Building Energy Efficiency

Research & Innovation Workshop

SUSTAINABLE ENERGY WEEK

An initiative of the European Commission

Enabling public engagement in the energy transition through a Virtual Energy Currency

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Outline

1. Smart Energy Cities
2. Intelligent Energy Management
3. Virtual energy-currency approach
4. Numerical example
5. Conclusions

Smart Energy Cities 1|2

ENERGY TRANSFORMATION

Energy Grid + ICT = Smart Grid

Smart grid + OR + big data = smart energy

Reduction of energy consumption, waste and other resources, and a greater quality of life via enhanced residents’ engagement

Smart Energy Cities 2|2

- Global market for smart energy solutions → grow from $7.3 billion, 2015 to $21 billion by 2024.
- 92% of utilities executives believe that advanced data analytics will have the greatest impact on their business up to 2019.
- Global Energy Management Systems (EMS) market is expected to reach $58.6 billion by 2022.

Intelligent Energy Management 1|2

- **ICT-for-companies** are very sophisticated systems (BEMS, process analysis), which cannot be handled by the occupants.
- Energy end-user might want to know how to improve the building behaviour, performing a specific action.
- ICT-based solutions that exploit IoT technologies can contribute significantly to energy saving, by ⇨ **Simplifying the complexity of the information gathered by those systems.**

Intelligent Energy Management 2|2

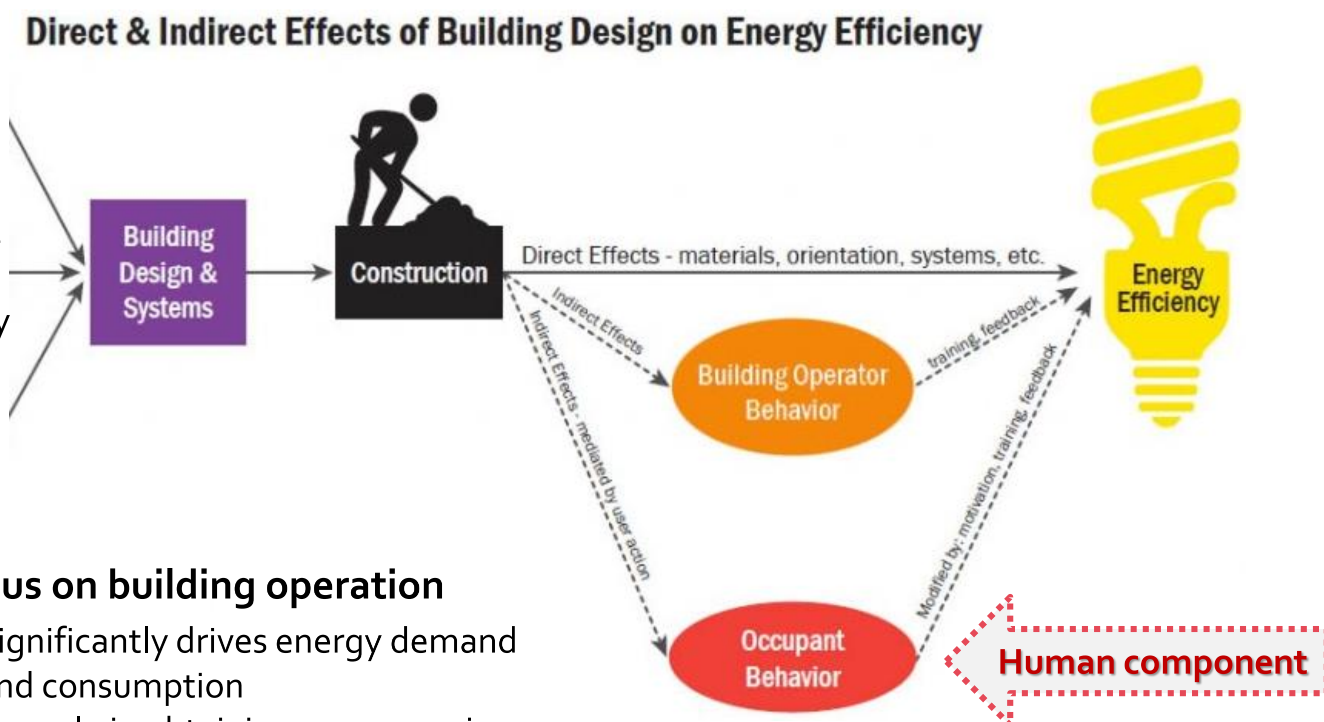
Engagement of energy end-users in the context of a Smart Energy Cities and the role that **advanced technologies** could play in improving quality of life for its citizens:

- How can smart technologies support energy **transformation** towards sustainability?
- How can the buildings' users get a deeper **understanding** about their building's consumption and its impact?
- How can the energy end-users be motivated towards **behavioural change** for energy conservation?

Virtual Energy-Currency Approach 1|7

I. Focus on building design

- Core and shell component
- Discrepancies between predicted VS actual energy consumption during their operation phase



II. Focus on building operation

- Significantly drives energy demand and consumption
- Key role in obtaining energy savings

Virtual Energy-Currency Approach 2|7

Urban environment

A city or municipality which participates in a program to reduce its energy consumption levels and thus has set an annual energy consumption goal.

Building households

Building occupants - the building units in the community.

ICT

Smart metering, monitoring devices, etc.

Virtual energy-currency

Energy-currency is created through monetary value allocation in virtual coins, namely ATOMcoin that can be obtained by saving energy.

Integration

Energy-currency

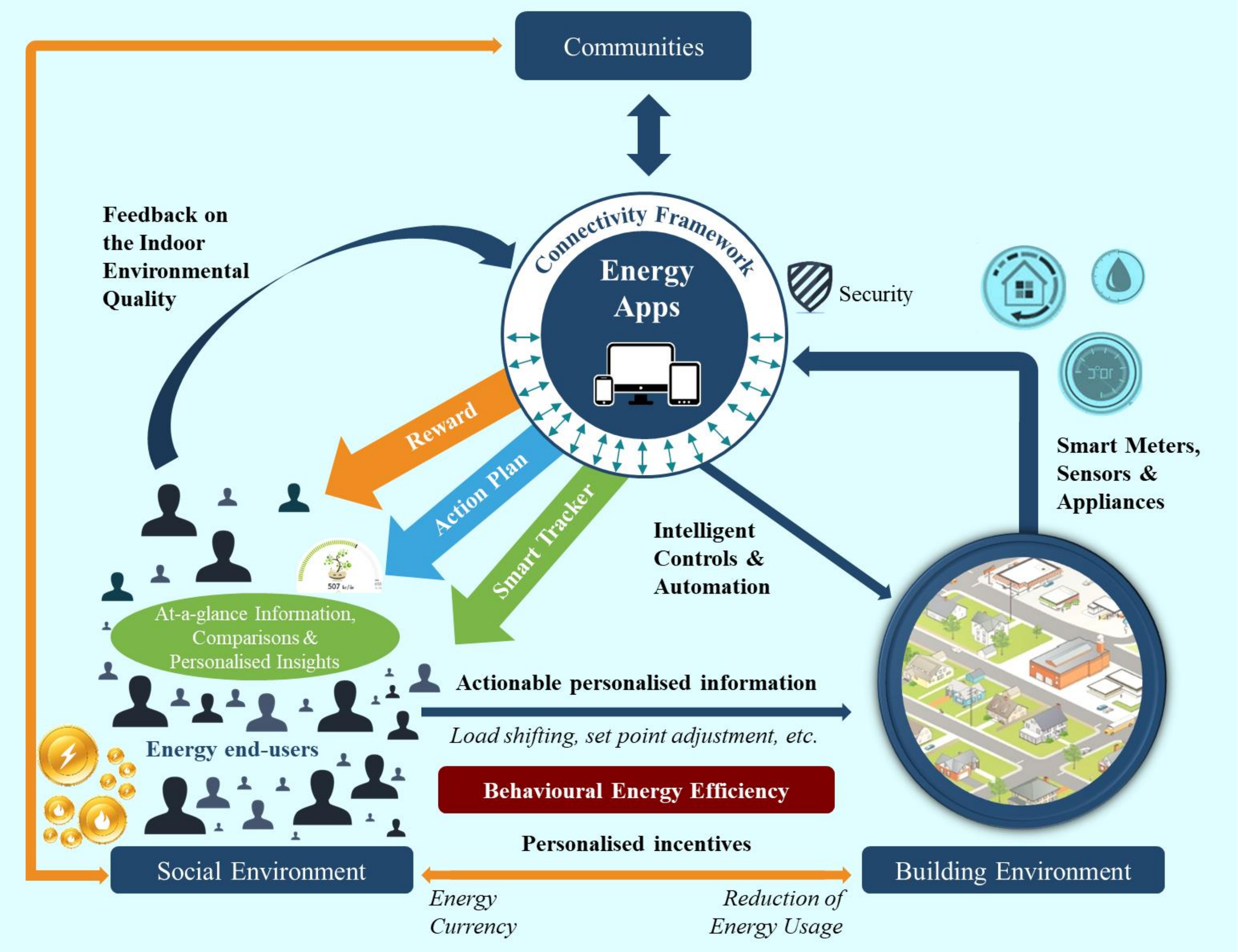
Virtual Energy-Currency Approach 3|7

Personalised behavioural change energy apps:

- **Smart Tracker:** Know how much energy is consumed in total and what is the contribution of the specific end-user and other peers to that.
- **Action Plan:** Get personalized recommendations of actions for energy conservation/ load shifting, along with an estimation of their impact on energy use and comfort.
- **Reward:** Be motivated for behavioural change towards energy conservation proposed actions.

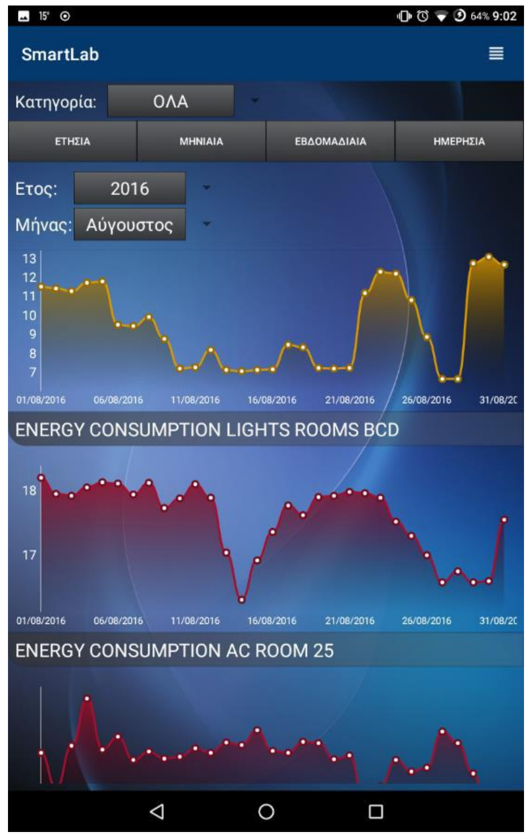
Virtual Energy-Currency Approach 4|7

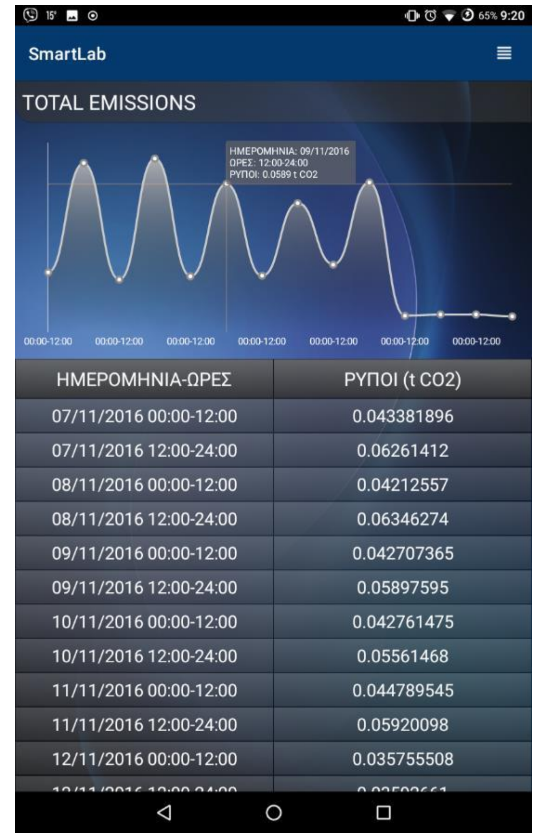
User-Centred Applications



Virtual Energy-Currency Approach 5|7

Energy Management Apps





Virtual Energy-Currency Approach 6|7

Proposed framework

- **Context**
  - Unban environment of a smart city
  - ***n* households** participate in a program that lasts ***k* days** to reduce energy consumption
  - Available funding $\boldsymbol{B_T}$
- **Every day *i*, share of the available funding allocated**
  - $B_i = B_T/k$ in "euro"
- **Every day *i*, each household *j* obtains $\boldsymbol{ES_{ij}}$ virtual coins**
  - Equal to the amount of "kWh" they saved
- **Daily currency rate $\boldsymbol{C_i}$ of the obtained coins at day *i***
  - $C_i = \frac{B_i}{\sum_{j=1}^{n} ES_{ij}}$ in "€/ATOMcoin"

Virtual Energy-Currency Approach 7|7

Proposed framework

- **After k days of participating in this virtual market, the total amount of ATOMcoins *mj* that each household *j* has collected**
  - $m_j = \sum_{i=1}^{k} ES_{ij}$, in "ATOMcoins"
- **Monetary gain of each household *j* through all obtained coins after *k* days**
  - $g_j = \sum_{i=1}^{k} (C_i \cdot ES_{ij})$ in "€"
- **Individual value of ATOMcoins VCj for household *j***
  - $VCj = \frac{Value\ of\ total\ amount\ of\ coins\ collected\ by\ HHj, g_j}{Total\ amount\ of\ coins\ collected\ by\ HHj, m_j} = \frac{\sum_{i=1}^{k} (C_i \cdot ES_{ij})}{\sum_{i=1}^{k} ES_{ij}}$, in "€/ATOMcoin"

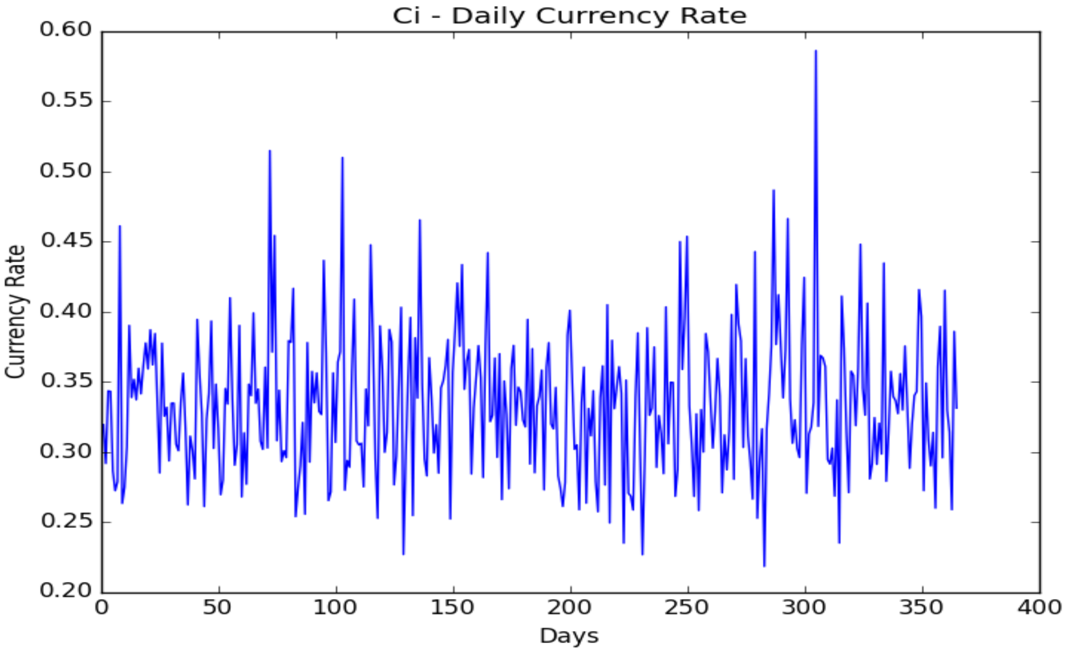
After *k* days, each household *j* has obtained m_j ATOMcoins of individual value of *VCj* which can be used within the community in several transactions that use the virtual currency of ATOMcoin

Numerical example 1|4

- Community in the Mediterranean that has been granted a yearly funding of 5,000 €, in order to reduce its energy consumption levels.
- Implementation of the developed framework.
- The community consist of n=100 households, and the scheme be implemented for 1 year, i.e., k=365 days.

Numerical example 2|4

- The daily bonus budget is B_i=5,000€/365 → B_i = 13.70 "€"



Daily Currency Rate for 365 days

$$C_i = \frac{B_i}{\sum_{j=1}^{n} ES_{ij}}$$ in "€/ATOMcoin"

- Energy savings Es_{ij} - normal distribution $N(\mu=0, \sigma^2=(4/3)^2)$
- A typical household of 4 people consumes 10 kWh and the energy savings normally vary from -4 to 4 kWh daily

Numerical example 2|4

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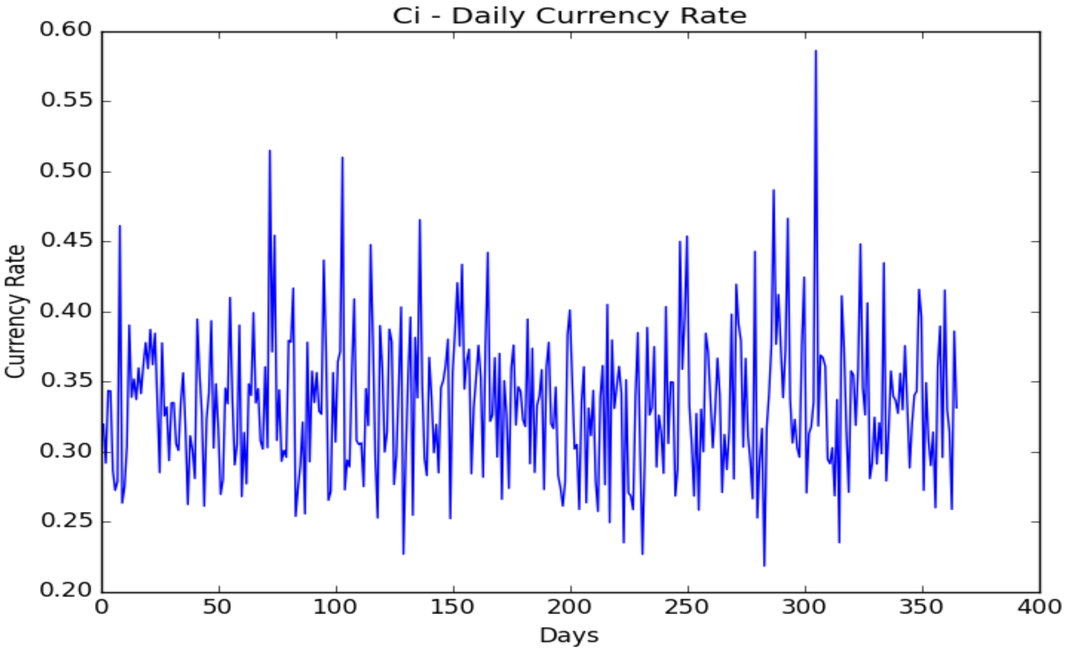

Daily Currency Rate for 365 days

$$C_i = \frac{B_i}{\sum_{j=1}^{n} ES_{ij}}$$ in "€/ATOMcoin"

- We have modelled a system that daily households save energy normally distributed around zero savings with a standard deviation being equal to 4/3.

Numerical example 3|4

Daily Currency Rate Calculation

Day i	Total Budget, B_i "€"	Total Coins, "coins"	Daily Currency Rate, Ci "€/coin"
1	13.70	40.7160	0.3192
2	13.70	44.5867	0.2915

The higher the energy savings from the whole community the smaller the currency rate is…

Numerical example 3|4

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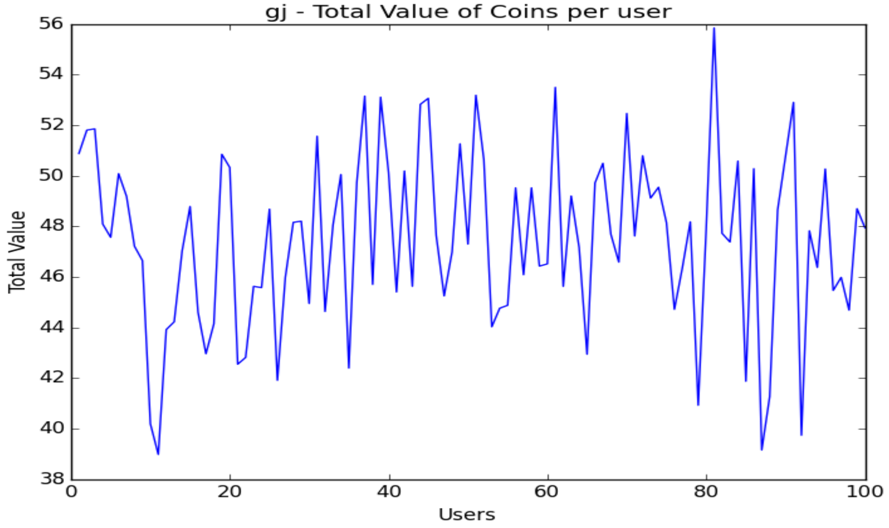
Energy Consumption and Coins Obtained

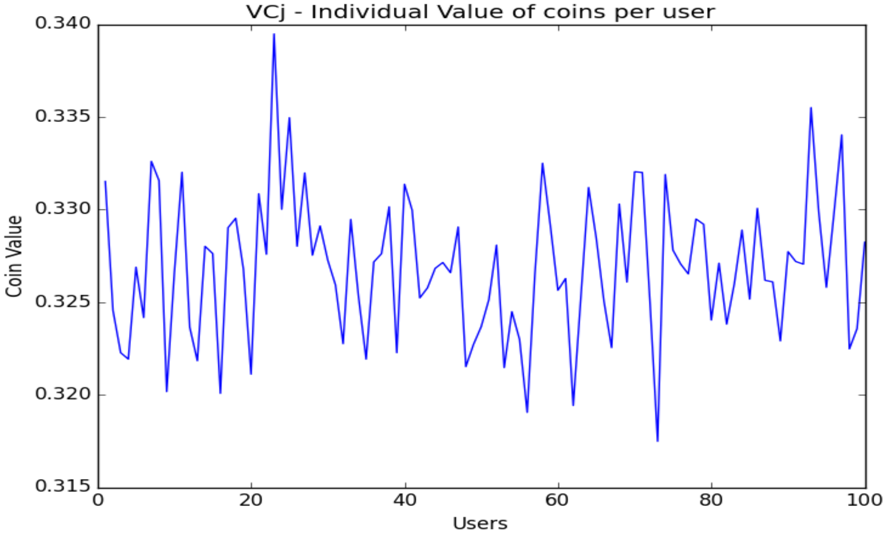
Households	Day, i=1	Day, i=2	ATOM coins	€	€/ATOMcoin
	Energy savings (kWh & coins)	Energy savings (kWh & coins)			
3	0.0000	0.9457	160.89	51.85	0.32
4	0.0000	0.0725	149.37	48.09	0.32
5	2.3123	0.0000	145.49	47.56	0.33

Saving energy they managed to gain value in the form of ATOMcoins, which can be used for any other type of transaction in the city.

Numerical example 4|4



Total Value of coins per household



Individual Value of coins per household

The total amount of energy saved is 34 MWh.

8-9% of the total energy the city was expected to consume (BAU), given that a typical household in the Mediterranean normally consumes about 3,500 to 4,000 “kWh” per year.

Conclusions

- **Multidisciplinary data** → Commonly accepted structures and enhanced connectivity and interoperability between different data sources.
- **Intelligent Energy management** → significant reduction of the energy consumption, CO_2 emissions and energy cost.
- **"App-in-context"** framework can support energy transition towards low carbon economies → engaging consumers for rational use of energy.
- **Innovative reward programs** → Integrate blockchain technology and energy efficiency, towards energy-based parallel currency.

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Thank you very much for your attention!

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