Smart Grid Energy Management Staff Exchange

SMARTGEMS
energy network

D2.3 Webinars in integration and innovation management: Recordings

WP2 - SMART GEMS Training Activities

WP Leader: UBRUN

REPORT

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H2020-MSCA-RISE-2014

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Table of Contents

1 Introduction

The report for the Deliverable 2.3 concerns the webinars in integration and innovation management, which are under the task 2.3 of Work Package 2 (SMART GEMS Training Activities). The webinars for the task 2.3 commenced on the 1st of March, 2017 and were completed on the 10th of May, 2017. Five webinars were delivered, each including questions and discussion; these were presented by AEA, TUC, UBRUN, EGM, and NUS, using the WebEx Platform. The assigned staff of the Smart GEMS partners attended the series of the five webinars with the following topics:

1. Optimised operation of smart grids presented by AEA and TUC,1st of March, 2017,
2. Integration capabilities of various technologies for smart grids presented by AEA,1st of March, 2017,
3. From innovation to final product in enterprise presented by UBRUN, 26th of April, 2017,
4. Innovation in smart metering presented by EGM, 26th of April, 2017,
5. Dynamic, flexible and human-centric – Innovation towards smart energy management presented by NUS, 10th of May, 2017.

The summaries of the five webinars were distributed to all partners well before the beginning of each webinar. The webinars were also disseminated using social media platforms. As an example the social media notifications for the webinar on 26 April 2017 is shown below:

Twitter - https://twitter.com/eu_smartgems/status/847023447859494914

Facebook - https://www.facebook.com/smartgemsproject/photos/a.1771758479721438.1073741830.1756959384534681/1913930248837593/?type=3&theater

LinkedIn - https://www.linkedin.com/groups/8551724/profile

The PPTs of the webinars are included in the annex of this report.

2 The webinars

2.1 Webinar 1 – Optimised operation of smart grids presented by AEA and TUC

2.1.1 General Information

The 1st double webinar was presented by AEA and TUC on the topic titled "Optimised operation of smart grids". The webinar which was held on the 1st of March, 2017, started at 10:13am CET and ended at 10:58am CET (45 minutes duration), with 22 participants of Smart GEMS project members:

1. Alaric Montenon (Cyl)
2. Angeliki Mavrigiannaki (TUC)
3. **Dr. Denia Kolokotsa (TUC) – Host**
4. **Dr. Laura Standardi (AEA) – Presenter**
5. Dr. Tatiana Kalganova (UBRUN)
6. Eli Tsirintoulaki (TUC)
7. Emmanuel Shittu (UBRUN)
8. Federica Fuligni (EXERGY)
9. **IDEA (5 participants)**
10. Lukas Samulevicius (EGM)
11. Marina Kyprianou (Cyl)
12. Miltiadis Samanis (CUT)
13. **Nikos Kampelis (TUC) – Presenter**
14. Prof. Maria Kolokotroni (UBRUN)
15. Tatiana Kalganova (UBRUN)
16. Thiago Santos (UBRUN)
17. Vassilis Lontorfos (UoA)
18. Zoi Mylona (UBRUN)

2.1.2 Summary of the 1st webinar

2.1.2.1 Summary of the presentation by AEA

The main objective of this webinar was to underline the need for optimised operation of smart grids. The webinar contents are summarised below:

- Unstable production and consumption and new actors: storage systems and prosumers
- What the market is proposing
- How to optimise

2.1.2.2 Summary of the presentation by TUC

In this webinar, TUC explained the role of Demand Response (DR) in both technical and regulatory framework for optimised operation of smart grids. The webinar contents are summarised below:

- Demand Response (DR) definition & scope by TUC
- DR program types by TUC
- Net load (Duck) curve by TUC
- User interface/consumer engagement by TUC
- Demand response in energy efficiency directive (2012/27/EU) by TUC
- Open automated demand response (open ADR 2.0) by TUC
- Conclusions by TUC

2.2 Webinar 2 – Integration capabilities of various technologies for smart grids presented by AEA

2.2.1 General Information

The 2nd webinar was presented by AEA on the topic titled "Integration capabilities of various technologies for smart grids". The webinar which was held on the 1st of March, 2017, started at 10:58am CET and ended at 11:26am CET (28 minutes duration), with the same AEA presenter and the same number of participants of Smart GEMS project members present in webinar 1.

2.2.2 Summary of the 2nd webinar

In this webinar, AEA explained how different technologies should be efficiently integrated in smart grids. A case study of industrial micro-grid by Loccioni which focused on the main components of this smart grids, and the communication and control systems that connect and coordinate all the different systems of the smart grid was presented. The webinar contents are summarised below:

- What is integrated in a micro-grid
    I. What to integrate
    II. Communication system
    III. Control system
    IV. Human interaction
    V. Conclusions

2.3 Webinar 3 – From innovation to final product in enterprise presented by UBRUN

2.3.1 General Information

The 3rd webinar was presented by UBRUN on the topic titled “From innovation to final product in enterprise”. The webinar which was held on the 26th of April, 2017, started at 11:52am CET and ended at 12:38pm CET (46 minutes duration), with 23 participants of Smart GEMS project members:

1. Angeliki Mavrigiannaki (TUC)
2. Chris Shearer (EXERGY)
3. Daniela Isidori (AEA)
4. Dominik Jasinski (EXERGY)
5. **Dr. Denia Kolokotsa (TUC) – Host**
6. Dr. Laura Standardi (AEA)
7. Dr. Martina Senzacqua (AEA)
8. Dr. Nerijus Kruopis (EGM)
9. **Dr. Tatiana Kalganova (UBRUN) – Presenter**
10. Dr. Theoni Karlesi (UoA)
11. Eli Tsirintoulaki (TUC)
12. Emmanuel Shittu (UBRUN)
13. Fabio Montagninon (IDEA)
14. Federica Fuligni (EXERGY)
15. Felipe Maya (EXERGY)
16. Filippo Paredes (IDEA)
17. Kostas Gobakis (TUC)
18. Maria Saliari (UoA)
19. Marina Kyprianou (CyI)
20. Nikos Kampelis (TUC)
21. Prof. Maria Kolokotroni (UBRUN)
22. Thiago Santos (UBRUN)
23. Zoi Mylona (UBRUN)

2.3.2 Summary of the 3rd webinar

In this webinar, UBRUN described the transition of innovative concepts to final product in enterprise via active collaboration between academia and industrial sections. The webinar contents are summarised below:

- The bottleneck of the blue sky research
- Industry vs academia perspectives
- Successful pathway for collaboration
- Case study 1: GEMSTONE technology
- Case study 2: Detection, Prediction and Visualisation of Distant Volcanic Ash using GPS
- Conclusion

2.4 Webinar 4 – Innovation in smart metering presented by EGM

2.4.1 General Information

The 4th webinar was presented by UBRUN on the topic titled "Innovation in smart metering". The webinar which was held on the 26th of April, 2017, started at 12:39am CET and ended at 01:21pm CET (42 minutes duration), with 24 participants of Smart GEMS project members:

1. Angeliki Mavrigiannaki (TUC)
2. Chris Shearer (EXERGY)
3. Daniela Isidori (AEA)
4. Dominik Jasinski (EXERGY)
5. **Dr. Denia Kolokotsa (TUC) – Host**
6. Dr. Laura Standardi (AEA)
7. Dr. Martina Senzacqua (AEA)
8. **Dr. Nerijus Kruopis (EGM) – Presenter**
9. Dr. Tatiana Kalganova (UBRUN)
10. Dr. Theoni Karlesi (UoA)
11. Eli Tsirintoulaki (TUC)
12. Emmanuel Shittu (UBRUN)
13. Fabio Montagninon (IDEA)
14. Federica Fuligni (EXERGY)
15. Felipe Maya (EXERGY)
16. Filippo Paredes (IDEA)
17. Kostas Gobakis (TUC)
18. Maria Saliari (UoA)
19. Marina Kyprianou (CyI)
20. Nikos Kampelis (TUC)
21. Prof. Maria Kolokotroni (UBRUN)
22. Thiago Santos (UBRUN)
23. Vassilis Lontorfos (UoA)
24. Zoi Mylona (UBRUN)

2.4.2 Summary of the 4th webinar

In this webinar, EGM presented the key innovative drivers for smart metering which are market drivers (which addressed the technical progress that has been achieved to meet customers' expectation, optimisation of price driven by market competition, marketing strategy, and product aesthetics), European Parliament and Council legal directives drivers, and social drivers pertaining to attracting specialist in the continuous innovation of smart meters. The webinar contents are summarised below:

- Elgama Elektronika in numbers
- Smart meter product roadmap
- Progress in metering devices
- Eco-design project (2006)
- Advanced Metering Infrastructure (AMI)
- Kaliningrad project «Янтарьэнерго»
- Pilot project in Astana (Kazakhstan)
- Pilot project«PALMA»in Latvia (2013)
- Substation pilot project in Latvia (2016)
- Smart Metering pilot in Greece (2017)
- Pilot project in Lithuania (2017)
- From simple to advanced functionality
- Technology innovation
- What is next? NB-IOT

2.5 Webinar 5 – Dynamic, flexible and human-centric – Innovation towards smart energy management presented by NUS

2.5.1 General Information

The 5th webinar was presented by NUS on the topic titled "Dynamic, flexible and human-centric – Innovation towards smart energy management". The webinar which was held on the 10th of May, 2017, started at 10.03am CET and ended at 10.45am CET (42 minutes duration), with 24 participants of Smart GEMS project members:

1. Angeliki Mavrigiannaki (TUC)
2. Chris Shearer (EXERGY)
3. Daniela Isidori (AEA)
4. **Dr. Denia Kolokotsa (TUC) – Host**
5. **Dr. Junjing Yang (NUS) – Presenter**
6. Dr. Laura Standardi (AEA)
7. Dr. Martina Senzacqua (AEA)
8. Dr. Tatiana Kalganova (UBRUN)
9. Dr. Theoni Karlesi (UoA)
10. Eli Tsirintoulaki (TUC)
11. Emmanuel Shittu (UBRUN)
12. Federica Fuligni (EXERGY)
13. Fernando Sanahuja (EXERGY)
14. **IDEA (5 participants)**
15. Kostas Gobakis (TUC)
16. Marina Kyprianou (Cyl)
17. Nikos Kampelis (TUC)
18. Prof. Maria Kolokotroni (UBRUN)
19. Vassilis Lontorfos (UoA)
20. Zoi Mylona (UBRUN)

2.5.2 Summary of the 5th webinar

Building GHG emission can be reduced by increasing the use renewable energy sources by suppliers at energy generation stations, energy efficient buildings, and most importantly, smart energy management of buildings to help implement effective use of limited energy resources. NUS are using their Building Energy Efficiency (BEE) Hub (a strategic research center at department of building) as a study case to address key challenges such "one-size fits all" concept of building systems and lack of building interaction between buildings/building systems and occupants. Energy consumption, CO_2 concentration profile and temperature profile were measured and analysed.

Also, NUS presented some innovative concepts and development in terms of building design, energy management of systems at buildings and communities, building interaction and connection with different systems and smart grid, and smart interaction between occupants and buildings for best possible environmental comfort. This will effectively reduce buildings' energy consumption and Green House Gas (GHG) emission.

3 Conclusions

This report is a summary of the five webinars for task 2.3 - Integration and Innovation Management via webinars of Work Package 2 (WP2 - SMART GEMS Training Activities). The presentations are included as Annexes to this report.

In addition, the video recordings of the webinars are available at the YouTube channel of the Energy Management in the Built Environment Laboratory (EMBER) of Technical University of Crete in the following URL:
https://www.youtube.com/user/EmberTUC

An additional webinar is scheduled for 31st May 2017 to be delivered by UoA on the topic of 'Occupancy and IEQ as controlling parameters of energy for spaces with different uses, a case study’. This will be reported in the next deliverable 2.4 together with lectures attended by the seconded staff.

Evaluation questionnaires have been created and the link distributed to all participants at the end of each webinar. Responses have been gathered and analysed to inform next training activities. These activities will be reported in the next deliverable 2.5 on ‘Evaluation Questionnaires and feedback report on training sessions’.

4 Annexes

4.1 Annex I: Slides of the 1st Webinar - Optimised operation of smart grids presented by AEA and TUC

4.1.1 Slides of the Webinar presented by AEA

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Webinar 1/a: Optimised Operation of Smart Grids
10:00 CET 1/3/2017

Marie Skłodowska-Curie Actions (MSCA)
Research and Innovation Staff Exchange (RISE)
H2020-MSCA-RISE-2014

The Need of Optimised Operation
by AEA

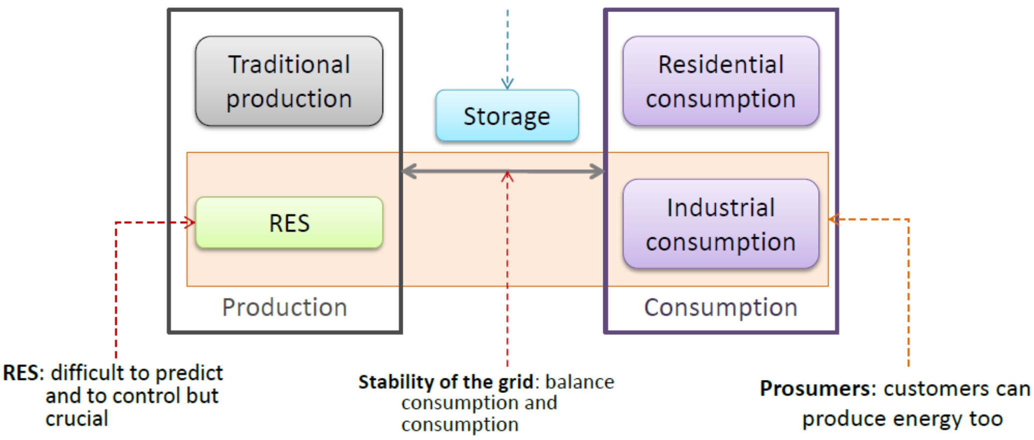
a. Unstable production and consumption and new actors: storage systems and prosumers

b. What the market is proposing

c. How to optimise

Unstable production and consumption and new actors: storage systems and prosumers

Store energy when it is more than consumption in order to use it when the consumption is higher than the production.



Smart Grids: why is optimisation so crucial?

- Difficult to plan in advance production and consumption with high accuracy
- Need to balance consumption and production for grid stability
- Not only production and consumption, but also storing energy
- Systems with different dynamics
- Several inputs and output with different time-scales
- A growing number of systems in a smart grid

Optimised operation
Multiple systems are coordinated and control through an optimisation-based control strategy.

What the market is proposing... ...now, and what it is going to demand for

Trading: portfolio and asset optimisation that includes real-time market prices.

Embedded MPC Controller: embedded controller with dedicated solver related to the type of costraint matrix that the optimisation control has.

EMS: at building and/or grid level.

Tipically, the EMS available on the market implement basic optimisation strategy that can be hardly customized.

A growing number of companies are focusing on developing **advanced control strategies for their assets**.

Flexibility and **Modularity** are meant to be crucial as new assets must be easily included/removed into/from the grid, thus, into/from the controller.

Integration with the **markets**: updated market prices are going to be used into the optimisation and also into **forecasting** modules.

How to optimise

Grid Level

• Balancing consumption and production aimed to keep grid frequency to 50 Hz.

• Storing renewable energy and using it whenever it is necessary.

Building Level

o Coordinating production and consumption based on market prices and loads.

o Reducing Energy Consumption.

o Reducing Power Peaks .

o Storing energy (electrical and/or thermal) through storage systems and/or thermal inertia of buildings (i.e. flexibility)

How to optimise

The features of optimal operation of smart grid are:

✓ **Including** the asset, grid and market **dynamics**,

✓ **Update input** (e.g. market price),

✓ **Optimise over different time scales**:
- IM 1 hour before delivery, BM 30 minutes before delivery, etc.
- Asset control inpunt: based on the asset dynamic.

✓ **Computational time**: based on where the optimisation model operates, optimal solutions could be required real-time, hence, sub-optimality in the solution can be accepted in order to gain a reduction in computational time.

✓ **Linear/Nonlinear, Real/Integer Models**: linear model and real variables are ideal, but nonlinearity and integer (mixed-integer) variables enable the modelling of various systems.

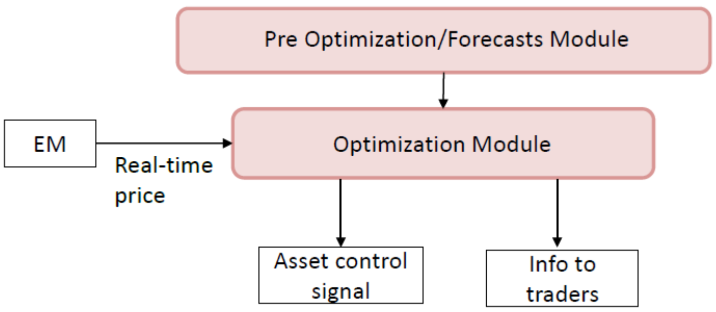
How to optimise

✓ **Modularity** and **Flexibility**: adding and modifying assets and dynamics is requested to be easy.

✓ **Reliability**: assets must be controlled and coordinated, if the optimisation problem does not compute the optimal solution within a determined time, then the control system must guarantee the control and the corodination of all various asset.

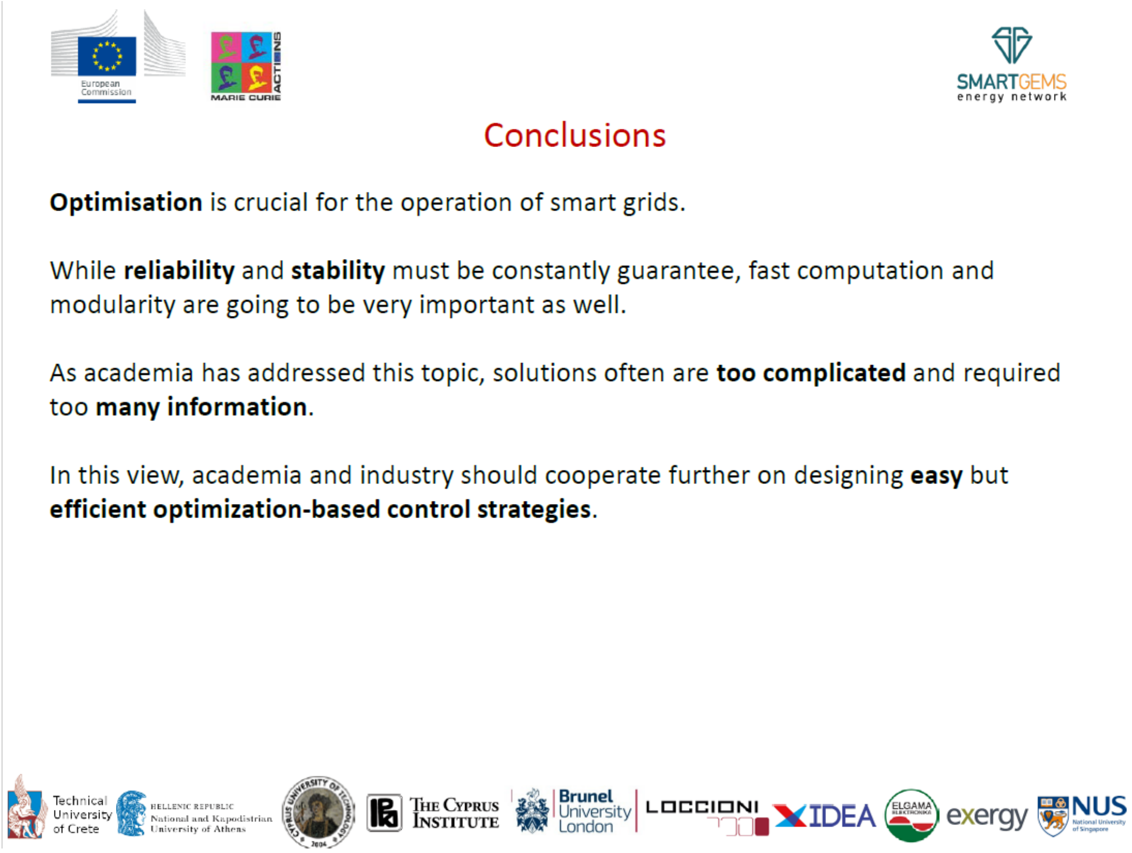
✓ **Fully decentralized** Vs **Centralized Control Strategy**.

Optimisation: an example



Optimisation Module

- Multiple time windows
- Multiple time scales
- Asset dynamics that differ from the market ones
- Mathematical Optimum
- Interaction with the trading platform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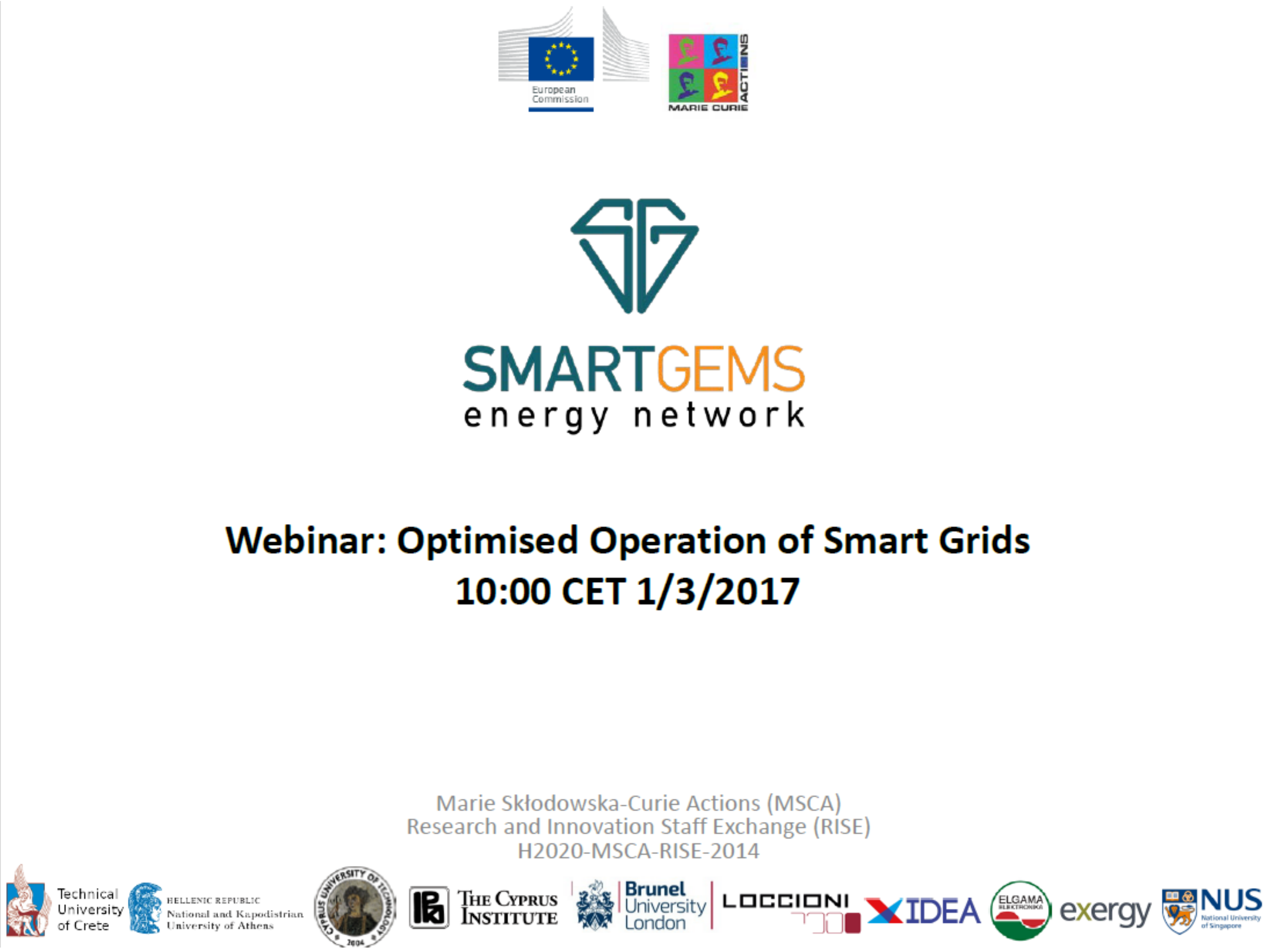
Conclusions
Optimisation is crucial for the operation of smart grids.
While **reliability** and **stability** must be constantly guarantee, fast computation and modularity are going to be very important as well.
As academia has addressed this topic, solutions often are **too complicated** and required too **many information**.
In this view, academia and industry should cooperate further on designing **easy** but **efficient optimization-based control strategies**.

4.1.2 Slides of the Webinar presented by TUC



Contents

- Demand Response (DR) definition & scope
- DR program types
- Net Load (Duck) Curve
- User interface / Consumer Engagement
- Demand Response in Energy Efficiency Directive (2012/27/EU)
- Open Automated Demand Response (Open ADR 2.0)
- Conclusions

Demand Response Introduction

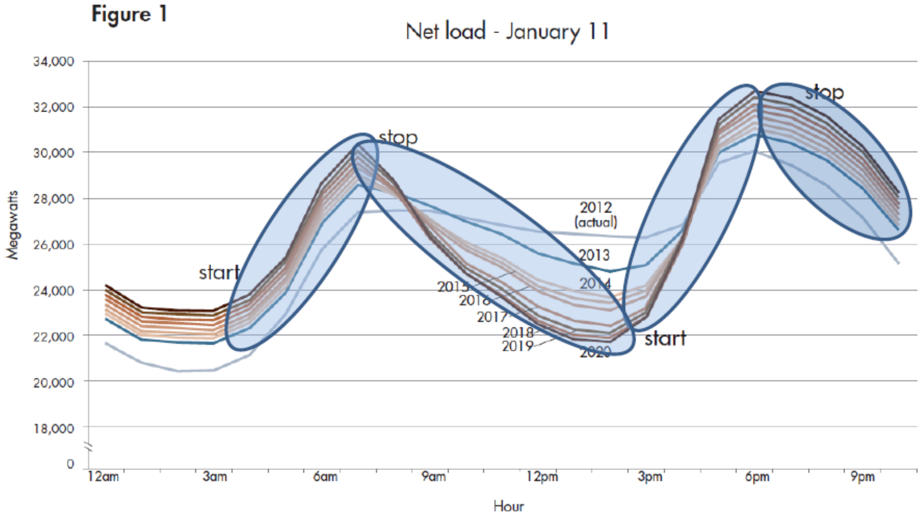
- **Demand response** is a program of incentives or a "way" to induce changes in electric consumption patterns by end-users
- Why Demand Response?
  - to induce lower electricity use at times of high market prices or when grid reliability is jeopardised.

Smart Grid Challenges

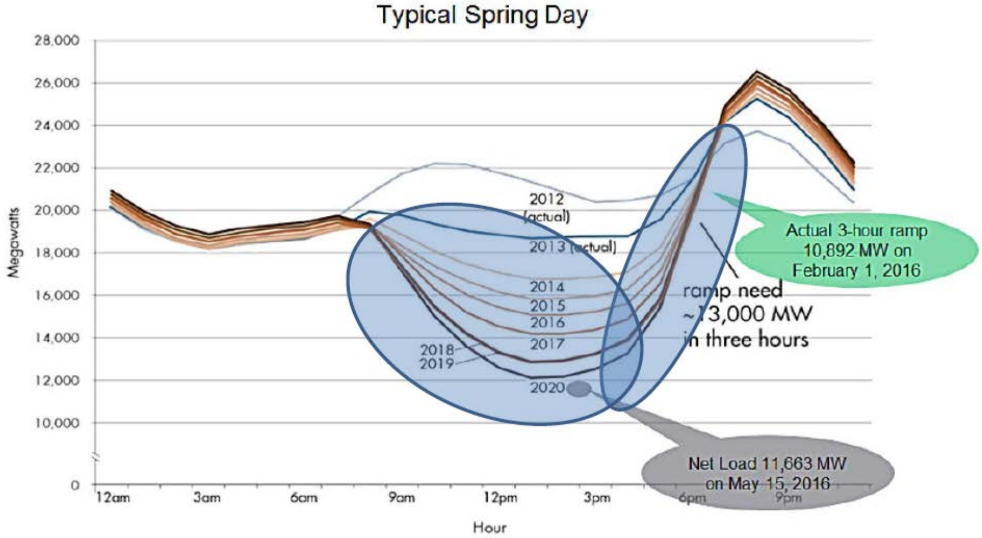
- Electric Vehicles – peak increase by 40%
- Electrification of heat
- RES volatility

Net Load (Duck) Curve

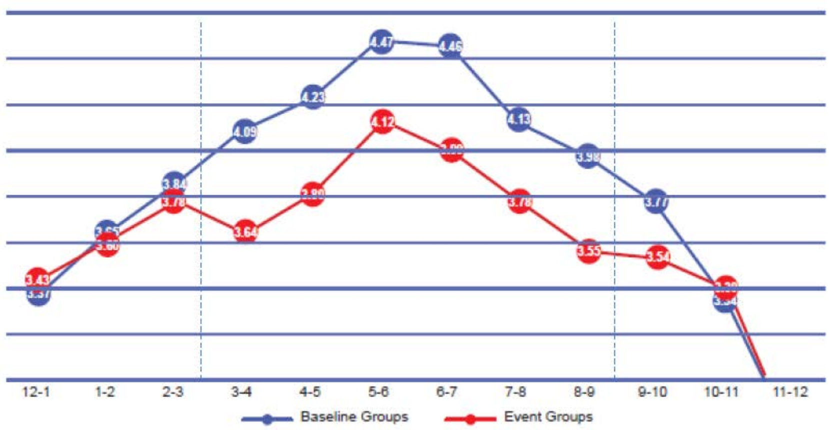
Figure 1



Net Load (Duck) Curve



Residential PTR: July 13 Event Hour 15 to Hour 21



Expected Benefits = Probability of Peak x Benefits of Reducing Peak

Expected Benefits > Cost of Calling Event

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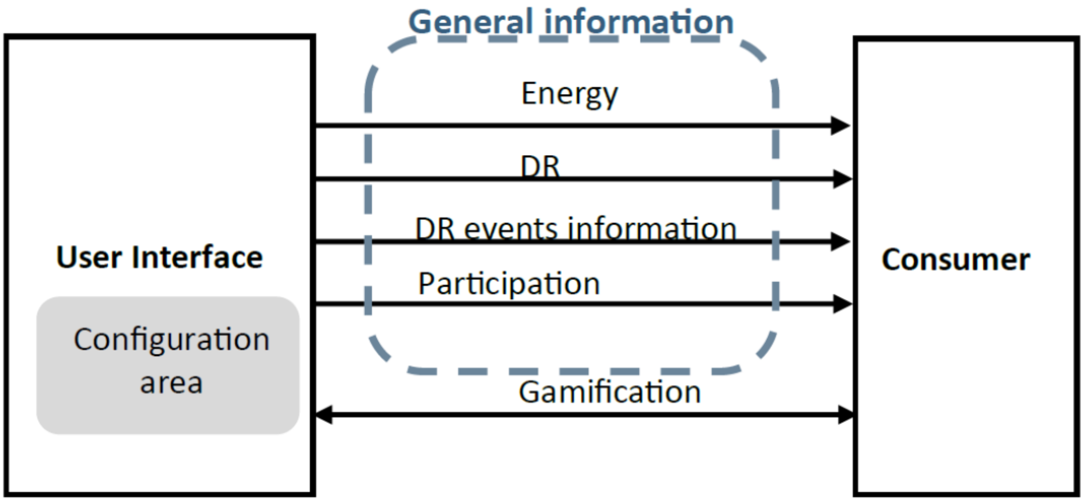
User Interface / Consumer Engagement



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Explicit Demand Response

- **Explicit Demand Response:**

Demand competes directly with supply in the wholesale, balancing and ancillary services markets through the services of aggregators or single large consumers.

Implicit Demand Response

- **Implicit Demand Response**

Consumers choose *time-varying electricity prices* and react to those price differences depending on their own capabilities.

Demand Response EU Policy

- Addresses key issues
- Projects funding – removal of barriers – minimisation of risks
- Monitoring progress
- Strategic direction / consultation

Demand Response in Energy Efficiency Directive (2012/27/EU)

Article 15.4 requires Member States to:

- *"**Ensure the removal of those incentives** in transmission and distribution tariffs that are detrimental to the overall efficiency (including energy efficiency) of the generation, transmission, distribution and supply of electricity or those **that might hamper participation of Demand Response,** in balancing markets and ancillary services procurement".*
- *- "Ensure that network operators are incentivised to improve efficiency in infrastructure design and operation, and, within the framework of Directive 2009/72/EC, that tariffs **allow retailers to improve consumer participation in system efficiency, including Demand Response,** depending on national circumstances".*

Demand Response in Energy Efficiency Directive

Art. 15.8 establishes consumer access to energy markets, either individually or through aggregation. :

*"Member States shall ensure that national regulatory authorities **encourage** demand side resources, such as Demand Response, to participate alongside supply in wholesale and retail markets."*

*"Subject to technical constraints inherent in managing networks, Member States shall ensure that transmission system operators and distribution system operators, in meeting requirements for balancing and ancillary services, treat Demand Response providers, including aggregators, in a **non-discriminatory** manner, on the basis of their technical capabilities."*

*"Member States shall promote access to and participation of Demand Response in balancing, reserves and other system services markets, inter alia by requiring national regulatory authorities [...] in close cooperation with demand service providers and consumers, **to define technical modalities** for participation in these markets on the basis of the **technical requirements of these markets and the capabilities of Demand Response**. Such specifications shall include **the participation of aggregators**."*

Demand Response in Energy Efficiency Directive

Article 15.8 requires that regulators, TSOs and DSOs to:

1. Authorise Demand Response, allowing consumer load to compete alongside generation assets in all markets;
2. Enable aggregation in all markets;
3. Adjust technical modalities in all markets

In successful cases, TSOs and regulators are using the deregulated and competitive market structures to empower providers and encourage market entry for consumers.

Role of aggregator

- An aggregator is a service provider who operates – directly or indirectly – a set of demand facilities in order to sell pools of electric loads as single units in electricity markets

Open Automated Demand Response (Open ADR 2.0)

- Standard framework for communicating DR events between the utility and downstream entities (resources), using equipment that facilitate communication exchange

Basic definitions in Open ADR

- **DR Program Party -** entity responsible for the Grid Infrastructure and managing the DR Programs.
- **Aggregator Party** – party that aggregates multiple Resources
- **Resource** – entity enrolled in the DR Program **Asset** – physical systems or loads "behind" a Resource

DR Program Types (1/2)

- **Critical Peak Pricing**: encourages reduced consumption during periods of high wholesale market prices or system contingencies
- **Capacity Bidding Program**: allows a demand resource in retail and wholesale markets to offer load reductions (curtailment) at a price
- **Thermostat Program/Direct Load Control**: program sponsor remotely controls a customer's electrical equipment (e.g. air conditioner) on short notice.

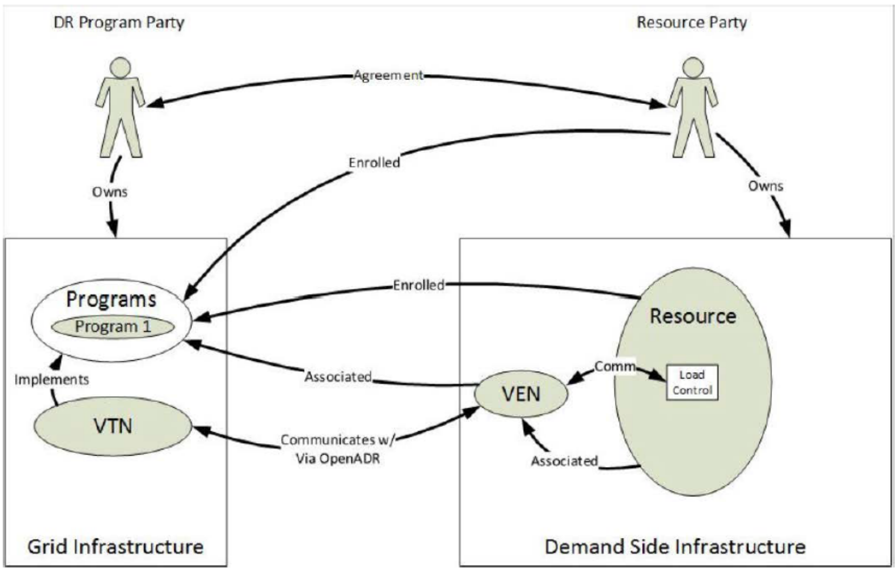
DR Program Types (2/2)

- **Fast DR Dispatch/Ancillary Services Program**: incentive payments to customers for load response during an Emergency Demand Response Event
- **Electric Vehicle (EV) DR Program**: the cost of charging electric vehicles is modified to cause consumers to shift consumption patterns.
- **Distributed Energy Resources (DER) DR Program**: utilized to smooth the integration of distributed energy resources into the smart grid.

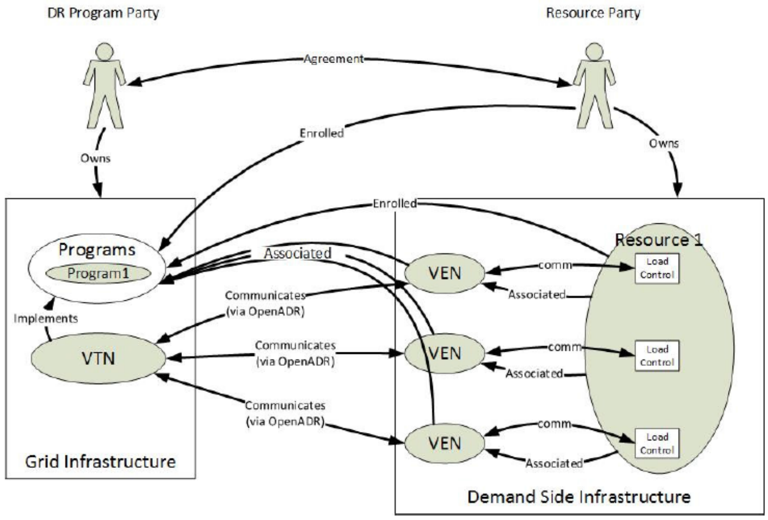
Deployment Scenarios

- Most fundamental entity for a Utility to interact with is a “Resource”.
  - Single customer load
  - Collection of customer loads
  - Thermostat

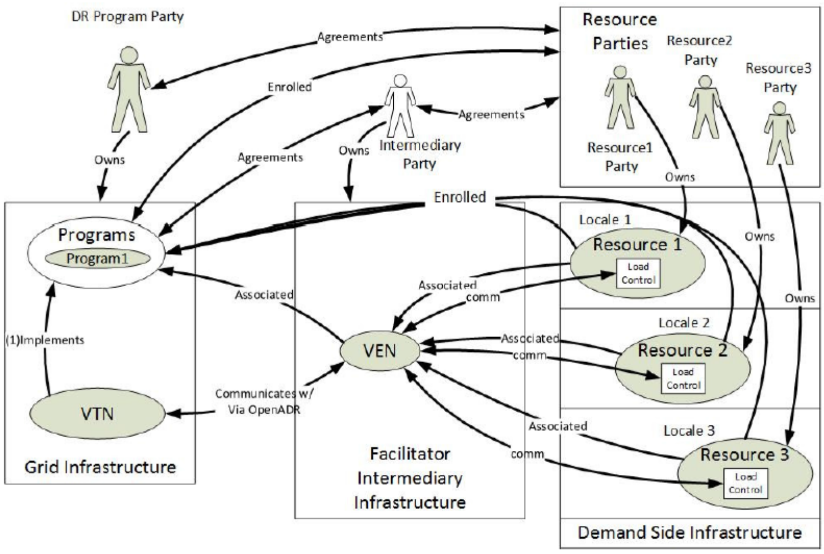
Deployment Scenario: Direct 1



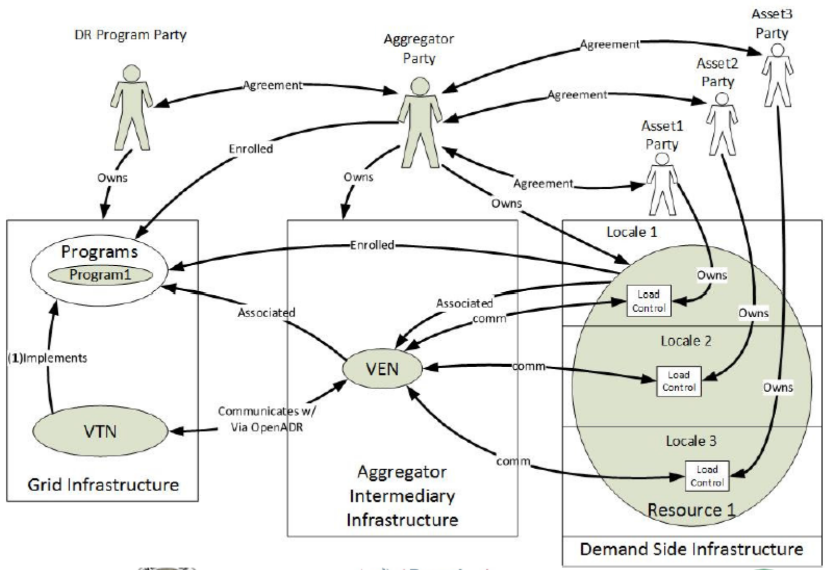
Deployment Scenario: Direct 4



Deployment Scenario: Facilitator 1



Deployment Scenario: Aggregator 1



Conclusions

- DR offers the technical and regulatory framework for higher efficiency, inclusive participation and operational transparency
- DR Research, innovative projects funding, market oriented efforts & targeted policies drive electricity markets closer to more elaborate and wide-scale DR in the foreseeable future.

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4.2 Annex II: Slides of the 2nd Webinar - Integration capabilities of various technologies for smart grids presented by AEA

SMARTGEMS
energy network

Webinar 2: Integration capabilities of various technologies for smart grids, by AEA, March 2017

10:00 CET 1/3/2017

Marie Skłodowska-Curie Actions (MSCA)
Research and Innovation Staff Exchange (RISE)
H2020-MSCA-RISE-2014

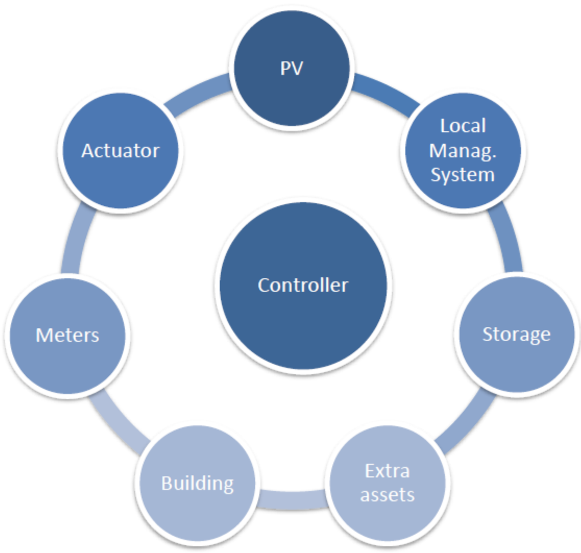
Contents

• **What is integrated in a micro-grid?**

I. What to integrate
II. Communication System
III. Control System
IV. Human Interaction
V. Conclusions

Summary: The webinar describes in details how different technologies must be efficiently integrated in smart-grids. To do so, the industrial micro-grid by Loccioni in presented ad a case study. Firstly, the main components of this smart-grids are introduced. Secondly, the focus will be on the communication and control system that connect and coordinate all the different systems. The human interaction is also very important and it is going to be described.

What should be integrated in a smart grid?



All the various assets of a smart-grid are enabled to be integrated via:

I. **Hardware**: must satisfy determined standards/certifications that are well defined even at country level.
II. **Software**: control system, communication protocol, etc. are in this area.
III. **Regional Transmission Code**: typically, TSOs define rules for connecting new asset into the main national grid.

Integration in smart grids requires:

- ❑ **Easy integration/removal new/old asset** into/from the smart grid.
- ❑ Follow a standard communication protocol that enables **interoperability.**
- ❑ **Integration** with **existing platforms**, such as trading, energy markets, remote control units, etc.

Integration capabilities of various technologies for smart grids

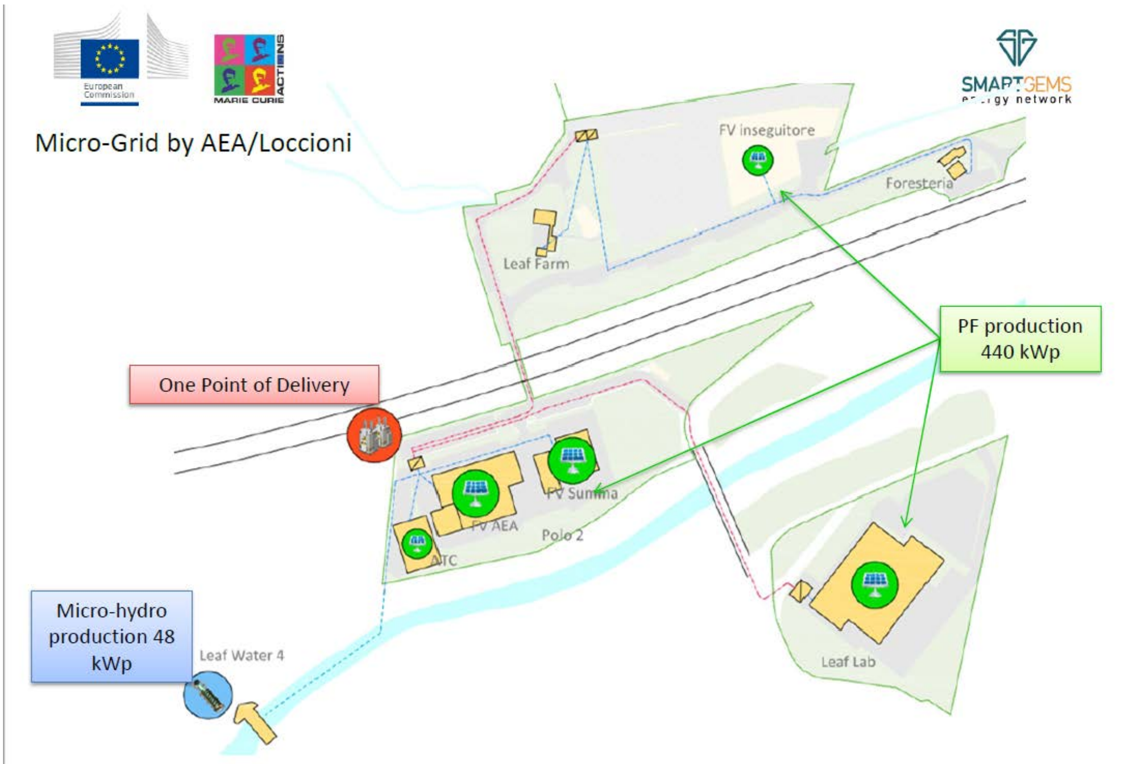
↓

Enabling interaction of different actors:

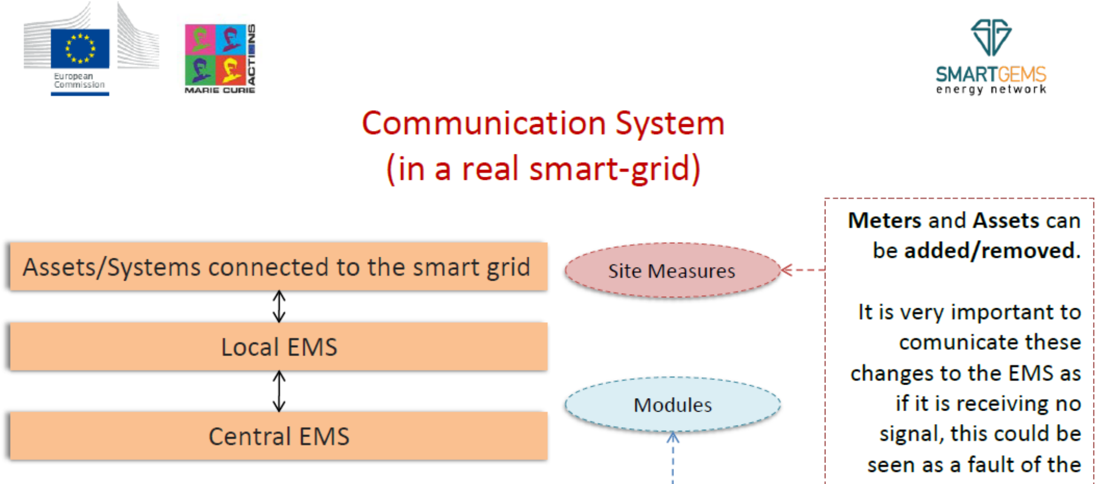
- ✓Consumers/producers
- ✓New assets
- ✓Existing systems and platforms
- ✓Communication protocols.

The Leaf Community by AEA/Loccioni is a real micro-grid that:

- ✓ **Integrates existing assets** (industrial buildings, PVs, and micro-hydro power plant) with **new ones** (industrial buildings, PVs, electrical and thermal storage systems.
- ✓ **EMS** controls and coordinates all the assets
- ✓ **Building Automation** in each building of the micro-grid
- ✓ Enabled for **island-mode**



Communication System (in a real smart-grid)



Meters and **Assets** can be **added/removed**.

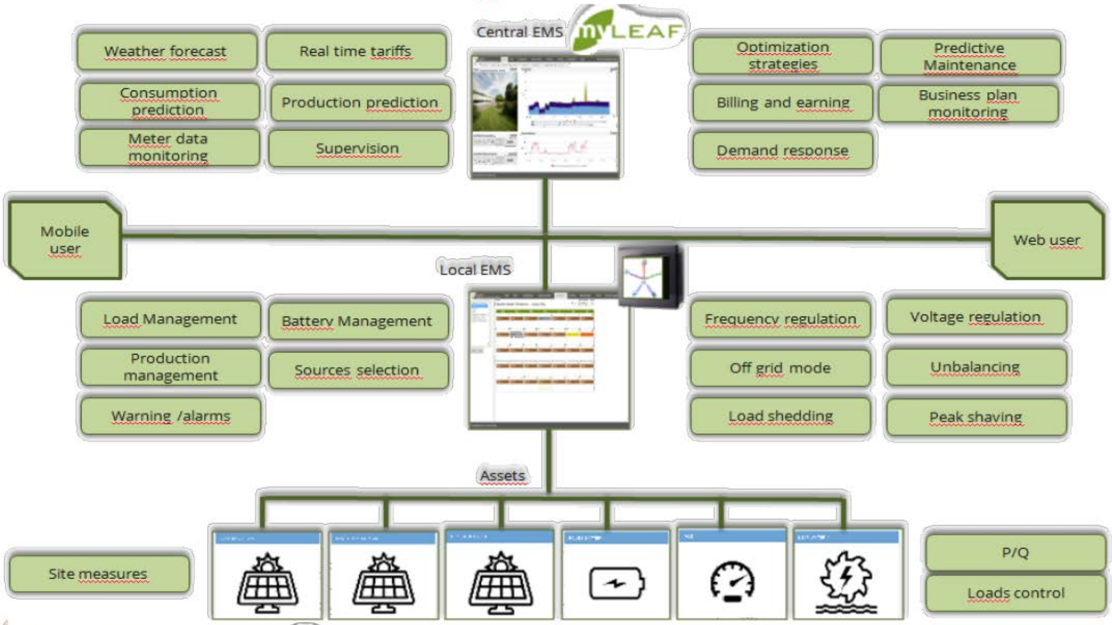
It is very important to comunicate these changes to the EMS as if it is receiving no signal, this could be seen as a fault of the corresponding asset/meter. Similarly, adding new measures requires the creation of a dedicated channel in the data flux to the EMS.

Modules implement tailored and standard algorithms related to:

- peak shaving
- optimisation
- fault detection and diagnosis
- data analysis
- new ☺

SMARTGEMS energy network

Loccioni Energy Automation Framework



SMARTGEMS energy network

The **communication system** in a smart grids requires experience in:

- ICT
- Coding
- Meters
- Electrical and thermal equipments

Control Systems

The control systems coordinate and control all the assets/systems connected into a smart-grids.

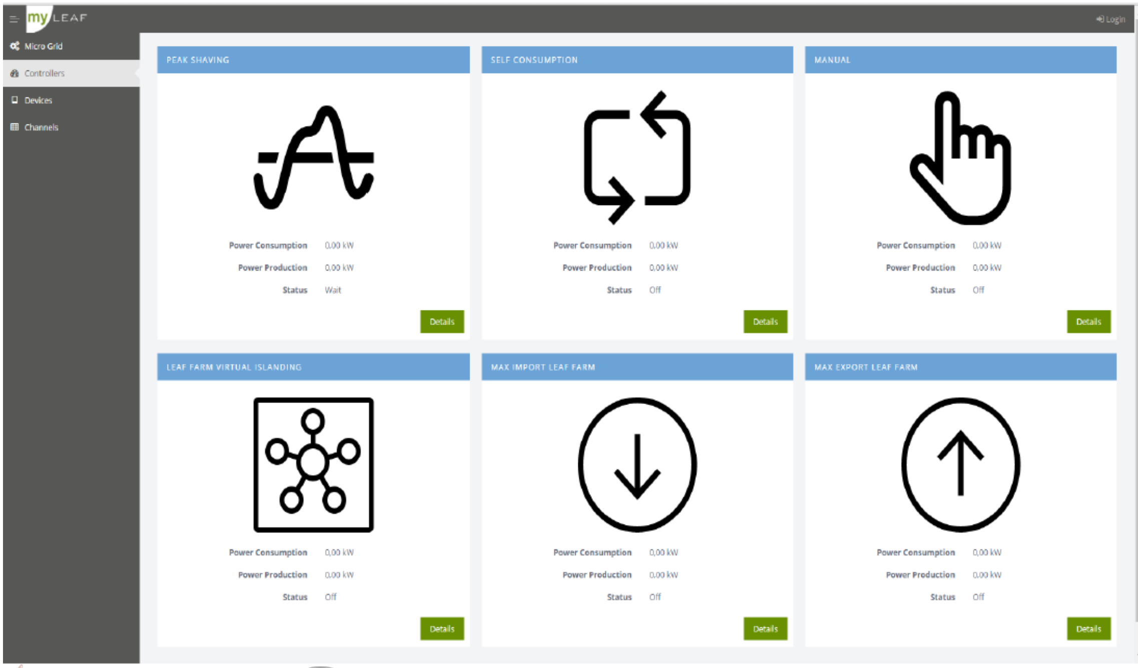
Optimisation-based controllers (see previous webinar) can be implemented too.

The Leaf Community has its own **EMS**, developed internally by Loccioni, that enables the implementation of various control strategies for different assets/systems:

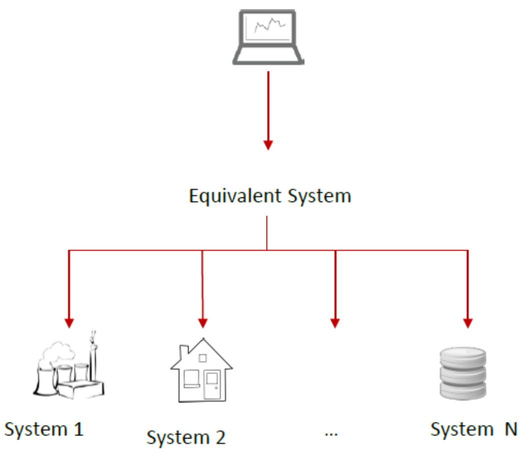
- Battery Energy Storage System utilized for Peak-Shaving and increasing self-consumption,
- Island-Mode
- Thermal Storage System for storing renewable energy during the weekends and to use it during week-days
- Etc.

Every control strategy implemented requests:

1. Interaction with the assets
2. Forecasts on renewable energy production and consumption,
3. Integration with the energy markets



Control Systems: Aggregators



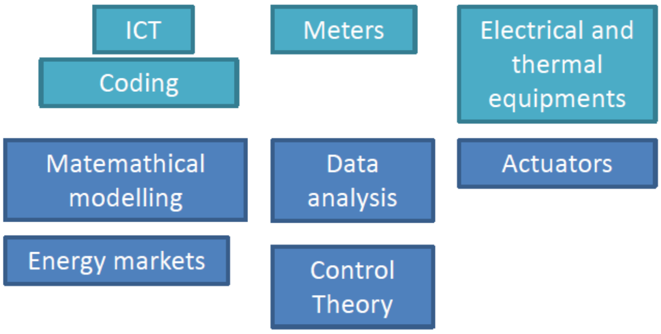
Multiple systems/assets of various dynamics are aggregated into an **equivalent system** that is then controlled remotely by the EMS.

The control signal from the EMS to the equivalent system is then **disaggregated** and send each individual control signals to the systems aggregated. This is done through:

- Merit order strategies
- Distributed optimisation techniques
- Including the performances of the assets aggregating
- Etc.

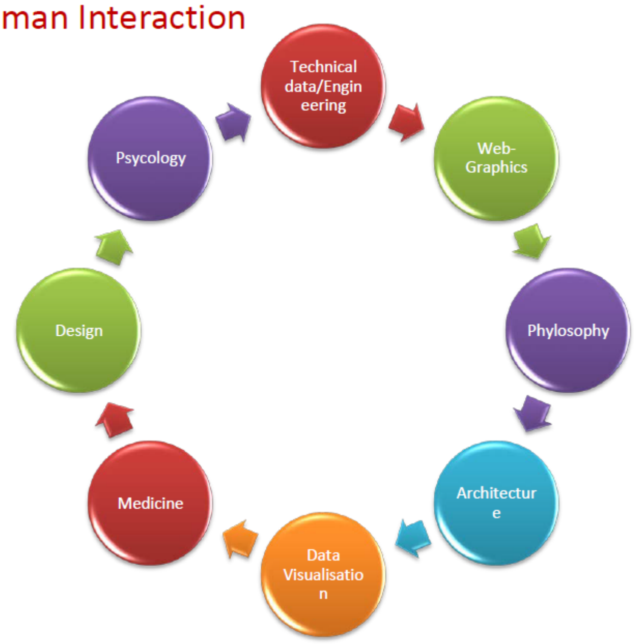
The **Equivalent System** might include both production and consumption.

The **control system** in a smart grids in the dark blue boxes yields to an increase in the knowledge requested for the grid operability:



Human Interaction

Human interaction is crucial because Smart-grids are drastically changing the idea of energy and grid, thus, people must accept this evolution; to do so, they must be well informed.



Web-Graphics & Data Visualization

It is very important to define a proper way to show data and results in order to communicate effectively.

Leaf Meter

Measures collected from the meters installed in a building (or group of buildings) are shown in a monitor located in a pot.

People are, then, informed and involved by having real-time access to the energy fluxes of the micro-grid/smart-grid/building monitored.

Design by Giorgio Di Tullio

Energy Solution and Design (@Continental in Italy)

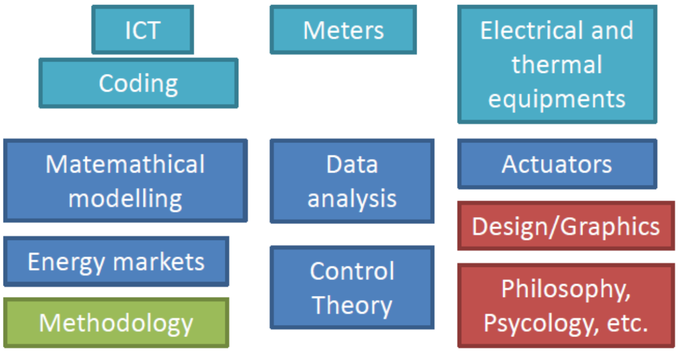

European Interoperability Centre
for Electric Vehicles and Smart Grids
LOCCIONI
Energy Storage for Microgrid
Energy Solution and Design: not a simple container
(@Ispra in Italy)


e·on
LOCCIONI
Energy Storage for Microgrid
Energy Solution and Design: not a simple container
(@Alstom in Sweden in Italy)

Conclusions

A smart grid is defined as multiple systems, that produce, consume and store electrical energy, in a smart way.

Therefore, the integration of such systems into a one grid require a huge set of capabilities, mostly in the following areas



Webinars Evaluation Questionnaire

- Evaluation Questionnaire for webinar "Optimised operation of Smart Grids" by TUC/AEA & "Integration capabilities of various technologies for Smart Grids" by AEA, of Task 2.3
  - https://survey.tuc.gr/58925/lang-en

4.3 Annex III: Slides of the 3rd Webinar - From innovation to final product in enterprise presented by UBRUN

Outline

- The bottleneck of the blue sky research
- Industry vs academia perspectives
- Successful pathway for collaboration
- Case study 1: GEMSTONE technology
- Case study 2: Detection, Prediction and Visualisation of Distant Volcanic Ash using GPS
- Conclusion

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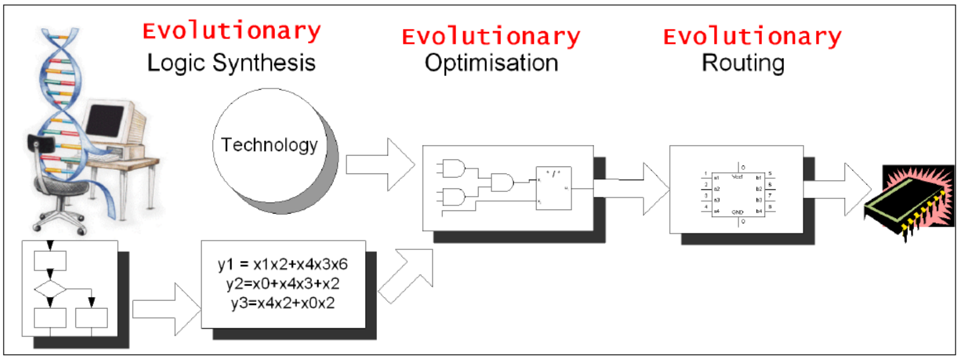
Blue sky research perspective: Evolvable hardware

• Blue sky research	Does not solve the actual problem
• Complexity of the problem is high	Has no real-world applications
• Potentially highly-employable technology	Complexity of the final solution is too low



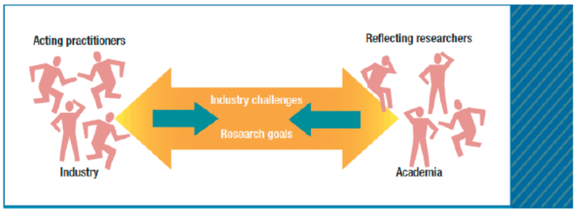
Brunel University London Dr Tatiana Kalganova

Industry vs Academia perspectives

Brunel University London   Dr Tatiana Kalganova

Successful industry vs academia collaboration

- Identify the common goal or interest
- Understand each other's priorities
- Get the terminology right
- Match the priorities through the timeline
- Establish effective way of communication
- Identify the lead / coordinator from industry and academia
- Establish a baseline and measurements of success / quality
- Introduce regular communication and brainstorming
- Ensure the regular quality review is carried out



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Teamwork:
Industry and Academic Perspectives

Partnerships

Relationships

Quality

Proximity or
Effective Communication

Brunel University London

Case study 1: Transportation network optimisation

- More than 3 million products.
- 3000+ suppliers, 700,000+ service parts.
- 100+ facilities in 20+ countries.
- 600+ carriers and 4500+ transportation lanes.
- Delivery to 3000+ dealer-owned facilities.
- 60 million US Dollars worth of logistic operations.
- Network with 7.360 nodes and 504.000 edges.

Brunel University London Dr Tatiana Kalganova


Roadmap of GEMSTONE technology
5 patents filed….
start
September 2011 New direction: supply chain optimisation
June 2012: Runner-Up in Strategy Demand Competition organised by Caterpillar (tie with winners, submitted 52 min later than winners)
July 2012: The University's Margaret Trier Prize.
July 2013: The Accenture prize.
June 2014: The best presentation at ResCon
September 2015: GEMSTONE technology developed by Brunel is deployed into Caterpillar Wide Network Library and is currently used globally
↓ 4.1%
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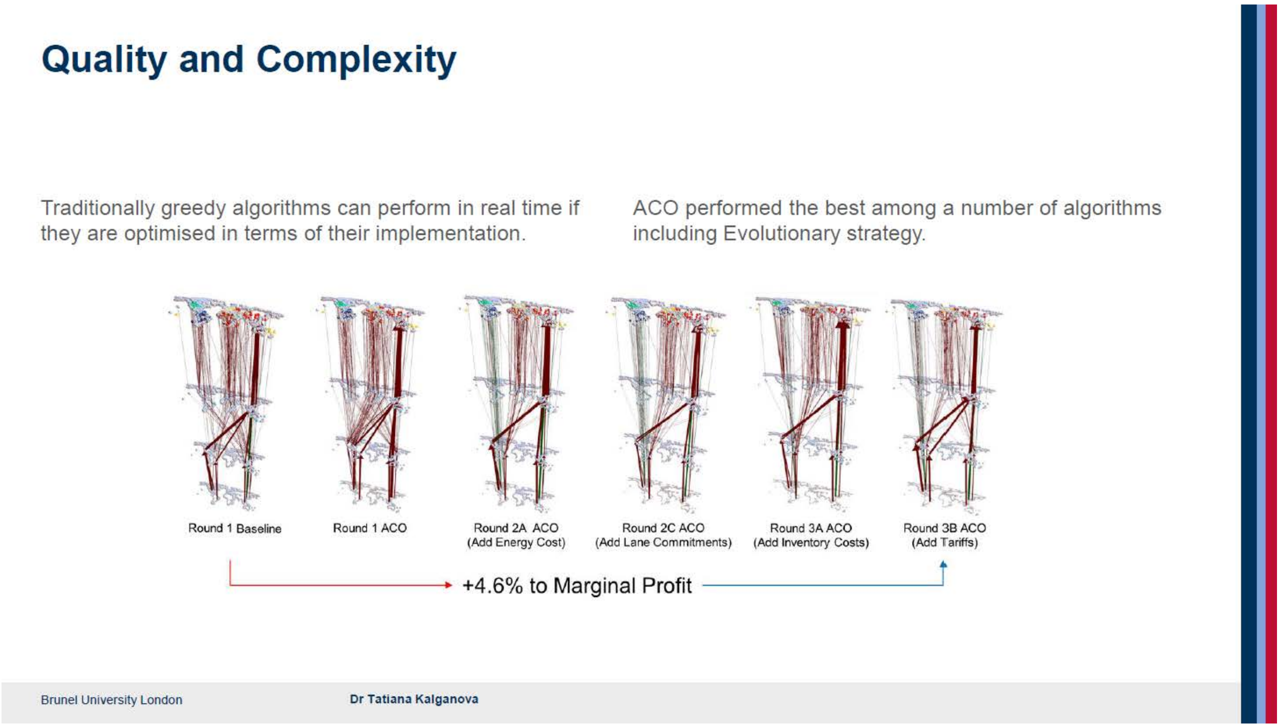
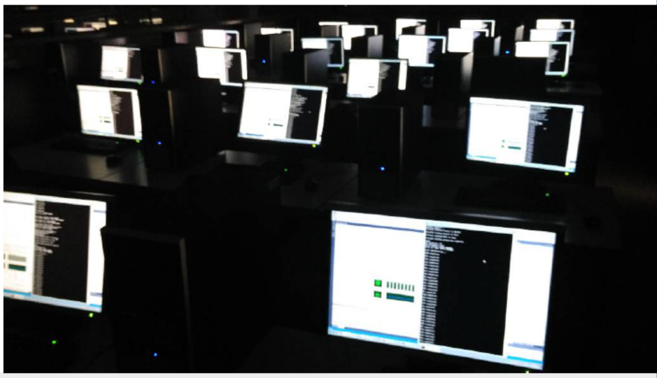
Dr Tatiana Kalganova


Quality and Complexity
Traditionally greedy algorithms can perform in real time if they are optimised in terms of their implementation.
ACO performed the best among a number of algorithms including Evolutionary strategy.
Round 1 Baseline
Round 1 ACO
Round 2A ACO (Add Energy Cost)
Round 2C ACO (Add Lane Commitments)
Round 3A ACO (Add Inventory Costs)
Round 3B ACO (Add Tariffs)
+4.6% to Marginal Profit
Brunel University London
Dr Tatiana Kalganova

Speed… Speed… Speed…

- Speed performance improved from **1.5 months** on HPC to **24 min** on PC, **without** loosing the quality of the solution.
- The algorithm has been modified to accommodate the distribution features of available hardware.
- The developed algorithm provides **consistently** better results in comparison with the base line provided.
- Total experimental computation time for one case study is **803 hours** that is equal to **33.5 days** (on Intel Core i7-4790) having completed **2 715** individual simulations.



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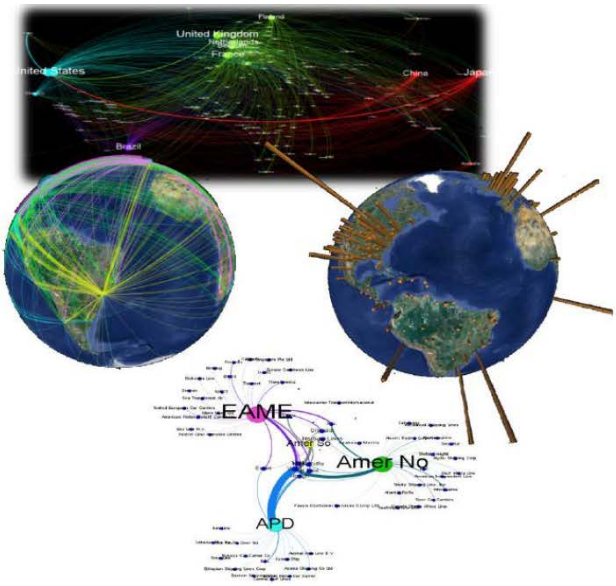
Future directions

- Visualization
- World wide optimisation
- Exploration of hardware acceleration
- Strategic decision making
  - Fault tolerance of the network
  - Closing gap between strategic management and engineering results
  - Quick understanding of use cases consequences prior decision making
- Real time responsive resilient supply chain decision making
- Integrated supply chain and data sharing with business partners
- Resilient supply chain architecture: from data centre failures to natural disasters



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Case study 2: Volcanic Ash Impact on Aviation

09 May 2017

- More than **90** jet-powered commercial aircraft over the past 30 years have **suffered** damage after encountering volcanic ash clouds (Boeing, 1999).
- This has cost businesses millions of pounds due to damages sustained to aircraft and has forced some operators, such as easyJet, to invest in research for a solution (easyJet PLC, 2012).
- The eruption began on the 14th April 2010, lasting for **39 days**, and concluding on the 23rd May 2010 (Arason, et al., 2011).
- During this period, the eruption went through 2 explosive phases, one in mid-April and the other at the beginning of May.
- It caused havoc for a majority of Europe and cost airlines more than **$1.7 billion in lost** revenue (International Air Transport Association, 2010) due to airspace closures.

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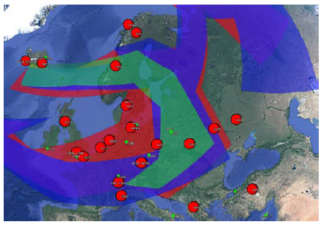
Detection, Prediction and Visualisation of Distant Volcanic Ash using GPS

- Over 100 GB of GPS data analysed from more than 50 group stations across Europe
- Ground stations spread some 8,000 km from volcano
- Incorporating over 4 times the number of ground stations and 10 times the distance spread compared to previous works
- Going further than any previous investigation by incorporating intelligent systems to predict ash presences, validating the results against actual VAAC data plots
- Potential for commercial application with an expected prediction accuracy of around 95%

Map showing all 52 GPS ground stations for which data has been collected to be used in this study

Data provided by

- *NASA*
- *European Space Agency*
- *European Satellite Services Provider*
- *UK Met Office*



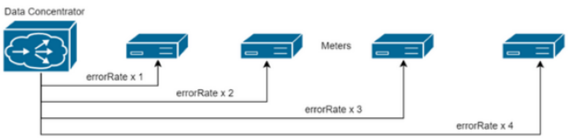
Simulation showing the classifier plots overlaid upon the VAAC model plots on the 17th April 2010 at around 14:00, where the red dots indicate a positive alert for ash from the classifier and the green dots represent the ground stations

Brunel University London **Dr Tatiana Kalganova**

Case study 3: Topology optimisation under different noise levels for minimum data loss in Power Line Communication

Problem: The company experiences a data loss of **50%** with only 60 – 70 meters connected to a concentrator.

Present solution: When the company replaces a data concentrator when it stops working, the meter data is not collected for the downtime.



Recommendation to Elgama Elektronika:

- to allocate a **priority level** to meters for data collection and assign the values according to the observed range.
- Using proposed evolutionary strategy, only **0.03% to 14.3% (in the worst case)** data loss is observed with 100 meters connected to a concentrator.

Parameter	Results from Elgama Elektronika	Results based on Project
Data loss	50%	Best Case – 0.3% Worst Case - 14.3%
# Repeaters (per 100 meters)	25% directly connected 25% one repeater 50% two or more repeaters	45% repeaters due to structure of grid used in topology
# meters connected to a concentrator	60 to 70	100
Priority for Data Collection	No	Yes
Retries for Data Collection	Yes	Yes

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Conclusion

- Only the active collaboration between academia and industry can lead to research with high value research impact.
- Teamwork is the main pillar that provides the successful pathway from innovation to the final product.

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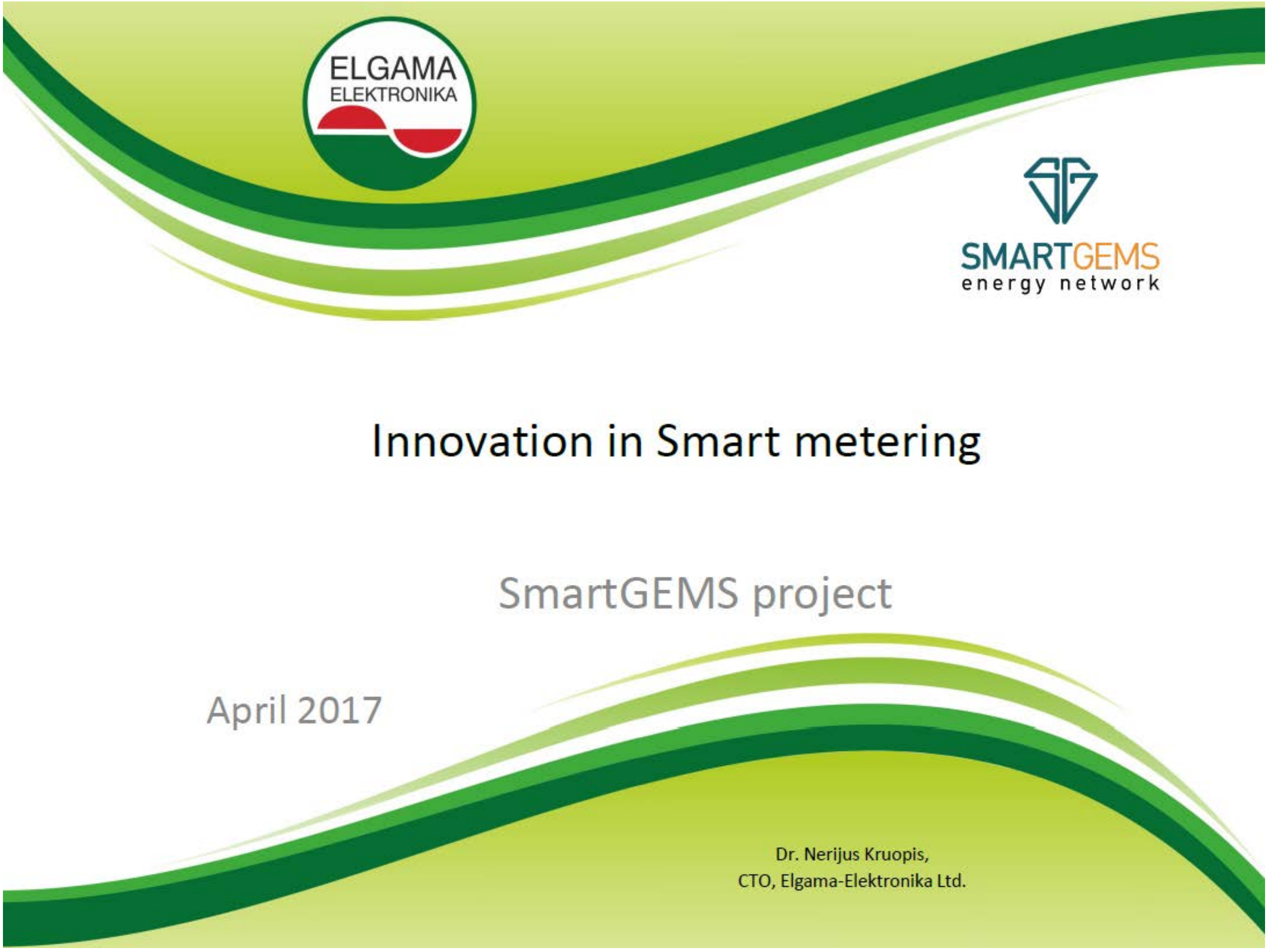
4.4 Annex IV: Slides of the 4th Webinar - Innovation in smart metering presented by EGM



Elgama Elektronika in numbers

Visorių str. 2

LT-08300 Vilnius

Lithuania

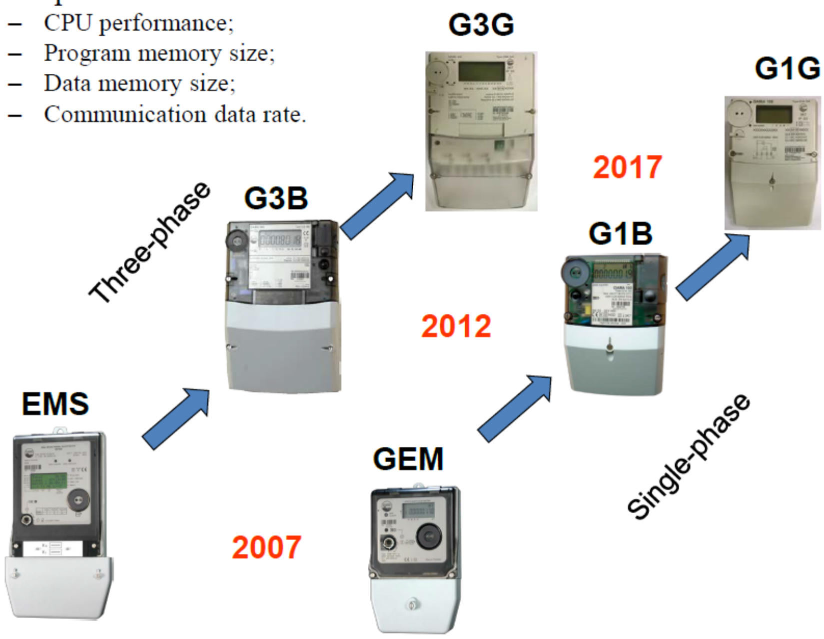
- 20+ years of experience on metering market
- Development and manufacturing of metering solutions
- Area of Manufacturing facilities 4400 m^2
- ≈80 employees (20 in R&D)
- Production capacity 200'000 meters per year

Innovation drivers

- Market drivers:
  - Technical progress, increasing expectations of customer;
  - From devices to turn-key solutions;
  - Increasing competition, optimization of costs;
  - Marketing strategy, modern exterior of the product
- Legal drivers – Directives of the European Parliament and the Council:
  - 2002/96/EB on waste electrical and electronic equipment (WEEE);
  - 2002/95/EB on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS);
  - 2004/22/EB on measuring instruments (MID)
  - 2005/32/EC ecodesign requirements for energy-using products
- Social drivers:
  - Challenging projects attract creative people (employees)

Smart Meter product roadmap

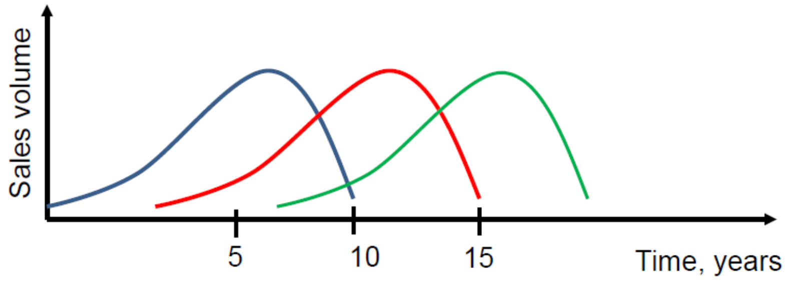
- Every 5 years – new platform (hardware + software)
- New platform means N× times increase in:
  - CPU performance;
  - Program memory size;
  - Data memory size;
  - Communication data rate.



Progress in metering devices

Year	2007	2012	2017
Platform	EMS/G3A	G3B	G3G
Processor	MCU	SOC	Multi-MCU
CPU clock	8 MHz	10 MHz	48 (120) MHz
Program memory	96 kB	256 kB	512 kB
Data memory	32 kB	512 kB	4 MB
Communication rate	9.6 kbps	19.2 kbps	115 kbps

Platform life cycle: introduction, growth, maturity, decline



Eco-design project (2006)

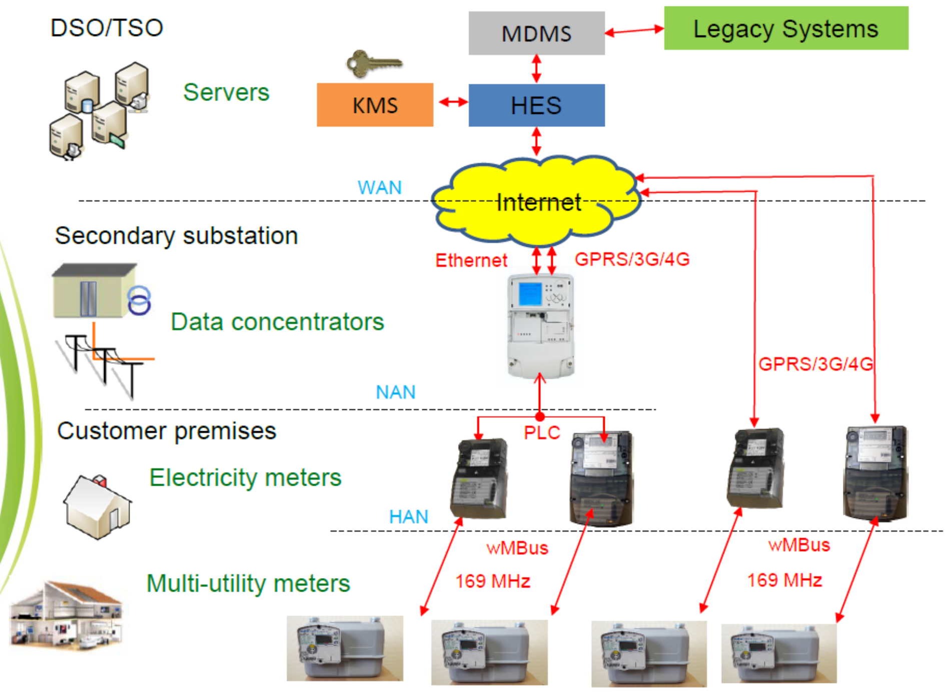
- Eco-design in product (meter) development is beneficial to the company, not just to the environment
- Minimized environmental impact along the entire life-cycle by 2,73 times in Ecoindicators’99 points (from 1158 to 423)
- Applied technical solutions: elimination of steel shields, reduction of internal wires, reduction of weight (plastic housing), elimination of PVC stickers, etc.

KTU APLINKOS INŽINERIJOS INSTITUTAS

ELGAMA ELEKTRONIKA

ktu 1922 kauno technologijos universitetas

Advanced Metering Infrastructure (AMI)



Kaliningrad project «Янтарьэнерго»

- Electricity metering in private houses
- Wireless (ZigBee) connection as an alternative to PLC communication
- Hourly load profile data
- Early reaction to Under-voltage conditions

ОТКРЫТОЕ АКЦИОНЕРНОЕ ОБЩЕСТВО ЯНТАРЬЭНЕРГО

ELGAMA ELEKTRONIKA

Sigma Telas

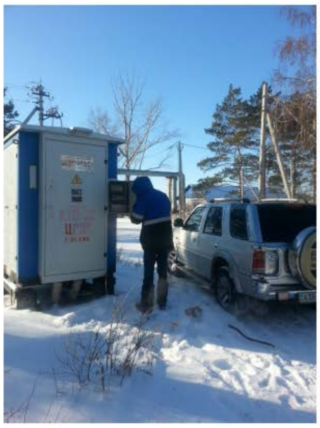
MTC

ZigBee radio (2.4 GHz)

Pilot project in Astana (Kazakhstan)

- Smart metering in “non-friendly” old multi-apartment buildings (4 water meters + 1 gas meter per apartment);
- PLC communication in “noisy and lossy” electricity network (aluminum wiring);
- Harsh climate conditions (-40°C)

Sigma Telas



Itron

ELGAMA ELEKTRONIKA

Pilot project «PALMA» in Latvia (2013)

- Prime PLC communication in multi-apartment buildings
- Readout of 5 minute load profile

PRIME ALLIANCE

ELGAMA ELEKTRONIKA · Sigma Telas · ELGAMA Sistemos · Latvenergo

Substation pilot project in Latvia (2016)

- Measurement of power quality
- Measurement of losses

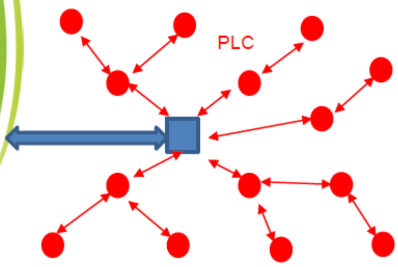
Ethernet (10BASE-T)

Smart Metering pilot in Greece (2017)

- Interoperability between different manufacturers (on the basis of companion standard);
- Demand side management (remote user disconnection);
- User engagement by means of In-Home-Displays.

Pilot project in Lithuania (2017)

- Integration of electricity and gas meters
- Key performance indicators (KPI): e.g. Total gas consumption [m^3] daily at 07:00 from each gas meter, at least 97% of data until 09:00



From simple ....

- Measurement of active [kWh] and reactive [kvarh] energy
- Communication interfaces
- Open standard protocol (DLMS/COSEM)
- Time-of-use metering
- Data profiles (load, billing, event log)
- Tampering detection
- Load management (internal mains relay)
- Self-diagnostics
- Time synchronization

... to advanced functionality

- Security: authentication and encryption (AES 128)
- Plug & Play (self-registration on communication network)
- Alarming (immediate messages about extraordinary events)
- Remote firmware update
- Remote configuration of meters
- Readout and profiling of water and gas consumption data
- Messages to/from In-Home Display
- Power quality monitoring
- Control (relay) outputs
- Remote consumer disconnection/reconnection
- Demand Side Management (DSM)

Technology innovation

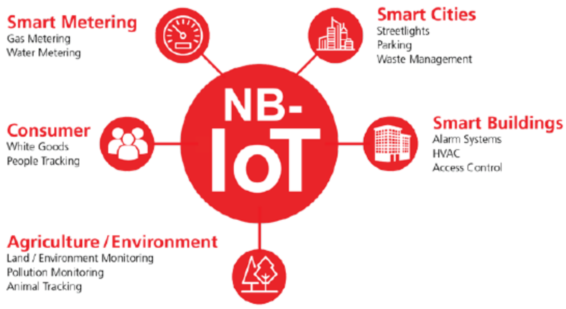
- Lead free soldering in nitrogen tunnel
- Laser marking
- Ultrasonic welding of plastic parts

LAAIF

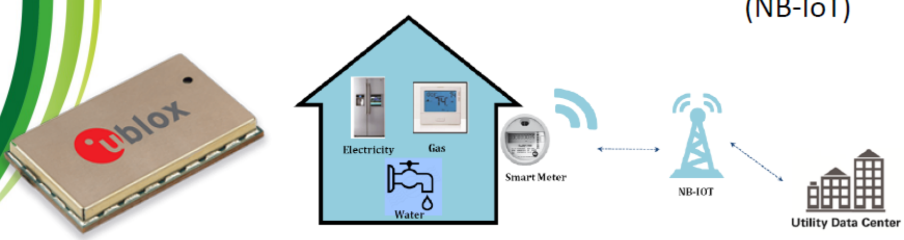
Funded by Lithuania Investment fund of Environment Protection (LAAIF)

What is next? NB-IOT

Narrowband IoT (NB-IoT), also known as LTE Cat. NB1 - Low Power Wide Area (LPWA) technology over mobile networks

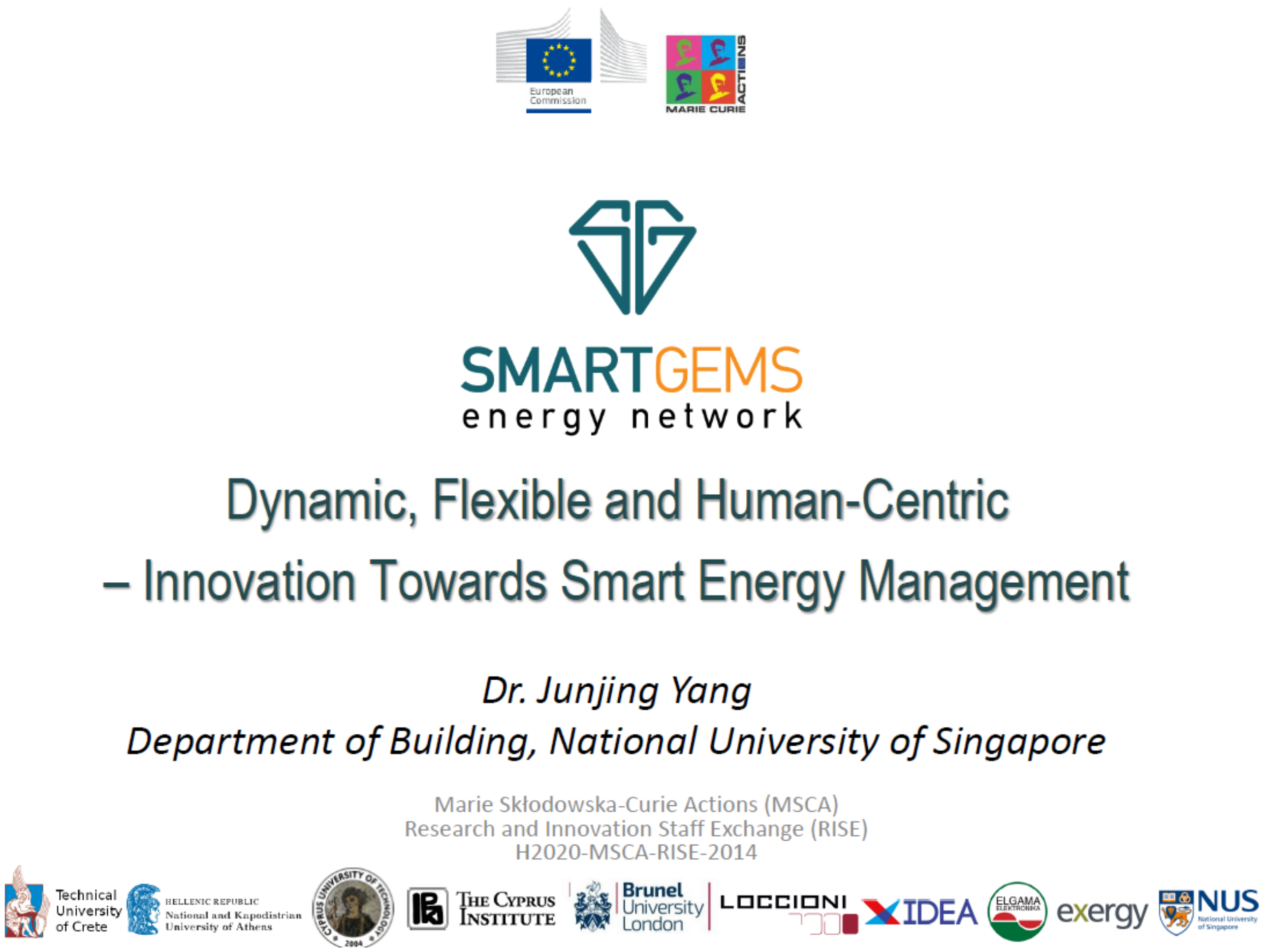


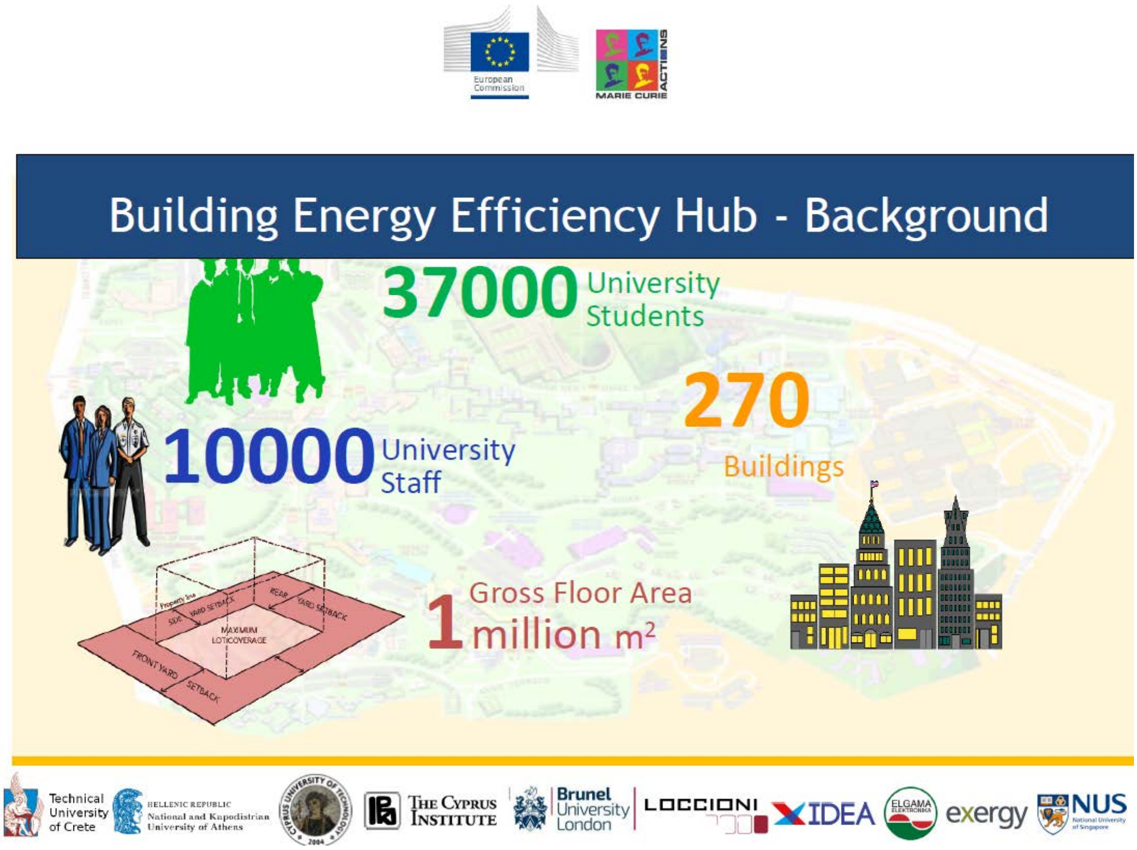
Collecting of electricity, water and gas meter data over the cellular network by means of Narrowband IoT (NB-IoT)

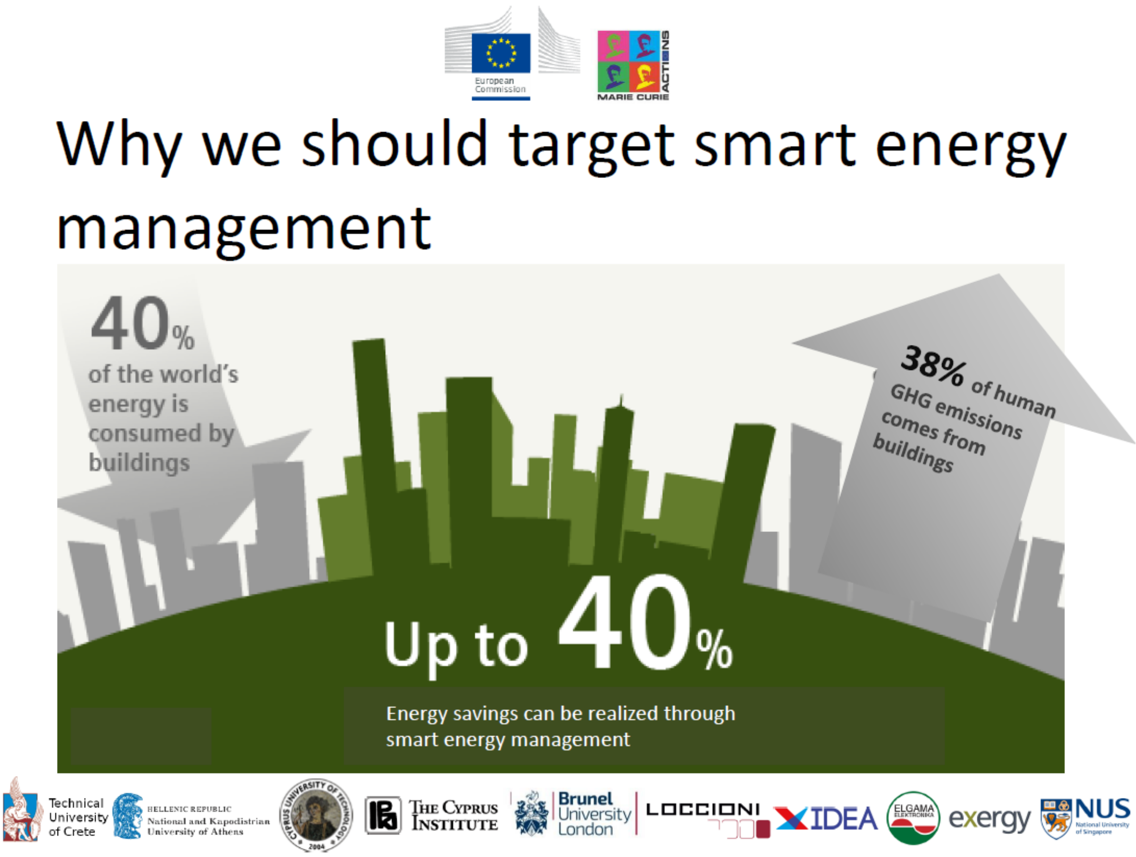


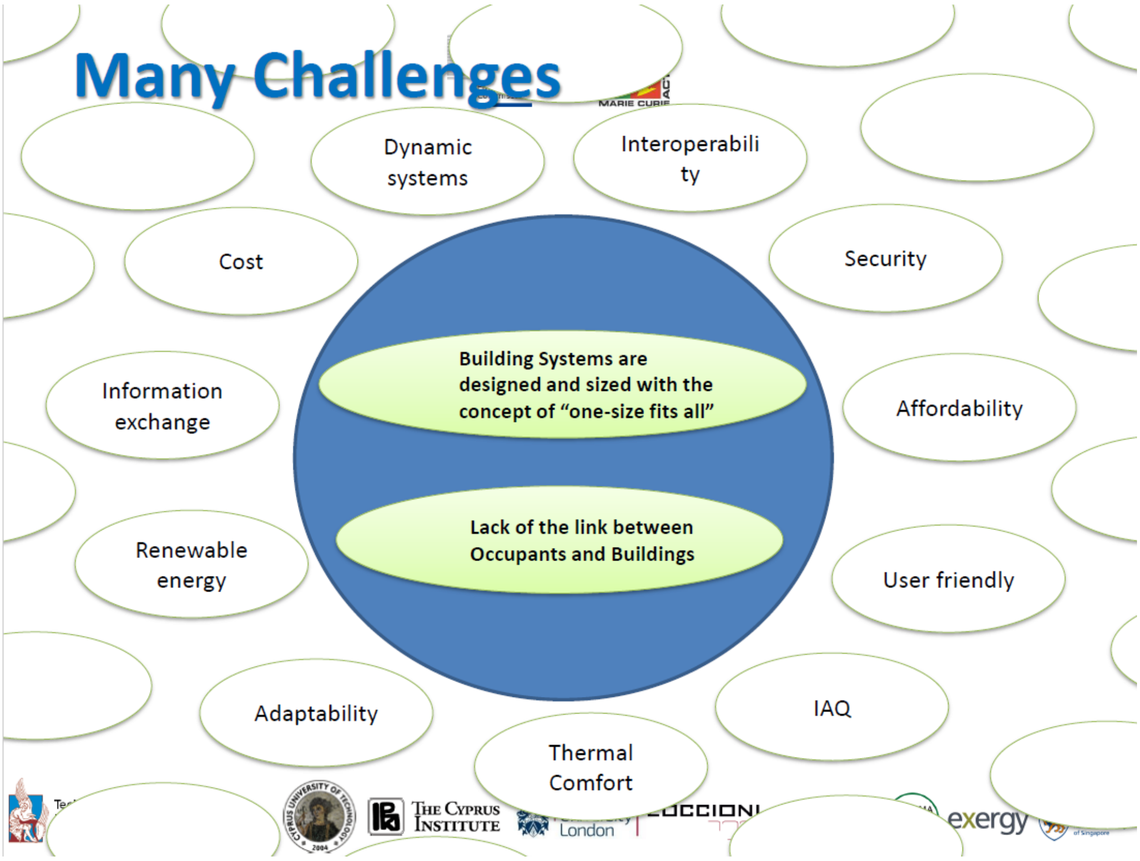

ELGAMA
ELEKTRONIKA
Thank you for your attention!
Any questions ?
www.elgama.eu
Dr. Nerijus Kruopis
nerijus.kruopis@elgama.eu

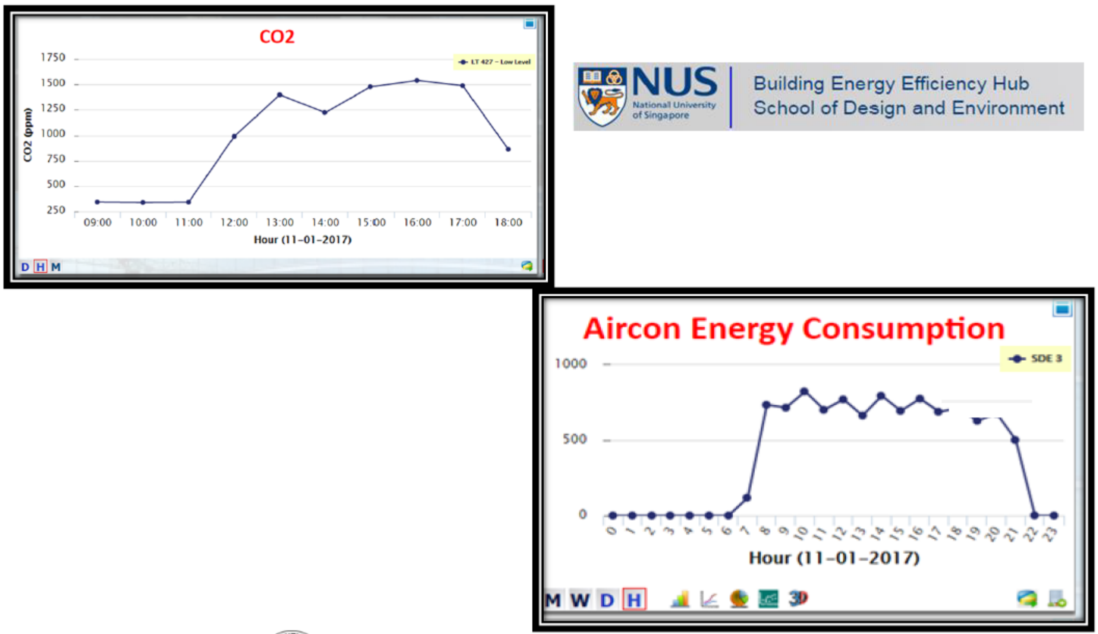
4.5 Annex V: Slides of the 5th Webinar - Dynamic, flexible and human-centric – Innovation towards smart energy management presented by NUS

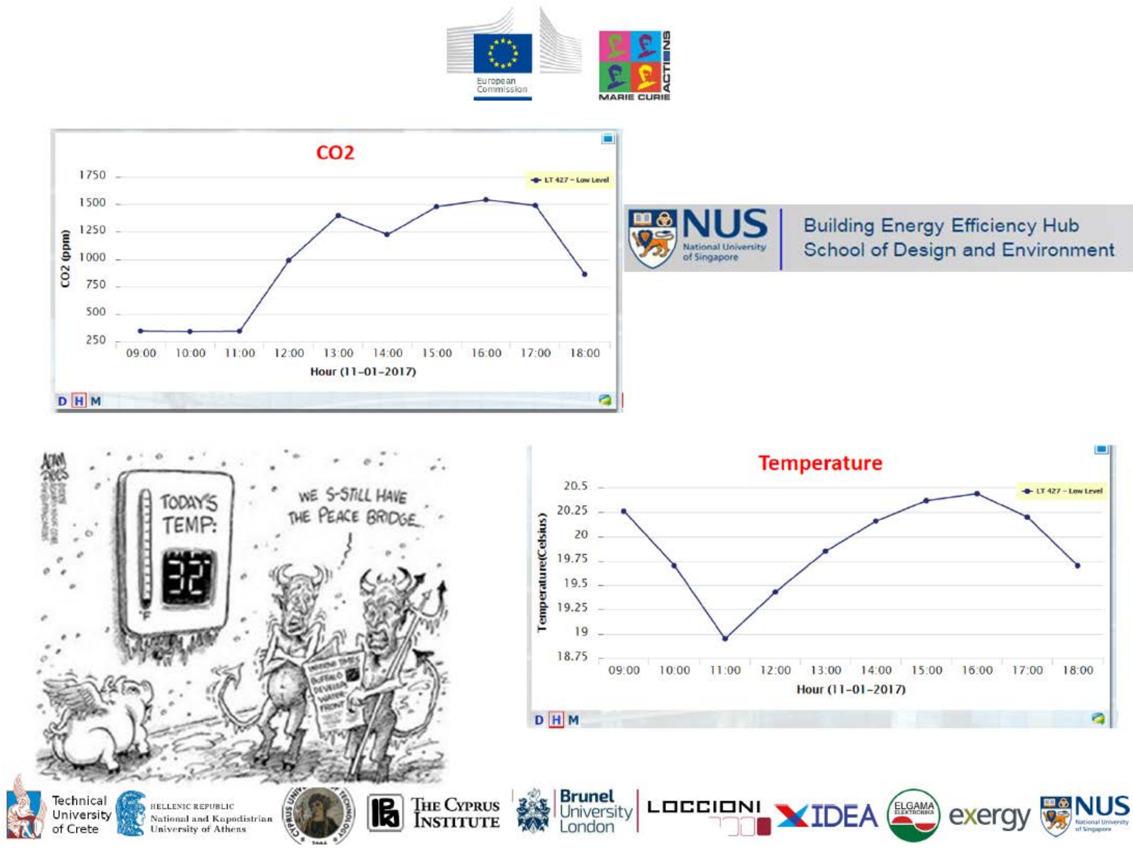



European Commission
MARIE CURIE ACTIONS
Building Energy Efficiency Hub - Background
37000 University Students
270 Buildings
10000 University Staff
1 Gross Floor Area million m²
Technical University of Crete
HELLENIC REPUBLIC National and Kapodistrian University of Athens
The Cyprus Institute
Brunel University London
LOCCIONI
IDEA
ELGAMA ELEKTRONIKA
exergy
NUS

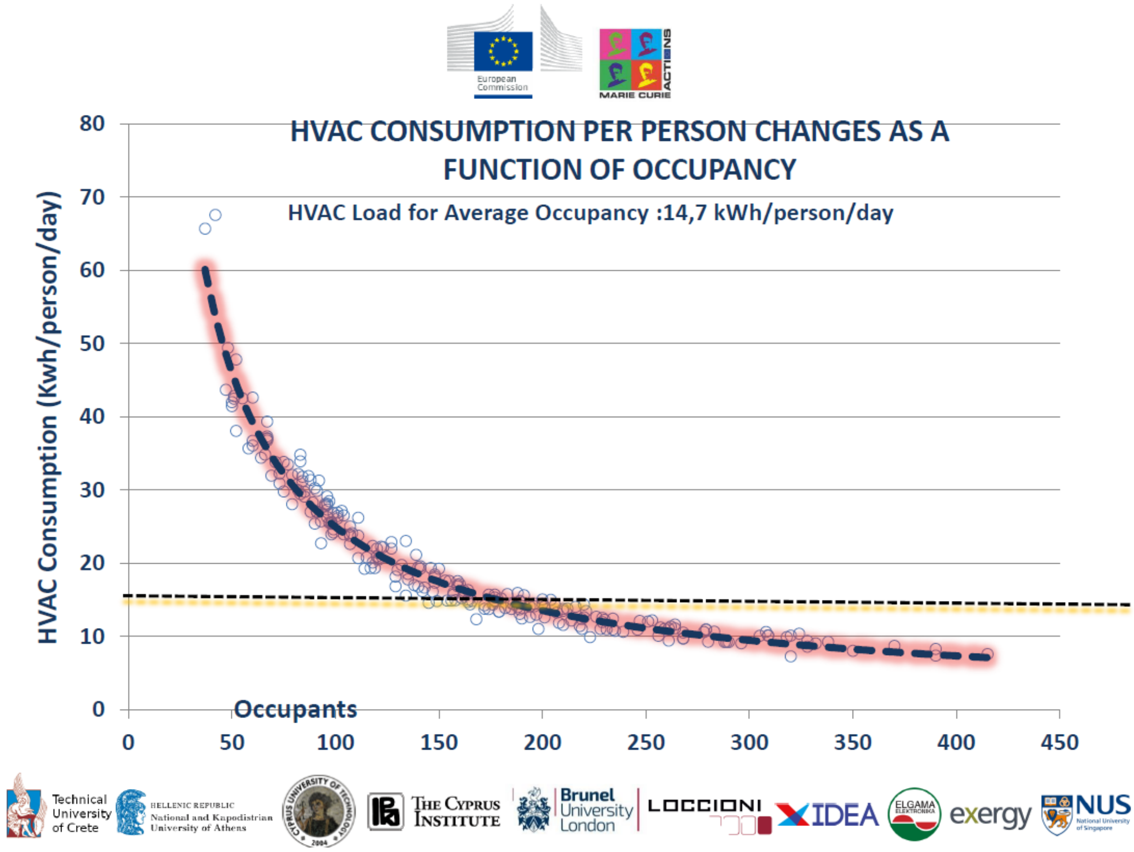

European Commission
MARIE CURIE ACTIONS
Why we should target smart energy management
40% of the world's energy is consumed by buildings
38% of human GHG emissions comes from buildings
Up to 40%
Energy savings can be realized through smart energy management
Technical University of Crete
HELLENIC REPUBLIC National and Kapodistrian University of Athens
The Cyprus Institute
Brunel University London
LOCCIONI
IDEA
ELGAMA ELEKTRONIKA
exergy
NUS

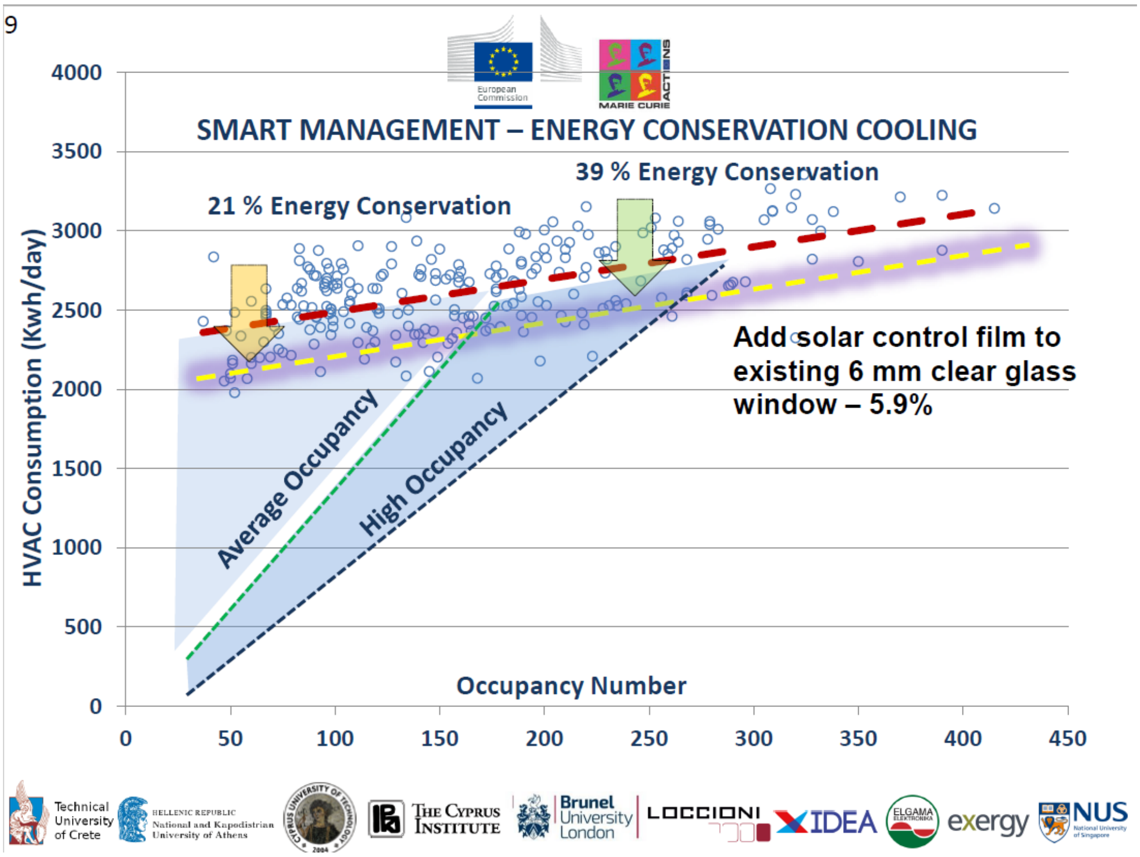

Many Challenges
Dynamic systems
Interoperability
Cost
Security
Building Systems are designed and sized with the concept of "one-size fits all"
Information exchange
Affordability
Lack of the link between Occupants and Buildings
Renewable energy
User friendly
Adaptability
IAQ
Thermal Comfort

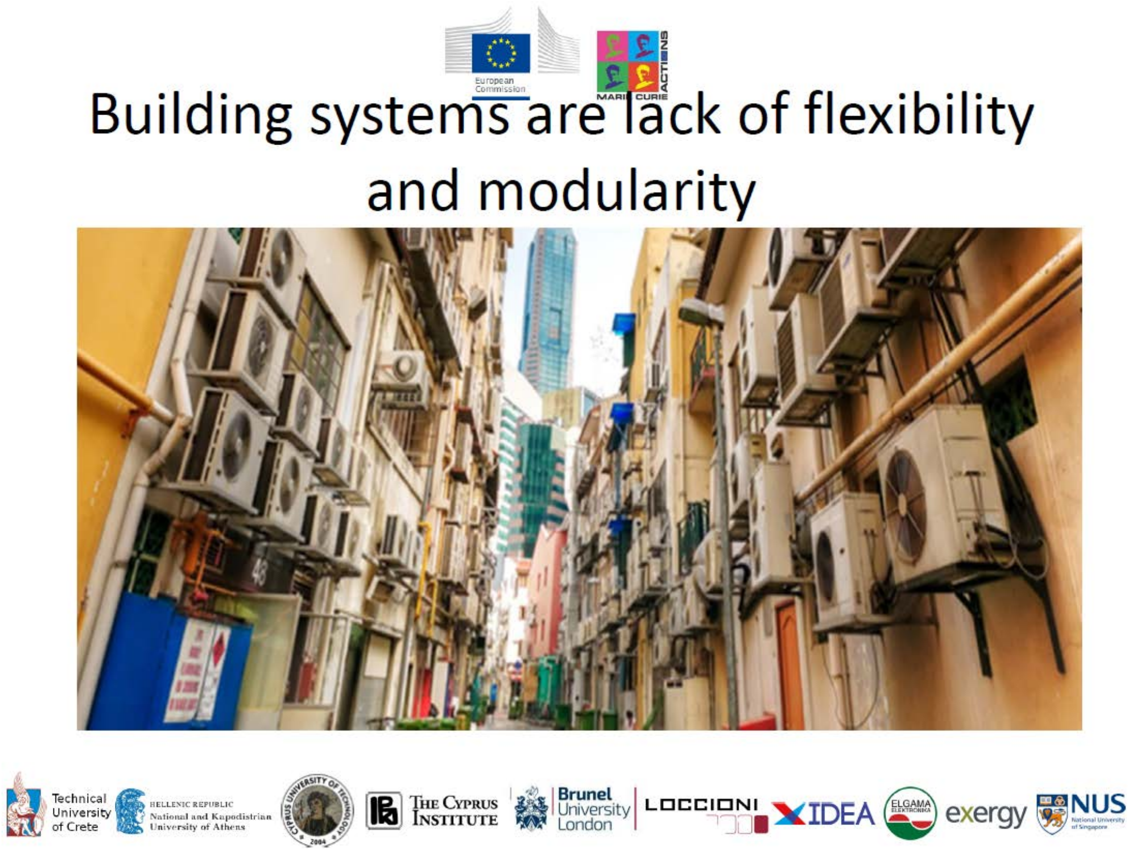

CO2
CO2 (ppm)
Hour (11-01-2017)
NUS National University of Singapore
Building Energy Efficiency Hub
School of Design and Environment
Aircon Energy Consumption
SDE 3
Hour (11-01-2017)

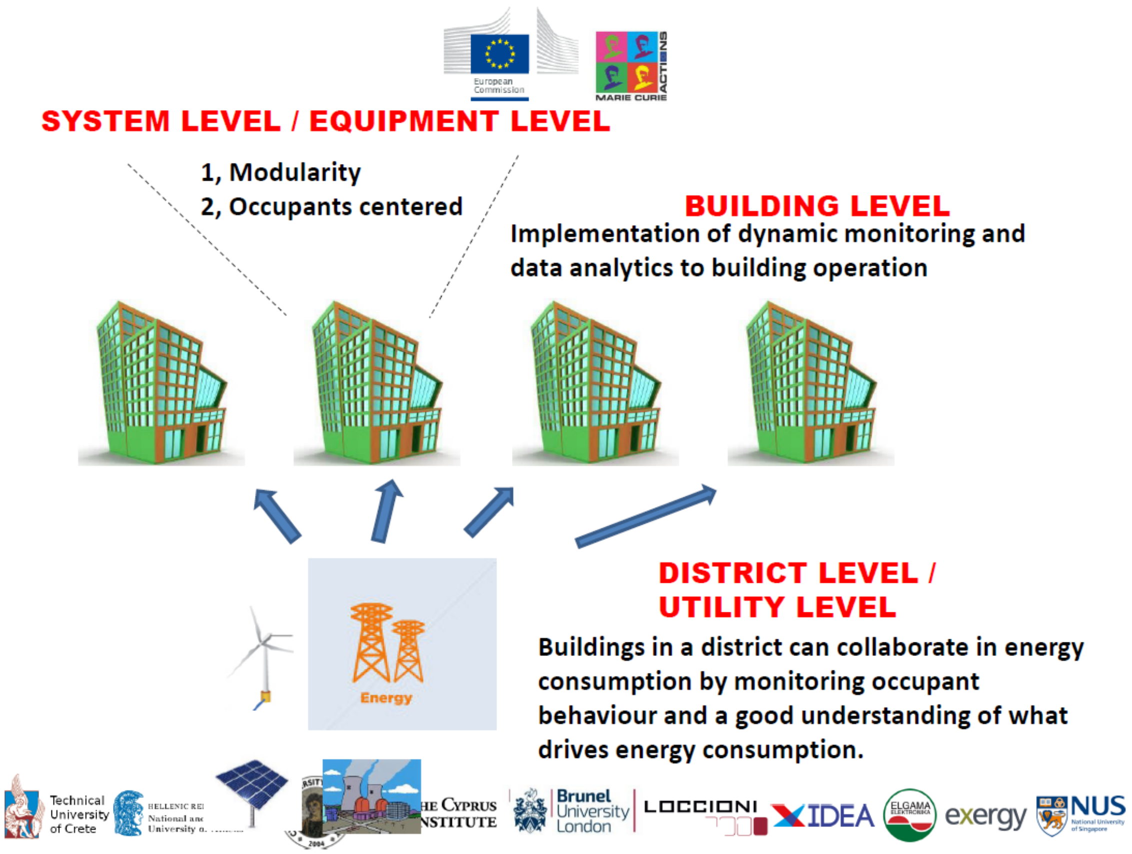

CO2
LT 427 – Low Level
CO2 (ppm)
1750
1500
1250
1000
750
500
250
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00
Hour (11-01-2017)
NUS National University of Singapore
Building Energy Efficiency Hub
School of Design and Environment
TODAY'S TEMP:
32
WE S-STILL HAVE THE PEACE BRIDGE
Temperature
LT 427 – Low Level
Temperature(Celsius)
20.5
20.25
20
19.75
19.5
19.25
19
18.75
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00
Hour (11-01-2017)

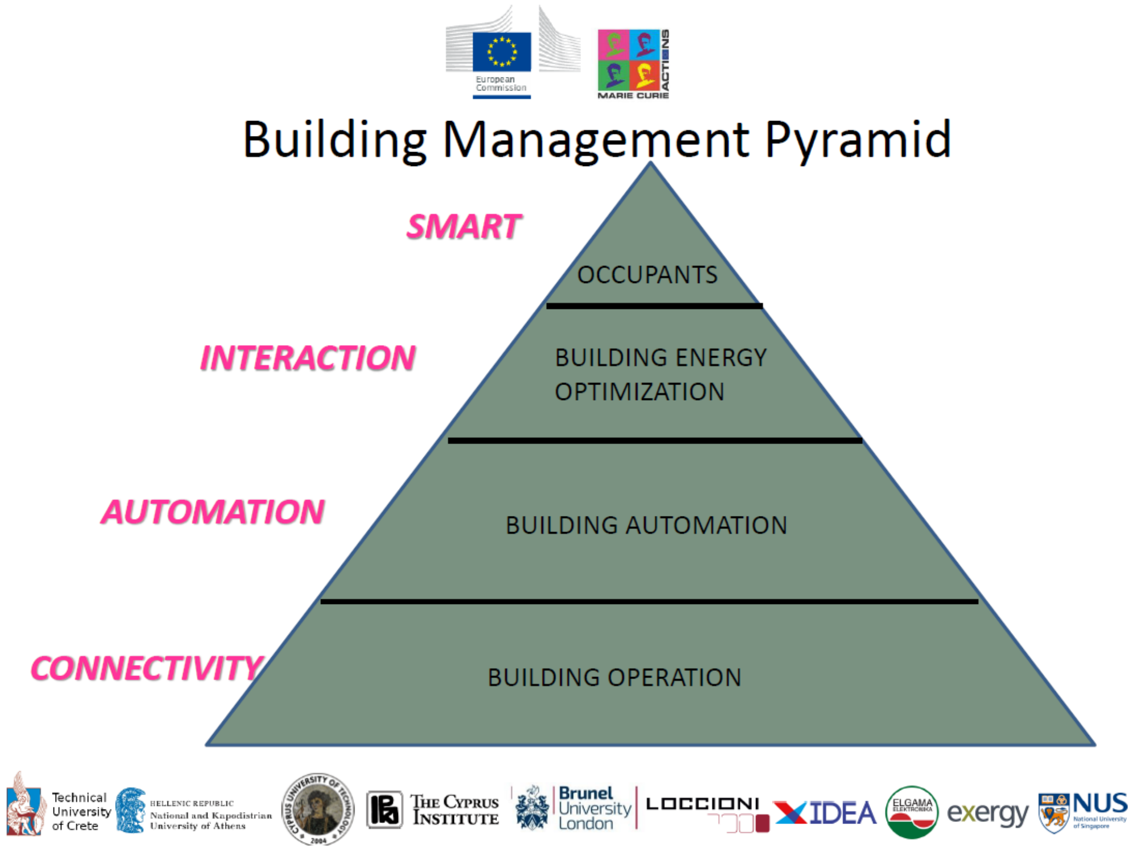

Can you control your building/room?
Yes, You "CAN control" it
Occupant controlled ventilation system in our sabbatical apartment. There are five settings, including unoccupied mode.
Like
Comment
Share


HVAC CONSUMPTION PER PERSON CHANGES AS A FUNCTION OF OCCUPANCY
HVAC Load for Average Occupancy :14,7 kWh/person/day
HVAC Consumption (Kwh/person/day)
Occupants
0
10
20
30
40
50
60
70
80
0
50
100
150
200
250
300
350
400
450


9
SMART MANAGEMENT – ENERGY CONSERVATION COOLING
39 % Energy Conservation
21 % Energy Conservation
Add solar control film to existing 6 mm clear glass window – 5.9%
Average Occupancy
High Occupancy
HVAC Consumption (Kwh/day)
Occupancy Number
0
500
1000
1500
2000
2500
3000
3500
4000
0
50
100
150
200
250
300
350
400
450


Building systems are lack of flexibility and modularity


SYSTEM LEVEL / EQUIPMENT LEVEL
1, Modularity
2, Occupants centered
BUILDING LEVEL
Implementation of dynamic monitoring and data analytics to building operation
Energy
DISTRICT LEVEL / UTILITY LEVEL
Buildings in a district can collaborate in energy consumption by monitoring occupant behaviour and a good understanding of what drives energy consumption.


Building Management Pyramid
SMART
OCCUPANTS
INTERACTION
BUILDING ENERGY OPTIMIZATION
AUTOMATION
BUILDING AUTOMATION
CONNECTIVITY
BUILDING OPERATION
Technical University of Crete
HELLENIC REPUBLIC National and Kapodistrian University of Athens
The Cyprus Institute
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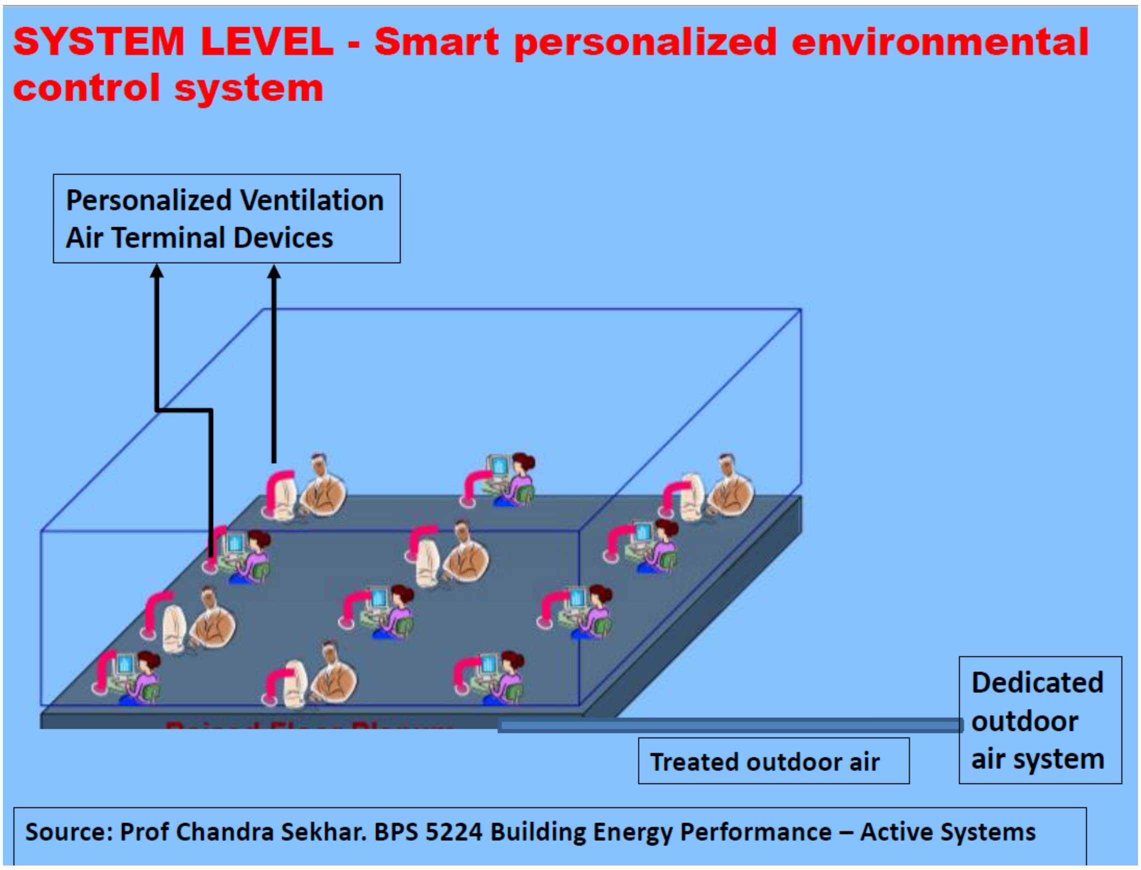
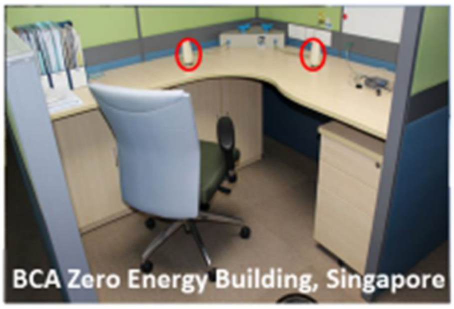

SYSTEM LEVEL - Smart personalized environmental control system
Personalized Ventilation Air Terminal Devices
Dedicated outdoor air system
Treated outdoor air
Source: Prof Chandra Sekhar. BPS 5224 Building Energy Performance – Active Systems

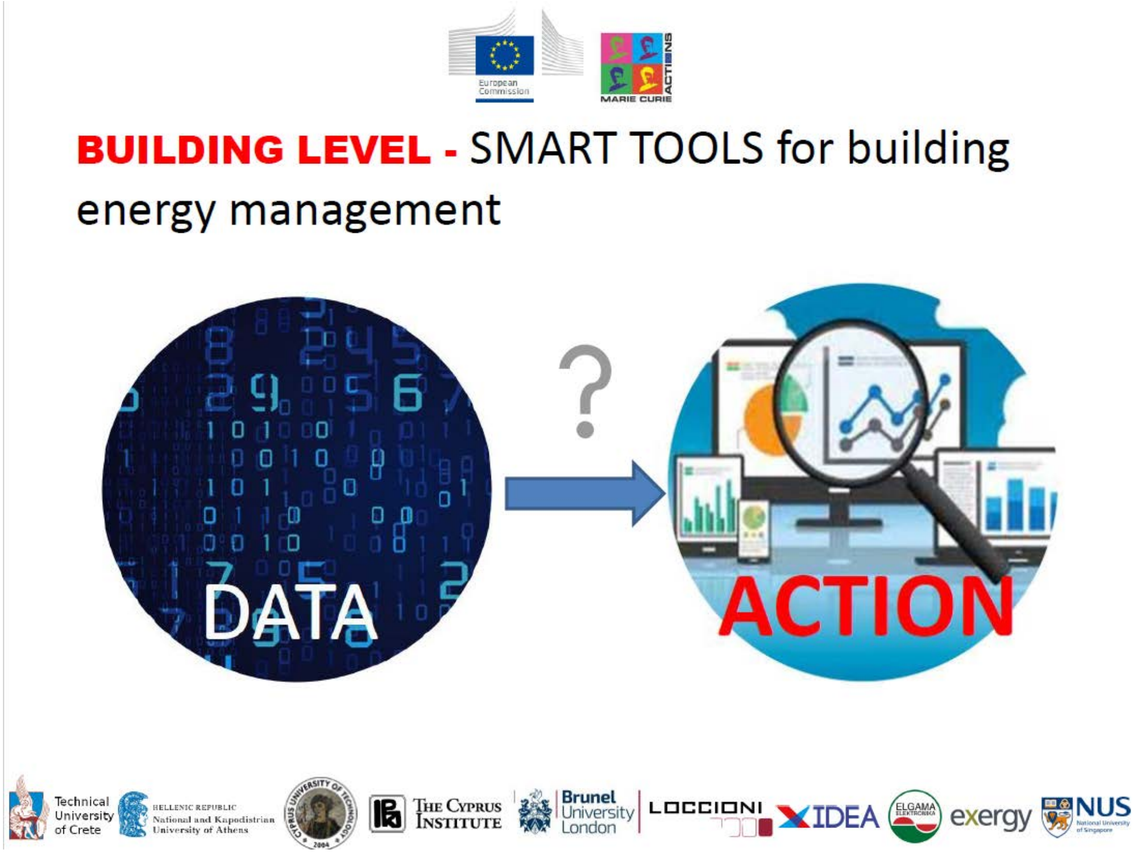
SYSTEM LEVEL - Smart personalized environmental control system

A warmer space temperature, such as 26 °C – 28 °C accompanied by a PV air temperature(eg, 23 °C), implies that the room cooling load is reduced in comparison with a conventional air-conditioning
system in which the space is typically maintained at 23 °C.



An absolute reduction in the total fresh air quantity required due to the direct supply as inhaled air to the occupant breathing zone.

Bridge that gap between infrastructure design and what the building are sensing


European Commission
MARIE CURIE ACTIONS
BUILDING LEVEL - SMART TOOLS for building energy management
DATA
?
ACTION
Technical University of Crete
HELLENIC REPUBLIC National and Kapodistrian University of Athens
The Cyprus Institute
Brunel University London
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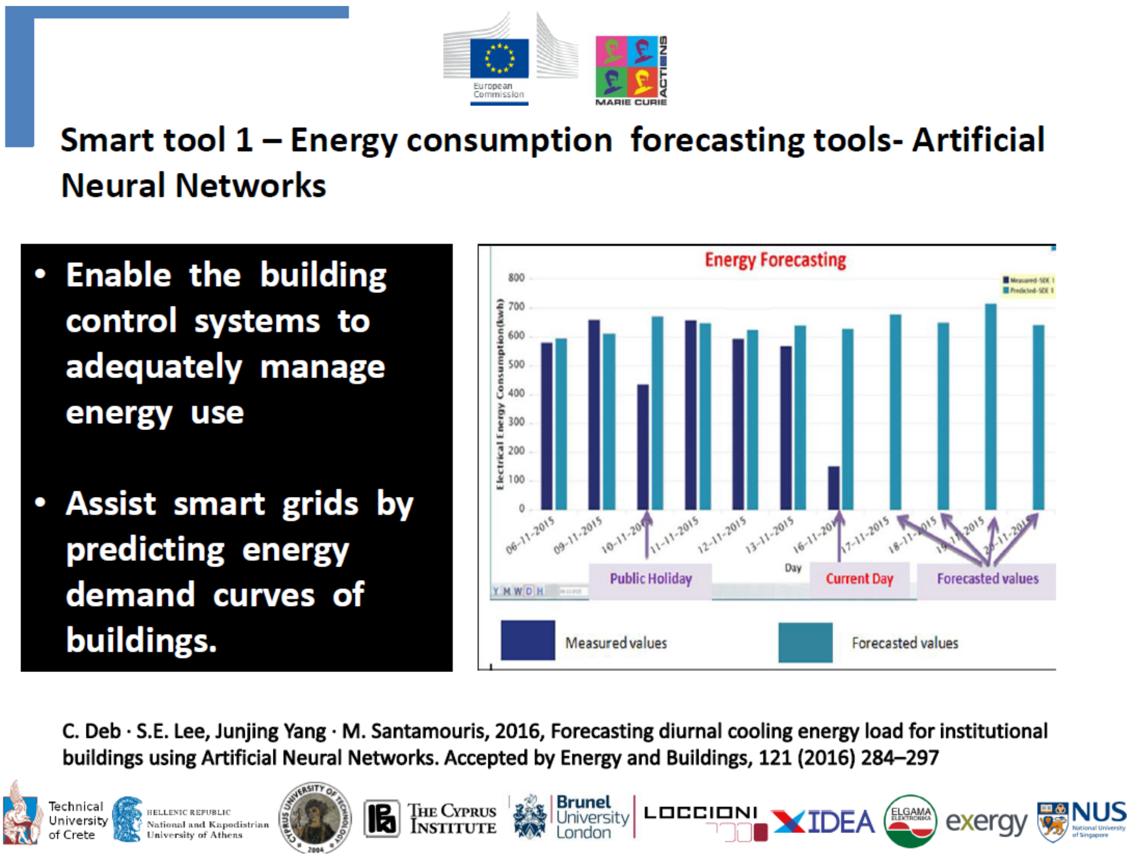
European Commission
MARIE CURIE ACTIONS
Smart tool 1 – Energy consumption forecasting tools- Artificial Neural Networks
• Enable the building control systems to adequately manage energy use
• Assist smart grids by predicting energy demand curves of buildings.
Energy Forecasting
Electrical Energy Consumption (kwh)
Day
Public Holiday
Current Day
Forecasted values
Measured values
Forecasted values
C. Deb · S.E. Lee, Junjing Yang · M. Santamouris, 2016, Forecasting diurnal cooling energy load for institutional buildings using Artificial Neural Networks. Accepted by Energy and Buildings, 121 (2016) 284–297
Technical University of Crete
HELLENIC REPUBLIC National and Kapodistrian University of Athens
The Cyprus Institute
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Smart tool 2 – Pattern/shape based K-Shape clustering tools

- Classify energy consumers
- Fault detection for abnormal energy consumption patterns

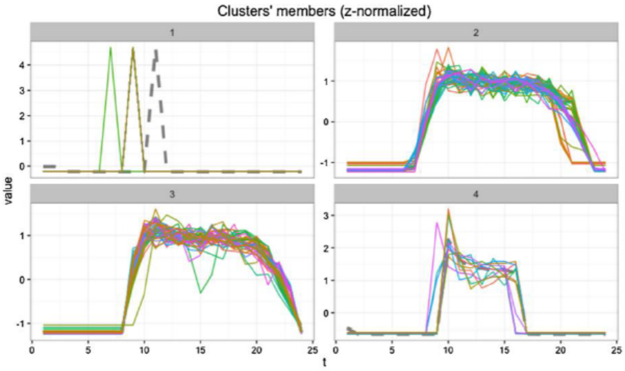
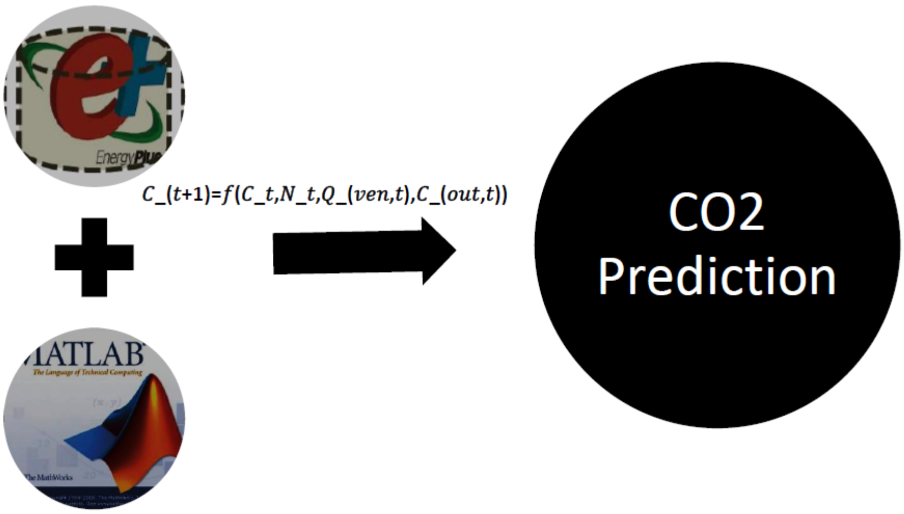


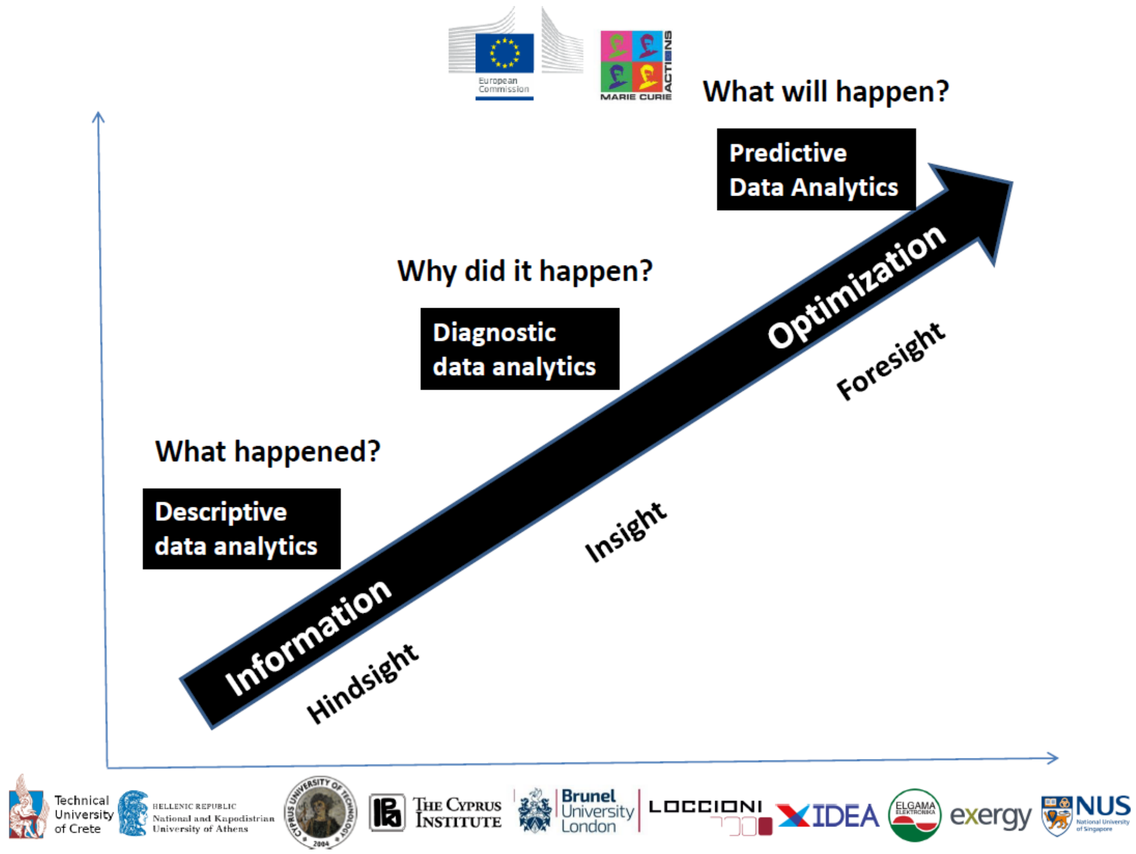
Fig. 13. Clustering result of daily consumption patterns with hourly interval, building 9, 4 clusters.

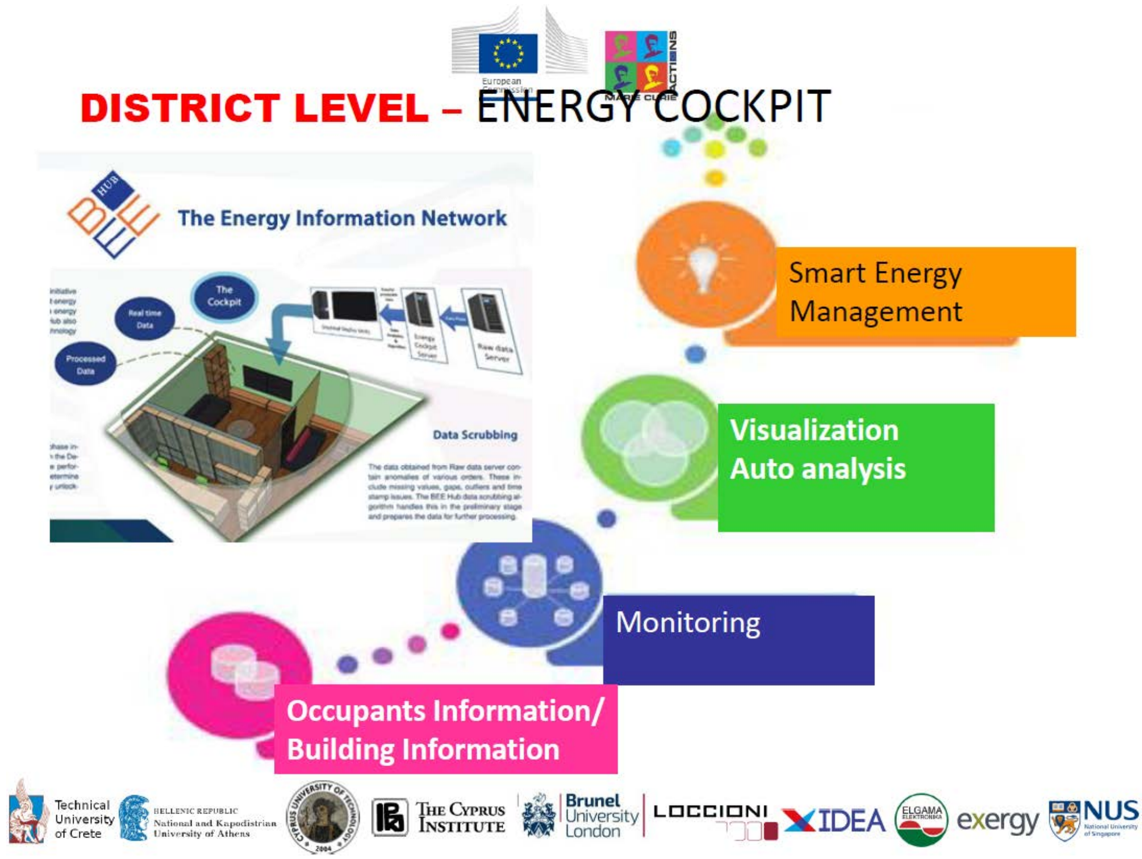
J YANG· et a;., 2017, K-Shape clustering algorithm for building energy usage patterns analysis and forecasting model accuracy improvement Energy and Buildings, 146 (2017) 17-37

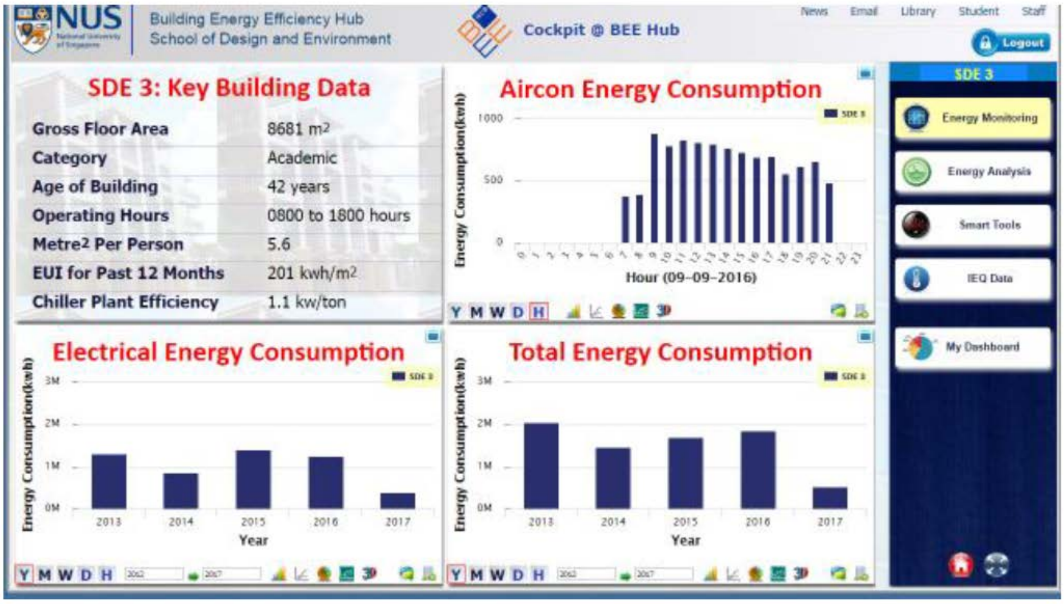
Smart tool 3 – Move from reactive control to predictive control

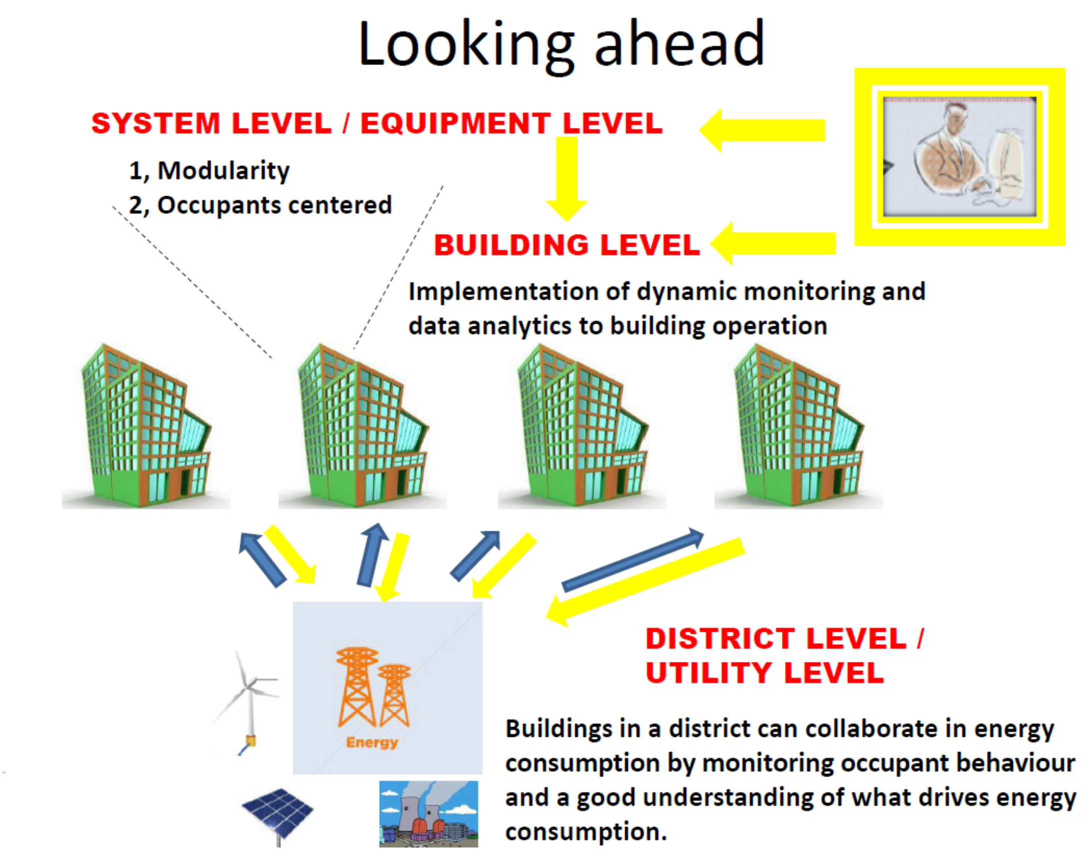


Pantazaras A., Lee S.E., Santamouris M., Yang J., Predicting the CO2 levels in buildings using deterministic and identified models, Energy and Buildings . http://dx.doi.org/10.1016/j.enbuild.2016.06.029

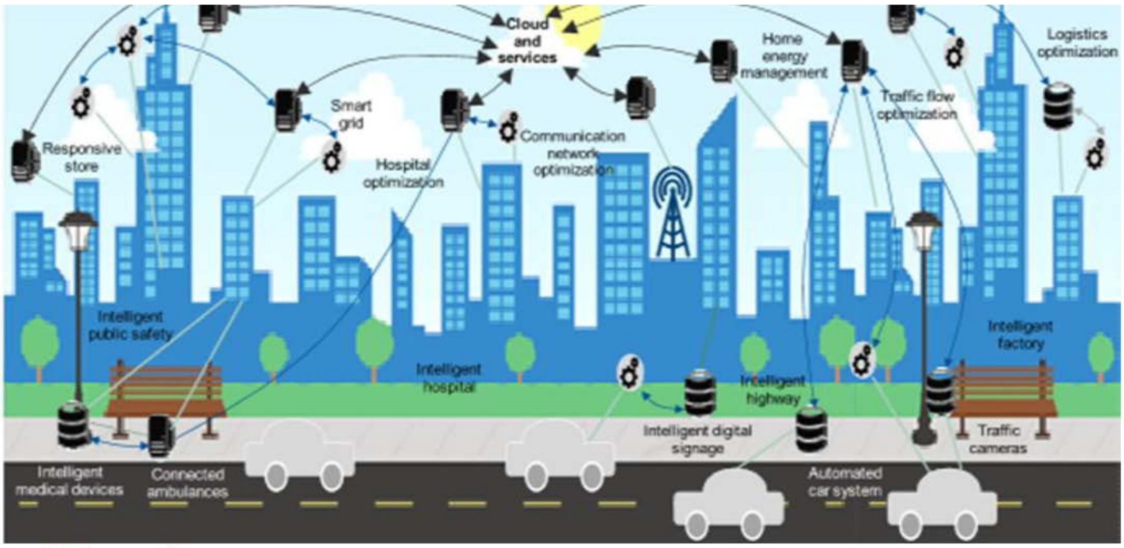

What will happen?
Predictive Data Analytics
Why did it happen?
Diagnostic data analytics
What happened?
Descriptive data analytics
Information
Optimization
Hindsight
Insight
Foresight


DISTRICT LEVEL – ENERGY COCKPIT
The Energy Information Network
Data Scrubbing
Smart Energy Management
Visualization Auto analysis
Monitoring
Occupants Information/ Building Information


NUS
Building Energy Efficiency Hub
School of Design and Environment
Cockpit @ BEE Hub
News
Email
Library
Student
Staff
Logout
SDE 3: Key Building Data
Gross Floor Area 8681 m2
Category Academic
Age of Building 42 years
Operating Hours 0800 to 1800 hours
Metre2 Per Person 5.6
EUI for Past 12 Months 201 kwh/m2
Chiller Plant Efficiency 1.1 kw/ton
Aircon Energy Consumption
Energy Consumption(kwh)
Hour (09-09-2016)
Electrical Energy Consumption
Total Energy Consumption
Year
SDE 3
Energy Monitoring
Energy Analysis
Smart Tools
IEQ Data
My Dashboard


Looking ahead
SYSTEM LEVEL / EQUIPMENT LEVEL
1, Modularity
2, Occupants centered
BUILDING LEVEL
Implementation of dynamic monitoring and data analytics to building operation
Energy
DISTRICT LEVEL / UTILITY LEVEL
Buildings in a district can collaborate in energy consumption by monitoring occupant behaviour and a good understanding of what drives energy consumption.

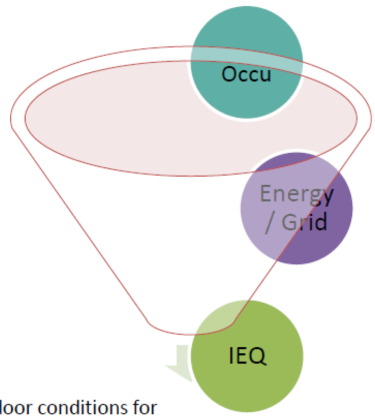
Looking ahead: "Internet of Energy Things"



Buildings that are
"smart energy management aware" or "smart energy management ready"

25

Looking ahead



Optimised indoor conditions for
a minimum amount of energy
based on occupants needs

Dr Junjing Yang
bdgyj@nus.edu.sg