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AGGREGATION AND ENGAGEMENT OF END USERS AS KEY ENABLERS OF A SUSTAINABLE ENERGY TRANSITION

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INTRODUCTION

A sustainable energy transition cannot focus solely on the technical aspect of switching to renewable energy generation, but must also involve end users, who are most affected by its economic and social changes. Within this broader vision, the activity of the student project Catharsis aims to evaluate two complementary strategies: aggregation of users into Renewable Energy Communities (RECs) and modification of users' energy consumption habits.

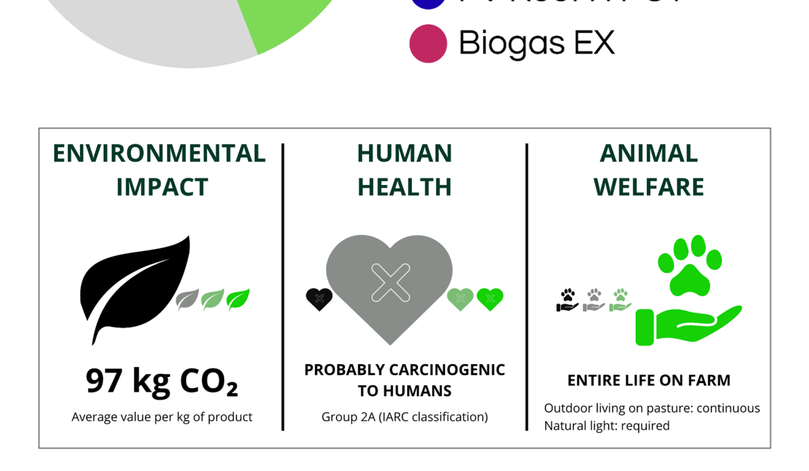
USERS AGGREGATION IN REC

METHODS

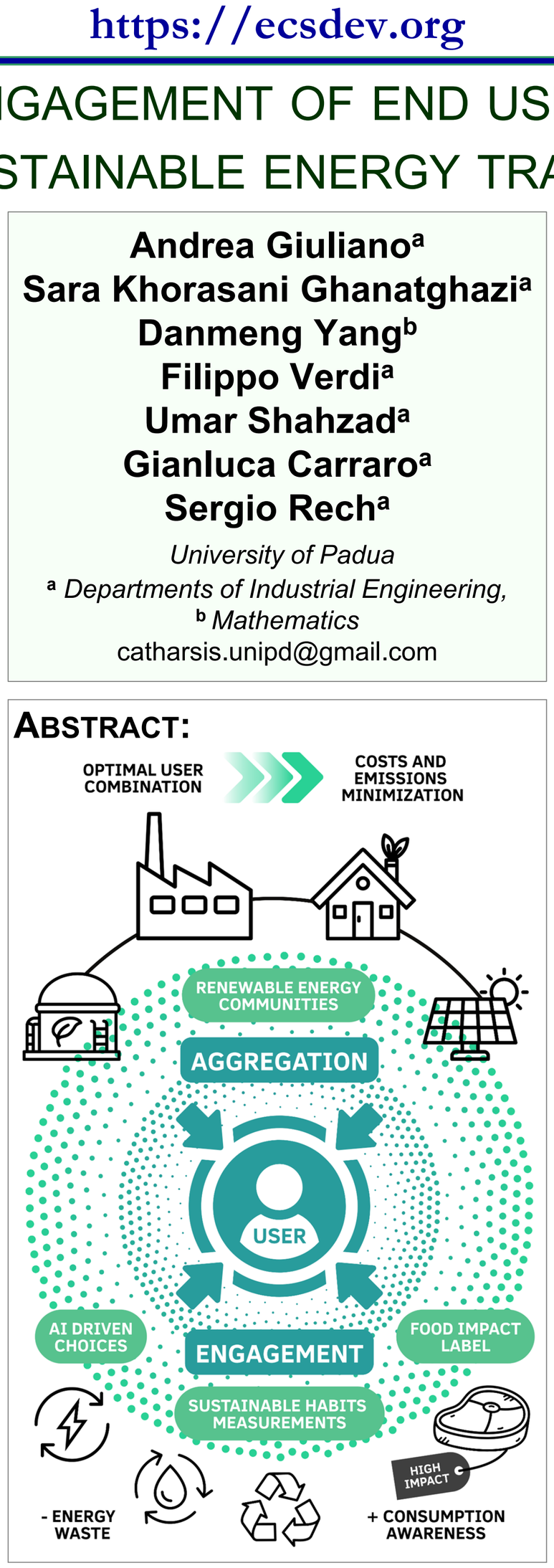
A Mixed Integer Linear Programming model was developed to identify optimal groupings of users in the area of Trieste, Italy. The goal is to minimize energy-related costs and CO_2 emissions by leveraging complementary demand and generation profiles, thus reducing imbalances between the usage of energy and the availability of renewables.

RESULTS

Industrial and tertiary users account for the majority of the final energy consumption. On the generation side (see the chart below), the major contributions come from conventional thermoelectric power and biomass, along with emerging photovoltaic potentials. The smart aggregation of industrial and tertiary users results to be particularly effective in increasing the penetration of photovoltaic systems, as their energy usage is typically daytime-oriented and relatively stable. Optimized user aggregation based on complementary demand and generation profiles improves the local self-consumption of renewable energy, reducing the need for storage systems and associated depletion of resources.



ABSTRACT:



COMMUNICATING THE FOOD CONSUMPTION IMPACT

METHODS

Studies show that labels highlighting environmental and health impacts of meat products reduce meat purchases, with pandemic and climate change warnings reducing meat consumption by up to 10% and 8% respectively. Combining these warnings with an animal welfare label could significantly improve the communication impact.

RESULTS

The proposed label shows CO_2 emissions, potential health impacts and animal living conditions on a graded colour scale with four levels, which is icon-based and intuitive. Below, two labels for beef and chicken meat.

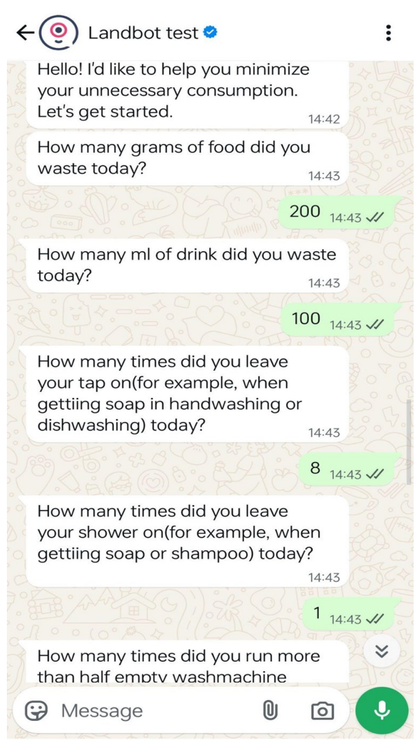
AN APP TO RAISE AWARENESS OF SUSTAINABLE HABITS

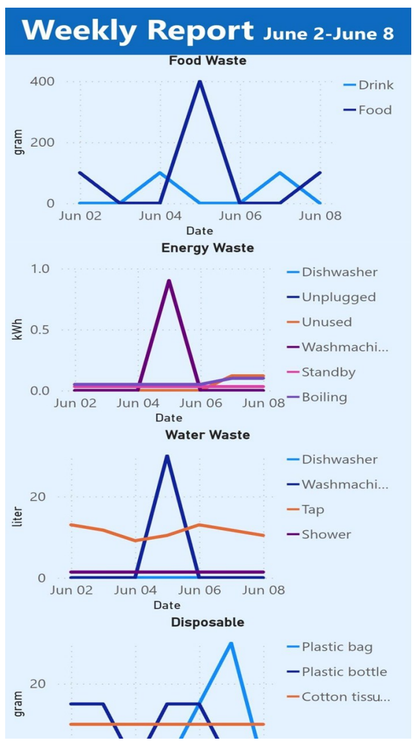
METHODS

In the proposed application, a chatbot was built to record and measure the impact of users' habits, while giving interventions for improvement. Daily self-reports collect users' evitable consumptions of 13 unsustainable habits in food, water and energy waste, as well as the use of evitable disposables. Weekly reports and practical suggestions are delivered as interventions to assist sustainable habit adoption.

RESULTS

Clear and straightforward data representation can raise users' awareness of the impact and cost of their habits. This application and framework can be applied to monitor sustainable daily behaviors.





ARTIFICIAL INTELLIGENCE TO REDUCE ENERGY CONSUMPTION

METHODS

The Home Energy Management System (HEMS) uses Internet of Things (IoT) sensors and smart controllers to monitor energy use in real-time, and an AI engine (e.g., a reinforcement learning agent with meta-heuristic optimization) to schedule appliances efficiently.

RESULTS

AI-assisted, IoT-based HEMS proves effective in reducing household energy consumption. Studies highlight that smart scheduling of appliances through HEMS enables substantial energy savings, thus reducing operational costs. For instance, the energy usage of Heating, Ventilation and Air Conditioning systems can be cut by 40%, and total domestic emissions can be reduced by a similar margin when AI can manage all domestic loads.

CONCLUSIONS

By combining optimized user aggregation in Renewable Energy Communities with data-driven behavioral interventions and effective communication, this project shows how end-user engagement drives a more efficient and inclusive energy transition. Awareness, monitoring systems and AI-supported choices empower individuals to adopt sustainable habits, pushing the transition from the bottom. These integrated strategies highlight the pivotal role of citizen participation in building a resilient, low-carbon society.