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# **Il Workshop Energy@Home** **Residential consumption** **and “smart consumer”**

26° November 2013





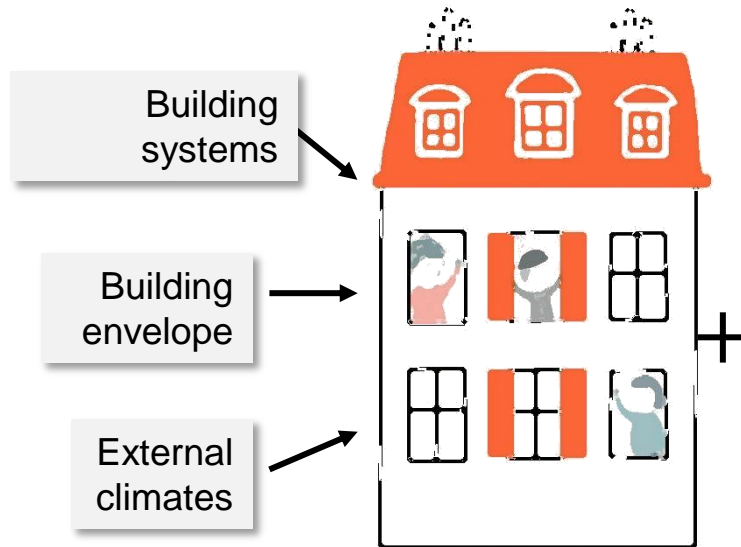
# BACKGROUND

RESIDENTIAL CONSUMPTION AND  
**SMART CONSUMER**

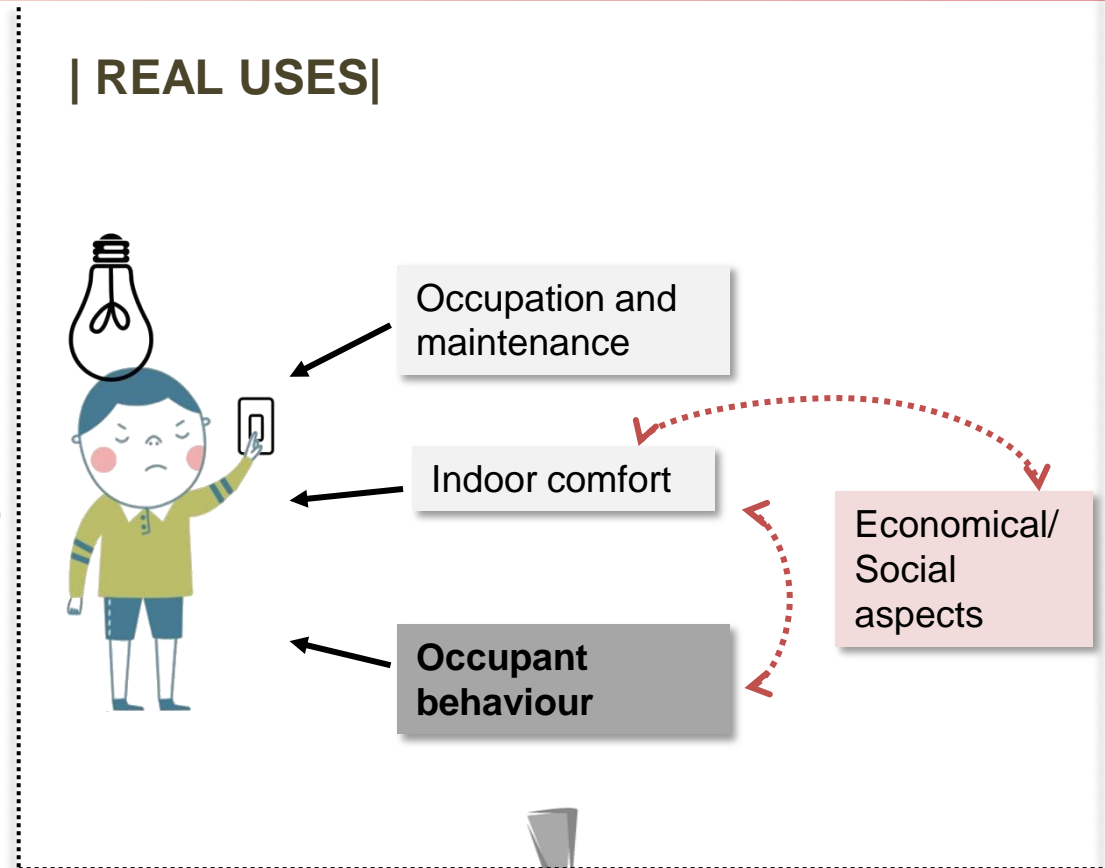


## ENERGY CONSUMPTION IN RESIDENTIAL BUILDINGS

### | BUILDING PERFORMANCE |



### | REAL USES |



**Crucial aspects** influencing real energy consumption in buildings



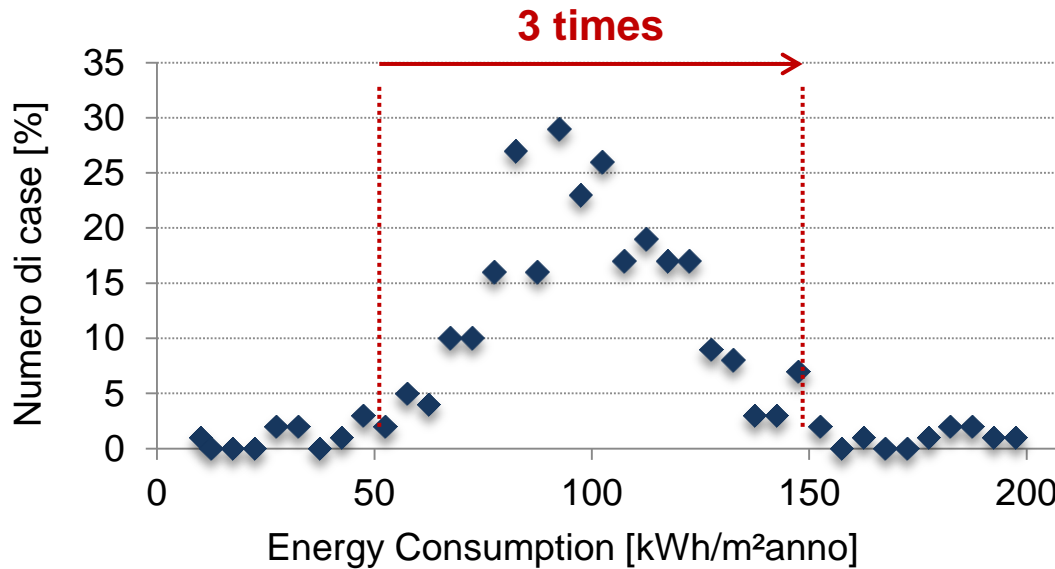
## ENERGY CONSUMPTION IN RESIDENTIAL BUILDINGS: occupant behaviour

**40%**  
Building sector  
Energy consumption  
in Europe

Salubrity

Comfort level

Energy consumption



Monitoring of 290  
[identical] dwellings  
in Denmark



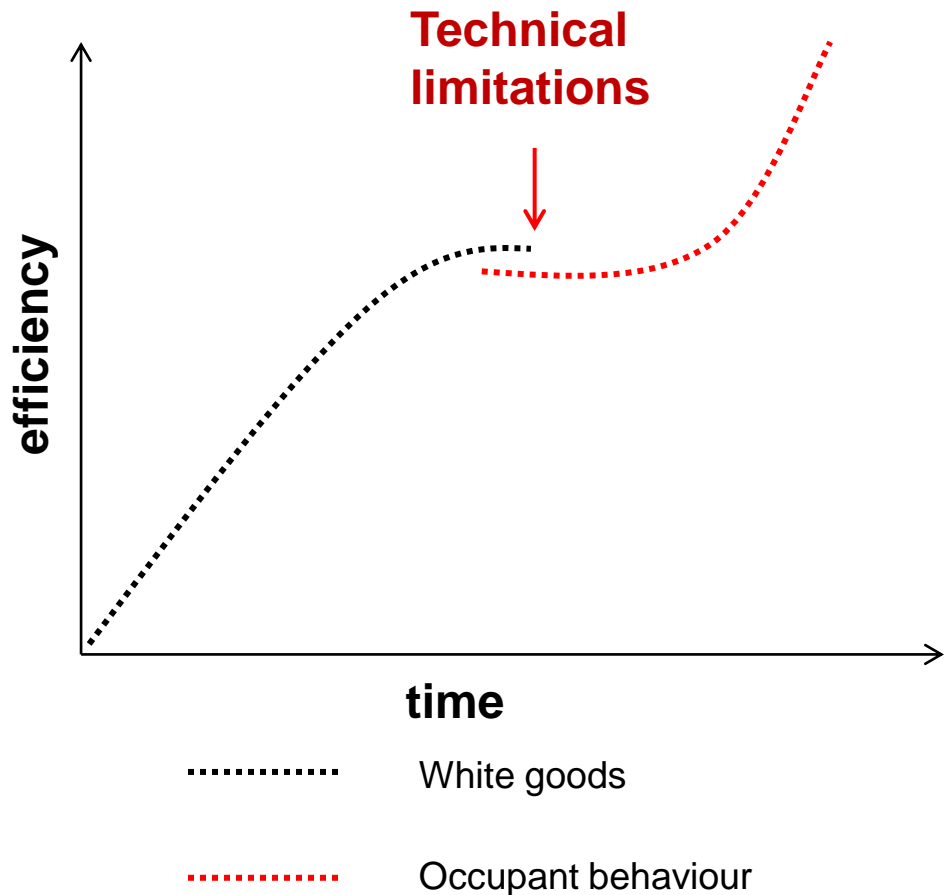
**Weakness** in replicating  
dynamics governing real uses in  
buildings

Energy consumption  
may vary  
up to

**▶ 150%**



## I CONSUMI ENERGETICI IN AMBITO RESIDENZIALE: il sistema casa



**White goods** reached asymptote in energy efficiency

**Occupant behaviour** is new driver for the enhancement of energy efficiency at home

Effect of awareness campaign and smart monitoring on energy consumption

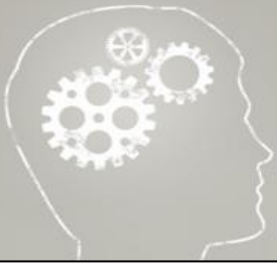
**▶ -15%\***

\*mean value accordingly to literature studies



# ANALYSIS METHODS

ENERGY CONSUMPTION AND  
**SMART CONSUMER**



# Il Workshop Energy@Home I consumi residenziali e lo “smart consumer”

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**THE BIG QUESTION**  
“how about the amount of  
energy we consume in  
our homes?”



**Energy@home**

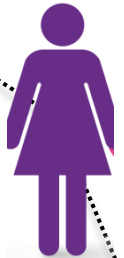
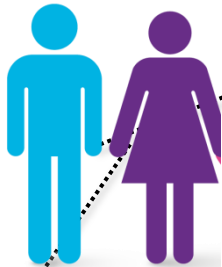
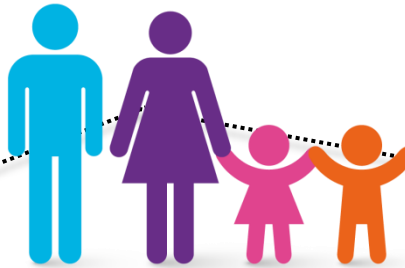


Improve occupant behaviour by means a **raise in awareness** in energy consumption at home.  
Usage of **real-time monitoring systems** and **persuasive communication** campaigns.





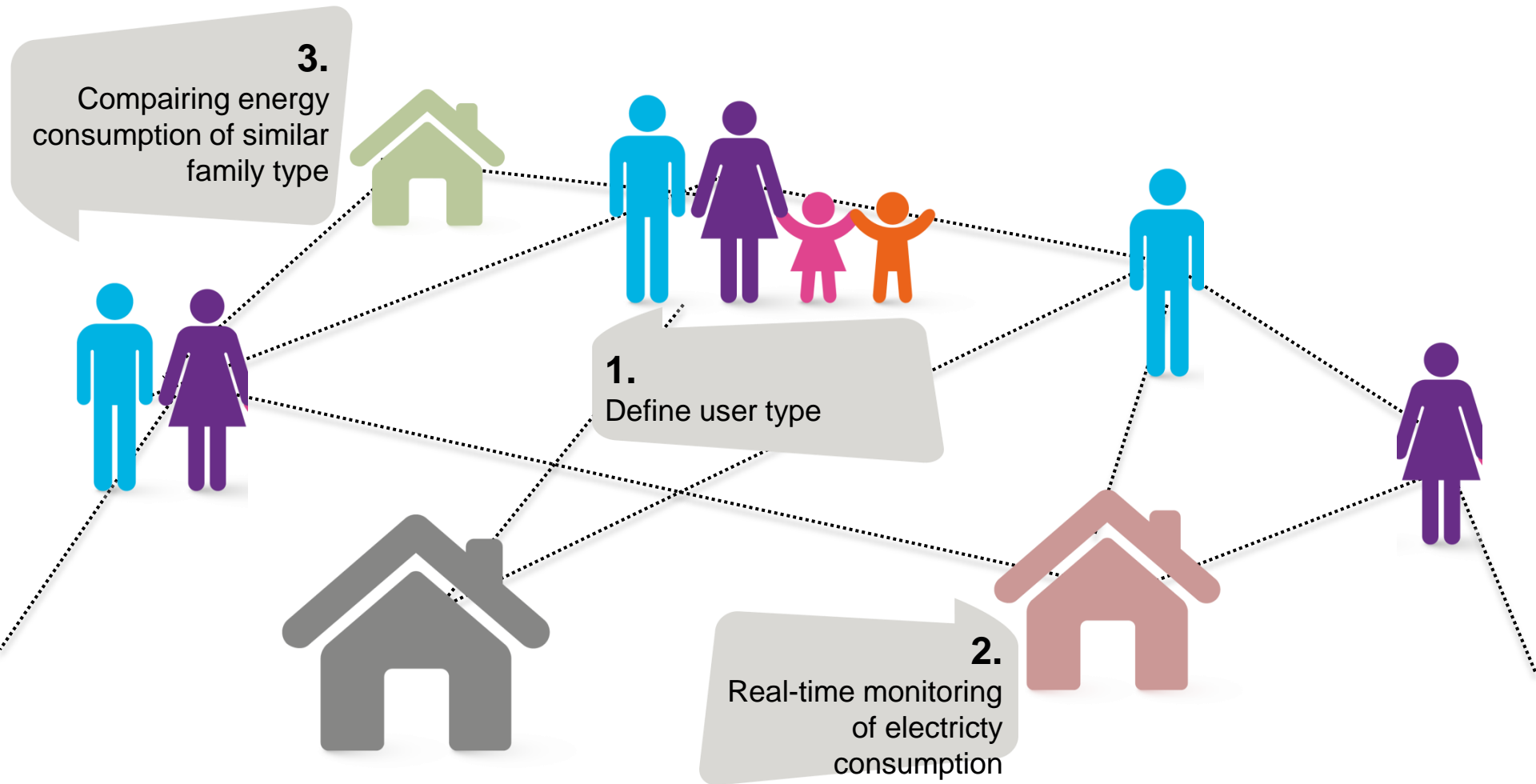
A useful tool for  
users



- Monitoring typical energy consumption at home
- Real time visualisation of electrical loads
- Predicting future energy consumption, based on typical pattern of usage of appliances and white goods
- Comparing domestic energy consumption to similar user type (family type) to induce and stimulate users into social-economical competition towards “energy-savings” profiles.

# Il Workshop Energy@Home I consumi residenziali e lo "smart consumer"

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# 1 User Profiling



**Interview  
web-questionnaire**

- House type/organisation
- Type of equipments/white goods
- Household composition

**Study of the influencing factor**

**Identification of typical user profiles**

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## Questionario “Energy@Home”: approfondimento sulla casa ed i suoi abitanti

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Ti chiediamo 10/15 minuti di tempo per compilare un questionario di approfondimento sull'organizzazione della tua casa e sulle caratteristiche del nucleo familiare. Se avrai voglia di compilarlo ci darai un grande aiuto per meglio identificare i profili medi d'uso e di consumo di energia elettrica in Italia. Il questionario richiede il tuo codice utente, ma questo dato durante le elaborazioni non sarà mai associato al tuo nome/cognome. I dati raccolti sono infatti trattati in modalità anonima ed aggregata per soli usi statistici. Grazie in anticipo per la gentilissima collaborazione!

\*Campo obbligatorio

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***Puoi indicare sotto il tuo codice utente di 3 cifre? \****

Il tuo codice utente è quello che trovi nella prima pagina dell'interfaccia grafica di Energy@home

Questa è una domanda obbligatoria



# 2 Smart Monitoring



- smart meter (Enel)
- smart appliance (washing machine Indesit)
- smart plug (dishwasher, TV, refrigerator)

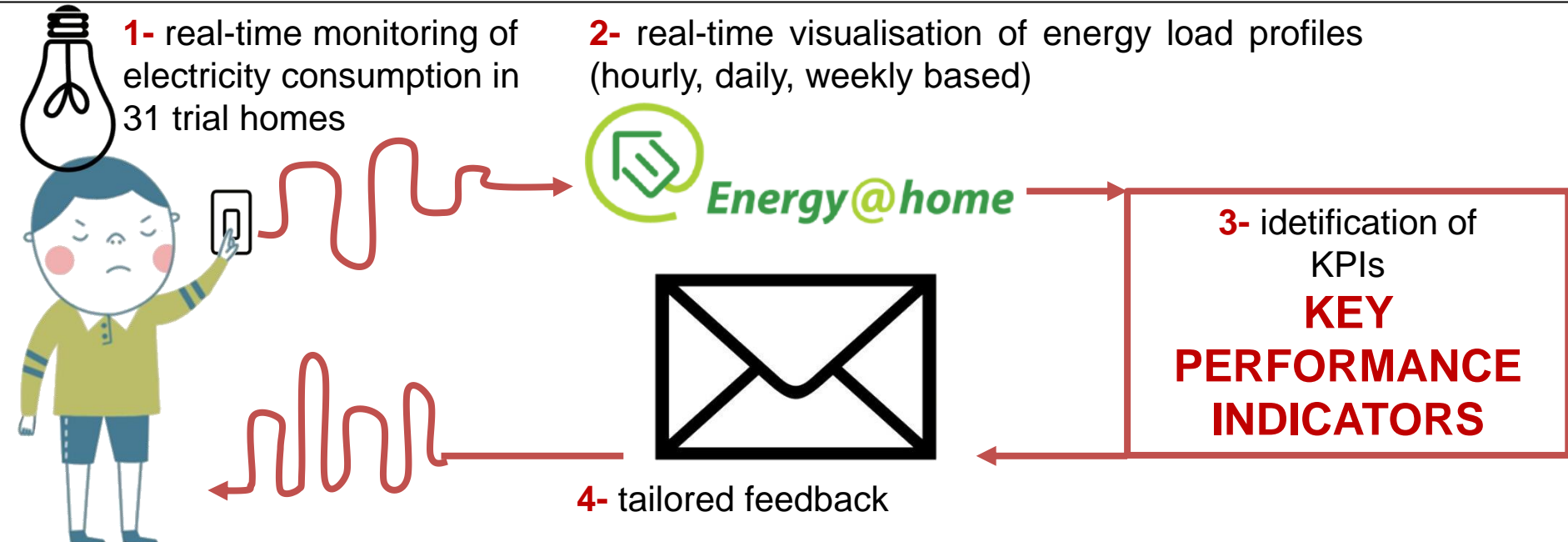
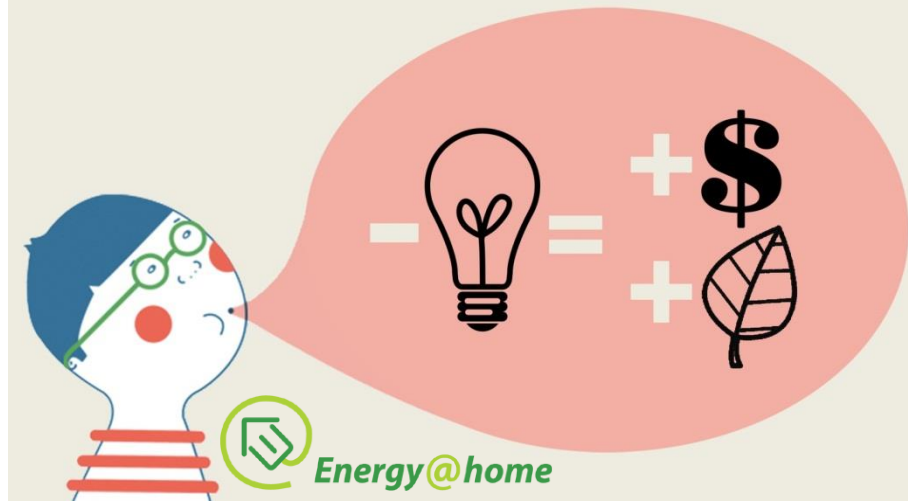
 Energy@home





# 3 Persuasive Communication

Energetic Feedback





# RESULTS

ENERGY CONSUMPTION AND  
**SMART CONSUMER**





# Data Analysis

## Energy@Home system

### Monitoring of 31 “trial” homes

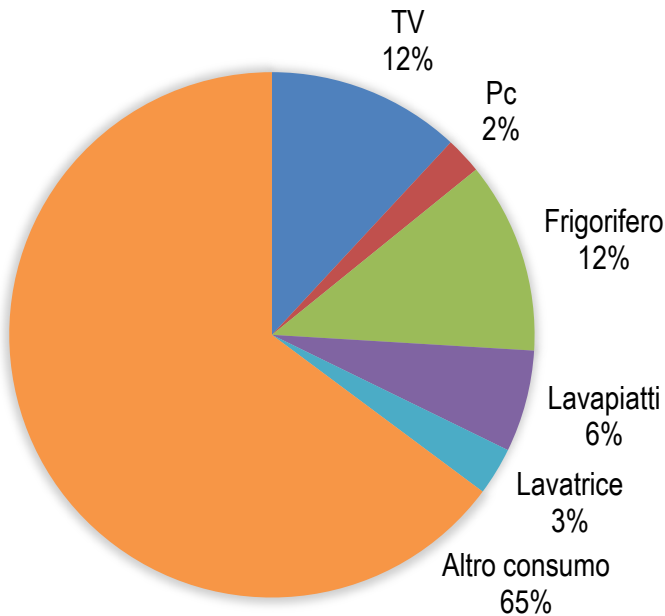
- 1.** **Data analysis from real-time monitoring**  
Analysis of annual consumption trends, energy consumption breakdown
- 2.** **Data analysis from real-time monitoring**  
KEY PERFORMANCE INDICATORS (KPIs)
- 3.** **Analysis of the effect of newsletters on energy consumption**  
Evaluation of seasonal impacts
- 4.** **Analysis of global energy consumption**  
Comparative analysis among user types
- 5.** **Analysis of “best practise” user’s behaviour**  
Evaluation of the effect of energy feedback and tailored information



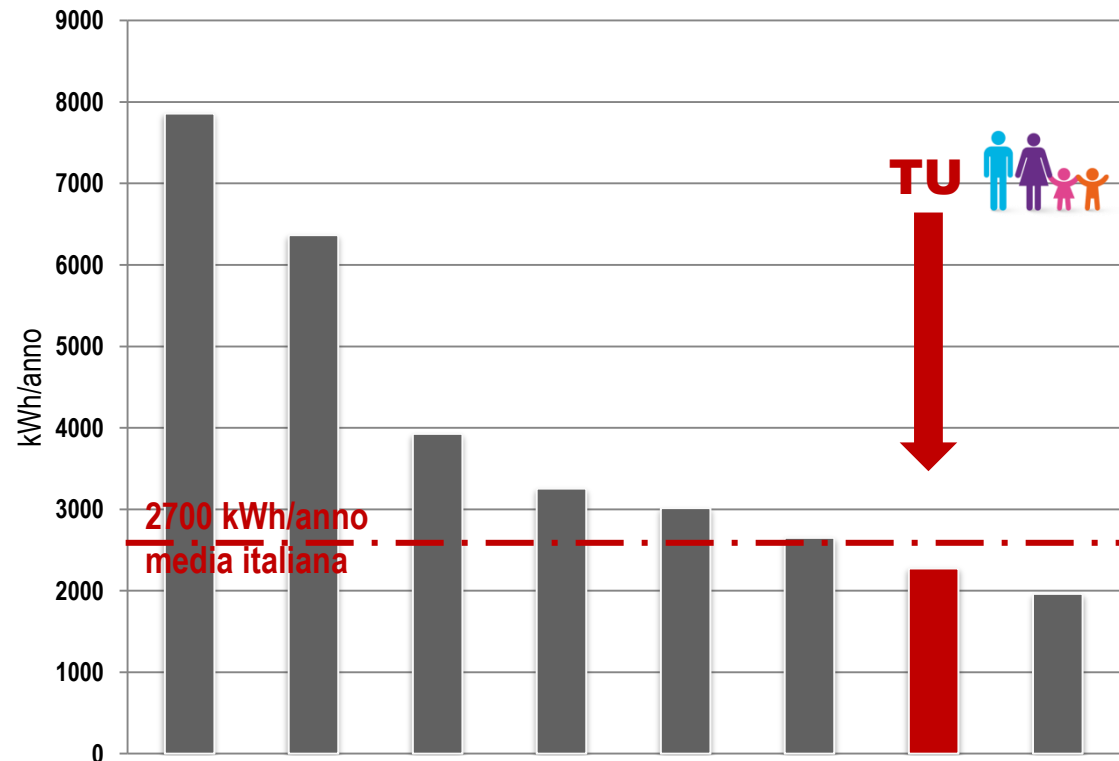
# 1 Data Analysis Energy@Home system

Analysis of annual consumption trends, energy consumption breakdown

La tua suddivisione dei consumi elettrici



La tua proiezione di consumo annuale comparata con quella di famiglie a te simili e rispetto alla media nazionale (fonte AEEG)





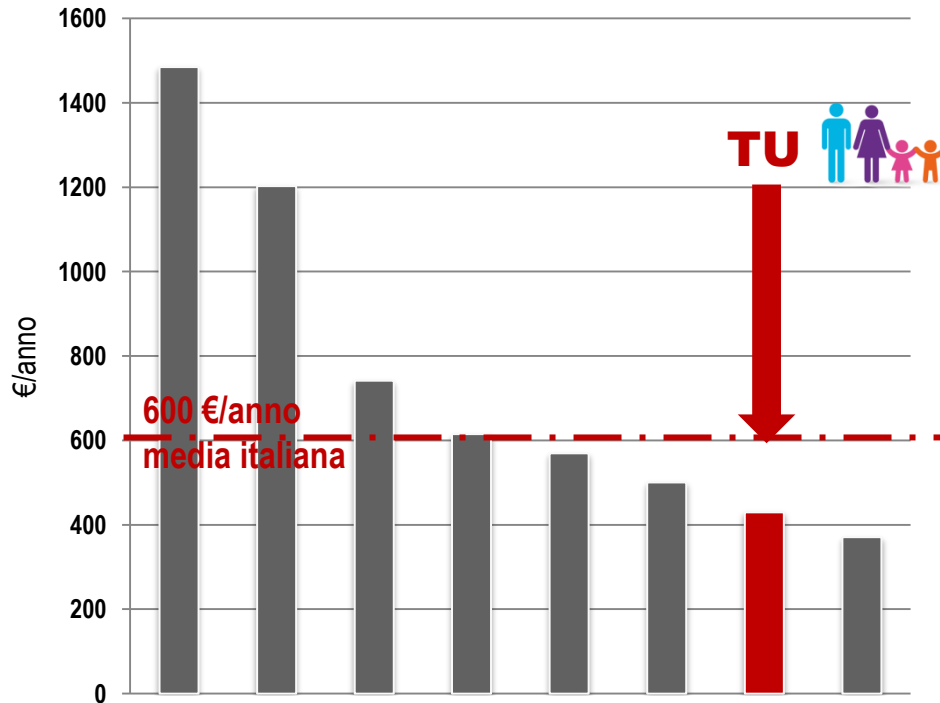


# 1 Data Analysis

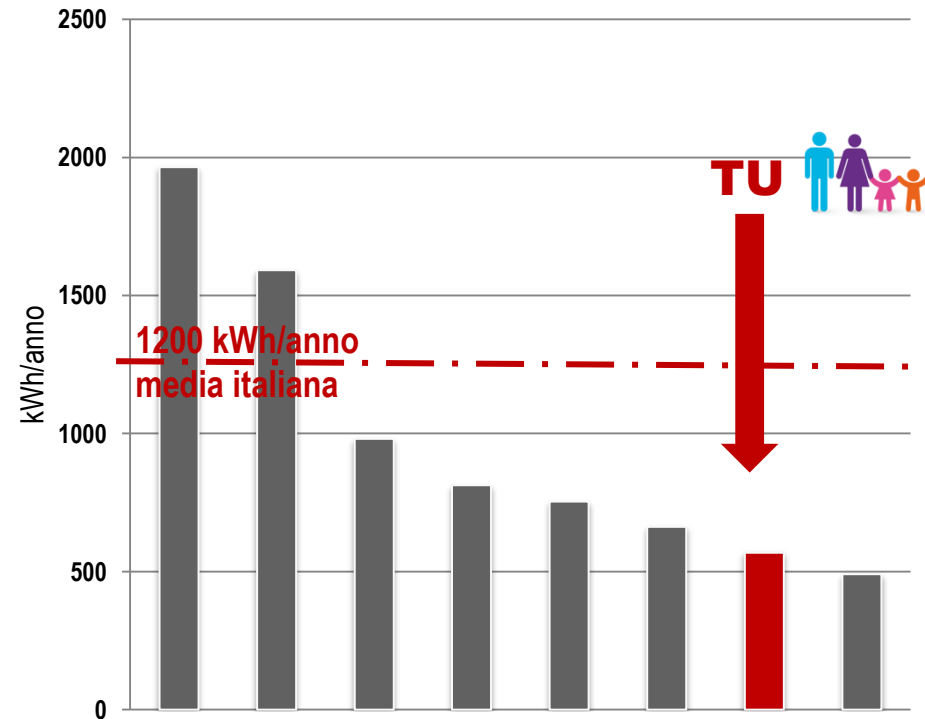
## Energy@Home system

Analysis of annual consumption trends, energy consumption breakdown

La tua proiezione di bolletta annuale comparata con quella di famiglie a te simili e rispetto alla media nazionale (fonte ISTAT)



La tua proiezione di consumo annuale pro capite comparata con quella di famiglie a te simili e rispetto alla media nazionale (fonte ISTAT)





# 2 Data Analysis

## Energy@Home system

### KEY PERFORMANCE INDICATORS (KPIs)

1. QUANTITATIVE

Can be presented with a number

kWh/yr  
€/yr

2. QUALITATIVE

Can't be presented with a number

Energy behavioural profile

3. PROCESS

Efficiency functioning

% reduction in energy consumption

4. LEADING

Energy consumption prediction

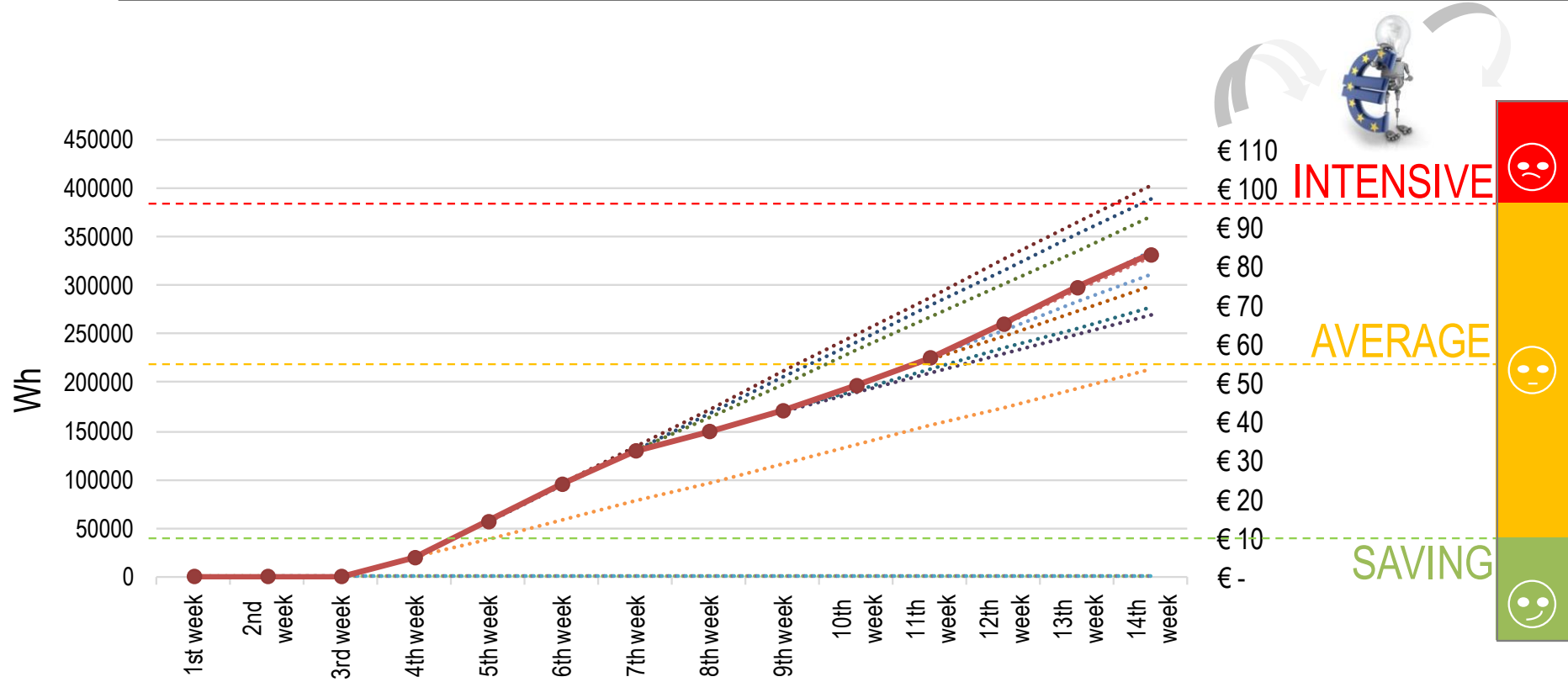
Dinamic calibrated schedules



# 2 Data Analysis

## Energy@Home system

### 1. QUANTITATIVE KPIs





# 2 Data Analysis

## Energy@Home system

### 2. QUALITATIVE KPIS

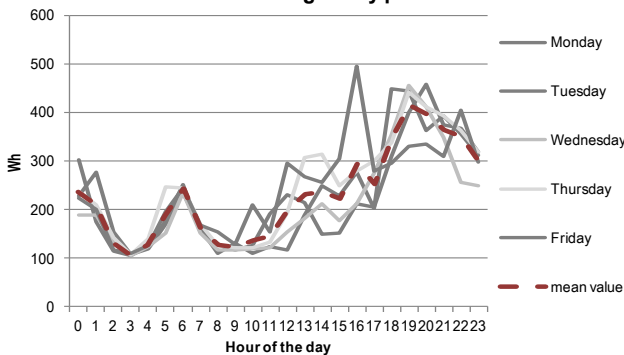
1. Definition of average daily electrical pattern load for each trial-user

For each of the household-family-type monitored trialists, an average 24 hour pattern load identifying household typical behaviour regarding global electric consumption (smart meter) was created

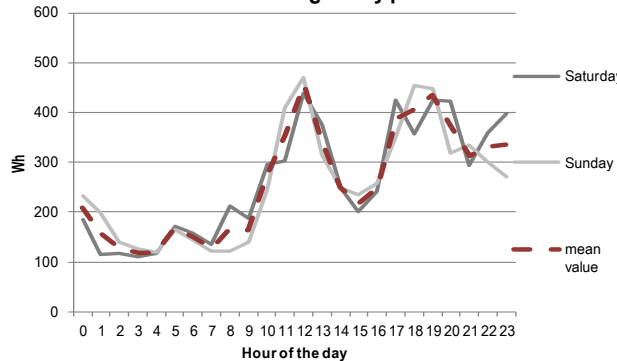
2. Family type profiling

Daily mean electric consumption for family type were created. Typical electrical consumption corresponds to the daily average load curve of families having same composition

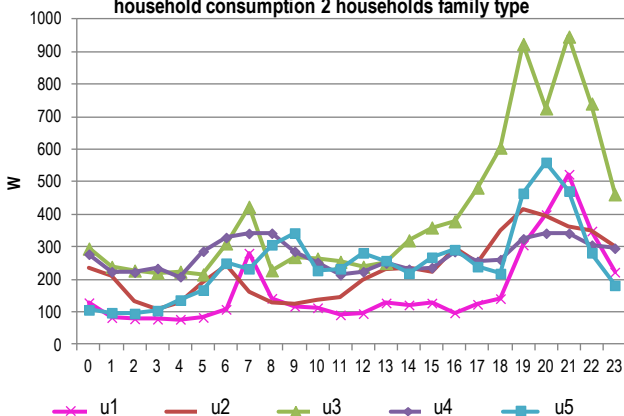
WEEK DAYS average daily pattern load



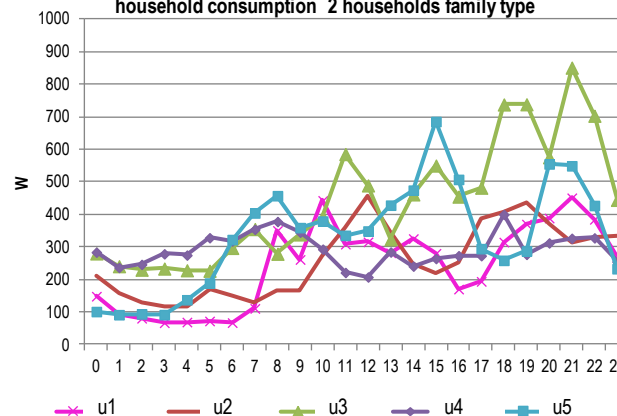
WEEK END average daily pattern load



AVERAGE DAILY PATTERN LOAD weekday household consumption 2 households family type



AVERAGE DAILY PATTERN LOAD weekend household consumption 2 households family type

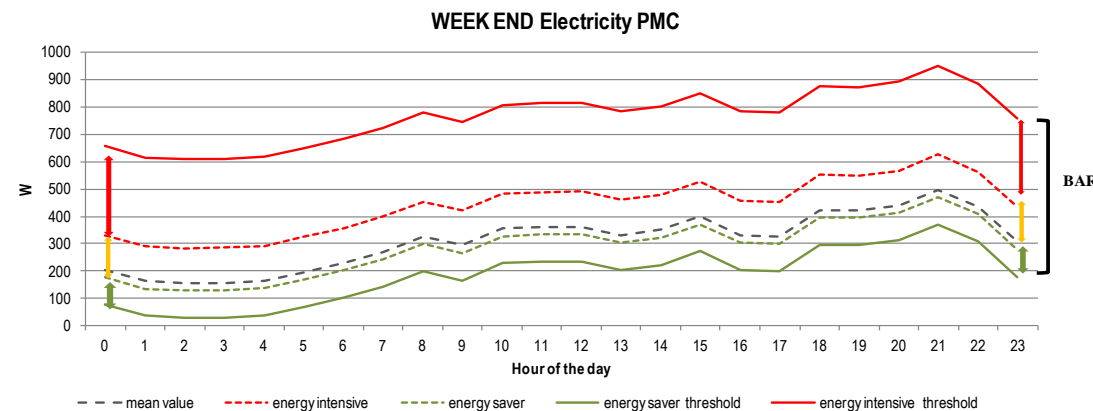
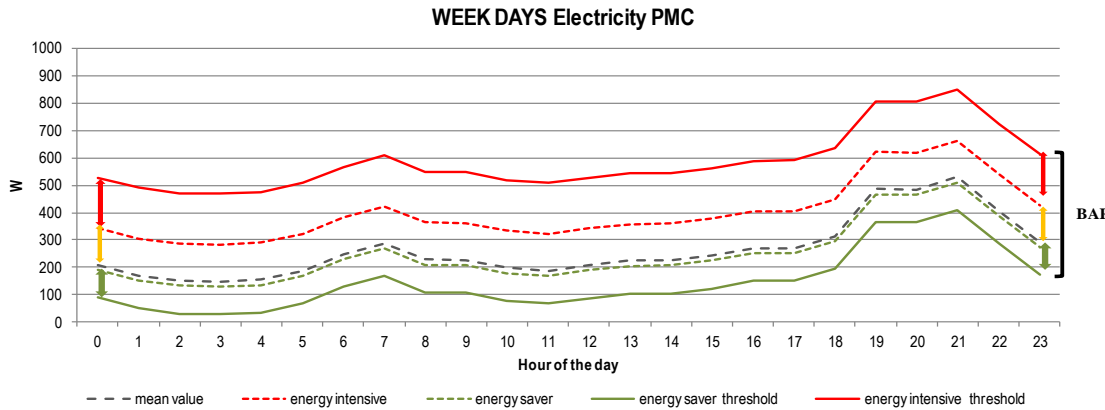




# 2 Data Analysis

## Energy@Home system

### 2. QUALITATIVE KPIS



### 3. Behavioural pattern profiling

Creation of average load profiles here named **Predicted Mean Consumption (PMC)** for electricity consumption. For every family type, threshold values were settled around the average

Predicted Mean Consumption (PMC), based on different behavioural pattern ranging from "energy saver", "on the average", up to "energy intensive" for that specific family type. Not a singular value, but a range of positive and negative values around the average were considered as acceptable for a predictable family type consumption.

Specifically, a **Buffer Acceptability Range (BAR)** composed by three bands was created.

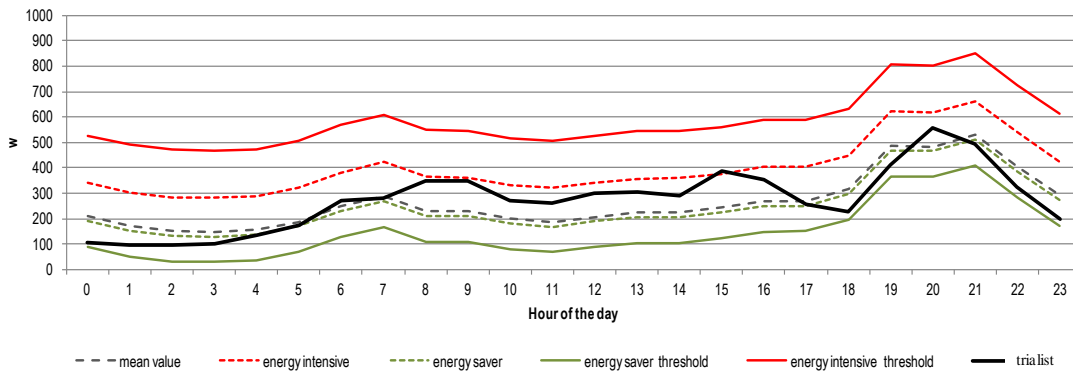


# 2 Data Analysis

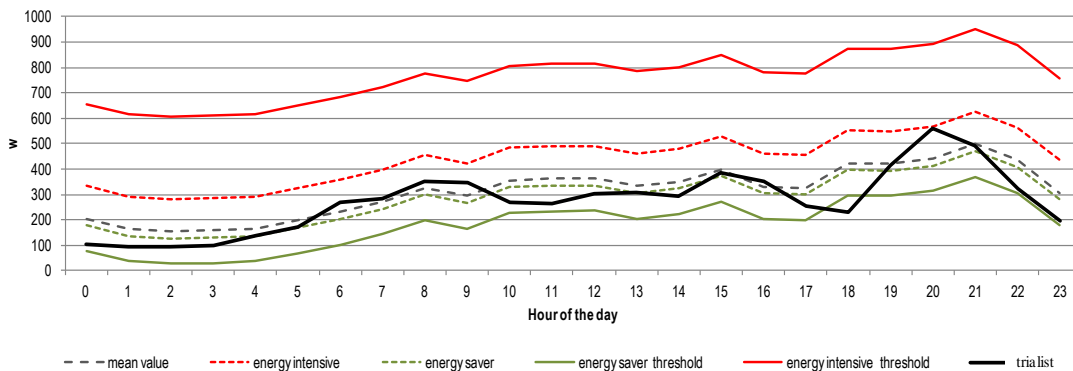
## Energy@Home system

### 2. QUALITATIVE KPIS

Average Daily Electricity Consumption and 2 Households PMC WEEK DAYS



Average Daily Electricity Consumption and 2 Households PMC WEEK END



#### 4. Comparison of daily pattern loads to PMC

Predicted Mean Consumption was used as self reference value (**horizontal benchmark**) for the average electricity consumption of each specific family type. Daily average pattern loads of trialists were compared to the PMC of their belonging family type,

#### 5. Evaluation of percentage of time in a BAR

By comparing daily pattern loads of singular trialists with PMC of the belonging family type, it became possible to highlight for how many hours during weekdays and weekend the electric consumption of each trialist was targeted as “**energy saver**”, “**on the average**”, up to “**energy intensive**”,



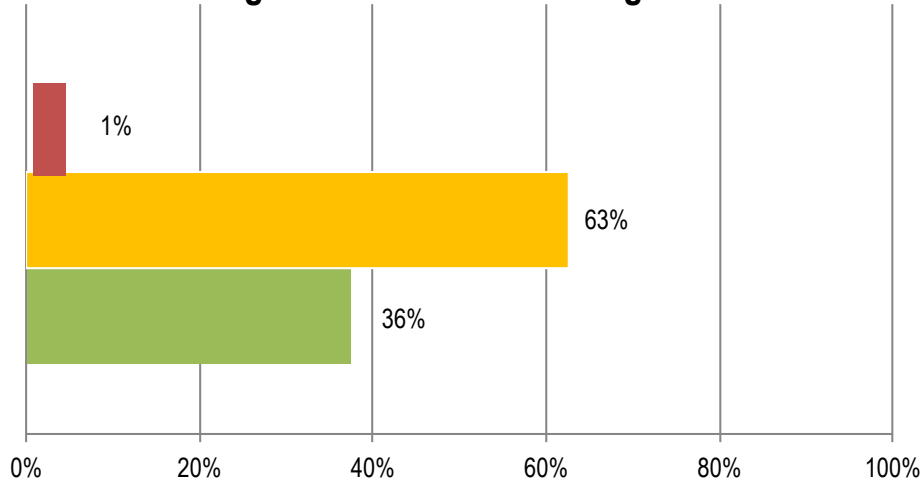
# 2 Data Analysis

## Energy@Home system

### 2. QUALITATIVE KPIS

Electricity Consumption

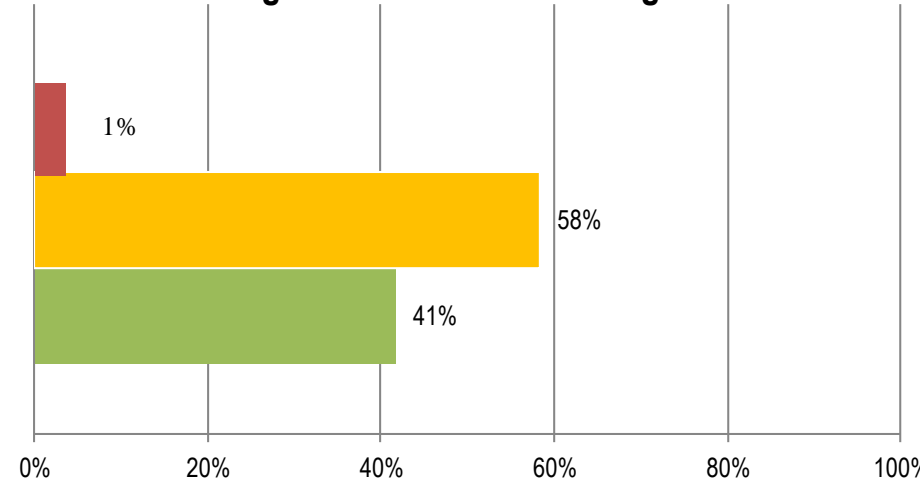
Percentage of time in a BAR during WEEK DAYS



■ Energy Intensive   ■ Average   ■ Energy Saver

Electricity Consumption

Percentage of time in a BAR during WEEK END



■ Energy Intensive   ■ Average   ■ Energy Saver

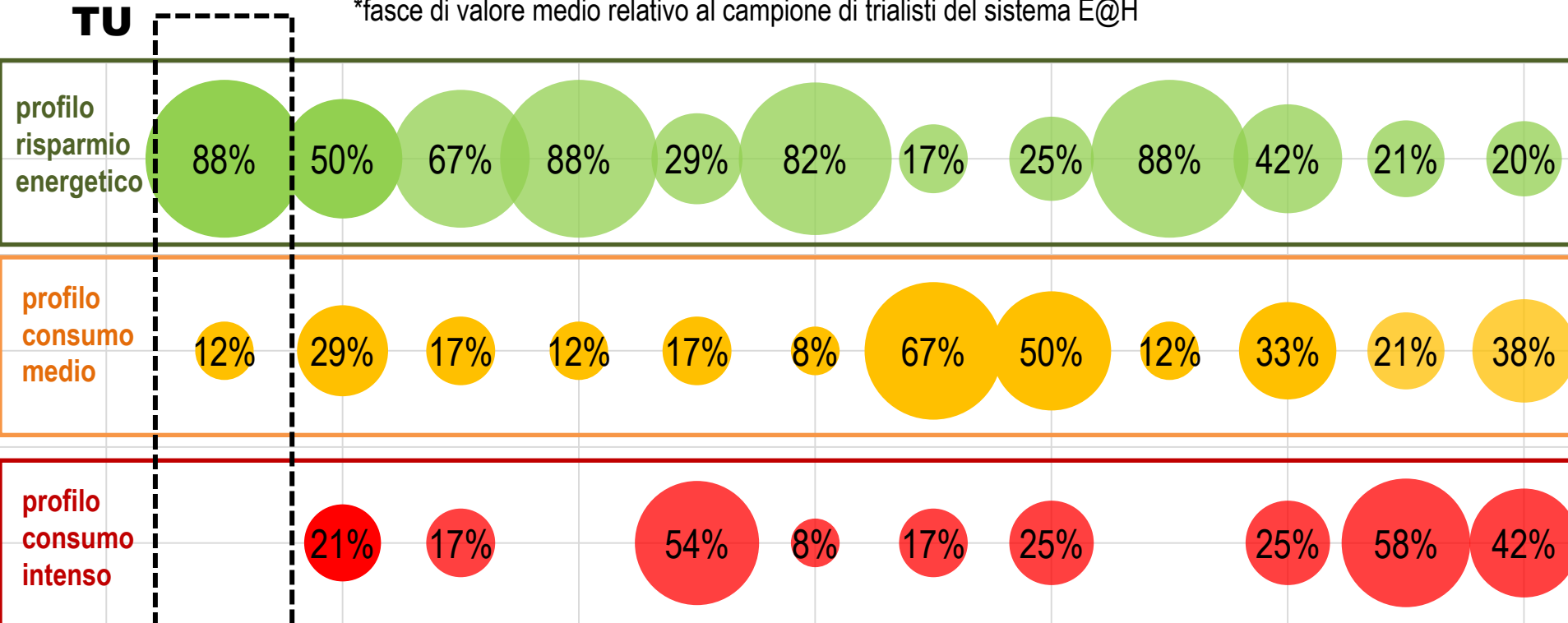


# 2 Data Analysis

## Energy@Home system

### 2. QUALITATIVE KPIS

Percentuale di tempo in cui il tuo consumo è associabile ad un profilo d'uso energetico \*  
\*fasce di valore medio relativo al campione di trialisti del sistema E@H







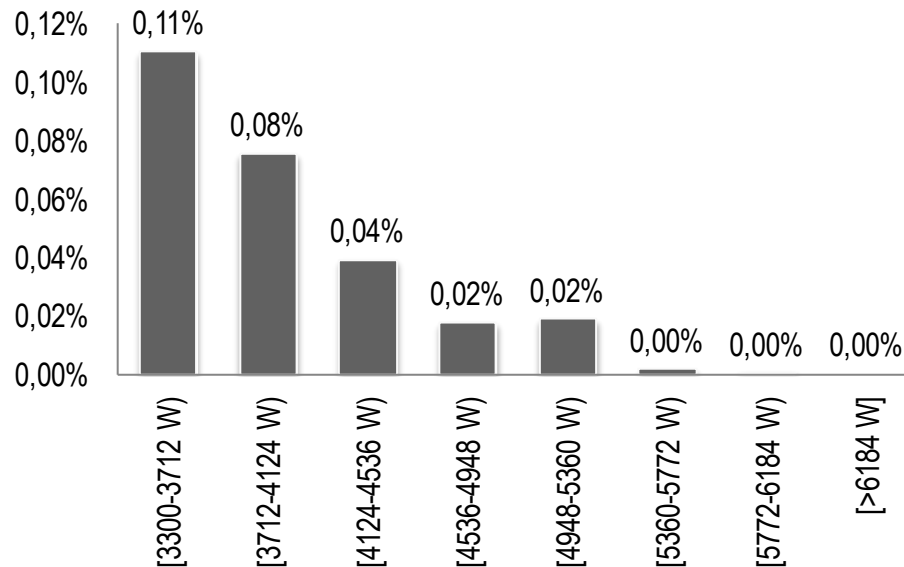
# 2 Data Analysis

## Energy@Home system

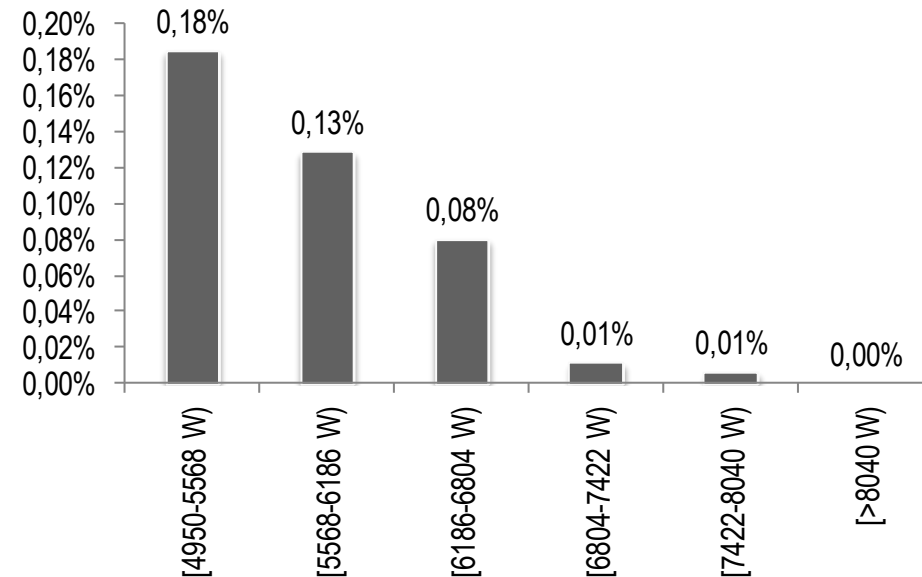
### 3. PROCESS KPIs

Analysis of the effect of newsletters on energy consumption  
Evaluation of seasonal impacts

**Trialists with 4.5 kW Contractual Power**  
Percentage of usage of the contractual power



**Trialists with 6 kW Contractual Power**  
Percentage of usage of the contractual power





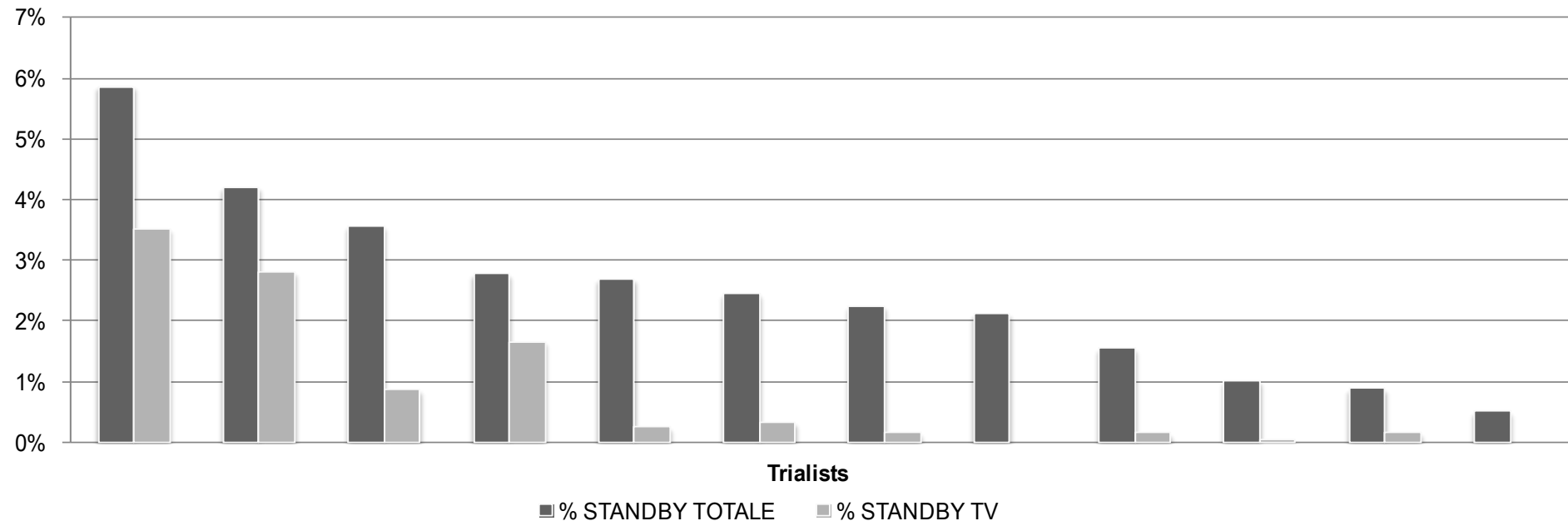
# 2 Analisi Dati monitoraggio real-time sistema Energy@Home

## 3. KPIs PROCESSO

### Analisi consumi stand-by utenti

analisi percentuale di incidenza su consumi globali

Influence of standby power on global electricity energy consumption



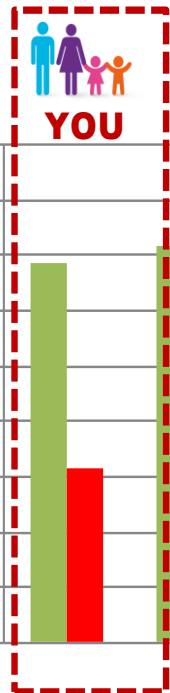


# 2 Data Analysis

## Energy@Home system

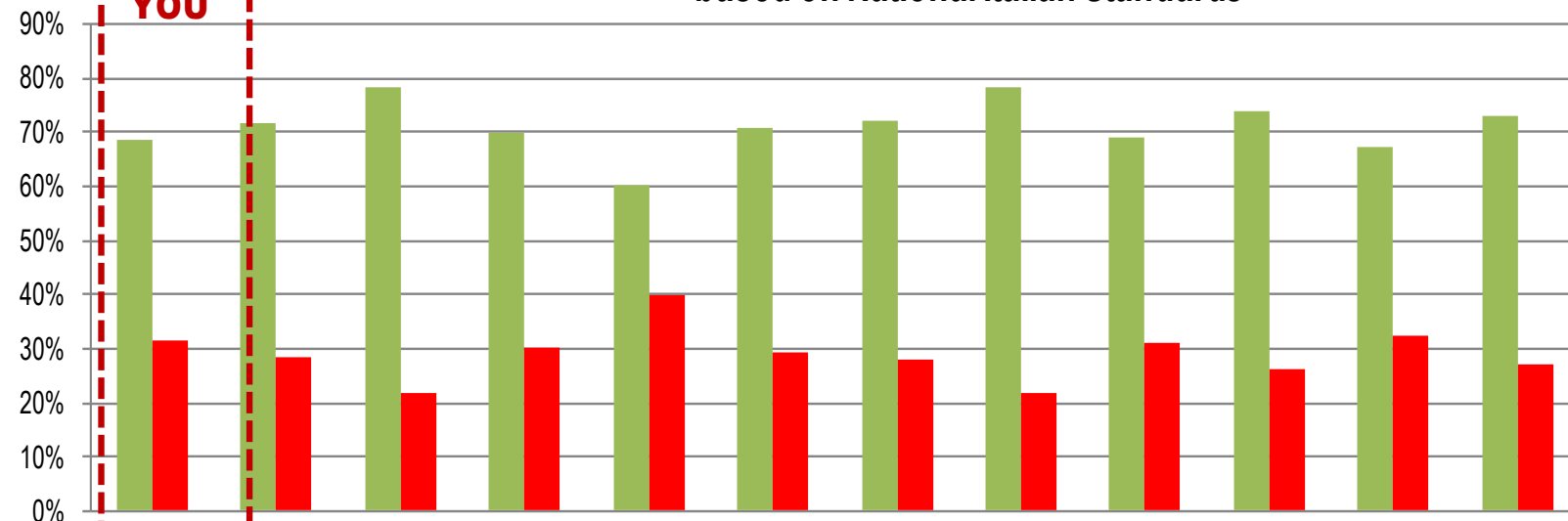
### 3. PROCESS KPIs

Energy consumption per hourly tariff



Economical Hourly Rate Category  
based on National Italian Standards

- Category F1**  
mon – fry 8 - 19
- Category F2**  
mon – fry 19 - 8
- Category F3**  
weekend/ holydays



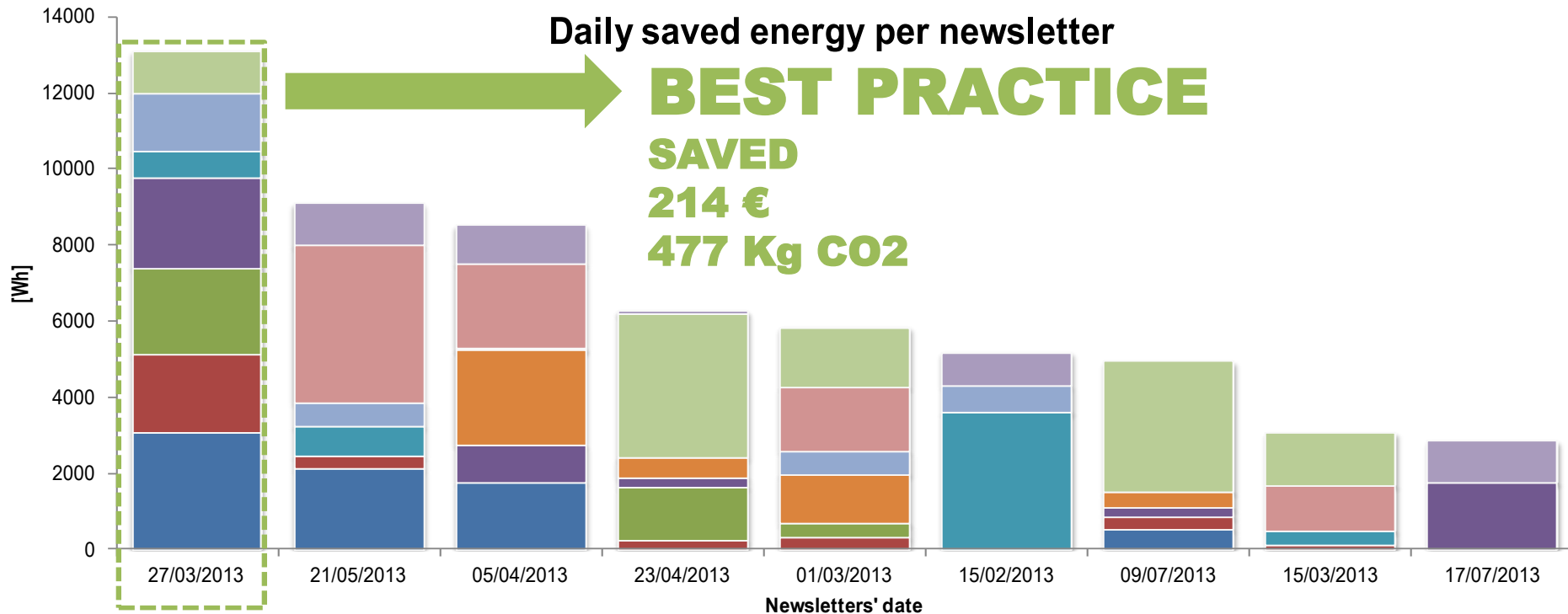


# 3 Data Analysis

## Energy@Home system

Analysis of the effect of newsletters on energy consumption

9 web-newsletters (via email) in the period from 27/03/2013 to 17/7/2013.





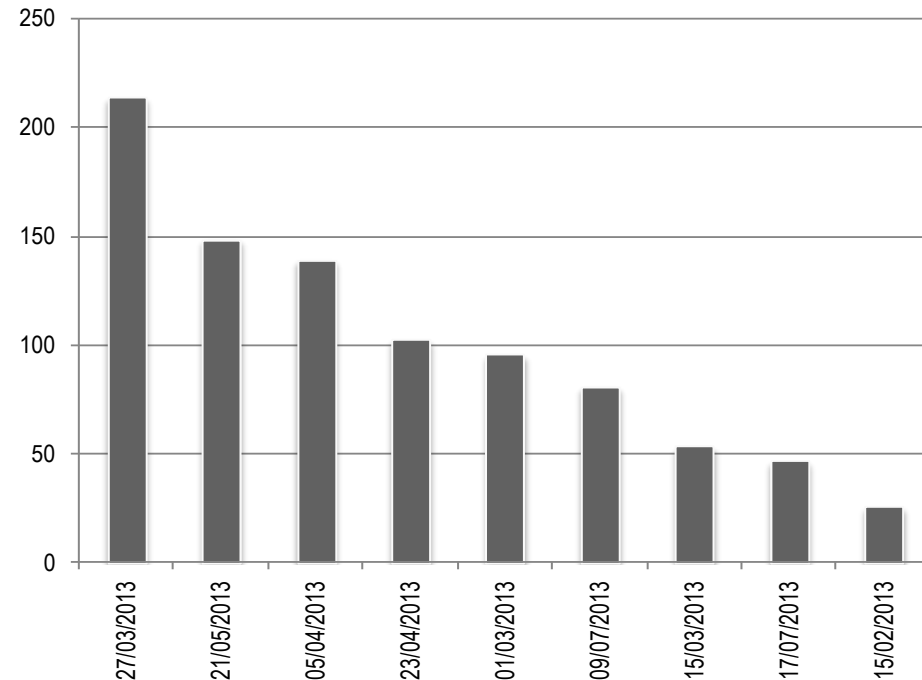
# 3 Data Analysis

## Energy@Home system

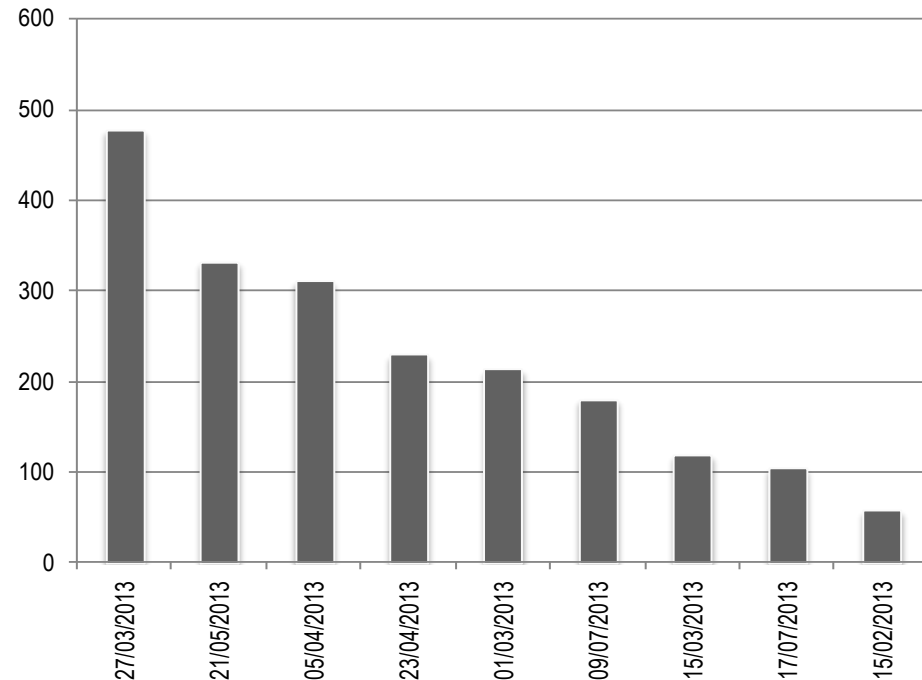
Analysis of the effect of newsletters on energy consumption

9 web-newsletters (via email) in the period from 27/03/2013 to 17/7/2013.

Global € savings per Newsletter



Global kg CO2 savings per Newsletter



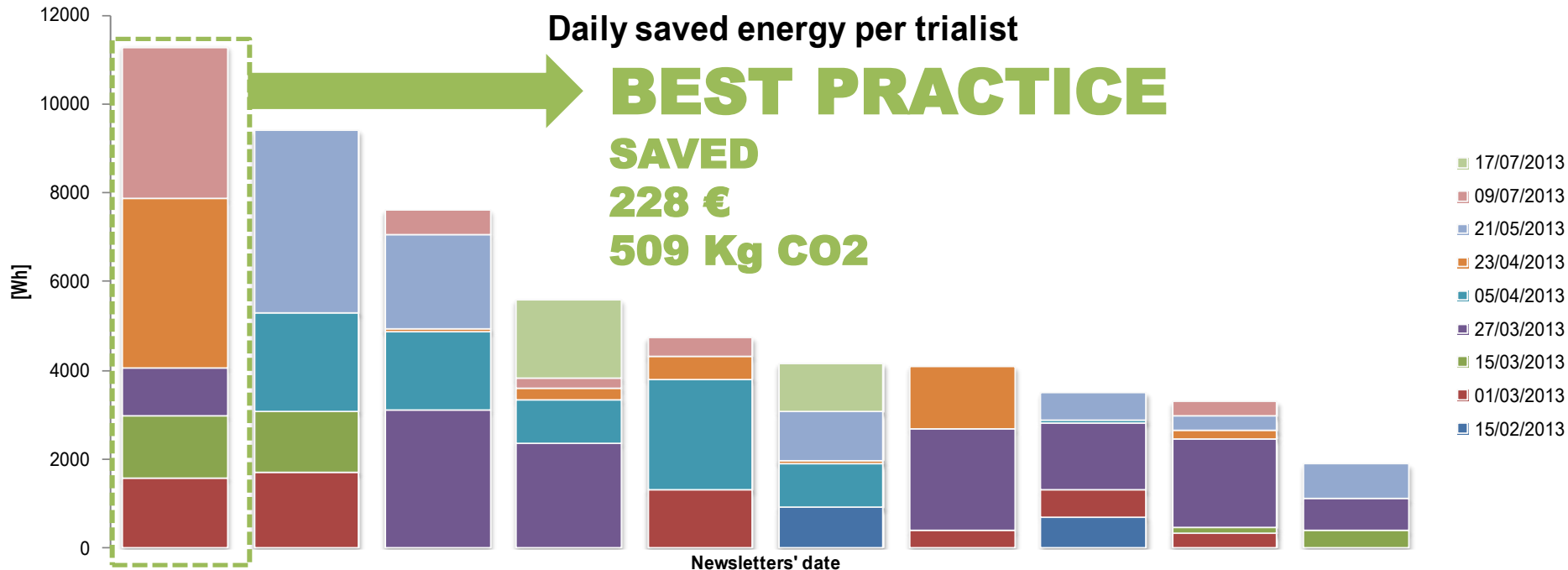


# 3 Data Analysis

## Energy@Home system

Analysis of the effect of newsletters on energy consumption

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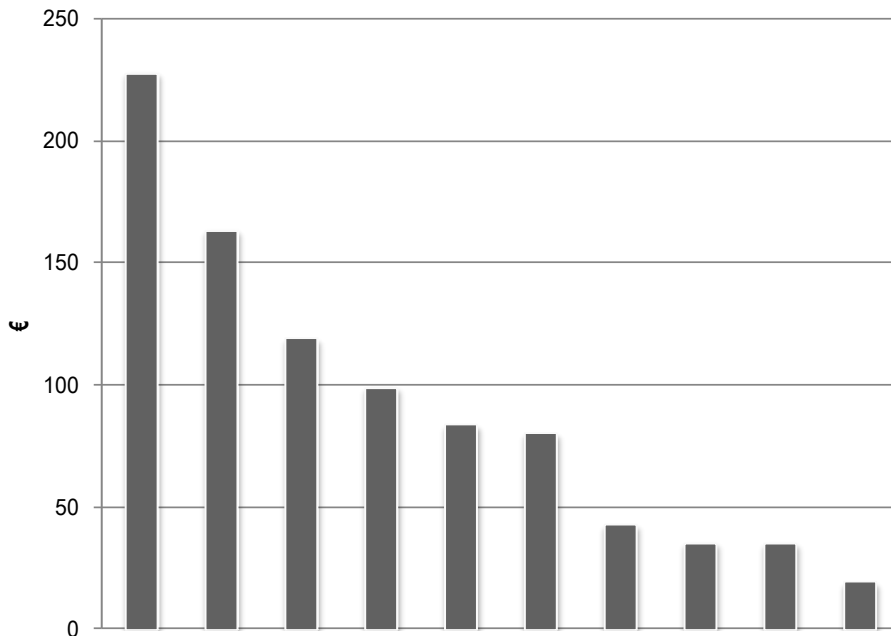
# 3 Data Analysis

## Energy@Home system

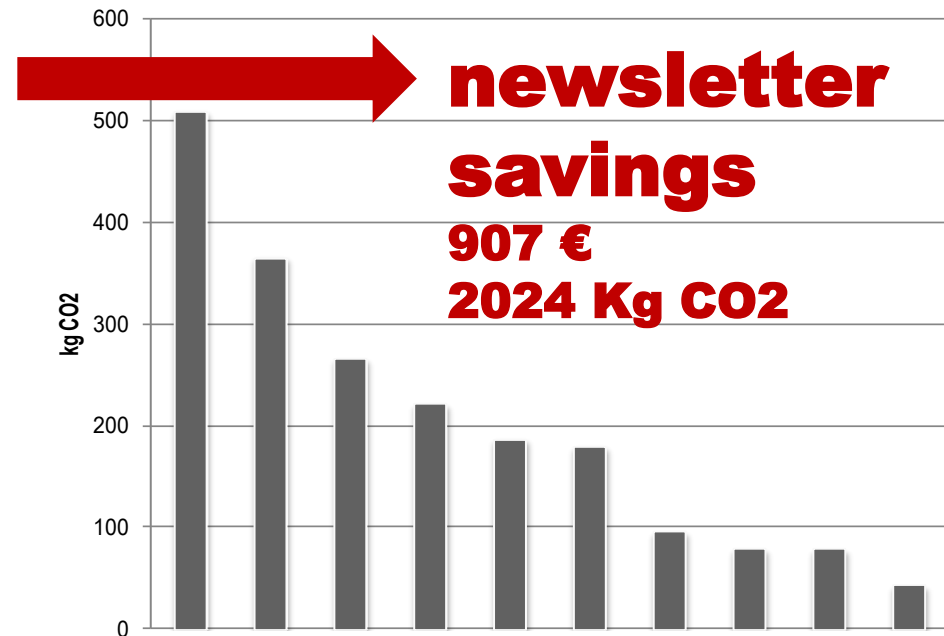
Analysis of the effect of newsletters on energy consumption

9 web-newsletters (via email) in the period from 27/03/2013 to 17/7/2013.

Global € savings per Trialist



Global kg CO2 savings per Trialist



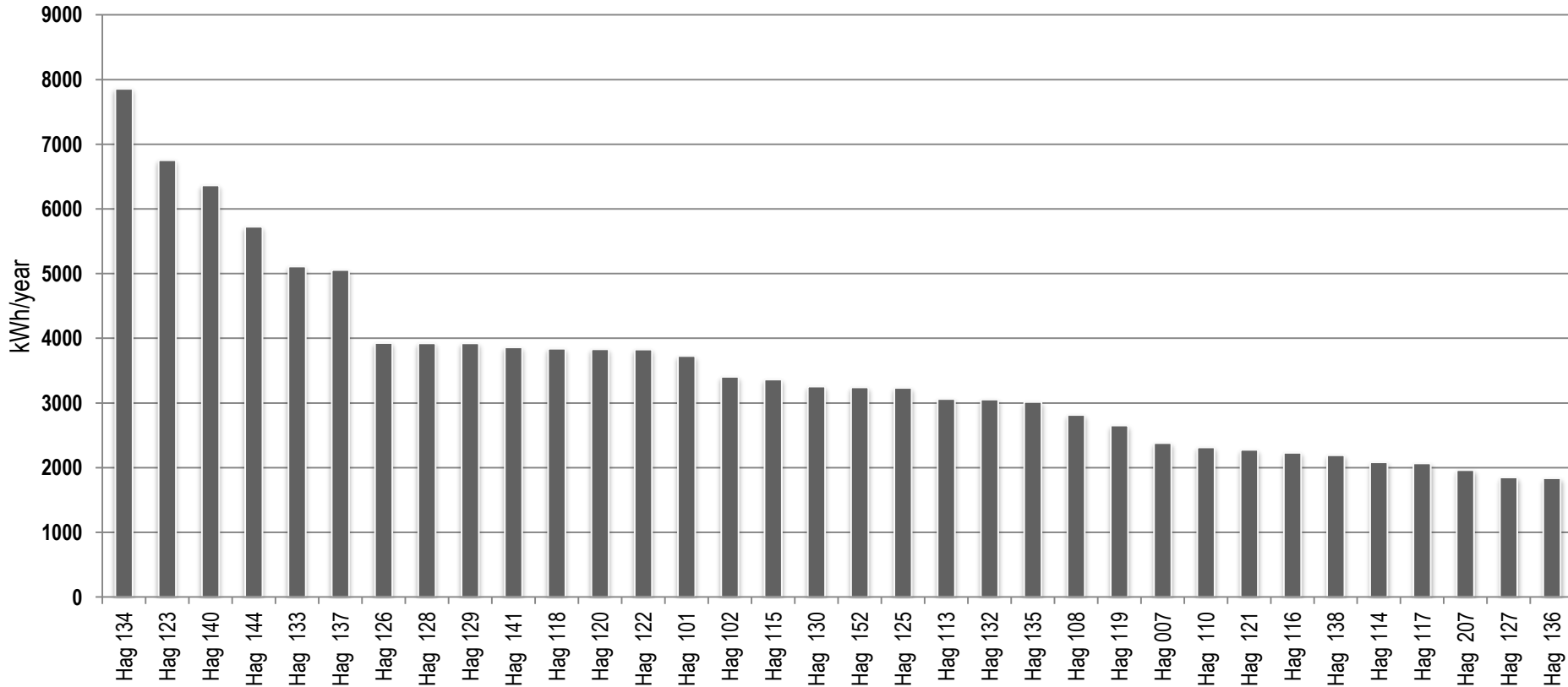


# 4 Data Analysis

## Energy@Home system

### Analysis of global energy trends

ANNUAL ENERGY CONSUMPTION PROJECTION





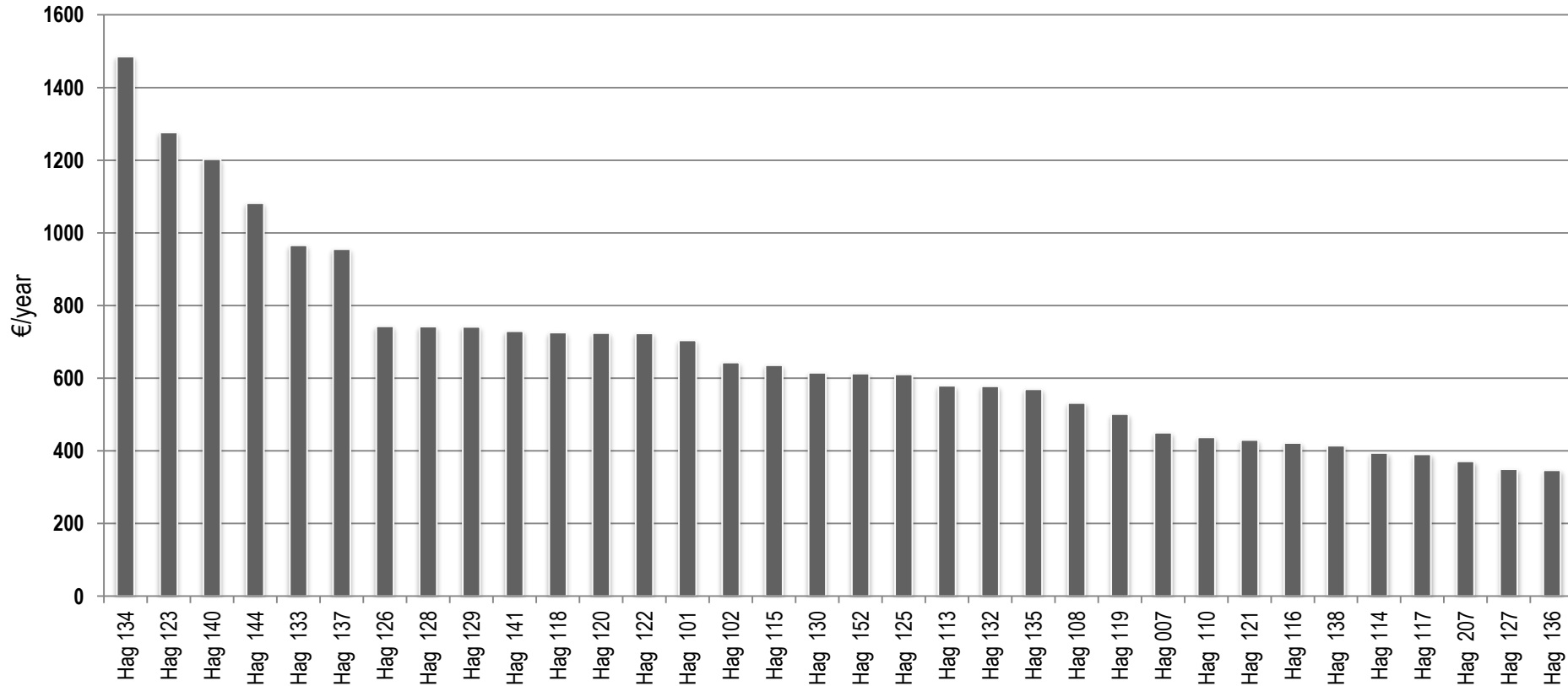


# 4 Data Analysis

## Energy@Home system

### Analysis of global energy trends

ANNUAL ENERGY BILL PROJECTION



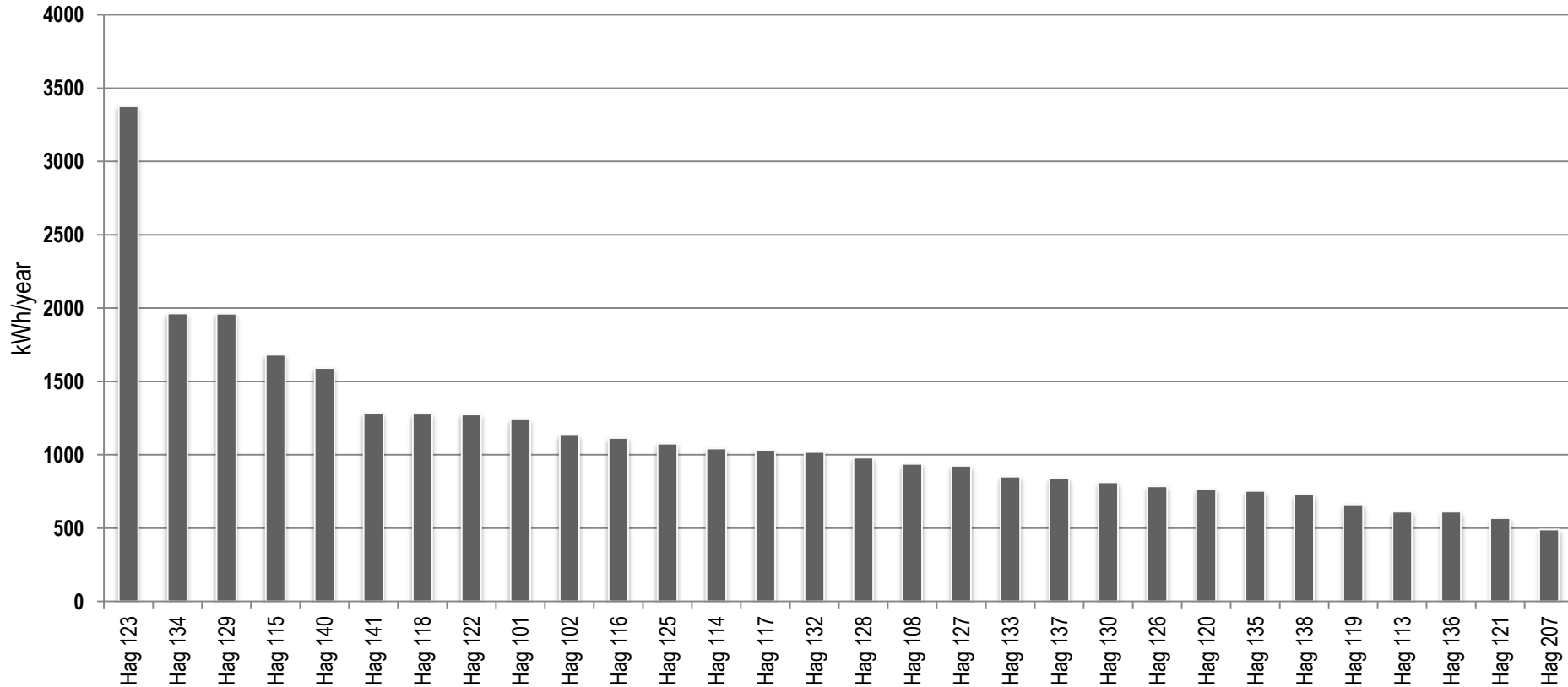


# 4 Data Analysis

## Energy@Home system

### Analysis of global energy trends

ANNUAL ENERGY CONSUMPTION PROJECTION procapite

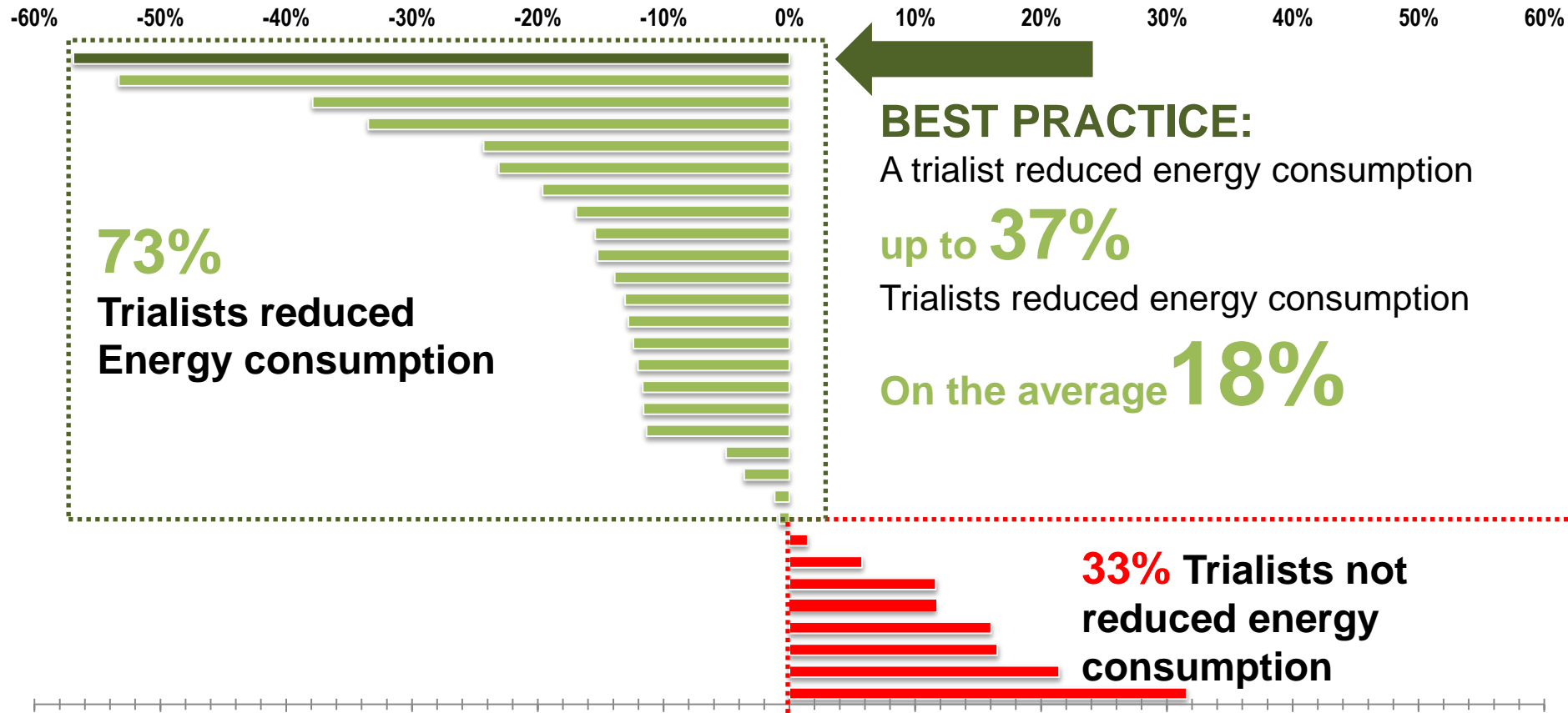




# 4 Data Analysis

## Energy@Home system

### Analysis of global energy savings





# 5 Data Analysis

## Energy@Home system

Analysis of «best practise» energy related behaviour

BEST PRACTICE:

-37% energy consumption

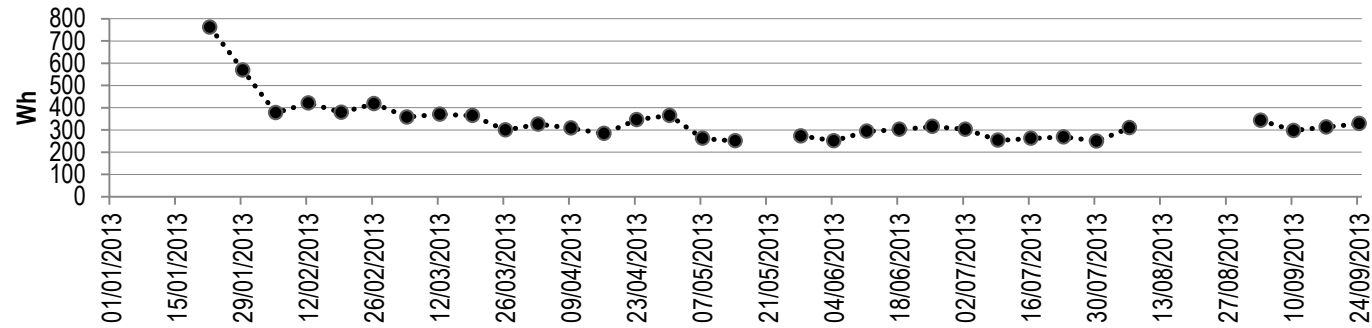


**Fallback effect**

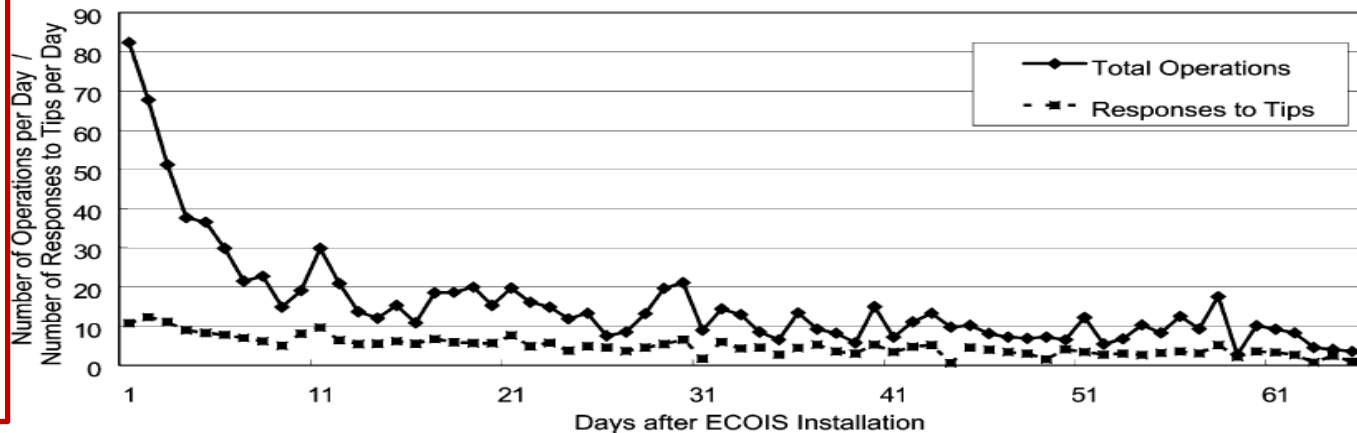
*"the phenomenon in which newness of a change causes people to react, but then the reaction diminishes and the newness wears off".*

Wilhite and Ling, 1999

Hag xxx



weeks of monitoring period





# 5 Data Analysis

## Energy@Home system

### Analysis of «best practise» energy related behaviour

#### Feedback from trialist

"Ritengo utili soprattutto le informazioni relative al consumo globale della settimana , per controllare l'andamento dei consumi . Sarebbe interessante , se disponibile anche il consumo globale relativo alla singola presa monitorata per eventualmente intervenire per adottare misure reletive ad un contenimento dei consumi.Posso dire che fin da ora dopo aver visto l'assorbimento del computer non lo lascio più acceso quando non lo utilizzo

"Per diminuire il consumo in stand by mi ripropongo di inserire un interruttore sulla presa di alimentazione della TV e togliere le luci di cortesia a led che ho nel corridoio , per poi verificare la diminuzione

"Noto con soddisfazione che il mio frigorifero ha il consumo più basso tra gli sperimentatori , come classe è A+."



# 5 Data Analysis

## Energy@Home system

### Analysis of «best practise» energy related behaviour

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"Dal terzo grafico risulta che uso soprattutto la lavatrice in fascia F1, al riguardo ho sensibilizzato mia moglie, anche mediante la dimostrazione dei grafici di evitare il più possibile l'uso della lavatrice nella fascia F1. Abbiamo il problema che la stanza dove è posta la lavatrice è vicina alle camere e il funzionamento durante la notte disturba.

"Ho mostrato il grafico a mia moglie, lei dice che è costretta ad usare cicli ad alta temperatura per i "bianchi" perchè altrimenti rimangono macchiati (ad esempio le tovaglie), pur usando il Dash.

"Penso che una parte sostanziale della diminuzione dei consumi sia dovuta ad un fattore stagionale perchè in inverno uso spesso due deumidificatori portatili. Come comportamento virtuoso mia moglie dice che cerca di usare meno spesso la lavatrice sfruttando ogni singolo lavaggio a pieno carico e magari questo potrebbe essere verificato dai vostri report."



# **6 Data Analysis**

## **Energy@Home system**

### **Conclusions: understanding the human factor**

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Measure occupant behaviour

Avoid energy wastes

Little changes in consumer behaviour

Boost occupant energy saving profiles

Low capital investment VS High potential of applicability

Energy related behaviour VS social-economical sphere



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**Thanks for the attention  
questions?**

