A new framework to design intelligent, and effective, Building Energy Management Systems – involving the end user

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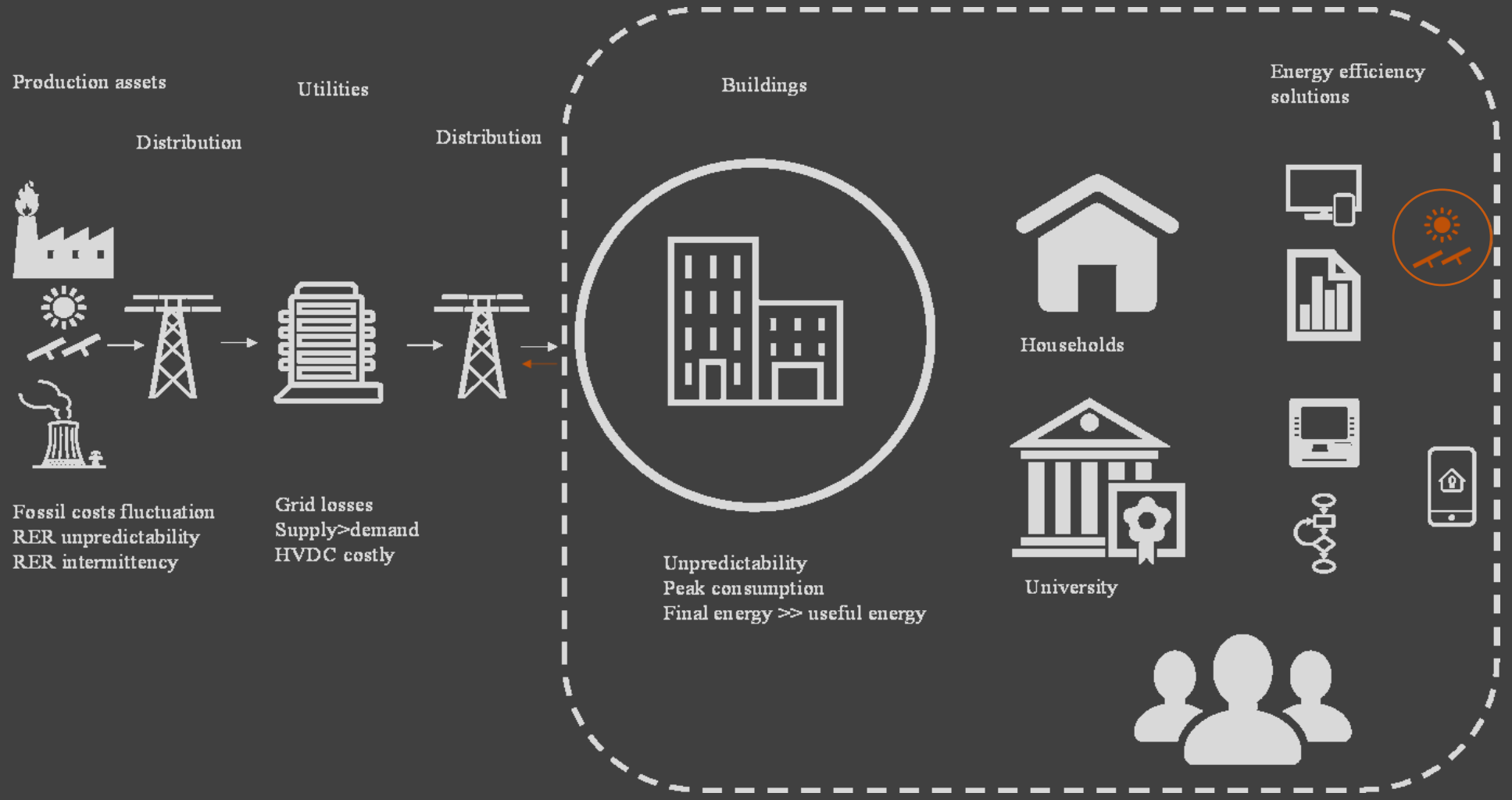
Energy demand/supply chain



PhD goal

Develop framework to increase energy efficiency in buildings

In an university building
- Integration with building energy management systems
- Collaborative control

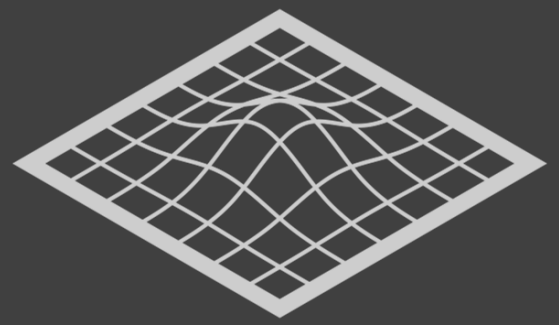
In households
- Engagement of end users
- Tailored feedback

An adaptive self-learning system

Understanding electricity consumption

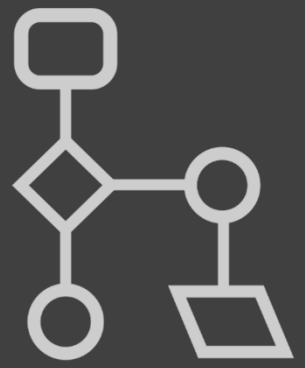
Accurate energy forecast: advanced energy modelling

- Neuro-fuzzy, self-learning
- Clustering
- Linear models
- Dynamic models
- …



Intelligent decision and control

- Evolutionary algorithms, adaptive
- Linear programming

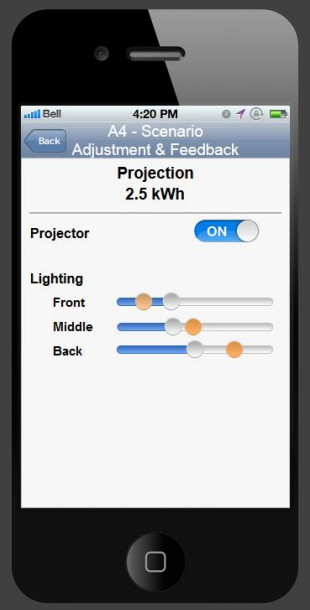


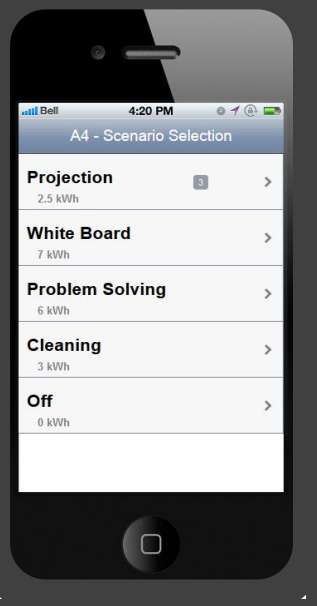
The ‘Smart Campus’

IST – Taguspark campus

Test beds:
- Set of offices
- Class amphitheater
- Library
- PC room
- Energy lab

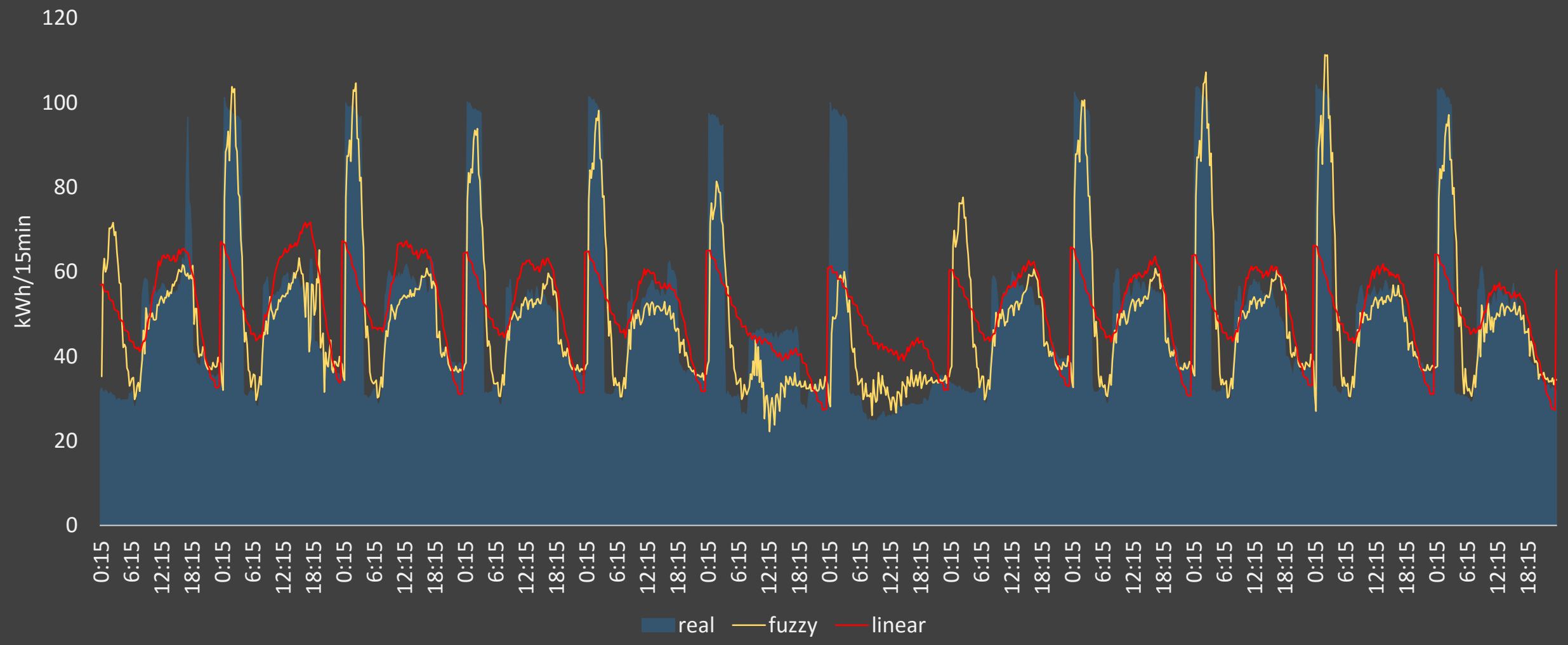
The goal:
- Monitor electricity consumption
- Control HVAC & lighting
- Engage staff & students





Collaborative management

Modelling and control



Modelling and control

- *kWh*

- *Occupancy*
- *Day length*
- *Solar radiation*
- *Solar radiation from the previous day*
- *Degree-days*

Linear regression
Fuzzy logic
Neural networks

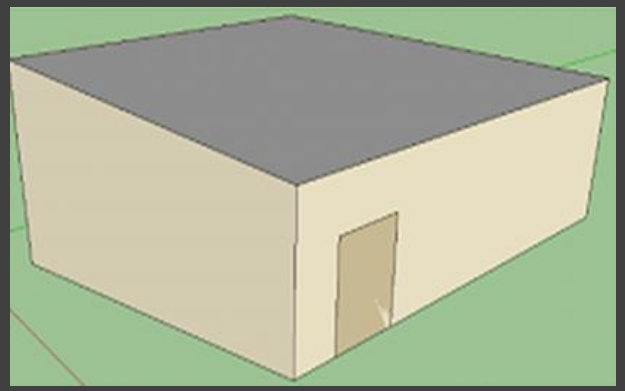
kWh' amphitheater
kWh' library

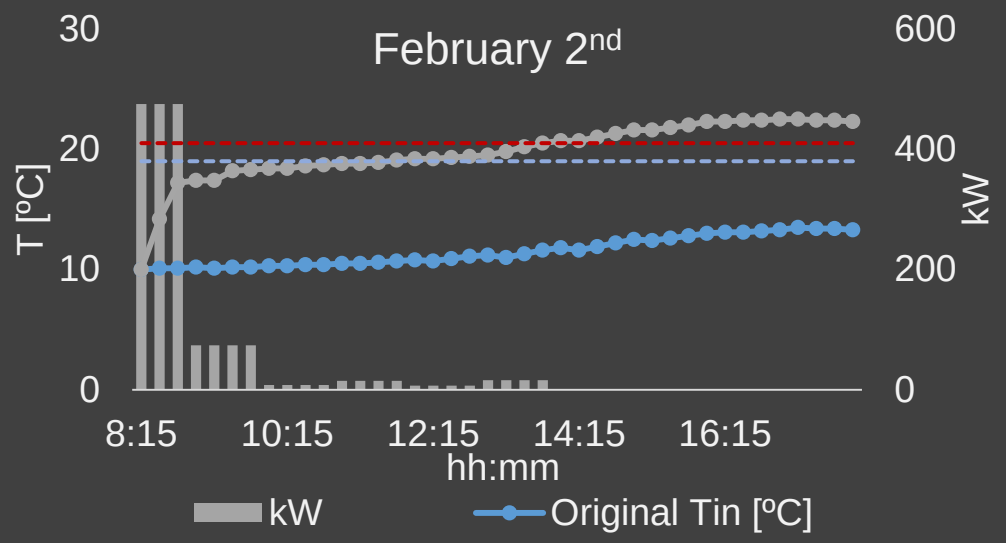
VAF
MSE
MAE

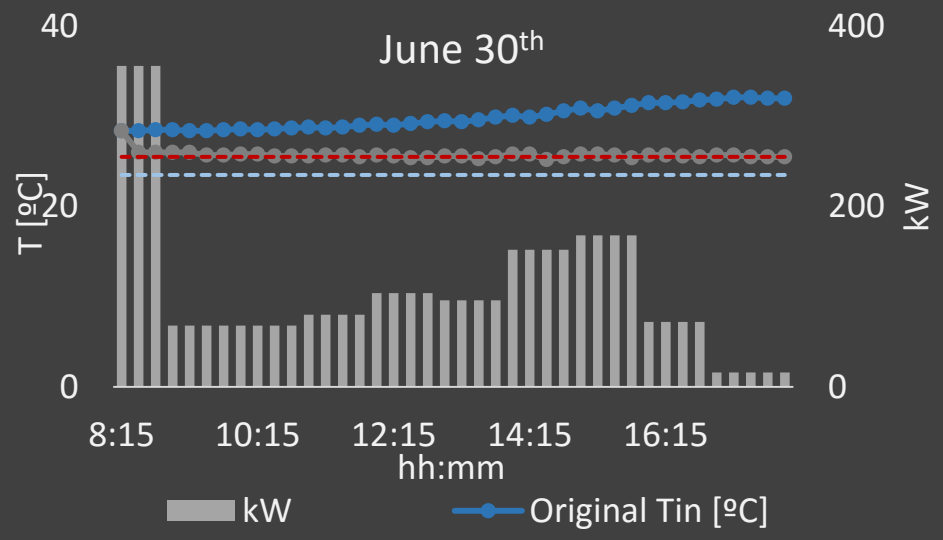
kWh'
-
kWh

Evolutionary
Algorithms

Optimization







Company	Frequency	Data granularity	Measuring units	Location	Presentation medium	Visual design	Push/pull	Recommendating action	Comparisons	Social sharing	Score
Tendril	●	●	●	◑	◑	◑	●	●	◑	●	8
Galp	●	●	●	◑	◑	●	◑	●	●	◑	8
AlertMe	●	●	●	●	●	●	●	◑	○	○	7.5
AzTech	●	●	●	●	●	●	●	◑	○	○	7.5
ISA sensing	●	●	●	●	●	●	●	◑	○	○	7.5
Intel	●	●	●	●	●	●	●	◑	○	○	7.5
Onzo	●	●	●	●	●	●	●	◑	○	○	7.5
Ambient Devices	●	●	●	●	●	●	◑	◑	○	○	7
Eragy	●	●	●	●	◑	●	●	◑	○	○	7
EDP	●	●	●	●	●	●	●	○	○	○	7
DIY KYOTO	●	●	●	●	●	●	◑	○	○	○	6.5
Energy Inc	●	●	●	●	◑	◑	●	◑	○	○	6.5
PeoplePower	●	●	●	◑	●	◑	◑	◑	○	◑	6.5
PowerHouse Dynamics	●	●	●	◑	◑	◑	●	●	○	○	6.5
Archos	●	◑	◑	●	●	●	●	○	○	○	6
Eco-eye	●	●	●	●	◑	◑	◑	◑	○	○	6
Efergy	●	●	●	●	◑	◑	●	○	○	○	6
Green Energy Options	●	●	●	●	◑	◑	◑	◑	○	○	6
Navetas	●	●	●	○	●	◑	●	◑	○	○	6
ThinkEco	●	●	◑	◑	●	●	◑	◑	○	○	6
Wattvision	●	●	●	◑	◑	◑	◑	◑	◑	○	6
OPower	◑	○	◑	○	●	◑	◑	◑	●	●	5.5

Company	Frequency	Data granularity	Measuring units	Location	Presentation medium	Visual design	Push/pull	Recommendating action	Comparisons	Social sharing	Score
Belkin	●	●	●	●	◑	◑	◑	○	○	○	5.5
Black and Decker	●	●	●	●	◑	◑	◑	○	○	○	5.5
Blueline Innovations	●	●	●	●	◑	◑	◑	○	○	○	5.5
Brultech	●	●	●	●	◑	○	◑	◑	○	○	5.5
Current Cost Ltd	●	●	◑	●	◑	◑	●	○	○	○	5.5
Ecobee	●	○	○	●	●	●	●	◑	○	○	5.5
Energate	●	●	◑	●	◑	◑	●	○	○	○	5.5
PassivSystems	●	●	●	○	◑	◑	●	◑	○	○	5.5
2 Save Energy	●	◑	●	●	◑	◑	◑	○	○	○	5
eGauge	●	●	◑	●	◑	◑	◑	○	○	○	5
Energy Hub	●	●	◑	●	◑	◑	◑	○	○	○	5
Joulebug	○	○	○	○	●	●	○	●	●	●	5
Nest	◑	○	◑	●	●	●	◑	◑	○	○	5
Verizon	●	◑	◑	◑	◑	◑	◑	●	○	○	5
Microsoft	●	○	○	●	●	●	◑	○	○	○	4.5
Plugwise	●	●	◑	◑	◑	◑	◑	○	○	○	4.5
Tenrehte	●	●	◑	◑	◑	◑	◑	○	○	○	4.5
TrickleStar	●	●	◑	◑	◑	◑	◑	○	○	○	4.5
Visible Energy, Inc	●	●	◑	◑	◑	◑	◑	○	○	○	4.5
Honeywell	●	●	◑	●	◑	○	○	○	○	○	4
iControl	◑	○	◑	◑	◑	●	◑	○	○	○	3.5
P3 International	●	●	◑	◑	○	◑	○	○	○	○	3.5
EcoDog Inc	●	●	●	○	○	○	○	○	○	○	3

Commercial solutions	Remote control	HVAC control	Goal/alarm setting	Lighting control	Load disaggregation	Performance analysis	Multivariable sensing	Tailored reports	Benchmarking	Dashboard	Hardware agnostic	Comfort feedback	Future scenarios (modelling)	HVAC intelligent control	Lighting intelligent control	Social sharing	Classification
Elster EnergyICT	●	●	●	●	●	◑	●	●	●	●	●	●	◑	◕	◕	●	14.5
Honeywell	●	●	●	●	●	●	●	●	●	●	●	●	◑	◔	◔	●	14
Siemens	●	●	●	●	●	●	●	●	●	●	●	◑	◑	●	●	●	13.5
Wipro EcoEnergy	●	●	●	●	●	●	●	●	●	●	●	◑	◑	●	●	●	13.5
Cylon Active	●	●	●	●	◑	●	◑	●	●	●	●	●	◑	◔	◔	●	13
GridPoint	●	●	●	●	●	●	●	●	●	●	●	◑	●	◕	◕	●	13
Philips	●	●	●	●	●	●	●	●	●	●	●	◑	●	◕	◕	●	13
Schneider Electric	●	●	●	●	●	●	●	●	●	●	◑	◑	◑	◑	◑	◑	13
Urjanet & Lucid	●	●	●	●	●	●	●	●	●	●	●	◑	○	◔	◔	●	13
BuildingIQ	●	●	●	●	●	●	●	●	●	◑	◑	◑	●	●	◔	●	12.8
eSight Energy	●	●	●	●	●	●	●	●	●	●	●	◑	◑	◑	◔	●	12.8
EnerNOC	●	●	●	●	●	●	●	●	●	●	●	◑	◑	◔	◔	●	12.5
SSE	●	●	●	●	●	●	●	●	●	●	●	◑	◑	◔	◔	●	12.5
Verisae	●	●	●	●	●	●	●	●	●	●	●	◑	◑	◔	◔	●	12.5
Ecova	●	●	●	●	●	●	●	●	●	◑	●	◑	◑	◑	◔	●	12.3
British Gas	●	●	●	●	●	●	●	●	◑	●	●	◑	◑	◔	◔	●	12
Cisco	●	●	●	●	●	●	●	●	●	◑	●	◑	●	◑	◑	●	12

Commercial solutions	Remote control	HVAC control	Goal/alarm setting	Lighting control	Load disaggregation	Performance analysis	Multivariable sensing	Tailored reports	Benchmarking	Dashboard	Hardware agnostic	Comfort feedback	Future scenarios (modelling)	HVAC intelligent control	Lighting intelligent control	Social sharing	Classification
E.ON Connecting Energies	●	●	●	●	●	●	●	●	●	◑	●	◑	◑	◔	◔	●	12
OSIsoft	●	●	●	●	●	●	◑	◑	●	●	●	◑	◑	◔	◔	◑	12
Panoramic Power	●	●	●	●	●	●	●	●	●	●	●	◑	◑	◔	◔	◑	12
Cofely	●	●	●	●	●	◑	◑	●	●	●	◑	◑	◑	◔	◔	◑	11.5
TCS	●	●	●	●	●	●	●	◑	●	●	●	◑	◑	◔	◔	●	11
Utilyx	●	●	●	●	●	●	◑	●	●	◑	●	◑	◑	◔	◔	◑	11
AtSite	●	●	●	●	●	◑	◑	◑	◑	●	●	◑	◑	◔	◔	●	10.5
IBM	●	●	●	●	◑	●	◑	◑	◑	●	●	◑	●	◑	◑	●	10.5
Tridium	●	●	●	●	●	●	●	◑	◑	●	●	●	●	◔	◔	●	10.5
Ingersoll Rand	●	●	●	●	◑	●	●	◑	◑	●	●	◑	●	◑	◑	●	10
CommScope	●	●	●	●	●	◑	●	◑	◑	◑	●	◑	◑	●	◕	●	9.8
Voyant	●	●	●	●	●	●	●	◑	◑	◑	●	○	◑	◔	◔	●	9.5
Johnson Controls	●	●	●	●	◑	●	◑	◑	○	◑	●	◑	◑	◑	◑	●	9
Npower	●	●	●	●	●	●	◑	●	◑	◑	●	◑	●	●	●	●	9
Optima Energy Manageme	●	●	●	●	●	◑	◑	◑	◑	◑	●	●	◑	●	●	●	9
Carrier	●	●	●	●	●	◑	●	◑	◑	◑	●	◑	◑	◑	●	●	9.3
Jones Lang LaSalle	●	●	●	●	◑	●	◑	◑	●	◑	●	◑	●	◑	◑	●	8

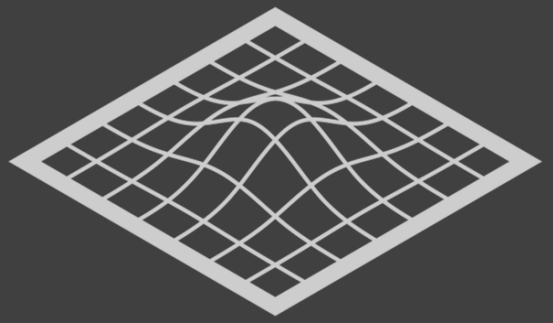
Engaging energy efficiency

User engagement

- Relevant information: which?
- Adequate interface design: how? What is qualitative analysis?
- Behavior change… What? More qualitative analysis?
- Usability.

Quantify savings

- Baseline. Again, advanced modelling.



On a national level: ‘A Sua Casa, a Sua Energia’

Provide feedback in a multi-platform

- Cluster families
  - Socioeconomic factors
- Tailor energy efficiency measures
- Assess behavior change

On a national level: ‘SusCity’

Divide families in:

- Control group
- Intervention group

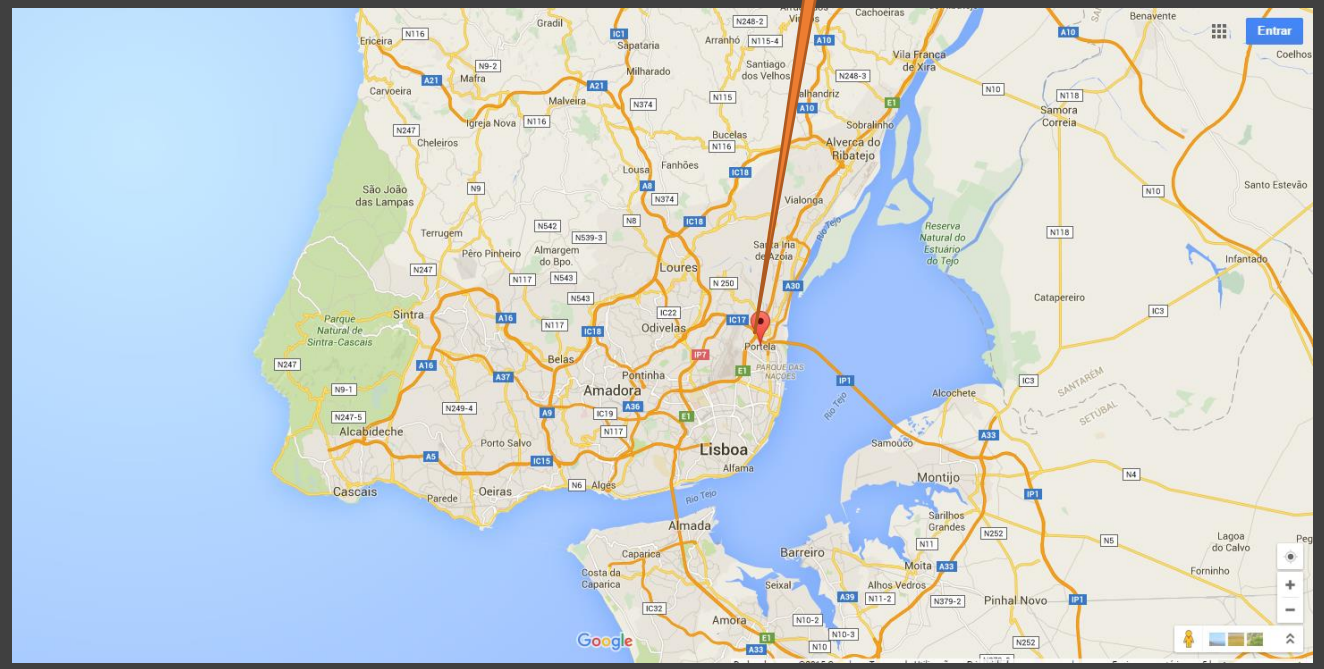
Clusters:

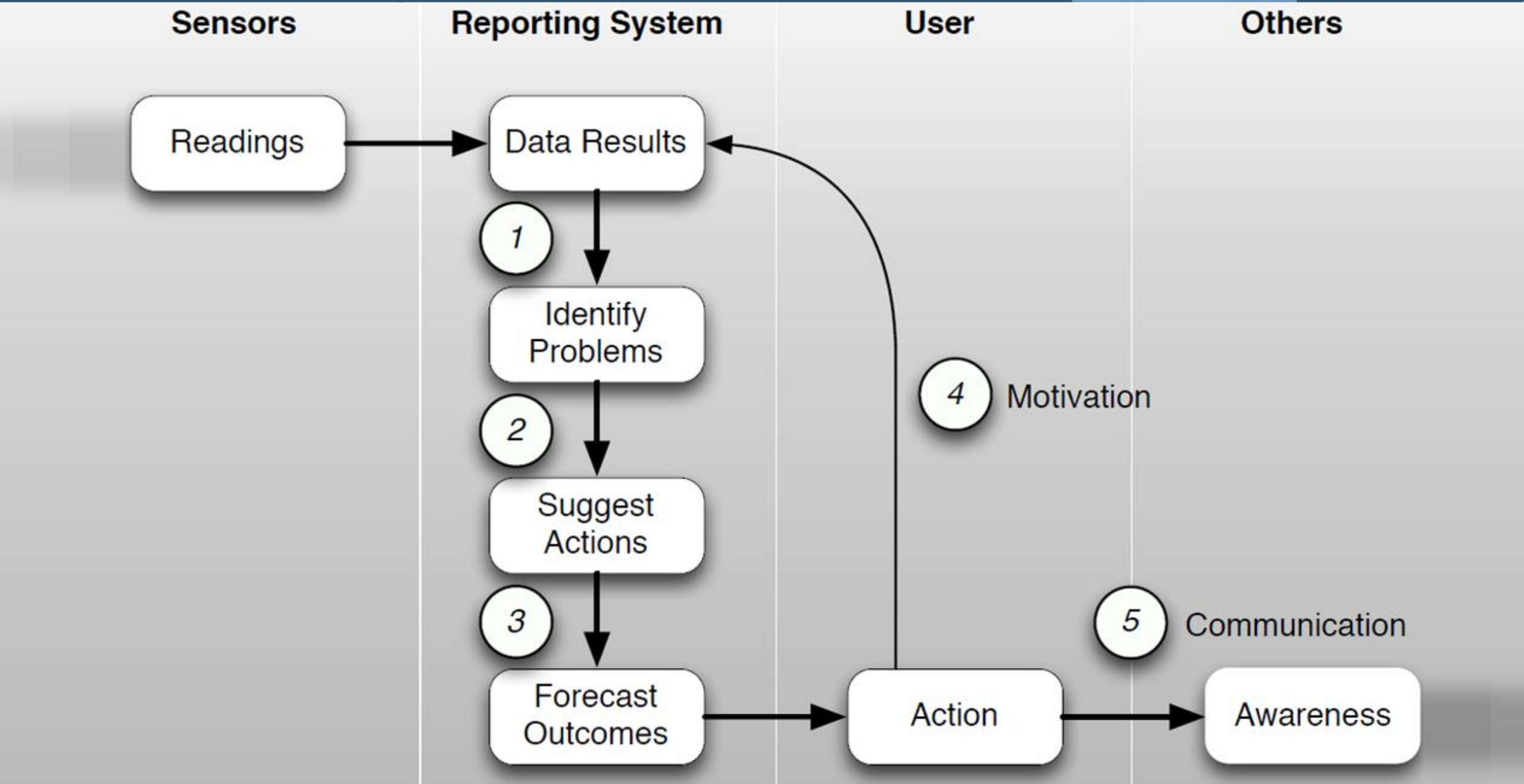
- Socioeconomic factors
- Archetypes

Tailor energy efficiency measures

Assess behavior change

Lisbon, Portugal




Sensors
Reporting System
User
Others
Readings
Data Results
1
Identify Problems
2
Suggest Actions
3
Forecast Outcomes
4
Motivation
5
Communication
Action
Awareness

a sua casa
a sua energia
Henrique Pombeiro
Início
A sua Casa
A sua Energia
Como Poupar
Sobre
€ 81 / ano
O que pode poupar
479 kWh / ano
O que pode poupar
0 €
O que já poupou
As suas medidas de eficiência energética
Limpe a grelha do seu frigorífico
Descongele frigorífico
Considere substituir o seu frigorífico
Ver Mais
Consumos mensais
Energia consumida (kWh)
1000
750
500
250
0
Nov 14
Dez 14
Jan 15
Fev 15
Mar 15
Abr 15
Mai 15
Jun 15
Jul 15
Ago 15
Set 15
Out 15
A sua casa
Casa média
Brevemente
Estamos a trabalhar os seus dados para que seja possível detalhar os consumos de cada um dos seus eletrodomésticos.
A Sua Conta
Veja os seus relatórios de eficiência energética aqui
Relatórios
Último Login:
08 de Outubro
Quinzena das Águas Quentes Sanitárias
Veja aqui o que pode fazer para ser mais eficiente na utilização das Águas Quentes Sanitárias!
Dicas

a sua casa a sua energia

Henrique Pombeiro

Início | A sua Casa | A sua Energia | Como Poupar | Sobre

- Casa
- Eletrodomésticos
- Agregado Familiar

Voltar

Casa | Morada

A Sua Casa

Tipo de instalação: Não se aplica	Tarifa energética: Bi-Horário	Contador: digital
Rendimento Mensal: <= 1000	Tipologia da casa: T2	Decada de construção: 1990 a 2000
Área da casa: 100 - 125 m^2	Localização da fração: Último piso, com cobertura (telhado) horizontal	Possui certificado energético: Não
Código do certificado energético: não sei	Permite o acesso ao certificado: Sim	Permite que usemos os seus dados: Sim
A sua casa é Arrendada?: Não	Moeda: Euros	

Editar

The main goal

Develop a framework to help buildings more sustainable

– Define the best strategies in our university campus

– Define the best strategies for households

A tool self-adaptable to different contexts

Thank you!

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