Towards an *in-between* practice to study energy shift at work

Elodie Bouzekri[1[0000−0002−7902−3541]] and Guillaume Rivière[1[0000−0001−8390−9751]]

Univ. Bordeaux, ESTIA INSTITUTE OF TECHNOLOGY, F-64210 Bidart, France
elodie.bouzekri@estia.fr g.riviere@estia.fr

Keywords: Sustainability · Task modelling · Energy shift · Design practice.

1 Introduction

Sustainable HCI (SHCI) field adds environmental issues to the design of interactive systems, whether in their manufacture or use [11]. To make users aware of the impact of their actions on the environment, eco-feedback interfaces sense and feed relative information on these actions [6] such as: resources consumed, waste produced or resource status. However, Bremer et al. [2] point out that SHCI actors, having faced the limitations and criticisms of the individual-centred approaches, are now moving towards approaches influencing groups or communities instead. In this way, practice-oriented approaches offered framework to design for groups and communities by embedding interactions but also know-how, norms, and expectations [1]. Such approaches can be applied to energy use issue [1]. Because renewable energy availability is variable and without effective storage capability, shift energy demand is a way to maximise the use of renewable energy rather than non-renewable energy. To support residential users to shift energy use, Brewer et al. [3] identify three challenges related to users understanding of shifting, definition of moment when shifting must occurred, and unpredictability of renewable energy availability. Then, designing shifting practice is challenging and lacks method and process. Despite being unable to tackle all practices facets (e.g., culture or politics), we show that modelling and analysis tasks through task models can improve practice design process by identifying potential demanding tasks and keeping track of practice transformation from current to future practices tasks.

2 Designing systems to shift energy demand

In order to target sustainable goals, such as energy efficiency, several technology-centred approaches has been developed to optimise energy use of households such as smart home systems [7] or smart grid for communities [17]. On households level, smart home systems make use of various captors to automatically manage heating or light for example. On community level, microgrids supply electricity produced locally to a small amount of consumers. However, user adoption of smart home systems seems to suffer from cost, security and potential usefulness concerns [7]. To enable human-controlled shifting strategies, interfaces displaying availability of locally generated renewable energy hour by hour via a histogram [4] or a colour-coded clock [8], or stored in the grid at the time of the interaction [5,13,14,15]. Among them, eco-feedback systems aim to make users aware of renewable energy availability by displaying current availability of renewable or non-renewable energy [13], or solar and wind energy availability [13], or rate of stored renewable energy [5]. In addition to eco-feedback, eco-forecast displays forecasts for environmental behavioural purposes. This strategy is explored by Kjeldskov et al. [9] and Daniel et al. [4]. Eco-forecasts can be related to price, and demand on the grid [9], or renewable energy availability during the day [9,4].

Bremer et al. [2] point out that SHCI actors faced the limitations and criticisms of the individual-centred approaches carried by the eco-feedback approaches. Indeed, these approaches fail to tackle complexity of organisational context. SHCI actors are now moving towards approaches influencing groups or communities instead. Such approaches required a deep understanding of contextualised current practices and reasons that shapes them in order to design systems that support more environmental practices [1].

3 Designing practices

Clear and Comber [1] define a practice as a "socially constituted phenomena that characterises our everyday activities and routines". They develop assertions to consider practice-oriented approaches to design for sustainability comprising understanding of current practices, considering incremental change and going beyond current configurations and resource use. In order to go beyond current configurations, exploring design fiction approaches that relate to anticipation of the future from science fiction to inspire design scenarios has been proposed [16,1]. To describe design fiction, Lindley and Coulton [10] propose a model composed of: a reality layer that represents the world today as users may know it, a story layer that extrapolate reality into a plausible fiction, and a provocation layer the system designed into the story.

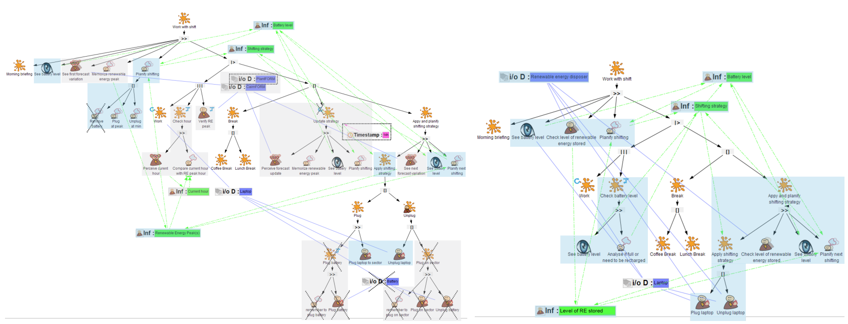
4 Design supported by models of an energy practice

We propose to explore a light-weighted design fiction process based on anticipated future of energy storage coupled with task modelling in order to design energy shift practice at work. A task analysis and modelling of current practice is performed. Then, based on a story, we design a possible future practice taking place in a fictional future. Then, based on both current practice and the future practice, an *in-between* practice was designed to be feasible in current working environment but include future practice tasks that can then be tested and anticipated today through user studies.

4.1 Illustrative example: transforming energy practice at work

Based on current employees practice and a story based on an anticipated future where renewable energy production and storage is easily disposable, we imagine an *in-between* practice feasible today while anticipating future context. We propose to support this process with task-models that enable identification and analysis of current tasks, future tasks, and tasks of the *in-between* practice under design.

As an input of our design process, we used previous results [4] on which we iterate. They determine that, currently in offices, most of employees always or often keep their laptop plugged to sector during the day. We describe a typical work day consisting of a morning briefing with coworkers, followed by laptop work. Work can be suspended for a coffee or lunch break. They remain unaware of renewable energy availability through the day. This, constitute our reality layer.



(a) In-between working task of employee with energy shift.

(b) Anticipated future working task of employee with energy shift.

Fig. 1: Task models describing with HAMSTERS [12] collaborative shifting with future tasks in blue, tasks performed only with the system under design in grey, and today tasks. Tasks removed after analysis activity are crossed out.

We based our story on a fictional anticipated future where battery can store important quantity of renewable energy on a long time and are accessible to anyone on workplace. In this anticipated future, one can imagine a renewable energy disposer: a box equipped with plugs displaying percentage of renewable energy stored. This renewable energy disposer enables users to shift their energy consumption to maximise renewable energy consumption. We model (see figure 1b) possible employee behaviour working with such renewable energy disposer. After morning briefing, employees see their battery level and plan when they will need to recharge or unplug their laptop. They can repeat these tasks in parallel of working. Then, working task can be suspended to take or break or to apply to plan shifting: plug or unplug the laptop, check level of renewable energy stored in disposer and laptop battery level to plan next shifting. These anticipated future tasks are highlight in blue.

Based on this anticipated future, Daniel et al. proposed an *in-between* practice by using laptop battery. Laptop battery is used to anticipate possible energy shift practice but must be managed individually. Then, an eco-forecast interface is introduced to support shifting. Rate of available renewable energy locally produced is displayed. Battery must be recharged when availability peak is reached. Battery must be discharged when availability rates increase. Battery must be removed when it is 50% discharged. Based on observations made during height-weeks experiment [4], we performed a task analysis of the resulting practice that employees themselves set up together to make it their routine at work. The task analysis highlights additional motoric and collaborative cognitive tasks required to implement energy shift that are potentially cognitively demanding. Indeed, after reading information displayed and recognising renewable energy availability peak, users must memorise or verify peak time, plan when the battery should be removed or when the laptop should be plugged or unplugged, remember to remove the battery and reinsert the battery, and when to plug the laptop. These tasks must be repeated for each peak and for each update. In addition, users declare to be lost after forecast updates. Some users accidentally turn off their laptop by removing the battery when they have previously disconnected their laptop. These *in between* tasks are highlight in grey in figure 1a.

As a result, we simplified the design of energy shift practice proposed by Daniel et al. [4] to propose an alternative *in between* shifting practice. We decide to no longer ask to remove the battery from the laptop[1]. Thus, users only need to schedule two tasks based on renewable energy availability: disconnect and connect the laptop. Battery must be recharged when availability peak is reached. Battery must be discharged when availability rates increase. We limit updates number to one after lunch break. These changes are indicated by dotted crosses in figure 1a.

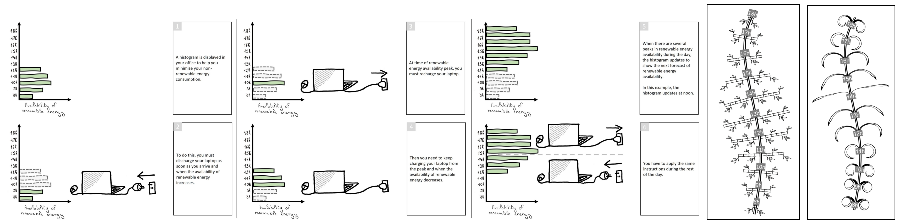
4.2 Evaluation

We design two eco-forecast interfaces in the form of bio-inspired histograms (BambHISTO figure 2b and PlantHISTO figure 2c) to support the practice. We compared their effectiveness, pragmatic and hedonic qualities. We used LimeSurvey[2] and recruited twenty-five participants (lecturer-researchers and business owners: 12 women, 12 men, 0 non-binary, 1 prefer not to disclose). Illustration of the practice is presented in figure 2a and each question is based on a mini-scenario.

To identify when to recharge battery (Q1, Q2, and Q4) success rate is high (between 84% and 100%) in both conditions. Success rate is lower to identify when to discharge battery (76% and 88% for Q3). A paired-samples t-test suggests that there is no significant difference between the two conditions (T=1.541, *p-value*=.14, 95% CI = [-2.04, 14.04]). Results are presented in table 1. The histograms' embellishments do not significantly impact the pragmatic, hedonic and

[1] This also enables taking into account that several devices such as laptops, smartphones, and cars use no easily removable batteries.

[2] https://www.limesurvey.org/fr/



(a) Instructions describing energy shift practice given to participants in the online study.
(b) Bamb-HISTO.
(c) PlantHISTO.

Fig. 2: Practice illustration and eco-forecast histograms prototypes.

global UX qualities. Overall UX qualities remain low. We assume that these low results are due to the fidelity level of the prototypes. Some participants praise the readability of BambHISTO, despite a lower success rate for it, and aesthetic qualities of PlantHISTO.

Table 1: Success rate for each histogram of study (n=25).

	Question 1		Question 2		Question 3		Question 4		Total	
Histogram	Rate	Std. dev.	Rate	Std. dev.	Rate	Std. dev.	Rate	Std. dev.	Rate	Std. dev.
BambHISTO	92.00%	0.28	92.00%	0.28	76.00%	0.44	**88.00%**	0.33	87.00%	0.38
PlantHISTO	**100.00%**	0	**100.00%**	0	88.00%	0.33	84.00%	0.37	**93.00%**	0.26

5 Conclusion

This work is still work in progress. However, good success rates in this study are encouraging to conduct field study of this new practice based on energy shift with laptop battery and supported by PlantHISTO interface. Finally, if this online study, which was not expensive to develop, allowed us to quickly orient our design process, user studies in a controlled environment are still to be conducted in order to deepen our results with higher fidelity prototypes. Also, realisation of the new practice will be subject to the dynamics, pressures and routines of the user groups in the workplace. These points will be the subject of a future longitudinal study. In this work-in-progress paper, we propose to make use of task modelling and analysis in practice design process to make a step towards new methods and techniques to design and analyse practices. This method enables to keep track of the incremental change of practice highlighting already performed task, future task, and tasks of the *in-between* practices under design. Making possible to designers to reason about the gap to fill between current and future desirable practice by identifying layer (current, future, *in-between*) of each tasks.

References

1. Adrian K. Clear, Rob Comber: Towards a social practice theory perspective on sustainable HCI research and design. Routledge (Nov 2017), pages: 31-43 Publication Title: Digital Technology and Sustainability
2. Bremer, C., Knowles, B., Friday, A.: Have We Taken On Too Much?: A Critical Review of the Sustainable HCI Landscape. In: Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. pp. 1–11. CHI '22, ACM, New York, NY, USA (Apr 2022). https://doi.org/10.1145/3491102.3517609
3. Brewer, R.S., Verdezoto, N., Rasmussen, M.K., Entwistle, J.M., Grønbæk, K., Blunck, H., Holst, T.: Challenge: Getting Residential Users to Shift Their Electricity Usage Patterns. In: Proceedings of the 2015 ACM Sixth International Conference on Future Energy Systems. pp. 83–88. e-Energy '15, Association for Computing Machinery, New York, NY, USA (Jul 2015). https://doi.org/10.1145/2768510.2770934
4. Daniel, M., Rivière, G., Couture, N.: CairnFORM: a Shape-Changing Ring Chart Notifying Renewable Energy Availability in Peripheral Locations. In: Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction. pp. 275–286. ACM, Tempe Arizona USA (Mar 2019). https://doi.org/10.1145/3294109.3295634, https://dl.acm.org/doi/10.1145/3294109.3295634
5. Elbanhawy, E.Y., Smith, A.F.G., Moore, J.: Towards an ambient awareness interface for home battery storage system. In: Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct. pp. 1608–1613. UbiComp '16, ACM, New York, NY, USA (Sep 2016). https://doi.org/10.1145/2968219.2968557
6. Froehlich, J., Findlater, L., Landay, J.: The design of eco-feedback technology. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 1999–2008. CHI '10, ACM, New York, NY, USA (2010). https://doi.org/10.1145/1753326.1753629
7. Förster, A., Block, J.: User Adoption of Smart Home Systems. In: Proceedings of the 2022 ACM Conference on Information Technology for Social Good. pp. 360–365. GoodIT '22, Association for Computing Machinery, New York, NY, USA (Sep 2022). https://doi.org/10.1145/3524458.3547118
8. Jensen, R.H., Raptis, D., Kjeldskov, J., Skov, M.B.: Washing with the Wind: A Study of Scripting towards Sustainability. In: Proceedings of the 2018 Designing Interactive Systems Conference. pp. 1387–1400. DIS '18, ACM, New York, NY, USA (Jun 2018). https://doi.org/10.1145/3196709.3196779
9. Kjeldskov, J., Skov, M.B., Paay, J., Lund, D., Madsen, T., Nielsen, M.: Facilitating Flexible Electricity Use in the Home with Eco-Feedback and Eco-Forecasting. In: Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction. pp. 388–396. OzCHI '15, ACM, New York, NY, USA (Dec 2015). https://doi.org/10.1145/2838739.2838755
10. Lindley, J., Coulton, P.: Modelling Design Fiction: What's The Story?
11. Mankoff, J.C., Blevis, E., Borning, A., Friedman, B., Fussell, S.R., Hasbrouck, J., Woodruff, A., Sengers, P.: Environmental sustainability and interaction. In: CHI '07 Extended Abstracts on Human Factors in Computing Systems. p. 2121–2124. CHI EA '07, ACM, New York, NY, USA (2007). https://doi.org/10.1145/1240866.1240963

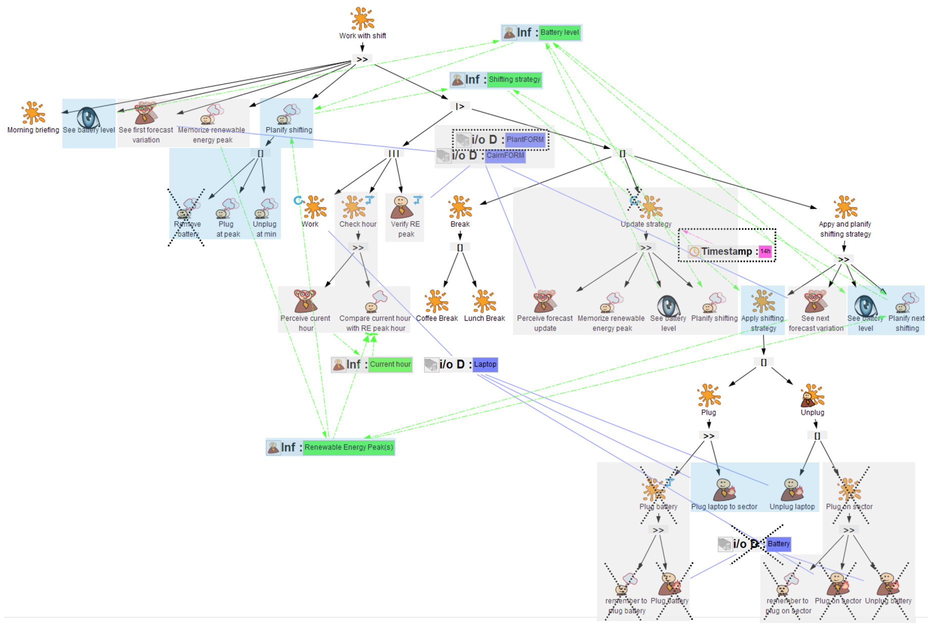
12. Martinie, C., Palanque, P., Winckler, M.: Structuring and composition mechanisms to address scalability issues in task models. In: 13th International Conference on Human-Computer Interaction (INTERACT 2011). vol. 6948, pp. 589–609. Springer (2011)
13. Pierce, J., Paulos, E.: The local energy indicator: designing for wind and solar energy systems in the home. In: Proceedings of the Designing Interactive Systems Conference. pp. 631–634. DIS '12, ACM, New York, NY, USA (Jun 2012). https://doi.org/10.1145/2317956.2318050
14. Quintal, F., Esteves, A., Caires, F., Baptista, V., Mendes, P.: Wattom: A Consumption and Grid Aware Smart Plug with Mid-air Controls. In: Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction. pp. 307–313. TEI '19, ACM, New York, NY, USA (Mar 2019). https://doi.org/10.1145/3294109.3295642
15. Quintal, F., Jorge, C., Nisi, V., Nunes, N.: Watt-I-See: A Tangible Visualization of Energy. In: Proceedings of the International Working Conference on Advanced Visual Interfaces. pp. 120–127. AVI '16, ACM, New York, NY, USA (Jun 2016). https://doi.org/10.1145/2909132.2909270
16. Wakkary, R., Desjardins, A., Hauser, S., Maestri, L.: A sustainable design fiction: Green practices. ACM Transactions on Computer-Human Interaction **20**(4), 23:1–23:34 (Sep 2013). https://doi.org/10.1145/2494265
17. Warneryd, M., Håkansson, M., Karltorp, K.: Unpacking the complexity of community microgrids: A review of institutions' roles for development of microgrids. Renewable and Sustainable Energy Reviews **121**, 109690 (Apr 2020). https://doi.org/10.1016/j.rser.2019.109690

6 Appendices

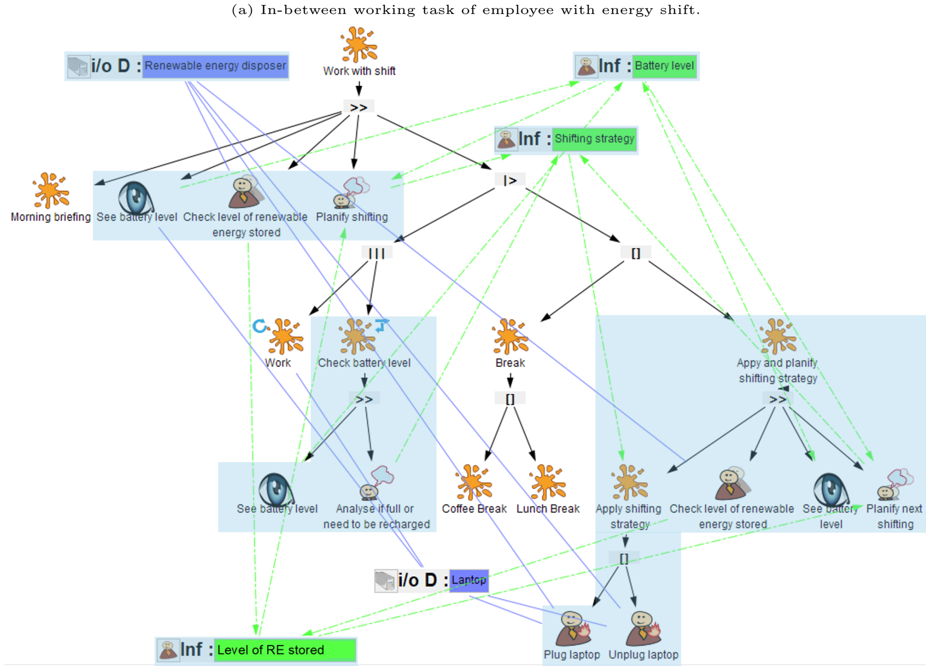
Online study questions:

Q1: As instructed, you disconnected your laptop at the beginning of your day at 8:30 [/9:00] am. At what time will you connect it back in?
Q2: As instructed, you disconnected your laptop at the beginning of your day at 9:00 [/8:30] am. At what time will you connect it back in?
Q3: Your laptop is charging quickly, at 1:00 [/2:00] pm the battery indicates full charge. According to the instructions and the histogram, at what time will you disconnect your laptop?
Q4: According to the instructions and the histogram, at what time will you connect your laptop back in?

Task models describing *in-between* and future practices tasks to shift energy at work added for readability.



(a) In-between working task of employee with energy shift.



(b) Anticipated future working task of employee with energy shift.

Fig. 3: Task models describing with HAMSTERS [12] collaborative shifting with future tasks in blue, tasks performed only with the system under design in grey, and today tasks. Tasks removed after analysis activity are crossed out.