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Integrated Solutions for Positive Energy and Resilient Cities

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D5.6

Novel Smart City Business Model portfolio and non-energy services Business models – V1

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Glossary

Abbreviation	Full form
AI	Artificial Intelligence
BOS	Building Operating System
BM	Business Model
EMS	Energy Management System
FC	Fellow City
GDPR	General Data Protection Regulation
HVAC	Heating, Ventilation, Air Conditioning
IE	Innovative Element
KPI	Key Performance Indicator
LHC	Lighthouse City
MIBB	Mandatory requirements, Impacts, Benefits and Barriers
NEB	Non-Energy Benefit
PEB	Positive Energy Building
PV	Photovoltaic
R2S	Ready to Service
V2G	Vehicle to Grid

Executive Summary

This deliverable is part of the Horizon 2020 Smart City project RESPONSE and has been redacted as part of the Task 5.5 *Novel Smart City Business Model portfolio increasing Governance capacity and linking energy and non-energy services at the Smart city level.*

The main output of the analyses performed within this D5.6 is the creation of a portfolio of business cases as result of a collection of good examples coming from Task 5.2 and Task 5.3 of RESPONSE plus the identification of non-energy services.

For the creation of this portfolio, a simplified template has been created in order to smoothly illustrate the key elements of each business model and with a high degree of similarity across them.

The result is a number of factsheets (the "BM Factsheets"), where the following information is presented, for each business model:

- Description of the solution;
- Stakeholders involved across the cycle;
- Mandatory requirements, Impacts, Benefits and Barriers (MIBB) analysis;
- Potential for replication.

The BM Factsheets illustrate how the BMs have been transposed in specific business cases, so the message delivered by a factsheet is that of an implemented solution thanks to a business model.

The second part of the Deliverable is dedicated to the identification of the so called Non-Energy Services. Non-Energy Services can be defined as secondary services that are offered in addition to the primary services focused on saving energy consumption and energy costs. A list of potential Non-Energy Services well applicable to the smart cities environment has been presented together with the related benefits. These services are referred to four main categories: comfort, air quality, noise control and surveillance. They are illustrated with explanation of achievable benefits and a quantification of the potential savings.

The selected non-energy services are related to:

- Heating and cooling;
- Domestic Hot Water;
- Ventilation;
- Lighting;
- Windows and fixtures;
- Noise;
- Other services.

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Chapter 1

Introduction

Chapter 1 - Introduction

1.1 Objectives

Leveraging on the lessons learnt throughout the Project in shaping successful business models in favour of the LightHouse City (LHC), the objective of this Deliverable is to create a portfolio of business models, applicable to the cities involved in RESPONSE as well to other cities through proper customization (i.e.: by tailoring the specific features of a given BM to the peculiarities of the target city), so as to increase their capacity to attract investments.

Moreover, a second objective of the Deliverable is to identify a list of promising non-energy services and to provide qualitative and quantitative evaluations of the related benefits.

1.2 Relationships with other tasks and deliverables

The activities performed in Task 5.5 concerned the analysis of existing Business Models already applied in the LHC for the deployment of some Innovative Elements (IEs).

The Deliverable has, by its intrinsic nature, strong relationships with Task 5.2 and Task 5.3, where several business models have been assessed for the specific cases of the IEs applied to the two LHC, and with D12.4:

- D5.3 for the analysis of the business models applicable to Dijon;
- D5.4 for the analysis of the business models applicable to Turku;
- D12.4, where business models have been assessed within the Technical and Innovation Management Plans.

1.3 Structure of the report

The report is structured as follows:

- Chapter 2 is dedicated to the creation of a portfolio of novel smart city business models, illustrated through a user-friendly summary template;
- Chapter 3 deals with the identification and evaluation of a list of non-energy services and related benefits;
- Chapter 4 draws the conclusions of the analysis.

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Chapter 2

Successful Business Cases

Chapter 2 – Novel Smart City Business Model Portfolio

The main output of Task 5.5 consists of a portfolio of smart city business models as result of the collection of good examples coming from Task 5.2 and Task 5.3 of RESPONSE plus the identification of non-energy services, illustrated in the next Chapter. In those mentioned Tasks, the LHC of Dijon and Turku have shaped a number of interesting business models addressing several IEs, and hence applied them to implement solutions.

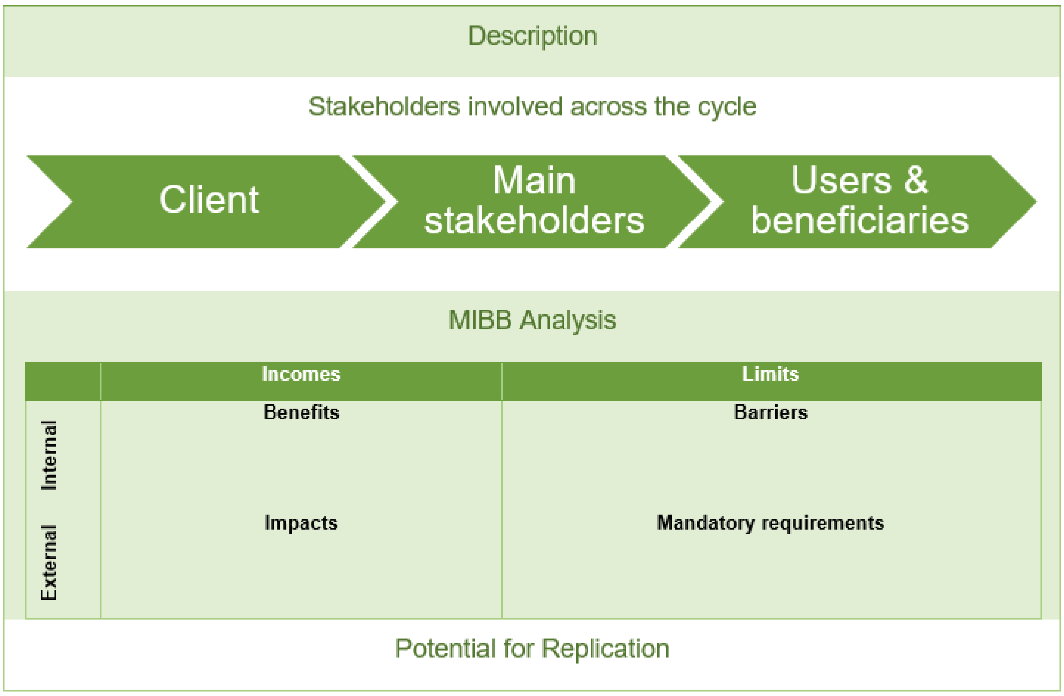
During the analysis, the importance of providing smooth and handy guidance on BM emerged; therefore, it was decided to convey the key messages of successful business cases into factsheets, named “BM Factsheets”.

It is important to underline that the BM Factsheets illustrate how the BMs have been transposed in specific business cases, so the message delivered by a factsheet is that of an implemented solution thanks to a business model, not a quick guide on a generic business model. These key messages resulted to be, for each BM:

- Description of the solution;
- Stakeholders involved across the cycle;
- Mandatory requirements, Impacts, Benefits and Barriers (MIBB) analysis;
- Potential for replication (easy to apply somewhere else, applicable with customization, need for major adjustments on case-by-case basis).

For the creation of this portfolio, a simplified template has been shaped in order to smoothly illustrate the key elements of each business case; the template also allows to have a portfolio of examples providing (as much as possible, indeed) the same kind of information case by case (Table 1).

Table 1: BM Factsheet Template



Moreover, among a wide set of potential business cases to pick, only those who appeared to be in a mature stage have been selected for this Deliverable. The result is the following list of 12 factsheets, with indication of the respective IE:

- Bifacial PV Balustrades (IE 1.1.3 - Table 2);
- Ready to Service (R2S) compliant Digital Architecture & building operating system (BOS) (IE 1.2.1 - Table 3);
- Collective self-consumption (IE 2.1.1 - Table 4);
- Artificial Intelligence (AI) enabled dynamic management of energy (IE 1.2.3 - Table 5);
- iBoard of Datanumia (formerly NetSeenergy) (IE 4.1.3 - Table 6);
- Indoor Climate for building energy efficiency/ energy saving/ human thermal sensation control (IE 1.2.8, IE 1.2.9, IE 1.2.10 – Table 7);
- New generation heating and cooling solution with prosumer collection to energy networks (IE 2.2.5 – Table 8);
- Vehicle to Grid (V2G) Charging Solutions for Flexibility Services (IE 3.1.3 - Table 9);
- Smart City Lighting Poles (IE 4.1.12 - Table 10);
- Air Quality Modelling (IE 5.2.5 – Table 11);
- Air Quality Sensors (IE 5.2.5 – Table 12);
- Smart City Knowledge Graph AI (IE 4.1.7 - Table 13).

In the following pages, the mentioned factsheets derived from the two specific deliverables of the LHC are presented. For a full understanding of each specific BM, the reader is invited to address the two mentioned deliverables of RESPONSE where details are provided (D5.3 and D5.4).

Table 2: BM Factsheet #1 - Bifacial PV Balustrades (IE 1.1.3)

Description

Bifacial PV (BiPV) balustrades are based on double laminated glass with bifacial cell technology embedded on it, for minimizing the roofs' overload and the casted shadows over the PV arrays.

Stakeholders involved across the cycle

Client: Social landlords, GDH and Orvitis → Main stakeholders: OnyxSolar, Bouygues, EDF, control offices, architects → Users & beneficiaries: Social landlords, DM, collective self consumption participants including residents

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** The implementation of BiPV balustrades allows maximizing PV production for the perimeter of the roofs from front and rear side.	**Barriers** Costs of raw materials (higher than expected due to the recent increase) and certifications (cf. Hereinbelow).
External	**Impacts** Aesthetic vision of buildings with photovoltaic roofs could divide opinions. Increase the renewable share of the city energetic mix.	**Mandatory requirements** In France, the BiPV balustrades must be IEC and ATEX certified.

Potential for Replication

Easy to apply somewhere else. For example, in Dijon several replication perspectives have been observed (i.e.: the other buildings of Fontaine d'Ouche district, all the other buildings of the municipality, the buildings of the 2 landlords, the hospital and the university).

Table 3: BM Factsheet #2 – Ready-to-service (R2S) compliant Digital Architecture & BOS (IE 1.2.1)

Description

Interoperable and shared digital architecture allowing convergence of building data, the building operating system orchestrates and coordinates these data.

Stakeholders involved across the cycle

- Client: Social landlords, GDH
- Main stakeholders: WITTYM (provider),data providers (water, electricity, heat distributers)
- Users & beneficiaries: Social landlord's technical and administrative team, OGGA(data exchange)

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** Overview of building's behaviour. Minimize maintenance costs by detecting and effectively treating incidents (such as fire, water damage, death of isolated people, preventive maintenance). Improve residents' satisfaction.	**Barriers** Connecting the BOS WITTYM to the IP network which will connect equipment of all the dwellings.
External	**Impacts** Accelerate migration to smart buildings by encouraging other buildings to do it. Reduce the environmental impact of storage on data centre.	**Mandatory requirements** GDPR: Agreement of residents required.

Potential for Replication

Easy to apply somewhere else

Table 4: BM Factsheet #3 – Collective self-consumption (IE 2.1.1)

Description

Operation enabling the local production of electricity and energy to share among a large number of consumers with no pre-existing relationship with the production site.

Stakeholders involved across the cycle

Client: Dijon metropolis, social landlords	Main stakeholders: EDF, Enedis, ONYXSolar, Kemiwatt & Sirea	Users & beneficiaries: CDD, social landlords, participants:inhabitants

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** The operation of collective self-consumption will enable to consume low-Carbone energy and reduce the cost of energy supply to each participant.	**Barriers** Designated legal entities (in French Personnes morales organisatrices = PMO) are responsible for the collective self-consumption operation within their patrimonial perimeter (e.g.: Orvitis is responsible for its tenants)
External	**Impacts** Reduce greenhouse gas emissions by producing and consuming locally, reduce pressure on electrical network, and problems related to energy supply.	**Mandatory requirements** Social landlords need the agreement of inhabitants in order for them to participate to the operation.

Potential for Replication

Easy to apply somewhere else. For example, in Dijon several replication perspectives have been observed (i.e.: the other buildings of Fontaine d'Ouche district, all the other buildings of the municipality, the buildings of the 2 landlords, the hospital and the university).

Table 5: BM Factsheet #4 – Artificial Intelligence enabled dynamic management of energy (IE 1.2.3)

Description

Eco-Touch tool builds the real thermal model of the building and propose monitoring scenarios without altering the occupants' freedom, thus allowing a forecasting of the heating consumption for limiting the peak.

Stakeholders involved across the cycle

Client: Social landlord Grand Dijon Habitat → Main stakeholders: GDH, OGGA (provider), WITTYM → Users & beneficiaries: social landlord GDH, inhabitants

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** Predict consumption in order to reduce its peaks, reduce heating consumption by 15%.	**Barriers** Install equipment (radiators, valves) in dwellings needs the acceptance of the system by the residents.
External	**Impacts** Transform buildings to smart buildings, no major impact on people's daily life.	**Mandatory requirements** Legal: regarding personal data collected into the apartments, data security needs to be ensured.

Potential for Replication

Easy to apply somewhere else

Table 6: BM Factsheet #5 – iBoard of Datanumia (formerly NetSeenergy) (IE 4.1.3)

Description

A remote energy-monitoring tool in order to follow multi-fluid consumption and production and assess energy performance of Positive Energy Buildings (PEBs).

Stakeholders involved across the cycle

Client: Dijon metropolis → Main stakeholders: EDF/Datanumia, Dijon Metropolis, Energy suppliers(as data providers),social landlords → Users & beneficiaries: Dijon metropolis, social landlords

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** Offer a data monitoring tool with the finest grain (regarding legal and technical barriers) for a more precise piloting from the corresponding operators.	**Barriers** Agreement on data scales and typologies regarding data requirement and technical possibilities.
External	**Impacts** Data sharing and transparency. Raises public awareness of energy issues and consumption.	**Mandatory requirements** GDPR / Data owners' policies: Need to ensure data security measures.

Potential for Replication

Applicable with customization. It is necessary to check all the points where some measurements can be made in order to feed correctly the iBoard (Depending on the use case, it could be necessary to add specific sensors, like Wattmeter).

Table 7: BM Factsheet #6 – Indoor Climate for building energy efficiency/energy saving/human thermal sensation control (IE 1.2.8, IE 1.2.9, IE 1.2.10)

Description

Three innovative solutions closely interrelated in terms of building HVAC energy efficiency, energy saving and resident thermal comfort: to provide better living comfort for the tenants, reduce waste of energy related to overheating/supercooling, and lower operating energy consumption costs for the property owners:

- a new high performance ventilation system (IE 1.2.8): thanks to highly efficient heat pump, heat recovery and energy recirculation system, it is possible to reduce energy consumption from 79.000 kWh to 15.000-20.000 kWh/building
- a new human thermal sensation control system based on the HTM (Human Thermal Model) technology and implemented with eGAIN clouds for data exchange (IE 1.2.9): this solution allows to calculate the indoor climate control signals and regulate them in compliance with the in and out energy balance of the building HVAC systems
- EnOcean technology-based smart radiator thermostats (IE 1.2.10) to guarantee the signals reception and distribution: this technology will allow to update easily the internal setpoint values with external signals.

Stakeholders involved across the cycle

Client: Building and property owners; providers → Main stakeholders: designers, provider, installers, maintenance, etc. → Users & beneficiaries: building users & providers

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** The individual thermal comfort optimization for the building users improves the living and productive work conditions. The internal parameters correct setting allows to reduce overheating and supercooling and consequently minimize energy waste. By reducing energy consumption, it is possible to reduce economic cost from peak consumption based and reduce CO_2 emissions.	**Barriers** The most important technical requirement is the presence of the DH distribution system. Furthermore, most of the existing radiator thermostats do not support wireless data communication or smart features. In order to optimize smart individually heating concepts, it is important to use new thermostats like energy self-sufficient wireless EnOcean technology based. Currently the cost of this type of smart radiator thermostats is higher than typical models.
External	**Impacts** Constructors and service providers can deliver better solutions for their customers. Facility managers delivers a maintenance-free smart individual thermal comfort solution and gets satisfied customers. In the market dynamic, the success of competitive products and services add values for business owners.	**Mandatory requirements**

Potential for Replication

Applicable with customization

Table 8: BM Factsheet #7 – New generation heating and cooling solution with prosumer collection to energy networks (IE 2.2.5)

Description

Due to the global warming, the building cooling demand could likely to increase while the heating need could likely to decrease. Through the presence of the district heating/cooling network, Turku Energia is planning to use waste heat from one set of customers (e.g., building owners, tenants) to produce heat and cooling for another set of customers. In this new dynamic business model, the traditional heating/cooling customer could operate as a producer (prosumer) of the district heating/cooling. Surplus heating/cooling energy is produced to the building and sold back to the network provider. The energy sale is regulated by dynamic pricing, which is based on a variable price list for selling/buying district heating/cooling. The main parameters affecting the price trend will be the variation of outdoor temperature and other market prices (e.g., electricity market hourly price).

Stakeholders involved across the cycle

- Client: Building and property owners; tenants
- Main stakeholders: DH distribution system owner; property owners; energy service consulting, providers, maintenance, etc.
- Users & beneficiaries: building users & providers

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** The customers could sell their extra heating/cooling energy and get economic benefits.	**Barriers** The most important technical requirement is the presence of the district heating/cooling network and the pipeline adaptation to the purpose. In order to support the dynamic model and enable leading by data, powerful IoT platform service is required.
External	**Impacts** By selling waste heat to the network, it is possible to support the project of provide district heating and cooling in the area from 100% renewable sources.	**Mandatory requirements**

Potential for Replication

Need for major adjustments on case-by-case basis

Table 9: BM Factsheet #8 – V2G Charging Solutions for Flexibility Services (IE 3.1.3)

Description

With the purpose of improving the energy grid flexibility and stability and giving support to the grid regulation market for ancillary or load flexibility services, two V2G (Vehicle to Grid) charging stations (each with three units of 22 kWe) will be deployed in Turku LHC Student Village PED area. The V2G systems will be connected directly to the four retrofitted buildings. By creating a microgrid based on LVDC technology, FerroAmp will support the development of the smart Energy Management System (EMS). This system, implemented as a cloud service, will collect data and control power flows at the distribution network connection points. Thanks to FerroAmp contribution and its bidirectional inverter it will be possible to control energy flows from different systems and optimize them between different level of distribution networks.

Stakeholders involved across the cycle

Client	Main stakeholders	Users & beneficiaries
Client: distribution system owners; electric vehicles users; building and property owners.	Main stakeholders: distribution system owners; charging station operators; property owners; providers, maintenance, etc.	Users & beneficiaries: building users & electric vehicles users

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** Through V2G charging stations the EV owners could get lower electricity bill or compensation for providing ancillary services towards the grid. It will be more control of local energy use and it could be a better mitigation of fluctuating electricity prices and tariffs. In addition, V2G enabled cars can reduce the large energy storage need in the facilities since collectively EVs will provide significant battery capacity functioning as back-up BESS, which will benefit the building and property owners.	**Barriers** The whole system is very complex and needs to be designed with the same technology and with a high degree of interoperability and scalability allowing for customized configurations. If the V2G technology would become too expensive and therefore available only to who could afford it, it will result in a less democratic way of contributing towards a society free from fossil energy.
External	**Impacts** The V2G technology systems will be able to contribute with their capacities in the grid regulation market for ancillary or load flexibility services, including support for power peak demands. By diffusing EVs it will be possible to reduce pollution in the air, fossil fuels consumption and improve the efficiency of the grid.	**Mandatory requirements** There are various standards and regulations tied to the EV as a product. Technology standardization, cyber security and regulation compliance need to be considered to ensure a safe operation across international markets.

Potential for Replication

Applicable with customization

Table 10: BM Factsheet #9 – Smart City Lighting Poles (IE 4.1.12)

Description

In order to provide 5G connectivity and connect IoT data with other smart city data, 10 smart street lighting poles will be installed in the PED area of Turku. Each pole on its own does not produce or receive any information but serves as a platform for the devices integrated into it. To realize a high-speed 5G network for very fast data transfer, the poles, developed by the company Sähkö-Jokinen, are combined with 5G technology. Through this solution it will be possible to collect and control data with many different types of pole-installed sensors and devices, such as air quality or traffic volume sensors.

Stakeholders involved across the cycle

Client: municipality & public organisation; data collectors → Main stakeholders: providers; 5G network operator; municipality & public organisation; maintenance, etc. → Users & beneficiaries: citizens; researchers

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** By using the existing electricity network, it is possible to develop a 5G network extensive enough for fast data transmission.	**Barriers**
External	**Impacts** With smart lighting poles any city can easily transform their regular lighting infrastructure into a smart one with supporting 5G network.	**Mandatory requirements** Between the pole production processes, the hot dip galvanization to prevent corrosion is one of the most nature-impactful process. To reduce the carbon footprint, it is important to consider possibility to apply another protective layer.

Potential for Replication

Easy to apply somewhere else

Table 11: BM Factsheet #10 – Air Quality Modelling (IE 5.2.5)

Description

The developed business model is based on the idea that high resolution and frequently updating air quality information can be provided on a timely fashion and be utilized in various third-party applications. The air quality forecasting system (FMI-ENFUSER) integrates several state-of -the art information sources for the prediction of urban air quality (e.g.: local air quality measurement, regional air quality forecast, numerical weather prediction data by meteorological model). FMI-ENFUSER will use all available air quality measurement stations in the area, and thanks to 5G network the model accuracy will be increased. In addition, based on such monitoring, the data when accumulated may also be able to provide suggestion for the users.

Stakeholders involved across the cycle

Client: municipality & public organisation; citizens; 3rd party applications → Main stakeholders: municipality & public organisation; supportig partners; providers; maintenance, etc. → Users & beneficiaries: citizens; 3rd party applications

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** City gets value by providing AQ information for its citizens. A better city planning, for AQ intervention actions, could be implemented. Potential users, such as health professionals, may be able to relate specific health symptoms of their clients due to personal AQ exposure.	**Barriers**
External	**Impacts** Core Partner gets business value from the access of new kind of information which can use in combination of other data types in their data service.	**Mandatory requirements**

Potential for Replication

Easy to apply somewhere else

Table 12: BM Factsheet #11 – Air Quality Sensors (IE 5.2.5)

Description

Through the new 5G network installation, new innovative air quality sensors will be installed in PED area and other representative sites around the city of Turku. These particulate matter sensors enable the extraction of real time air quality information which facilitates the assimilation of model predictions. According to the Finnish Meteorological Institute (FMI) this solution would have the potential to impact and increase the data on the air quality, exposure to pollutants and their health effects as well as on climate warming effects of black and brown carbon.

Stakeholders involved across the cycle

- Client: municipality & public organisation; citizens; 3rd party applications
- Main stakeholders: municipality & public organisation; installers; providers; maintenance, etc.
- Users & beneficiaries: city; citizens; 3rd party applications

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** City and individual citizens will be able to benefit from a better information on the air quality, regarding the concentration and depositions of CO, NO, NO_2, O_3, SO_2, PM_{10} and $PM_{2.5}$ in the installation area. The better information will help to making decisions to improve air quality and reduce health effects	**Barriers** Currently, the accurately identification and quantification of the emission sources in an urban setting is very complex. The network expansion and used instruments are very important. The limits for a correct analysis are: high cost of components, large size of the units, complicated installation and the exploitation process, resource heavy maintenance.
External	**Impacts** The sensors hardware might have the potential to recirculate consumable parts.	**Mandatory requirements**

Potential for Replication

Easy to apply somewhere else

Table 13: BM Factsheet #12 – Smart City Knowledge Graph AI (IE 4.1.7)

Description

With the aim of producing a hugely valuable source of data that offers unprecedented insights into various smart city problems, the Smart City Knowledge Graph has been implemented. This solution is a network-like structure that combines various smarty city data into a unified entity consisting of interconnected nodes and edges. Provides a natural and intuitive way for describing real-world concepts and their relationships. Data in the graph is automatically processed using advanced computational models and algorithms developed in close cooperation with University of Turku (UTU). In RESPONSE, the aim is to extend the current data model and create new interfaces to fetch the relevant smart city data into the Smart City Knowledge Graph.

Stakeholders involved across the cycle

- Client: municipality & public organisation; citizens; 3rd party applications
- Main stakeholders: municipality & public organisation; data providers; software developers; etc.
- Users & beneficiaries: city; citizens; 3rd party applications

MIBB Analysis

	Incomes	Limits
Internal	**Benefits** Through the combination of different types of data, it will be possible to connect several smart city concepts (e.g., streetlight, buildings, addresses, local transportation) and find solutions to city and citizens complex questions. By comparing existing city KPIs to measured data, it will be possible to measure progress and improve city strategy.	**Barriers** Appropriate software and hardware infrastructure are required for operating the platform.
External	**Impacts** By reusing city data assets will make more useful the ecological footprint of data collection and storage.	**Mandatory requirements**

Potential for Replication

Applicable with customization

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Chapter 3

Identification of Other non-Energy Services

Chapter 3 – Identification of Other Non-Energy Services

The scope of this Chapter is to explore and identify other Non-Energy-Services. The analysis has been based on a literature review process (papers, research on the same topics, sectorial guidance).

Non-Energy Services can be defined as secondary services that are offered in addition to the primary services that are focused on saving energy consumption and energy costs. Non-Energy related services refer to impacts often delivered by energy improvements beyond energy savings. Some examples include improved indoor air quality due to enhanced ventilation, comfort, increased asset value and productivity.

Especially in the segment of residential buildings, existing technologies offer several possibilities related to comfort, air quality, noise control or surveillance.

This set of services deals with additional services for domestic users, not related with efficiency or flexibility. In other words, these services do not generate a revenue stream by means of the direct application but opportunistically take advantage of the digital platform and the analytic engines to offer value-added services for which users are willing to pay.

Among these services, comfort preservation by monitoring of comfort parameters and automatic control of HVAC systems could be of high interest for many domestic users. Other parameters such as air quality, noise or presence / consumption for security service provision are envisaged. These services have, by definition, no influence on energy performance and the intended benefit performance (comfort, noise, quality, security) is rather subjective and difficult to measure.

Four macro families of non-energy services are identified for buildings.

- **(Thermal) Comfort services**. Comfort preservation and automation at minimum energy costs. Requires comfort parameter sensors, smart controls and switches;
- **Indoor air quality preservation**. Preservation of Indoor air quality by means of air quality sensors. Smart ventilation;
- **Noise reduction services through Noise sensors**. Scheduling of noise devices and appliances at certain periods of time, smart ventilation, others;
- These energy services use real-time data to monitor comfort parameters, consumption and indoor air quality parameters (CO_2 concentration) to proactively operate (through algorithms) the HVAC system or the ventilation system. The algorithms shall be trained to learn about the building thermal performance, the reaction time to setpoint changes and the user's preferences when they interact with the system. The service provides an automatic regulation and control of the HVAC systems based on this forecast at real time, the outside weather conditions and the building thermal performance, thus ensuring that the indoor temperature and other comfort

parameters are kept within range at all times at the minimum energy cost. Value added for users: users gain comfort in an automated way without an increase in energy consumption by means of artificial intelligence and trained forecast algorithms;

- **Security and surveillance services**. Presence sensors, scheduling of lighting at night / absences to create a dissuasive security system.
- This energy service uses real-time data to monitor presence in a dwelling and automation systems to schedule lights and appliances switch on and off at night or in absence of the dwellers, to create a dissuasive security system. Information about unexpected energy consumption can also be used to identify illegal occupation of dwellings. Ultimately, this system could communicate to the police, or to private security companies to set off alarms or give warnings of possible trespassing or private property violations.
- Value added for users: use advanced digital technology and data platforms to add one important domestic service such as the security and surveillance.

Looking at the macro-categories identified above, a selection of non-energy services relevant to the building environment is presented in the list below:

- **Heating and cooling:**
  - individual room control with occupancy detection
  - control of heating system based on local predictions
  - advanced central automatic control with intermittent operation and/or room temperature feedback control
- **Domestic Hot Water**:
  - automatic control based on information about context conditions (electricity prices, local generation, etc.)
- **Ventilation**:
  - local Demand Control based on air quality sensors
  - real time monitoring & historical information, warning in case of occupant actions (e.g.: window opening)
- **Lighting**:
  - automatic occupancy-based lights control
  - automatic dimming
- **Windows and fixtures**:

  - predictive blind control (based on weather forecast)
  - centralized coordination of operable windows (for natural cooling purposes)
- **Noise**:
  - noise level sensors to provide input to utilities (HVAC)
- **Other non-energy services**:
  - road illumination sensors – a smart motion sensor street lighting control system that automatically activates when a car or pedestrian is noticed in the area
  - traffic management sensors – traffic surveillance and monitoring system are pre-requisites for any efficient traffic control system. Sensors (non-intrusive traffic detection devices, video cameras and video image processing, etc.) can be installed on roadways to obtain the necessary geographical and critical time coverage to inform the road management system
  - waste management sensors - smart sensors can be incorporated with fleet management and intelligent routing software for a comprehensive waste collection process, to receive alerts for fill level, bin temperature and other input to prioritise activities.

The impact associated to the listed non-energy services can be categorized under three main categories, namely (Table 14):

- Comfort: this impact category refers to the impacts of services on occupant's comfort. Comfort refers to conscious and unconscious perception of the physical environment, including thermal comfort, acoustic comfort and visual performance;
- Convenience: this refers to the impacts of services on convenience for occupants, i.e. the extent to which services "make life easier" for the occupant;
- Well-being and health: referring to the impacts of services on the well-being and health of occupants.

Table 14: Selection of Non-Energy Services and Related Impact

	Non-energy service	Macro Family	Impact
1	Individual room control with occupancy detection	Thermal Comfort services Indoor air quality preservation Noise reduction services Security and surveillance services	Comfort
2	Control of heating system based on local predictions	Thermal Comfort services	Comfort

	Non-energy service	Macro Family	Impact
3	Advanced central automatic control with intermittent operation and/or room temperature feedback control	Thermal Comfort services Indoor air quality preservation	Comfort Convenience Well-being and health
4	DHW Automatic control based on information about context conditions (electricity prices, local generation, etc.)	Thermal Comfort services	Comfort Convenience
5	Local Demand Control based on air quality sensors	Indoor air quality preservation	Comfort Convenience Well-being and health
6	Real time monitoring & historical information, warning in case of occupant actions (e.g.: window opening)	Security and surveillance services	Convenience Well-being and health
7	Automatic occupancy-based lights control	Comfort services	Comfort Convenience
8	Automatic dimming	Comfort services	Comfort Convenience
9	Predictive blind control (based on weather forecast)	Thermal Comfort services	Comfort Convenience
10	Centralized coordination of operable windows (for natural cooling purposes)	Thermal Comfort services Indoor air quality preservation	Comfort Convenience
11	Noise level sensors to provide input to utilities (HVAC)	Noise reduction services	Comfort
12	Road illumination sensors	Transport and mobility	Comfort Convenience
13	Traffic management sensors	Transport and mobility	n.a.
14	Waste management sensors	Waste management	Convenience

Some of the Non-Energy services can be associated with some of the Non-Energy benefits (NEB) or so-called Multiple benefits of energy efficiency (like improved comfort), whereas others are rather auxiliary services that are required to satisfy customers' more global needs (like maintenance).

NEBs are an array of positive and negative effects of energy efficiency programs, beyond energy and associated savings on the energy bills. Over the last 20 years, a wide range of NEBs have been identified in studies and literature allows to sort these benefits into three "perspectives" based on the beneficiary of the effect[1]:

[1] Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California https://assets.ctfassets.net/ntcn17ss1ow9/1LNLp3UBSjYLSaWv5BGyss/13518eaf1453294dd8e40cc8ca3d5871/LIEE_Non-Energy_Benefits_Revised_report.pdf

- utility system: these are indirect costs or savings to the utility and its ratepayers. They include bill payment improvements, infrastructure savings;
- society: these impacts are indirect program effects beyond those realized by utilities, their ratepayers, or program participants, but accrue to society at large. The several potential societal effects belong to the categories of emissions, job creation/economic development, hardship benefits (employment scores, family stability, mobility, and reduced dependence on state benefits), other (health, infrastructure (water and power) and national security impacts);
- participants: operations and maintenance, comfort, productivity.

These benefits are therefore the resulting consequence of the non-energy services once implemented. Table 2 summarizes the most common NEBs related to the selection of non-energy services.

Table 15: Examples of Non-Energy Benefits by Beneficiary[2]

Utility System	Participants/Users	Society
Reduced carrying cost on arrearages	Control over bill and energy decisions	Economic development benefits, including job creation, increase in personal income and state GDP benefits
Reduced shutoffs/reconnections	Improved indoor air quality	Improved air quality and reduced healthcare costs
Fewer notices, calls and collection costs	Improved health Improved comfort	Attracting businesses that demand clean energy and energy efficiency
Insurance premium savings	Bill savings	Energy security
Reduce ancillary services costs	Improved property values	Preservation and affordable housing
Improved power quality and reliability	Improved aesthetics/appearance	
Reduced subsidy payments	Fewer shutoffs and reconnections	
Lower transmission and distribution losses	Lower operating and maintenance costs	
	Improved employee productivity and retention	
	Reduced tenant turnover	

The quantification of the listed benefits is a hard excercise unless specific boundary conditions are set for each individual case.

The materiality of benefits may concern energy savings (kWh, m3, liters of fuel, etc.), water savings, resources savings, CO_2 emissions reduction, economic savings. Savings can be quantified in % compared to the baseline

[2] https://www.mwalliance.org/sites/default/files/media/NEBs-Factsheet_0.pdf

scenario and depend on many factors such as the users' behaviour, the quality of the technologies installed, the accuracy of forecast.

It is not possible, therefore, to provide a realistic quantification of savings so as to be applicable to the majority of cases. The assumptions underlying the quantifications would make estimates not accurate and affected by tolerances exceeding ±100%.

The Deliverable D5.11 ("Novel Smart City Business Model portfolio and non-energy services Business models – V2") will be providing some case studies, where a number of solutions will be quantified in their real environment.

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Chapter 4

Main Outcomes and Conclusions

Chapter 4 – Main Outcomes and Conclusions

The analyses carried out for the preparation of this Deliverable allowed to identify the key elements of a number of promising business models, thus offered to the Cities for a smooth overview of the whole processes. The ultimate goal of the analysis on BM is to help the cities increase their capacity to attract investments.

Hence, the analysis shall be deepened by entering the details of a specific business model of interest, as properly described by RESPONSE in the D5.3 and D5.4.

The factsheets of each business model illustrate the main elements involved in the process: a description of the solution, the identification of the stakeholders involved across the cycle, the MIBB analysis and eventually the potential for replication. Since the IEs have been originally selected also thanks to their flexibility and high potential for replication, as well as for their degree of maturity, one of the results of the analysis has been that most of the business models can be replicated in other cities, of course after proper customization, without major needs for adjustment.

Through literature review, a list of non-energy services has been identified along with the description of the related benefits. Non-Energy Services are secondary services that are offered in addition to the primary services that are focused on saving energy consumption and energy costs. Non-energy related services refer to impacts often delivered by energy improvements beyond energy savings. Some examples include improved indoor air quality due to enhanced ventilation, comfort, increased asset value and productivity. In other words, these services do not generate a direct revenue stream but bring to additional benefits (the so called non-energy benefits) for which users are willing to pay in return.

In D5.11 (“Novel Smart City Business Model portfolio and non-energy services Business models – V2”), these same elements will be fine tuned; additional examples will be brought, wherever the screening through research reveals new interesting elements and/or upon new achievements of the RESPONSE cities worth mentioning.

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