Research Proposal

A design case study

In partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE

in

Human Computer Interaction

by

Yanwei Miao

(1627738)

Under the supervision of

Prof. Dr. Gunnar Stevens

Dr. Songmin Yu

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ABSTRACT

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Notations and Abbreviations

EU European Union. 1, 2, 14

GHG greenhouse gas. 1

Chapter 1

Introduction

Human-induced climate change is causing dangerous and widespread disruption in nature and affecting the lives of billions of people around the world [IPCC, 2022]. To tackle climate change and its negative impacts, the historic Paris Agreement sets long-term goals to guide all nations to substantially reduce global greenhouse gas (GHG) emissions to limit the global temperature increase to 2 degrees Celsius in this century [UNFCCC, 2015]. On European Union (EU) level, "Energy 2020. A strategy for competitive, sustainable and secure energy", published in November 2010, and "Energy Roadmap 2050", published at the end of 2011, are the most important strategy papers currently, pointing the direction for energy developments in the EU [Langsdorf, 2011]. The aim is to confirm Europe's commitment to lead in global climate action and to present a vision that can lead to achieving net-zero GHG emissions by 2050 through a socially-fair transition in a cost-efficient manner [European Commission, 2018].

To achieve these goals, two central strategies are pursued by the EU and its Member States concerning the energy system [Brugger et al., 2021]:

1. Enhancing energy efficiency (EE).
2. Decarbonizing energy supply, in particular via large diffusion and wide-use of renewable energy sources.

1.1 Energy shift

In 2019, 80.9% of our total energy supply still depended on burning fossil fuels, namely 26.8% coal, 30.9% oil and 23.2% natural gas [IEA, 2021]. Nonetheless, investments into low-carbon power generation accounted for 15% recently are expected to rise to more than 30% by 2030, corresponding to a quadrupling in absolute volumes [Bertram et al., 2021]. Solar, wind, and the investments for enabling the integration of these technologies to the grid dominate the investments into low-carbon power generation [Bertram et al., 2021].

1.2 Societal trends

Previous research has shown that in many areas energy efficiency gains were counteracted by societal trends that increased corresponding activities, leading to much smaller decreases (or even increases) of energy demand than technologically feasible [Brugger et al., 2021]. Therefore, it is important to access current and (foreseeable) future societal trends concerning the impact that they might have on future energy demand [Brugger et al., 2021].

Climate change can only be tackled if people actively engage, as consumers and as citizens [European Commission, 2018].

Chapter 2

The newTRENDs Project

The aim of NewTRENDs is to increase the qualitative and quantitative understanding of impacts of New Societal Trends on energy consumption and to improve the modelling of energy demand, energy efficiency and policy instruments [Fraunhofer ISI, 2023].

2.1 Concept

With increasing renewable generation integrated into the power system, supply-side fluctuations must be balanced by demand-side flexibility. Electrification and demand response (DR) are becoming increasingly relevant to the heating transition of buildings, which demands the diffusion of

- heat pumps (HPs),
- photovoltaic (PV) and energy storage (e.g., battery and hot water tank),

- smart energy management systems (SEMSs).

Combining the three technologies is also beneficial from an individual household (or building) perspective. The household can optimize the heat pump operation to reduce energy costs by saving energy in the tanks or pre-heat the building when the electricity price is lower. Besides, the energy-saving benefit could be further increased with PV and battery system. From a market perspective, DR flexibility and PV generation also facilitate the concept of "energy community". The households can trade electricity with each other (peer-to-peer, P2P) within a local micro-grid or even trade with the other side of the country through the national grid, depending on the infrastructure, business model, and policies. In addition, households can also buy the services from an "aggregator", who bundles and manages the flexibility of small consumers and producers and participate in the market activities (Kerscher and Arboleya 2022). Promoted by the declining costs of technologies and support policies, more and more household "consumers" are expected to become "prosumers" (with PV) and "prosumagers" (plus energy storage and SEMS) (Fereidoon Sioshansi 2019).

2.2 FLEX models

The FLEX-Operation and FLEX-Community models were built to improve the building modeling suite and to analyze the societal trends of prosumaging and energy communities. The figure below shows how FLEX interacts with other bottom-up models involved in the newTRENDs project.

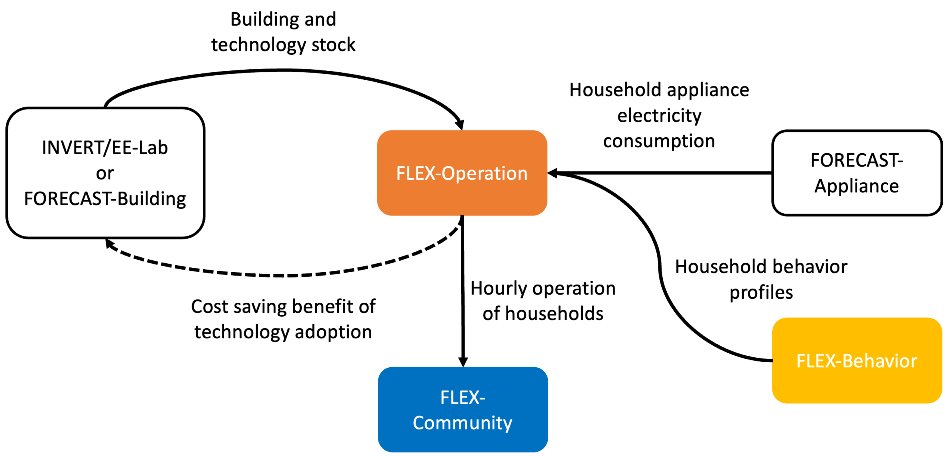

Figure 2.1: FLEX

2.2.1 FLEX-Operation

FLEX-Operation models the energy system operation of an individual household in hourly resolution. It calculates the energy consumption of each representative building, including operation of technologies (e.g., battery, PV, heat pump, etc.) and load profiles in hourly resolution.

2.2.2 FLEX-Community

FLEX-Community models the operation of an energy community, i.e., household interaction, aggregator optimisation. It can be applied to support the aggregators designing and evaluating business models, as well as making investment decisions, for example, the self-owned battery, PV panels, etc.

2.2.3 FLEX-Behavior

FLEX-Behavior models the behavior (activity profile) of households' and corresponding load profiles. It generates the hourly activity and energy demand profile of a pre-defined individual household. The results include

1. appliance electricity demand,
2. domestic hot water demand,
3. driving profile, and
4. building occupation.

Data will be considered by the model is

- building,
- heating system (heat pump, fuel-based boiler, electric heater),
- thermal storages for space heating and domestic hot water,
- space cooling technology,
- PV,
- battery, and
- electric vehicle.

This proposed thesis is going to focus on FLEX-Behavior model.

2.3 Motivations

This would be an opportunity to encourage European households, that are under suitable conditions, to switch to greener energy options. That actually do benefits for not only the environment but also for the planet.

2.4 Research gaps and questions

There is a lack of research and design case studies to promote energy optimisation solutions from a user's perspective. This proposed thesis will unfold from following perspectives

- Awareness and understanding of new energy sources
- Demand for new energy sources
- Confidence in new energy solutions
- Feasibility of adopting new energy options

The aims of the proposed thesis are *(i)* implementation of proposed smart energy optimisation recommender as a web application, using data visualisation techniques designed for different types of households. *(ii)* evaluation of the explainability of smart energy optimisation recommender at the user level and measuring the impact of the households perceptions towards energy optimisation solutions. *(iii)* provide a design guideline on how to enable trust in energy optimisation solutions when trying to promote green energy plans.

- Building typical household profiles.
- A decision tree is used to obtain information about the user by analysing the profiles and predicting them in order to reduce the number of steps involved in entering user data.
- The result is an interpretable energy optimisation solution.

Chapter 3

Methodology

Introductory lines...

3.1 Section-1 Name

Some text here ...

Chapter 4

Supervision agreements and time planning

Introductory lines...

4.1 Justification for 30 ECTS

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4.2 Supervision

This master thesis project will be supervised by Prof. Dr. Gunnar Stevens (Gunnar.Stevens@uni-siegen.de) and Dr. Songming Yu (songmin.yu@isi.fraunhofer.de).

4.3 Time planning

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Appendices

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