HotCity—A Gamified Token System for Reporting Waste Heat Sources

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Abstract Urban planning needs to discover and incorporate new energy sources to meet climate protection targets in the future. Waste heat from industrial and urban infrastructure has proven to be a viable solution, but its proper identification can be challenging, especially for smaller and unconventional sources. Our project relies on the principles of gamification enhanced by a blockchain based token system and crowdsourcing as methods to collect and utilise spatial data such as the location and the size of previously unused heat sources. The mobile platform-neutral HotCity App en ables users to collectively patrol the city in search of waste heat sources and to gain tokens that can be exchanged for rewards. The blockchain platform Ardor was used for cheat proofing and to enable transparency for the reward system. The field test conducted in winter 2020/2021 showed high usability scores as well as high acceptance ratings of our approach opening up new use case scenarios in the context of spatial energy planning.

Keywords Blockchain · Blockchain Game · Gamification · Energy Saving · Crowdsourcing

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1 Introduction

Availability of reliable data is one of the most important elements for fact-based decisions. Urban planning and spatial energy planning often suffers from a lack of availability of good, validated and up-to-date data sets. Furthermore, integrated spatial and energy planning needs to incorporate new spatially distributed energy sources and understand how these sources can be used in the future to meet climate protection targets. These new energy sources can be, for example, waste heat from industrial food production, local industrial/commercial enterprises, data centers, or urban infrastructure such as tunnels and metro stations. The utilization of such waste heat sources in heating networks has been demonstrated several times, however, their proper identification in an urban environment can be challenging, especially for smaller and unconventional sources [16].

Gamification as an innovative way to collect the needed data was investigated within a national funded research project "HotCity". Gamification builds on the use of game mechanics in contexts that are, by nature, unrelated to the game [7]. Within the project the "HotCity App" was developed enabling users to spatially report and evaluate different sources of waste heat. The gamification of data collection was also intended to raise awareness of waste heat and energy use on the one hand, and to facilitate the collection of data from small energy sources on the other. For the first time, the game framework is secured using a blockchain and mapped by means of a token system. The HotCity App was tested in the Austrian cities Vienna and Graz as a proof of concept to analyse if and how the gamification approach can deliver valid results.

The HotCity App makes it possible to identify and georeference also smaller sources of waste heat in order to use the available energy. Two test runs were each conducted in Graz and Vienna, which provided helpful feedback from the testers regarding promising features as well as showed barriers reducing the success of this data collection approach.

The paper will elaborate the game development, discuss the gamification approach and the lessons learned during the proof of concept project.

2 Gamifying the challenge

The energy system of the future will most likely consist of many different decentralised units (e.g. rooftop PV systems, individual heat pumps, etc.). For the development of districts with high energy efficiency and increased use of locally available and sustainable energy sources, a detailed spatial identification of possible energy potentials is necessary in order to plan cost-efficiently and future-proof. In particular, waste heat from industry (foundries, food production...) and commerce (data centres, supermarkets...) as well as urban infrastructure (tunnels, metro stations) can make an important contribution to heating and hot water in plus-energy neighbourhoods. While "low-hanging-

fruits" such as waste heat from large industrial plants are already used on a large scale, the identification of smaller sources is associated with various difficulties [16]. Many larger cities already have a dataset, e.g. Open Government Data, but it is usually not up-to-date enough, not (spatially) detailed enough and often does not contain the necessary data. The often chosen top-down methodology for determining waste heat potential, i.e. via a survey of the largest pollutant emitters (e.g. [3]), does not cover smaller sources, which thus do not appear in these databases.

Gamification, on the other hand, offers the possibility of generating targeted incentive systems for data collection (crowdsourcing/crowd collecting). Games like "Pokemon Go" have shown the unimagined dynamics that can be generated. As part of the HotCity project funded by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), the HotCity App was developed that allows users to spatially record and evaluate new sources of waste heat. The application for the collection of waste heat was chosen as an example for other spatial energy data. The gamification of waste heat data collection was also intended to raise general awareness of the issue and facilitate the collection of data from small energy sources that are not normally considered in top-down approaches.

2.1 Gamification as a method for incentivizing the identification of waste heat sources

The massive distribution and market penetration of digital games (approx. 37 billion dollars in sales in 2020 in the USA alone as stated by [5]) is impressive. For example, 510 million people are currently actively playing games (5.3 million in Austria as stated by [20]), with an average age of 35. Gamification is based on the use of game mechanics in contexts that are, by nature, unrelated to games [7]. The aim of gamification usually is to apply the motivational and feedback techniques that have been tried and tested in games. Games provide clear goals ([10] e.g. in the form of quests), they reward ([18]; e.g. badges, level-ups),), they allow to compete or cooperate with others ([19]; e.g. in the form of rankings, multiplayer elements) and they provide an interactive framework for different experiences and skills ([11,12].

Gamification has already been successfully used in various application areas to promote participation, such as in the context of civic courage [6], citizen participation [17], e-learning [2] and e-government [1]. The application of gamification has also yielded positive results in the mobility sector, e.g. in terms of promoting sustainable forms of mobility [13].

Pfeiffer et. al. [14] coined a new definition of Gamification: "Gamification is the use of game mechanics as a further dimension within and around both gaming and non-gaming contexts, in an endeavour to nudge participants to perform certain actions, by adopting a playful attitude". This definition shows that gamification can also take place within games, whenever further elements outside the core mechanics and the core storyline are used to get the players

to explore certain content. Furthermore, the definition also shows the relation to the principle of nudging and that gamification can be seen as one of the tools to trigger positive behaviour.

2.2 Blockchain as a method for securing the gamification framework

Due to its decentralisation, transparency and security, the blockchain is dominating technological and social discourse [4] and is being treated as a disruptive innovator for a wide range of applications: from transaction processing to land registry entries to logistics chains, the intermediary is to be eliminated in the future [9]. Previous crypto technologies such as Bitcoin and the first version of Ethereum rely on the "proof of work" architecture. A small percentage of the cryptocurrency in the network is used to reward "miners", who keep the entire network alive and validate all transactions, for solving randomly generated computing tasks. The computing power required for this increases linearly with the difficulty of the computing tasks and consumes more and more resources, which leads to grounded environmental concerns [8]. This is where new blockchain technologies such as "Ardor" or "NXT" come into play. These solutions are based on the "proof of stake" algorithm and are much more energy-efficient. In this case, it is not about computing power in the form of graphics card performance or CPU-power, but about holding a certain stake in the network-maintenance token, as well as other aspects such as the total time of being active online as a verification node and a certain degree of randomness. Regardless of the particularities of architecture, the peer-to-peer principle, the strong encryption and the permanent and validatable storage of information represent an opportunity for diverse industries - including, of course, the gaming industry [15].

Ardor offers the possibility to generate utility tokens on the child chain Ignis. Approval models can be set up around these created tokens and therefore the set of rules can be specified. Furthermore, there is the possibility to develop smart contracts. As a bonus, there is also a ready-made marketplace that can be used within the scope of the decentralised applications (DApps) generated using the Ardor blockchain and its child chain Ignis.

In HotCity, the blockchain was used to prevent cheating on the one hand and to ensure transparency for the players on the other. It was used to automate the management of redeemed prizes and rewards and to reduce the administrative effort to a minimum. The concept involved incentives (such as coffee vouchers) - mapped on a blockchain token - that could be redeemed at project partners. Double spending or counterfeiting of vouchers can thus be avoided. In addition, the accounting settlement can be automated. For example, similar to a current account system, the partners could send the tokens to our billing account on a monthly basis, thus triggering the transfer of Euro funds from the game operator to the prize provider.

Fig. 1 Screenshots from HotCity App as they would look on the user's device

3 The HotCity App

A platform-neutral app design was created for the HotCity App in order to appeal to users from both worlds (iOS and Android). This platform-agnostic design also offers the possibility of drawing users more strongly into the Hot City world, as the branding elements from the style guide are implemented everywhere. For a quick overview, explanatory screens were developed for rapid onboarding, which users are shown at the start of the app and can also view again and again while using the app. The app is based on learned UI patterns (e.g. menu navigation, call-to-actions, map with markers), so that no specific knowledge or explanations are necessary to use the app.

The home screen of the app or main game area is the overview map. The map is divided into rectangular districts that can be conquered by users and crews. From there, the user has an overview of everything. The user sees the city from a bird's eye view, above it the districts and the heat sources. The heat sources have a status that shows how much information can still be added by users. Users can add new heat sources directly from the home screen via the "Upload photo" function. The photo is first saved and then entered on the Basemap Austria via a map picker. In the next step, the user is asked to add first details to the found heat source.

By earning more heat tokens, users can climb up the ranking in the app's leaderboard and earn new badges. Besides, they can form crew and engage in cooperative play. In this scenario, each user and each crew aims to occupy predefined squares according to the plan in the app and thereby both increase their heat score and earn new badges.

3.1 The token framework

The gamification framework consists of three utility tokens realised within the blockchain Ardor and its child chain Ignis that represent points: bronze, silver and gold tokens. Users receive bronze tokens for simple tasks such as uploading unconfirmed images and later receive points with higher value, when heat sources are confirmed by other payers. These tokens can later be redeemed for incentives, with better incentives distributed for gold tokens than for bronze tokens. As a further game mechanic, tokens can be exchanged for each other, e.g. 10 silver tokens result in 1 golden token. Furthermore, all badges are displayed as tokens.

The actual transfer of the respective tokens in the form of assets takes place entirely on the blockchain. A lightweight contract (cf. smart contract) was developed for this purpose, which, in conjunction with the API, ensures that the assets are transferred correctly. This contract is initially triggered by the backend and contains, for example, information about which "heat spot" has triggered an asset transfer. The lightweight contract then calls the API and checks whether the entries and information are valid and correct and then transfers them. In a freely definable period of time, the API checks whether the asset transfer was successful. If, for example, the transfer of the assets fails due to technical circumstances or insufficient fee, a new process takes place. The Ardor node primarily manages and executes the lightweight contracts for the transfer of the application. As already mentioned, the API acts as a validation unit for this contract and only transfers assets or badges if the correct information is available.

In summary, blockchain technologies in the HotCity project secure those relevant parts of the game where values for the players or project partners are affected. On the one hand, tokens, badges and vouchers earned and, on the other hand, the accounting modalities. All other data, such as the description of the heat sources, are saved in a conventional database, which is of course designed in the best possible way and continuously backed up. Transactions on the blockchain, as accessed from the graphical interface of the main account full-node as well as a triggered badge.

4 The HotCity field test

The field test took place in two different phases during the winter 2020/2021. The first phase was performed in November 2020, while the second phase was launched mid of February 2021 for 3 weeks. For a part of the test persons, fees were awarded for 5-8 hours playing time. All participants received a briefing in advance in the form of a tutorial on the app and in the form of marked districts that showed a high potential in terms of waste heat sources. The responses were collected in anonymous form with a request for open critical feedback. A total of 836 tokens were sent out for a) heat sources, divided into bronze, silver and gold and b) badges.

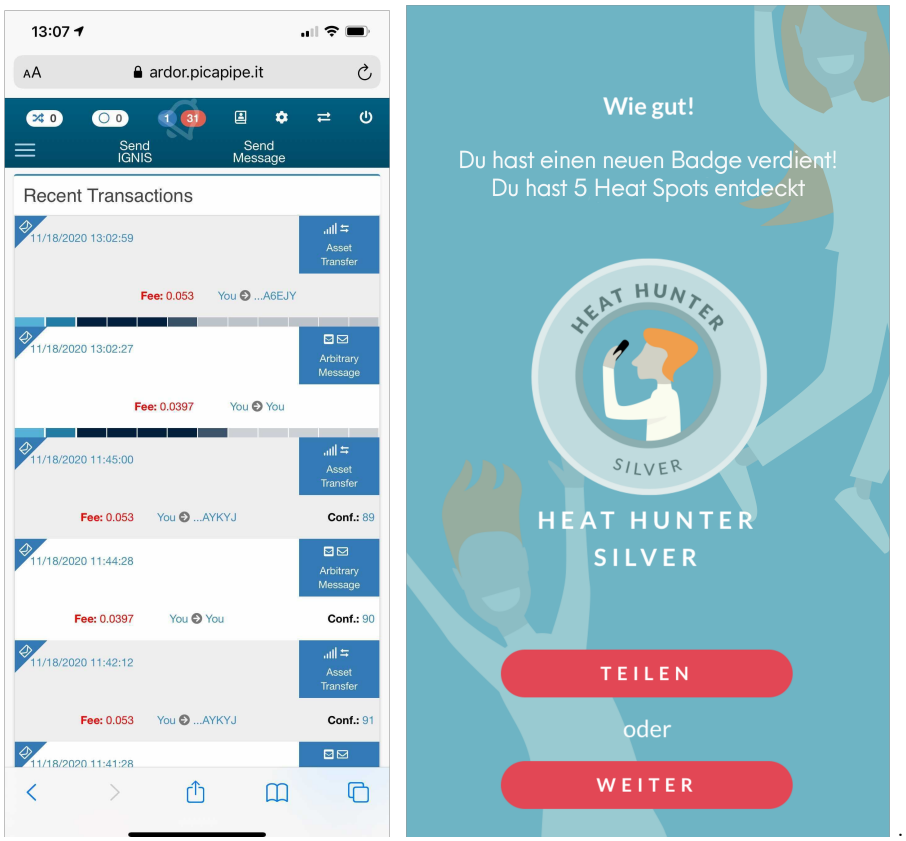

Fig. 2 Blockchain token transactions (on the left) and visualisation of the triggered badge (on the right)

After a 2-3 week test phase, an online questionnaire was created and submitted using the "Survey Monkey" software. The item collection contained both open and closed questions with dichotomous and rating scaled gradations. A total of 31 people took part in the test and filled out the online questionnaire. The majority of the test persons (almost 68%) tested the app in Vienna, the rest (32%) in Graz.

4.1 The game rating and winning strategies

Satisfactory values could be reported with regard to the usability and acceptance of the app. The usability is subjectively high (mean values from 2.03 to 2.62). The simple user interface (M=2.07) and the assessment of the comprehensibility for other users (M=2.03) are particularly noteworthy in this regard. The normalised SUS (system usability scale) score is 79.675, which corresponds to an above average value (maximum = 100, minimum = 0).

A comparison between the first and second test phase shows that incremental improvements to the tutorial led to heat sources being found more easily (M=2.2 in the second test phase). Solely the input of the additional information should still be improved. Game enjoyment was rated as high (M=1.83 in the second test phase).

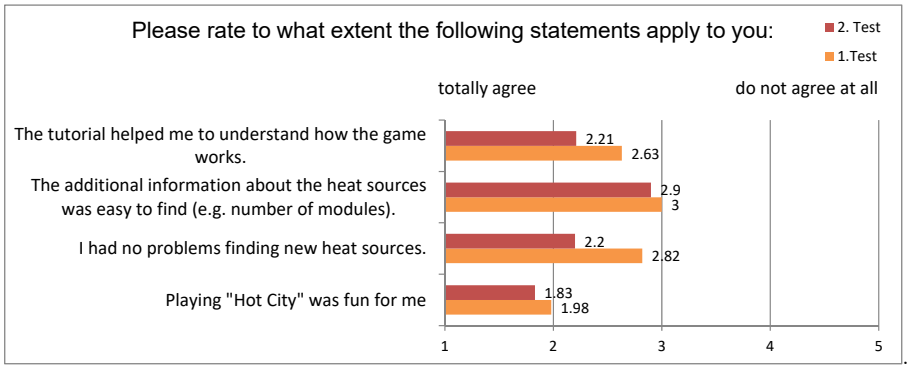

Fig. 3 The game rated by the test players

Going for a walk was named as the most successful or popular game strategy (27%) because of the positive health effects, followed by the targeted search for heat sources in industrial districts (20%) and searching in advance on Google satellite maps (16%).

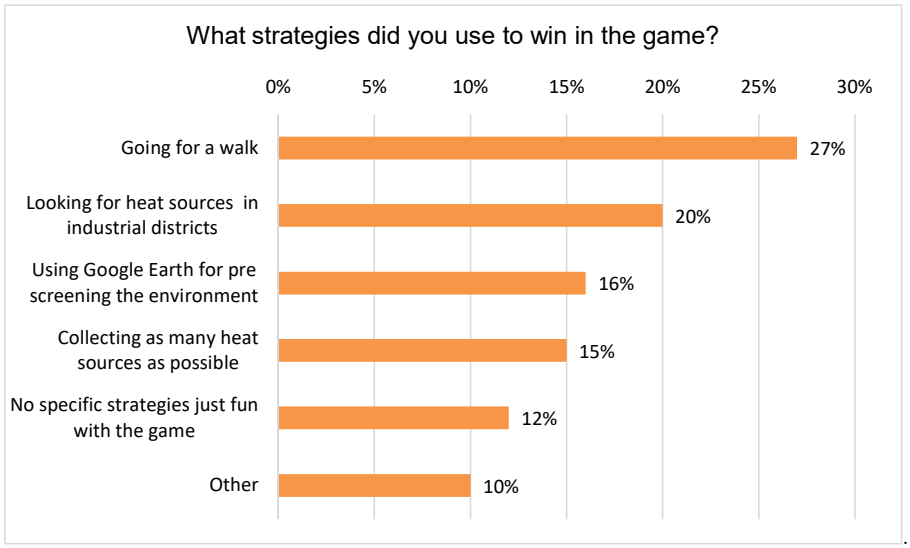

Fig. 4 Winning strategies of the test group

4.2 Lessons learned

The results of the field test show high values for the acceptance of the app. The fun of play and the level of difficulty were also rated as appropriate. The standardised SUS score is in the upper fifth, a high subjective usability is thus evident.

The core functionality of the app - the search for heat sources, which was designed and integrated in accordance with the project goals - is seen as motivating by the users; compared to other game features, the entertainment value is particularly high.

With regard to the qualitative aspects, the design of the app, the game idea and the ease of use were praised by the test persons.

Problems were encountered with regard to GPS positioning, which sometimes did not work immediately and had to be corrected manually (A technical problem here is that automatic GPS positioning reduces the duration of one battery load, thus a compromise has to be chosen, or using manual GPS positioning, which reduces the usability). In addition, as the first phase of the field test in particular showed, it was sometimes difficult for the users to find suitable heat sources, and chimneys from private households were often photographed. Through clearer communication and tutorials, this problem was alleviated in the second test phase.

Suggestions for improvement mainly refer to an improved tutorial (phase I) and an automated location on the map and of the heat sources.

5 Conclusion and Outlook

Gamification can be a promising way to identify urban energy data such as waste heat. The reward system could be secured in a transparent way using the energy-efficient proof of stake blockchain Ardor. The HotCity-App has been sucessfully developed and tested in two Austrian cities. The two test phases have shown that the app seems to be very promising from a user point of view as the usability score shows. The lessons learned from the two test phases demonstrate that a good briefing (tutorial material) is important to gain useful results within the respective context. Compared to the already existing waste heat data for Vienna and Graz new promising waste heat proposals could be found, which have not been in the data sets so far and for some existing data sets an increased accuracy of the GPS position could be established thanks to the crowdsourcing approach. Interestingly even with the relatively low amout of testers a significant number of valid waste heat proposals could be found. However the tests also helped us to identify potential obstacles especially regarding details attached to heat spot entries which can be used for estimating the amount of waste heat for each waste heat proposal. The results indicate that these are hard to collect with the current app, thus more advanced users (experts) or higher incentives are needed to collect this information. The developed interactive evaluation tool (web-application)

seems to be a very good starting point for experts (not necessarily players) in order to filter the most promising waste heat proposals and to estimate their actual potential.

5.1 Recommendations regarding gamified apps for serious application scenarios

Based on the feedback obtained during testing we suggest that similar approaches take into account the following recommendations:

- Provide an optional tutorial video and a half-hour webinar to introduce and explain the app. As user segmentation in the future could include regular users, experts as well as community experts. Such a webinar is an efficient method for onboarding and providing the necessary skills to assess heat sources according to their potential.
- Simplify the registration process by publishing it in the app stores. The current process requires several steps, which cause a time delay for users and thus make "seamless onboarding" difficult. In addition, the release had to be done manually due to restrictive settings on company devices. A release in the app store would prevent such problems.
- Integration of a button to update one's GPS position within the app. This function facilitates correct positioning, and a "double-select" interaction for uploading photos should be introduced so that users can enter or readjust their GPS position correctly.
- Switching the map view to a satellite view. This makes it easier to recognise heat sources, and it is also possible to estimate the height of objects/heat sources using Google Earth 3D, for example.
- Integration of notifications for finding heat sources and invitations to groups. This also regularly encourages users to use the app, but a good balance must be struck so as not to exert a disruptive influence.
- The token logic should be adapted so that the confirmation of heat sources is only possible between different groups/crews. The "report" function for uploaded heat sources should be reframed to create a positive connotation and thus encourage use by users.

5.2 Recommendations regarding the use of blockchain technology in gamified frameworks

With regard to the blockchain, we suggest that future or similar approaches fulfill the following basic requirements:

- It must be a fully decentralised public blockchain.
- Users can, if they want, run a node of the blockchain on one of their devices, such as a laptop or mobile phone.

- We can use approval models to ensure that various conditions are met. One of these conditions is that the tokens cannot be transferred to other unregistered wallets.
- Identity management can potentially be implemented. In our case, this would be a possible connection of decentralized identifiers (DIDs).
- Users do not need cryptocurrencies to pay network fees, we can take care of this as an operator with bundling accounts.
- Individual transactions must be manageable in terms of costs, even if the crypto market fluctuates massively.
- Messages attached to transactions must be encryptable.
- However, it must be possible to generate shared keys. To make the information readable for authorised parties.
- It needs the possibility to programme lightweight smart contracts, in our case it is the exchange of the different token classes as part of the game mechanics.

References

1. Al-Yafi, K., El-Masri, M.: Gamification of e-Government Services: A Discussion of Potential Transformation. AMCIS 2016 Proceedings (2016). URL https://aisel.aisnet.org/amcis2016/eGov/Presentations/8
2. Barata, G., Gama, S., Jorge, J., Gonçalves, D.: Improving participation and learning with gamification. In: Proceedings of the First International Conference on Gameful Design, Research, and Applications, Gamification '13, pp. 10–17. Association for Computing Machinery, New York, NY, USA (2013). DOI 10.1145/2583008.2583010. URL https://doi.org/10.1145/2583008.2583010
3. Brueckner, S., Miró, L., Cabeza, L.F., Pehnt, M., Laevemann, E.: Methods to estimate the industrial waste heat potential of regions – A categorization and literature review. Renewable and Sustainable Energy Reviews **38**, 164–171 (2014). DOI 10.1016/j.rser.2014.04.078. URL https://www.sciencedirect.com/science/article/pii/S1364032114003165
4. Buhl, H., Urbach, N., Schweizer, A.: Blockchain-Technologie als Schlüssel für die Zukunft? Zeitschrift für das gesamte Kreditwesen **70**(Nr.12), 596 (2017)
5. Clement, J.: Leading gaming markets worldwide in 2020, by gaming revenue. Tech. rep., Statista (2021). URL https://www.statista.com/statistics/308454/gaming-revenue-countries/
6. Coronado Escobar, J.E., Vasquez Urriago, A.R.: Gamification: an effective mechanism to promote civic engagement and generate trust? In: Proceedings of the 8th International Conference on Theory and Practice of Electronic Governance, ICEGOV '14, pp. 514–515. Association for Computing Machinery, New York, NY, USA (2014). DOI 10.1145/2691195.2691307. URL https://doi.org/10.1145/2691195.2691307
7. Deterding, S., Dixon, D., Khaled, R., Nacke, L.: From game design elements to gamefulness: defining "gamification". In: Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek '11, pp. 9–15. Association for Computing Machinery, New York, NY, USA (2011). DOI 10.1145/2181037.2181040. URL https://doi.org/10.1145/2181037.2181040
8. Goodkind, A.L., Jones, B.A., Berrens, R.P.: Cryptodamages: Monetary value estimates of the air pollution and human health impacts of cryptocurrency mining. Energy Research & Social Science **59**, 101281 (2020). DOI 10/gf82hj. URL http://www.sciencedirect.com/science/article/pii/S2214629619302701. 00000
9. Hopf, S., Picot, A.: Revolutioniert Blockchain-Technologie das Management von Eigentumsrechten und Transaktionskosten? In: Interdisziplinäre Perspektiven zur Zukunft

der Wertschöpfung, pp. 109–119. Springer Fachmedien, Wiesbaden (2018). DOI 10.1007/978-3-658-20265-1_9. URL https://doi.org/10.1007/978-3-658-20265-1_9
10. Hunicke, R., LeBlanc, M., Zubek, R.: MDA: A Formal Approach to Game Design and Game Research. Proceedings of the AAAI Workshop on Challenges in Game AI **4**(1), 1722 (2004)
11. Ivory, J.D., Kalyanaraman, S.: The effects of technological advancement and violent content in video games on players' feelings of presence, involvement, physiological arousal, and aggression. Journal of Communication **57**(3), 532–555 (2007). DOI 10.1111/j.1460-2466.2007.00356.x. Place: United Kingdom Publisher: Blackwell Publishing
12. Jansz, J.: The Emotional Appeal of Violent Video Games for Adolescent Males. Communication Theory **15**(3), 219–241 (2005). DOI 10.1111/j.1468-2885.2005.tb00334.x. URL https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1468-2885.2005.tb00334.x. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1468-2885.2005.tb00334.x
13. Kazhamiakin, R., Marconi, A., Perillo, M., Pistore, M., Valetto, G., Piras, L., Avesani, F., Perri, N.: Using gamification to incentivize sustainable urban mobility. In: Proceedings of 1st Institute of Electrical and Electronics Engineers (IEEE) International smart cities conference 2015 (ISC2-2015). Guadalajara, Mexico (2015). DOI 10.1109/isc2.2015.7366196. URL https://rgu-repository.worktribe.com/output/1239044/using-gamification-to-incentivize-sustainable-urban-mobility. Publisher: Institute of Electrical and Electronics Engineers
14. Pfeiffer, A., Bezzina, S., Koenig, N., Kriglstein, S.: Beyond Classical Gamification: In- and Around-Game Gamification for Education. In: 19th European Conference on e-Learning (ECEL), pp. 18–30. Berlin (2020)
15. Pfeiffer, A., Kriglstein, S., Wernbacher, T.: Blockchain Technologies and Games: A Proper Match? In: International Conference on the Foundations of Digital Games, 71, pp. 1–4. Association for Computing Machinery, New York, NY, USA (2020). URL https://doi.org/10.1145/3402942.3402996
16. Schmidt, R.R., Geyer, R., Lucas, P.: Discussion Paper. The barriers to waste heat recovery and how to overcome them? Tech. rep., Austrian Institute of Technology (2020). URL https://www.euroheat.org/wp-content/uploads/2020/06/Discussion.pdf
17. Thiel, S.K., Lehner, U.: Exploring the effects of game elements in m-participation. In: Proceedings of the 2015 British HCI Conference, British HCI '15, pp. 65–73. Association for Computing Machinery, New York, NY, USA (2015). DOI 10.1145/2783446.2783587. URL https://doi.org/10.1145/2783446.2783587
18. Vorderer, P., Klimmt, C., Ritterfeld, U.: Enjoyment: At the heart of media entertainment. Communication Theory **14**(4), 388–408 (2004). DOI 10.1111/j.1468-2885.2004.tb00321.x. Place: United Kingdom Publisher: Blackwell Publishing
19. Yee, N.: Motivations for Play in Online Games. CyberPsychology & Behavior **9**(6), 772–775 (2006). DOI 10.1089/cpb.2006.9.772. URL https://www.liebertpub.com/doi/10.1089/cpb.2006.9.772. Publisher: Mary Ann Liebert, Inc., publishers
20. ÖVUS: 5,3 Millionen Österreicher spielen Videospiele. Tech. rep., Wien (2019). URL https://www.ovus.at/news/ueber-fuenf-millionen-oesterreicher-spielen-videospiele/