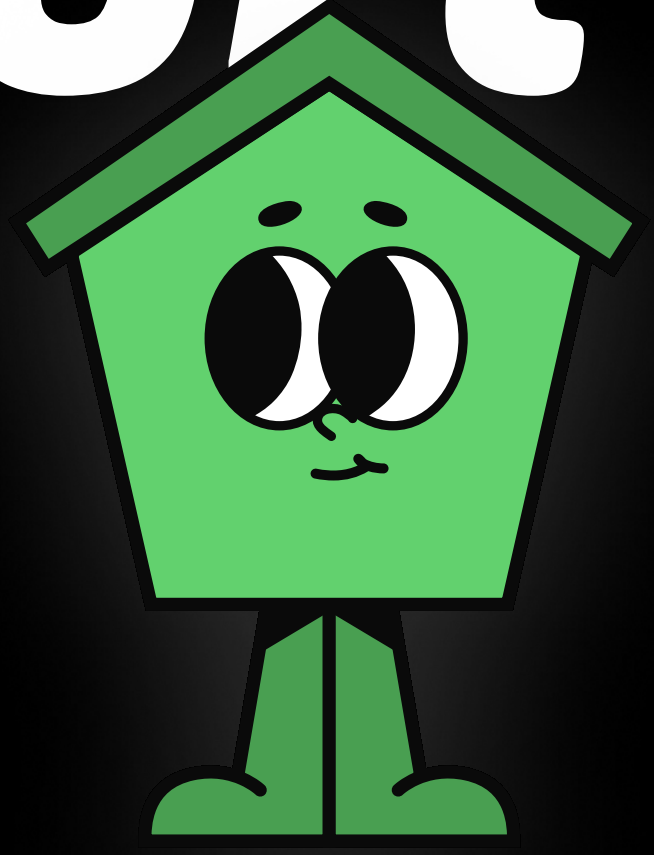
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ARERA Smart



Transforming domestic energy with AI by prioritizing user needs

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INTRODUCTION ENERGY FIELD - WHY?

Our project focuses on **energy services** to address the lack of clear explanations for users. We started by researching **how Italians perceive energy services** to understand their needs.

Quantitative data

27%

of Italians are worried about not being able to pay household bills.[1]

46%

of Italians believe that reducing energy costs requires changing habits and adopting efficient solutions.[2]

90%

of Italians don't know how to properly read bills.[3]

46%

of Italians say they check the details of reported consumption to monitor them.[4]

39%

of the sample regret not understanding how much they are actually paying for the energy they consume.[5]

2%

of Italians claim to understand everything in the bills.[5]

Qualitative data - Inteviews

Target
People who are the account holders of energy bills and have a smart attitude

Sample
4 bill holders - 25/58 y.o. - Confident with technology

Topics
Bill management | consumption awareness | energy ecosystem | home appliances

People want to see how much they consume **compared to others.**

They would like to have an **all-in-one place** that helps them manage their consumption.

To stay informed, you need to take initiative as the energy provider may not offer comprehensive information.

Economic savings drive users to change their energy habits.

FRAMING

The data collected during the research reveals that one of the main concerns of Italians is the cost of living, particularly **the cost of energy.** This concern has led people to become more informed about the energy sector and to **pay more attention to their bills and costs**. However, most Italians do **not understand the content of their bills** and are unable to comprehend and quantify their consumption.

Energy is also perceived as boring.
As a result, users do not know **how to save money and energy** and are unable to change their possibly bad habits. On the basis of all the considerations gathered during the research phase, we defined our problem statement with the aim of **identifying the current problems** in the management and relationship between users and the energy sector.

Framing the problem

People would like to **save money and be sustainable**, which often clash with the common energy consumption habits that lead to over-exploitation of the planet's resources.

People **struggle to save money** and be sustainable

Why?

Because they use **more energy than necessary**

Why?

Because they cannot **quantify their energy consumption**

Why?

Because they do not know how to read and **undersand their own consumption**

Why?

Because **consumption is not clear** and accessible to the users

REFRAMING

We began by applying the **five Whys technique** to our initial problem statement to better specify and **understand the true needs** of our users in the energy sector. This method proved invaluable in gaining a **deeper comprehension of the problem** and in refining both the problem statement and the real needs of our users.

Problem statement

Many people use too much energy because they **don't understand how much they're using.** The difficulty in reading their own consumption makes it hard to understand their energetic impact.

User needs

01. Users need to understand **how to read their bills**

02. Users need to **quantify** their energy consumption

03. Users need to **compare** themselves with others

04. User need to understand and **reduce their energy consumption**

IDEATION

Starting from the problem statement, the objective was to understand how we could respond to it by developing our service. Using the "How Might We" method, we started our ideation process, which allowed us to generate several ideas for viable design solutions. The main question was **"How can we make information about energy consumption understandable to users to help them adopt more informed and sustainable consumption habits?"**. From this starting point, we then broke the problem down into different sub-problems, trying to understand what data we needed to address thoese problems and how AI could come into play to solve them.

How might we... Features Data

propose a more efficient energy model to optimize user consumptions?	Identify inefficient appliances Forecast future consumption	**AI** could identify which appliances are in a low energy class and provide futuristic models of possible savings by changing the appliance to a more efficient one. Historical consumption data · Appliances patterns
change the experience of reading the bill and make it more engaging and understandable?	Clear and engaging bill explanation	Use **AI** to monitor user consumption and propose a usage model to optimize energy consumption. Provider's energy price · Historical consumption data · Weather variables · Temporal variables (season, month...)
make the user aware of how much renewable energy is coming into their home?	Identifying energy sources	Understad where the energy provider buys its energy from and distribute that data over the user's consumption. Provider's energy sources
make the user visualize how much energy they consume and quantify energy consumption?	Consumption divided by appliances Historical consumption Comparison with similar users	**AI** could recognise the consumption patterns of different appliances and provide the user with a clear reference to which appliance has the greatest influence on their consumption. Appliances patterns · Energy passage with the smart meter · Provider's energy price **AI** could identify your consumption profile and compare you with similar users. User household data · Location and size of house
help inform the user in the energetic field?	Information service	**AI** could recommend, based on user preferences, which articles to read and on which topics to inform themselves. Articles on energetic news · User preferences

CONCEPT

This energy service aims to **simplify and make energy consumption information understandable to everyone**, regardless of their technical background or energy literacy.
Key features of the service include detailed appliance-level monitoring, which provides users with a comprehensive breakdown of their energy consumption at an individual appliance level. This allows users to clearly see which appliances devices are consuming the most energy, empowering them to **monitor usage and make informed decisions** to increase energy efficiency. In addition, the service uses AI algorithms and historical usage data to predict each user's energy consumption for the upcoming month, giving them valuable foresight to better plan and manage their energy budgets.

The service also compares each user's energy consumption with averages for similar households in the same geographical location, providing contextual information to help users **understand their usage patterns compared to their peers** and motivating them to implement energy saving measures. By delivering these features in a clear and user-friendly way, this impartial energy service equips all users, regardless of their technical expertise or environmental awareness, with the tools and insights they need to take control of their energy usage, reduce their carbon footprint, and achieve meaningful cost savings. The service's **impartial, data-driven approach** ensures that users receive reliable, unbiased information to guide their energy management decisions.

Target

Italian bill holders with an interest in reducing their consumption and staying informed about developments in the open market.

Goals

01. Inform the user

02. Analyze real time and past consumption

03. Help the user to save energy

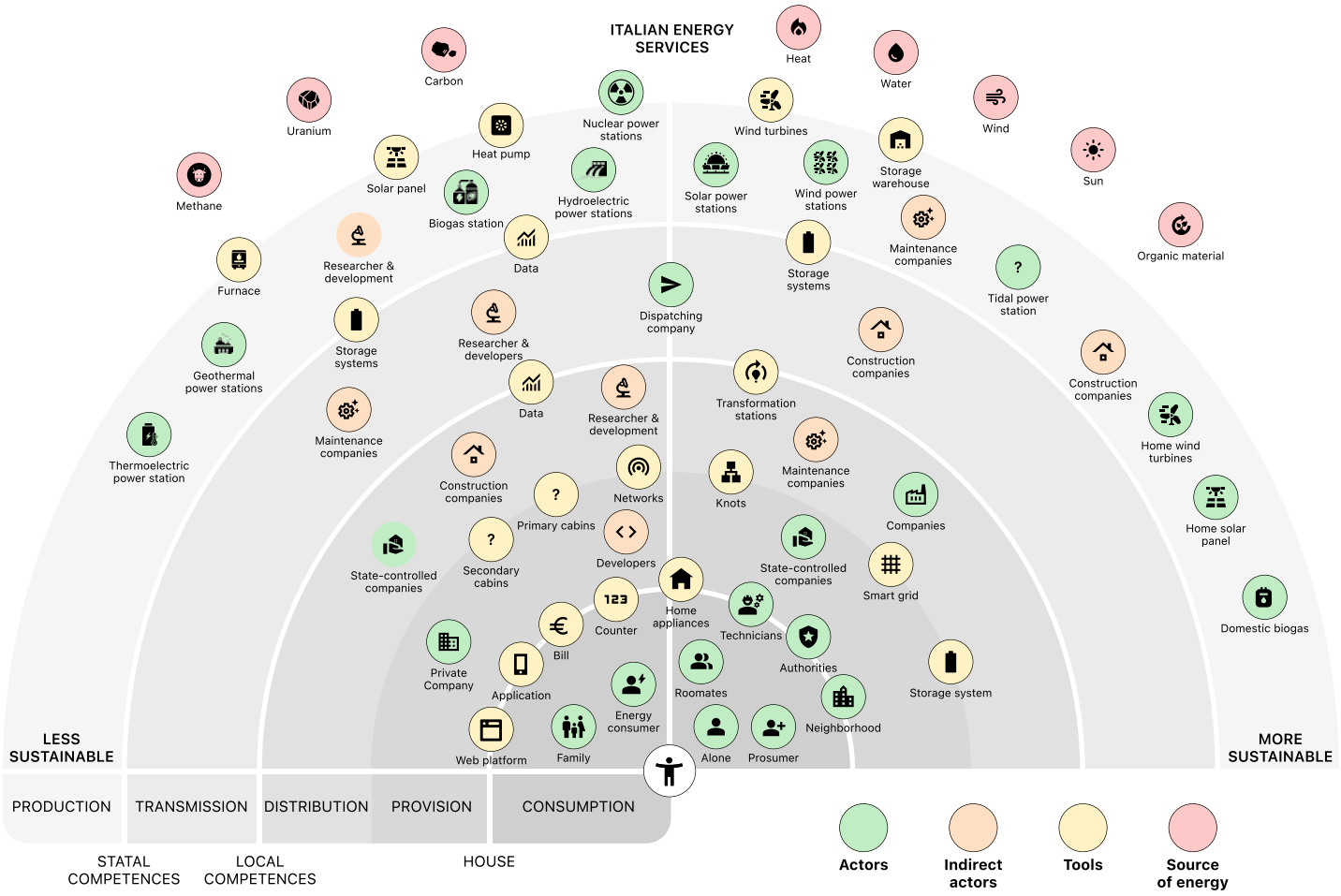
04. Make bill reading engaging

05. Create a future saving goal

06. Compare the user with friends and average

ENERGY ECOSYSTEM

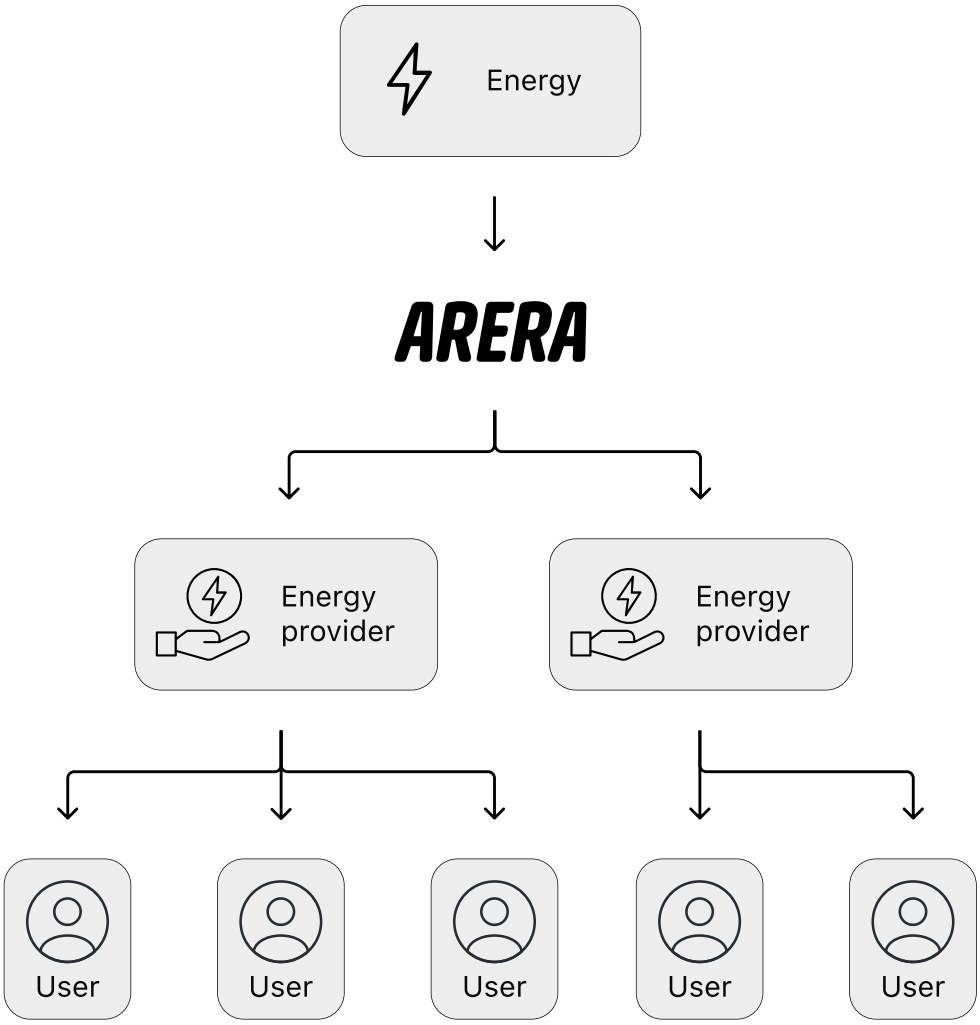
To create a neutral system that benefits all users, regardless of their energy provider, we first **studied the current energy landscape[6].** By developing an ecosystem map, we were able to summarise the roles and objectives of the various stakeholders and identify potential partners for our service[7]. Through this process, we identified ARERA - the Italian regulator for energy networks and the environment - as a key entity. ARERA regulates and oversees the electricity, natural gas, water and urban waste sectors, and maintains a regulatory and supervisory relationship with energy providers[8]. **It safeguards user and consumer interests through independent regulatory oversight.** ARERA plays a crucial role in Italy's energy sector: it regulates electricity and natural gas prices to ensure fairness, enforces service quality and consumer protection standards, and monitors suppliers' compliance. It promotes market competition, supports consumer rights with clear information and dispute resolution, and promotes energy efficiency and sustainability in Italy. This integrated approach underlines ARERA's crucial role in **maintaining an efficient, fair and sustainable energy market in Italy**, and is in line with our mission to provide a comprehensive and impartial service to all energy users.



ARERA Supervision

ARERA SMART

We decided to develop our system as an **extension of the services ARERA** currently provides to Italian citizens. ARERA offers a personal consumption portal[9], accessible via SPID, where bill holders can view their energy usage. However, the current service lacks the advanced features we aim to provide.
Through SPID, ARERA already has access to extensive energy data for many citizens, which is crucial for implementing our features.
This led to the creation of ARERA Smart, an energy monitoring dashboard developed by ARERA. By leveraging ARERA's existing data and public trust, ARERA Smart offers a reliable and impartial public service, positioning itself as a neutral state body in relation to energy providers.



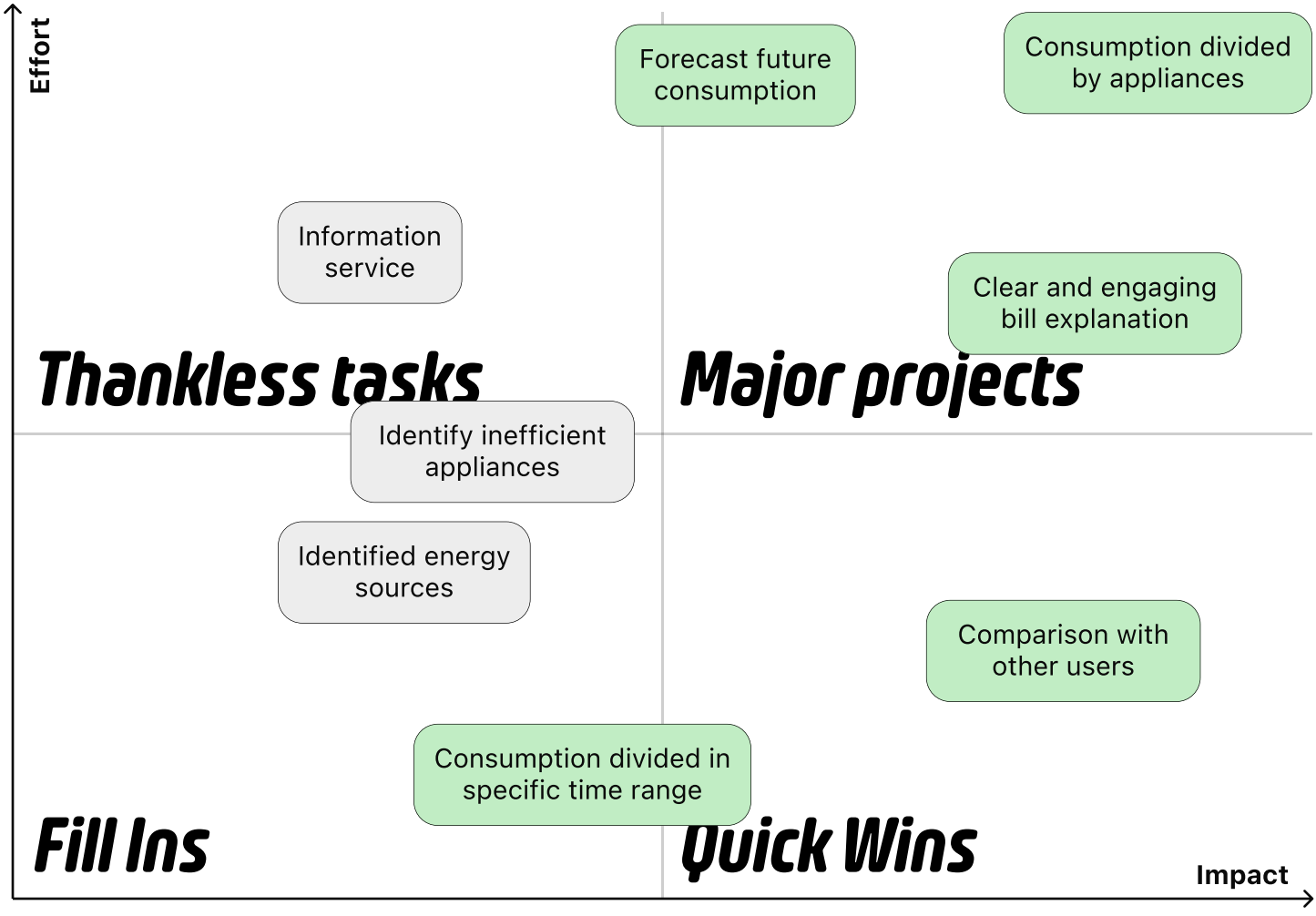
IMPACT-EFFORT MATRIX & VALUE PROPOSITION

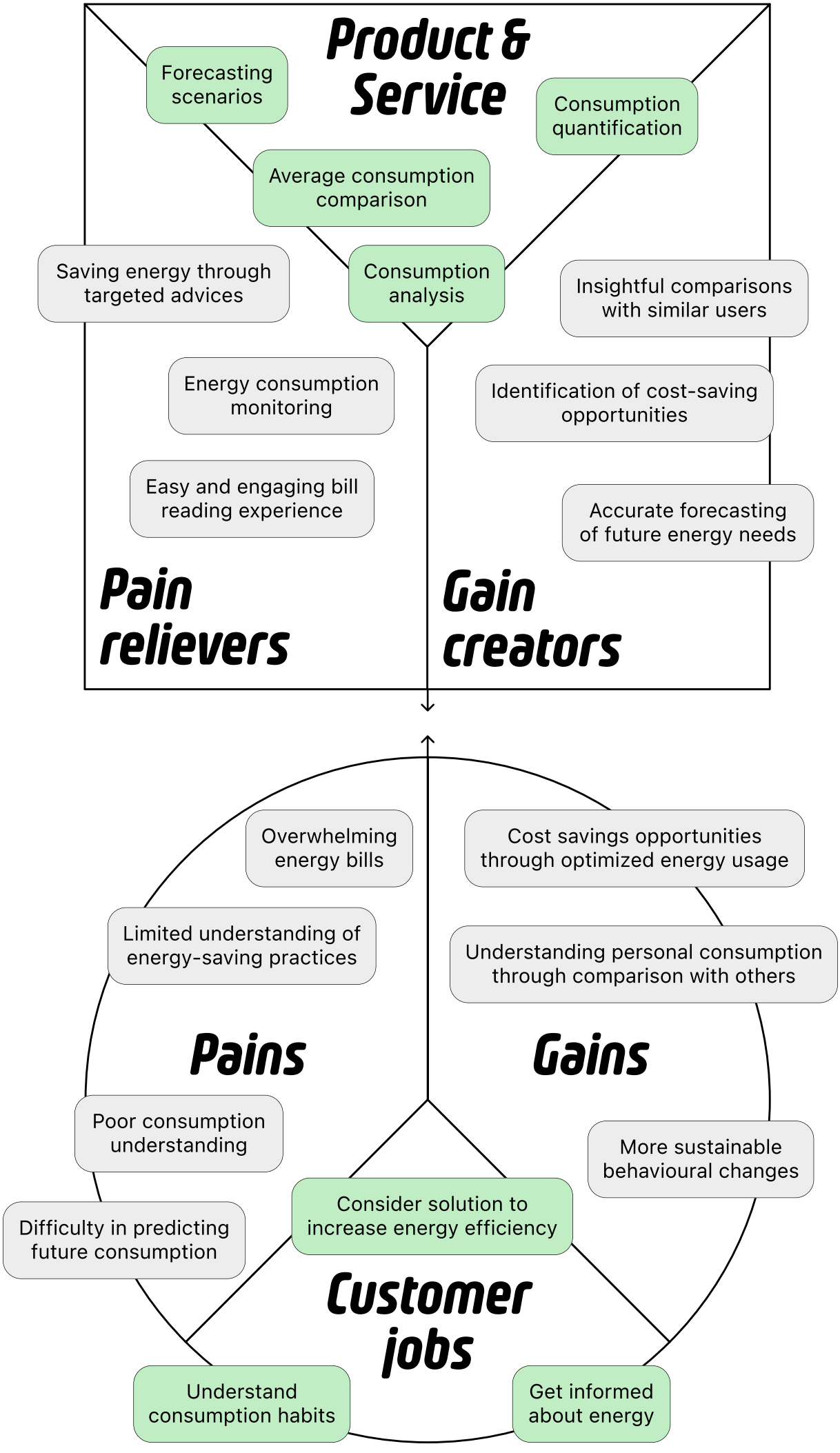
To identify the key features for our service, **we started by writing user stories** to imagine how users would engage with the service. This process allowed us to **prioritise our efforts** by identifying what would deliver the greatest user value. We then categorised the user stories by system feature. After that, the **Impact-Effort Matrix** was very helpful in understanding which parts of the service to focus on for project implementation and which features required too much energy for the actual value delivered.

***As a** young worker sharing a flat with two roommates, Sergio **wants to** understand their utility bills better **so that** they can track their consumption patterns effectively, especially since they have different schedules and are frequently away from home.*

***As a** father and hard worker, Enrico **wants to** monitor and manage his monthly consumption meticulously, and understand his possible future consumptions, **so that** he can save money, effectively manage his budget, create an energy saving plan.*

***As a** professional living alone for the first time in Milan, Francesca **wants to** compare her energy usage to others similar to her, **so that** she can understand typical consumption patterns and manage her energy more effectively.*




Product & Service
Forecasting scenarios
Consumption quantification
Average consumption comparison
Saving energy through targeted advices
Consumption analysis
Insightful comparisons with similar users
Energy consumption monitoring
Identification of cost-saving opportunities
Easy and engaging bill reading experience
Accurate forecasting of future energy needs
Pain relievers
Gain creators
Overwhelming energy bills
Cost savings opportunities through optimized energy usage
Limited understanding of energy-saving practices
Understanding personal consumption through comparison with others
Pains
Gains
Poor consumption understanding
More sustainable behavioural changes
Consider solution to increase energy efficiency
Difficulty in predicting future consumption
Customer jobs
Understand consumption habits
Get informed about energy

USER JOURNEY

User Goal	User Action	Touchpoints	Needed data	Artificial Inteligence	Thoughts
Discover and understand better the energy ecosystem	Download the ARERA app, log in wth SPID and follow the onboarding	App store SPID Arera Smart On boarding Home	SPID database		"It will be very convenient for me to have all the information at hand"
Monitor consumption in real time to understand how to behave better	See the energy goal for the current month, and explore the weekly tips	Arera Smart Home	Tips database Predicted future consumption	**Forecasting energy consumption** **Clustering**	"I have a clear goal, and I can monitor my progress for this month. Finally, I understand how much I'm consuming"
Change perspective on the consumptions	Change the unit of measurement from kwh to euros	Arera Smart Home	Conversion data Real-time energy price		"Finally I can quantify my consumption in a more understandable way"
View last month consumption and see what appliances consumed the most	Open last month consumption and discover what is the most used appliance	Arera Smart Analysis	Historical consumption divided by appliances Historical user consumption database	**Energy disaggregation**	"I have a database of my consumption, it's cool that I can see how much each appliance consumed"
Understand how similar users consumes	See the year overview compared with the average, scroll to analyze the graphs	Arera Smart Peers	Users household data Users location data Users consumption divided by appliances		"I can understand how I'm doing compared to others like me. It helps me improve and do better"
Compare consumes with friends	Add friends and see the comparison	Arera Smart Peers	Friends consumption data		"I can challenge my friends, and the leaderboard makes energy much more fun"
Share house consumes with housemates	Share the profile with the housemates	Arera Smart Profile			"I have a place where I can monitor our consumption together and save on managing the house"
Review and understand the bill at the end of the month	Open the EasyBill pop-up	Arera Smart Easybill	Bill data		"I can see my consumption in a fun and playful way"
Understand the consumption of the finished month	Explore the EasyBill cards	Arera Smart Easybill	Bill data Forecasting results	**Forecasting energy consumption** **Clustering**	"Finally I can understand the consumes in my bill"
See the bill file	Finish EasyBill and open the file of the bill	Provider's website Arera Smart Easybill	Bill data		"I still have the file of my actual bill to explore"

AI APPROACH

To develop the AI features within our service, we adopted the '**learning by doing' approach.** By participating in various circle games, we were able to directly experience and understand the complexities behind the use of artificial intelligence. The goal that guided us was to **understand how we could integrate AI** in a way that would **add value to both our service** and the user, ultimately improving the overall experience.

Understanding the inner workings of this technology and identifying the **necessary data required** to make it work effectively was challenging. Before using the Impact-Effort Matrix we had a lot of features in the service and the complexity of the algorithms was confusing.

As a result, we proposed numerous AI integrations that were all poorly structured. However, once we realised which features were the core offerings of the service and which required too much effort to have a real impact on the user, we were able to **refocus our efforts.** This clarity allowed us to concentrate on developing the key AI features that would **provide the most value to our users.**

Overall, the 'learning by doing' approach, combined with the strategic use of the Impact-Effort Matrix, enabled us to **navigate the intricacies of AI integration** and ultimately deliver a more **refined and impactful set of AI-powered capabilities** within our service.

Process

Goal

Initially, we established the goals we aimed to accomplish through the utilization of AI.

Data

Subsequently, we delineated the data we needed to acquire in order to attain our goals.

Algorithm

Starting from the data, we selected the algorithms that could effectively achieve the goals we had set.

SMART METER 2G

What is a smart meter?

A Meter is the device whose purpose is to measure the consumption of electricity that is used by the end customer. This measurement is made in kWh. There are 2 types of meter: the **mechanical meter** and the **electrical meter**[10].

The mechanical meter is a non-electronic meter that displays consumption directly from the dial but **can't record usage by time slots** and lack circuit breakers, making them unsuitable as safety devices. They have been replaced by electronic meters, which are more accurate and safer. These modern meters can measure energy by time bands and provide detailed information on consumption.

A **2G smart meter** is an advanced electrical meter that records your energy consumption **every 15 minutes** and sends the data to a central system for accurate billing. Benefits include:

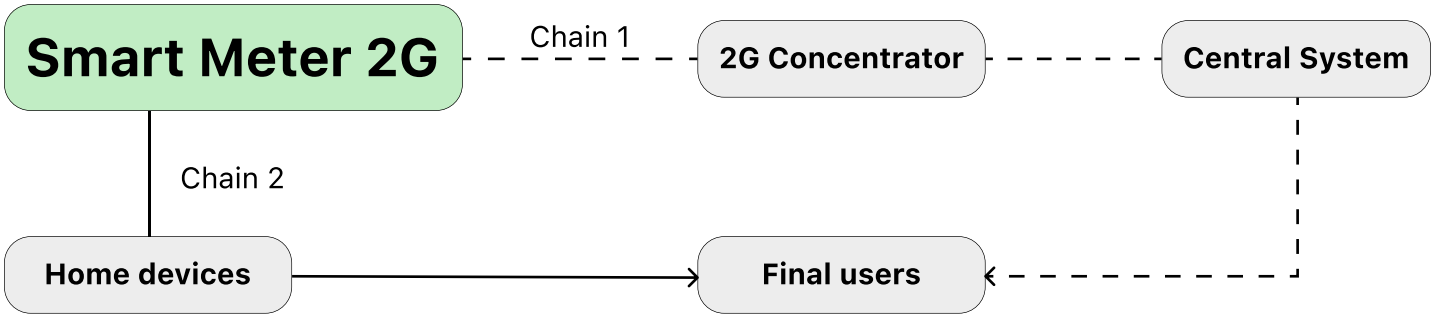
1. **Accurate Measurements**: Reduces estimated bills by providing precise consumption data.
2. It enables **two-way communication** between the meter and the supplier.
3. **Consumption Awareness**: Allows real-time monitoring and detailed tracking of energy use, aiding in energy saving.
4. **Smart Grid Integration**: Enhances grid efficiency and sustainability, supporting dynamic electricity pricing and better handling of energy peaks.

Availability

Throughout Italy, distributors are implementing smart metering systems that offer advanced features as mandated by Italian Legislative Decree 102/2014, which enforces the EU Directive 2012/27/EU on energy efficiency[11]. This upgrade is provided at no cost to consumers. Currently, all Italian distributors are actively rolling out these smart meters, having already reached millions of households. In a few years, every home in Italy is **expected to have a smart meter installed**, significantly enhancing energy management and efficiency across the country.

AI opportunities

Leveraging data from 2G smart meters, AI algorithms can revolutionize energy management by providing precise consumption insights, enabling real-time monitoring, and enhancing billing accuracy. These algorithms support dynamic pricing models, optimize grid efficiency, and identify energy-saving opportunities. By analyzing detailed consumption patterns, AI can forecast demand, detect anomalies, and disaggregate appliance usage, empowering users to make informed decisions about their energy use, ultimately promoting sustainability and reducing costs.



MAIN DATA SOURCES

ARERA Database

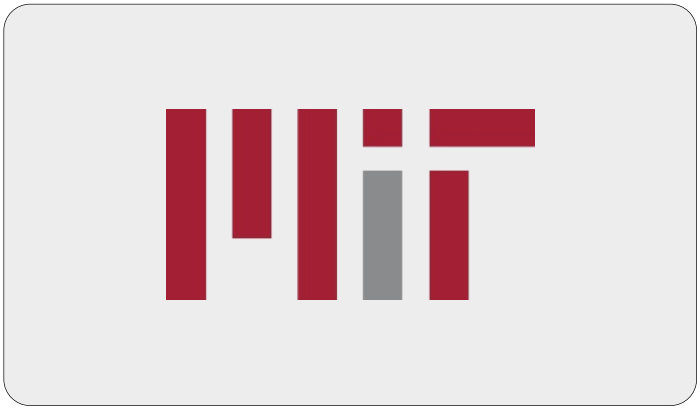
ARERA has a consumption portal[9] (**Portale Dei Consumi**), that gives access to the final user to the **reading of their meters.** This data is legitimately available to the distributor, the Integrated Information System (SII), and the seller. The distributor, responsible for the measurement activity, **conducts readings according to the minimum frequency established** by ARERA regulations.
SII acquires the validated measurement data from the distributor and notifies its availability to the sellers. The SII is managed by Acquirente Unico, an entity under the control of ARERA.
This data is already used by ARERA to for **creating personalized offers and improving energy efficiency,** as long as it adheres to privacy regulations. As ARERA, we have access to this data. However, since this is currently a project, we cannot physically access it yet.





REDD Database

The Reference Energy Disaggregation Dataset (REDD)[12] is a publicly available dataset designed to **further research in the field of energy disaggregation.** Introduced by J. Zico Kolter and Matthew J. Johnson in 2011, REDD contains **detailed power usage information** from several homes, making it a **valuable resource for developing algorithms that determine individual appliance** contributions from aggregated electricity signals. The dataset includes both high-frequency (kHz) and low-frequency (Hz) data.
The high-frequency data consist of current and voltage measurements, while the low-frequency data cover power measurements of individual circuits within the houses.



Weather Spark

WeatherSpark[13] is a dataset that **contains detailed historical weather** information for a specific location. These datasets typically include various a lot of **meteorological parameters recorded** over a certain period, like temperature, humidity, precipitations, extreme events.



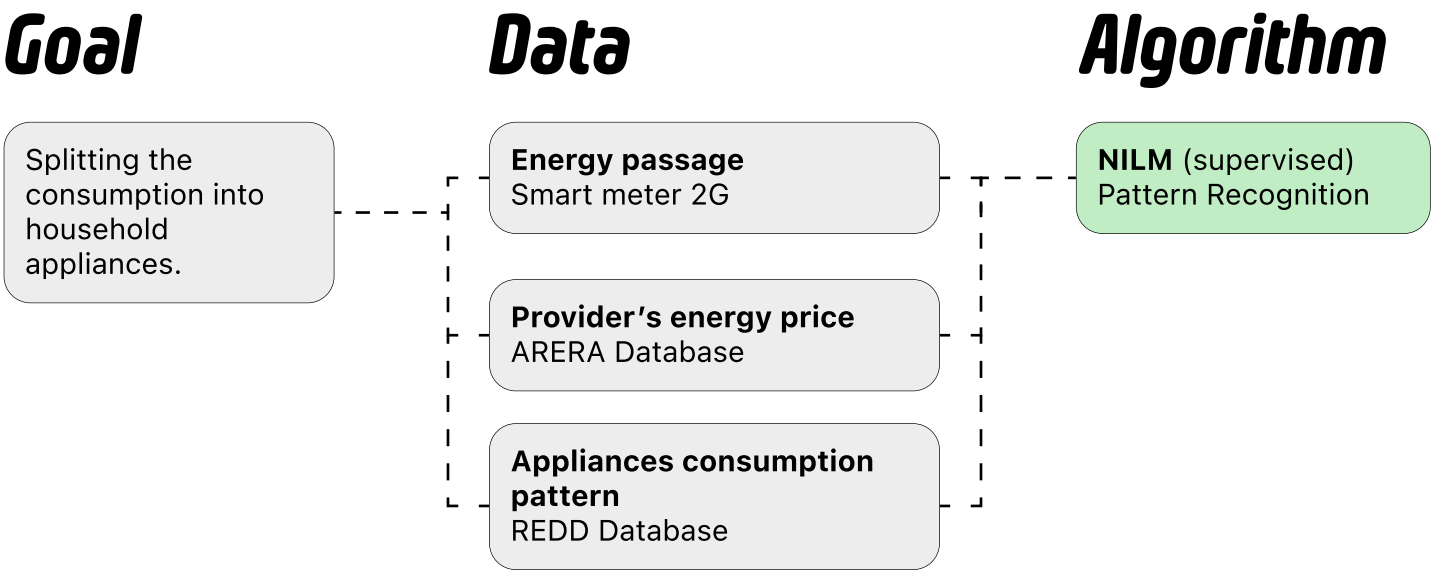
ENERGY DISAGGREGATION

Energy Disaggregation employs a range of statistical techniques to derive specific end-use or **appliance-level information** from a comprehensive building energy signal, all without needing individual plug-level sensors. It's highly anticipated as a transformative energy data analytics technology in both residential and small commercial sectors.
A policy paper by Stanford researchers[14] describes Energy Disaggregation as the "Holy Grail of Energy Efficiency," emphasizing its potential to harness Smart Meter investments for substantial, **low-cost energy savings by more effectively engaging consumers**. Smart Meters collecting detailed data from millions of homes, and initiatives like Home Area Network and Green Button making this data accessible, Energy Disaggregation represents a new era in energy management, combining non-intrusive and effective methods to **optimize energy usage.**

Energy disaggregation is proved to have a **significant impact on the final user,** enhancing energy management capabilities.[15] Benefits from this technique include:

1. **Increased Awareness and Engagement:** Energy disaggregation boosts consumer awareness by detailing appliance-specific energy use, encouraging more mindful behavior and energy-efficient practices.
2. **Behavioral Change:** Identifying energy-intensive devices helps consumers take targeted actions to reduce consumption, achieving up to 15% energy savings through altered behavior and usage patterns
3. **Informed Decision Making:** Detailed consumption data allows consumers to make informed choices about appliance usage and replacements, leading to long-term energy savings and cost reductions.

The goal is to accurately disaggregate monthly energy usage to show users the **impact of each appliance** on their final bill. This information empowers users to manage and reduce their energy consumption, promoting energy efficiency and conservation behaviours. To achieve this, we will use an **energy disaggregation algorithm**.



ENERGY DISAGGREGATION

NILM

Non-Intrusive Load Monitoring (NILM)[16] is a sophisticated technique used to **track and analyze the energy consumption of individual devices within a household** or building **from a single aggregate electrical signal**, such as the total power consumption recorded by a smart meter. This method eliminates the need for installing separate sensors on each appliance, thereby reducing hardware costs and installation complexity.

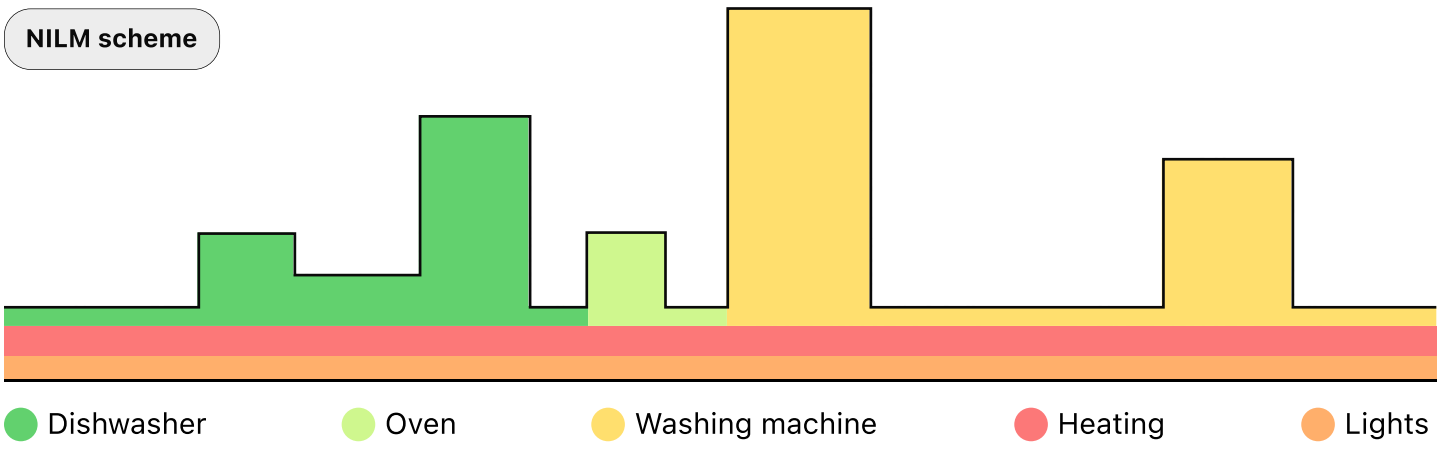
During the training phase of NILM, **historical data is analyzed** to determine the likelihood of a device being in various operational states at different times. This involves **collecting and processing large datasets** that capture the power usage patterns of multiple devices over time. The training phase aims to identify unique electrical signatures, or load signatures, of individual appliances, which include characteristics such as **changes in voltage, current, power, and frequency.**

NILM systems primarily rely on **detecting changes in voltage and current** to determine **when devices are switched on or off.** These changes are referred to as events. For example, when a device like a refrigerator compressor turns on, it creates a distinct pattern in the electrical signal that can be recognized by the NILM system. The system then uses machine learning algorithms, such as **deep neural networks (DNNs)**[17] to classify these patterns and **match them to specific devices.**

The data processing in NILM involves several steps. Initially, the aggregate electrical signal is monitored in real time. When a change is detected, **the system segments this event and extracts features** that describe the characteristics of the change. These features might include the magnitude and duration of the change, the shape of the signal, and the timing of the event. The system then compares these features against the trained models to **identify the most likely source of the change.**

In more advanced implementations, NILM systems can also **account for devices with variable power consumption patterns** and those with multiple operating states. This involves creating more complex models that can accurately **disaggregate the energy usage even when devices do not follow simple on/off** patterns. For instance, devices like dimmable lights or variable-speed pumps require sophisticated algorithms to correctly identify their power consumption patterns.[18]

Overall, NILM provides a powerful tool for energy management, allowing for **detailed monitoring** and analysis of energy consumption without intrusive hardware installations. This information can be used for various applications, **including energy efficiency optimization, demand response, anomaly detection, and even predictive maintenance.**



FORECASTING + CLUSTERING

A report by the American Council for an Energy-Efficient Economy (ACEEE)[19] reviewed multiple programs and found that energy feedback programs can lead to sustained energy savings over time. These programs provide users with detailed information about their energy consumption, often **comparing it to past usage or the usage of similar households.** On average, households continued to save energy even after the initial feedback period, indicating that the feedback prompted lasting behavioral changes. This suggests that once **users become aware of their energy consumption patterns and potential savings,** they tend to adopt more energy-efficient habits that persist over time.

Additionally, a study by McCalley and Midden[20] **explored the impact of goal setting on household energy consumption.** They found that households given specific energy-saving goals reduced their energy usage by about 12% compared to those who were not given specific goals. **This finding highlights the importance of setting clear benchmarks** or goals to motivate behavior change. When households have concrete targets to aim for, they are more likely to take action to reduce their energy consumption. The study underscores that **providing specific, achievable goals can be a powerful tool in encouraging energy-saving behaviors** and enhancing energy efficiency programs.

The goal is to **accurately predict monthly energy usage for domestic purposes** at the beginning of each month. This prediction serves as a benchmark for users, encouraging them to actively **manage and reduce their energy consumption** below the forecasted amount, thus promoting energy efficiency and conservation behaviors. To achieve this goal we are going to use a **forecasting algorithm.**

Goal
Predict monthly domestic energy usage at the start of each month

Data

Historical consumption data
ARERA Database + Smart Meter

Consumption data of users within the same cluster
Clustering results

Weather Variables
Weather Spark Database

Temporal Variables
Day of the week, seasonality...

Algorithm
Forecasting
Deep Neural Network

Since individual user data may be insufficient to make highly accurate predictions, we are also **incorporating data from similar users** to enhance the accuracy of our forecasts. To achieve this, we will use a **clustering algorithm** to group users based on their consumption patterns. This approach allows us to **leverage the collective data from users with similar behaviors**, leading to more reliable predictions.

Goal
Enhance prediction accuracy, by clustering users based on their consumption patterns

Data

Historical consumption data
Household settings
Geographical data
ARERA Database

Temporal Variables
Day of the week, seasonality...

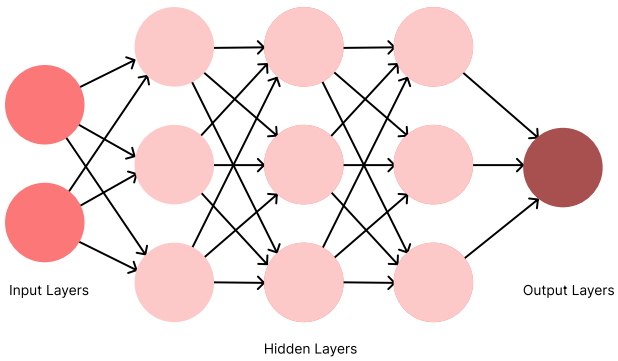
Algorithm
Clustering
K-Means

FORECASTING + CLUSTERING

DNN

At first, we considered using a simple polynomial regression model for our forecasting algorithm due to its straightforward implementation and ability to fit non-linear data. Polynomial regression **extends the capabilities of linear regression by considering polynomial terms,** which can capture the **non-linear relationships between the input variables and the target variable**, in our case, the monthly energy usage. However, polynomial regression can be limited by its tendency to overfit the training data, especially when dealing with higher-degree polynomials and complex datasets with many interacting variables.

Given the multifaceted nature of energy consumption, influenced by numerous factors, we ultimately opted for a **Deep Neural Network (DNN) algorithm.** DNNs are well-suited to **handle the complexity and high dimensionality** of our dataset due to their hierarchical structure, which enables the automatic extraction of features and the modelling of intricate relationships among variables.
A typical DNN consists of **multiple layers of neurons, including an input layer, several hidden layers, and an output layer.** Each neuron in a layer is connected to every neuron in the subsequent layer, with each connection associated with a weight that is learned during training. The network employs **non-linear activation functions** to introduce non-linearity, allowing it to model complex patterns in the data.



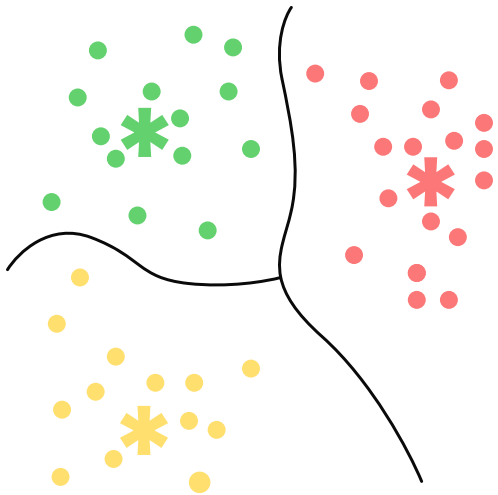
DNN scheme

K-Means

Data preprocessing involves normalization and feature engineering. Normalization scales consumption data, demographic information, weather conditions, and other variables to a common range, ensuring equal feature contribution to distance calculations. Feature engineering constructs features that capture aspects of energy consumption like **daily usage profiles, peak usage times, seasonal variations, and appliance usage patterns.**

The K-Means clustering algorithm partitions users into kkk clusters based on their feature vectors, **minimizing the sum of squared distances between users and cluster centroids.**
The clustering process begins with random initialization of kkk centroids. Users are then assigned to the nearest centroid, and centroids are recalculated as the mean of assigned users. This assignment and update process repeats until convergence.
Cluster information is incorporated into the forecasting model by augmenting user data with **cluster-based features** like centroid coordinates or labels. This enhances the training set for the Deep Neural Network (DNN) model, **improving predictive accuracy.**

Continuous improvement involves dynamic clustering to **update the model with changing consumption patterns** and incorporating user **feedback to refine clusters.**[21]



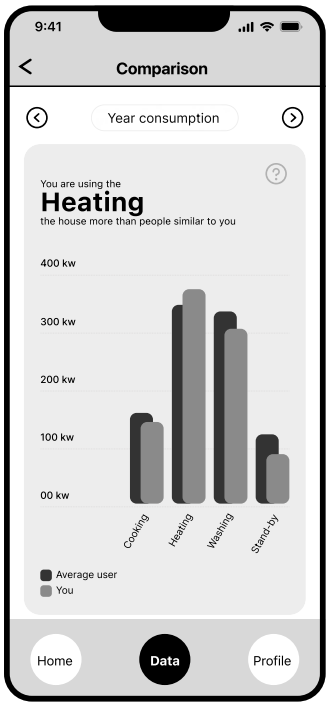
K-Means scheme

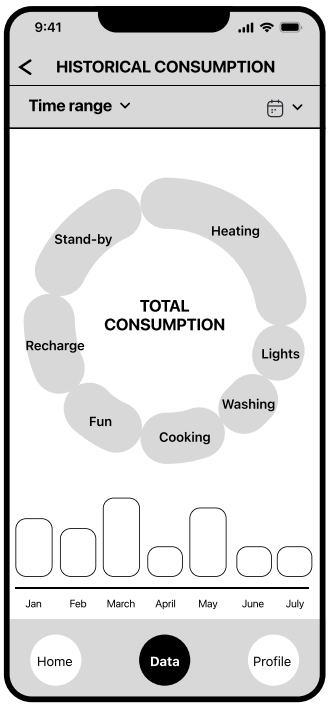
WIREFRAMES & HOMIE

Once we understood the content of the various screens, we began **to develop wireframes to organise the elements of the application**, visualise the complexity of the graph and divide the data in the different sections (a). However, we soon realised that our initial approach lacked a clear narrative and risked confusion and cognitive overload rather than clarity for the user.
We needed **a metaphor** to help us manage the complexity of data visualisation and the reduction in data volume.
We went back to basics with paper wireframes (b), focusing on simplifying energy information and creating clear, intuitive data visualisations. Our aim was to make the interface more user-friendly and engaging, and to **reduce the cognitive overload of the amount of data.**

When creating the mid-fidelity wireframes, the challenge was to find an engaging and intuitive scale to represent energy consumption.
This led to the creation of **Homie** (c): a distinctive colour scale designed to visually represent the user's progress towards their energy consumption goals. **Homie has five statuses** that indicate how well the user's energy consumption matches the AI's predictions.
When the user consumes less energy than predicted, Homie is labeled "Excellent" and shown in green, indicating efficient energy use.
If consumption matches the AI's prediction, Homie is labeled "Mediocre" and displayed in yellow. However, if the user consumes significantly more energy than predicted, Homie is labeled "Terrible" and appears in red.

(a)

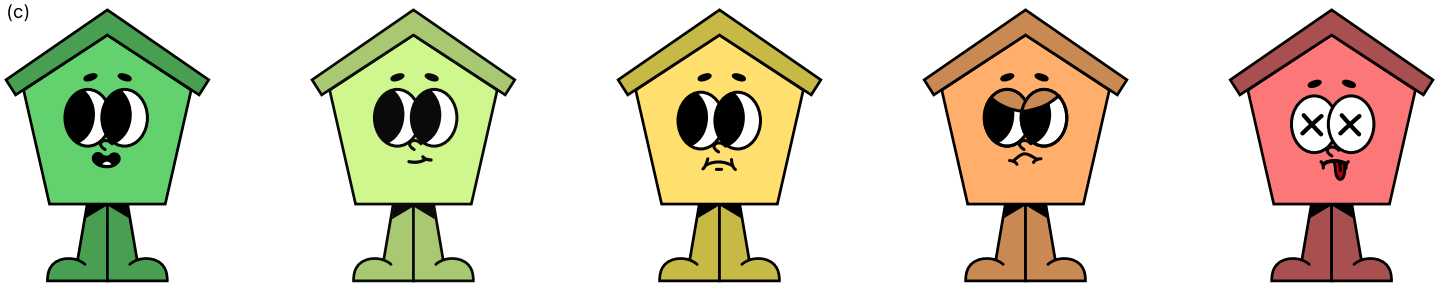




(b)

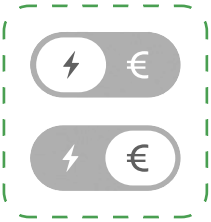


(c)



DESIGN SYSTEM

Our design system has been design to **simplify and make engaging the complexity of energy data.** The use of cards, vibrant colors and Homie methafor makes the application **user-friendly** and youthful. Buttons consistently follow the same rules and aid interaction. **Buttons for the calendar and dropdown menus** simplify and intuitively enhance the usability of charts and data within the app, adhering to the chosen style.



H1 48PT / 100 SF PRO BOLD

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H2 32PT / 100 SF PRO BOLD

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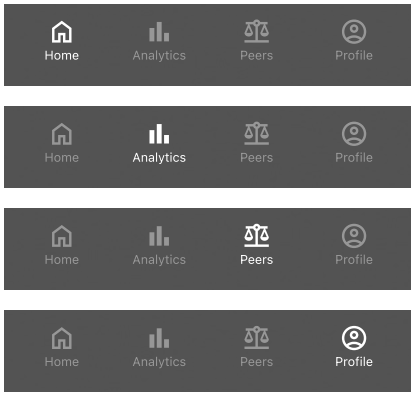
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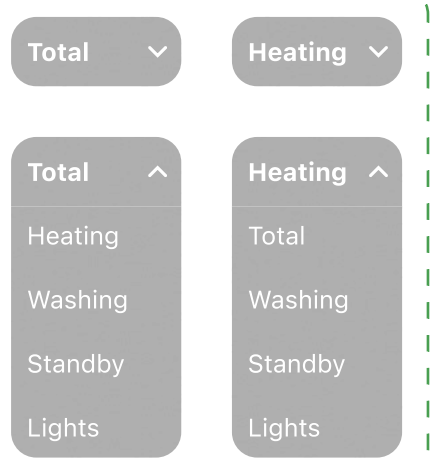
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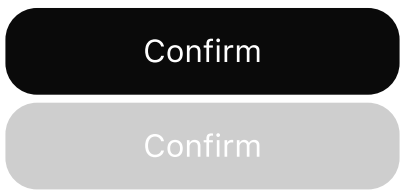




	EXCELLENT HOMIE	GOOD HOMIE	AVERAGE HOMIE	BAD HOMIE	TERRIBLE HOMIE
Black #0A0A0A					
Dark grey #616161	#63D26E	#D0F88E	#FFDF6E	#FFAF6B	#FC7878
Light grey #EDEDED	#C1EDC5	#EFFFD5	#FFF2C5	#FFDFC4	#FEC9C9
White #FFFFFF	#49A052	#A9C973	#C6BA46	#CA8A53	#A94F4F

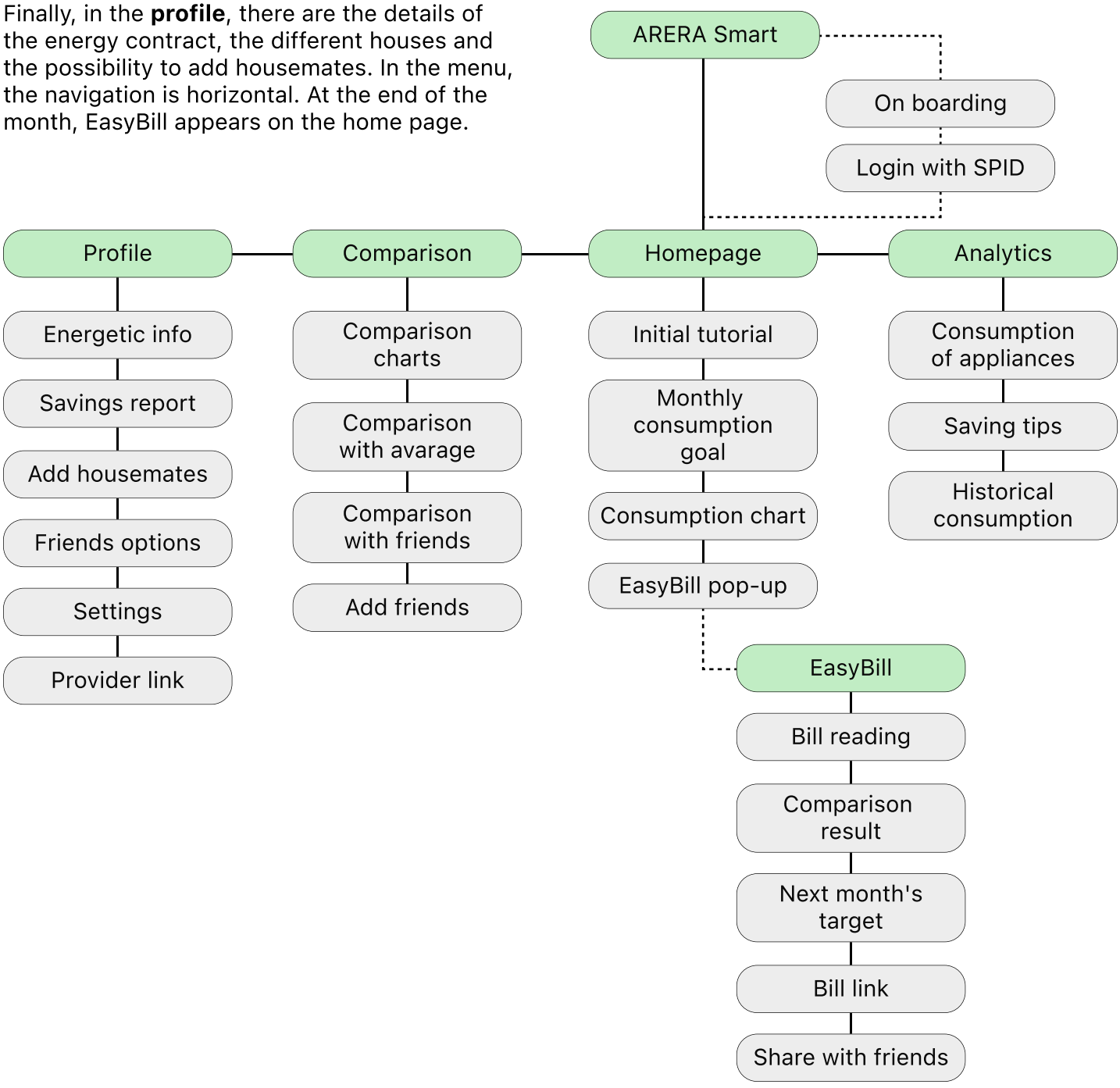






INFORMATION ARCHITECTURE

To clarify the content of each section, we developed an information architecture.
The **home page** contains the most relevant content and information that is useful to the user at first glance. The **analysis** contains the historical consumption per appliance and some related weekly tips. The **peers section** allows the user to compare himself with the average or with his friends and to see the graphs of the year or the ranking of his friends.
Finally, in the **profile**, there are the details of the energy contract, the different houses and the possibility to add housemates. In the menu, the navigation is horizontal. At the end of the month, EasyBill appears on the home page.

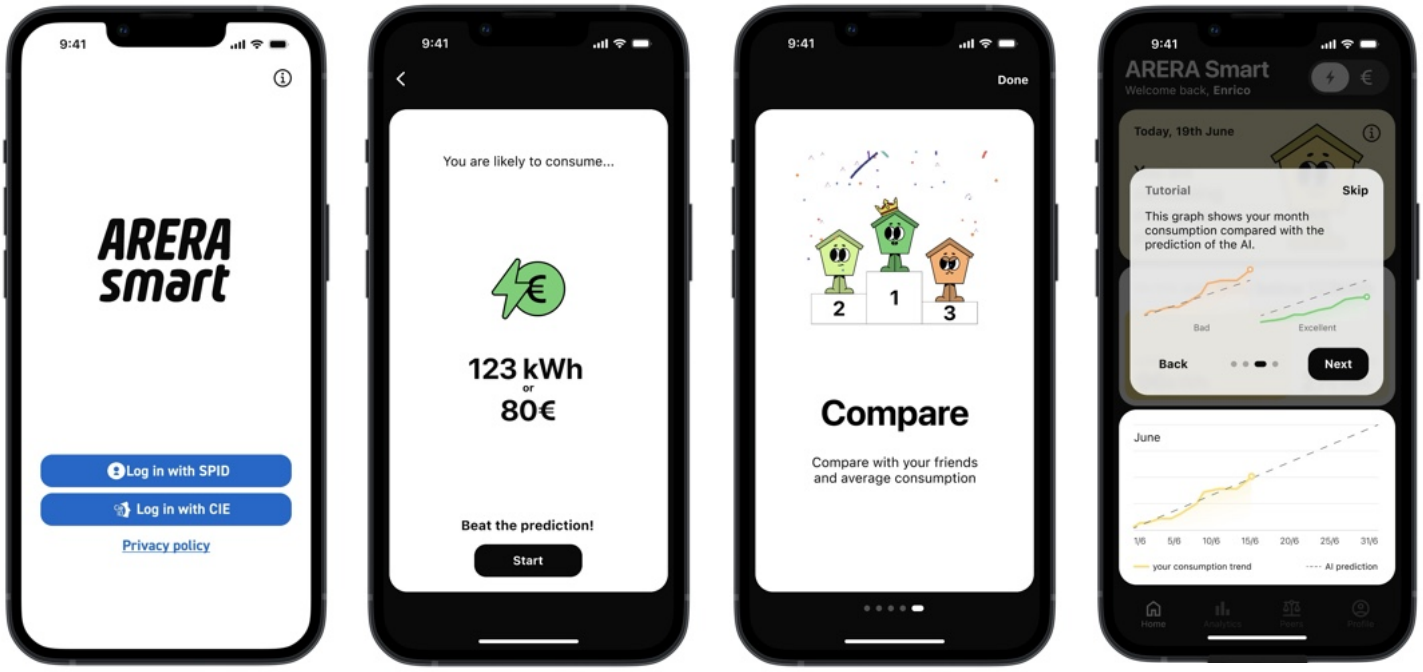


ONBOARDING/TUTORIAL

The ARERA Smart experience begins with an **onboarding process** that visually introduces the app's main features through four swipeable screens. These screens explain the **service's context and purpose.** After onboarding, users complete the SPID login and receive an **AI-calculated energy-saving target** for the next month. Afterward, the user is ready to start their experience. Before navigating the application, a tutorial explains the **four main sections** of the home page, helping the user to understand the system and how it works.

UX & UI principles

The information is divided across multiple screens to **prevent information overload and aid users' selective attention**.
Important buttons are easily accessible, following **Fitt's law**.
The flow always proceeds with horizontal navigation, creating consistency and promoting usability. Information about how user data is collected is available through info pop-ups, providing **help and documentation**. Icons used to represent service features are intuitive and match real-world counterparts.
After onboarding, a step-by-step tutorial explains homepage layouts, offering comprehensive information and explanations.
Users always have the option to navigate back to **prevent errors**.



HOME

On the homepage, we focused on avoiding information overload by highlighting only the most useful data for the user. Here, **users can track their energy consumption progress against AI predictions**. The app's character, **Homie, changes its appearance daily** to reflect consumption levels, and the homepage color adapts to show progress clearly.
A graph below outlines the monthly goal, displaying how much energy has been used and what remains compared to the prediction.
This color-coded system helps users easily analize their alignment with the AI prediction.
Additionally, the final card provides a monthly overview, comparing actual consumption trends to the AI forecast.
A **switch button** at the top lets users change the unit of measurement from energy to euros, allowing them to track progress in their preferred format for better clarity and usefulness.

UX & UI principles

The information is organized into distinct sections or "cards" to make it easier to digest. **Important data are highlighted** with bold text and larger font size, and the daily consumption trend is clearly indicated. **To avoid information overload**, users can select the unit of measurement they prefer to view the data in. The trend chart is an effective way to visualize the user's consumption compared to the AI's prediction. Additional explanatory information, such as the meaning of the "Homie" scale, is available through an info icon.
This allows the user to access supplementary details as needed, without cluttering the main interface.



ANALYTICS

A key challenge was **simplifying the complexity** of the consumption data for easy understanding, that is also **divided by appliances** thanks to AI. On the Analytics page, users see **current and past monthly consumption**, categorized by usage, such as 'Cooking' for kitchen appliances. Each category shows its **percentage and energy** consumed, with graphs proportional to the first for easy comparison.
Clicking on a category reveals **detailed appliance usage**. To help reduce consumption, a 'weekly tip' suggests habits to adopt. **Users can switch the unit of measurement here**, and the choice remains consistent with the home page for clarity.

UX & UI principles

The analytics initially show the current month's data, keeping the experience consistent with the rest of the application.
The consumption data is **organized into easier to understand categories**, rather than individual appliances.
Category bars are proportional to the first group: clicking on them reveals specifics appliances data with intuitive icons, fully coloring the bar with animation. **Help and documentation** on the data calculations is always available through the recognizable info icon.
To customize the experience, the user can switch the unit of measurement, which remains consistent across the application.
The calendar button allows the user to view analytics for other months beyond the current one. The **color coding** of the data cards provides immediate visual feedback, indicating how the user's consumption compares to the AI's prediction for that month.
This adds an extra layer of contextual information to the analytics.



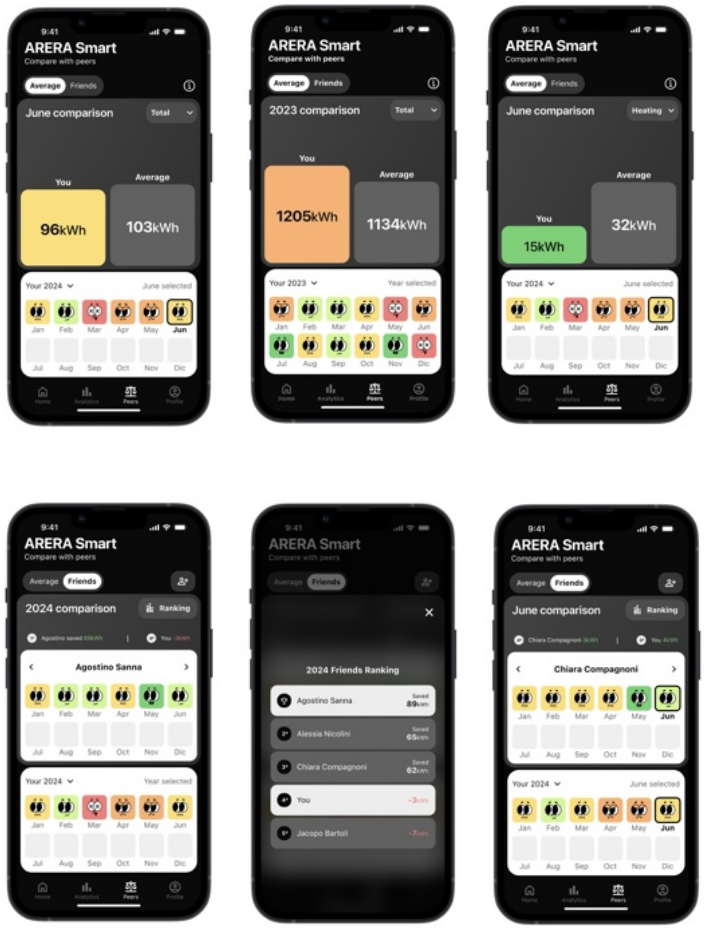
PEERS

The Peers section aims to **compare the user's consumption** with others to help them understand if their usage is average. Initially, it compares their consumption with the **average** of people in the same area and household size (data provided by ARERA). The first part features a bar graph comparing the user's consumption with the average for the current month's total energy usage. Users can select specific **consumption categories** from a dropdown menu or choose another month from the overview below, where they can also see the Homie figures for different months and switch the comparison year.

The bar graph keeps the average column centered, adjusting the user's column accordingly.
From Peers, users can access the **Friends section** to compare their consumption with friends, encouraging mutual savings. Here, users can view specific months or the entire year and see a complete leaderboard. Since friends might have different consumption levels and not fit into the same average category, comparisons are **based on kWh saved**. Additionally, due to varying energy rates, switching between units of measurement is not available in this section.

UX & UI principles

The comparison chart is a very useful tool, allowing the user to directly see how their consumption compares to the average user. At the bottom of the screen, the user can easily select a specific month to view.
The information is **well-prioritized**, with interactive elements, important data, and less critical details clearly distinguishable. The Info icon provides access to **helpful documentation**, such as explanations on how the averages are calculated, without disrupting the user experience. Following **Hick's law**, the options have been reduced: the user can only choose one appliance at a time and one month at a time. Color coding is crucial - the size and color of the bars immediately convey the user's consumption trend. The different "Homie" characters further reinforce this trend information for each month. In the "Friends" section, the cards have a **distinct appearance compared** to the user's own data, clearly differentiating the two views. The dropdown selection menu is consistent with the overall UI, enabling smooth user interaction.

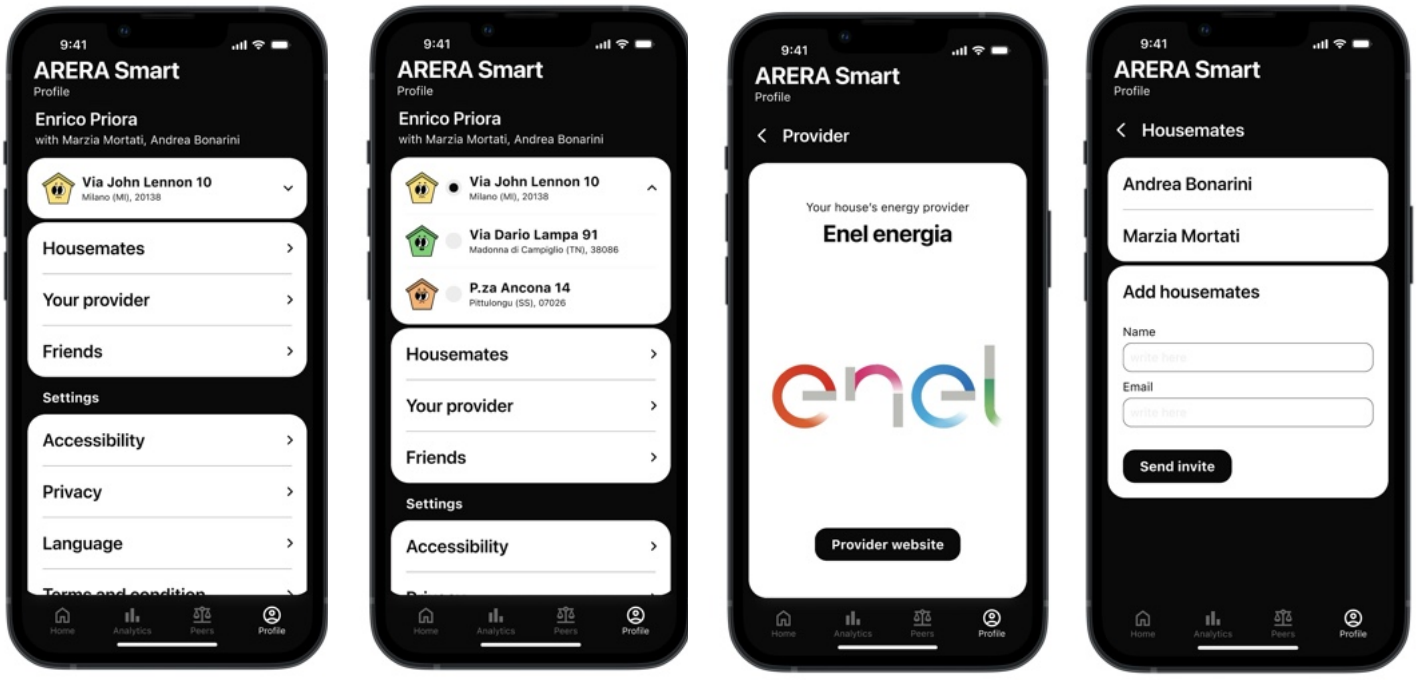


PROFILE

In the Profile section, users can **add housemates** to share their profile, enabling multiple people to access ARERA Smart. If users have different bills under their name, they can switch between **different households**, effectively changing the profile. The Profile also allows users to access **their provider's information** by redirecting them to the provider's personal area. Additionally, users can manage their friends from this section.

UX & UI principles

The subsections are divided by topic into cards, according to the **common region principle**: this also applies a clear hierarchy and, following the magic number **seven rule**, avoids information overload by presenting information in chunks.
The house selection follows the style of the drop-down menus used throughout the application, **providing consistency to the system**. As switching the house may be the most frequently used option by users, it is positioned as before, has an icon and does not lead to another page but rather allows the energy contract switch directly from the profile.

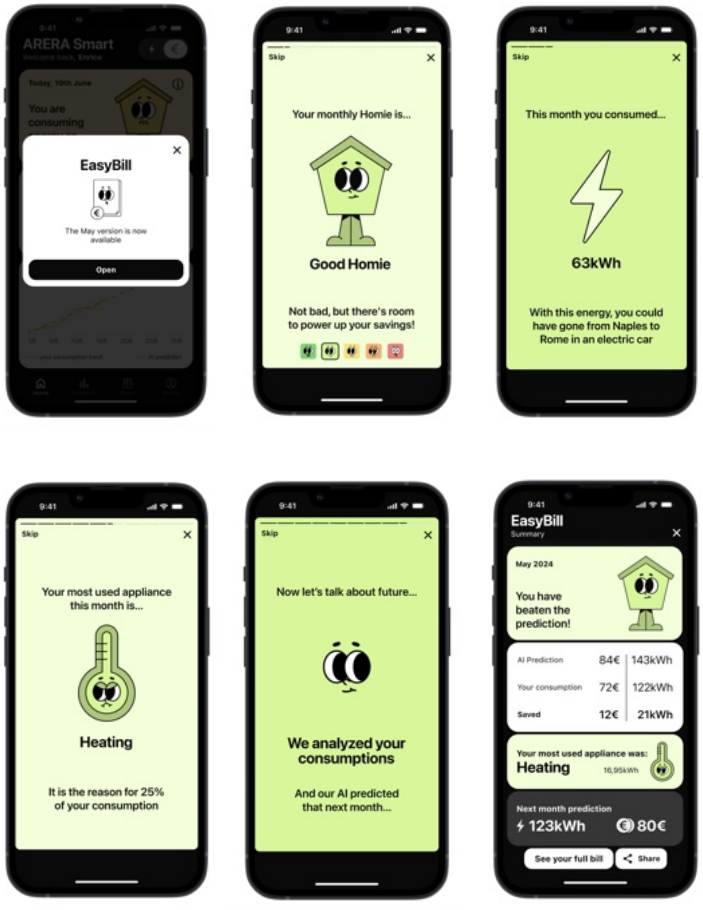


EASYBILL

EasyBill offers a smart and **engaging way to read the bill**, transforming the typically tedious experience. At the end of each month, users are notified when EasyBill is available. A pop-up in the app provides access, and a widget remains on the home screen during the first week of the following month to re-access the EasyBill.
Clicking the pop-up starts the experience: users are guided through several screens, **summarizing their monthly consumption**.
The screens are styled like Instagram Stories and Spotify Wrapped, so they are familiar to the user. Each screen presents useful data, such as **kWh consumed,** with appealing aesthetics and simple metaphors to make the information accessible. At the end of the bill reading, the user **can see the prediction** made by AI for the following month. The summary provides an **overview of the month** and includes a button to access the actual bill on the provider's site. Additionally, the summary is shareable, allowing the bill owner to easily share it with housemates.

UX & UI principles

Data is divided into different screens, **avoiding information overload**. The style of the EasyBill is similar to popular formats like Spotify Wrapped and social media Stories, creating an iconic and easily **recognizable interface**.
The buttons to skip the experience or close it are not easily reachable according to with **Fitt's law**, making it less convenient for the user to prematurely leave the experience. This encourages them to fully engage with the provided information. In the final summary screen, the data is organized into topical cards, not only grouping related information, but also **maintaining consistency** with the broader UI system. This adherence to principles like proximity helps create a cohesive, **user-friendly experience.** By thoughtfully structuring the information architecture and drawing inspiration from familiar design patterns, the EasyBill interface strikes a balance between comprehensive data and an intuitive, engaging presentation.



USER TEST

We conducted user tests to evaluate whether the application and complexity management were understandable for different target of users. The user tests were **divided into specific tasks**, each with subtasks to evaluate every part of the app and better assist the user. During the experience, users were asked to **speak aloud**, and at the end of each task, questions assessed their understanding and **difficulty level**.

We conducted four user tests for each cluster. The target selection was made to identify user clusters based on age and level of digital literacy. The first two clusters fall within our specific target and helped us understand various issues relevant to **tech-savvy individuals**. The third cluster, on the other hand, was designed to make the app as accessible as possible to those who are **not fully confident with technology**.

Target 1

Bill holders
Age 18-30
Level digitalization
High
Occupation
Off-site student

Target 2

Bill holders
Age 30-45
Level digitalization
Medium-high
Occupation
Tech-savvy worker

Target 3

Bill holders
Age 45-60
Level digitalization
Medium - low
Occupation
Worker

User flow - Questions

Flow 1
App interaction

Task 1
Understand monthly goal

Task 2
See historical consumption

Task 3
Peer comparison task

Task 4
Discover the profile

Flow 2
EasyBill

Task 5
Explore EasyBill

Questions

Questions per task
Level of difficulty

Users were asked to **complete onboarding** and visit the homepage to **assess their understanding** of consumption.

Users were asked to **view their consumption by appliance**, assess their understanding of the consumption, and **see historical consumption.**

In the third task, users were asked to **compare themselves with the average**, interact with graphs, and compare themselves with friends.

Explore the fourth task required **checking your provider**, **adding housemates**, and **changing your residence** in the profile section.

In the second user flow, the final task required to the user to **explore EasyBill** and **assess their understanding of the data**.

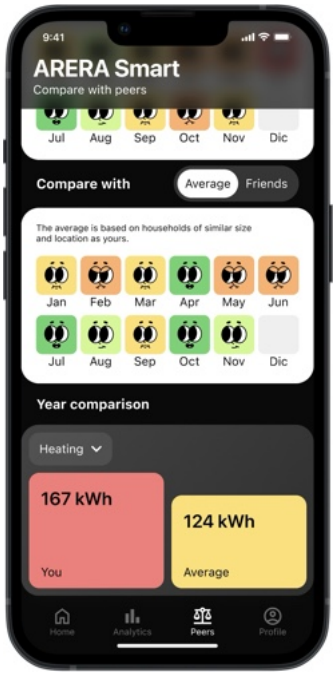
Specific questions were prepared for **each subtask**. In addition, after each task, we asked users to **rate the task using the SEQ scale.**

RESULTS - PEERS

Through the conducted user tests, we identified various issues within the application. Specifically, regarding the "Peers" page, most participants had difficulty **fully understanding the different comparisons**. The primary issue was with the visualization of graphs, which most users did not navigate because they did not scroll the page. Consequently, we moved the graphs to the top to facilitate comparison with the average.

Additionally, we **removed the "average village,"** which was confusing for users, who preferred the more intuitive graph. The month selection remained similar, but we added **a dropdown menu to view previous years.** In the "Friends" section, most users did not view the ranking because they did not scroll the page. To address this, **we added a button** to easily display it and a preview of the ranking at the top of the page.

First draft



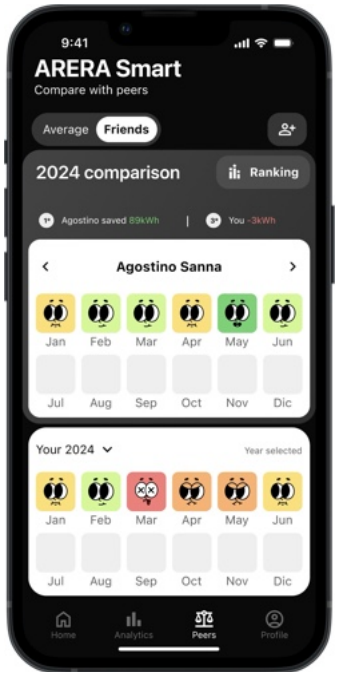




Final UI





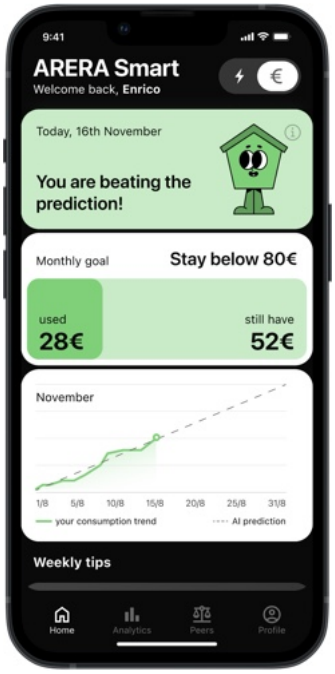


RESULTS

Another issue that emerged from user tests concerns the **understanding of the switch** from kWh to euros. Most users could not immediately understand the switch and needed a more detailed description of its functionalities on the home page. To address this problem, we decided to **include a tutorial** that appears on the user's first visit, guiding them through understanding all parts of the home page.

One more issue involved the tips, initially on the homepage. Users preferred **receiving tips alongside consumption data**, so we moved them to the analysis section within specific categories. Additionally, some users found difficult interact with the EasyBill stories. Consequently, we made the **story format more consistent with existing ones** (like instagram) and included a call to action on how to interact.

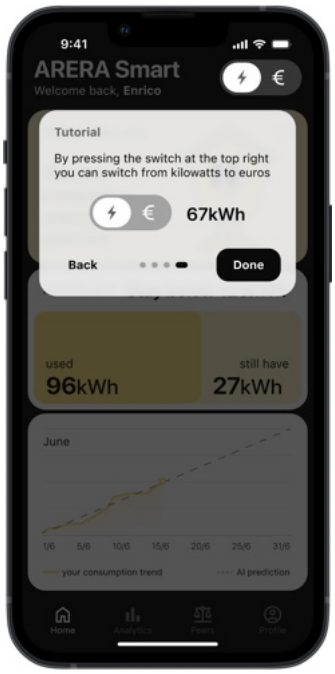
First draft



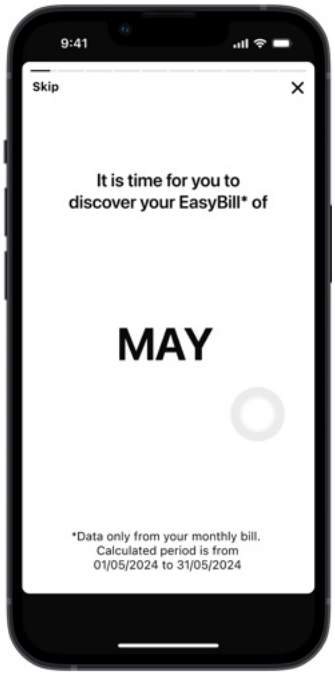




Final UI







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ARERA Smart