Invasion of the Energy Monsters:
A Spooky Game About Saving Energy

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Abstract: We present a cooperative tabletop game called *Invasion of the Energy Monsters* designed to encourage entire families to reflect on how to use energy at home and to think about implications for global environmental sustainability. After briefly reviewing related work, we outline our design principles, describe our game, and share preliminary findings from playtesting sessions with families in their homes.

Introduction

Confronting issues of global climate change will require creative approaches to energy production and consumption across a range of human activities. One pressing area of concern is residential energy consumption, which, in the United States, accounts for over 20% of the country's overall energy expenditure (US EIA, 2015). Reports from the US Energy Information Administration suggest a range of simple actions that families can take to reduce their impact on the environment. Yet research on environmental education and eco-feedback technology has repeatedly demonstrated that consumers lack a basic awareness of the magnitude of their own consumption, the basic units of energy (such as kilowatt hours), the relative impact of different appliances, and the cost of energy in their city or region (IBM, 2011; Chetty, Tran, & Grinter, 2008; Kuo & Horn, 2014).

To help address these issues, Green Home Games is a research and design initiative with the goal of creating playful learning experiences to help families think about how they use energy and how they can reduce waste. Our prior games have focused on heating and cooling systems (Horn et. al, 2014) and hidden forms of energy consumption (Banerjee & Horn, 2013). In this paper we present a tabletop board game called *Invasion of the Energy Monsters* that deals with household electricity consumption.

The premise of the game is that your home is being invaded by a menagerie of menacing energy monsters, each representing a different form of waste. The monsters start out weak but quickly grow stronger as they feast on your excess energy use. You, the energy heroes, must band together and expel the monsters before it's too late. Below we review related work, describe a set of design principles, and provide an overview of the game. We then share preliminary findings from playtesting sessions with 5 families in their homes along with reflections on directions for future work.

Related Work

Our game builds upon the following areas of previous research: (1) eco-feedback technology for homes and (2) playing to encourage pro-environmental behavior.

Eco-feedback technology for homes

Prior work has argued that environmental sustainability is not a global standard, but something that must be defined by families and communities for themselves and on their own terms and in light of their unique circumstances (Fitzpatrick & Smith, 2008). However, in the case of electricity consumption, household energy use remains largely invisible and intangible (Chetty, Tran, & Grinter, 2008). Energy bills at the end of the month do little to shed light on this situation and they don't provide appliance-level consumption data. Thus, one important goal of eco-feedback technology is to help make consumption more visible in terms of scale and impact (Chetty et al., 2008). Over the past decade, the human-computer interaction community has created many innovative designs that visualize resource consumption on a personal level (e.g., Kuznetsov & Paulos, 2010; Gustafsson & Gyllensward, 2005; Laschke et al., 2005; Froelich, 2012).

Playing to encourage pro-environmental behavior.

The research community has long explored games as a means of fostering engagement with environmental issues. For example, Trails Forward (Bell-Gawne et al., 2011) is a multi-player simulation game that provides an approach to help understand human behavior in relation to local environments. Similarly, Greenify (Lee et al., 2012) is a Real-World Action Game (RWAG) designed to teach adult learners about climate change and motivate informed action. While the example listed earlier are mostly adult oriented, researchers have also investigated gameplay that caters to teenagers and younger children. Cumbo et al. presented foundation work (Cumbo et al., 2014) that helps us understand what motivates children to interact with nature, and a discussion of how technology based play may enhance this interaction. With Youtopia, Antle et. al (Antle et al., 2014) presented a tabletop learning game that allowed children to share their values around sustainable development during game play. Horn et al. presented Turn Up the Heat (Horn et al., 2014), a cooperative board game that encourages families to reflect on the use of residential thermostats and tradeoffs related to money, comfort, and sustainability.

In line with the research cited above, Invasion of the Energy Monsters uses gameplay to improve the visibility of energy consumption. The game attempts to do so by building upon the social dynamics of households while giving players the opportunity to get a realistic look at appliance-level consumption.

Design Principles

Our game design was guided by four overarching principles that helped us set priorities and evaluate the relative success of individual iterations.

Principle 1: Designing to engage entire families in intergenerational learning

In our work we emphasize the interplay between children, adolescents, and parents. Young people represent the next generation of adults who will face increasingly complex challenges related to energy consumption and the environment. However, prior research suggests that kids are often excluded from consequential household energy decisions (Horn et al., 2015). Kids are often passionate about the environment and can play an important role in influencing a family's eco-friendly behavior (Larsson et al., 2010). More than that, we agree with researchers such as Ballantyne (Ballantyne et al., 1998) and Darby (Darby, 2006) who make the case that we should not treat children as one-way recipients of environmental knowledge. Rather, kids are active participants in helping families and communities co-construct knowledge about what it means to be environmentally sustainable. In our game testing sessions

with families, we have observed many instances in which adolescents took a leading role in developing strategies and interpreting game representations. Kids are also often more willing to engage in playful explorations of the game interfaces and rules than their parents. Parents, on the other hand, play an important role by encouraging reflection, focusing children's attention to relevant details, and bringing a more nuanced, real-world perspective (Crowley et al. 2001; Gutwill & Allen, 2012).

Principle 2: Build on cultural forms of literacy, learning, and play

Games are prominent cultural forms of literacy, learning, and play that are valuable for shaping social interaction in free-choice learning activities (Horn, 2013). But, within the broader universe of games, there are many different genres that invite subtly different forms of social interaction and learning (Guberman & Saxe, 2011; Berland & Lee, 2011; Horn, 2014). For example, tablet computer games might engender very different kinds of in-room (Stevens et al., 2007) play experiences than console games, board games, card games, or playground games. In our designs, we have focused on board games and playground game forms (e.g. hide-and-seek, tag) because we see them as well suited for engaging *entire* families. Cooperative board games, in particular, have excelled at promoting discussion and collaborative strategy development (see also Berland and Lee, 2011).

Principle 3: Fun first!

This third principle should be obvious to the Games, Learning, and Society community but is still worth restating. Games should be fun. Yes, we want families to reflect on the relationship between household energy consumption and environmental sustainability. We also want families to pick up on specific learning objectives related to energy saving strategies, the magnitude of energy consumption, and the relative impact of different appliances and electronics. But, if families never play our game because it isn't fun, then we have failed in all respects. We have spent close to two years of design and testing to achieve a balance of suspense, enjoyment, and replayability. In thinking about our learning objectives, we are guided by the notion of *intrinsic integration* (Habgood & Ainsworth, 2011) that emphasizes that target learning objectives and representations should be tightly aligned with core game mechanics.

Principle 4: Connections to real home infrastructures and data

The final design principle, which in some ways has been the most difficult to achieve, is that the game should be integrated with real household infrastructures and data. For Invasion of the Energy Monsters this means that doing something like turning on the TV or toasting a slice of bread should make the monsters stronger. By the same token, turning off the lights should make the game easier for the energy heroes. Families should also be able to see their own energy consumption data play out over time. Our intention is to blur the line between in-game and in-world activity as a way to translate game strategies to everyday life. Unfortunately, our ability to test this level of integration in real homes with real families is limited by existing infrastructures and technologies. However, as whole-home smart meters become increasingly common, we expect this will become more feasible. For the time being, we are using a combination of proxy technologies such as wifi-enabled electrical sockets that can transmit the energy use of a single device ("IDevices Switch", 2016). We describe this more fully in the next sections.

Game Design

Invasion of the Energy Monsters is a cooperative tabletop game for 2-4 players ages 6 and up. In the game, three energy monsters, each personifying a different form of waste, attack your home. Bonehead is a mindless energy zombie who's always forgetting to turn off lights and appliances. Wattwolf loves poor insulation and old, inefficient appliances. Ampire has a knack for doing things inefficiently, like running a half-empty dishwasher on heated-dry mode.

In the past two years, we have gone through numerous rounds of concept development, playtesting, and design iteration, with at least six major instantiations of the game. Here we first describe the basic, non-digital version of the game, followed by an overview of a planned expansion that will make use of an iPad app connected to a whole-home electricity meter.

Game Play

To win the game, the energy heroes must band together and expel the energy monsters from their home before it's too late. On each turn, the monsters find a devious new way to waste energy. As the energy level rises, your electricity bill gets more expensive and the monsters become stronger. If the monsters ever get the power level above 3,000 watts or the heroes run out of money, the game is lost. The heroes work together to turn off appliances and electronics while avoiding the monsters.

Figure 1: Monster figures (Bonehead, Wattwolf, & Ampire). Design by Eric Uchalik (euchalik.com).

At the beginning of the game, players create a house from a collection of 21 room tiles. Monsters make their appearance in the attic, basement, and back porch. Each tile has an OFF side and an ON side that indicate the power used by an appliance or device in that room. For example, the Basement has a spare refrigerator that uses 200 watts when plugged in (see Figure 2). Each tile also indicates the type of switch needed to turn the appliance off. Switches include sockets, remote controls, light switches, power buttons, and thermostats. For the basement, the heroes need to play socket cards to unplug the refrigerator.

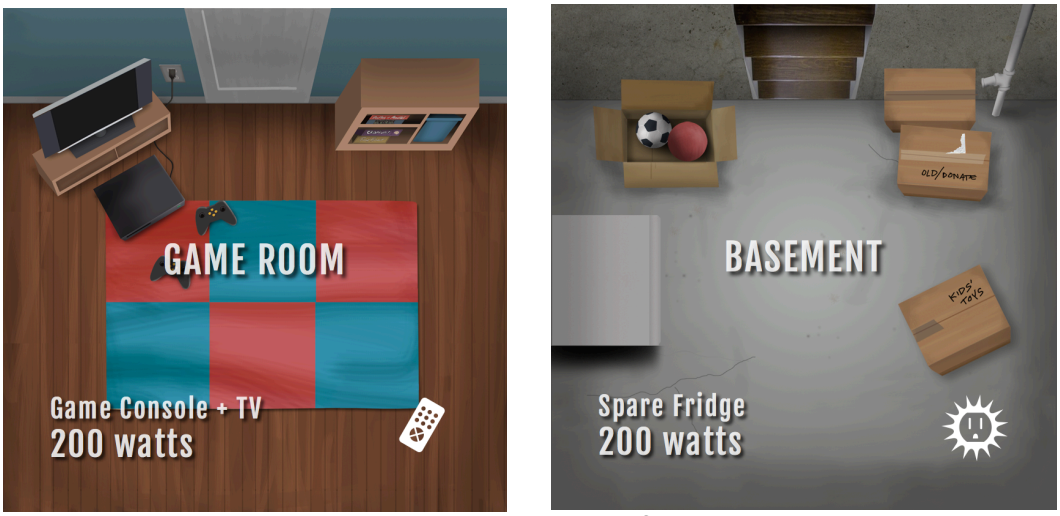

Figure 2: Example room tiles showing appliances, rates of energy consumption, and switch cards needed to turn the room off. Artwork by Maisa Morin (maisamorin.com).

On each turn a player rolls a modified six-sided die (with numbers from 2 - 5) and then moves his or her hero token up to the number of rooms shown on the die. Players may then play hero cards from their hands and trade cards with other players in the same room. At the end of their turn, players must flip over one purple monster card indicating a new form of energy waste. For example, flipping over the basement card means that Wattwolf plugs in the old spare fridge in the basement. Players must then pay an energy bill indicated by the current power level. For example, if the power rate is 550 watts, players must pay $10, the approximate weekly bill for electricity consumption at that rate. To turn a device or appliance off,

players must move to that room and play two corresponding switch cards. Heroes can also attack monsters by playing an attack card against monsters in the same room and then spinning a power spinner with a probability that changes with the energy consumption level (visible in Figure 3). If the spinner lands in the black region, the heroes win the attack and the monster is temporarily removed from the game. Heroes win the game by expelling all four monsters before they run out of money.

Energy Meter Expansion

We are developing an expansion of this game that will make use of a tablet computer app connected to a whole-home electricity meter. In this version, players will start the game with an *Energy Blitz* in which they run around their house turning on as many lights and appliances as they can. This will immediately be reflected on a digital power meter. As the game progresses, heroes will be able to play special cards allowing them to turn off real appliances and devices in their house, thus weakening the monsters.

Preliminary Findings

To evaluate our game, we visited five families in their homes to conduct playtesting sessions. Participants included 7 parents and 8 children (ages 6 to 14). Several of these families were visited on multiple occasions to test different design iterations of the game. All sessions were video recorded with informed consent (Figure 4). We also conducted informal playtesting sessions with our own families, with middle school students at a local after school program, with a family at a community game night, and with students at our university. These sessions were not video recorded.

Here we reflect on some of the strengths and weaknesses of our current game design using examples from a session conducted in the fall of 2015. This family included a father, two daughters, and a son. The families played the game on two separate occasions for roughly an hour and a half each session. This family played a slightly different version of the game than described above. In this version, two teams (monsters versus heroes) competed against one another.

Figure 4. Video capture from a family playing a version of the Energy Monsters game. Right: Celebrating after a successful spin of the energy spinner

One strength of this version of the game is that it created fairly high level of suspense and competition. After about 15 minutes of play, the tide started to turn in favor of the monsters, and the hero team began to express increasing levels of anxiety. This cued strategic discussions around movement of player tokens and the use of energy cards. Early on it appeared that the discussions would only emphasize attacking monsters while failing to compare energy consumption from different sources. For example, the father suggested discarding a cards that would turn off lights: “It’s only 50 watts. Do you want to discard it?” In another instance he suggested moving to the garage to turn off the appliance there: “The garage is 100 watts.” In both of these instances, he used energy terminology but didn’t mention the specific appliances (lights and refrigerator). And, even though he implied a comparison when he said “it’s only 50 watts”, his strategy didn’t explicitly compare one appliance to another.

But the family strategy discussions started to change when the monster team drew cards for two energy-intensive appliances. In each case, the son made emphatic statements about the advantage of these cards: “Space heater for 500 more watts!”, “Huahh! Air conditioning 500 watts.” As the heroes got increasingly desperate, the dad started to make more explicit comparison between appliances:

Dad: "The most important thing that we need to do is we got to get that space heater off."
Daughter: “Because it is taking up a lot of space. A lot of energy."
Dad: “That’s the worst thing right now. 500 watts.”

And, interestingly, even though the concept of waste was never explicitly emphasized in the game play, the youngest daughter introduced this terminology in a debate over whether or not to lock the bathroom door to keep the monsters from attacking.

Dad: Let's lock the bathroom.
Daughter: We're wasting electricity because the lights are on. If we lock it the lights will still be on.

One weakness of this version of the game is that there was no reflection on energy savings beyond turning off appliances. There was also no connection between game play and the family’s real home energy consumption, at least as evidenced by their conversation.

On our second visit with this family, we introduced a Magic Meter card that allowed the energy monster team to turn on a real appliance and measure it with a point-source energy meter. In this excerpt, two girls playing the monster team decided to plug in a lamp in the living room. Unfortunately, it turned out to be difficult to access the electrical outlet behind a couch.

Dad: Oh come on, there has to be an easier one.
Daughter: No this is the brightest lamp.
[... searching for the plug…]
Daughter: There [Light turns on]
Dad: How much is it? What's the number?
Daughter: Oh, this is lame.
Dad: Ha. Should have picked something better.
Daughter: The only thing on in the house are lamps.
Dad: Yeah. I wouldn't let you do the refigerator. Sorry.
Daughter: <SIGH> It's only 9 watts
Dad: Nine?! Ha ha ha: Bummer.

This excerpt illustrates the learning opportunities associated with connecting game play to the entire home. Unfortunately, it also highlights problems such as disrupting game play and accessing only things like lamps that can be easily unplugged. Our future versions will tie directly in to whole-home electricity meters to address these shortcomings.

References

Antle A., Warren J., May A., Fan M & Wise A. (2014). Emergent Dialogue: Eliciting Values during Children’s Collaboration with a Tabletop Game for Change, In IDC 2014, 37-46.

Ballantyne R., Connell S., and Fien J.(1998). Students as catalysts of environmental change: A framework for researching intergenerational influence through environmental education. Environmental Education Research, 285-298.

Banerjee, A., and Horn, M.S. (2014). Ghost Hunter: Parents and children playing together to learn about energy consumption. Proceedings of Tangible, Embedded, and Embodied Interaction (TEI'14).

Berland, M. & Lee, V.R. (2011). Collaborative strategic board games as a site for distributed computational thinking. International Journal of Game-Based Learning, 1(2), 65-81.

Bell-Gawne K. (2012). Meaningful Play: The Intersection of Videogames and Environmental Policy, GLS.

Chetty, M., Tran, D., & Grinter, R.E. (2008). Getting to green: understanding resource consumption in the home. UbiComp’08, 242-251.

Crowley, K., Callanan, M. A., Jipson, J. L., Galco, J., Topping, K., & Shrager, J. (2001). Shared scientific thinking in everyday parent-child activity. Science Education, 85, 712–732.
Cumbo B. J., Paay J., Kjeldskov J., & Jacobs B.C. (2014). Connecting Children to Nature with Technology: Sowing the Seeds for Pro-environmental Behaviour, In IDC 2014, 189-192.
Darby S. (2006). Social learning and public policy: Lessons from an energy-conscious village. Energy Policy, 34, 2929-2940.
Fitzpatrick, G. & Smith, G. (2009). Technology-enabled feedback on domestic energy consumption: Articulating a set of design concerns. In Pervasive Computing 2009, 37-44.
Froehlich J., Findlater L., Ostergren M., Ramanathan S., Peterson J., Wragg I., Larson E., Fu F., Bai M., Patel, S. and Landay J. (2012). The design and evaluation of prototype eco-feedback displays for fixture-level water usage data. In CHI 2012, 2367-2376.
Guberman, S.R. & Saxe, G.B. (2000). Mathematical problems and goals in children's play of an educational game. Mind, Culture, and Activity 7(3), 201-216.
Gustafsson, A. & Gyllensward, M. (2005). The power-aware cord: energy awareness through ambient information display. In CHI 2005 ext. abstracts. ACM (2005), 1423-1426.
Gutwill, J. P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. Journal of the Learning Sciences, 21(1), 130-181.
Habgood, M. J., & Ainsworth, S. E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. The Journal of the Learning Sciences, 20(2), 169-206.
Horn, M.S. (2014). Beyond video games for social change. ACM Interactions, 21(2), 66-68.
Horn, M.S. (2013). The role of cultural forms in tangible interaction design. Proceedings of Tangible, Embedded, and Embodied Interaction (TEI'13).
Horn M.S., Banerjee A., D'Angelo S., Kuo P., Pollock D. H., & Stevens R. (2014). Turn Up the Heat! Board Games, Environmental Sustainability, and Cultural Forms, In GLS 2014.
Horn, M.S., Leong, Z.A., Greenberg, M.D., and Stevens, R. (2015). Kids and thermostats: Understanding children's involvement with household energy systems. In IDC 2015, 3-4, 14-22.
Huizinga, J. (1950). Homo Ludens: A study of the play- element in culture. Boston: The Beacon Press.
IDevices Switch | HomeKit and Wi-Fi Enabled Plug. (n.d.). Retrieved April 15, 2016, from http://idevicesinc.com/switch/
IBM Global Utility Consumer Survey (2011). http://www-03.ibm.com/press/us/en/pressrelease/35271.wss
Kuo, P-Y. & Horn, M.S. (2014). Energy Diet: Energy feedback on a bathroom scale. ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp'14).
Kuznetsov, S. & Paulos, E. (2010). UpStream: motivating water conservation with low-cost water flow sensing and persuasive displays. In CHI 2010, 1851-1860.
Laschke M., Hassenzahl M., Diefenbach S., and Tippkämper M. (2011). With a little help from a friend: a shower calendar to save water. In CHI 2011, 633-646.
Larsson, B. ; Andersson, M. ; Osbeck, C. (2010). Bringing Environmentalism Home: Children's influence on family consumption in the Nordic countries and beyond". Childhood, vol. 17(1), pp. 129-147.
Lee J. J., Ceyhan P., Jordan-Cooley W. & Sung W, (2012). Greenify: Real-World Missions for Climate Change Education, In GLS 2012.
Stevens, R., Satwicz, T., & McCarthy, L. (2007). In-game, in-room, and in-world: Reconnecting video game play to the rest of kids' lives. In K. Salen (Ed.) The Ecology of Games: Connecting Youth Games, and Learning, MIT (2007), 41-66.
U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (n.d.). Retrieved April 15, 2016, from http://www.eia.gov/totalenergy/data/monthly/

Credits

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