TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE

VITORIA-GASTEIZ ✣ TARTU ✣ SØNDERBORG

Deliverable 6.6: Strategies for Value Added Services

WP6, Task 6

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[1] PU = Public

PP = Restricted to other program participants (including the Commission Services)

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
VAS	Value Added Service[2]
CIOP	City Information Open Platform
WWSSN	World-Wide Standardized Seismic Network
GDPR	General Data Protection Regulation
GDP	Gross Domestic Product
PPP	Private Public Partnership
QoL	Quality of Life
AES	Advanced Encryption Standard
RSA	Rivest-Shamir-Adleman public-key cryptosystem
DH	Diffie-Hellman key exchange
DNS	Domain Name System
DNSSEC	Domain Name System Security Extensions
DHCP	Dynamic Host Configuration Protocol
IoT	Internet of Things
M2M	Machine to Machine
EU	European Union
DPO	Data Protection Officer
KPI	Key Performance Indicator
IT	Information Technology
DoW	Description of Work
CAPS	Collective Awareness Platform for Sustainability
NGO	Non-Governmental Organization
CIO	Chief Information Officer
IDC	International Data Corporation
ESE	Energy Service Enterprises
SVM	Support Vector Machine
NoSQL	Not only SQL

[2] https://en.wikipedia.org/wiki/Value-added_service

ACID	Atomicity, Consistency, Isolation, Durability properties of database transactions
SQL	Structured Query Language
API	Application Programming Language
HDFS	Hadoop Distributed File System
POSIX	Portable Operating System Interface
DDFS	Disco Distributed File System
MD5	MD5 is one in a series of message digest algorithms designed by Professor Ronald Rivest of MIT (Rivest, 1992)
HQL	Hibernate Query Language
HMAC-SHA256	Hash Message Authentication Code with Secure Hash Algorithm 2 and 256 bit key
SSH	Secure Shell
SASL	Simple Authentication and Security Layer
ACL	Access Control List
PBKDF2	Password-Based key Derivation Function 2
SSL	Secure Sockets Layer cryptographic protocol
BI	Business Intelligence
ETL	Extract, Transform and Load
TQM	Total Quality Management
ASC	Amsterdam Smart City
LoRa	Proprietary, chirp spread spectrum radio modulation technology
ERDF	European Regional Development Fund
eSESH	Saving Energy in Social Housing with ICT project
EAS	Energy Awareness Services
EMS	Energy Management Services
DSNY	New York City Department of Sanitation
AoT	Array of Things
CSO	Combined Sewer Overflows

Table 1: Abbreviations and Acronyms

0 Publishable Summary

SmartEnCity focuses on the development of a highly adaptable and replicable systemic approach towards urban transformation into sustainable, smart and resource efficient urban environments in Europe, through the planning and implementation of measures aimed at improving energy efficiency in the main consuming sectors in cities and increasing the supply of renewable energy. This approach will be defined in detail, and subsequently laid out and implemented in the three Lighthouse demonstrators (Vitoria-Gasteiz in Spain, Tartu in Estonia and Sonderborg in Denmark), to be further refined and replicated with the development of Integrated Urban Plans (IUPs) in all participant (both Lighthouse and Follower) Cities.

WP6 aims to devise a common ICT platform that will be the reference for the deployment of the “City Information Open Platform” (CIOP) in each one of the pilot lighthouse projects. The platform will provide a standardized data model to accommodate data from each pilot and will also define standardized services and modules for data consumers, especially relevant are those related to the monitoring of SmartEnCity KPIs, those requested by the EC in the call and those identified as ICT solutions for the project.

Deliverable 6.6 focuses on the Value Added Services[3] (VAS) on top of CIOP. Value Added Services are context dependent and they depend on factors like:

- CIOP capabilities
- Partner environment
- Citizen engagement
- Investment environment
- Research and Development capabilities

For this reason Deliverable D6.6 focuses on toolbox to help build local Value Added Services that match the context. This involves identifying capabilities, partners and use-cases. After which use-cases should be evaluated, deployed and results validated.

Document covers 4 main phases to be executed locally in order to identify potential for VAS, how to evaluate this potential, how to deploy these services and how to validate end results against forecasted values. Also the set of tools will help local execution teams with SOTA (Sate Of The Art) examples that can be used in order to better understand and explain potential VAS Use-Cases while Identifying potential Partners and Use-Cases.

[3] Document title has been changed from Added Value Services to Value Added Services due to later being more commonly used

1 Introduction

What is considered as Added Value in this context? Added Value Services in this context is to be taken equal to term Value Added Services[4] term that is now more widely used than just the Telecom sector. This is often and within the context of this document a Service or a Functionality that was not in the initial core scope of the project but possible to achieve by using the capabilities developed and deployed within the project.

Example: When a project develops a remote metering capability for the purpose of better data collection in the interest of billing end-users for utilities (water, gas, electricity or similar) this is the core scope. Value Added Service in this situation could be a service that allows end-users to compare their consumption to similar peers in order to determine their personal behavior and how to maybe consume less. A service that would give advice tailored to that particular end-user based on the consumption metering data and therefore more relevant than general advice for that end-user. Added value in this example would be more efficient use of resources and smaller impact to environment. Using less would also directly bring value to the end-user in a form of lowering the costs associated.

This document is designed to be a set of tool for the CIOP operator, owner or stakeholder to be used as a reference guide while in the process of extending the Services deployed on CIOP. Consider the new potential VAS as add-on value to the original investment into CIOP. This is similar to the much-improved data from the Worldwide Standardized Seismograph Network (WWSSN) instruments allowed seismologists to map precisely the zones of earthquake concentration worldwide while WWSSN was built to monitor the compliance of the 1963 treaty banning above-ground testing of nuclear weapons.[5]

This document will not give a complete list of best VAS to be implemented as it is highly dependent on several factors like:

- CIOP capabilities – what are the integrated data sources, their data resolution, control capabilities, number of inputs (volume) etc.
- Partner environment – best results are achievable with partners and therefore it depends on what partners are locally addressing and whether they have an interest in joint development of VAS.
- Citizen engagement – how do the citizens position themselves towards new possibilities? What is the segment being addressed with the planned service and how open are they to try new things.
- Investment environment – any development of new services requires investment and therefore overall willingness to invest into a particular Service area or geographical area has an impact.
- Research and Development capabilities – ability to execute local research and therefore tailor new services more precisely increases the likelihood of successful VAS deployment.

VAS are finding their ways into many sectors but may manifest themselves indifferent ways. Their success or failure depends on their ability to truly add value to users or customers. Successful VAS find their user-base in a sustainable way, meaning that the economic value

[4] https://en.wikipedia.org/wiki/Value-added_service
[5] https://pubs.usgs.gov/gip/dynamic/developing.html

generated by the service exceeds the upkeep of the service and its promotion/marketing costs. This economic value is then translated into 2 main benefits for companies in regards to their core business.

a) Economic value directly from VAS.

   With this approach VAS are paid services and generate their own direct economic impact.

b) Economic value is converted into attraction or loyalty.
   With this approach the value is converted to attraction or loyalty to core services and therefore create stronger customer revenue picture on the customer.

Both approaches have their pro's and con's and therefore one should always consider the particular case where the new VAS is being deployed.

This document describes the main phases on how to identify the potential and partners, how to evaluate potential VAS ideas. How to deploy them or what to consider during the planning of deployment. And finally how to validate the actual impact of the VAS.

1.1 Purpose and target group

The purpose of this document is to provide a good how-to approach for Smart Cities to follow in order for them to develop their own successful VAS to better support their development into a better living environment. VAS may often be good investments when comparing effort spent and impact they generate. This is because they are built on top of existing components and with relatively little additional development of major infrastructure. This means that the development of such services usually encompasses relatively smaller development scope compared to building something from ground up.

This document will cover 4 main phases to be executed locally in order to identify potential for VAS, how to evaluate this potential, how to deploy these services and how to validate end results against forecasted values. Also the set of tools will help local execution teams with SOTA (State Of The Art) examples that can be used in order to better understand and explain potential VAS Use-Cases while Identifying potential Partners and Use-Cases.

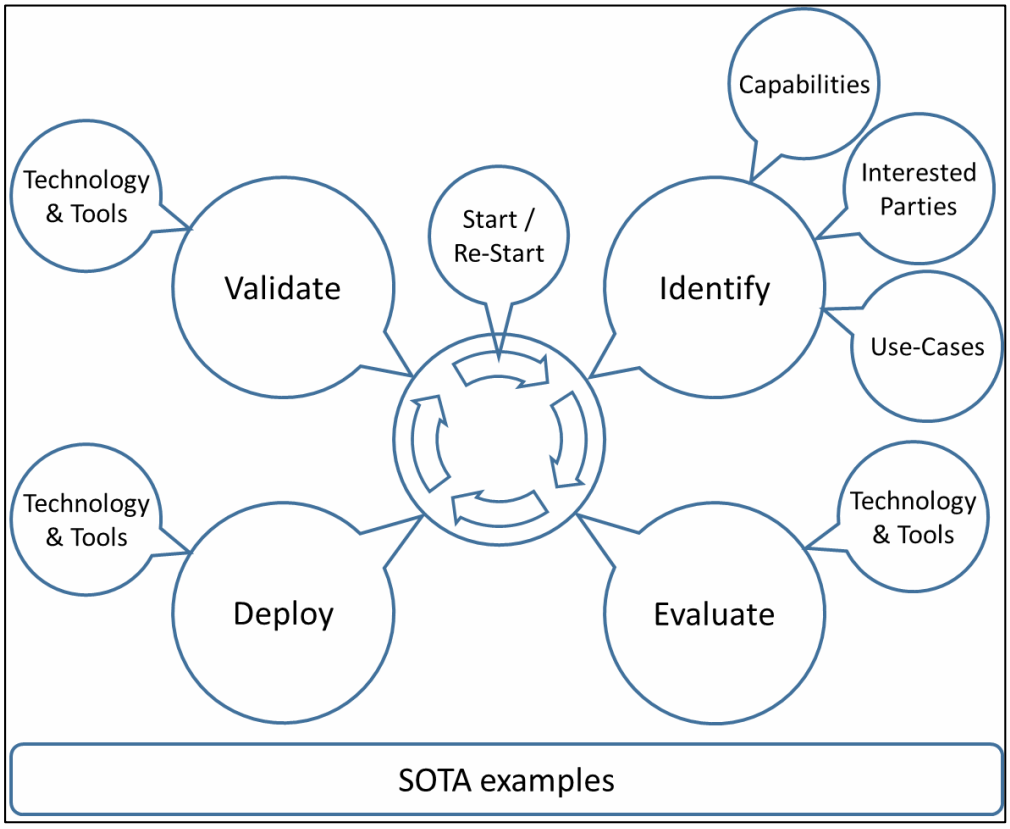


Figure 1: Overall process of VAS potential Identification, Evaluation, Deployment and Validation

The target group for this document is other cities and large organizations in the process of defining potential benefits of migrating from multiple IT systems to a common CIOP model. While such projects may need significant investments and poses challenges while comparing the benefits to the costs, VAS potentials are additional benefits from such projects. There are good examples in the Private sector of the situations where the core service has ended up being the 0 margin business while most economical value is delivered by VAS. An example of this are petrol-stations that increasingly derive their net business results from sales of

snacks and food rather than fuel. Fuel in their context is the core and snacks are VAS. “In 2006 the shop gross yield of leased brand petrol station reached 53,4% (2004: 48,3%) of the entire gross yield while fuel sales amounted only to 20,1% (2004: 22,6%)” (Sector study on the Petrol Station Market, 2007 pages 16 & 17)[6]

[6] https://www.bft.de/files/2913/5946/6901/btsmarkt07_en.pdf

1.2 Contributions of partners

Table 2 depicts the main contributions from participating partners in the development of this deliverable.

Participant short name	Contributions
ET	Task Leader. Responsible of the content of the deliverable. Main contributor for chapters 0, 1, 2, 3.1 and 5. Will review contributions of all sections.
TEC	Main contributor to chapter 4 (4.3)
MON	Main contributor to chapter 4 (4.1, 4.2 and 4.3)
GIS	Main contributor for chapter 3.2 and 3.4
ETIC	Main contributor for chapter 3.3
CAR	Contributor to sections 3.3, 3.4 and 4

Table 2: Contribution of partners

1.3 Relation to other activities in the project

Table 3 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the SmartEnCity project and that should be considered along with this document for further understanding of its contents.

Deliverable Number	Contributions
T3/4/5.7	Implementation of the added value services into the city urban platforms
D6.1	This deliverable provides the requirements identified for SmartEnCity
D6.2	This deliverable provides the data models necessary for SmartEnCity
D6.3	This demonstrator extends D6.2 considering the data models necessary for SmartEnCity
D6.4	This deliverable provides interoperability mechanisms
D7.2 & D7.3	Evaluation protocols and KPIs, in particular, ICT evaluation protocol
D7.6 & D7.8	Monitoring programmes whose data should be integrated in the platforms

D7.9	Data collection approaches for integration into the services and questionnaires for evaluation

Table 3: Relation to other activities in the project

2 Objectives and Guiding Principles

The objective of the Value Added Services is to find additional Values for each City and its inhabitants from the CIOP beyond the original project scope. This is done by principles of finding alternative valuable usages for data gathered and benchmarked against variable potential parties, to whom it may be very valuable in their context – Public, Private or Scientific field.

Objectives: Find value beyond original scope.

Guiding principle: re-usage of data and/or control capabilities of CIOP for the benefit of the citizen.

2.1 Objectives

VAS in the context of SmartEnCity are those services that can be constructed from data available in the platform and from the usage of the solutions provided within the project. Those services are grouped in three categories; Energy assessment services, Sustainable mobility services and Citizens engagement services. The objective of this task is to offer those services which support decision making on new activities that boost engagement or launch awareness campaigns.

The main objective is to find a sustainable model in which Added Value is created. This means a working value-chain of continues co-operation and sharing of data rather than one time collection and analysis. CIOP in this context as a VAS Enabler, has the possibility to grant access to a wide variety of data and functionality that is built within the scope of the project. Within this deliverable alternative uses of the data and functionality is studied in order to maximize the value generated.

Public Sector

Most likely there are many ways the gathered data could improve Public Sector services provided within the project area or even wider. It may be by giving better transparency for decisions (based on data); better living environment by more optimized services; better utilization of services provided for public funding etc. The extended use of the data gathered via CIOP is a potential source of VAS for the Public sector and will be one of the focus points within this deliverable (to find clear examples and deploy them).

Private Sector

The main objective while working with the Private sector is to find economic value in the data gathered and made available by the CIOP. This economic value may be in a form of insight to a company, so that they can better provide their services (example: behavioral data that enables better targeting of advertising) or they can create new services that relay on this data directly – new or modified business models (example: more accurate and usage based billing models).

Research

Having more data enables possibilities into research in unprecedented ways as it greatly extends the fields on which data is gathered and also greatly improves the amount and

resolution of the data. This will enable new research into areas that were previously cumbersome to achieve due to the difficulties in the data gathering process. New insights also could be found from the higher resolution of data.

Citizen

All above Added Values will only remain sustainable in case they benefit the citizen as otherwise the value-chain will not work. There will be no usage for the data if it does not benefit the citizen as then there will be no value in it.

2.2 Principles

Looking for new values beyond original scope of CIOP is a very creative work and therefore setting too much restrictions early in the process may limit creativity that is needed for innovation. Having some crucial principles in place is important as ignoring them might undermine the whole project.

Data Privacy and Security

Always while deploying a new service on top of existing infrastructure it is important to validate if the use of the data in the new service is at the same security level as it is intended for this type of data. Also if the usage of said data is allowed from the privacy aspect. This is a particularly hot topic at this time as the new legislation, EU General Data Protection Regulation – GDPR in short is coming into effect.[7]

Local law

Still there are significant differences in legislation between EU countries and countries outside of EU, therefore it is imperative that local legislation is taken into account and fully applied.

Citizens first

The foundation of success in an open environment (competitive) is based on who can best serve the needs of the citizen or end-user. While the public sector might not be in a competitive situation one should still take this principle from private sector. The reason is : Customer centric services enjoy better results on the private sector and therefore their gross-margin is better. To the public sector the same situation would translate into better result for the public funds spent on the service development. A customer centric design results in higher customer satisfaction and likelihood of a service recommendation to other customers. This in itself can reduce the cost of service communication significantly.

Openness and Transparency

Due to the need for the public sector being equally available to all segments it is important to take digital divide[8] into account while developing new services. It is worth putting extra effort into making sure that all segments needs and potential fears are addressed. Being open and transparent is a key principle while being in dialogue with less digitally literate segments as when it comes to public acceptance it is with equal vote and voice from all segments of citizens and not only from the tech savvy.

[7] http://www.eugdpr.org/
[8] https://en.wikipedia.org/wiki/Digital_divide

3 Overall Approach

There are 4 main phases in new VAS developments:

1) Identify
    a. Capabilities (data sources, resolution + control capabilities)
    b. Potentially interested parties across sectors (public, private, research)
    c. Identification of use-cases
2) Evaluate
    a. Interviews with identified parties on applicability of data and capabilities in order to determine the potential value
    b. Identify valuable use-cases of data and control and their value
3) Deploy
    a. Set legal framework for data and control access via CIOP (Data & Access consent)
    b. Run Proof-Of-Concept and evaluate results, compare to predicted value
    c. Implement, monitor
4) Validate

As stated earlier – this document will not give out one or few “best” VAS descriptions as they strongly depend on local context (see: 1 Introduction). Instead partner cities’ involvement in the overall approach is to execute “Overall Approach” in their local city. This is done by the means of locally identifying the data and capabilities of CIOP and finding potential interested parties across sectors (Public, Private and Research communities).

Together with identified Partners and capabilities the Evaluation process has to be executed in order to identify valuable use-cases based on the capabilities of CIOP beyond what was originally scoped within the project.

The testing and Execution plan shall be agreed locally with clear validation Tools and Methods agreed beforehand.

3.1 Identify

The goal of this process is to have clearly identified Capabilities (data and control) of the CIOP on the one side and potential local partners, who are interested in gaining access to these capabilities on the other side.

3.1.1 Identifying available capabilities via CIOP deployment

This task should clearly map the data and its resolution that is gathered or accessible by CIOP. By data we mean any kind of information regardless of its origin (example: temperature measurements data with coordinates of the location, where the measurements are from). By resolution we mean data quality dimensions that can be either measurements in time or accuracy level (example: temperature measured every 15 minutes or every 15 seconds and is done with a device that has accuracy class of +/-2C or +/-0,002C). It is important also to map the owner of that particular data and legal framework dependencies that have to be followed for gaining access to it. Who is the right counterpart to grant access to data? Are they legally in this position in order to have the right to grant the access?

Control capabilities of the CIOP have to also be mapped. This involves mapping all functionality that controls any systems into which CIOP can make changes directly. This does not take into account any systems that use the data from CIOP and based on this initiate their own control flows as the CIOP does not have direct “write or execute” access level to such systems. Also the intention of opening up the CIOP data to many partners is to allow the growth of such systems without too much burden of reporting all capabilities back to CIOP operator.

The result of this task is a clearly identified list of Data and Control functionalities of the CIOP with applicable parameters.

3.1.2 Identifying potential interested Parties

This task should clearly identify parties, who would be interested in using the capabilities of the CIOP identified in 3.1.1. As the data is in the heart of more and more of today’s life, businesses, public processes and research then all these sectors should be covered in the quest for partners. Approach to potential partners should be based on a proposal built on capabilities of the CIOP accompanied with SOTA examples from the world of what has been done. This way partners can relate the capabilities to their operations and identification and selection of applicable data sources and control functionality is made easier. If possible then SOTA examples from similar fields should be used in order to have more relevance to that particular organization. Terms of access to the data and control functionalities should also be covered so that from the beginning all aspects of data privacy and security should be in the design of any future co-operation.

Public Sector Partners

A clear target group as re-using the CIOP for other services provided from the public sector to citizens directly improves the lives of the citizens. Also it will add more clear value to all citizens as these use-cases will most likely be applicable to wide groups.

Private Sector Partners

The private sector should consider the capabilities from the CIOP for 2 main reasons. Their internal process improvements (Example: using data from the CIOP instead of gathering it by themselves) and therefore reducing cost. Or adding value by extended functionality to their services or products that they provide to citizens based on the capabilities of the CIOP (Example: integration of temperature data from CIOP instead of shipping weather-station with every heating-unit) and therefore improving their product or service.

Research Partners

Data is required for all research and therefore is an interesting topic to all research organizations. As the CIOP gathers a lot of information from public areas and groups of citizens of higher than previously precision then there should the clear value in gaining access to this data for researchers.

3.1.3 Identification of Use-Cases

Working with identified Partners, CIOP capabilities and SOTA examples, a list of potential use-cases shall be compiled that looks promising in adding value to partners, CIOP or citizens directly.

The result of the task should be a list of identified partners with clear indication of the CIOP capabilities that they are interested in with the description of the use-case that is the ambition of joint co-operation.

3.1.4 Example “Use-Case identification”

This example is in the process of being built into Proof-of-Concept on top of the CIOP deployed in Estonia. It has not been deployed yet and is described here as an example case.

Smart Lights

More and more street lights are being converted to LED technology for various reasons – energy efficiency being the most prominent one. They also are becoming more and more remotely controllable, mostly for even more efficiency. All street lights in SmartEnCity project scope will be connected to CIOP. The identified CIOP capability in this use-case is street-lights remote controllability via CIOP.

Emergency Assets (Police, Rescue etc.)

Most of the crucial emergency assets in Estonia have active GPS tracking on them so that complete situational awareness is possible on the assets location and usage. This means that all Ambulances, Police and Rescue cars constantly report their GPS location to the central command. The GPS location feed may be considered another identified CIOP capability.

Public Safety

Public safety is one of the key topics and main deliverables from the public sector. Any help is especially appreciated in the sector of emergency responses. This may be considered an interesting sector. An identified party for this use-case development is Rescue services. The following use-case has been proposed to them and it was welcomed.

Identified possible use-case to enhance public safety

Functionality 1: Awareness creation zone for alarming emergency vehicles. This is done by the means of controlling street lights in a specific manner around the emergency vehicle while it is travelling with speeds in excess of 5kmh. The current aim is to create a zone of about 200-300m around the vehicle a zone where street-lights dim up and down. The aim of this activity is to raise awareness of approaching emergency vehicles in order to avoid accidents on route and provide better passage through traffic. The functionality is active only while flashes are being used on the rescue vehicle.

Functionality 2: Better working conditions on site. This is done by putting all controllable street-lights to 100% light regardless of the efficiency program target around stationary Rescue vehicle. The vehicle is considered stationary while its reported speed is below 5kmh. The aim of this functionality is to provide the best working conditions at potential accident or rescue sites. The functionality is active only while flashes are being used on the rescue vehicle.

3.2 Evaluate

The evaluation phase of the overall approach is the task that has to identify and evaluate the potential value of the use-cases proposed in 3.1.3. Having a clear value-proposition on every use-case enables a more straightforward approach in setting the goals and evaluation criteria for deployment.

The evaluation process also contains Technologies and Tools to help evaluate VAS from many different angles that deal with lowering of risks involved in development of new VAS like usability, learnability etc. These evaluation points are crucial to go through while evaluating the new potential VAS as all of them may have significant impact on the future performance of the service in question.

3.2.1 Technology and Tools

The evaluation, deployment and validation involve checking whether the VAS conforms to the characteristics or exhibits the qualities that are expected from the service itself. The more characteristics that are satisfied, the more satisfactory is the evaluation and the validation. Yet, not all qualities have equal weight. For example, for Usability-Understandability, user documentation may be comprehensive for users but inadequate for developers.

Scoring can also be affected by the nature of the service itself e.g. for Learnability that has been well-designed and consequently is so easy to use that tutorials aren't needed. Portability can apply to both the service and its development infrastructure and in most of the cases the whole system has to be portable.

Criterion	Sub-criterion	Notes – to what extent is/does the service…
Usability	Understandability	Easily understood?

	Documentation	Comprehensive, appropriate, well-structured user documentation?
	Buildability	Straightforward to build on a supported system?
	Installability	Straightforward to install on a supported system?
	Learnability	Easy to learn how to use its functions?
Sustainability and maintainability	Identity	Project/service identity is clear and unique?
	Copyright	Easy to see who owns the project/service?
	Licensing	Adoption of appropriate license?
	Accessibility	Evidence of current/future ability to download?
	Community	Evidence of current/future community?
	Testability	Easy to test correctness of source code?
	Portability	Usable on multiple platforms?
	Supportability	Evidence of current/future developer support?
	Evolvability	Evidence of current/future development?
	Interoperability	Interoperable with other required/related service?

From now on, each category will be described in greater depth.

3.2.1.1 Usability

Usability is the ease of use and learnability of a human-made object such as a tool or device. In software engineering, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.[9]

Understandability How straightforward is it to understand? • What the service does and its purpose? • The intended market and users of the service? • The service's basic functions? • The service's advanced functions?	**Yes/No, supporting comments if warranted**

[9] https://en.wikipedia.org/wiki/Usability

High-level description of what/who the service is for is available.	
High-level description of what the service does is available.	
High-level description of how the service works is available.	
Design rationale is available – why it does it the way it does.	
Architectural overview, with diagrams, is available.	
Descriptions of intended use cases are available.	
Case studies of use are available.	

Documentation Looking at the user documentation, what is its • Quality? • Completeness? • Accuracy? • Appropriateness? • Clarity?	**Yes/No, supporting comments if warranted**
Provides a high-level overview of the service.	
Partitioned into sections for users, user-developers and developers (depending on the service).	
States assumed background and expertise of the reader, for each class of user.	
Lists resources for further information.	
Further information is suitable for the level of the reader, for each class of user.	
For problems and error messages, the symptoms and step-by-step solutions are provided	
Consists of clear, step-by-step instructions.	
Gives examples of what the user can see at each step e.g. screen shots.	
API documentation, documents APIs completely e.g. configuration files, property names etc.	

Documentation on the project web site makes it clear what version of the service the documentation applies to.	

Buildability How straightforward is it to: • Meet the pre-requisites for building the service on a build platform? • Build the service on a build platform?	**Yes/No, supporting comments if warranted**
Web site has instructions for building the service.	
Source distributions have instructions for building the service.	
An automated build is used to build the service.	
Web site lists all third-party dependencies that are not bundled, along with web addresses, suitable versions, licenses and whether these are mandatory or optional.	
Source distributions list all third-party dependencies that are not bundled, along with web addresses, suitable versions, licenses and whether these are mandatory or optional.	
Dependency management is used to automatically download dependencies.	
All mandatory third-party dependencies are currently available.	
All optional third-party dependencies are currently available.	
Tests are provided to verify the build has succeeded.	

Installability How straightforward is it to: • Meet the pre-requisites for the service on a target platform? • Install the service onto a target platform? • Configure the service following installation for use? • Verify the installation for use? Note that in some cases build and install may be one and the same.	**Yes/No, supporting comments if warranted**
Web site has instructions for installing the service.	
Binary distributions have instructions for installing the service.	

Web site lists all third-party dependencies that are not bundled, along with web addresses, suitable versions, licenses and whether these are mandatory or optional.	
Binary distributions list all third-party dependencies that are not bundled, along with web addresses, suitable versions, licenses and whether these are mandatory or optional.	
Dependency management is used to automatically download dependencies.	
All mandatory third-party dependencies are currently available.	
All optional third-party dependencies are currently available.	
Tests are provided to verify the install has succeeded.	
Installers allow user to select where to install service.	
Uninstallers uninstall every file or warns user of any files that were not removed and where these are.	

Learnability How straightforward is it to learn how to achieve: • Basic functional tasks? • Advanced functional tasks?	**Yes/No, supporting comments if warranted**
A getting started guide is provided outlining a basic example of using the service.	
Instructions are provided for many basic use cases.	
Instructions are provided supporting all use cases.	
Reference guides are provided for all command-line, GUI and configuration options.	
Documentation is provided for user-developers and developers.	

3.2.1.2 Sustainability and maintainability

Identity To what extent is the identity of the added value service clear and	**Yes/No, supporting**

unique both within its application domain and generally?	**comments if warranted**
Service has a distinct name within its application area.	
Project/service name does not violate an existing trade-mark.	
Service name is trade-marked.	

Copyright To what extent is it clear who wrote the service and owns its copyright?	**Yes/No, supporting comments if warranted**
Web site states copyright.	
Web site states who developed/develops the service, funders etc.	
If there are multiple web sites then these all state exactly the same copyright, licensing and authorship.	
Each component of the service has a copyright statement.	

Licensing Has an appropriate license been adopted?	**Yes/No, supporting comments if warranted**
Web site states license.	
Service has a license.	

Community To what extent does/will an active user community exist for this service?	**Yes/No, supporting comments if warranted**
Website has statement of number of users/developers/members.	
Website has success stories.	
Website has quotes from satisfied users.	

Website has list of important partners or collaborators.	
Website has list of the project's publications.	
Website has list of third-party publications that cite the service.	
Website has list of service that uses/bundles this service.	
Users are requested to cite the project if publishing papers based on results derived from the service.	

Accessibility To what extent is the service accessible?	**Yes/No, supporting comments if warranted**
Distribution of the service is available (whether for free, payment, registration).	
Binary distributions are freely available.	
Binary distributions are available without the need for any registration or authorization of access by the project.	
Source distributions are available (whether for free, payment, registration).	
Source distributions are freely available.	
Source distributions are available without the need for any registration or authorization of access by the project.	
Access to source code repository is available (whether for free, payment, registration).	
Anonymous read-only access to source code repository.	
Ability to browse source code repository online.	
Repository is hosted externally to a single organization/institution in a sustainable third-party repository.	

Testability How straightforward is it to test the service to verify modifications?	**Yes/No, supporting comments if**

	warranted
Service has tests for verification.	
Project has integration tests.	
Project recommends tools to check test coverage.	
Project has automated tests to check test coverage.	
A minimum test coverage level that must be met has been defined.	
There is an automated test for this minimum test coverage level.	
Tests are automatically run nightly.	
Continuous integration is supported – tests are automatically run whenever the source code changes.	
Test results are visible to all developers/members.	

Portability To what extent can the service be used on other city platforms?	**Yes/No, supporting comments if warranted**
Application can be built on other city platforms.	

Supportability To what extent will the added value service be supported currently and in the future?	**Yes/No, supporting comments if warranted**
Web site has page describing how to get support.	
User doc has page describing how to get support.	
Service describes how to get support.	
If there is a blog, is it is regularly used.	
E-mail lists or forums, if present, have regular posts.	

Evolvability To what extent will the service be developed in the future: • For a future release? • Within a roadmap for the service?	**Yes/No, supporting comments if warranted**
Web site describes service roadmap or plans or milestones.	

Interoperability To what extent does the service's interoperability: • Meet appropriate open standards? • Function with required third-party components? • Function with optional third-party components?	**Yes/No, supporting comments if warranted**
Uses open standards.	
Uses mature, ratified, non-draft open standards.	
Provides tests demonstrating compliance to open standards.	

3.2.1.3 Economic Evaluation

Rather than being an expense, smart technology integration can create considerable opportunities for added value in any city. Technology integration helps cities to improve efficiency, enhance their economic potential, reduce costs, open the door to new business and services, and improve the living conditions of its citizens. A key condition for value creation through integration is the compatibility of technologies; which is best achieved through common and consensus-based standards that ensure interoperability. Presently, however, smart city projects concentrate mainly on vertical integration within existing independent infrastructure and services silos, e.g. energy, transport, water or health. A truly smart city requires horizontal integration as well as creating a system of systems capable of achieving considerable increases in efficiency and generating new opportunities for the city and its citizens.

Economic sustainability

Cities need to provide citizens with the capacity to develop their economic potential, and attract business and capital. With the global financial crisis, the economic sustainability of cities has taken center stage. The crisis has unearthed considerable weaknesses in the financial models and planning strategies of public authorities in the provision of services and in their infrastructure investments. Their financial sustainability now depends also on new financial models, as well as more efficient and better integrated services and infrastructures.

Economic sustainability refers to the business environment and wealth generation capacity of the city. It is a proxy for gross domestic product (GDP) growth, but encompasses wider criteria than just GDP. Population growth, the quality of private undertakings, the attractiveness for being investment location as well as the ability of city authorities to tax the citizens for public services, all depend on the city's ability to attract business and capital. The development of smart cities, the financing of change and the fullest adoption of innovations by city inhabitants, require an understanding of the economic fabric of the city and the market for smart solutions. Understanding the market allows for the development of new approaches to infrastructure financing, as well as influencing citizen behavior through those approaches. For cities requiring public private partnerships (PPPs) and systems of cost recovery using user charges, this knowledge is of paramount importance. Smart city services contribute to the economic sustainability and the resilience of cities to economic shocks, as those generate a new level of economic diversification. Economic sustainability is also closely linked to financial sustainability, particularly in the wake of financial crises. Many cities have seen their access to capital curtailed and their credit rating deteriorate, while financial institutions have restricted the access to credit.

Nevertheless, investing in the city structures of the future can be done using novel financial models, which monetize savings and use them to finance the reimbursement of capital expenditures. In addition, the cities of the future are expected to have much more decentralized energy services and supply provision systems, creating new economic activities and allowing PPPs. The right models should be able to combine financial sustainability with higher investment rates. Depending on the circumstances of each city, the need for special support by donors, governments and international financial institutions may arise. Financial models need to be well designed, aiming ultimately at developing cost effective and sustainable solutions, and also at attracting foreign investment. Importantly, financing models must be based on solid cost-benefit analysis, including wider socio-economic benefits where necessary.

Social sustainability

A city's attractiveness to people, business and capital is closely related to the quality of life (QoL), business opportunities and security and stability, which are guaranteed by social inclusiveness.

When large numbers of people live in agglomerations, actual or perceived social inequalities and social exclusion of sections of the population can lead to social unrest. City authorities have a key interest to ensure social inclusion, which starts with a basic level of services for all citizens. In a smart city, it is important to take into account the risks of alienating important groups of citizens. This may happen because smart services are limited to richer areas of the town, or because user charges make important services unaffordable for certain parts of the population. All models of development of cities have to ensure that public transport, water, sanitation, electricity, and telecommunications are affordable and accessible to all population groups. Citizens are also the ultimate beneficiaries and users of "smart" changes. Inclusiveness can be achieved by involving all relevant stakeholders from the start, and ensuring that new changes are understood and accepted, and thus inclusive. Smart city infrastructures or services need to respond to the following questions:

- Are the expected objectives of the planned changes taking into account real behavior of the city stakeholders?
- How can it be guaranteed that basic city services are affordable?
- Who is paying for the services? Are the users that can afford them the right target group?
- Can the new services and infrastructures be understood and used by all citizens targeted?
- Are the social and cultural values of the citizens taken into account?

Smart city approaches strongly focus on technology and often rely on sophisticated applications. Badly understood or poorly implemented, they may be pursued for their own sake and divert cities from real issues (employment, education, crime, etc.). Ideally, smart city projects should be carried out only if they help cities to meet their needs, with a quantifiable added value facilitated by technology integration, usability or cost reductions.

Environmental sustainability

Cities face a number of environmental sustainability challenges, generated by the city itself or caused by weather or geological events. To reduce the impact of the city on the environment resource it is important to promote the efficient and intelligent deployment of technology and to integrate infrastructures. This process can also be developed in such a manner as to increase the resilience of the city to environmental shocks.

Environmental concerns are growing in cities. Three pressures arise. The first is on resource limitations, such as water scarcity and quality, or fuel requirements. The second is on QoL and health. Not only are citizens and authorities more environmentally aware, but the economic implications of pollution can be serious, due to the impact on health and the attractiveness for businesses to operate from the city. The third is risk management and resilience to environmental shocks (such as heat waves and flooding caused by climate change). One of the first stages to address environmental sustainability is to increase resource efficiency in all domains, such as energy efficiency in buildings and networks, fuel efficiency in transport, water efficiency and new methods to transform waste to energy. Technology is not the only aspect required for sustainability, but is an important and necessary step forward. Efficiency gains can need significant investments, and the integration of different technologies can be complex. Resilience and risk management need to be integrated in city planning, based on estimated future risks. The integration of different technologies in the areas of ICT, transport, energy, water etc., which form the infrastructure backbone of cities, currently offers the best prospect for sustainability.

Stakeholders for added value services

A smart city cannot be imposed by decree, as the city is shaped by a large number of individual decisions and social and technological changes cannot be fully accounted for. With the present advances in ICT and affordable energy efficiency and energy production tools are changing the relationship between citizens and city services. Citizens are increasingly becoming providers of city services and not only users. A good plan requires the participation, input and ideas from a wide range of stakeholders within the city. This means

that city planning needs to allow for bottom-up processes of modernization. The stakeholders are:

- Political leaders, managers and operators of the local government (city).
- Service operators – public or private: water, electricity, gas, communication, transport, waste, education, etc.
- End users and prosumers (a person who consumes and produces): inhabitants and local business representatives.
- Investors: private banks, venture capitalists, pension funds, international banks.
- Solution providers: technology providers, financiers and investors.

Giving to each of these groups a true stake in smart city development is important to achieve the necessary consensus for the changes. Their concerns need to be carefully considered and acknowledged, and ultimately the direction and next steps have to be collectively approved. In the absence of proper consultation, the authorities will sooner or later face considerable additional obstacles to make their vision a reality.

Building new Added Value Services

One of the particularities of smart cities is the need to incentivize citizens to adopt smarter ways of living and interacting within and with the city. Citizens should also no longer be the users of city services, but also the providers and developers of smart city solutions. The need to integrate citizens into the process of shaping the city means that smart cities cannot be built by decree, but need to naturally grow into the urban fabric. Many of the solutions need the active participation of city dwellers as users, consumers, service providers and de facto voters. This may not be through ballot boxes, but can also take place through their own actions, by adopting new forms of living and working. The need to factor in citizen behavior places city authorities in front of a daunting challenge. First and foremost, the authorities need to develop a strategy, which takes into account the needs, objectives and the long-term development scenarios of the city.

3.2.2 Recommendations

The previous section listed the criteria that would be recommendable to analyze in order to evaluate the potential value of the use-cases proposed for a project. The evaluation phase should define and follow a methodology in order to do a correct evaluation of the criteria.

Once the criteria have been identified it would be recommendable to assign a weight (ex: from 0 to 3) for each one regarding how the use-case meets the expectation in order to easily visualize and interpret the results. It is also appropriate to use the same scale of weights for all criteria, although they belong to different categories. This should ensure the overall consistency of results and will lead to a better and more complete interpretation of them (for instance this recommendation would allow to order the sub-criteria with reference to the punctuation, and compare criteria of different categories in order to see if there are major differences between them).

It is also important to consider the specific scope of the project and use-case it is going to be evaluated within. Different projects cover different fields and activities and on the evaluation phase it is allowed to add more criteria in order to fulfill the different aspects that would be evaluated.

Regarding the economic evaluation it should include the economic, social and environmental sustainability. In order to focus only on the economic part three main recommendations should be followed:

- Strict definition of what is going to be evaluated: This is a crucial question when doing almost any kind of evaluation. Knowing what exactly is going to be assessed allows asking the correct questions covering all the scope during the evaluation.
- Related to the first point, it is also important to define the group of people whom will address the evaluation, if any. A part of the project partners, many times the evaluation involves people from public administrations, citizens, etc. Having this information clear, it is possible to adjust the scope of the evaluation and the contents to be evaluated. And it also allows accommodating the way in which these evaluations should be made.
- Comparison between the current state and the state after applying the technology: It is crucial to know the current state of what is going to be evaluated and also to have reliable predictions of what is going to be achieved, or which the resulting benefits are. This allows comparing the benefits that can be achieved.

3.3 Deploy

In this section different strategies, methods and tools for evaluating VAS are described. Depending on the VAS to be evaluated some of these methods will more suitable than others. Apart from the nature of the data, it is also necessary to consider how these data are handled and generated by the tools, especially considering the legal restrictions.

3.3.1 Methods for evaluation

Designing the methods to be used for the evaluation may seem daunting, however it need not be complicated or challenging. It is important that the methods and tools used are appropriate for the evaluation questions. The approach to be taken will be determined by the aims and objectives of your evaluation.

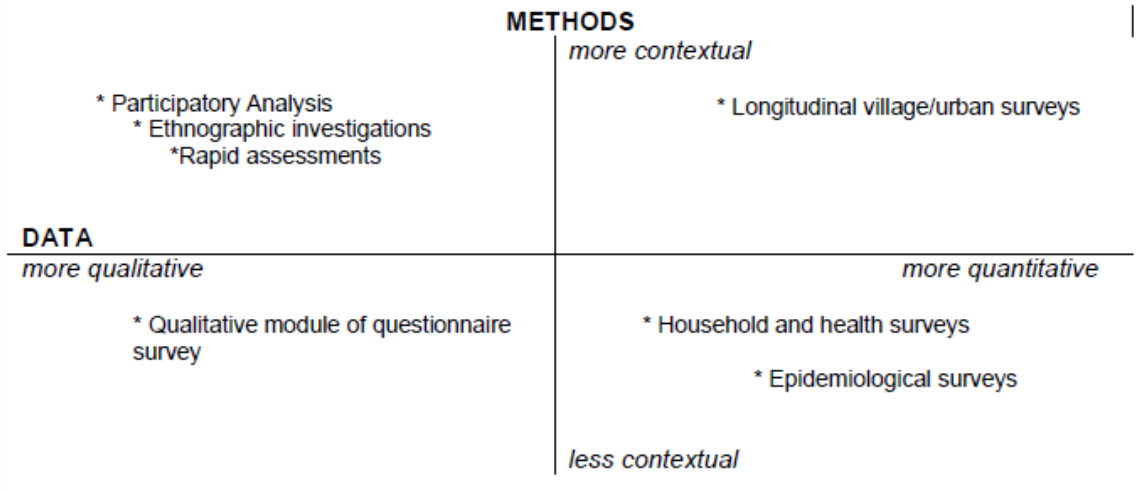
Quantitative and qualitative methods represent different ways data can be collected and used to inform your evaluation.

- Quantitative approaches give numerical results. For example, the percentage of participants using electric cycles in the city. Quantitative methods are most often used to assess a project's outcome.
- Qualitative approaches use narrative or descriptive data rather than numbers. For example, a description of the views and attitudes of those using electric cars and their thoughts on how it could be improved. Qualitative methods are most often used in a formative evaluation to aid a project's planning stage and when assessing participants' needs.

Both qualitative and quantitative methods can be appropriately used alone or in combination in evaluation. For example, when it is needed to evaluate diverse or complex aspects of the service it may better to use multiple methods within the evaluation. It is crucial that the method chosen measures what it is intended to and answers the question asked.

3.3.1.1 Quantitative and qualitative research

The terms 'qualitative' and 'quantitative' should refer to the type of data generated in the research process. Quantitative research produces data in the form of numbers while qualitative research tends to produce data that are stated in prose or textual forms. In order to produce different types of data, qualitative and quantitative research tend to employ different methods. Typically, the random sample survey produces quantifiable data that can be statistically analyzed with the main aim of measuring, aggregating, modelling and predicting behavior and relations. Contextual methods in contrast are applied to a specific locality, case or social setting and sacrifice breadth of population coverage and statistical generalizability in order to explore issues in depth. Contextual research includes ethnographic techniques, such as participant observation, interviews and participatory tools that are often group-based and visual. Using open-ended questions these methods are designed to capture judgements and perceptions and allow complex analyses of often non-quantifiable cause-and-effect processes.



In common with qualitative research, participatory research tends to employ more contextual methods and elicit more qualitative and interpretive information, but brings an important additional commitment to respect local knowledge and facilitate local ownership and control of data generation and analysis. This aspect of ownership and control in participatory research is intended to provide space for locals to establish their own analytical framework. In contrast to the individualized observation and discussions in much qualitative investigation, participatory research focuses on public and collective reflection and action. At its most extractive, participatory research simply uses a suite of participatory methods to improve outsiders' understanding of local context.

Participatory methods generate both qualitative and quantitative data. 'Participatory numbers' can be generated and used in context, but have also been taken to scale, most notably through participatory surveys or through aggregation of group-based scoring and ranking activities. Participatory methods can be quick and efficient, producing data in a timely fashion for evidence-based analysis and action. One key requirement, however, is to produce results from a sufficiently large sample for national level inference and analysis. This can imply working in a larger number of research sites than is usually the case with participatory research.

3.3.1.2 Qualitative methods

Qualitative evaluation uses a wide range of standard social research methods (i.e. ways of collecting data) and an ever-increasing number of innovative qualitative social research methods including:

- Open-ended questions in structured questionnaires
- Semi-structured and in-depth interviews with key informants
- Group interviews (essentially interviews with several people at the same time)
- Focus groups (groups discussions that are actively facilitated to focus on specific topics and where the discussion in the group is an important part of the process)

- Workshops, often with table-based or group exercises, including variants such as World Café
- Role plays and games

- Expert panels, citizen's juries and other deliberative methods
- Document analysis (i.e. analyzing all available documents, photos, letters, emails, and other outputs of the activities associated with an added value service.
- Go-along interviews, in situ interviewing, shadowing (where the researcher/interviewer follows the participant as they go about their normal daily business)
- Story-telling with stories either written down, audio-recorded, or video-recorded
- Photo-elicitation (photovoice) and other visual 'triggering' techniques to stimulate participants to recall and articulate their thoughts and/or stories about certain topics
- Mental models, mind maps, and mud maps (i.e. a representational diagram showing the interconnections between related concept)
- Participant diaries, logbooks and audio or visual recordings of reflections/comments as soon after they happen as practical
- Observation (sometimes aided by video recording)
- Participant observation and other experiential techniques
- Researcher diarizing (systematically recording notes in a field notebook)

There is a wide range of methodologies (ways of organizing data) and frameworks for thinking about information. There are also numerous theoretical frameworks (ways of interpreting data). In general, however, irrespective of the methodology or theoretical framework applied, the above techniques for collecting data tend to be utilized. In social research, especially in qualitative methods, partly as a quality-control mechanism, the use of multiple methods is common (also called 'mixed methods' especially when in conjunction with quantitative methods), and is methodologically preferred on the basis of a concept called 'triangulation' – that different methods should be used, with different sources of data, and from different perspectives.

It should be noted that there are many approaches that combine theoretical understandings, methodologies and specific techniques into holistic and coherent frameworks that are suitable for particular situations. Many of the tools/methods used in these approaches can be very creative, which makes the construction of a comprehensive list of methods quite difficult.

Sample size is a quantitative concept. In qualitative research there is concern about the veracity of statements made, and there is discussion about the robustness of analysis and interpretation. However, the justification of the robustness of the research is not drawn from statistical notions of significance drawn from probability calculations. Typically, in qualitative research small numbers of people are included with interviews being conducted until 'saturation' is reached. People are typically selected purposively (deliberately) for their particular characteristics rather than randomly.

3.3.1.3 Quantitative methods

Quantitative methods use numbers for interpreting data and are distinguished by emphasis on numbers, measurement, experimental design, and statistical analysis. Large numbers of cases may be analyzed using quantitative design, and this type of design is deductive in

nature, often stemming from a preconceived hypothesis. The potential to generalize results to a broader audience and situations make this type of research/assessment design popular with many. Although assessment can be carried out with the rigor of traditional research, including a hypothesis and results that are statistically significant, this is not a necessary component of programmatic outcomes-based assessment. It is not essential to have a certain sample size unless the scope of your assessment is on the institutional level.

A traditionally favored type of research design that has influenced outcomes-based assessment methodology is quantitative assessment. Quantitative assessment offers a myriad of data collection tools including structured interviews, questionnaires, and tests. It is important when engaging in quantitative methodological design, sampling, analysis, and interpretation to ensure that those individuals involved are knowledgeable about.
Quantification involves developing and/or applying indicators or indexes that measure changes in qualitative impacts, including both perception scoring data and observable changes in behavior. These indicators will allow for measurement and aggregation of non-material and often complex multi-dimensional impacts.

The indicators can be collected in different ways. One efficient method is to develop a qualitative module to add to an existing longitudinal survey instrument that is being applied to a relatively large sample of the targeted population and, where required, to a comparator population. An alternative method is to use contextual methods in a random stratified sample of sites to generate and aggregate indicator data on qualitative impacts.

3.3.1.4 Mixed methods

The term “mixed methods” refers to an emergent methodology of research that advances the systematic integration, or “mixing,” of quantitative and qualitative data within a single investigation or sustained program of inquiry. The basic premise of this methodology is that such integration permits a more complete and synergistic utilization of data than do separate quantitative and qualitative data collection and analysis.

Mixed methods research originated in the social sciences and has recently expanded to multiple domains and studies. In the last decade, its procedures have been developed and refined to suit a wide variety of research questions. These procedures include advancing rigor, offering alternative mixed methods designs, specifying a shorthand notation system for describing the designs to increase communication across fields, visualizing procedures through diagrams, noting research questions that can particularly benefit from integration, and developing rationales for conducting various forms of mixed methods studies.

The core characteristics of a well-designed mixed methods study include the following[10]:

- Collecting and analyzing both quantitative and qualitative data.
- Using rigorous procedures in collecting and analyzing data appropriate to each method’s tradition, such as ensuring the appropriate sample size for quantitative and qualitative analysis.
- Integrating the data during data collection, analysis, or discussion.
- Using procedures that implement qualitative and quantitative components either concurrently or sequentially, with the same sample or with different samples.

[10] https://pcmh.ahrq.gov/page/mixed-methods-integrating-quantitative-and-qualitative-data-collection-and-analysis-while

These are five primary mixed methods[11]:

Validate findings using quantitative and qualitative data sources. Evaluators can use a *convergent design* to compare findings from qualitative and quantitative data sources. It involves collecting both types of data at roughly the same time; assessing information using parallel constructs for both types of data; separately analyzing both types of data; and comparing results through procedures such as a side-by-side comparison in a discussion, transforming the qualitative data set into quantitative scores, or jointly displaying both forms of data.

Use qualitative data to explore quantitative findings. This explanatory sequential design typically involves two phases: (1) an initial quantitative instrument phase, followed by (2) a qualitative data collection phase, in which the qualitative phase builds directly on the results from the quantitative phase. In this way, the quantitative results are explained in more detail through the qualitative data.

Develop survey instruments. This exploratory sequential design involves first collecting qualitative exploratory data, analyzing the information, and using the findings to develop an instrument well adapted to the sample under study. This instrument is then, in turn, administered to a sample of a population.

Use qualitative data to augment a quantitative outcomes study. Within this type of an outcomes study, the researcher collects and analyzes both quantitative and qualitative data. The qualitative data can be incorporated into the study at the outset during the intervention and after the intervention.

Involve community-based stakeholders. A community-based participatory approach is an example of a multiphase design. This advanced mixed methods approach involves community participants in many quantitative and qualitative phases of research to bring about change.

3.3.2 Security framework for data and control access

The VAS generally is not a single-use, single-ownership solution. The devices and the CIOP platform on which data may be consumed and shared could have different ownership, policy, managerial and connectivity domains. Consequently, devices will be required to have equal and open access to a number of data consumers and controllers concurrently, while still retaining privacy and exclusivity of data where that is required between those consumers. Information availability while providing data isolation between common customers is critical. The appropriate identity controls have to build trust relationships between entities to share the right information.

There are seemingly competing, complex security requirements to be deployed on a platform with potentially limited resources:

- Authenticate for different point of access
- Ensure that data is available for multiple requests and consumes
- Manage the contention between that data access

[11] https://pcmh.ahrq.gov/page/mixed-methods-integrating-quantitative-and-qualitative-data-collection-and-analysis-while

- Manage privacy concerns between multiple consumers
- Provide strong authentication and data protection (integrity and confidentiality) that are not easily compromised
- Maintain availability of the data for each VAS
- Allow for evolution in the face of unknown risks

These issues have particular relevance in the CIOP platform where secure availability of data is of importance. For example, an energy process may rely on accurate and timely temperature measurement. If that endpoint is undergoing an attack, the data gathering process must somehow be made aware and the CIOP should be able to take appropriate actions in real-time, such as sourcing data from a secondary connection, or delay the information transmission. It must also be able to distinguish between loss-of-data due to an on-going attack and loss of the device due to a failure event in the sensor or the infrastructure. It might accomplish this by using learning machine techniques (for example, comparing a normal operational state to an attack state previously learned).

The CIOP can be affected by various categories of security threats including the following:

- Common worms jumping from ICT
- "Script kiddies" or others targeting residential devices: For example: Unprotected webcams stealing content.
- Organized crime: Access to intellectual property, sabotage, and espionage
- Cyber terrorism: For example, Stuxnet virus attacking traffic monitoring,

As the applications supported on the VAS affect our daily lives, whether it is in the transportation, energy, mobility or citizen verticals, it becomes imperative to ensure a secure CIOP platform. The possible attacks will continue to grow in both magnitude and sophistication. The potential impact could span from minor irritant to grave and significant damage to the infrastructure and, more importantly, to people.

Although the threats in the city platform environment might be similar to those in the traditional IT environments, the overall impact could be significantly different. That is why there are several efforts in the community to focus on threat analysis and risk assessments to gauge the impact if a security incident or a breach occurs

One of the fundamental elements in securing a city infrastructure is around device identity and mechanisms to authenticate it. Today's strong encryption and authentication schemes are based on cryptographic suites such as Advanced Encryption Suite (AES) for confidential data transport, Rivest-Shamir-Adleman (RSA) for digital signatures and key transport and Diffie-Hellman (DH) for key negotiations and management. Consequently, authentication and authorization will require appropriate re-engineering to accommodate our new connected city and world.

Other elements in security that could be considered include the following:

- Application of geographic location and privacy levels to data
- Strong identities
- Strengthening of other network-centric methods such as the Domain Name System (DNS) with DNSSEC and the DHCP to prevent attacks

Many of the security considerations rely on encryption. For example, an energy meter may last fifty years, whereas the encryption protocol might only survive half that time before it is compromised.

3.3.2.1 Authentication

At the heart of access to VAS is the authentication layer, used to provide and verify the identify information for accessing from an added value service. The way to store and present identity information may be substantially different for different VAS. Some may be identified by a human credential (e.g., username and password, token or biometrics). However, the challenges of the new form factors, as well as new modalities, create the opportunity for further research in defining smaller footprint credential types and less compute-intensive cryptographic constructs and authentication protocols.

3.3.2.2 Authorization

The second layer of this framework is authorization that controls a device's access throughout the network fabric. This layer builds upon the core authentication layer by leveraging the identity information of an entity. With authentication and authorization components, a trust relationship is established between IoT devices to exchange appropriate information. For example, a car may establish a trust alliance with another car from the same vendor. That trust relationship, however, may only allow cars to exchange their safety capabilities. When a trusted alliance is established between the same car and its dealer's network, the car may be allowed to share additional information such as its odometer reading, last maintenance record, etc.

Fortunately, current policy mechanisms to both manage and control access to consumer and enterprise networks map extremely well to the IoT/M2M needs. The big challenge will be to build an architecture that can scale to handle billions of IoT/M2M devices with varying trust relationships in the fabric. Traffic policies and appropriate controls will be applied throughout the network to segment data traffic and establish end-to-end communication.

By using some real statistical analysis on the security data it will be possible to pick out some anomalies. Further, by including all elements that aggregate and correlate the information it is possible to use it for reconnaissance and threat detection. Threat mitigation could vary from automatically shutting down the attacker from accessing further resources to running specialized scripts to initiate proper remediation. The data, generated by the IoT devices, is only valuable if the right analytics algorithms or other security intelligence processes are defined to identify the threat. We can get better analytical outcome by collecting data from multiple sources and applying security profiles and statistical models that are built upon various layers of security algorithms.

Network infrastructures are becoming more complex. Imagine topologies with both public and private clouds; the threat intelligence and defense capabilities must also be cloud-based. Orchestration of the visibility, context and control is required to drive accurate intelligence. The components within this layer include the following:

- The actual IoT/M2M infrastructure from which telemetry and reconnaissance data is acquired and gathered

- The core set of functions to coalesce, analyze the data for the purposes of providing visibility, and provide contextual-awareness and control
- The delivery platform for the actual analytics, built from the first two components, discussed above

While the actual IoT/M2M implementations may be different, the framework can be applied to any architecture. The framework is simple and flexible enough to service manned devices as well (e.g., laptops, handheld scanners, etc.) if they reside in the IoT infrastructure.

Can you have an architecture that provides 100 percent protection from threats by leveraging this framework? Unfortunately not. However, we do believe that big data and analytics platforms will play a key role. Security threats are continuously emerging and requires the development of an architecture that can defend itself against those threats. This security framework provides the foundation from which appropriate security services can be selected. As specific contexts and verticals are considered, gaps can also be identified and addressed.

3.3.3 Privacy

Preservation of privacy has been a concern since the dawn of the Internet. IoT and the proliferation of new devices, systems and smartphones will exacerbate the problem because many applications generate traceable signatures of the location and behavior of the individuals. Privacy issues are particularly relevant in healthcare, and there are many interesting healthcare applications. In this environment, it is essential to verify device ownership and the owner's identity while decoupling the device from the owner. Shadowing is a mechanism that has been proposed to achieve this. In essence, digital shadows enable the user's objects to act on her behalf, storing just a virtual identity that contains information about her attributes.

Identity management may offer new opportunities to increase security by combining diverse authentication methods for humans and machines. For example, bio-identification combined with a smartphone could be used to open a door.

Privacy and compliance are intertwined and are under the purview of country regulation. As the technology is evolving so quickly, the consumer must be cognizant of how these issues apply to his or her daily life.

Security framework to be deployed

To address the highly diverse VAS and the related security challenges, a flexible security framework is required with the following mechanism implemented:

- Authentication
- Authorization
- Network Enforced Policy
- Secure Analytics: Visibility and Control

3.3.4 Legal framework of the data

The legal considerations about the protection of the data have to be assimilated from one single source that will apply for the whole European Union (EU) countries and the organizations operating inside them.

GDPR as main legal framework in Europe

During four years of development, the GDPR (General Data Protection Regulation) was matured and adjusted until the 14 April 2016 when it was approved by the EU Parliament, and was done official 20 days after its release in the EU Official Journal. Two years after, 25 May 2018, the GDPR will become mandatory for all the member states, and consequently all non-compliances by the affected organizations will have to face large fines.

This GDPR will be the replacement form the Data Protection Directive 95/46/EC, and was created to harmonize data privacy laws across Europe, protecting and empowering the EU citizen data privacy and forcing a change on the approach in data privacy for the different organizations across the region.

Evolution of the GDPR in respect with former directive

As the title suggest, the main difference from the previous directive 95/46/EC is that the GDPR is a regulation and not a normative, and consequently the application in all cases inside the EU is mandatory, and not only a goal to be achieved by each EU member.

Now the norm applies to all companies, with roles of data processor or data controller.

The territorial scope has been increased, and now the regulation applies to all companies processing data of subjects residing in the EU, independently from the location of the company.

The fines for breaching the norms have been adjusted, and can be as high as 4% of the total global turnover or 20M € (the higher). The fines are scaled based on the severity of the fail.

The conditions for consent have been reinforced for the sake of clarity and intelligibility of the legal terms and conditions, and also making easy the processes of withdrawal.

Concerning the data subject rights, the changes are the following:

- Breach notification. They should be done within 72 hours after the breach. The data processors should also notify the customers, and the data controllers have to do it after becoming aware of the data breach.
- Right to access. The data subjects now have the right to get, from the data controller, confirmation that the data is being processed and the purpose of that process. Moreover, the subjects have the right to request a copy of these personal data in electronic format, free of charge.
- Right to be forgotten. The data subject has the right to oblige the data controller to erase the data, cease dissemination and halt processing of the data from third parties. This right has to be compared to the “public interest” issue in case of conflict.
- Data portability. The data user, once he has received his personal data in a legible digital format from one controller, can send them to another one.
- Data protection officers (DPO). In case of having a systematic monitoring of data subjects on a large scale or of special categories that might include things like

criminal convictions and offences, the controller should have a DPO who will have some defined features and tasks: he must be appointed on the basis of professional qualities and, in particular, expert knowledge on data protection law and practices, he may be a staff member or an external service provider, the contact details must be provided to the relevant DPA, he must be provided with appropriate resources to carry out their tasks and maintain their expert knowledge, he must report directly to the highest level of management and finally he must not carry out any other tasks that could result in a conflict of interest.

GDPR main details

The document itself consists of 99 articles grouped into 11 chapters. Within the 261 pages the evolution of the normative into the regulation takes final form, comprising the protection issues they have been previously addressed. As a summary of the document, the content of the chapters, pointing out the articles that could affect the development of the current project, is the following:

Chapter 1. General provisions.

(Pages 109-117). The articles indicate the subjects and data out of scope from the regulation, and the definitions for the items that are handled in the document.

Chapter 2. Principles.

(Pages 118-129). The articles include how the personal data has to be basically processed (Article 5), the conditions in which these data are considered lawful (Article 6), and conditions of consent on diverse data (general, children, special data or criminal records). It is also indicated that processing without identification can be out for application of certain articles of the regulation.

Chapter 3. Rights of the data subject

(Pages 130-150) The first section includes articles about the transparency and modalities for the exercise of the rights for the data subject. The second section is about the information available about the data subject, in cases when the data have been taken from the subject and from external sources and the right of access by the data subject. Section three specifies the rectification and erasure issues, restriction in processing and data portability. Section four includes the rights to object and profiling. Section five includes the restrictions to safeguard the Union member security, judicial independence, regulations and similar.

Chapter 4. Controller and processor.

(Pages 151-186) The section one is about the definition of controller and processor, and cover concepts like the data protection by design and by default, joint controllers, representatives of both subjects outside of the Union, processing and record of the processing activities. The second section is about security of personal data, including also data breach notifications. Section three explains the assessment of data impact and prior consultation issues to the supervisory authority. Section four covers the DPO features, including designation, position and tasks associated. Section five specifies the codes of conduct and their monitoring, certification and certification bodies.

Chapter 5. Transfer of personal data to third countries of international organizations.

(Pages 186-199) The content of these articles include some topics in transference of data, appropriate safeguards, corporate rules, transfers not authorized by the Union law and derogations in specific situations, as well as cooperation for the protection of data.

Chapter 6. Independent Supervisory Authorities.

(Pages 200-214) The first section describes the independent status for supervision authorities, the independence and general conditions of them, and also their rules of establishment. The second section describes the competence, the tasks and powers recognized to the supervisors, and the reports of the activities.

Chapter 7. Cooperation and Consistency.

(Pages 214-239) The chapter contains three sections. Section one describes the cooperation between supervisors, mutual assistance and joint operations. Section two gathers the articles related to the consistency of the regulation considering the cooperation between the supervisory authorities, including dispute resolutions, urgency procedures and exchange of information. And finally, section three includes everything related to the European Data Protection Board: definition, tasks, reports, procedures, staff and confidentiality.

Chapter 8. Remedies, Liability, and Sanctions.

(Pages 239-249) The chapter contains several rights specified, like the complaints to superior authorities, judicial remedies against supervisors, controllers or processors, representation of data subjects, compensation and liability, and also contains conditions for the administrative fines and penalties.

Chapter 9. Provisions relating to specific data processing situations.

(Pages 250-255) The chapter covers certain single cases like the freedom of expression, official documents, national identification numbers, employment processes, public interest, scientific or historic research, secrecy for member States and data from religious associations.

Chapter 10. Delegated Acts and Implementing Acts.

(Pages 256-257). The chapter has two articles, for delegation exercises and committee procedures.

Chapter 11. Final provisions.

(Pages 258-261) Contains the articles about the legal relations and repeals of directives directly related to the new regulation and commission reports.

Making an exercise of extraction of the articles that might affect directly the development of the project activities, the ones included in chapter 2, 3 and 4 have to be mainly considered. As a brief selection, here are some especially relevant articles:

Article 5. Principles relating to processing of personal data. Point 1. (b).

Personal data shall be collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, in accordance with Article 89(1), not be considered to be incompatible with the initial purposes ('purpose limitation');

Article 5. Principles relating to processing of personal data. Point 1. (c).

Personal data shall be adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed ('data minimization');

Article 5. Principles relating to processing of personal data. Point 1. (e).

Personal data shall be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed; personal data may be stored for longer periods insofar as the personal data will be processed solely for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) subject to implementation of the appropriate technical and organizational measures required by this Regulation in order to safeguard the rights and freedoms of the data subject ('storage limitation');

Article 5. Principles relating to processing of personal data. Point 1. (f).

Personal data shall be processed in a manner that ensures appropriate security of the personal data, including protection against unauthorized or unlawful processing and against accidental loss, destruction or damage, using appropriate technical or organizational measures ('integrity and confidentiality').

Article 7. Conditions for consent. Point 1.

Where processing is based on consent, the controller shall be able to demonstrate that the data subject has consented to processing of his or her personal data.

Article 7. Conditions for consent. Point 2.

If the data subject's consent is given in the context of a written declaration which also concerns other matters, the request for consent shall be presented in a manner which is clearly distinguishable from the other matters, in an intelligible and easily accessible form, using clear and plain language. Any part of such a declaration which constitutes an infringement of this Regulation shall not be binding.

Article 7. Conditions for consent. Point 3.

The data subject shall have the right to withdraw his or her consent at any time. The withdrawal of consent shall not affect the lawfulness of processing based on consent before its withdrawal. Prior to giving consent, the data subject shall be informed thereof. It shall be as easy to withdraw consent as to give it.

Article 7. Conditions for consent. Point 4.

When assessing whether consent is freely given, utmost account shall be taken of whether, inter alia, the performance of a contract, including the provision of a service, is conditional on consent to the processing of personal data that is not necessary for the performance of that contract.

Article 11 Processing which does not require identification. Point 1.

If the purposes for which a controller processes personal data do not or do no longer require the identification of a data subject by the controller, the controller shall not be obliged to maintain, acquire or process additional information in order to identify the data subject for the sole purpose of complying with this Regulation.

Article 13. Information to be provided where personal data are collected from the data subject. Point 1.

Where personal data relating to a data subject are collected from the data subject, the controller shall, at the time when personal data are obtained, provide the data subject with all of the following information:

(a) the identity and the contact details of the controller and, where applicable, of the controller's representative;

(b) the contact details of the data protection officer, where applicable;

(c) the purposes of the processing for which the personal data are intended as well as the legal basis for the processing;

(d) where the processing is based on point (f) of Article 6(1), the legitimate interests pursued by the controller or by a third party;

(e) the recipients or categories of recipients of the personal data, if any;

(f) where applicable, the fact that the controller intends to transfer personal data to a third country or international organization and the existence or absence of an adequacy decision by the Commission, or in the case of transfers referred to in Article 46 or 47, or the second subparagraph of Article 49(1), reference to the appropriate or suitable safeguards and the means by which to obtain a copy of them or where they have been made available.

Article 14 Information to be provided where personal data have not been obtained from the data subject. Point 1.

Where personal data have not been obtained from the data subject, the controller shall provide the data subject with the following information:

(a) the identity and the contact details of the controller and, if any, of the controller's representative;

(b) the contact details of the data protection officer, where applicable;

(c) the purposes of the processing for which the personal data are intended as well as the legal basis for the processing;

(d) the categories of personal data concerned;

(e) the recipients or categories of recipients of the personal data, where applicable;

(f) where applicable, that the controller intends to transfer personal data to a recipient in a third country or international organization and the existence or absence of an adequacy decision by the Commission, or in the case of transfers referred to in Article 46 or 47, or the second subparagraph of Article 49(1), reference to the appropriate or suitable safeguards and the means to obtain a copy of them or where they have been made available.

Article 17. Right to erasure ('right to be forgotten'). Point 2.

Where the controller has made the personal data public and is obliged pursuant to paragraph 1 to erase the personal data, the controller, taking account of available technology and the cost of implementation, shall take reasonable steps, including technical measures, to inform controllers which are processing the personal data that the data subject has requested the erasure by such controllers of any links to, or copy or replication of, those personal data.

Article 24. Responsibility of the controller. Point 1.

Taking into account the nature, scope, context and purposes of processing as well as the risks of varying likelihood and severity for the rights and freedoms of natural persons, the controller shall implement appropriate technical and organizational measures to ensure and to be able to demonstrate that processing is performed in accordance with this Regulation. Those measures shall be reviewed and updated where necessary.

Article 24. Responsibility of the controller. Point 2.

Where proportionate in relation to processing activities, the measures referred to in paragraph 1 shall include the implementation of appropriate data protection policies by the controller.

Article 25. Data protection by design and by default. Point 1.

Taking into account the state of the art, the cost of implementation and the nature, scope, context and purposes of processing as well as the risks of varying likelihood and severity for rights and freedoms of natural persons posed by the processing, the controller shall, both at the time of the determination of the means for processing and at the time of the processing itself, implement appropriate technical and organizational measures, such as pseudonymization, which are designed to implement data-protection principles, such as data minimization, in an effective manner and to integrate the necessary safeguards into the processing in order to meet the requirements of this Regulation and protect the rights of data subjects.

Article 25. Data protection by design and by default. Point 2.

The controller shall implement appropriate technical and organizational measures for ensuring that, by default, only personal data which are necessary for each specific purpose of the processing are processed. That obligation applies to the amount of personal data collected, the extent of their processing, the period of their storage and their accessibility. In particular, such measures shall ensure that by default personal data are not made accessible without the individual's intervention to an indefinite number of natural persons.

Article 25. Data protection by design and by default. Point 3.

An approved certification mechanism pursuant to Article 42 may be used as an element to demonstrate compliance with the requirements set out in paragraphs 1 and 2 of this Article.

Article 26 Joint controllers. Point 1.

Where two or more controllers jointly determine the purposes and means of processing, they shall be joint controllers. They shall in a transparent manner determine their respective responsibilities for compliance with the obligations under this Regulation, in particular as regards the exercising of the rights of the data subject and their respective duties to provide the information referred to in Articles 13 and 14, by means of an arrangement between them unless, and in so far as, the respective responsibilities of the controllers are determined by Union or Member State law to which the controllers are subject. The arrangement may designate a contact point for data subjects.

Article 28. Processor. Point 1.

Where processing is to be carried out on behalf of a controller, the controller shall use only processors providing sufficient guarantees to implement appropriate technical and organizational measures in such a manner that processing will meet the requirements of this Regulation and ensure the protection of the rights of the data subject.

Article 30 Records of processing activities. Point 1.

Each controller and, where applicable, the controller's representative, shall maintain a record of processing activities under its responsibility. That record shall contain all of the following information:

(a) the name and contact details of the controller and, where applicable, the joint controller, the controller's representative and the data protection officer;

(b) the purposes of the processing;

(c) a description of the categories of data subjects and of the categories of personal data;

(d) the categories of recipients to whom the personal data have been or will be disclosed including recipients in third countries or international organizations;

(e) where applicable, transfers of personal data to a third country or an international organization, including the identification of that third country or international organization and, in the case of transfers referred to in the second subparagraph of Article 49(1), the documentation of appropriate safeguards;

(f) where possible, the envisaged time limits for erasure of the different categories of data;

(g) where possible, a general description of the technical and organizational security measures referred to in Article 32(1).

Article 30 Records of processing activities. Point 2.

Each processor and, where applicable, the processor's representative shall maintain a record of all categories of processing activities carried out on behalf of a controller, containing:

(a) the name and contact details of the processor or processors and of each controller on behalf of which the processor is acting, and, where applicable, of the controller's or the processor's representative, and the data protection officer;

(b) the categories of processing carried out on behalf of each controller;

(c) where applicable, transfers of personal data to a third country or an international organization, including the identification of that third country or international organization and, in the case of transfers referred to in the second subparagraph of Article 49(1), the documentation of appropriate safeguards;

(d) where possible, a general description of the technical and organizational security measures referred to in Article 32(1).

Article 32 Security of processing. Point 1.

Taking into account the state of the art, the costs of implementation and the nature, scope, context and purposes of processing as well as the risk of varying likelihood and severity for the rights and freedoms of natural persons, the controller and the processor shall implement appropriate technical and organizational measures to ensure a level of security appropriate to the risk, including inter alia as appropriate:

(a) the pseudonymization and encryption of personal data;

(b) the ability to ensure the ongoing confidentiality, integrity, availability and resilience of processing systems and services;

(c) the ability to restore the availability and access to personal data in a timely manner in the event of a physical or technical incident;

(d) a process for regularly testing, assessing and evaluating the effectiveness of technical and organizational measures for ensuring the security of the processing.

Finally, of special interest is the article 89, *Safeguards and derogations relating to processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes*, due to the nature of a European project inside the framework given by the Horizon 2020. It indicates that although some articles can be derogated by the purpose of the work (15, 16, 18 and 21), the core of the regulation still applies and has to be considered. These derogations apply mainly upon certain rights to cease the processing activity of personal data, rectification of data and access by the data subject.

Apart from that, it has to be evaluated if a DPO is necessary for the project (internal or external), and also to define the controllers and processors of data among the partners that will be gathering, handling, storing or showing data that could be the object of regulation inside the GDPR. The measures to be taken about the DPO can be found in Chapter 4, Section 4, articles 37, 38 and 39.

For more and detailed info, the entire regulation can be accessed (in pdf format) in the following location, provided by the Council of the European Union: http://data.consilium.europa.eu/doc/document/ST-5419-2016-INIT/en/pdf

3.4 Validation

Validation phase involves the way the results are validated after the correct deployment of all technologies and tools. Once the implemented system has been functional for a period of time it is possible to evaluate whether the system meets the specifications planned. In other words it has to be compared what is achieved in agreement to what was programmed.

Although the correct deployment of the KPI's implies the existence of a VAS, it also has to be taken into account that potentially another VAS may appear that was not predicted at the beginning. The analysis of this new VAS implies to all actors participating on the project a valuable knowledge that enforces their expertise.

Projects have different types of partnerships including private, public and research. All of them have usual KPIs that are related to the nature of the partner. These partners expect the VAS to be confirmed in order to satisfy its needs.

Usually, different partners scope leads to different KPI's or interests for VAS.

Private Sector Partners

Besides the financial aspects of a private company, it is also important to mention additional types of expertise that are positive and beneficial for them.

- The new or additional business opportunities for the development of the company
- Acquisition integration
- Connection of different companies and clients for future business
- Extend market penetration
- Discovering talents

In this way, the validations of the KPI's that are related to their interests prove that these VAS are accomplished and the private companies could rely on them.

Public Sector Partners

For public administrations which focus on the citizen the most significant VAS to validate would be those related to social welfare. By doing the validation exercise, the administrations can demonstrate that they are aware of the citizen's well-being and quality of life. It may also contribute to improve the general social behavior. Public administrations should improve the information access to the citizens, increase the information dissemination and also improve the citizen engagement.

Although public sector partners should work for people, it has to be done without ignoring the economic impact of their actions. A validated improvement of the public budget leads to both, economic and social growth. The impacts of this could be:

- Increasing democratic participation
- Promoting greater accountability

- Improve social cohesion
- Generating environmental benefits
- Identifying previously unknown links between different policy areas

Research Partners

In the research sector, the validation of a successful VAS is key to confirm that the work is done and it presents results that can be studied and interpreted and after presented in a conference, research paper or journals.

The benefits of the study of the validated results for a research partners can be mainly expressed as:

- Career progression
- Contribution to the community
- Enhancement of technical writing skills and knowledge
- Connection to other institutions

It has to be noted, that the process of writing a research paper, in most cases implies the process of the validation of VAS itself, so it also can be considered a tool for validation.

In the early stages of the projects, it is usual to be optimistic about the outputs that can be achieved and the VAS these outputs will carry. Although these objectives must be monitored on the different phases of the projects, sometimes there is a misalignment with the original planning. In previous paragraphs, it has been indicated the main outcomes when it is confirmed a successful validation of a VAS regarding the KPIs established at the beginning of any project. However, another important issue is to predict the deviation management topics in case the KPI's do not match the predictions

3.4.1 Technology and Tools

In this section the different technologies and tools that are suitable to validate the VAS defined during the project are analyzed. As stated in previous sections, the validation of the VAS should be done after the deployment phase when the system is functional during a period of time. After the validation, it should be possible to conclude if the VAS has been correctly implemented or not. So the validation phase allows concluding and ratifying the final state of the project regarding the VAS.

When it comes to carry out the validation processes, methods, technologies and tools that can be mentioned will be strongly dependent on the scope of the project, and also will rely on the participant partner's background. In any case, there are general guidelines to follow when doing a validation process.

Interviews

Interviews allow gathering a wide range of data. Doing interviews is a time consuming duty and requires significant resources but may can come up with valuable results regarding the participant experience, satisfaction level and problem solving. .

Depending on the project and also depending to the VAS to be validated, the interviews can have different target people:

- **Citizens:** for a project whose target are the citizens (like SmartEnCity) it is crucial to know how they feel about it. The results of citizen interviews can show if the VAS are truly successful. Even more, they can demonstrate new VAS that were not expected. Usually citizens are not experts on the system and it is not possible to expect technical or accurate answers but they can give information with high relevance for the validation of VAS.
- **Final users of a system:** There are projects that are not intended for citizens but for members of a community, private company employees, public staff… These are the final users of the system. These are the people who have been working with the system, and their opinions and experiences are fundamental to know if VAS is accepted or not.
- **Public administrations:** They should be conscious of working to improve the citizen's life, and this involves improving their quality of life and also reducing the public expenses maintaining and improving the sustainability. Interviews to public administration and workers should be oriented to validate it the system is successfully implemented and if actually covers the necessities, and which are the issues then have faced out during the process. It also has to be evaluated the general improvement of a process and the acceptability ratio from the citizens.
- **Private companies:** This involves private companies that have participated in the project, or private companies that take profit of it. Regarding the companies that have participated on the project, they would expect some VAS to be successful not only for the benefit of the final users but for their own benefit and respectability.
- **Experts:** Although the final users of a system provide very helpful information related to the level of VAS acquired, usually they are not experts. Interviewing the experts in the scope of the project can also bring other points of view that will help when validating. Their inputs can be about the improvement of a product or service, or risk reduction.
- **Focus groups:** focus groups are a small group of people with diverse backgrounds that can be asked about their opinion, feelings or experience with a new project. Due to the nature of these groups, interviews to focus groups can validate if the VAS has been equally accepted in different sectors of the society.

There are different ways to classify interviews: telephone interviews, face to face interviews, group interviews, informal conversations… Due to the different nature of these types of interviews, the results would be different. For instance, in informal conversations it is possible to obtain more information about the user's feelings, there are no predetermined questions and the interviewer should adapt the questions to the user's response. In group interviews people's opinions are more diluted than face to face ones.

As seen, there is a huge variety of interviews depending on the target, the formality, the means used or the purpose. Each project should select how best to validate the VAS defined. If the interviews are well done and complete, the results will have a great importance for validation.

Questionnaires

Questionnaires, like interviews are also a method to ask people about a particular topic. So they are used for the same purposes. The main differences between questionnaires and interviews are:

- Questionnaires consist of a series of previously written questions, and the interview process is oral. This implies that the questions on the questionnaires cannot be changed whereas questions during interviews can be reorganized and even add new ones depending on the user's responses and preferences. Therefore; questionnaires are static and interviews are dynamic.
- The nature of the questions in a questionnaire should be objective, versus interviews that are more subjective questions. This leads to closed responses obtained in questionnaires contrasting to the open ended ones on the interviews method.
- The cost of performing a questionnaire is lower and more scalable than the cost of doing an interview. The same questionnaire can be filled out for many people at the same time. But the interviews should be done one by one. Questionnaires have a lower response rates than interviews and this leads to difficulties in reaching statistical sample sizes can be difficult.

Leaving aside the differences that may be found between questionnaires and interviews, questionnaires are a good method of validation. Due to the nature of the questionnaires, the results can easily be obtained in means of percentage or quantity of responses for instance. The interpretation of these numerical results can bring the conclusions in a more quantitative approach.

In this sense and related to D7.9, questionnaires are also a powerful tool that provides information about the social acceptance of the project. In this way, a set of questionnaires will be shared to gauge the opinion of the citizens where all the aspects shall be taken into account. Among them, the usability of the technologies and the assessment of the provided services are key aspects to be considered. Hence, taking advantage of the questionnaire procedure depicted in D7.9, this evaluation will be merged within the data collection approach.

Visualization Software

Visualization software is the group of software tools that provide graphic displays and interfaces for data visualization. Within the group of visualization software there are multiple tools and software libraries that allow creating this graphical information. Some of them are focused on the creation of charts, others are focused on graphs visualization, including 3D, the following are for general purposes: DataVisual, Google Chart, D3, Tableau, ChartBlocks, PowerBI, GeoDashboard, ChartIO, Teechart, Bokeh, Spagoby… and many many more.

Using this type of software it is possible to create charts, tables or graphics that allow doing comparisons or progresses evaluations. This would be very helpful for instance regarding the validation of the VAS related to economic savings. Viewing the line plots of the expenses graphically, it is possible to analyze the overall trends, and extract conclusions from it.

Open data

Provide universal and open access to data is one of the most important VAS in many projects. It facilitates the data accessibility to the citizens, administrations, and people from public and private sectors. Transparency for an institution that it is gained with the creation of an open data platform is significant since it helps to be more accepted and recognized by the people. A comparison between the amounts of total data with the open data that is really accessible by the people could validate if the VAS of offering open data is actually accomplished.

Communications Media

Reliable communications media could also be a tool to look at when validating VAS. The results covered by media in positive way can be used as a proof of validation.

There are many types of communication media, from the classical ones; journals, television, radios or newspapers, to the ones that can also be considered like that as they carry out communication activities; conferences, meetings, education institutions, newsletters.

With the proliferation of IT technologies, internet and social networks, the way in which people communicate with others has changed tremendously. In recent years there has appeared different resources providing, in most cases real-time, information to the people, for instance, nowadays it is easy to access any kind of information from any electronic device. Due to the large number of communication media, people should be aware that not all have a high reliability. This is an issue that should be taken into account. Regarding this reliability of the communication media, validating a VAS requires a media with high reputation on the topic, in order to satisfy the quality levels or requirements for a good validation.

Benchmarking

For this section we understand the benchmarking techniques as the techniques that can be used to validate in order to compare the current status of the VAS, with the planned one, or with the previous status before the implementation.

For doing the benchmarking, first it is necessary to define what is going to be analyzed in the new system and same for the previous one. This is a very important task in order to get reliable results and interpretation of them. Here we list potential methods, technologies and tools to be used for validation

In this way, D7.3 already establishes a methodology about the evaluation of the ICT tools (in particular, section 7). The main objectives established are the assessment of the improvements in the existing urban platforms by the deployment of new services, integration of additional data (i.e. IoT sensors) and the performance of the urban platforms. Here, the difference with energy assessment lies in the baseline that cannot be properly set, apart from the status before the project. Thus, extracted from such deliverable and according to the foreseen implementations of the urban platforms, a set of indicators have been defined for each city following Table 4. These KPIs evaluate both the improvements in terms of services and new information integrated, as well as performance of the urban platforms.

City	KPIs	
Vitoria - Gasteiz	Response time	Types of measurements
	Scalability	Percentage of equipment connected
	Extensibility	Recharging points equipment connected
	Storage Capacity	Smart lighting equipment connected
	Hours of maintenance	Number of services developed
	Non-expected hours off-line	Types of services
	# of HEMS connected	Percentage of dwellings connected
	# of BEMS connected	Percentage of Buildings connected
	# of EV connected	APIs integrated
	# of mobility equipment connected	Open-Data sets available
	Total amount of data generated	
Tartu	Response time	# of mobility equipment connected
	Scalability	Total amount of data generated
	Extensibility	Recharging points equipment connected
	Storage Capacity	Smart lighting equipment connected
	Hours of maintenance	Number of services developed
	Non-expected hours off-line	Types of services
	# of HEMS connected	Percentage of dwellings connected
	# of BEMS connected	Percentage of Buildings connected
	# of EV connected	Open-Data sets available
Sonderborg	Response time	# of mobility equipment connected
	Scalability	Percentage of equipment connected
	Extensibility	Recharging points equipment connected
	Storage Capacity	Smart lighting equipment connected
	Hours of maintenance	Number of services deployed
	Operating hours	Types of services (related to society)
	# of HEMS equipment connected	Percentage of dwellings connected
	# of BEMS equipment connected	Percentage of buildings connected
	# of DEMS equipment connected	APIs integrated
	# of EV connected	

Table 4: KPIs for the ICT assessment

3.4.2 Recommendations

Recommendations when validating the VAS of a project are strongly dependent on the scope of the project. The different nature of the projects and the actors involved in them makes the process of generalization very difficult. In any case, general guidelines and recommendations should be followed in order to do a reliable validation of VAS:

- Another general advice that could be raised is that, independently of additional validations for a VAS, the process of talking with people is crucial. For instance, a dialogue with a group of citizens that are living and in most cases interacting with the system daily, can be even more beneficial than validations based on numbers. In projects like SmartEnCity that ultimately, are targeted to improve people's lives, it is important to gather feedback from them in order to assume if a VAS is correctly implemented or not.
- Related to the previous point, it is also important to consider the type of people that is going to be asked to adapt the interaction to them. It is not the same to talk with young citizens, as with senior citizens, and also regarding the background of the people with the project, etc. The interviews or questionnaires should fit the target group in order to have more relevant results.
- it has to be clear what is going to be validated. In order to do a good validation of one concrete VAS, this VAS has to be very well defined without possibility of ambiguous interpretations or misunderstandings. This also facilitates the results interpretation.
- One more recommendation could be to know the initial predictions for one determined VAS. The reason for that is to validate correctly the results comparing what you expected versus what you achieved after the project is completed.

Sometimes it is possible that a not predicted VAS comes up, when validating a different one. People involved in the process of validations, should be aware of this and have a certain "state of alert" to realize that new VAS are emerging.

4 SOTA of Value Added Services

This chapter presents the State Of The Art (SOTA) for Value Added Services in the context of SmartEnCity. The SOTA has been oriented to the objectives marked in the Description of Work and the requirements set in (SmartEnCityD6.1, 2016).

The objectives marked in the DoW consider that two types of mechanisms should be studied to be able to create added value services for solution providers and other stakeholders. 1) Solutions providers need to measure the impact of ICT solutions analyzing data and user behavior. 2) Machine learning and business intelligence (BI) techniques provide tools to perform that analysis enabling the generation of reports, dashboards and many other elements for validation.

(SmartEnCityD6.1, 2016) Further defines these two groups as follows:

Values Added Services (VAS) consist of ICT solutions that can offer suitable information and recommendations to empower citizens on decision making (e.g. in relation to home energy consumption and mobility) but also can boost the use of Urban Platforms through the connection of platforms with social networks, contributing to raise the awareness about energy consumption and launching awareness campaigns. Thus, ICT solutions and experiences that help empower people by providing them with information and recommendations should be identified.

Added value services consist of ICT solutions that also include machine learning, big data or business intelligent techniques with the aim of dealing with complex data analysis and user behavior. Thus, ICT solutions that use machine learning, big data, etc. to analyze data and behaviors should be addressed.

Another subject for study marked in the DoW is social networks. Some of the solutions selected for the project might use applications or social networks placed outside the platform. Consequently, this section dedicates a section to that subject.

Another perspective identified in (SmartEnCityD6.1, 2016) is the need to focus the SOTA to address the main verticals identified in the project:

- Energy assessment services in order to identify energy consumption patterns of different actors.
- Sustainable mobility services in order to manage public charge points and shared green vehicles.
- Citizens' engagement services in order to agile communication channel among the citizens, the municipality and the operators of the energy and sustainable transport services.

According to the needs identified in the DoW and in (SmartEnCityD6.1, 2016), the chapter is divided into three sections. The first one addresses empowerment and proposals to engage users into participation. The second section presents ICT solutions for data analysis and user behavior detection. The final section presents examples of solutions, projects and initiatives using Value Added Services. The examples are classified according to verticals identified in the project.

4.1 ICT Solutions for empowerment

4.1.1 Empowerment definition and process

The term empowerment refers to measures designed to increase the degree of autonomy and self-determination in people and in communities in order to enable them to represent their interests in a responsible and self-determined way, acting on their own authority. A good definition of the term is given by (Rappaport, 1984) “Empowerment is viewed as a process: the mechanism by which people, organizations, and communities gain mastery over their lives”. Empowerment as action refers to the process to support people in recognizing and using their resources and capabilities. That is supporting them in decision making. Empowerment forms a practical approach of resource-oriented intervention. It can be applied to many fields; citizenship education, economics, legal, gender, workplace management, etc.

According to (Conger, 1988) the empowerment process is divided into five stages. The first stage is the diagnosis of conditions. This leads to the use of empowerment strategies in Stage 2. The employment of these strategies is aimed not only at removing some of the negative external conditions, but also at providing people with self-efficacy information in Stage 3. As a result of receiving such information, people feel empowered in Stage 4, and the behavioral effects of empowerment are noticed in Stage 5.

Information is key to the process. Moreover, how that information is received is essential.

In the context of energy, the report “Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities” (Ehrhardt-Martinez, Donnelly, & Latiner, 2010) summarizes three decades worth of research on the subject of providing information. The report describes the importance of advanced metering and relevant feedback. The figure below describes five different types of feedback that is divided into indirect feedback and direct feedback.

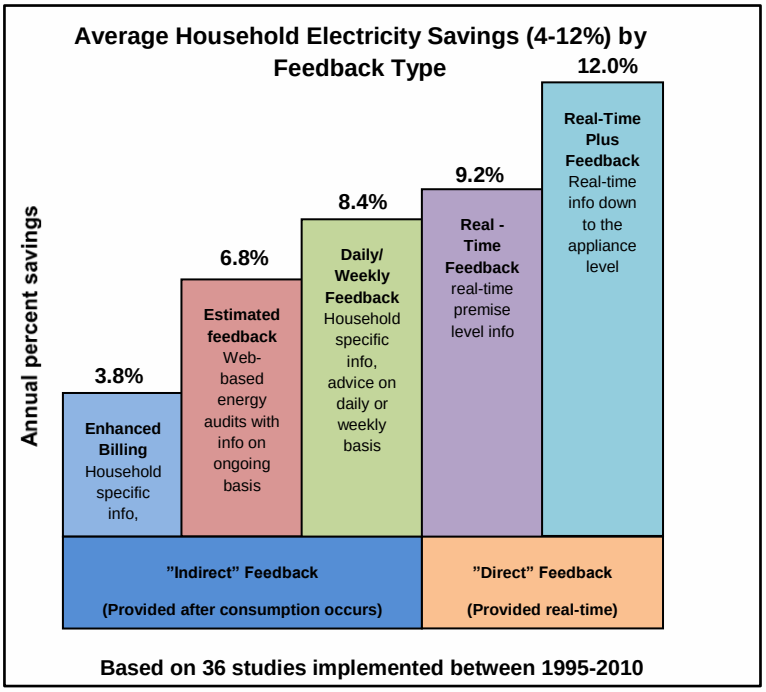


Figure 2: Evaluation of feedback methods. (Ehrhardt-Martinez, Donnelly, & Latiner, 2010)

The study suggests that "real-time feedback down to appliance level" is the most efficient way of reaching substantial energy savings. It also states that "Achieving maximum feedback-related savings will require an approach that combines useful technologies with well-designed programs that successfully inform, engage, empower, and motivate people." In addition to this feedback tips for energy saving and behavioral techniques can add to the energy saving (Amrel, 2012).

Another important question is what makes people interact with the information. When information is available, the level of usage depends on how people choose to interact with it. The following key factors impact on the level of usage:

- Access: Visualization of information should be made easily accessible.
- Simplicity: Interfaces should be simple to use and give concise and relevant information.
- Figures and colors: The use of figures or colors can facilitate direct and concise communication of information.
- Charts: The use of charts also eases the understanding of information.
- Real time data: Real time data enables the understanding of what is happening and consequently act upon real situations that are taking place at the moment.
- Historical data: Historical data provides information about evolution and enables the evaluation of the measures taken into account.
- Neutral messenger: The information and the way to present it (visualization solution) should come from a party that is not a beneficiary. That way it is considered more credible.
- Ability to set personal goals: The user must be involved in the process and consequently be able to interact with the interface establishing goals.

- Feedback: related to the previous point, the user should be able to get feedback on his performance and progress towards the established goals.
- Remote control: Including remote control functionality in the interface where users interact with the devices increases the capabilities users have upon their resources.
- Customization: Customized visualization interfaces can increase individual usage by means of friendlier displays.

Another important aspect to consider when addressing empowerment is how to change user behavior. That is, how can we make the user understand that they can impact on a resource or capability by changing their behavior. There are four different topics related to behavioral changes:

Segmentation: by dividing users into different segments, the information can be adapted to different profiles. Demographic differences, psychosocial behavior and technical knowledge are some examples.

Information: with the right configuration of the information, a better result is to be expected. The information should be able to increase the knowledge, confirm how others do, enhance the feeling of control, confirm the impact off the behavioral change, appeal to a specific value, be simple and practical and have a credible sender.

Social norms: there are various ways to try to change social norms. Well-focused marketing campaigns could show that a “new” kind of behavior is acceptable and even preferred. Current and future social norms regarding resource usage might not be evident to the users. By normative information on an invoice/letter or via visualization application users may compare their resources consumption with others. Showing statistics on how many others have changed their resource usage might encourage a behavioral change.

Social engagement: users need to be a part of the solution. By involving users in an early stage of the process and having personal contact with them, a higher participation is expected. To be in the area physically is a good way of sending a message and an opportunity to answer questions. Knocking on doors creating a personal dialogue, encourage engagement by creating forums or associations are other ways of creating social engagement.

Finally measuring the impact of that behavioral change is desired. This is not always an easy task since actions towards optimization of resources are not always direct or are not registered. Tools and methodologies to quantitatively measure that impact are still limited and consist of research projects. Du Feng, 2016 presents a mathematical model of human behavioral dynamic interactions on a social network to calculate energy savings. Energy savings from the whole network is expressed as mathematical expectation from probability theory. This expected energy savings model includes both direct and indirect energy savings of individuals in the network.

4.1.2 Social Networks for empowerment

Social networks have become one of the Internet activities with more impact in users. Social networks are one of the largest Internet activity[12] not only considering the number of users but also considering users´ time or dedication. Three statements characterize social networks nowadays:

[12] http://www.medialiteracycouncil.sg/media-and-internet/Pages/popular-activities-on-the-internet.aspx

- Most Internet users are social network users.
- The social network users spend more and more time in social network activities.
- The opinions on products, services, etc. have an impact in the purchase decision. Many reviews made by final users are poured on social networks or product / service oriented sites, which provides an added value component (social perspective).

Many citizens use the social networks in their day to day activities as a common media and everything points to that social networks are here to stay for a long time.

There are many social networks and social content sites. There are several classifications regarding the current social networks

- Generalist: Facebook, Twitter.
- Vertical or Thematic: LinkedIn.
- Content Networks: YouTube, Flickr, Slide Share.

Furthermore, there are social networks based on the people location by means of geo-locating (usually called nomad social networks), which allow users interacting one way or another depending in their location.

Social networks are an interesting tool to enhance engagement. Social networks to change people's behavior through engagement are used by Non-Governmental Organizations (NGO) and public government initiatives.

4.1.3 The Collective Awareness Platforms for Sustainability and Social Innovation (CAPS)

The Collective Awareness Platforms for Sustainability and Social Innovation (CAPS) are ICT systems leveraging the emerging "network effect" by combining open online social media, distributed knowledge creation and data from real environments ("Internet of Things") in order to create awareness of problems and possible solutions requesting collective efforts, enabling new forms of social innovation. The CAPS are expected to support environmentally aware, grass-root processes and practices to share knowledge, to achieve changes in lifestyle, production and consumption patterns, and to set up more participatory democratic processes. Although there is consensus about the global span of the sustainability problems that are affecting our current society, including the economic models and the environment, there is little awareness of the role that each and every one of us can play to ease such problems, in a grassroots manner. The distributed situational awareness enabled by such platforms can have very concrete impacts, for instance in empowering (and motivating) citizens to make informed decisions as consumers, or in fostering collective environmentally-savvy behavioral changes and a more direct democratic participation. These platforms are collective tools of social innovation, to design new visions of sustainable societies and environmentally sound solutions.

Concrete examples of technical functionalities would include:

- accessing real-time and easily understandable information on resource consumption
- comparing individual lifestyles against some ecological / environmental benchmark
- defining and accessing complex environmental models and simulations
- promoting sustainable and collaborative consumption, as a basis for an effective Low-Carbon economy

Ultimately, these platforms will enable dialogues and discussions in the civil society to collectively orchestrate the most appropriate actions in a truly democratic, informed and non-mediated manner (Commission E. , 2015). (Commission E. , 2017) presents projects and initiatives addressing societal problems through a network effect, in line with “Collective Awareness Platforms for Sustainability and Social Innovation” including energy, mobility and citizen engagement.

4.1.4 Gamification

Gamification describes the broad trend of employing game mechanics to non-game environments such as innovation, marketing, training, employee performance, health and social change," said Brian Burke, an analyst (Gartner, 2011). "Enterprise architects, CIOs and IT planners must be aware of, and lead, the business trend of gamification, educate their business counterparts and collaborate in the evaluation of opportunities within the organization."

The goals of gamification are to achieve higher levels of engagement, change behaviors and stimulate innovation. The opportunities for businesses are great – from having more engaged customers, to crowdsourcing innovation or improving performance. Gartner identified four principal means of driving engagement using gamification:

1. Accelerated feedback cycles. In the real world, feedback loops are slow (e.g., annual performance appraisals) with long periods between milestones. Gamification increases the velocity of feedback loops to maintain engagement.

2. Clear goals and rules of play. In the real world, where goals are fuzzy and rules selectively applied, gamification provides clear goals and well-defined rules of play to ensure players feel empowered to achieve goals.

3. A compelling narrative. While real-world activities are rarely compelling, gamification builds a narrative that engages players to participate and achieve the goals of the activity.

4. Tasks should be challenging but achievable. While there is no shortage of challenges in the real world, they tend to be large and long-term. Gamification provides many short-term, achievable goals to maintain engagement.

Behavioral change programs are a vital component for sustainable strategies in any field, serving as a good value proposition for many players keen to improve on resource efficiency. Gamification is just one approach to instigate behavioral change and engage consumers by providing a modern approach using characteristics that are familiar to large segments of the population, including some demographics that are often harder to engage through conventional communication programs.

Various approaches to gamification in the energy sector are being piloted or commercially deployed, each adopting differing gamification techniques and having different key objectives. A common factor is their use of granular and real-time energy data, which allows them to provide instantaneous feedback. Mass deployment of smart meters and smart grids is likely to result in increased adoption of gamified applications in new markets, IDC contends.

Although it is early days for the concept of eco-gamification, there are some early, stand-out examples of how the theories have worked in practice to engage staff and citizens in pro-environment habit shifting and behavioral change. For example, in the United States a start-

up software business has been working with utility companies to persuade households to actively lower their utility bills by pitching them in direct competition with their neighbors. On average they reduced 2% of every participating household's energy bills. Future Operations & Maintenance, Facilities Management or Energy Supply contracts could integrate as a standard these tools to help occupants, consumers and machine operators change their behavior.

4.2 ICT Solutions for Data Analysis and User Behavior Detection

Several references point to the importance of data analysis in the scope of Smart Cities. According to Gartner (Gartner, 2015), data management and business intelligence solutions will help achieve the goal of a smarter smart city. Analysis refers to looking into separate components for individual examination. Data analysis is a process for obtaining raw data and converting it into information useful for decision-making by users. The idea behind data analysis is to extract knowledge from the stored data by means of Business Intelligence techniques as well as through Data Mining techniques. The analysis of the whole information stored in the cloud will allow the production of reports, warnings, recommendations, and support to the different stakeholders: Energy Service Enterprises (ESE), mobility managers, municipality administrators, citizens, etc.

This section presents what techniques and methods are more appropriate to analyze data available in a repository. The section also addresses behavioral analysis. Behavioral analysis focuses on understanding how consumers act and why, enabling accurate predictions about how they are likely to act in the future. Mainly it is used to enable marketers to make the right offers to the right consumer segments at the right time but may also be used for:

- Online gaming – predicting usage trends, load, and future user preferences.
- Cohort analysis – breaking users down into similar groups to gain a more focused understanding of their behavior.
- Suggestions – people who liked this also liked...
- Presentation of relevant content based on user behavior.

4.2.1 Data analysis definition and process

Data Analysis is a process of inspecting, cleaning, transforming, and modelling data with the goal of discovering useful information, suggesting conclusions, and supporting decision-making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains.

Data Mining is a particular data analysis technique that focuses on modelling and knowledge discovery for predictive rather than purely descriptive purposes. Business Intelligence covers data analysis that relies heavily on aggregation, focusing on business information. In statistical applications, some people divide data analysis into descriptive statistics, exploratory data analysis and confirmatory data analysis. Predictive analytics focuses on the application of statistical models for predictive forecasting or classification, while text analytics applies statistical, linguistic, and structural techniques to extract and classify information from textual sources, a species of unstructured data. All are varieties of data analysis.

Data integration is a precursor to data analysis, and data analysis is closely linked to data visualization and data dissemination. The term data analysis is sometimes used as a synonym for data modelling.

In the process, there are several phases that can be distinguished. The phases are iterative, in that feedback from later phases may result in additional work in earlier phases.

Data requirements: Data necessary as input to the analysis are specified based upon the requirements of those directing the analysis.

Data collection: Data is collected from a variety of sources. The data may also be collected from sensors in the environment, such as traffic cameras, satellites, recording devices, etc. It may also be obtained through interviews, downloads from online sources, or reading documentation.

Data processing: The phases of the intelligence cycle used to convert raw information into actionable intelligence or knowledge are conceptually similar to the phases in data analysis.

Data initially obtained must be processed or organized for analysis. For instance, this may involve placing data into rows and columns in a table format for further analysis, such as within a spreadsheet or statistical software.

Data cleaning: Once processed and organized, the data may be incomplete, contain duplicates, or contain errors. The need for data cleaning will arise from problems in the way that data is entered and stored. Data cleaning is the process of preventing and correcting these errors. Common tasks include record matching, deduplication, and column segmentation. Such data problems can also be identified through a variety of analytical techniques. For example, with financial information, the totals for particular variables may be compared against separately published numbers believed to be reliable. Unusual amounts above or below pre-determined thresholds may also be reviewed. There are several types of data cleaning that depend on the type of data. Quantitative data methods for outlier detection can be used to get rid of likely incorrectly entered data. Textual data spellcheckers can be used to lessen the amount of mistyped words, but it is harder to tell if the words themselves are correct.

Exploratory data analysis: Once the data is cleaned, it can be analyzed. Analysts may apply a variety of techniques referred to as exploratory data analysis to begin understanding the messages contained in the data. The process of exploration may result in additional data cleaning or additional requests for data, so these activities may be iterative in nature. Descriptive statistics such as the average or median may be generated to help understand the data. Data visualization may also be used to examine the data in graphical format, to obtain additional insight regarding the messages within the data.

Modelling and algorithms: Mathematical formulas or models called algorithms may be applied to the data to identify relationships among the variables, such as correlation or causation. In general terms, models may be developed to evaluate a particular variable in the data based on other variables in the data, with some residual error depending on model accuracy.

Inferential statistics includes techniques to measure relationships between particular variables. Some algorithms are regression, classification, random forest, neural networks, Bayesian networks etc. Analysts may attempt to build models that are descriptive of the data to simplify analysis and communicate results.

Data product: A data product is a computer application that takes data inputs and generates outputs, feeding them back into the environment. It may be based on a model or algorithm. An example is an application that analyzes data about customer purchasing history and recommends other purchases the customer might enjoy.

Data visualization and communication: Once the data is analyzed, it may be reported in many formats to the users of the analysis to support their requirements. The users may have feedback, which results in additional analysis. As such, much of the analytical cycle is iterative.

When determining how to communicate the results, the analyst may consider data visualization techniques to help clearly and efficiently communicate the message to the audience. Data visualization uses information displays such as tables and charts to help communicate key messages contained in the data. Tables are helpful to a user who might look up specific numbers, while charts may help explain the quantitative messages contained in the data.

4.2.2 Techniques for data analysis

Traditional data analysis uses proper statistical methods to concentrate, extract and redefine massive useful data hidden in a batch of chaotic datasets. Data analysis have a very important role in making development plans for a country, understanding customer demands for commerce, and predicting market trend for enterprises. There are many traditional methods that are utilized for the data analysis.

Cluster Analysis*:* Is a statistical method for grouping objects and classify those according to some features. It is used to differentiate objects with particular features and divide them into clusters according to this. Objects in the same category (cluster) will have high homogeneity while different categories will have high heterogeneity.

Factor Analysis: Is primarily targeted at describing the relationship among many elements with only a few factors, grouping several closely related variables into a factor, and the few factors are then used to reveal the most information of the original data.

Correlation Analysis: This analytical method determines the law of relations, such as correlation, correlative dependence and mutual restriction. Those relations may be classified into two types.

- Function
- Correlation

Regression Analysis: A mathematical tool that searches for correlations between one variable and several other variables. Based on a group of experiments or observed data, regression analysis identifies dependence relationships among variables hidden by randomness.

Statistical Analysis: Based on statistical theory, a branch of applied mathematics. This kind of analysis can bring a description and an inference for big data. Descriptive statistical analysis is able to summarize and describe datasets in the meantime, using inferential statistical analysis conclusions could be taken from data subject to random variations. This kind of analysis is applied in economics and also in medical care fields (Anderson, 1958).

Data Mining Algorithms: Used to extract hidden unknown potentially useful information from massive and incomplete data (Wu X, 2008). There are some algorithms like k-means, SVM, Apriori and Naive Bayes.

4.2.3 Big Data and NoSQL storage

The increase in data volumes needed to process by data analysis systems and the complexity of relations between the data sets available has resulted in a new catalogue of technologies necessary to store and manage data. Data Analysis systems must rely on technologies able to cope with large volumes of data.

Supporting traditional Entity-Relationship Models or relational Data Base systems, a new set of technologies has emerged; distributed file systems and non-structured data systems (no-SQL) (Strozzi, 1998). Distributed systems and applications have contributed to the expansion of the Big Data paradigm. Big Data is a term applied to data sets, which overcome the common software capability to capture, manage and process data in a reasonable time. The big data name has its origin in the volume, speed and variety (heterogeneous and non-structured data) that imply difficulty related to storage and data processing. Compared with the more traditional ACID model (where everything is predefined) stiffness, the Big Data technology and the distributed systems shall be tolerant fault, low cost scalable, allow the resource sharing, flexible, quick, open and with high performance.

Some advantages of NoSQL systems are:

- They are able to manage big amounts of data due to its distributed structure.
- They run in low cost Equipment clusters: they do not require as much computation as traditional based SQL databases.
- No bottlenecks are generated, main problem of SQL systems.
- Simple systems with simple operations to read data.

This section presents which technologies and standards are used to store data in non-structured data systems (no-SQL).

More open source Big Data Technologies can be found in (Olavsrud, 2012).

Distributed file systems for cloud

Cloud storage is a model of data storage in which the digital data is stored in logical pools, the physical storage spans multiple servers (and often locations), and the physical environment is typically owned and managed by a hosting company. These cloud storage providers are responsible for keeping the data available and accessible, and the physical environment protected and running. People and organizations buy or lease storage capacity from the providers to store user, organization, or application data.

Cloud storage services may be accessed through a co-located cloud computer service, a web service application programming interface (API) or by applications that utilize the API, such as cloud desktop storage, a cloud storage gateway or Web-based content management systems.

Cloud storage is based on highly virtualized infrastructure and is like broader cloud computing in terms of accessible interfaces, near-instant elasticity and scalability, multi-tenancy, and metered resources

There are many benefits to using cloud storage, most notable is file accessibility. Files stored in the cloud can be accessed at any time from any place so long as you have Internet access. Another benefit is that cloud storage provides organizations with off-site (remote) backups of data which reduces costs associated with disaster recovery.

The biggest disadvantage to cloud storage is that users are limited by bandwidth. If your Internet connection is slow or unstable, you might have problems accessing or sharing your files. Organizations that require a large amount of storage may also find costs increase significantly after the first few gigabytes of data stored.

Below, some of the existing distributed file systems are described.

Google File Systems: A scalable distributed file system for large distributed data-intensive applications. It provides fault tolerance while running on inexpensive commodity hardware, and it delivers high aggregate performance to a large number of clients [Ghemawat2015]. A Google File System cluster consists of a single master and multiple chunk servers and is accessed by multiple clients. Each of these is typically a commodity Linux machine running a user-level server process. It is easy to run both a chunk server and a client on the same machine, as long as machine resources permit and the lower reliability caused by running possibly flaky application code is acceptable. Files are divided into fixed-size chunks. Each chunk is identified by an immutable and globally unique 64-bit chunk handle assigned by the master at the time of chunk creation. Chunk servers store chunks on local disks as Linux files and read or write chunk data specified by a chunk handle and byte range (US Patente nº 9,047,307, 2015).

Hadoop Distributed File System: A distributed file system designed to run on commodity hardware. It has many similarities with existing distributed file systems. However, the differences from other distributed file systems are significant. HDFS is highly fault tolerant and is designed to be deployed on low-cost hardware. HDFS provides high throughput access to application data and is suitable for applications that have large data sets. HDFS relaxes a few POSIX requirements to enable streaming access to file system data. HDFS was originally built as infrastructure for the Apache Nutch web search engine project. HDFS is part of the Apache Hadoop Core project (Apache, 2008).

Disco Distributed File System (Nokia, 2008)**:** Provides a distributed storage layer for Disco. DDFS is designed specifically to support use cases that are typical for Disco and mapreduce in general: Storage and processing of massive amounts of immutable data. This makes it very suitable for storing, for instance: log data, large binary objects (photos, videos, indices), or incrementally collected raw data such as web crawls.

In this sense, DDFS is complementary to traditional relational databases or distributed key-value stores, which often have difficulties in scaling to tera- or petabytes of bulk data. DDFS is not a general-purpose POSIX-compatible file system.

NoSQL Databases

NoSQL (Not Only SQL) databases usually do not perform the same restraints on every piece of data as relational databases do (such as atomicity, consistency, isolation and durability). NoSQL data models are also usually simpler. These two factors make NoSQL databases generally faster than traditional relational databases. In return, NoSQL databases have a

lack of reliability and consistency that relational databases do when performing those restraints (Leavitt, 2010).

Key-value

As the name implies, a key-value store is a system that stores values indexed for retrieval by keys. These systems can hold structured or unstructured data (Leavitt, 2010).

Cassandra: Cassandra is an open-source distributed storage for managing big data. It is a key value NoSQL database which is used in Facebook. The properties mentioned in Han, 2011 for Cassandra are the flexibility of the scheme, supporting range query and high scalability. All passwords in Cassandra are encrypted by the use of MD5 hash function and passwords are very weak. If any malicious user can bypass client authorization, the user can extract the data because there is no authorization mechanism in inter-node message exchange (Zahid, 2014). Cassandra is sensitive for denial of service attack because it performs one thread per one client and it does not support inline auditing. Cassandra uses a query language called Cassandra Query Language (CQL), which is something like SQL. The authors of (Okman, 2011) show that injection attack is possible on Cassandra like SQL injection using CQL. Cassandra also has problem in managing inactive connection (Noiumkar, 2014).

Voldemolt: Voldemort[13] is a key value NoSQL database used in LinkedIn. This type of database matches keys with values and the data is stored as a pair of key and value. Voldemort supports data encryption if it uses BerkeleyDB as the storage engine. There is no authentication and authorization mechanism in Voldemort. It also does not support auditing (Grolinger, 2013).

Redis: Redis is an open source key value database. Data encryption is not supported by Redis and all data stored as plain text and the communication between Redis client and server is not encrypted (Noiumkar, 2014). Redis does not implement access control, so it provides a tiny layer of authentication. Injection is impossible in Redis, since Redis protocol does not support string escaping concept[14].

DynamoDB: DynamoDB is a fast and flexible NoSQL database used in amazon. It supports both key value and document data model[15]. Data encryption is not supported in Dynamo but the communication between client and server uses https protocol. Authentication and authorization is supported by dynamo and a requests need to be signed using HMAC-SHA256 [Grolinger2013].

Column Oriented

Rather than store sets of information in a heavily structured table of columns and rows with uniform sized fields for each record, as is the case with relational databases, column-oriented databases contain one extendable column of closely related data (Leavitt, 2010).

HBase: HBase is an open-source column oriented database modeled after Google big table and implemented in java. Hbase can manage structured and semi-structured data and it uses distributed configuration and write ahead logging. Hbase relies on SSH for inter-node communication. It supports user authentication by the use of SASL (Simple Authentication

[13] http://www.project-voldemort.com
[14] http://redis.io/
[15] http://aws.amazon.com/dynamodb

and Security Layer) with Kerberos. It also supports authorization by ACL (Access Control List) (Zahid, 2014).

HyperTable: HyperTable is an open source high performance column oriented database that can be deployed on HDFS. It is modeled after Google's big table. It uses a table to store data as a big table (Khetrapal, 2006).

HyperTable does not support data encryption and authentication (Noiumkar, 2014). It does not tolerate the failure of range server and if a range server crashes it is not able to recover lost data (Khetrapal, 2006). Even though HyperTable uses HyperTable Query Language (HQL) which is similar to SQL, but it has no vulnerabilities for the injection (Noiumkar, 2014). Additionally there is no denial of service is reported for HyperTable (Noiumkar, 2014).

Document based stores

These databases store and organize data as collections of documents, rather than as structured tables with uniform-sized fields for each record. With these databases, users can add any number of fields of any length to a document (Leavitt, 2010).

MongoDB: Is a document based database. It manages collection of documents. MongoDB support complex datatypes and has high speed access to huge data (Han, 2011); flexibility, power, speed and ease of use are four properties (Boicea, 2012) of MongoDB. All data in MongoDB is stored as plain text and there is no encryption mechanism to encrypt data files (Noiumkar, 2014). All data in MongoDB are stored as plain text and there is no encryption mechanism to encrypt data files (Noiumkar, 2014). This means that any malicious user with access to the file system can extract the information from the files. It uses SSL with X.509 certificates for secure communication between user and MongoDB cluster and intra-cluster authentication (Zahid, 2014) but it does not support authentication and authorization when running in Sharded mode (Okman, 2011). The passwords are encrypted by MD5 hash algorithm and MD5 algorithm is not a secure algorithm. Since mongo uses Javascript as an internal scripting language, Okman, 2011 show that MongoDB is potential for scripting injection attack.

CouchDB: Is a flexible, fault-tolerant document based NoSQL database (Han, 2011). It is an open source apache project and it runs on HDFS (Noiumkar, 2014). CouchDB does not support data encryption (Noiumkar, 2014), but it supports authentication based on both password and cookie (Zahid, 2014). Passwords are encrypted using PBKDF2 hash algorithm and are sent over the network using SSL protocol (Zahid, 2014). CouchDB has potential for script injection and denial of service attack [Noiumkar2014].

DynamoDB: DynamoDB is also viable option for document based stores

Graph

Neo4J: Neo4j[16] is an open source graph database. Neo4j does not support data encryption and authorization and auditing. The communication between client and server is based on SSL protocol (Grolinger, 2013).

[16] http://neo4j.com

4.2.4 Topics related to Data Analysis

This subsection presents topics related to data analysis that can be used as Valued Added Services since they ease the understanding and presentation of data and provide additional knowledge.

Business Intelligence

Business Intelligence comprises the strategies and technologies used by enterprises for the data analysis of business information. BI technologies provide historical, current and predictive views of business operations. Common functions of business intelligence technologies include reporting, online analytical processing, analytics, data mining, process mining, complex event processing, business performance management, benchmarking, text mining, predictive analytics and prescriptive analytics. BI technologies can handle large amounts of structured and sometimes unstructured data to help identify, develop and otherwise create new strategic business opportunities. They aim to allow for the easy interpretation of these big data. Identifying new opportunities and implementing an effective strategy based on insights can provide businesses with a competitive market advantage and long-term stability (Rud, 2009).

Analytics

Analytics is the discovery, interpretation, and communication of meaningful patterns in data. Especially valuable in areas rich with recorded information, analytics relies on the simultaneous application of statistics, computer programming and operations research to quantify performance. Organizations may apply analytics to business data to describe, predict, and improve business performance.

Business reporting

Business reporting or enterprise reporting is "the regular provision of information to decision-makers within an organization to support them in their work." (Hill, 2008). Reporting is a fundamental part of the larger movement towards improved business intelligence and knowledge management. Often implementation involves extract, transform, and load (ETL) procedures in coordination with a data warehouse and then using one or more reporting tools. Reports can be distributed in print form, via email or accessed via a corporate intranet. Different types of reports are identified:

- **Metric Management** - Typically, there are agreed targets to be tracked against over a period of time. Business performance is managed through Service Level Agreements (SLAs) or Key Performance Indicators (KPIs). They may be used as part of other management strategies such as Six Sigma or Total Quality Management (TQM).
- **Dashboards** – Consists of presenting a range of different indicators on one page, like a dashboard in a car. It is common to have traffic lights defined for performance (red, orange, green) to draw management attention to particular areas.
- **Balanced Scorecards** - A method developed by Kaplan and Norton (Norton, 1996) that attempts to present an integrated view of success in an organization. In addition to financial performance, they also include customer, business process and learning and growth perspectives.

Visual Analytics

Visual analytics is "the science of analytical reasoning facilitated by interactive visual interfaces" (Cook, 2005). Visual analytics integrates new computational and theory-based tools with innovative interactive techniques and visual representations to enable human-information discourse. Analytical reasoning is central to the analyst's task of applying human judgments to reach conclusions from a combination of evidence and assumptions (Cook, 2005). Visual analytics can attack certain problems whose size, complexity, and need for closely coupled human and machine analysis may make them otherwise intractable.

4.3 Examples of value added services examples

This section contains a table with the most significant VAS examples identified in the SOTA. The table is divided in five blocks depending on the domain each example addresses. Those are general, energy, mobility, citizen engagement or others.

Each example includes:

- A description of the sample solution.
- The type of VAS classified as product (hardware), Web application, API, social network, methodology, etc.
- The type of example classified as vendor driven (commercial), case study project or city initiative.

Solution example	Description	Type of AVS	Type of solution example	Use Case Domain
General				
The Things Network (https://www.thethingsnetwork.org/)	Community that supports and impulses the use of LoRaWAN technologies for IoT as a new decentralized and low power network architecture.	Hardware	Case study project	GENERALIST
LIBELIUM (http://www.libelium.com/)	Internet of Things, Smart Cities and M2M platform provider. Wireless Sensor Networks hardware manufacturer.	Hardware	Vendor driven	GENERALIST
City Protocol (http://cityprotocol.org/)	City Protocol breaks down barriers to sharing information, common problems, and solution experience. Exploring how to improve cities by looking at their systems as interconnected and networked, rather than siloed. City Protocol is a rich set of resources, which facilitate collaborative city learning, city solution innovation, and city transformation. City Protocol is a protocol platform based on City Anatomy. This protocol platform provides a global and publicly viewable resource for cities and city-serving cross-sector organizations, organized according to a City Protocol common language.	Methodology	Case study project	GENERALIST
SMARTAPPCITY (http://smartappcity.com/en/)	First App in Spain that brings together all city services: immediate information with tourist interests, which promotes the commercial sector and generate value to citizens. It consists of developing a mobile application that integrates all the city services, making them more available to citizens.	Mobile app	Case study project	GENERALIST
URBANAIRAPP (http://www.urbanairapp.com/)	UrbanAir is a citizen centric app that serves its users by bringing together all the services in a city in one platter. Announcements & Alerts, Campaigns & Events, Data & Analytics.	Mobile app	Case study project	GENERALIST
Manchester – Smarter City (https://cms.manche	The Manchester Smarter City Program has been developed to explore ways of making the city work better through use of technologies. The program takes things that the city is already doing around transport, health,	Methodology	City initiative	GENERALIST

ster.gov.uk/smarterci ty)	environment and energy efficiency and aims to encourage further investment, through supporting pilot projects and working with partners in the universities, business and the public sector.			
Helsinki region Infoshare (http://www.hri.fi/en /)	Open data from the Helsinki Metropolitan Area.	API (Open data)	City initiative	GENERALIST
Amsterdam Smart City (https://amsterdams martcity.com/)	Amsterdam Smart City (ASC) is your innovation platform for a future proof city. ASC is constantly challenging businesses, residents, the municipality and knowledge institutions to test innovative ideas & solutions for urban issues. ASC believes in a livable city where people can live and work pleasantly. We are active in different themes in which we bring together different organizations to start innovative projects. One of the themes is the Infrastructure & Technology including several projects, such as City Data (Overview of all available open data in Amsterdam (https://amsterdamsmartcity.com/projects/dataamsterdamnl) or IoT Living Lab (An open and public test environment for beacons and LoRa enabled sensor beacons to kick-start Amsterdam's IoT economy https://amsterdamsmartcity.com/projects/iot-living-lab).	Methodology	City initiative	GENERALIST
Smart Dublin (http://smartdublin.i e/)	Smart Dublin is an initiative of the four Dublin Local Authorities to engage with smart technology providers, researchers and citizens to solve challenges and improve city life. We aim to position Dublin as a world leader in the development of new urban solutions, using open data, and with the city region as a test bed. Smart Dublin is delivering a program that encourages the creation of solutions to address city needs. It has an emphasis on using the opportunities offered by emerging technology and public data. Smart Dublin has identified mobility, environment, energy, waste and emergency management as priority challenges.	Methodology	City initiative	GENERALIST
Chicago (https://www.cityofc hicago.org/city/	The City of Chicago's Data Portal is dedicated to promoting access to government data and encouraging the development of creative tools to engage and serve Chicago's diverse community. The site hosts over 200	API	City initiative	GENERALIST

en/narr/foia/CityData.html)	datasets presented in easy-to-use formats about City departments, services, facilities and performance.			
Dubai (http://www.smartdubai.ae/about.php)	The Smart Dubai initiative aims to make Dubai the happiest city on earth. Collaborating with private sector and government partners, Smart Dubai was established to empower, deliver and promote an efficient, seamless, safe and impactful city experience for residents and visitors. To achieve its strategic pillars, Smart Dubai aims to introduce strategic initiatives and develop partnerships to contribute to its Smart Economy, Smart Living, Smart Governance, Smart Environment, Smart People and Smart Mobility dimensions.	API (Open Data)	City initiative	GENERALIST
MYCOLUMBUS **https://www.columbus.gov/technology/innovation/Mobile-Application/**	MYCOLUMBUS tries to do it all. Along with reporting problems like graffiti and potholes, the app includes a local news feed, links to the city's social media presence and resources for four mayoral initiatives: My Neighborhood, Get Active, Get Green and 311. The My Neighborhood tab has a list of bus schedules, capital project information, neighborhood pride information and events, health inspections of area restaurants, markets, pools, spas and tattoo parlors. Get Active has information about parks, community centers, golf courses, pools, sports facilities, park and trail guides. The Get Green initiative tries to encourage sustainable actions with pointers and data, along with information on which local restaurants and businesses are taking part in green practices. The 311 tab offers general functions to submit sightings of eyesores like dumping and graffiti along with an area to lets users sign up for news and alerts.	Mobile App	City initiative	GENERALIST
City-wide sensors, Santander, Spain **(http://www.smartsa**	One of the world's most comprehensive pilot projects involving city-wide sensors has been launched in Santander, where more than 120,000 sensors are collecting data on everything from the availability of parking spaces to air quality. The city is sharing its information to make it possible for	HW API	City Initiative	GENERALIST

ntander.eu/)	innovators to create various apps and tools to improve things such as interaction with government agencies. (http://www.smartsantander.eu/index.php/testbeds/item/132-santander-summary)			
GrowSmarter **(http://www.grow-smarter.eu/)**	GrowSmarter is an EU funded project under the H2020 program, which brings together cities and industry to integrate and demonstrate "smart city solutions" in energy, infrastructure and transport, to provide other cities with valuable insights on how they work in practice and opportunities for replication. GrowSmarter aims to stimulate city uptake of 'smart solutions' by using the three Lighthouse cities (Stockholm, Cologne and Barcelona) as a way to showcase Smart City solutions from advanced ICT. The complete set of solutions developed can be shown in http://www.grow-smarter.eu/solutions/	Several ICT solutions	EU Project	GENERALIST
Citadel – Open Data **(http://www.citadelonthemove.eu/)**	"Citadel on the Move" offers an online platform which allows citizens to use Open Data provided by their cities to develop mobile applications. The project bases on the concept of Open-Convert-Use. Data are open and published by anyone. Tools are provided to convert datasets into live files. An App generator tool allows creating applications from a selected dataset. More than 800 applications have been created using this tool and they are available on the catalog on line (http://www.citadelonthemove.eu/en-us/exploremycitadel/appcatalogue.aspx).	Open Data	Project	GENERALIST
CitySDK **(http://www.citysdk.eu/)**	CitySDK is a suite of open source tools for the development of digital services for cities. CitySDK is the unification of different parts and components of various software / hardware platforms of the Smart Cities, which are made available to developers of applications. CitySDK is a socio-technological ecosystem of software where the infrastructures of the city act as an enabling platform of the innovation. The project has 22 partners, both public and private, from eight European cities: Helsinki, Barcelona, Amsterdam, Manchester, Lamia, Istanbul, Lisbon and Rome: http://www.citysdk.eu/partners/	Open Data	Project	GENERALIST

Energy				
TELENSA (http://www.telensa.com/)	Adds wireless remote control for your street, roadway and area lighting.	Hardware API	Vendor driven	STREET LIGHTING
LUMINEXT (https://www.luminext.eu/index.php/en/)	Luminext offers sustainable solutions for conventional, static dimmable and dynamic outdoor lighting. With the smart Luminizer software and robust systems the citizen is in total control over the outdoor space and well informed about what is going on in the area.	Web app Open API	Vendor driven	STREET LIGHTING
ECHELON (http://www.echelon.com/applications/pl-rf-outdoor-lighting)	Echelon offers a sophisticated, comprehensive, open standards-based approach to outdoor lighting control that makes it easy and affordable for lighting owners to increase the efficiency, safety, and versatility of their municipal and commercial lighting systems.	Hardware	Vendor driven	STREET LIGHTING
Glasgow City Energy (http://futurecity.glasgow.gov.uk/energy/)	The Glasgow City Energy Model will map in 2D & 3D the energy consumption of residents and businesses across Glasgow. Through either the web portal, accessible via a standard web browser, or the app developed as part of the demonstrator, users will be able to enter information relating to the property they live or work in, which will run a simulation to calculate the anticipated energy consumption of their property. The simulated results will be compared against their actual energy consumption and the consumption of residents/businesses residing in similar properties across Glasgow, allowing the User to understand if they are energy efficient or not.	Web app	City initiative	ENERGY
ICT on Energy Efficiency (EU 2008) http://ec.europa.eu/information_society/activities/sustainable_growth/docs/consultations/advisory_group_reports/ad-hoc_advisory_group_	Report on the usage of ICT for energy efficiency measures.	Report	European Commission	

report.pdf				
Assessing the potential of ICT to increase energy efficiency http://www.europarl.europa.eu/RegData/etudes/etudes/join/2009/429976/IPOL-JOIN_ET(2009)429976_EN.pdf	Report on the usage of ICT for energy efficiency measures.	Report	European Commission	
Sociological Analysis, Social Networks and Gamification To Change the Energy Consumption in Households	(Salas-Prat, Zelco, Carrasco, & Segura, 2014) present an interesting article on building a platform composed by a multi-device front end (web, mobile app, reports, newsletters) and intelligent back-end (patent pending algorithms that use data from smart meters and other devices and sources) that aims a reduction of energy consumption. The article points out the importance of presenting understandable information to residents, using gamification techniques and providing communities to share information and experiences. They also identify 3 groups of users with different attitudes and beliefs towards energy efficiency and motivations and barriers that incentivize or reduce the probability of adopting pro-efficiency behaviors. These groups are the Environmentalist saver, the Comfort-oriented indifferent and the Environmentalist Investor. The alternatives, services and solutions proposed by several manufacturers were also considered ((Cloogy, n.d.), (Current cost, n.d.), (Wattio, n.d.) etc.).	Article	Research	
Fit For Green	Regarding the energy efficiency and the mindful energy consumption, there are interesting initiatives such as Fit For Green (http://www.fitforgreen.com/), which tries to increase the awareness about a healthier world. At Fit For Green people generate energy by means of	Product / Social Network	Vendor driven	

	fitness exercise (i.e. at gyms) which can be used to light a bulb or charge an iPod, but the main goal is that the users realize how much it really takes to generate energy and how important controlling consumption is.			
International Performance Measurement and Verification Protocol (IPMVP) (EVO-. Efficiency Valuation Organization) https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp	Framework used for measurement and verification. Related to data collection and treatment for energy savings.	Protocol	Non-Profit Organization	
ASHRAE, Guideline 14-2002 Measurement of Energy and Demand Savings http://ateam.lbl.gov/mv/	Reports and guidelines in measuring and verification	Reports	Governmental	
Encerticus http://www.med-encerticus.eu/it/index.asp	The project "ENCERTICUS", co-financed with ERDF funds of the European Commission through the MED Program, proposes: To Pilot and monitor the impact of ENCERTCUS energy awareness services on inhabitants' resource use behavior on 3 MED countries. To provide households detailed near real-time energy use information in a way that is meaningful to them. To engage individual households as active players in developing water and energy conservation practices.	Interventions / Web apps	Project	
eSESH http://esesh.eu/fileadmin/eSESH/downlo	The project is developing a range of new ICT-based services for social housing tenants, to be evaluated in pilots across Europe. eSESH Advanced Energy Awareness Services (EAS) provide direct, timely and comprehensible	Several ICT solutions	Project	

ad/documents/eSESH_project_summary.pdf	feedback on energy consumption, enabling tenants to adapt their energy consumption behavior. In addition, a comprehensive set of Energy Management Services (EMS) help reduce consumption peaks and optimize the timing of domestic consumption. Optimized timing of consumption can reduce generation capacity requirements and, with appropriate tariffs, tenant costs. EMS are also used to control delivery of locally generated, renewables-based heat and power.			
Energy Social Network **http://energy.ning.com/**	EnergySocialNetwork.com is a social network to share and follow clean energy developments.	Social network	Social Network	
Welectricity http://www.welectricity.com/home	Welectricity is a free service that helps users track and reduce energy consumption at home. Users introduce their energy bill and is offered dashboards and comparisons.	Web app / social network	Social Network	
STECHome (http://stechome.es/)	A device called STECHome controls the energy in the house and from that point the unit gradually deducts money from the user's account as energy is consumed by the house, as long as there is a positive balance in the account. Users can thus see at all times what they are consuming and the money they have left, while paying only for what is consumed. This is a new energy model for Spain, since users pay before consuming and can see in real time what they spend on energy. Once the balance falls below €10 the device sounds an alarm that alerts the consumer that he must top up the account, which he can do from the device itself, on the Internet or through a free phone-in service.	Mobile app	Vendor driven	ENERGY
Mobility				
KIUNSYS (http://www.kiunsys.	Kiunsys designs and develops innovative solutions for the management of sustainable mobility - Smart Urban Mobility, Smart Parking and City.	Hardware Web app	Vendor driven	MOBILITY

com/)		Mobile app		
PLACEMETER SENSOR (http://www.placemeter.com /solutions/smart-cities)	Placemeter is an open urban intelligence platform. Using proprietary computer vision algorithms, they transform video streams into meaningful data about the volume and direction of pedestrians, bikes, and vehicles.	Hardware Web app Mobile app API	Vendor driven	MOBILITY
BESTMILE (https://bestmile.com/)	BestMile offers an ecosystem to manage autonomous vehicle fleets: a fleet management software, a smartphone application, a system for traveler information and solutions for the control of smart infrastructure.	Mobile app	Vendor driven	MOBILITY
PARKIFI (https://www.parkifi.com/)	With spot-level parking data from lots, garages, and on-street parking a click or touch away, operators can access inventory and gain actionable insights effortlessly. Manage your facilities from anywhere, at any time, from any device through ParkiFi's cloud-based analytics dashboard.	Web app	Vendor driven	MOBILITY
SUNSET http://sunset-project.eu	The project is part of the European Commission's 7th Framework program Smart Cities & Sustainability that exploits social networks to manage urban mobility in a sustainable manner.	Social network	Project	
Eco - Routing	A navigation system that finds a route requiring the least amount of fuel and/or producing the least amount of emissions. It is based on a dynamic roadway network database, a source of historical and real-time traffic information, a database of energy/emissions based on vehicle types under roadway characteristics and traffic conditions and a routing engine to calculate the shortest path.		Project	MOBILITY
Blablacar (https://www.blablacar.com)	Blablacar is the world's largest ridesharing community. It connects drivers and passengers willing to travel together to share the cost of the journey, while they reduce CO_2 emissions.	Web app Mobile app Social Netwok	Product	MOBILITY
ZipCar	An American car-sharing company that provides automobile reservations to its members. Zipcar members have automated access to Zipcars using an	Web app	Product	MOBILITY

(https://www.zipcar.com)	access card which works with the car's technology to unlock the door; the keys are already located inside. They only use clean fuel and low-emission vehicles.	Mobile app		
STREETLIFE **(http://www.streetlife-project.eu/)**	Is a project supported by the European Commission. It aims at engaging users to change their mobility routines by means of gamifications mechanisms.	Framework / Software	Project	MOBILITY / CITIZEN ENGAGEMENT
Waze **(https://www.waze.com/en/**	Community-based traffic and navigation app. Users can notify about police, accidents, road hazards or traffic jams, so other users can avoid them. Moreover, the app also alerts you when you are driving above the speed limit and identifies the cheapest gas stations on your route. This way, the app can reduce the amount of time spent in the road, the money spend on gas and the fines for traffic infractions.	Mobile app	Social Network	Mobility
BA móvil **(http://movilidad.buenosaires.gob.ar/ba-movil/)**	Is a mobile application that identifies your location and provides real time data about mobility in the city of Buenos Aires. It provides traffic times, Ecobici bike availability, subway times and parking information.	Mobile app	Vendor driven	Mobility
GO MOBILE PGH **http://www.gomobilepittsburgh.com/**	Pittsburgh Parking Authority lets residents and visitors pay for parking via their phones. Powered by Parkmobile, drivers can park at spots with GO MOBILE PGH signs and use the app to register their car for the spot and pay for parking. The app lets users set 15-minute parking expiration notifications and even extend parking sessions from the phone until the maximum time is reached.	Mobile app	City Initiative	Mobility
Cycle Atlanta **http://cycleatlanta.org/**	Cycle Atlanta was developed with multiple governmental departments and Georgia Tech to track users cycling routes, and lets riders flag potholes and other problems for the city. That data is uploaded to a server that helps inform the city of where people are and are not biking, allowing them to focus in on cycling infrastructure — like bike paths — where it is needed most.	Mobile app	City Initiative	Mobility/Citizen engagement

Smart traffic system, Singapore	Singapore's intelligent traffic system includes electronic payments and sensors on taxis, which generate a large quantity of traffic data. The system proposes a smart urban mobility where people and the transportation system are seamlessly connected. The city analyses this data, making it possible, for example, to map traffic conditions at various times of the day. https://www.lta.gov.sg/content/dam/ltaweb/corp/RoadsMotoring/files/SmartMobility2030.pdf	Several ICT solutions	City Initiative	
Bitcarrier – Zaragoza (Spain) **(http://www.worldsensing.com/success-story/traffic-flow-management-zaragoza-city/)**	More than 150 sensors were implemented in the city to obtain real-time information on city traffic. Collected information is sent to the city's command center. Information is processed to provide users (managers and citizen): • Real-time information about the traffic situation. • Web interface specifically optimized for management. • Possibility to divert traffic on alternative routes. • Dynamic calculation of the duration of urban journeys. Public web and app to plan journeys.	Product Web app	City Initiative	
Dordrecht (The Netherlands) **(https://repository.tudelft.nl/islandora/object/uuid:68a1d7d2-3828-4df5-9c05-63a2511188e4?collection=education)**	Public authorities are worried about the impact that the increase of people could have in the urban planning of metropolises. The IoT is enabling the detection of the most regular routes; volume of cars, bicycles or pedestrians and most crowded streets passing times. Due to the significance of the region, local authorities want to rebuild the city in order to change the land uses and increase the level of public services. Using the data collected by the system and the known distances between the sensors, the movement speed of each device has been computed. As a result, each street's road modality has been studied and also the relationship between the categories throughout the day, and the preferred streets for each kind of users are recognized. The outcome of this research has been very useful for public authorities to work on the urban planning in the area based on the information from the IoT Gateways and the data analysis.	Several ICT solutions	City Initiative Project	Urban planning
Citizen Engagement				

Smart Citizen (https://smartcitizen.me/)	Smart Citizen is a platform to generate participatory processes of people in the cities. Connecting data, people and knowledge, the objective of the platform is to serve as a node for building productive and open indicators, and distributed tools, and thereafter the collective construction of the city for its own inhabitants. In traditional smart city visions, cities are covered in thousands of expensive sensors, managed by professionals, to collect data on everything from air quality to the movement of cars and people. But people can also get involved in measuring and mapping air quality themselves. The Smart Citizen Kit can be placed in outdoor locations, such as balconies, windowsills and on top of buildings. Once set up, the kit streams data over WiFi to SmartCitizen.me, an open platform where data from kits is shared, creating a crowdsourced map of environmental data from cities around the world. In the near future, crowdsourced data could be used to supplement professional sensing networks and could make data collection much cheaper. Another purpose of low cost sensing kits is to create better awareness among people in cities about their urban environments so that they can use this knowledge to make informed decisions about their behavior and to campaign for their governments to take action.	Hardware Web app Mobile app API	Case study project	CITIZEN ENGAGEMENT
SENSE.CITY (http://sense.city)	The sense.city platform provides the tools that activate citizen's creativity, imagination and communication, engages urban thinking and improves the relationship between citizens, the municipality and public services. By using the sense.city platform, citizens become the city sensors! With their own communication devices (mobile phones) or via the sense.city application, citizens can post in real time issues and problems for something that happens in their city, inform their fellow citizens and the municipality for problems and incidents that occur every moment. Citizens actively participate in the processes and solve problems concerning their lives in the city. They help in urban development while improving the relationship between citizens and public services of the city.	Mobile app	Case study project	CITIZEN ENGAGEMENT
Improve My City	The application enables citizens to report local problems such as potholes,	Mobile app	Case study project	CITIZEN

(http://smartcityapps.urenio.org/improve-my-city_en.html#)	illegal trash dumping, faulty street lights, broken tiles on sidewalks, and illegal advertising boards. The submitted issues are displayed on the city's map. Users may add photos and comments. Moreover, they can suggest solutions for improving the environment of their neighborhood			ENGAGEMENT
TELEFÓNICA-AURA (https://www.telefonica.com/)	AURA will enable users to manage their digital experiences with the company and control the data generated by using Telefónica's products and services in a transparent and secure manner. Telefónica becomes the first company in the industry to provide its customers the possibility of managing their relationship with the company based on cognitive intelligence.	Web app	Project	CITIZEN ENGAGEMENT
DSNY Info **http://www1.nyc.gov/connect/mobile-applications.page**	The New York City Department of Sanitation (DSNY) launched DSNY Info, an app for smartphones and tablets that allows users to set sanitation service reminders, get updates on weather-related delays and access special event schedules. The app also connects residents with donateNYC, a site that helps New Yorkers donate second-hand items — generally textiles and household items — that can be reused. The app also includes tips on how to reduce, reuse and recycle, which pushes New Yorkers to help reach the city's goal of zero waste to landfills by 2030.	Mobile app	City Initiative	CITIZEN ENGAGEMENT
Find It, Fix It **http://www.seattle.gov/customer-service-bureau/find-it-fix-it-mobile-app**	Seattle's Find It, Fix It app lets residents report hazards or indecencies like abandoned vehicles, graffiti and potholes to the city. Users simply take photos of the issue straight in the app, write additional details and mark it on a map.	Mobile app	City Initiative	CITIZEN ENGAGEMENT
BOS:311 **https://www.boston.gov/departments/innovation-and-technology/apps**	Originally called Citizens Connect, BOS:311 debuted in 2009 to make it easier for citizens to report problems to the city. Users can report graffiti, roadkill, illegally parked cars or schedule waste pick-ups. The report gets placed on a map that is also accessible in the app. Reports can be shared on social media, and users can also connect with the service by tweeting @BOS311. Over 1 million reports have been submitted by users so far.	Mobile app	City Initiative	CITIZEN ENGAGEMENT
Repara **http://reparaciudad.c**	Repara Ciudad is an example of this approach: members of the public can use their mobiles or the Web to report street-related incidents simply and easily, so that local authorities can react more swiftly, focusing on the	Mobile app	Vendor Driven	CITIZEN ENGAGEMENT

om/	incidents that affect and concern people the most and informing them of the action taken.			
Avisos Madrid **http://www.madrid.es/portales/munimadrid/es/Inicio/El-Ayuntamiento/Atencion-a-la-ciudadania/Aplicacion-movil/Aplicacion-movil-Avisos-Madrid-?vgnextfmt=default&vgnextoid=c67bd881111f7410VgnVCM1000000b205a0aRCRD&vgnextchannel=b9254bbed88f7410VgnVCM1000000b205a0aRCRD#**	The mobile application 'Avisos Madrid' is Madrid City Council's channel for the communication of notices and incidents relating to street furniture, lighting, urban cleaning and waste, green or wooded areas, sidewalks and pavements, abandoned vehicles and other causes. Started by the Department of Economy, Finance and Public Administration, currently the Department of Citizen Participation, Transparency and Open Government, the communication of any notice begins with the making of a photograph, continues with the geolocation of the incidence in a plan, and ends with the introduction of a brief description. At the same time, it is automatically recorded in the computer systems of the Madrid City Council's Notification Management System to be attended by the competent municipal services in each case.	Mobile app	City Initiative	CITIZEN ENGAGEMENT
Suggestion Box Vitoria-Gasteiz **http://www.vitoria-gasteiz.org/we001/was/we001Action.do?idioma=en&claveArea=54&accion=areas&nuevaPag=&aplicacion=wb021&id=&tabla=area**	Web application to place complaints or submit suggestions regarding these topics: Mobility and Transport, Public streets, Environment and sustainability, Citizen services and information, Citizen participation, Sports, Leisure and culture, Social services, The Treasury, Financial promotion, Tourism, City Planning , - Housing, Health and consumption, Education, Public safety, Training and employment, Social equality, integration and cooperation	Web app	City Initiative	CITIZEN ENGAGEMENT
PetaJakarta	The Jakarta provincial government developed the Smart City Platform, which consists of an issue–reporting app known as Qlue; a flood map that	Mobile app	City initiative	CITIZEN ENGAGEMENT

(http://petajakarta.org/banjir/en/research/)	crowdsources citizen flood reports from Twitter, called PetaJakarta; and a crowdsourced traffic management tool based on Waze, Google's navigation app. Focusing on citizens rather than smart infrastructure and hardware, allows Jakarta to build on its unique attributes, including the fact that it tweets more than any other city in the world and, as a result, produces a huge amount of data for researchers and city officials to analyze.			
Participatory budget in Paris **(http://www.paris.fr/english/english/over-21-000-parisians-back-gardens-on-the-walls-project/rub_8118_actu_155139_port_19237)**	Paris has set up the participatory budgeting scheme, 'Madame Mayor, I have an idea', which will allocate €500 million to projects proposed by citizens between 2014 and 2020, and claims to be the largest exercise of its kind in the world. The most popular proposals so far, with more than 21,000 votes, is an idea to develop 41 vertical garden projects across the city. The city has committed to investing €2 million in these projects. Other popular projects include setting up recycling stations, gardens in schools and co-working spaces for students and entrepreneurs.	Online app	City initiative	CITIZEN ENGAGEMENT
Sharing City Seoul **(http://billiji.com/)**	The initiative has certified 50 sharing projects that provide people with an alternative to owning things they rarely use, and given grants to a number of these projects. Certified projects range from local car–sharing company SoCar, and websites like Billiji that help people share things with their neighbors, to schemes that match students struggling to find affordable housing with older residents who have a spare room. Sharehub, a platform launched by Creative Commons Korea, has been trying to promote public acceptance of the collaborative economy as part of the Sharing City Seoul initiative.	Online app	City initiative	CITIZEN ENGAGEMENT
Blockpooling Singapore **(https://www.blockpooling.sg/)**	BlockPooling, a social network for communities in Singapore, was set up in 2013 with a grant from the government to enable neighbors to share belongings and offer or ask for services. The platform, which has the twin goals of strengthening communities in Singapore and making more efficient use of resources, does this through a number of unique features. For example, the 'lend and borrow' function uses postcodes to help people find	Online app	City initiative	CITIZEN ENGAGEMENT

	others in their neighborhood who have items they are willing to share or have a thing they need to borrow.			
Better Reykjavik **(https://betrireykjavik.is/)**	The Reykjavik city council has committed to debating the most popular ideas from the Better Reykjavik website and discuss whether there is enough political backing to implement them. So far, almost 60 per cent of citizens have used the platform, and the city has spent €1.9 million on developing more than 200 projects based on ideas from citizens. Better Reykjavik is built on a web-based platform developed by the Icelandic Citizens Foundation. The platform enables groups of people to develop and prioritize ideas and decide which ones to implement. Since 2008, the Citizens Foundation has used the web platform to promote online, democratic debate in Iceland and worldwide. The open source platform is available free of charge to any group, city or country around the world interested in using it to source ideas from citizens.	Online app	City initiative	CITIZEN ENGAGEMENT
Minecraft: Block by Block **(http://blockbyblock.org/)**	With "Block by Block", United Nations Human Settlements Program, and Mojang, makers of popular online game Minecraft, are exploring how the game could be used to find out how people want to see their cities develop in the future. Using the game, residents can build simple 3D models of their community. This is a simple and effective way to visualize future developments and create a consensus within the community. For instance, in Haiti, the project worked with a group of fishermen who could not read or write and had never used a computer. They used the program to visualize the changes they would like to see in an area that had been badly affected by flooding. Using Minecraft they built a new seawall as well as adding public toilets to the area. This was then turned into a plan by architects.	Online app	City initiative	CITIZEN ENGAGEMENT
Wheelmap **(http://wheelmap.org/en/)**	Wheelmap, an online map developed by the German NGO Sozialhelden, enables people to share information about how accessible places are by wheelchair. Launched in 2010, users have mapped 500,000 locations across the world. The map has two functions: one is to let people know how accessible the city is, the other is to change the way city governments think	Online app	City initiative	CITIZEN ENGAGEMENT

	about accessibility and give NGOs and activists a tool to use to lobby for improvements.			
Walk [Your City] **(https://walkyourcity.org/)**	In most cities, street signs are aimed at drivers, and often do not show those on foot the quickest way to a destination in a city. Walk [Your City] in the US produces signs that explain how long it will take to walk between popular destinations. Anyone can go on the Walk [Your City] website and order signs for their own city. These can be attached to lampposts or other structures, and also have a QR code which brings up walking directions on Google maps when scanned with a smartphone. As well as helping people to get around the city, it can be used to raise awareness and lobby governments to improve walkability.	Online app	City initiative	CITIZEN ENGAGEMENT
PiMi Airbox **(http://www.pimiair.com/data/)**	Many researchers are creating sensing equipment to crowdsource environmental data. These technologies could soon be used to supplement data collected by the city, with the benefit of being much cheaper than professional equipment. While data collected by professionals is highly accurate, a large enough number of low–cost sensors will produce results that are good enough to allow policymakers to make decisions about air quality. One of the most promising examples of this technology is the PiMi Airbox developed by Tsinghua University. Individual devices achieve a much higher level of accuracy than similar low–cost sensors and they also upload all the data they collect to create a crowdsourced map of indoor air pollution in Beijing.	Low cost HW Mobile application	City initiative	CITIZEN ENGAGEMENT
Other Domains				
ENEVO (http://www.enevo.com/)	Enevo ONe is a comprehensive logistics solution that saves time, money and the environment. It uses wireless sensors to measure and forecast the fill-level of waste containers and generates smart collection plans using the most efficient schedules and routes. It works with any type of container and any type of waste mixed, glass, bio, metals or fluids such as oils and waste	Hardware Web app Mobile app	Vendor driven	WASTE MANAGEMENT

	water etc. The solution provides up to 50% in direct cost savings.			
EVERIMPACT (http://www.everimpact.org/#home)	It provides a turnkey solution so your City can get its emissions' maps in real-time, based on data from satellites, and from their ground sensors positioned around the city.	Web app	Vendor driven	ENVIRONMENT
India (http://smartcities.gov.in/content/innerpage/strategy.php)	Smart Cities Mission. The strategic components of area-based development in the Smart Cities Mission are city improvement (retrofitting), city renewal (redevelopment) and city extension (greenfield development) plus a Pan-city initiative in which Smart Solutions are applied covering larger parts of the city.	Methodology	City initiative	URBAN PLANNING
Array of Things (https://arrayofthings.github.io/)	Urban sensing project, a network of interactive, modular sensor boxes that will be installed around Chicago to collect real-time data on the city's environment, infrastructure, and activity for research and public use. AoT will essentially serve as a "fitness tracker" for the city, measuring factors that impact livability in Chicago such as climate, air quality and noise.	Hardware API (Open data)	City initiative	TRAFFIC, FLOODING, CLIMATE
FINTONIC (https://www.fintonic.com/)	Find out what is happening with your accounts, how banks rate you, and receive alerts on fees, overdrafts, etc. You can get loans and insurance from over 50 banks and institutions using the app. More control, more power and easier with Fintonic, the first Financial Optimiser.	Mobile app	Vendor driven	WASTE MANAGEMENT
DATUM (https://datum.org/)	Datum is a decentralized and distributed high performance NoSQL database backed by a blockchain ledger. This technology allows anyone to backup structured data like social network data, data from wearables, smart home and other IoT devices in a secure, private and anonymous manner. Datum provides a marketplace where users can share or sell data on their own terms.	Mobile app	Vendor driven	MARKETPLACE FOR DATA
ORACLE. Real-Time Insights From the Connected Factory (https://cloud.oracle.com/en_US/iot-	Deliver products on time with IoT Production Monitoring's continuous tracking and prediction of production performance across factories, products, and machines.	HARDWARE	Vendor driven	MANAGEMENT

production-monitoring-cloud)				
PAY-PER-TRACKING (http://www.sciencedirect.com/science/article/pii/S0020025516322587?via%3Dihub)	(Javier Parra-Arnau, 2017) A new tracking paradigm that aims at returning control to users over tracking and advertising, and allowing them to participate in the monetization of their browsing data.	ARTICLE	Research	MANAGEMENT
SFBeaches **http://www.sfwater.org/cfapps/lims/beachmain1.cfm**	Released by the San Francisco Public Utilities Commission, SFBeaches lets users check water quality at their favorite shore spots. Shoreline bacteria are routinely monitored at fifteen different stations in San Francisco year-round. The app shows a map with warnings, including if there are combined sewer overflows (CSOs).	Mobile app	City Initiative	WATER QUALITY

5 Conclusions and outputs for other WPs

Two are the outputs obtained in this task. The first output is the overall approach necessary to identify, evaluate, deploy and validate Value Added Services within SmartEnCity. This will give a direct toolbox to Lighthouse demonstrators and Follower cities to develop their own Value Added Services depending on their local context of CIOP capabilities and socioeconomic context.

The second is the state of the art in reference to Value Added Services. This state of the art presents an extensive list of applications and solutions that could be adopted in the three demonstrators (WP3, WP4, and WP5). The solutions implemented should be evaluated using the approach proposed in this deliverable. State of the art in this document also serves as an example base of what has been done in this field elsewhere. It serves as an idea-bank of what could be done in any Lighthouse or Follower city while engaging local partners for Value Added Services possibilities identification.

Deliverable D6.6 presents the results of Task 6.6 “Added Value Services” within WP6 of the SmartEnCity project. The main objective for this task is to offer those services, which support decision making on new activities that boost engagement or launch awareness campaigns. These services can be developed using VAS approach described in D6.6 on top of local CIOP and partner’s environment.

6 References

Amrel, K. C. (2012). *IS DISAGGREGATION THE HOLY GRAIL OF ENERGY EFFICIENCY?* Stanford: Stanford Univercity.

Anderson, T. (1958). An introduction to multivariate statistical analysis, vol 2. New York: Wiley.

Apache, F. (2008). *https://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-hdfs/HdfsDesign.html*. Retrieved from https://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-hdfs/HdfsDesign.html: https://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-hdfs/HdfsDesign.html

Boicea, A. a. (2012). MongoDB vs Oracle-Database Comparison. *EIDWT*, 330-335.

Cloogy. (n.d.). Retrieved 03 09, 2015, from Cloogy by ISA: Http//cloogy.com

Commission, E. (2015, 02 12). *https://ec.europa.eu/digital-single-market/en/collective-awareness*. Retrieved from https://ec.europa.eu/digital-single-market/en/collective-awareness: https://ec.europa.eu/digital-single-market/en/collective-awareness

Commission, E. (2017, 05 09). *https://ec.europa.eu/digital-single-market/en/caps-examples*. Retrieved from https://ec.europa.eu/digital-single-market/en/caps-examples: https://ec.europa.eu/digital-single-market/en/caps-examples

Conger, J. A. (1988). The Empowerment Process:Integrating Theory and Practice. *The Academy of Management Review, Vol. 13, No. 3* , 471-482.

Cook, J. J. (2005). *http://vis.pnnl.gov/.* Retrieved from http://vis.pnnl.gov/: http://vis.pnnl.gov/pdf/RD_Agenda_VisualAnalytics.pdf

Current cost. (n.d.). Retrieved 03 09, 2015, from Current cost: Http://www.currentcost.com/

Du Feng, Z. J. (2016). Modelling the impact of social network on energy savings. *Applied Energy Volume 178*, 56-65.

Ehrhardt-Martinez, K., Donnelly, K. A., & Latiner, J. A. (2010). *Advanced Meetering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities.* Washington, D.C.: ACEEE.

Gartner. (2011, 04 12). *http://www.gartner.com/newsroom/id/1629214*. Retrieved from http://www.gartner.com/newsroom/id/1629214: http://www.gartner.com/newsroom/id/1629214

Gartner. (2015, 09 11). *Gartner, Market Trends: Building Smart City Information and Digital Business Value Through City Data.*

Ghemawat, S. a.-T. (2015). *US Patent No. 9,047,307.*

Grolinger, K. a. (2013). Data management in cloud environments: NoSQL and NewSQL data stores. (S. B. Heidelberg, Ed.) *Journal of Cloud Computing: Advances, Systems and Applications, 2*(1).

Han, J. a. (2011). Survey on NoSQL database. *Pervasive computing and applications (ICPCA), 2011 6th international conference on* (pp. 363-366). IEEE.

Hill, G. (2008). *https://en.wikipedia.org/wiki/Business_reporting*. Retrieved from https://en.wikipedia.org/wiki/Business_reporting: https://en.wikipedia.org/wiki/Business_reporting

Khetrapal, A. a. (2006). HBase and Hypertable for large scale distributed storage systems. *Dept. of Computer Science, Purdue University*, 22-28.

Leavitt, N. (2010). Will NoSQL databases live up to their promise? (IEEE, Ed.) *Computer, 43*(2), 12-14.

Noiumkar, P. a. (2014). A Comparison the Level of Security on Top 5 Open Source NoSQL Databases. *The 9th International Conference on Information Technology and Applications (ICITA2014).*

Nokia, c. (2008). *https://disco.readthedocs.org/en/latest/howto/ddfs.html*. Retrieved from https://disco.readthedocs.org/en/latest/howto/ddfs.html: https://disco.readthedocs.org/en/latest/howto/ddfs.html

Norton, R. K. (1996). *The Balanced Scorecard: Translating Strategy Into Action.* Harvard Business Press.

Okman, L. a.-O. (2011). Security issues in nosql databases. In IEEE (Ed.), *2011IEEE 10th International Conference on Trust, Security and Privacy in Computing and Communications*, (pp. 541-547).

Olavsrud, T. (2012, 06 8). *https://www.networkworld.com/article/2289422/applications/9-open-source-big-data-technologies-to-watch.html#slide1*. Retrieved from https://www.networkworld.com/article/2289422/applications/9-open-source-big-data-technologies-to-watch.html#slide1: https://www.networkworld.com/article/2289422/applications/9-open-source-big-data-technologies-to-watch.html#slide1

Rappaport, J. (1984). Studies in empowerment: Introduction to the issue. *Prevention in Human Services, 3*, 1-7.

Rud, O. (2009). *Business Intelligence Success Factors: Tools for Aligning Your Business in the Global Economy.* Hoboken, N.J: Wiley & Sons.

Salas-Prat, P., Zelco, S., Carrasco, J., & Segura, R. (2014). *Sociological Analysis, Social Networks and Gamification To Change the Energy Consumption in Households.* Barcelona, Catalonia-Spain: Enerbyte Smart Energy Solutions.

SmartEnCityD6.1. (2016). *SmartEnCity Deliverable 6.1: CIOP Functional and Non-Functional Specifications.*

Strozzi, C. (1998). *http://www.strozzi.it/cgi-bin/CSA/tw7/I/en_US/nosql/Home%20Page*. Retrieved from http://www.strozzi.it/cgi-bin/CSA/tw7/I/en_US/nosql/Home%20Page: http://www.strozzi.it/cgi-bin/CSA/tw7/I/en_US/nosql/Home%20Page

Zahid, A. a. (2014). Security of sharded NoSQL databases: A comparative analysis. *Information Assurance and Cyber Security (CIACS), 2014 Conference on* (pp. 1-8). IEEE.

Wattio. (n.d.). Retrieved 03 09, 2015, from Wattio: http://www.wattio.com/en

Wu X, K. V. (2008). Top 10 algorithms in data mining. . *Knowl Inf Syst* , 14(1):1–37.