like monetary rewards, players generally preferred the competitive aspect [18].

According to the SpilGames Industry Report, about 44% of people with Internet access currently play computer games [19]. This statistic raises the prospect of using gamification to correct consumption patterns. However, an important aspect of developing applications aimed at modifying energy consumption patterns are the need to collect data through smart city infrastructure, including IoT. Unfortunately, Iran is lagging behind in the adoption of smart electricity meters, in contrast to the EU Recommendation 2012/148/EU, which called for at least 80% of residential customers in EU member states to be equipped with smart meters by 2020. However, EU member states were given the flexibility to make alternative decisions based on their respective cost-benefit analyses [12].

3. Methodology

For this study, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 edition guidelines were adopted, serving as the guiding framework for the conduct and reporting of this systematic review [20, 21].

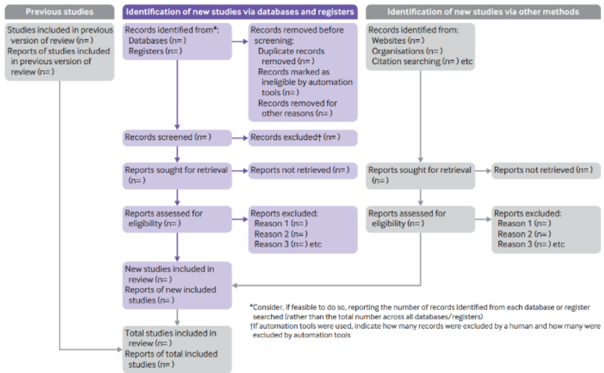


Fig. 1. Systematic review's flow diagram PRISMA 2020 edition [20]

3.1. Search strategy and Selection of articles

To obtain a comprehensive overview of applied gaming in the context of Smart Grids, with a focus on consumer engagement for energy efficiency, a comprehensive computer-based search was carried out in the following databases: Web of Science, PubMed, IEEE, and Scopus. The search string utilized for this endeavor was:

[(energy saving* OR energy efficiency* OR smart grid* OR sustainable consumption* OR electrical demand response* OR demand management)] AND [(Computer Game* OR Digital Game* OR Gamification OR Serious Game* OR mobile app game)].

to minimize the risk of bias and adhere to PRISMA guidelines, recent publications exploring the application of gaming in Smart Grids for energy efficiency, with a particular emphasis on their efficacy, key features, and success stories, were identified. While the search terms were broad, there was a potential for some results to fall outside the scope of the review (e.g., considering forms of energy other than electricity). However, these records could be manually excluded. After executing the search, the obtained records (n = 172) were subject to initial screening by examining their titles and abstracts. Some records were subsequently excluded for falling outside the scope of this study or for not being full-text papers, such as abstracts only (n = 112). Notably, a significant number of records were discarded at this stage for using the term "energy" in a context unrelated to electrical energy, such as to refer to a property of a physical activity or an object (n = 64). In this study, the term "energy" is utilized exclusively in reference to electrical energy consumed in residential settings.

3.2. Gamification background and features for comparison

The following key principles should be kept in mind when incorporating gamification into a real-life situation to motivate the target audience (such as enterprise employees or application users) to engage in a particular task or activity [10]:

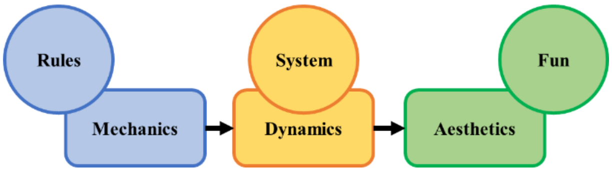


Fig. 2. MDA framework (adopted from [10])

(M) Game Mechanics are the fundamental building blocks that make up the structure and behavior of a game, encompassing elements such as data representation and algorithms. For instance, the implementation of game levels constitutes a game mechanic, allowing users to progress within the system by advancing to higher levels (often referred to as 'leveling up') or, conversely, dropping to lower levels (termed 'leveling down').

(D) Game dynamics represent the real-time interactions among the game mechanics and player inputs, forming a feedback loop that shapes and influences the player's motivation towards the game. Gamification designers, therefore, must identify and cater to the diverse desires of different user groups, such as the desire for rewards, achievement, self-expression, altruism, status, attention, or recognition, among others.

(A) Aesthetics pertain to the emotional responses triggered in the player as they interact with the game system, including feelings such as fun, excitement, and surprise. These emotional responses contribute to increased user motivation and engagement. The MDA framework posits that fostering such emotional responses within the gaming environment enhances user engagement and motivation.

In the literature, there are different categories for game mechanics and types of players. In the methodology of this research, the following categories will be used (the most repeated in the literature on the research topic).

Table 1. Human desires-Game mechanics (adopted from [10], [12, 13])

Game Mechanics	Human Desires					
	Reward	Status	Achievement	Self-Expression	Competition	Altruism
Points/Badges						
Levels						
Challenges						
Tips & Feedback						
Leaderboards						
Social Sharing						
Quizzes						
Prizes						
Suitable mechanic guide		low				high

The research conducted by Bartle (1996) describes various user types based on their motivations and behaviors. Most users do not fit neatly into one specific type; they often possess characteristics of multiple types (Multiple User Types). Users may shift between types or archetypes during their learning experiences (Dynamic User Types). Balancing user types is essential for designing effective gamified learning experiences, as it involves understanding and catering to the different needs and preferences of these various user types. The study outlines four main types of users, defined by Bartle, as follows [22]:

- **Killers:** Users who enjoy competition and strive to triumph over others.
- **Achievers:** This category encompasses users who are motivated by the desire to accumulate points, achieve higher levels, and climb up the rankings in the game. They derive satisfaction from the process of accumulating in-game rewards and moving up the ranks.
- **Socializers:** Users who focus on interacting with other users, leveraging the app as a social bridge.
- **Explorers:** Users motivated by discovering the application's full potential and boundaries.

Fig. 3. Bartle's player types (adopted from [22])

Collaboration is a powerful approach for engaging diverse player profiles, given that the population of players typically exhibits a distinct distribution across different categories, with an average of 80% socializers, 50% explorers, 40% achievers, and 20% killers. By fostering cooperation between these distinct player groups, game designers can create a compelling and engaging gaming experience that caters to the diverse motivations and desires of different types of players [23].

From another perspective, the Fogg Behavior Model (FBM) outlines a simple yet effective approach to understanding and influencing human behavior, encompassing three critical elements: Motivation, Ability, and Trigger. By organizing and systematizing various psychological theories, the FBM offers a practical and comprehensive framework for facilitating behavior change [24]. From the point of view of this model, when the user performs the desired behavior of the system designer:

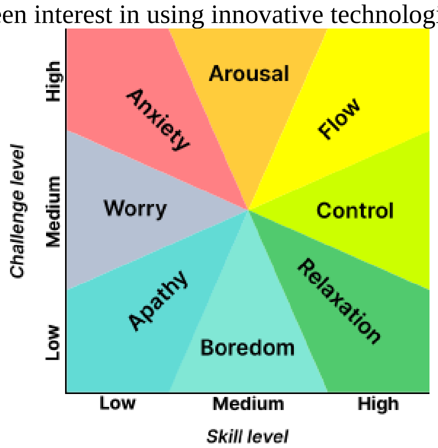
- have the necessary motivation to perform that behavior, whether it is internal (such as ideology) or external (such as monetary rewards)
- have the mental and physical ability to perform that behavior
- A Trigger to lead him to perform that behavior (such as a notification)

Assuming the "ability" of users and the existence of a "trigger" in a gamified mobile application, sufficient "motivation" is provided through the correct tailoring of appropriate mechanics to the attitude of the target audience. Specifically, in the field of electricity consumption, Frankel et al. surveyed 2,500 citizens in the United States to measure their behavioral tendencies. The primary objective of their study was to identify practical tools and strategies to attract buyers and meet their specific needs, as well as to evaluate the requirements for scaling up the implementation of enhanced energy-efficiency-performance measures. Furthermore, they identified five distinct categories of energy consumers [25]:

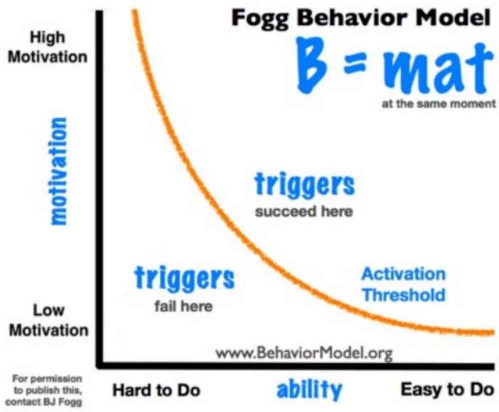
1. **Green-Advocate (G-A) Sector**: The Green/Early Adopter consumer segment represents individuals who are motivated by environmental concerns and display energy-saving behaviors, as well as a strong inclination towards adopting cutting-edge technologies. The defining characteristics of this segment not only encompass their "green" ethos but also a keen interest in using innovative technologies.
2. **Traditionalist Cost-Focused Energy Saver (TC-F) Segment**: This category, individuals who are primarily motivated by cost savings and exhibit a range of energy-saving behaviors. This group has a limited interest in new technologies and is primarily driven by the financial benefits associated with reduced energy consumption.
3. **Home-Focused Selective Energy Saver (H-F) Group**: This consumer segment is characterized by individuals who seek to enhance their homes through a combination of cost-saving measures and technological advancements.
4. **Non-Green Selective Energy Saver (N-G) Users**: This consumer segment consists of individuals who tend to exhibit energy-saving behaviors but prefer interventions that are "set and forget," meaning they require minimal effort or attention on their part. These individuals are not motivated by environmental concerns and prefer energy-saving solutions that do not require them to actively think about saving energy.
5. **Disengaged Energy Waster (D.E.W.) Sector**: In contrast to the G-A sector, this group is indifferent to saving energy or money and shows no interest in new technologies or environmental issues.

The term "flow" was originally introduced by Mihaly Csikszentmihalyi (1975) to define a positive emotional state that individuals can experience during specific activities, notably those that provide a balance between the individual's skill level and the degree of challenge posed by the task. In this context, flow is viewed as a motivating factor that drives people's involvement in a wide range of activities, such as work, sports, and artistic pursuits [22].

Therefore, electricity subscribers, as gamified mobile application users, will continue to use the application in conditions where the design of the game mechanics will keep them at the halfway point of the flow theory diagram.



(a) Flow Theory Model



(b) The Fogg Behavior Model (FBM)

Fig. 4. Important theories of gamification background (adopted from [22] and [24])

Drawing from the concepts described above, this study aims to present existing gamified mobile applications designed for smart grids, with the primary objective of providing users with incentives and motivation to engage in energy efficiency and consumption reduction. To gain a comprehensive understanding of these applications and their effectiveness, the following parameters will be analyzed and compared:

- Goals of electricity consumption efficiency
- Target Audiences
- Type of application users

Features and mechanics of gamification (most common)/gameplay

Table 2. Goals of electricity consumption efficiency

3.1. Energy target segment		**(G-A)**	**(TC-F)**	**Saver (H-F)**	**(N-G)**	**(D.E.W.)**
Characteristics		They make a conscious effort to adopt a sustainable lifestyle that is environmentally conscious and resource efficient.	They prioritize cost-effective management of their household, with a keen focus on maximizing resource efficiency and minimizing expenses.	They are technology enthusiasts who avidly follow new developments in the field and are often among the first to adopt the latest gadgets.	They only consider their comfort	They don't have to worry about expenses in their lifestyle
Smart household appliances		They prioritize the longevity and energy efficiency of the products they purchase.	Limited interest	They lean toward to purc hase them on the cutting edge of innovation	They pay attention to ease of use	Limited interest
User availability		They use smartphones and are not necessarily active on social media	They are mostly connected through their smartphone and are social media users	Anywhere and always via smartphone, they are online in social media	They are mostly connected through their smartphone and are social media users	They are mostly connected through their smartphone
Energy awareness		They care very much	For these individuals, energy conservation is paramount, and they strive to adopt sustainable practices within their means.	They try to save energy within their abilities	Saving energy is not a priority for them	They do not care
Goals of electricity consumption efficiency	**Demand response/Energy sharing (O1)**					
	Sustainable energy use (O2)					
	Raising energy awareness (O3)					
Suitable goal guide		low				high

4. Review of Global Experiences

4.1. Gamified mobile apps in global experiences

In the research literature, there are many examples of gamified programs to increase energy efficiency, which include a wide range of web-based programs, smart mobiles and types of computers, and a wide range of energy sources such as gas, water, and electricity.

For example, "Energy Battle", a web-based serious game, has demonstrated its potential in stimulating short-term energy savings, with players' motivation to conserve energy being strongly influenced by the game context. The results revealed that, on average, energy savings amounted to 24%, with the highest savings level recorded at an impressive 45%. Notably, while energy consumption increased in most households directly following the completion of Energy Battle, the consumption levels remained lower than the baseline measurement taken prior to the game's commencement. Follow-up interviews with players revealed that some of the energy-saving behaviors adopted during the game had transformed into habits [26]. As another example: "Trashwar", a game developed by Bardhan and Bahuman, is designed to educate children about recycling and waste management [19]. To ensure the relevance of the literature review to the scope of this study, which focuses on electricity efficiency within the context of smart grids, and the gamification of mobile applications targeting non-specialist audiences, the results were refined to identify the applications listed in Table 3. Furthermore, programs like Social "Mpower" and "DLT Energy Game", which are tailored for members of the energy community, were excluded from the study's findings [27, 28].

Table 3. Gamified Mobile Apps for electricity consumption efficiency

Gamified Mobile App	**Scope**	**Goals of electricity consumption efficiency**	**Real World**	**Audience**	**Suitable For Segment**	**Features and mechanics of gamification/gameplay**							
						Points/ Badges	**Levels**	**Challenges**	**Tips & Feedback**	**Leaderboards**	**Social Sharing**	**Quizzes**	**Prizes**
EnergyCoupon [29]	USA	O1	*	Households	(H-F)				*	*			*
EnergyWiz [30]	Germany	O1	*	Households	(G-A), (H-F)			*		*	*		
ChArGED [31]	Spain, Greece, and Luxembourg	O2	*	Anyone	(G-A)	*		*		*	*		
GreenSoul [13], [32]	Spain, Greece, UK, and Austria	O2	*	Office workers	(G-A), (H-F), (TC-F)	*	*			*	*		*
enCOMPASS [33]	EU, Switzerland	O2	*	Households	(G-A), (H-F)	*		*	*	*	*		*
EnerGAware [34]	EU	O2, O3	*	Households	(H-F), (N-G), (D.E.W.)			*			*		*
ENTROPY [35]	EU	O1, O3	*	Office workers	(H-F), (N-G), (D.E.W.), (TC-F)	*	*	*	*	*		*	*
GreenPlay [13]	EU	O2, O3	*	Households	(H-F), (N-G), (D.E.W.)	*		*	*		*		*
MyEarth [13]	USA	O2	*	Anyone	(G-A)	*	*		*				
JouleBug [36], [37]	USA	O2	*	Office workers	(G-A), (H-F), (TC-F)	*	*	*	*	*	*		*
Energy Cat [38, 39]	UK	O2	_	Households	(H-F)	*	*	*					*
Energy Piggy Bank [40]	Sweden	O2	*	Households	(G-A), (H-F)	*	*	*	*	*	*		*
Power Agent [36], [39]	Sweden	O2	*	Teenagers	(H-F)	*	*	*	*	*			*
Power House [23], [41]	USA	O1	*	Households	(H-F)	*	*	*	*	*	*		*
EnergyLife [39], [42]	Italy	O3	*	Households	(N-G), (D.E.W.)	*	*		*			*	
Power Explorer [37], [43]	Sweden	O2	*	Teenagers	(H-F)	*	*	*	*	*	*		*
EcoIsland [44]	Japan	O2	*	Households	(G-A)	*	*	*	*				
The Ghost Hunter [39], [45]	USA	O3	*	Children	(TC-F), (N-G), (D.E.W.)			*	*				

Gamified Mobile App	**Scope**	**Goals of electricity consumption efficiency**	**Real World**	**Audience**	**Suitable For Segment**	**Features and mechanics of gamification/gameplay**							
						Points/ Badges	**Levels**	**Challenges**	**Tips & Feedback**	**Leaderboards**	**Social Sharing**	**Quizzes**	**Prizes**
Ringorang [46], [47]	USA	O3	_	Anyone	(N-G), (D.E.W.)	*		*	*	*		*	
ecoGator [23], [48], [49]	EU	O2, O3	*	Anyone	(H-F), (N-G), (D.E.W.)	*	*	*	*	*		*	*
Social Power Game [23], [50]	Switzerland	O2	*	Households	(H-F), (N-G), (D.E.W.)	*		*		*	*	*	*
ECO ECO [51]	Maldives	O2, O3	*	Children	(G-A), (TC-F)	*	*	*					
Reduce Your Juice (RYJ) [52, 53]	Australia	O2	*	Households	(H-F), (N-G), (D.E.W.)	*	*	*	*	*	*		*
GAIA Challenge [54]	Greece, Italy, and Sweden	O2, O3	–	Students	(N-G), (D.E.W.)	*		*		*	*	*	
Power Pets [55]	Australia	O3	_	Children	(N-G), (D.E.W.), (TC-F)	*	*	*					
Changing the Game – Neighbourhood [37], [56]	Germany	O1	*	Anyone	(H-F), (N-G), (D.E.W.)	*		*	*	*	*		*
Electric City [37], [57]	Netherlands	O3		Anyone	(N-G), (D.E.W.)	*	*	*			*		
Apolis Planeta [58]	France and Spain	O2, O3	*	Households	(N-G), (D.E.W.)	*		*	*		*	*	
FunergyAR [59]	EU H2020 Program	O3	*	Children	(N-G), (D.E.W.), (TC-F)	*						*	
SHAREBUDDY [37], [60]	UK	O1	*	Students	(G-A)	*		*	*				*
Green my place [61]	Finland, Netherlands, Portugal, Sweden, and UK		*	Anyone	(H-F), (N-G), (D.E.W.)	*		*			*	*	*
Less Energy Empower You (LEY) [62]	Portugal	O2	*	Households	(N-G), (D.E.W.)	*	*	*		*	*	*	
Personal Energy [63]	USA	O2	*	Households	(G-A), (N-G), (D.E.W.)	*	*	*	*	*	*		
BAENERGY[2]	Iran	O2	*	Households	(H-F), (G-A)	*	*	*	*			*	*

[2] https://cafebazaar.ir/app/com.mcinext.energy?l=en

In terms of use case, each of the above applications can be classified into four categories in Table 4. Considering that BAENERGY is developed by the Iranian government, "Crowdsourcing", "Energy efficiency", and "Energy awareness" use cases are more important in this research. In the next step, we will describe the features of BAENERGY.

Table 4. Categories of mobile applications

Category	Description	Example
Crowdsourcing	They use the power of crowdsourcing to demand response and control peak consumption points	EnergyCoupon, SHAREBUDDY, Changing the Game-Neighbourhood
Energy management	They provide a practical tool for energy management to building managers and office officials	GreenSoul, ENTROPY, JouleBug
Energy efficiency	In the real world, users have missions aimed at increasing energy efficiency	Reduce Your Juice (RYJ), Energy Piggy Bank, BAENERGY
Energy awareness	In the virtual world, they increase the concern of users about energy through entertainment	Power Pets, FunergyAR, Electric City

For a better understanding, the user interface view of some applications is shown in Fig. 5 to 11.

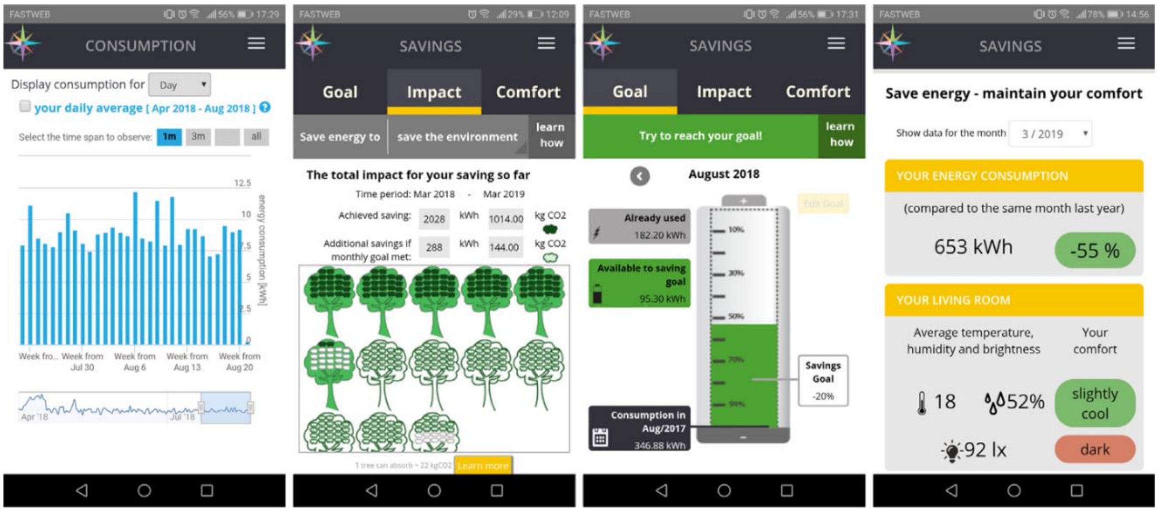


Fig. 5. The user interface view of enCompass [33]

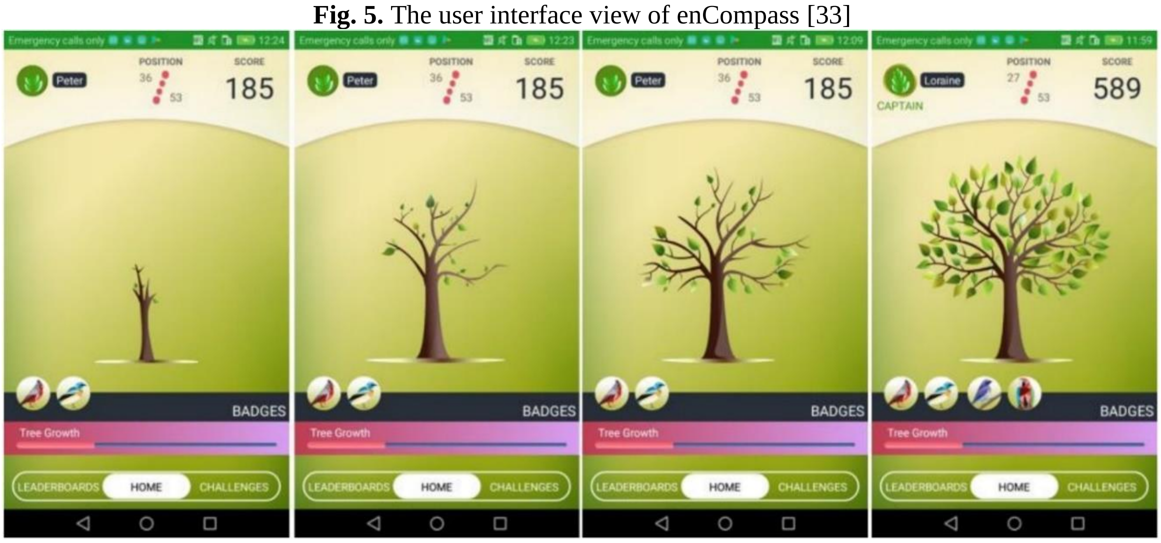


Fig. 6. The user interface view of ChArGED [31]

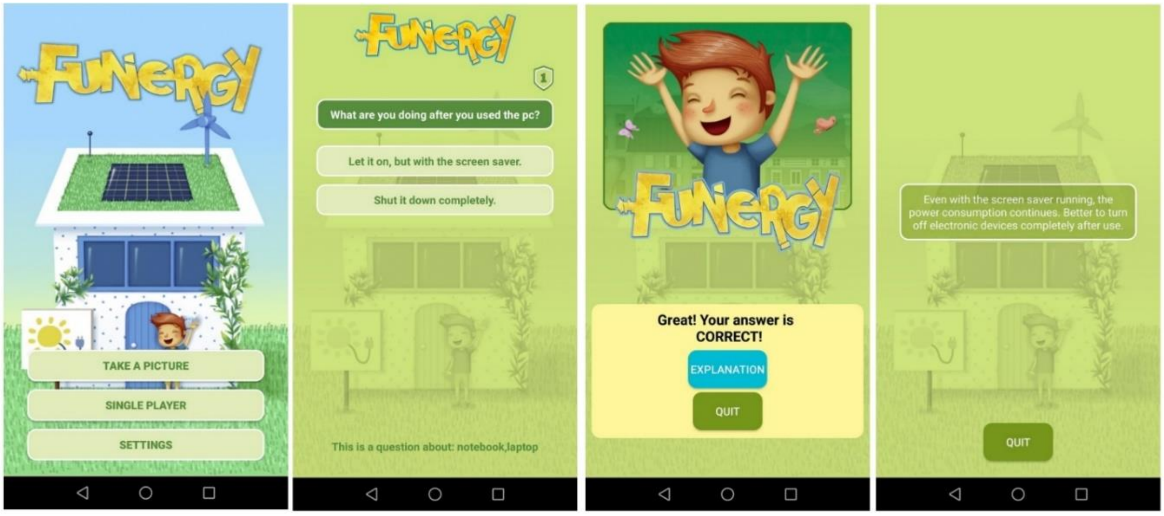


Fig. 7. The user interface view of FunergyAR [59]

Fig. 8. The user interface view of EnergyLife [42]

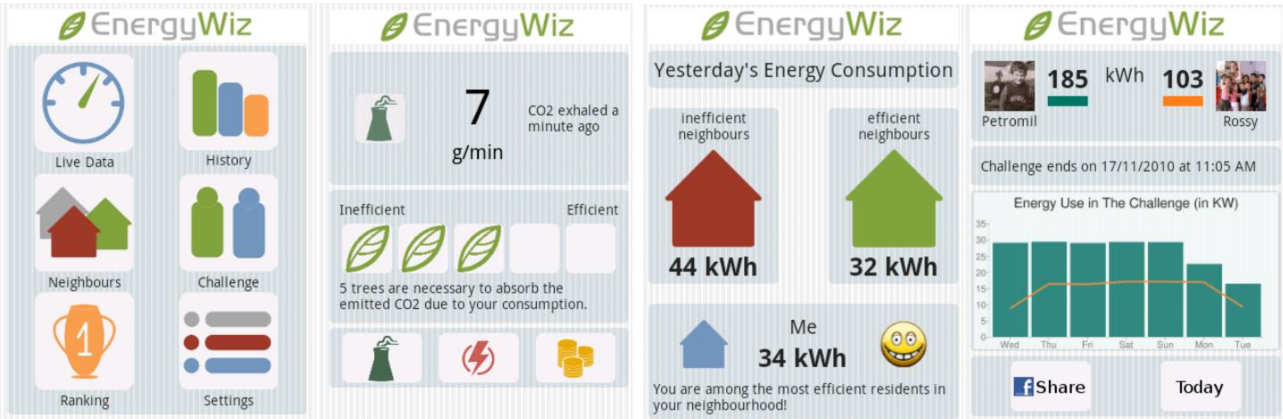
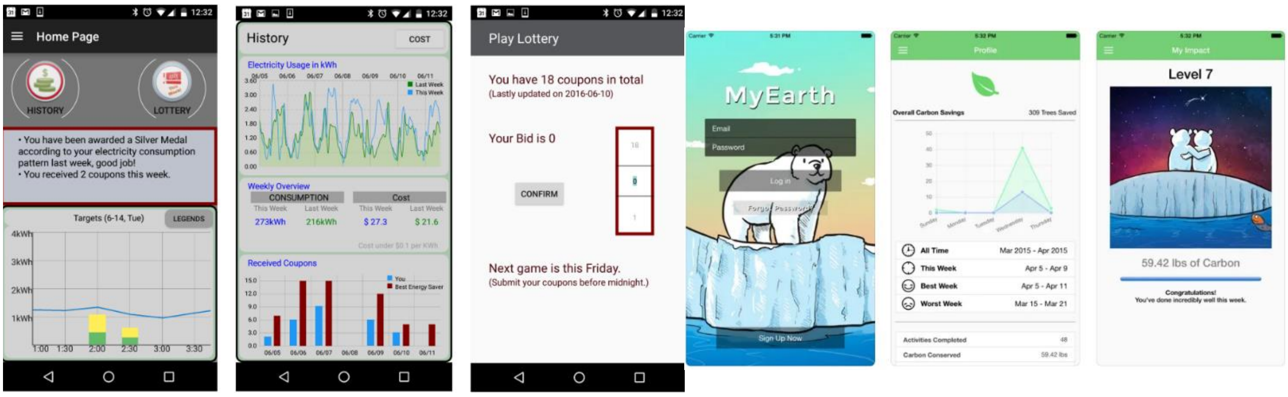


Fig. 9. The user interface view of EnergyWiz [30]

Fig. 10. The user interface view of ecoGator [48]



EnergyCoupon [29] MyEarth

Fig. 11. The user interface view of EnergyCoupon and MyEarth

4.2. BAENERGY

Paying attention to the cultural, social, and economic contexts of the audience is crucial for the successful design of a gamified mobile application. In Iran, due to specific economic conditions, most people are sensitive to saving money. However, the abundance of resources over the past years and the cheap price of all energy types have made people less concerned about environmental effects. One of the important infrastructures in smart cities is the Internet of Things (IoT), with smart meters being a prime example.

In a power grid equipped with smart meters, we can gather real-time energy consumption data, monitor it, and provide more information to users through a mobile application. Unfortunately, most of Iran's electricity meters are outdated, making it impossible to collect the detailed information needed to design an efficient mobile application. Therefore, considering that BAENERGY was developed by the Iranian government, the following points are taken into account in BAENERGY's design:

1. **Target Segments**: The main energy target segments are TC-F (Traditionalist Cost-Focused) and H-F (Home-Focused), based on the cultural, social, and economic contexts in Iran.
2. **Goals**: The goals for electricity consumption efficiency in BAENERGY are sustainable energy use (O2) and raising energy awareness (O3), aligned with IoT infrastructures in Iran.
3. **Game Mechanics**: The game mechanics of BAENERGY are designed as shown in Fig. 12, considering the cultural, social, and economic contexts in Iran.

The main goal of the BAENERGY project is to create the necessary infrastructure to implement consumption pattern modification plans with the cooperation of householders. For example: since the publication of BAENERGY, the first campaign called "Summer Energy" was held to achieve a 15% reduction in electricity consumption compared to the same period in the previous year. The non-updated infrastructure of Internet of Things technology made it difficult to implement the campaign. Therefore, to provide sufficient motivation, valuable prizes and raffles were considered for participating households. Due to the lack of home smart meters, the daily mission of the households was to take a picture of the meter and read the consumption number. Finally, the application support experts checked the accuracy of the information sent by the households and confirmed the consumption reduction points.

Households could then redeem their points for small prizes or save their points to enter an end-of-campaign drawing with more valuable prizes (Fig. 12).

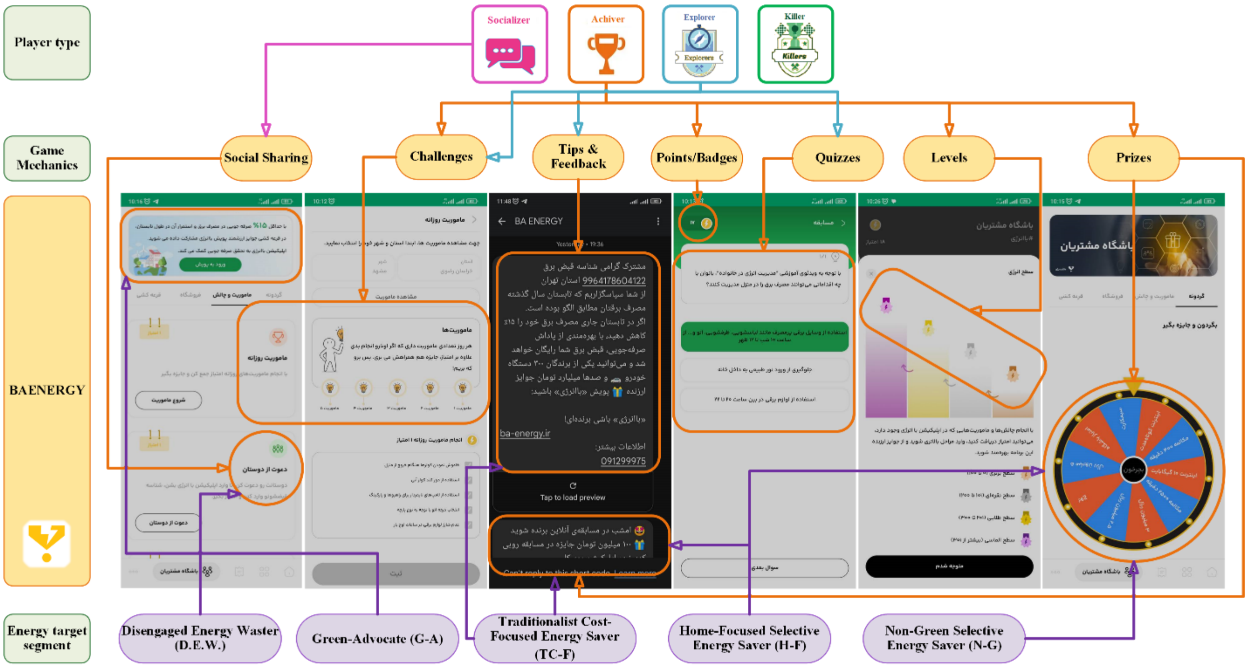


Fig. 12. The gamification elements

Three months after launch, more than 200 K users are using the BAENERGY app, and we are eagerly receiving feedback and learning from it.

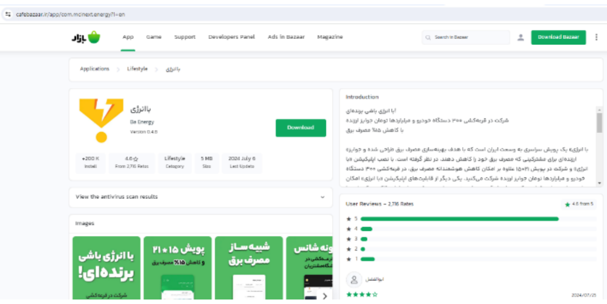


Fig. 13. BAENERGY rates and feedback at Café Bazar[3]

To create appropriate behavioral habits aimed at increasing energy efficiency based on Fogg's behavioral model, the mechanisms shown in Fig. 14 have been used in the design of the BAENERGY application.

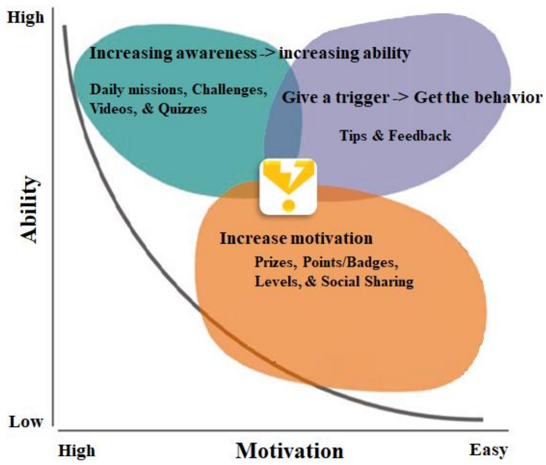


Fig. 14. The game mechanics of BAENERGY based on Fogg's behavior model

One of the main challenges in designing BAENERGY game mechanisms is not changing the difficulty level of the challenges according to the skill level of the users. Because of this, users get bored and stop playing the game after a while. According to the flow theory, in the next versions of this application, the game mechanisms should be redesigned in such a way that the users stay engaged.

5. Conclusion

We believe in Temporal Comparison Theory, which posits a human drive to evaluate oneself through self-comparison over time. Therefore, by increasing awareness, providing information, and offering self-assessment training to people, energy consumption efficiency can be improved. In this study, through a systematic review of global experiences regarding the use

[3] https://cafebazaar.ir/app/com.mcinext.energy?l=en

of gamification in the smart power grid, we identified four main categories of mobile applications use cases include “Crowdsourcing”, “Energy management”, “Energy efficiency”, and “Energy awareness”. Additionally, by introducing the features of the "BAENERGY" application, we aimed to share Iran's experience of using gamification in the smart grid, hoping it will inspire researchers and activists in the field of energy, especially electric energy. In summary, to address the main research questions, the key findings revealed the following:

In the literature, electricity consumers have generally been divided into five audience categories with three main types of energy efficiency goals. Each of these categories has a unique approach to achieving energy efficiency goals (as shown in Table 2).

A review of global applications demonstrated that eight main elements were utilized as most common gamification mechanics (gameplay) to motivate and engage citizens in enhancing the efficiency of the power grid (as illustrated in Table 3).

In order to effectively utilize gamification in the power grid, real-time and high-quality data are essential. Obtaining accurate and comprehensive electricity consumption data for display to citizens through a mobile application necessitates the installation of smart meters and the development of a smart grid infrastructure.

The BAENERGY application has made significant efforts to educate citizens about sustainable and efficient energy usage, employing gamification elements within the confines of the existing Iranian power grid infrastructure. This effort can be seen as a promising step towards the effective use of gamification in this domain. However, to enhance the effectiveness of the BAENERGY application, it is crucial to maintain the state of "flow" among users, which can be achieved by increasing the level of challenge as users' skills improve. This is essential to retain user engagement and achieve the desired outcomes.

To fully leverage the four identified use cases of gamification in the power grid, particularly the 'crowdsourcing' case, the installation of smart meters and the development of a smart grid are essential prerequisites. Unfortunately, the absence of these infrastructure elements has created limitations in the development of the BAENERGY application, thereby restricting its ability to fully exploit the potential of gamification.

6. Acknowledgments

The completion of this research project would not have been possible without the contributions and support of *Iran's Power Generation and Distribution Company (Tavanir)*[4]. We are deeply grateful to all those who played a role in the success of this project.

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