En-join: Speculative LLM Play for Energy Community Engagement and Sustainability Awareness

Luiz Sachser
luiz.sachser@gmail.com
ITI/LARSyS - Interactive Technologies Institute
Lisbon, Portugal
University of Madeira
Funchal, Portugal

Andrés Isaza-Giraldo
isazag@gmail.com
ITI/LARSyS - Interactive Technologies Institute
Lisbon, Portugal

Anna Jiskrová
annajiskrova0@gmail.com
University Jana Evangelista Purkyne
Ústí nad Labem, Czech republic
ITI/LARSyS - Interactive Technologies Institute
Lisbon, Portugal

Vanessa Cesário
vanessa.cesario@staff.uma.pt
ITI/LARSyS - Interactive Technologies Institute
Funchal, Portugal
University of Madeira
Funchal, Portugal

Pedro F. Campos
pedro.campos@iti.larsys.pt
Wow!Systems
Funchal, Portugal
ITI/LARSyS - Interactive Technologies Institute
Funchal, Portugal

Lucas Pereira
lucas.pereira@iti.larsys.pt
ITI/LARSyS - Interactive Technologies Institute
Lisbon, Portugal
Instituto Superior Técnico
Lisbon, Portugal

Paulo Bala
paulo.bala@tecnico.ulisboa.pt
ITI/LARSyS - Interactive Technologies Institute
Lisbon, Portugal
ARDITI - Regional Agency for the Development of Research, Technology and Innovation
Funchal, Portugal

Abstract

Energy Communities (ECs) are confronted by diverse and intricate challenges concerning sustainability development goals and climate change awareness. This demonstration introduces En-join, a speculative game that addresses these complexities by using Large Language Models (LLMs) to engage players in negotiating solutions for such challenges. En-join demonstrates a novel approach by integrating an LLM as a dual-agent, serving simultaneously as a narrative guide and evaluator, to simulate EC dynamics. Players interact with LLM-powered Non-Player Characters (NPCs) to navigate open-ended scenarios, promoting reflection on sustainability and community participatory decisions on their own resources, alongside pro-social behaviors. This work highlights the potential of LLMs as mediators in serious games, fostering engagement and critical thinking on sustainable energy practices.

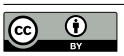
CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**.

Keywords

Large Language Models (LLM), Energy Communities, Environmental Games, Serious Games

ACM Reference Format:
Luiz Sachser, Andrés Isaza-Giraldo, Anna Jiskrová, Vanessa Cesário, Pedro F. Campos, Lucas Pereira, and Paulo Bala. 2025. En-join: Speculative LLM Play for Energy Community Engagement and Sustainability Awareness. In *Designing Interactive Systems Conference (DIS '25 Companion), July 5–9, 2025, Funchal, Portugal*. ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3715668.3735600



DIS '25 Companion, Funchal, Portugal

ACM ISBN 979-8-4007-1486-3/2025/07
https://doi.org/10.1145/3715668.3735600

1 Introduction

Climate change is one of the most pressing challenges that global society is facing [15], forcing governments to take immediate action. In recent years, the production of renewable resources has increased substantially, accounting for over 45% of all energy sources in the European Union [6]. Despite positive growth, more efforts are needed to completely decarbonize Europe's energy consumption, specifically those that involve citizen participation, as stated in EU Directive 2019/944 on common rules for the internal market for

electricity [24]. However, citizens often lack the choice, financial resources, and agency to decide how their energy is produced.

The concept of Energy Communities (EC) emerged as a way of involving citizens to actively produce and share renewable resources [26], often in decentralized local communities. Currently, there is no consensus on what exactly ECs should be and how they should operate. For example, what does it mean to have active participation, how does it work with varying sizes of communities, and how do we balance relationships among community members [1]?

While serious games might be an effective communication tool for leveraging knowledge and fostering behavioral change to take environmental action [2], we are interested in using serious games to speculate on issues related to EC as a concept. Adding to the body of work exploring games as interactive experiments on sharing resources [18], we developed *En-join*, a game in which players solve open-ended challenges by negotiating with characters in a growing EC. Solving EC challenges is done through interaction with a Large Language Model (LLM), increasing the possibility of choice, reflection, and exposition [11, 17].

The game uses speculation to foster critical thinking, as players are asked to create solutions that are not clear-cut. Furthermore, the game employs speculation by exposing players to an EC scenario, story, and characters inspired by real-world dynamics. As such, players must navigate several stages of community growth, thus experiencing EC of different sizes (household, neighborhood, and regional) with inherent types of challenges.

Overall, the game as a demonstration intends to show how important individual action and pro-social attitudes are while also inviting players to speculate on the future of EC inside a fun narrative about renewable energy production.

The game, as an artifact, is of interest to researchers seeking to engage audiences in sustainability practices.

2 Related Work

ECs are speculative due to competing visions for sustainable energy transitions [9]. Defined as decentralized civic energy collectives with diverse structures [1, 26], their inherent ambiguity stems from balancing environmental, economic, and social objectives, positioning them between utopian ideals and implementation realities. Given the inherent complexity of EC design, integrating human and digital technologies presents specific challenges for shared energy management. Platforms for civic participation must balance individual and collective needs, avoiding competitive designs [13].

To foster transparency and inclusion, recognizing the diverse contexts, cultural norms, economic constraints, and spatial realities of ECs is key to effective energy-sharing practices [5]. Sustained civic involvement requires viewing ECs as dynamic social contracts, not static technical solutions, given the need for fair benefits, accountability, and diverse member needs in community ownership [18]. This underscores their potential to reimagine energy systems as participatory sociopolitical processes where digital tools mediate, rather than dictate, collective action.

Speculative game design can explore complex issues, such as human-machine teaming (asymmetric cooperative games) [10] and alternative futures/global challenges [4]. This is achieved either by having players experience complex topics that are not present in their daily lives or by having game developers create stories and gameplay that are future-thinking and/or introspective. For example, games can enable personal and social reflection, such as gender identity exploration in game jams [7]. An important characteristic of speculative games is the open-ended nature of their challenges [16] to allow player's interpretation and critical thinking.

LLMs as play elements can be used as a conduit for open-ended challenges. Using LLMs as game elements is evident in examples like *Closer Worlds*, where GPT-4 enables intimate conversation and world-building via context-aware questions [14]. Similarly, *Hacc-Man* challenges players to "jailbreak" the LLM, revealing security flaws [25]. LLMs can effectively evaluate, aligning with human judgment [27], and are aware of sustainability concerns (for example, being used for sustainability visual novels [8]). NPCs [21, 22] show role-playing promise (80% personality accuracy) [19, 20, 23, 28–30].

Our previous work [12] suggests character behavior influences evaluation, allowing LLMs to both roleplay as characters and evaluate according to their views.

3 *En-join: We are all in grid together*

Motivated by the potential of games to engage the public with complex issues like ECs and by aligning this with the use of LLMs as characters and evaluators, we sought to understand how speculative games can simulate EC scenarios and if exposure to these games can alter players' attitudes and beliefs towards energy sharing.

Using research through design approach [31], we iteratively developed an artifact for future studies with participants. This artifact invites the player into the imagination and construction of a shared energy environment. The game *En-join*[1] is designed to represent energy communities on different scales (household, neighborhood, and regional), offering an idea of how different challenges have to be faced by different types of communities and diverse members. By playing the game, players can learn more about negotiating with community members, making concessions to ensure the environmental development of the community, and various topics related to energy production, including solar power utilization, carbon footprint, and energy efficiency.

3.1 Technical Setup

Fig. 1 illustrates the En-join gameplay cycle, where story exposition is interleaved with the core loop (interaction with an LLM character to solve a challenge). En-join was developed using the Unity game engine and it uses the Llama 3.1:8b language model[2], optimized for local deployment to ensure low-latency interactions through the Ollama tool[3].

The Llama model processes conversational logic through structured prompts that enforce dual NPC roles: narrative guides and solution evaluators. This dual-agent design reflects [3] frameworks for simulating socio-technical systems, where characters must balance technical problem-solving with community dynamics. The

[1] Interaction demo video: https://vimeo.com/isaza/enjoin
[2] https://github.com/meta-llama/llama3
[3] https://ollama.com/

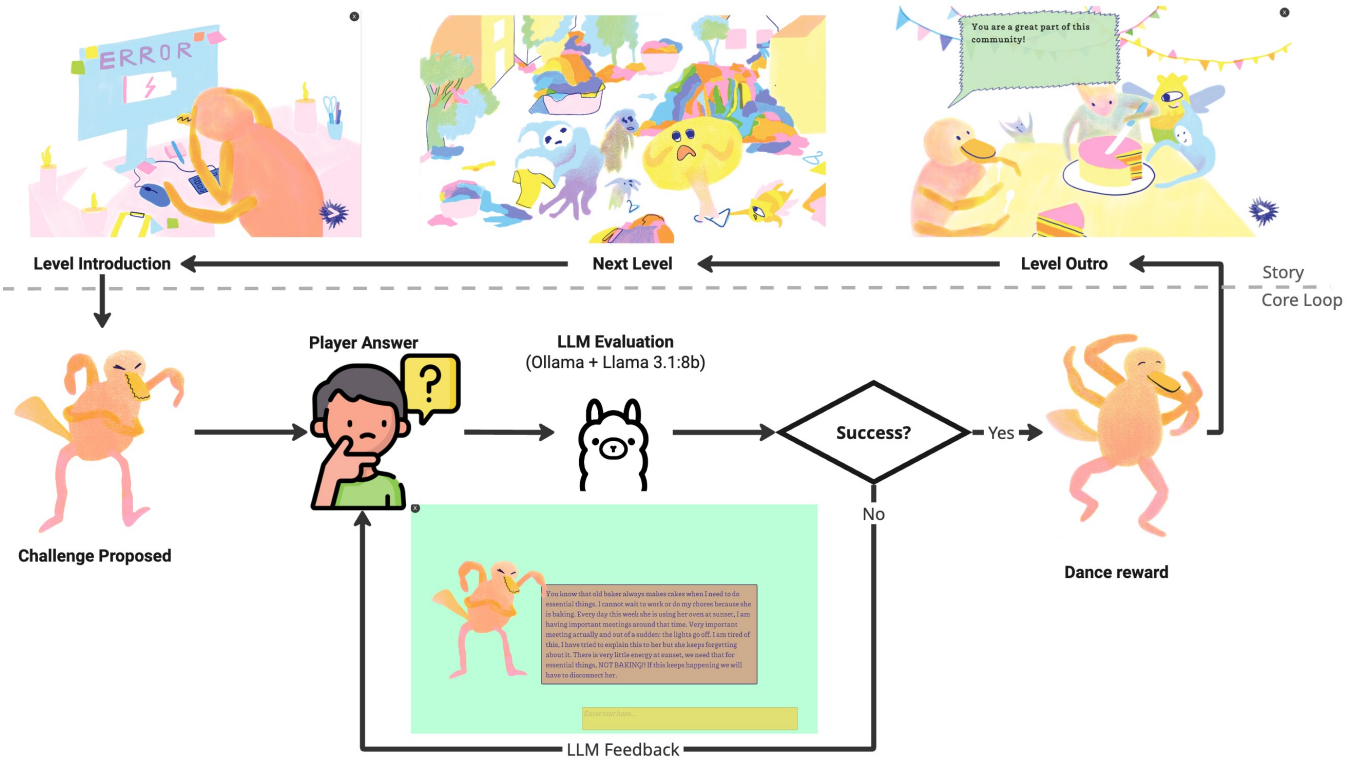


Figure 1: Gameplay in En-join, cycling through story exposition and core loops (interacting with an LLM to solve an EC challenge)

workflow progresses through cyclical phases: challenge presentation, player input, LLM evaluation, and adaptive feedback, reinforced by Unity's animation system for success/failure states. LLM prompt structures and examples can be consulted in Isaza-Giraldo et al [12].

The system integrates anonymized analytics features to capture interaction patterns, including time spent per level, chat transcripts between players and NPCs, and success rates. Upon launch, players generate a unique ID through an on-boarding interface. Data is stored locally in structured formats (metadata and JSON for dialogue logs) to support future analysis of speculative solutions.

3.2 Narrative Structure & Gameplay

The game's tiered structure (see fig. 2) introduces escalating complexity in the gameplay: (1) household challenges focus on individual behaviors; (2) the neighborhood stage emphasizes collective coordination within a group; and (3) regional-scale problems address systemic energy policies. Each tier utilizes distinct evaluation parameters aligned with energy community simulations, where NPCs assess solutions against technical viability and social equity metrics.

Players can choose to play one of the stages, each composed of three levels, or play all nine levels. After a brief tutorial, the challenge for the level is introduced (see Fig. 1) through visual story exposition and textual challenge presented by the character.

The player interacts with the character through a chat interface composed of sent and received messages and input fields. Based on the player's response, the LLM evaluates its adequacy to the specific challenge and provides feedback. An arrow button to advance to the next level appears if the player's answer is evaluated as successful; after three unsuccessful answers, the player can still advance to the next level.

Characters have different personalities depending on their role, and personality can affect how answers are evaluated (e.g., if the character is greedy, they might decline solutions that offer no benefit for them) [12]. Fig. 2 represents the tier structure, with the characters and their assigned challenges.

4 Summary

En-join uses LLM-powered NPCs to engage players in negotiating solutions for EC challenges. Its speculative design explores EC complexities and promotes reflection on sustainability and climate change awareness, alongside pro-social behaviors.

The game demonstrates a novel approach by integrating an LLM as a dual-agent (narrative guide and evaluator) within a serious game context. Future evaluation with players is planned to answer the research question of how speculative play can alter attitudes toward energy sharing in a community.

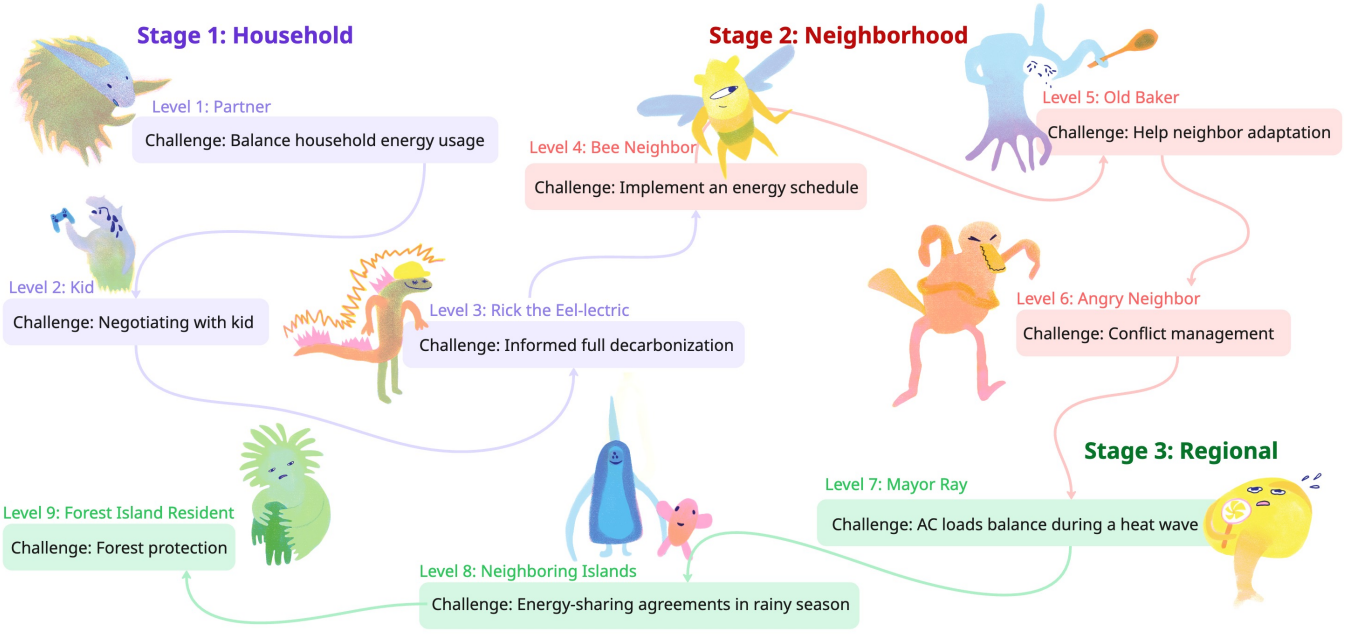


Figure 2: Narrative structure showing characters and challenges. Tier structure is color coded (in purple, red, and green).

Acknowledgments

This research was funded by the Portuguese Recovery and Resilience Program (PRR), IAPMEI/ANI/FCT under Agenda no.26, C645022399-00000057 (eGamesLab). The authors would also like to acknowledge the Portuguese Foundation for Science and Technology, for projects 10.54499/LA/P/0083/2020; 10.54499/UIDP/50009/2020 & 10.54499/UIDB/50009/2020. LP acknowledges FCT for the project CEECIND/01179/2017. PB acknowledges a work-program contract between the Autonomous Region of Madeira and ARDITI.

References

[1] J. Blasch, N. M. van der Grijp, D. Petrovics, J. Palm, N. Bocken, S. J. Darby, J. Barnes, P. Hansen, T. Kamin, U. Golob, M. Andor, S. Sommer, A. Nicita, M. Musolino, and M. Mlinarič. 2021. New Clean Energy Communities in Polycentric Settings: Four Avenues for Future Research. *Energy Research & Social Science* 82 (Dec. 2021), 102276. doi:10.1016/j.erss.2021.102276

[2] Ștefan Boncu, Octav-Sorin Candel, and Nicoleta Laura Popa. 2022. Gameful Green: A Systematic Review on the Use of Serious Computer Games and Gamified Mobile Apps to Foster Pro-Environmental Information, Attitudes and Behaviors. 14, 16 (2022), 10400. doi:10.3390/su141610400

[3] Nathan A. Brooks, Simon T. Powers, and James M. Borg. 2020. A Mechanism to Promote Social Behaviour in Household Load Balancing. In *ALIFE 2020: The 2020 Conference on Artificial Life*. MIT Press, 95–103. doi:10.1162/isal_a_00290

[4] Paul Coulton, Daniel Burnett, and Adrian Gradinar. 2016. Games as Speculative Design: Allowing Players to Consider Alternate Presents and Plausible Futures. In *Future Focused Thinking – DRS International Conference 2016*, Peter Lloyd and Erik Bohemia (Eds.). Design Research Society, Brighton, United Kingdom, 15. doi:10.21606/drs.2016.15

[5] Geraint Ellis, Nina Schneider, and Rolf Wüstenhagen. 2023. Dynamics of social acceptance of renewable energy: An introduction to the concept. *Energy Policy* 181 (2023), 113706. doi:10.1016/j.enpol.2023.113706

[6] Eurostat. 2025. Electricity from renewable sources reaches 47% in 2024. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250319-1 Eurostat Newsrelease.

[7] Leya George, Aneesha Singh, Nadia Berthouze, Lorna Hobbs, and Jo Gibbs. 2023. Jamming-as-exploration: Creating and Playing Games to Explore Gender Identity. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 208, 19 pages. doi:10.1145/3544548.3580646

[8] Mustafa Can Gursesli, Pittawat Taveekitworachai, Febri Abdullah, Mury F. Dewantoro, Antonio Lanata, Andrea Guazzini, Van Khôi Lê, Adrien Villars, and Ruck Thawonmas. 2023. The Chronicles of ChatGPT: Generating and Evaluating Visual Novel Narratives on Climate Change Through ChatGPT. In *Interactive Storytelling*, Lissa Holloway-Attaway and John T. Murray (Eds.). Vol. 14384. Springer Nature Switzerland, 181–194. doi:10.1007/978-3-031-47658-7_16 Series Title: Lecture Notes in Computer Science.

[9] Erik Harpstead, Kimberly Stowers, Lane Lawley, Qiao Zhang, and Christopher Maclellan. 2023. Speculative Game Design of Asymmetric Cooperative Games to Study Human-Machine Teaming. In *Proceedings of the 18th International Conference on the Foundations of Digital Games* (Lisbon, Portugal) *(FDG '23)*. Association for Computing Machinery, New York, NY, USA, Article 77, 4 pages. doi:10.1145/3582437.3587200

[10] Erik Harpstead, Kimberly Stowers, Lane Lawley, Qiao Zhang, and Christopher Maclellan. 2023. Speculative Game Design of Asymmetric Cooperative Games to Study Human-Machine Teaming. In *Proceedings of the 18th International Conference on the Foundations of Digital Games* (Lisbon, Portugal) *(FDG '23)*. Association for Computing Machinery, New York, NY, USA, Article 77, 4 pages. doi:10.1145/3582437.3587200

[11] Andrés Isaza-Giraldo, Paulo Bala, Pedro F. Campos, and Lucas Pereira. 2024. Prompt-Gaming: A Pilot Study on LLM-Evaluating Agent in a Meaningful Energy Game. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–12. doi:10.1145/3613905.3650774

[12] Andrés Isaza-Giraldo, Paulo Bala, Anna Jiskrová, Luiz Sachser, Pedro F. Campos, and Lucas Pereira. 2025. Meta-evaluating the Effects of Social Preferences on NPC-evaluators in an Energy Community Game. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25), April 26-May 1, 2025, Yokohama, Japan*. ACM, New York, NY, USA, 1–13. doi:10.1145/3706599.3720218

[13] Victor Vadmand Jensen, Kristina Laursen, Rikke Hagensby Jensen, and Rachel Charlotte Smith. 2024. Imagining Sustainable Energy Communities: Design Narratives of Future Digital Technologies, Sites, and Participation. In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (Honolulu HI USA, 2024-05-11). ACM, 1–17. doi:10.1145/3613904.3642609

[14] Cassandra Lee and Jessica R Mindel. 2024. Closer and Closer Worlds: Using LLMs to Surface Personal Stories in World-building Conversation Games. In *Companion Publication of the 2024 ACM Designing Interactive Systems Conference* (IT University of Copenhagen, Denmark) *(DIS '24 Companion)*. Association for Computing Machinery, New York, NY, USA, 289–293. doi:10.1145/3656156.3665430

[15] Valérie Masson-Delmotte, Hans-Otto Pörtner, Jim Skea, Panmao Zhai, Debra Roberts, and Priyadarshi R. Shukla. 2019. Global warming of 1.5°C. (2019), xiii,

616 p. :. http://digitallibrary.un.org/record/3893415

[16] Julieta Matos Castano, Estefanía Morás Jiménez, Corelia Baibarac-Duignan, Anouk Jacoba Petronella Geenen, and Robert-Jan den Haan. 2023. Harnessing the potential of simulation and speculative games for transdisciplinary collaboration: lessons from experience. In *Simulation and Gaming for Social and Environmental Transitions* (54 ed.), Nicolas Becu (Ed.). La Rochelle University, 602–605. https://shs.hal.science/halshs-04209935

[17] Scott Nicholson. 2015. A RECIPE for Meaningful Gamification. In *Gamification in Education and Business*, Torsten Reiners and Lincoln C. Wood (Eds.). Springer International Publishing, 1–20. doi:10.1007/978-3-319-10208-5_1

[18] Mikko Nykyri, Tommi J. Karkkainen, Salla Annala, and Pertti Silventoinen. 2022. Review of Demand Response and Energy Communities in Serious Games. *IEEE Access* 10 (2022), 91018–91026. doi:10.1109/ACCESS.2022.3202013

[19] Kayla Schroeder and Zach Wood-Doughty. 2024. Can You Trust LLM Judgments? Reliability of LLM-as-a-Judge. doi:10.48550/arXiv.2412.12509

[20] Murray Shanahan, Kyle McDonell, and Laria Reynolds. 2023. Role play with large language models. *Nature* 623, 7987 (Nov. 2023), 493–498. doi:10.1038/s41586-023-06647-8

[21] John Sissler. 2024. Enhancing Non-Player Characters in Unity 3D using GPT-3.5. *Games: Research and Practice* 2, 3 (Sept. 2024), 1–16. doi:10.1145/3662003

[22] Penny Sweetser. 2024. Large Language Models and Video Games: A Preliminary Scoping Review. In *ACM Conversational User Interfaces 2024*. ACM, Luxembourg Luxembourg, 1–8. doi:10.1145/3640794.3665582

[23] Yu-Min Tseng, Yu-Chao Huang, Teng-Yun Hsiao, Wei-Lin Chen, Chao-Wei Huang, Yu Meng, and Yun-Nung Chen. 2024. Two Tales of Persona in LLMs: A Survey of Role-Playing and Personalization. http://arxiv.org/abs/2406.01171

[24] European Union. 2022. Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on Common Rules for the Internal Market for Electricity and Amending Directive 2012/27/EU (Recast). http://data.europa.eu/eli/dir/2019/944/2022-06-23/eng

[25] Matheus Valentim, Jeanette Falk, and Nanna Inie. 2024. Hacc-Man: An Arcade Game for Jailbreaking LLMs. In *Companion Publication of the 2024 ACM Designing Interactive Systems Conference* (IT University of Copenhagen, Denmark) *(DIS '24 Companion)*. Association for Computing Machinery, New York, NY, USA, 338–341. doi:10.1145/3656156.3665432

[26] Gordon Walker and Patrick Devine-Wright. 2008. Community renewable energy: What should it mean? 36, 2 (2008), 497–500. doi:10.1016/j.enpol.2007.10.019

[27] Lei Wang, Chen Ma, Xueyang Feng, Zeyu Zhang, Hao Yang, Jingsen Zhang, Zhiyuan Chen, Jiakai Tang, Xu Chen, Yankai Lin, Wayne Xin Zhao, Zhewei Wei, and Jirong Wen. 2024. A survey on large language model based autonomous agents. *Frontiers of Computer Science* 18, 6 (2024), 186345. doi:10.1007/s11704-024-40231-1

[28] Xintao Wang, Yunze Xiao, Jen-tse Huang, Siyu Yuan, Rui Xu, Haoran Guo, Quan Tu, Yaying Fei, Ziang Leng, Wei Wang, Jiangjie Chen, Cheng Li, and Yanghua Xiao. 2024. InCharacter: Evaluating Personality Fidelity in Role-Playing Agents through Psychological Interviews. http://arxiv.org/abs/2310.17976

[29] Rui Xu, Xintao Wang, Jiangjie Chen, Siyu Yuan, Xinfeng Yuan, Jiaqing Liang, Zulong Chen, Xiaoqing Dong, and Yanghua Xiao. 2024. Character is Destiny: Can Large Language Models Simulate Persona-Driven Decisions in Role-Playing? http://arxiv.org/abs/2404.12138

[30] Daijin Yang, Erica Kleinman, and Casper Harteveld. 2024. GPT for Games: An Updated Scoping Review (2020-2024). https://arxiv.org/abs/2411.00308

[31] John Zimmerman and Jodi Forlizzi. 2014. Research through design in HCI. In *Ways of Knowing in HCI*. Springer, 167–189.