Technical annex section 1-3

BUNDLING INNOVATIVE SERVICE ECOSYSTEM FOR THE BUILDING SECTOR

ARYES

List of participants

Participant No. *	Short name	Participant organisation name	Country
1 (Coordinator)	UPC	Universitat Politècnica de Catalunya	Spain
2	AAU	Aalborg University	Denmark
3	NEO	Neogrid Technologies	Denmark
4	CCB	Confédération Construction Bruxelles-Capitale / Confederatie Bouw Brussel-Hoofdstad	Belgium
5	BED	Baskent Electricity Distribution Company	Turkey
6	VGT	Vilnius Gediminas Technology University	Lithuania
7	VIA	Vilnius Industry And Business Association	Lithuania
8	BSC	Barcelona Supercomputing Center	Spain
9	COM	COMSA SA	Spain
10	ADV	Advantic sistemas y servicios SL	Spain
11	SLX	Seluxite A/S	Denmark
12	BAM	BAM Belgium nv	Belgium

Abstract

The building sector is one of the priority areas in Europe with regard to energy efficiency due to its intensiveness in energy consumption and its low performance. Moreover, Europe is prioritizing the electrification of the energy market, and shifting to a decentralised energy generation and control, in parallel with market liberalization.

In this context, heating, ventilation and air conditioning (HVAC) systems offer an opportunity to provide intelligent mechanisms, which improve the performance of buildings and add flexibility to the building's energy consumption, while allowing buildings to be included in the new energy market paradigm.

The shift to a service-oriented approach, also called servitization, of HVAC optimization mechanisms enables to create small and very specialized services that, orchestrated together, can provide benefits to energy consumption as well as non-energy services such as comfort and energy prediction. Therefore, servitization promotes the introduction of new stakeholders in the construction value chain.

The ARYES project will focus on the development of an ecosystem of services with a high Technical Readiness Level that will be demonstrated in the scope of realistic environments. The ARYES solutions will be applied in 4 demonstration sites, and then be replicated in 20 other buildings in market conditions. The sites pertain to different market segments comprising schools, commercial areas and office complexes, in 5 European countries (Spain, Denmark, Lithuania, Belgium and Germany). The consortium is formed by stakeholders covering all relevant stages of the construction value chain, to guarantee the proper implementation of trials, validation and evaluation activities, and to ensure replicability and scalability of project results. A streamlined measurement pipeline will support the evaluation of the savings and the forecast of the benefits, also relating them to investments into HVAC optimization techniques and renewable energies.

Table of Contents

List of figures

List of tables

1 Excellence

1.1 Objectives

1.1.1 Context

Buildings are responsible for approximately 40% of the final energy consumption and 36% of greenhouse gas emissions in the EU, and 75% of the building stock is energy inefficient (European Commission, 2019). As a consequence, the building sector is one of the priority areas in Europe with regard to energy efficiency, not only because it consumes a great amount of energy, but also because it remains greatly inefficient.

Buildings consume energy in their entire life cycle, but 80-90% of their life-cycle energy is consumed during the operational stage (Huang et al., 2018). One challenge in the building sector is to optimise the heating, ventilation, and air-conditioning (HVAC) systems because they consume half of the operational energy used in a building (Bianchini et al., 2019). Moreover, HVAC systems often work inefficiently.

In parallel, large scale electrification of the energy system coupled with deployment of renewables is a strategic priority for the EU agenda. Moreover, the electricity market is moving to a new paradigm in order to carry out a modernization and optimization of the existing grid (Reynolds et al., 2017). In the new paradigm the centralised approach to generation and control is replaced by a decentralised system enabling the bidirectional flow of energy and communication between energy market and consumers. In addition, the new paradigm is promoting the liberalisation of the energy market. This new paradigm requires that existing consumers become an active actor in the energy market, and not just a consumer of energy, and thus become prosumers of energy, and services at demand side can be instrumental in this sense.

In this context, HVAC systems offer a big opportunity to implement services in order to reduce the building energy consumption and enable flexibility of the buildings energy consumption, the latter being important for its potential to shave off energy consumption peaks. Those services, mixed with prediction of buildings energy consumption and production, will help to introduce local energy production based on renewable resources in the energy market.

Nowadays, these functionalities have been prototyped and tested in relevant environments, but some barriers are still relegating them away from full commercial application. Lack of interoperability, standardization, and general high entrance barrier force actors in the construction industry to implement a great deal of the value chain to be able to offer these functionalities. Even though there exist frameworks to facilitate the application of advanced functionalities in other industries, the construction industry lags behind. Applying the service oriented approach would enable to lower this barrier, by enhancing the inherent interoperability between the different actors, allowing each actor to focus on its business expertise, and bundling together the functionalities of each end energy users service.

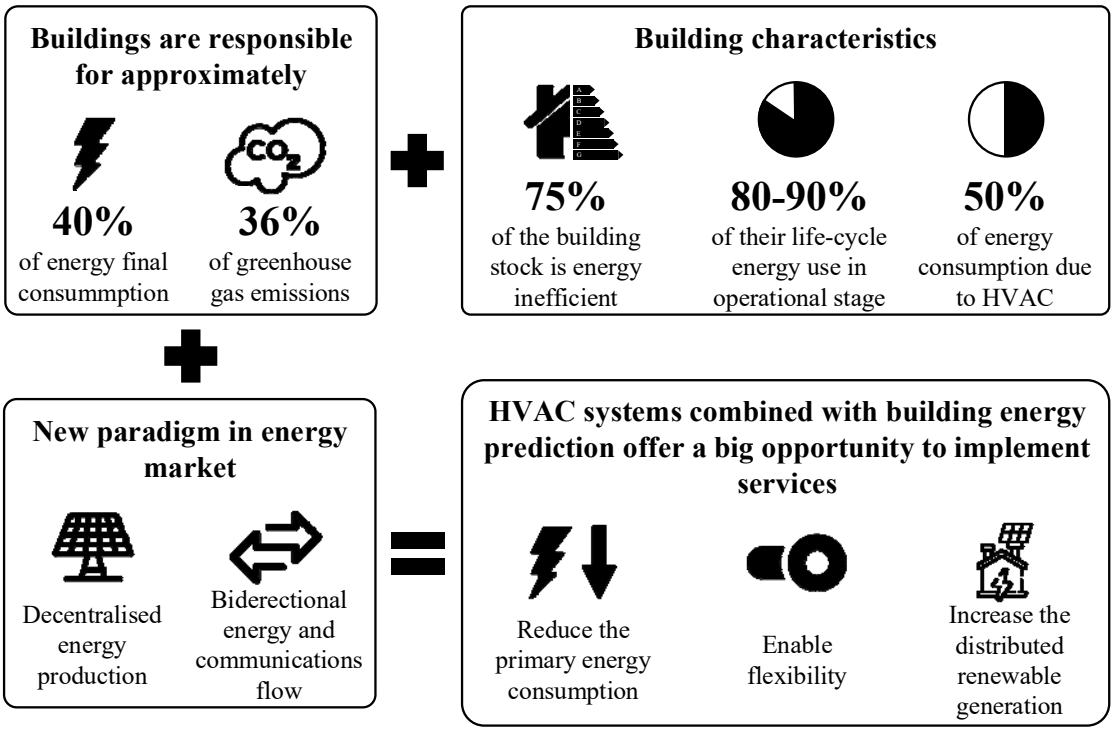

Figure 1. Project context

1.1.2 Overall and specific objectives

The overall objective of the ARYES project is to develop and validate an ecosystem of innovative services for the building sector in order to reduce the buildings' primary energy and facilitate the implementation of renewable energies.

The ecosystem of services will offer to the end users 3 main sets of services, organized into 3 service families: HVAC optimization services, building energy prediction services, and energy saving certification services. These services will be supported by services for model calibration, weather and climate, and general support services, organized into 3 service families that are not supposed to be accessed by the customer. The service-based structure of the ecosystem will support the viability of each service family, improving interoperability, encouraging the competition between service providers within each service family, and allowing each service provider to specialize its business function while still facilitating its interaction with other actors in the ecosystem.

The overall objectives of ARYES project are:

- To eliminate technical barriers to the usage of HVAC predictive and adaptive control optimization techniques and renewable energies in buildings.
- To create an ecosystem of services that covers the whole construction value chain, having low entrance barrier and proven socio-economic benefits.
- To demonstrate that the ARYES end energy services are effective in achieving high general level protection of the environment as a whole, and that it can be implemented in the building sector under economically and technically viable conditions.
- To increase the confidence of construction actors in order to increase the investment in HVAC control systems and in renewable energies.
- To valorise big data generated by smart meters, smart devices and sensors of existing buildings to create monitoring and validation tools, to label and certify energy services.

The specific objectives (SOBJ) of the ARYES project are listed below:

- **SOBJ 1.** Ecosystem: To design and develop a service-oriented ecosystem, bundling different services together in order to create more advanced and specialized services.
- **SOBJ 2.** Demonstrators implementation: To implement the integrated ARYES ecosystem in the three demonstrators described in the proposal.
- **SOBJ 3.** Demonstrators monitoring and evaluation: To monitor and evaluate the energy and cost savings as a result of the implementation of the service ecosystem.
- **SOBJ 4.** Demonstrator validation: Based on the achieved energy and cost savings, to show evidence of the recovery of the investment, and thus of the sustainability of the ARYES business model on the medium and long term.
- **SOBJ 5.** Definition of methodologies: To develop a methodology to assess the quality of the proposed services.
- **SOBJ 6.** Continual improvement process: To manage the service lifecycle by means of an iterative process, to make use of evaluation data to improve next generation of the services.
- **SOBJ 7.** Exploitation: To outline a marketing and exploitation plan for the project results.
- **SOBJ 8.** Market replication: To deploy the ARYES technology in twenty additional buildings under market conditions, which will become part of the ARYES ecosystem, in order to reach critical mass and sustainability in the medium/long term.

1.1.3 Measures and indicators

In order to determine during the execution of the project its progress and the achievement of the specific project objectives, a set of measurable results with its success criteria are determined. These measurable results are time-bounded in Table 1 and will be used also as metric for milestones ML3, ML5 and ML7 (see section 3.2.5). The consortium of the ARYES project is composed by partners portraying different profiles and contributing with different expertise, and in fact will have impact on different specific objectives. Table 2 depicts what each partner brings along a specific objective according to its respective experience.

Table 1. Measurable results and success criteria for the specific objectives of ARYES project

Specific objective		Success criteria		
		ML3	**ML5**	**ML7**
SOBJ1	Requirements elicitation	Collection of requirements from industrial partners and external stakeholders	60% of requirements implemented	All requirements implemented
	Platform development	ARYES alpha version to be deployed	ARYES alpha deployed and assessed, beta version ready to be deployed	Beta version deployed and assessed
	Interoperability	Integration in ARYES platform of Arrowhead framework	Cover at least 3 mainstream protocols (e.g.: CoAP, MQTT, OPC-UA)	Demonstrate interoperability with at least 3 leading platforms / middleware (e.g.: FiWare, 61499, INTERCONNECT*)
SOBJ2	Demonstrators implementation	Data to build the demonstrators energy baselines available	Services tested: Support, Weather and climate, HVAC optimization, Energy prediction	All service families tested
SOBJ3	Demonstrators monitoring and evaluation	Operational version of the monitoring platform	Report on midterm evaluation	Report on final evaluation
SOBJ4	Demonstrator validation	-	Report on achieved savings in demonstrators	Report on achieved savings in demonstrators and market replication buildings
SOBJ5	Definition of methodologies	Concept defined	Concept validated in implemented services	Concept validated in all service families
SOBJ6	Continual improvement process	Definition of a continual improvement process	Implementation of an improvement process in the ecosystem	Holistic improvement of services and related business models
SOBJ7	Exploitation	First feedback on proposed business models; First exploitation plan	Second feedback on proposed business models; Exploitation plan updated; Legal framework and types of energy performance contracts available	Final business models, exploitation plans and energy performance contracts available
SOBJ8	Market replication	-	-	Implementation of ARYES ecosystem in 20 buildings different from the initial demonstrator sites

* European project funded by the call DT-ICT-10-2018.

Table 2. Partners contributions in achieving specific objectives

OBJ		**UPC**	**AAU**	**NEO**	**CCB**	**BED**	**VGT**	**VIA**	**BSC**	**COM**	**ADV**	**SLX**	**BAM**
SOBJ1	Requirements elicitation	+	+	+	+	+	+	+	+	+	+	+	+
	Platform development		+	+							+	+	
	Interoperability		+	+							+	+	
SOBJ2	Demonstrators implementation	+	+	+			+	+	+	+	+	+	+
SOBJ3	Demonstrators monitoring and evaluation	+	+	+			+	+	+	+	+	+	+
SOBJ4	Demonstrator validation	+		+			+	+		+	+	+	+
SOBJ5	Definition of methodologies	+			+	+	+		+	+			
SOBJ6	Continual improvement process				+		+	+					
SOBJ7	Exploitation	+	+	+	+	+	+	+	+	+	+	+	+
SOBJ8	Market replication			+	+			+		+	+	+	+

1.2 Relation to the work programme

This proposal relates to the Horizon 2020 work programme topic: LC-SC3-EE-13-2019: Enabling next-generation of smart energy services valorising energy efficiency and flexibility at demand-side as energy resource under the call: Building a low-carbon, climate resilient future: secure, clean and efficient energy.

Table 3. Justification about how the project meets the specific challenges, scope and EU objectives.

Specific challenges of the topic	How ARYES meets these specific challenges
Energy Efficiency services (e.g. Energy Performance Contracting (EPC)) are available on the market already for quite some time. However, there is a **big untapped potential in sectors and with actors not yet engaged in services triggering energy**, CO2 and cost savings.	The ARYES project outlined in this proposal will address the specific challenge identified in the work programme topic by bundling services related with HVAC optimization, building energy prediction and energy saving certification. Those services will offer also **other non-energy benefits depending on the combination of services and the stakeholder involved**. For example, the building energy prediction services can be used **by financers and investors to develop tools to** analyse the risk of refurbishment or renewable energy projects, or can be used by building owners to plan and prioritize building investments. The benefits of ARYES results will be demonstrated by developing proper business models and analysing them in a context of being self-sustainable even after the project ending. In addition, to carry out the energy prediction, weather and climate data in different time horizons (days, weeks, months and years) will be required to achieve accurate predictions. For this reason, the project will explore the possibility to **introduce weather and climate providers** in the construction value chain.
New technologies have emerged opening the door for new types of services which use ICT to better control and steer energy consumption according to market and system needs and to the availability of renewable energy; others are able to integrate energy services with non-energy benefits such as comfort. **By bundling various services and benefits, additional target groups, sectors and financial resources can be accessed.**	The ecosystem will make possible service orchestration across different application areas (HVAC optimization, prediction of energy consumption and production of building, certification of energy saving, weather forecast, climate forecast, access to historical climate data, etc) **to streamline the access of the users to composed services**. Moreover, this will allow to increase interoperability and foster competition between service providers, and to allow for composite services that outperform existing approaches. By bundling energy services, it is expected that new services arise and that new revenue streams appear. In addition, the project aims to develop business models for the developed services using a co-creating methodology. The co-creation methodology involves that all stakeholders of the construction value chain and the consortium are expected to generate innovative business models with different revenue streams coming from different market segments and actors. The implementation of HVAC optimization services can offer a control strategy considering users' comfort, reducing the energy costs, reducing the primary energy and market flexibility. This kind of benefits are usually provided by means of supervisory control and data acquisition (SCADA) systems and/or require a dedicated building energy manager. By locating its intelligence in a set of service constituting a service ecosystem, the end energy user will be able to access the gains of an HVAC optimization service without the need of prolonged costs caused by operating a SCADA. As a consequence, it is possible to offer HVAC optimization services to **additional target groups**, and the viability of the proposed services is increased due to economy of scale. This action will also contribute to improve energy efficiency levels towards the objectives of the 2030 climate and energy framework.
The challenge is **to structure and label the quality of demand side service providers** (like ESCOs aggregators and energy cooperatives) and improve their accessibility for end energy users	Aligned with the specific challenges in the topic description, the ARYES project will develop a methodology **to structure and label the quality of demand side services providers**. In addition, the service ecosystem developed in the project will comprise a service family whose services provide access to the labelling information, increasing the accessibility of end energy users to those services.

Scope of the topic	How ARYES meets the scope
Projects should focus on demonstrating and testing innovative energy services in a real environment, across several market segments and across different actors in the value chain.	The ecosystem built by ARYES project will be demonstrated and tested by means of the creation of **four demonstrators in real environments**, comprising a library, offices, and a residential complex with commercial areas, – see Table 7 in section 1.4.3. Together, the demonstrators will cover all aspects considered in ARYES and thus demonstrate the feasibility of its approach, from both a technological and an economical point of view. In addition, the participation of relevant companies with a significant building stock management (COM, BAM, NEO, SLX and ADV) will ensure that the proposed services will enjoy market replication, which will be tested by performing **replication of the ARYES approach in 20 more buildings under market conditions**. The services are tested across different actors in the value chain: (i) Financer and investors; (ii) Building owners or facility managers; (iii) ESCOs; (iv) Technical support service provider; and (v) aggregators and energy traders.
To be economically viable, these services need to be able to rely on sound measurement and verification methodologies. They should cover several but not necessarily all of the relevant areas and aspects identified above, blending in innovative manner different revenue streams coming from different market segments and they should in all cases include innovative verification and monitoring measures. Moreover, they should demonstrate how potential legal and contractual aspects (e.g. in relation to existing contracts or linked to the use of equipment) have been accounted for.	The ARYES project will take advantage of existing big data generated by smart meters, smart devices and sensors in order to calibrate reduced-order building models. Those models will be used to create a novel methodology to assess energy savings. With this challenge in mind, the project will devote a considerable effort in creating a measurement platform for both online evaluation of the energy savings and potential flexibility, and to support the labelling of the provided services in terms of their historical and predicted effect on primary energy reduction. The same measurement platform will also be applied to renewable energy production, to allow investors and other stakeholders with similar interests to estimate the risk related to investments in sustainable energy. With this strategy the project aims to access to additional financial resources and facilitate the implementation of renewable energies in the building sector. In this way, the project will contribute to achieve the European target objective for 2030 to at least 32% share for renewable energy. Other types of models will be used to capture the characteristics of the service ecosystem itself. Techniques such as formal verification and model checking will be used to prove the ecosystem's robustness, scalability, and other desirable characteristics. A concoction of real and simulated services will be used to test the service ecosystem again heavy workload, to increase the trust of the stakeholders into the technical solution. By considering a real environment, the demonstrators will have to take into account the complexity of current regulations and the social impact of the ARYES results. In fact, considerable efforts will be dedicated to analysing the social and regulatory sides.
Proposals should demonstrate that the tested business models and services are **self-sustainable** after the end of the project. The upfront investments in energy efficiency measures (e.g. upgrading of building energy performance) and in smart building systems should be paid back at least in part by revenues coming from energy savings and remunerated flexibility.	Once the service ecosystem reaches a critical mass, the **increased viability of the services** shall take care of ensuring the self-sustainability of the service ecosystem itself, since more service providers will want to join the ecosystem both to access the services provided, and to offer their own services. Together with the developed business models, which will study economical and financial benefits and required investments of the project, this approach will guarantee the long-term sustainability of our results. Another direction taken by ARYES to ensure self-sustainability of its results after the end of the project, is to create liaisons with other European projects, to both extend ARYES reach, and to increase the generated interest in its results. In particular, we consider to connect along the way to projects by both sharing the knowledge we create, and taking measures for interoperability such as by proposing common ontologies and interfaces.
… contribution from the EU of between EUR 3 and 4 million …	Our budget is aligned with the recommendation, please refer to section 3.4.

Where possible and appropriate, the actions should cooperate with the projects funded under the topics: DT-ICT-10-2018: Interoperable and smart homes and grids, DT-ICT-11-2019: Big data solutions for energy in the WP 5.i ICT, and LC-SC3-ES-6-2018-2020: LC-SC3-ES-5-2018-2020: TSO – DSO – Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation.	The project will create a technical advisory board where coordinators of projects funded by the calls mentioned in the specific challenge and of other relevant EU projects will plan and coordinate common actions. During the creation of the project proposal, communication already started with the coordinators of INTERCONNECT project (funded by the call DT-ICT-10-2018) and of INTERRFACE project (funded by the call LC-SC3-ES-5-2018-2020), the latter being also part of the ambitious Bridge-H2020 cooperation group. Moreover, we have interacted with the coordinator of project Arrowhead Tools (ECSEL Joint Undertaking), which is developing the leading European middleware for industrial applications; we were provided with a support letter by Arrowhead Tools' coordinator. We plan to establish cooperation with project GoFlex (funded by call LCE-02-2016), which is another partner in the Bridge-H2020 cooperation group and develops the concept of flex-offer, which is a mathematical tool used to allow small prosumers to interact with the energy market; this liaison will be made easier by being AAU a partner in GoFlex. We also plan to create collaborations with projects funded under the topic DT-ICT-11-2019 and the topic LC-SC3-ES-6-2018-2020, as soon as their funding results are published.
Expected Impact: Primary Energy; …;	All the expected impacts are demonstrated by means of KPIs specified in section 2.1.
EU objectives	**How ARYES meets the EU and UN objectives**
SET Plan	When considering the overarching goals of the Integrated SET Plan, ARYES is related to the goal "Energy Efficiency in Building", but tackles also challenges related to other goals. In fact, our service oriented approach aims at "reaching the customers with smart solutions"; an ecosystem of services is a step forward towards the decentralization of the energy system, which is a building block for a "resilient energy system"; by covering much part of the value chain and creating collaborations with other European research projects, we contribute towards "an integrated roadmap".
The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. At its heart are the 17 Sustainable Development Goals (SDGs).	ARYES is able to support multiple SDGs with its overarching goals. Goal 11 *Sustainable cities and communities* and Goal 7 *Affordable and clean energy* are both very central to ARYES objectives, the latter since Goal 7 is concerned with energy efficiency. ARYES will support Goal 13 *Climate action*, since we will exploit flexibility to shave off consumption peaks and thus abstain from using peak centrals. Finally, a viable service ecosystem will support Goal 9 *Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*.
2030 climate & energy framework	European Commission established by 2030 a cut of at least 40% of greenhouse gas emissions; at least an increase of 32% share for renewable energy; and a headline EU energy efficiency target of at least 32.5%. ARYES will boost these targets through: - Lowering barriers in the implementation of predictive and adaptive controls in order to increase the efficiency of building sector. This will also produce a reduction of the greenhouse gas emissions. - Lowering the barriers in the implementation of renewable energies developing reliable tools to predict the energy prediction and developing HVAC controls systems that integrates in the policy control the renewable energies. - ARYES will integrate stakeholders pertaining to all stages of the value-chain, assuring that their needs are satisfied and promoting the results' usage. This will boost the innovation and the use of scientific results by all societal actors.
Energy Performance of Buildings Directive [EU 2018]	Energy Performance of Buildings Directive stablish in the article 2 that to support the mobilisation of investments appropriate mechanisms for the reduction of the perceived risk of energy efficiency operations for investors and the private sector are need. ARYES project will develop reliable service

	to improve the confidence of investors and owners in order to support the mobilisation of investments into buildings energy efficiency renovations.
Heating and cooling EU strategy	ARYES project fits in the EU strategy for heating and cooling providing intelligent controls for building HVAC system, reducing the energy consumed by heating and cooling in buildings.
Roadmap for moving to a low-carbon economy in 2050	The roadmap states that energy efficiency will be a key driver of the transition to a low-carbon economy. So, apart for the target 40-32-32.5 established by the 2030 climate & energy framework, this roadmap addresses to **maximise benefits from energy efficiency**. ARYES project will also contribute to address this because the successful implementation of servitization strategies in building HVAC systems can drive to implement the same strategy in other building system in order to improve the building efficiency. In addition, ARYES ecosystem will contribute to the **fully decarbonising Europe's energy supply** engaging building to use electricity as a unique source of energy, demonstrating the benefits in the building operation. Besides, the final ARYES ecosystem will be easily replicable and deployed in any type of buildings (such as commercial and residential).

1.3 Concept and methodology

1.3.1 Concept

Manufacturing (Delsing, 2017) and maintenance (Albano et al., 2019) are just two examples of industries that have been revolutionized in the past few years by servitization, which is the transition of a company business focus from product to product and supporting services to product and differentiated services to product as a service (Ducq et al., 2012). Servitized business are able to improve the company's efficiency and its time to market, since servitized business functions are interacted with in a formally defined manner and thus can be composed with other functions to realize more complex functionalities, which ends up being much faster than by reinventing the novel capabilities from scratch. Service-oriented architectures are a matching choice for the approach, and their distributed nature allows for easier maintenance, higher availability, reliability and scalability. Moreover, the formal definition of its interfaces enhances interoperability and gives the potential for the formal verification of the provided functionalities. Moreover, the decomposition of complex systems into smaller components that can be executed autonomously leads the way to a lower entrance barrier for new actors, since a new actor can focus on a step in value chain and specialize its business function to covering that particular service, which can be used as part of a composed service.

This proposal aims to bundle energy services in order to find synergies to create an ecosystem of specialized energy and non-energy services that increase the economic and technological viability of the overall system. The servitization process will help to generate new business case hidden in the current approach with isolated energy services, and incorporate new actors in the construction value chain.

The proposed process is represented in Figure 2. In the current paradigm, an isolated energy service (ES in the Figure 2) can be decomposed into different functions (ES-F in the Figure 2) and it is applied in a unique business case (ES-BC in the Figure 2). The servitization process will help to decompose each isolated service into its constituent elements, which will become the services (S in the Figure 2) in the ARYES ecosystem. These services interact with each other when orchestrated together, to recreate the isolated energy service, but also to provide additional energy and non-energy services or benefits that can be hidden in an isolated service vision. This way, it will be possible to access new market segments and as a consequence new revenue streams.

The project will start with two energy services based on predictive and adaptive control: thermostat setbacks management using neural networks and ventilation optimization service using model predictive controls (Figure 3-project starting point)**.** Those services are well known, and exists many operational examples in the literature (e.g. Moon et al., 2016, Afram et al., 2017), however, nowadays those services have 4 main barriers to market uptake.

The first one is the interoperability between different building energy management systems (BEMS) existing in the market (B1). This implied that, if a provider wants to provide widely applied services, it should develop multiple plugins or adaptors to implement the aforementioned control systems in buildings. The second barrier is the complexity of the service. The service provider has to deal with many software issues and cannot focus on its main business (B2). In addition, the thermostat setbacks management based on neural networks needs a large number of historical data to configure the system (B3), and ventilation optimization using model predictive controls requires high computational efforts (B4).

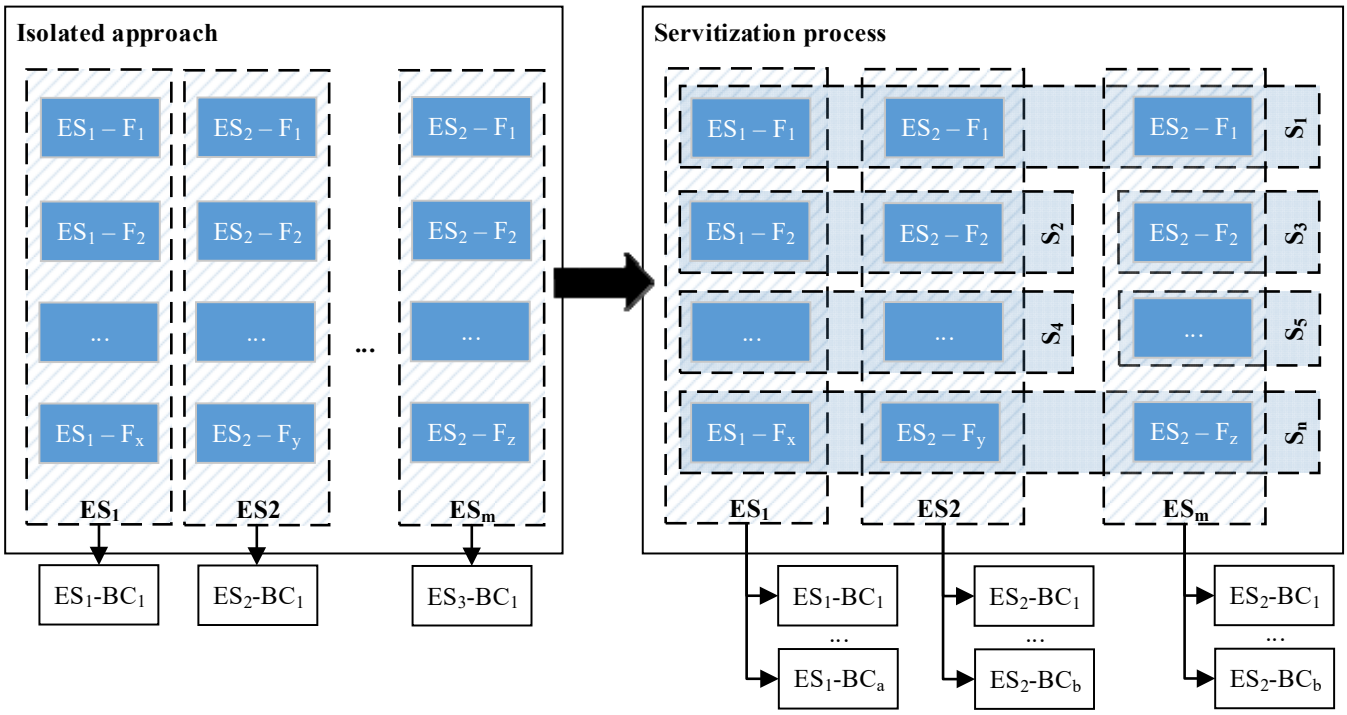

Figure 2. Servitization approach

The introduction of reduced-order models (Figure 3-Innovation within an isolated approach) can reduce barriers regarding the implementation of predictive and adaptive controls. Reduced order models are based on resistances and capacitances, and can be used to model in a computationally cheap and fast way the building or one of its main parts. This way, controls based on neural networks can lower the historical data required to configure the neural networks. A reduced-order model can be calibrated and then be used to generate data required to configure the neural network, then B3 is removed. On the other hand, reduced-order models can be used to lower the computational requirements of model predictive controls, removing B4. Even when considering the benefits of using reduced-order models, barriers regarding the interoperability (B1), and the impossibility to focus on the main business (B4) are still remaining. In addition, the complexity of the services increases due to the need of knowledge in new technologies and the need to access to weather and climate data. For all these reasons, the viability of the services is at risk.

ARYES ecosystem aims at creating **specialized services** in order to enable actors to focus in its main business(removing B2), and **incorporating new actors in the construction value chain** (Figure 3-ARYES concept). The **incorporation of weather and climate prediction actors** should facilitate the access to weather and climate data such as climatology and short term predictions (from days to week), but also will enable to use other weather and climate prediction horizons (months to years) and increase the potential services offered by the ARYES service ecosystem. In fact, climate prediction techniques are already mature enough to be useful for societal applications, but climate information is often un-tailored and they require the development of robust methodologies to address decision-making needs. The **incorporation of aggregator actors** will help to increase the effectiveness of the initial energy services, not only enabling the traditional optimization of energy, but also enabling the introduction of energy flexibility services. The project will also develop middleware services in order to facilitate the interoperability with different BEMS, removing B1. Finally, the orchestration of the initial energy services with the reduced-models and the weather and climate data will enable innovative energy and non-energy services. This may lead to the access to new target groups and sectors, and facilitating the implementation of renewable energies. In addition, the services will help to access to financial resources providing tools for investors and financers.

The ARYES concept requires an **inter-disciplinary team** able to deal with the different proposed challenges: the implementation of predictive and adaptive controls in buildings; the use of reduced-order models; the use of different weather and climate prediction horizons; as well as dealing with service orchestration, interoperability and security. In addition, experts in **co-creation activities are needed in order to engage end users and actors in the construction value chain** involved in the ARYES ecosystem in order to ensure the developed services add value to the customers and all stakeholders.

ARYES project will articulate the services into service families, and interaction with them will be specified through formal interfaces and interoperable contracts between the services, to foster interoperability between the actors in the value chain. Each service family will be related to a clear position in the value chain, which on its part will lead the

value chain actor to focus on its business functionalities. This architecture ensures that the actor not only will be able to access required functionalities from other actors in the value chain, but also to find alternative service providers, enhancing the robustness of the support given to the actor. Moreover, the actor will be able to specify which service it provides, and register it in the ecosystem, to allow other actors (and stakeholders in general) to discover and use its services.

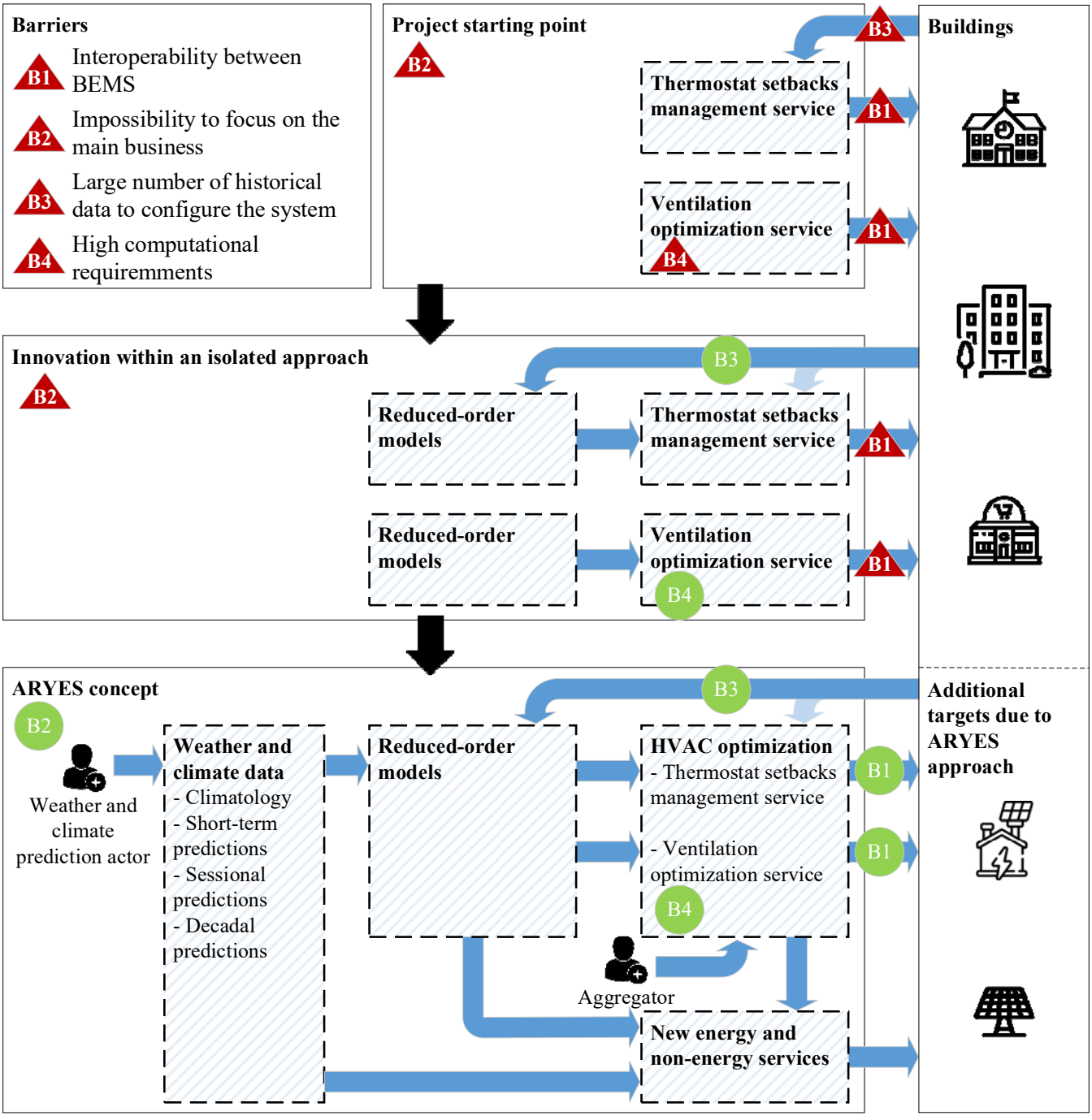

Figure 3. Evolution to ARYES ecosystem concept. Triangles mean barriers, circles mean that barriers were overcome.

The ARYES ecosystem of services will mainly feature 3 service families offered to the costumers, and 3 service families consumed only by other service producers (service-to-service families).

Heating ventilation and air conditioning (HVAC) optimization service family. End energy users will be able to use two HVAC optimization services: thermostat setbacks management service, and ventilation optimization service. The objective of the **thermostat setbacks management service** will be to determine the time required to achieve thermal comfort levels at the beginning of the working day, according to the surrounding environment. This service will be used to turn on the central heating or cooling system in order to optimize the energy use. To setup the service monitoring data from the last year will be used. Once the service will be configured the service will control the central heating or cooling system in order to accomplish the range of temperatures indicated by the end energy user. This

service will be based on neural networks technology, support vector machines, or other techniques from the artificial intelligence domain. This technology is at **"TRL 7 – system prototype demonstration in operational environment"**, as the system is operational but exists barriers in the implementation of the functionality regarding the data needed to configure the neural network (see section 1.5.3). The second service of this family will be **the ventilation optimization service**. This service will manage the ventilation system with a predictive control satisfying a set of constraints, and optimizing a cost function. The end energy user (or any service provider such as an aggregator) will send the building monitoring data to the service. Then the service will configure a reduced-order model representing the building ventilation system. In the operational stage the end energy user (or any service provider such as an aggregator) will stablish the constraints and the variables in the cost function and the service will manage automatically the ventilation system according to the specifications. In this sense, the service will enable the energy demand flexibility and the interaction of the building with the energy market. The technology is at **"TRL 7 – system prototype demonstration in operational environment"**, as exists many examples in the literature of tests and demonstrations in operational environment (see section 1.4.3). However, exists barriers in the implementation of this kind of control due to interoperability issues.

Energy prediction service family. The building energy prediction services will enable different usages according to the weather and climate service horizon used (see weather and climate service family). Energy prediction services will be considered at different time horizons and with different usages depending on the actor involved. Short predictions will be mainly used for market interaction actions, and long horizon will be used for planning purposes such as estimate the building energy bill for the next year, or plan investments. The proposed models to use in this section will be reduced-order building models. The prediction services will be used to predict the building energy consumption and the building renewable energies production (e.g. small scale solar systems). These models can be labelled as **"TRL 6 – technology demonstrated in relevant environment"**, as exists in the literature many examples of validated applications of this models (see section 1.4.2).

Energy saving certification service family. The energy saving certification services will be a service that certify the energy savings achieved in a building. The service will use a calibrated model of a building before the implementation of the energy upgrading and will run the simulation with the real weather data during the reporting period. Then the results will be compared with the measurements during the reporting period. The difference between the model and the measured data will represent the energy savings achieved. The proposed method is innovative and has not been tested. However, exists many evidences in the literature that a reduced order model calibrated can simulate the reality with a low error. As a consequence, the proposed service should be labelled as **"TRL 6 – technology demonstrated in relevant environment"**.

Model calibration service family. ARYES project proposes to use reduced order models to support the different end energy user service family. Reduced order models can be calibrated using different procedures, from a manual calibration to an automatic calibration (see 1.4.2). The building calibration service family will receive data from a building and will provide a reduced order modelling of the building. In the literature exists many validated procedures to calibrate reduced order models. For this reason, this technology can be labelled as **"TRL 6 – technology demonstrated in relevant environment"**.

Weather and climate service family. ARYES ecosystem will contain a service family that will provide to other services or final end energy users different weather and climate predictions in different timescales (from days, to months and years). Usually building operations do not use weather and climate prediction mainly because some time horizons are not available. ARYES ecosystem will include services related to weather forecasting (from day to week), seasonal forecasting (from month to year), and decadal prediction (from year to decade). Weather forecasts (predictions from day to week) are available into the market with different service providers, as a consequence this technology can be labelled as "**TRL 9 – actual system proven in operational environment**". Regarding the climate predictions (predictions from months to years), the progress in these technologies has led to a skill level that is now considered useful for societal applications, for this reason they can be labelled as **"TRL 7 – system prototype demonstration in operational environment"**.

Support service family. A number of support services not related to the business cases are necessary, in particular to allow for service discovery and orchestration, interoperability and security. These services can be considered as part of a support framework, and in our case they will be offered by the Arrowhead Framework, which is one of the leading European service oriented platform for industrial automation. Its development started in 2013, and it has since been applied to many different application domains comprising "Smart buildings and infrastructure", "Energy production and end-user services", "Virtual market of energy". Given that ARYES's goals are related to the creation of a service ecosystem, the access to a framework that can provide support services allows to save on the efforts that would be required for the creation of the support services themselves. Authorization service, which is in charge of security, and service discovery are currently used in production environments, as a consequence can be labelled as

"TRL 8 – system complete and qualified". Both orchestration service and translation service, the latter used to provide interoperability with protocols and third-party frameworks, were demonstrated in production environments to a reasonable extent, and they are considered to be at **"TRL 7 – system prototype demonstration in operational environment"** and **"TRL 6 – technology demonstrated in relevant environment"** respectively.

As discussed above, only 3 of the 6 service families are available to the final customer. Figure 4 discusses how data from and regarding buildings is acquired into the ARYES ecosystem, and final customers can use the services. **Financers and investors** will perform risk analysis of the investments needed. **Building owners or facility managers** will analyse how to invest in HVAC equipment and verify energy savings. **ESCOs** will create better EPCs, energy services and verify the performance of energy saving services. **Technical support service provider** will use HVAC optimization services. **Aggregators and energy traders** will trade energy more efficiently and introduce flexibility services.

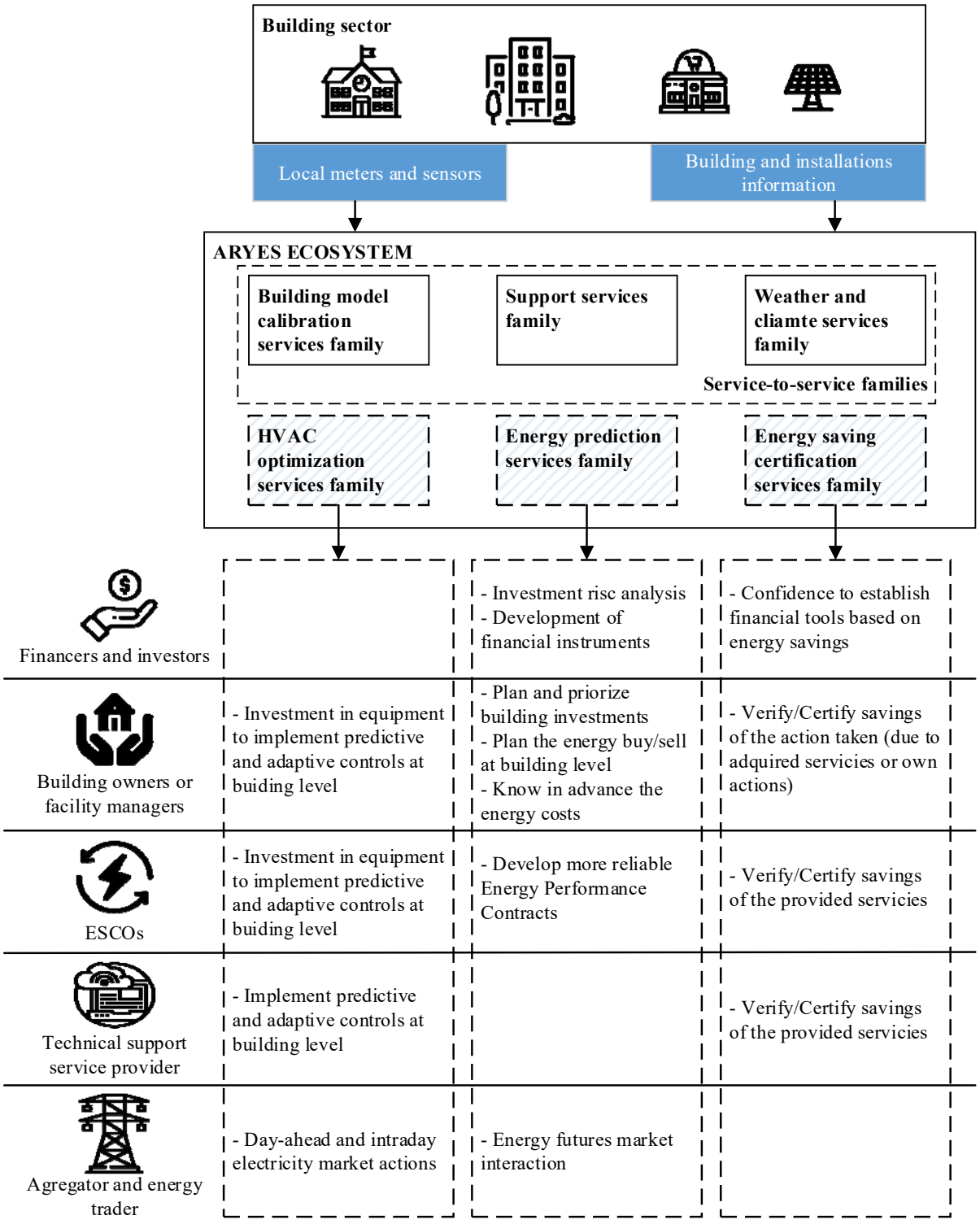

Figure 4. Usage of proposed service family depending the actor of the value chain

1.3.2 Technology Readiness Level

The TRL of each service proposed in the ARYES project is summarized in Table 4. The TRL comprises both the technological maturity of the services and of its business model.

Table 4. Technology Readiness Level of the technologies used, and the target at the end of the project.

Family of services	Service name	Current TRL	Final TRL	Evidences
HVAC optimization services	Thermostat setbacks management service	7	9	Market replication
	Ventilation optimization service	7	9	Market replication
Building energy prediction services	Intraday prediction	6	9	Market replication
	Monthly prediction	6	9	Market replication
	Year prediction	6	9	Market replication
Energy saving certification services	Energy saving certification services	6	9	Market replication
Model calibration services	Model calibration services	6	9	Market replication
Weather and climate services	Weather forecasts	9	9	Market replication
	Seasonal and decadal predictions	5	7	Prototype of prediction system integrated in the ecosystem
Support services	Registry	8	9	Market replication
	Orchestration	7	9	Market replication
	Security	8	9	Market replication
	Translation	6	7	Prototype of translation system integrated in the ecosystem

We aim to raise TRL of most services to TRL 9 by creating a market replication process, except for the seasonal and decadal prediction services, and translator service. In the case of the former, we will be able to reach TRL 7 only since the algorithms used to predict seasonal and decadal climate are not adaptable and refined yet and thus need a good deal of manual intervention to be applied to novel areas and climatologies. The translator service will reach TRL 7, since with the current approach for the support of novel protocols and third-party middleware will still need development efforts, thus impairing market replication.

1.3.3 Relation to other research activities

The ARYES project will exploit the knowledge gained from related research projects previously conducted by the consortium partners with ongoing projects indicated in the Table 5.

Table 5. Results from other projects used in ARYES project

Initiative	Partner	Relationship to ARYES	Plan for collaboration
ENERWAGARE	UPC, ADV	Completed H2020 project aimed at developing a serious game linked to the real energy use of social tenants homes.	Learned lessons in smart metering and energy saving calculations will be used to create new methods to monitor and measure energy savings.
GESTENSIS	UPC, ADV	Completed Spanish National project aimed at developing a platform for tertiary building energy managers.	Control strategies developed for HVAC systems will be used in the project in order to provide proved technologies to reduce energy in buildings.
ENCOURAGE	UPC, AAU, ADV	Completed project funded by ARTEMIS, aimed at designing and implementing a smart grid that optimises energy usage in HANs by moving the decision-taking to the cloud. Data are encoded using industry-accepted standard and transmitted through a high-performance middleware. ENCOURAGE provides libraries for fast development of adapters for easy interoperability with other systems.	ENCOURAGE high-performance middleware can be adapted to manage data in ARYES. The experience with international smart grid standards can be reused to enhance ARYES interoperability with existing systems, and for importing real-time data collected in the context of other solutions.

SEAM4US	UPC	Completed FP7 project aimed at developing a methodological and technological framework that supports the optimal electrical control of a metro station and the midterm energy efficiency planning.	Learned lessons in smart metering in harsh and vandalism exposed environments and user behaviour change will be provided. Energy audit strategies, cost-benefit procedures and Canvas modelling procedures will be reused in ARYES.
Arrowhead	AAU	Completed ARTEMIS project that built a service-oriented framework (Arrowhead Framework) for industrial automation. It is considered one of the best open frameworks for interoperability in industrial applications.	Instead of building its own middleware, ARYES will use the Arrowhead framework, which has a reasonable TRL and allows for easy interoperation with a number of protocols and middleware.
MANTIS	AAU	Completed ECSEL project that built a platform for proactive maintenance of machinery. It uses high-performance communication, cyber-physical systems, machine learning and advanced HMI. MANTIS makes use of the Arrowhead Framework in some of its demonstrators.	ARYES will leverage on the MANTIS experience, which applied the Arrowhead Framework in a novel application area (maintenance). In fact, ARYES aims at a similar result (application of the Arrowhead Framework in the construction industry).
Productive 4.0	AAU	Productive 4.0 is an ECSEL project that is developing further the Arrowhead Framework. One of the main goals is to make it easier to develop and deploy applications that make use of the Arrowhead Framework.	ARYES will use the results of Productive 4.0 (Arrowhead .deb packager, Arrowhead Client Library, etc) for a faster time-to-market of services. ARYES will share its results with Productive 4.0, and possibly will have a joint demonstrator.
DoNUT	AAU	Danish national project that aims at innovating in monitoring of urban water cycle. One of the goals of DoNUT is to predict water level, using weather prediction etc. Particular importance is given to energy efficiency and short time-to-market. DoNUT makes use of the Arrowhead Framework.	DoNUT is extending Arrowhead Framework to the SigFox protocol. We envision that ARYES will extend Arrowhead to novel protocols, thus an exchange of results with DoNUT can be useful. Both DoNUT and ARYES consider business models for climate and weather prediction.
Regional Center of the WMO	BSC	BSC jointly with AEMET (the Spanish met office) coordinates the Regional Center on Sand and Dust Storm Warning Advisory and Assessment System (sds-was.aemet.es/) and the Barcelona Dust Forecast Center (https://dust.aemet.es/) of the WMO	The meteorological core of the mineral dust system (MONARCH) that provides the mineral dust forecasts will be the one implemented in ARYES to provide short term meteorological forecasts.
S2S4E	BSC	Innovative service to improve the management of renewable energy variability by combining seasonal and sub-seasonal climate predictions.	Implementation of seasonal predictions in an operational real-time forecasts system using temperature and solar radiation as essential climate variables.
PEAKAPP	BED	Completed H2020 project aimed at supporting an energy efficient lifestyle of European citizens	Learned lessons regarding the market uptake strategy for energy services will be used within ARYES.

In addition, the project will cooperate with the projects funded under the topics: DT-ICT-10-2018 (INTERCONNECT), DT-ICT-11-2019, LC-SC3-ES-6-2018-2020 and LC-SC3-ES-5-2018-2020. Although, the proposal includes a cooperation leader that will have the responsibility to define the cooperation plan, the guidelines for the cooperation with those projects is presented in the following Table 6.

Table 6. Cooperation with projects mentioned in the call

Initiative	Relationship to ARYES	Plan for collaboration
INTERCONNECT (DT-ICT-10-2018)	New standard and architecture for interoperability in building sector	Reuse or make compatible the standard and architecture created (see task T2.4 and T3.1).
INTERRFACE and CoordiNet (LC-SC3-ES-5-2018-2020)	Those projects are focused on the demand response, storage and small-scale generation. Although the focus of ARYES project is not the same part of those services can be reused or can be integrated in the servitization process	We will analyse the viability to introduce the services created in those projects into the servitization process of ARYES ecosystem (see task T2.2). In addition, those projects, and especially INTERRFACE, will create APPs markets to sell services. We will explore the possibility to make compatible the developed services in those APPs market (see task T3.1 and T6.5), and study the possibility to carry out market replication activities (see task T4.3.3).

DT-ICT-11-2019 and LC-SC3-ES-6-2018-2020 calls are not published yet. Anyway, we expect to find synergies between the ARYES services and the new services for the electricity grid developed in projects funded by DT-ICT-11-2019. On the other hand, the energy prediction service family developed in ARYES project will analyse synergies with projects funded under the call LC-SC3-ES-6-2018-2020 (see task T3.5)

1.3.4 Methodology

In order to achieve the ARYES project's aims and objectives a trans-disciplinary approach and stakeholders' knowledge will be fundamental in the project development. For this purpose, the ARYES project will be guided by the living lab methodology to drive the exploration, experimentation and evaluation process in real settings in order to finally perform market replication of the services implemented. The living lab methodology will use the following core principles: user engagement, multi-stakeholder participation, co-creation and real-life setting.

Co-creative techniques give to communities and individuals more direct involvement in defining their needs and priorities, collaboratively finding solutions, influencing decisions and achieving better outcomes. This process requires the transparency that can be guaranteed by a co-creation process, as well as supporting tools and methodologies for the flow of information and ideas among stakeholders, to allow for mutual development of knowledge and skills. This process will be done by using consultation, involvement and co-design strategies (focus groups, visual preference surveys, creativity groups, prototype testing, usability testing, idea generation with lead-users, and design thinking workshops).

The ARYES project will engage the end energy users and all stakeholders in the construction value chain in a co-creation process to carry out the servitization activities (WP2), the business models development, the service contracts and the energy performance contracts definition, and the labelling system (WP6). The co-creation for ARYES ecosystem means a joint development, generation, production and creation of new proposals of "contextual and unique solutions" that are based on specific, local and personal knowledge and skills, potentials and opportunities as well as problems, and obstacles of the community and place. This way the project will benefit from the stakeholders' knowledge in order to create services that add value to the customer and all stakeholders.

Leveraging the aforementioned efforts, the services will be developed (WP3) and the alpha version of ARYES ecosystem will be implemented (WP4) in real-life setting through 4 demonstrators selected in the proposal stage with the following principles: controlled environment, motivation of the end energy user to implement new services in its building and its capacity to assume operational risks, high understanding of the building by the project partner that brings the demonstrator, ease of implementation (see Table 7).

Table 7. Summary of demonstrators involved in the project

Building	Description	What to test
Library campus, Plaça del campus 1, Terrassa, (Spain)	Library built in 1996 with 2,393 m^2. The building has a BEMS from Schneider control that controls the HVAC system. The total energy consumption from 2017 and 2018 was 245.4 MWh and 203.9 MWh.	This demonstrator will be based on owner, facility managers and technical support service provider actions: HVAC optimization services Planning energy buying and know in advance the energy costs Verify /certify savings of the provided services

Office building, *Location is not specified due to confidential issues,* (Denmark)	Office building from 2005 with 1,851 m^2. The building is equipped with existing TREND BEMS systems for their control. Its HVAC system includes heating (through both ventilation and water-based radiator/floor heaters), cooling and ventilation with heat recovery. Building yearly demand is: heat 93.8 MWh, electricity for ventilation 13.1 MWh, and cooling 5.5 MWh.	This demonstrator will be based on aggregator actions: HVAC optimization services Planning energy buying and know in advance the energy costs Day-ahead and intraday electricity market actions in order to provide flexibility services Energy futures market interaction Verify /certify savings of the provided services
L.I.G.H.T. wing high tech center, Mokslininkų 6, Vilnius, (Lithuania)	Office building built in 2013 with 30,200 m^2. The building has created a BEMS control from TREND that controls HVAC system. The building is also equipped with a unique and patented heating and cooling system. The total energy consumption in 2017 4,889.4 MWh and 2018 6,153.6 MWh.	This demonstrator will be based on financers and investors and facility managers actions: Investment risk analysis HVAC optimization services Planning energy buying and know in advance the energy costs Verify /certify savings of the provided services
Tivoli GreenCity, Rue du Tivoli, Brussels (Belgium)	397 apartments, 2 kindergartens and some commercial areas. Hot water for heating is provided by a central heating installation and urban network. The installation is managed through a connected BEMS system (Siemens – Era). Predicted gas consumption: 2500MWh/year; pellets: 400MWh/year; production of electricity from cogeneration: 780MWh/year, solar panels: 330MWh/year.	This demonstrator will be based on financers and investors and facility managers actions: Investment risk analysis HVAC optimization services Planning energy buying and know in advance the energy costs Verify /certify savings of the provided services

The feedback of the implementation of ARYES alpha version (WP4, WP5) will be used to improve the ARYES platform and provide a new version, called ARYES beta version (WP3), which will include all the improvements suggested during the alpha version testing, as well as all functions initially planned but not included in the alpha version. The beta version of the ARYES ecosystem will be implemented in the demonstrators, and in 20 other buildings (WP4) to demonstrate market replicability of the developed system; the buildings will be selected among the ones where the ARYES technological providers give service (COM, ADV, NEO, SLX and BAM), and the ones controlled by companies associated to the business organization partners (CCB and VIA).

Table 8. Summary of buildings involved in the project

Partner	Location of the buildings	Demonstrators	Buildings for market replication
COM	Spain	-	4
ADV	Spain	1	4
NEO	Denmark	1	2
CCB	Belgium	-	2
VIA	Lithuania	1	4
SLX	Germany	-	2
BAM	Belgium	1	2

1.3.5 Gender issues and action plan

We will base our research and realization with specific regard to published "Strategy for equality between women and men 2010-2015" (European Commission, 2010) and "Gender Equality in Horizon 2020" (European Commission, 2014) publications. The project team will ensure that the gender balance issues will be covered in all the project activities and in the project management. Team leaders have been identified based on skills and expertise, assuring a gender balance. It is our belief that this policy will stimulate the excellence of the scientific and technical achievements that are expected and will promote and boost the professional carriers of all the participants in the project.

A gender-sensitive stakeholder analysis will be undertaken throughout all stages of the project. In terms of project implementation, the local communities, companies and groups of stakeholders involved will be heterogeneous and

include male as well as female persons. Besides gender, the assessment of the demonstrators will consider thus specific indicators to understand whether the interventions are inclusive of all social groups.

People are a main component of the project. The experimental application of the new developed systems will inform, query, and motivate them. All of these activities will be assessed, modelled and implemented in a gender neutral way. Moreover, ARYES also explores the diversity of users and stakeholders and therefore will explore age as one of the factors that could influence typical use and involvement.

1.4 Ambition

This section motivates the choices we made regarding the advances we propose beyond the state of the art. Four topics were selected according to the main barriers identified in Figure 3, and on the general goals of this proposal. The ARYES project proposes to study middleware platforms, in particular of the service oriented kind, for both overcoming interoperability issues (barrier 1) and to allow the engineers to focus on their main business, disregarding general ICT aspects (barrier 2). Improvements on current building models, and in particular the application of reduced order models, are useful to attack the third and fourth barrier. The main goal of the project is to enhance the energy efficiency of the buildings, and we opted to focus on HVAC optimization. Finally, we want to develop best practices for the insertion of new actors in the construction value chain, and we will do that by welcoming weather and climate prediction services in the picture. In fact, climate prediction techniques are already mature enough to be useful for societal applications. However, there is the need to push forward the state-of-the-art on this aspect since climate information is often un-tailored, and there is the need to develop robust methodologies to address decision-making needs.

1.4.1 Middleware platforms

Review

The application of the service oriented approach to industrial informatics is not completely novel (Komoda, 2006), but it got relegated to research environments for a long time. In the last few years things started to change, and one of the most prominent actions in this regard was the Arrowhead project (Delsing, 2017), which pushed forward the vision by creating a framework of services that can support real-life applications. The Arrowhead Framework addressed five main application areas (manufacturing, smart buildings, electro mobility, energy production and virtual market of energy) and provided demonstrators that paved the way for the adoption of the technology in the industry. Later on, the work was continued through other research actions such as Productive 4.0 and Arrowhead Tools (see section 1.3.3) to both address novel application areas, and improve the framework with new services and abstraction that enabled an easier learning curve. Current priorities for the Arrowhead Framework is to allow for code generation from a formally defined interface between services, security management, and improved interoperability with other industrial frameworks.

Advances

To date, Arrowhead had not considered the construction industry, and to the best of our knowledge no approach has taken the lead using a mainstream service oriented architecture (SOA) in application areas related to the construction industry. Thus, ARYES would allow the construction industry to experiment with a set of approaches that aim at improved interoperability and shorter time-to-market of applications. Moreover, a particular Arrowhead services called Translator is reaching production environments right now, and it shall empower Arrowhead with the capability of converting its SOA communication to other paradigms (event messages, declarative communication, etc). ARYES efforts will have a strong focus on leveraging this service for interoperation with frameworks such as the ones referenced in section 1.3.3, and at the same time improve the internals of the Translation service for both better performance and easier integration of new protocols and frameworks. Finally, ARYES will study novel business models for SOA (and Arrowhead), with particular stress on the construction value chain, but with the aim of providing new techniques to monetize the SOA paradigm in other industries.

1.4.2 Building modelling

Review

Within the discipline of building modelling, different approaches can be discerned. Those approaches can be classified using three main categories: black box, grey box and white box models. Black box models use monitored data to introduce the model parameters (Giretti et al., 2018). This type of models does not need an understanding of underlying mechanisms; however, they need relatively large set of data to achieve the necessary reliability in prediction. In addition, this type of modelling has a low capability of generalization (Agram et al., 2015). In the other hand, white box models are based on fundamental theoretical principals and implement a set of well-defined physical laws. In this case, monitoring data is only used for validation purposes. The weakness of white box models is that in

many practical cases, the model is made of hundreds or thousands of parameters, making simulation computationally intensive. As a consequence, white box modelling generally requires simplifying assumptions. Another weak point is that these models are not capable of including the uncertainties into the model (Estrada-Flores et al., 2006). Grey box modelling can be considered as hybrid modelling, it combines the physical knowledge and the information embedded in the monitored data. Grey box modelling use low-order building physics and uses statistical methods for model identification (Bacher et al., 2011). Despite their reduced-order structure, grey box models have a relatively accurate performance in different fields such as energy and building energy prediction (Reynders et al., 2014), or indoor air quality (Macarulla et al., 2018). Although the data set required by grey box models is substantially less than black box models, in some cases the required data set could be unreachable. In these cases, some authors explored the possibility to use reduced order modelling with manual calibration algorithms instated of statistical process to determine model parameters (see Giretti et al., 2018).

Advances

Although the benefits of reduced order modelling with statistical or manual parameters estimation, this type of modelling is not fully exploited. ARYES project will use reduced order modelling as a base for all its services.

Reduced order modelling will be used to lower barriers in the implementation of predictive and adaptive controls (see section 1.5.3), but in addition to develop models to predict the building energy consumption and the renewables energy production in different time horizons. To carry out these predictions different weather and climate temporal scales (from days, to months and years) will be used (see section 1.5.5).

Finally, ARYES project will used reduced order models to obtain a calibrated model, easy and quick to calibrate in order to create building baselines in order to determine energy savings.

1.4.3 Predictive and adaptive controls

Review

Many control methods have been developed or proposed in the literature for HVAC systems (Lee 2016 and Afram 2014 for a summary), from classical controls (e.g. on/off, P, PI and PID) to more advanced hard controls (e.g. gain scheduling or robust and optimal control) or soft controls (e.g. fuzzy logic and neural network control). In some cases, hybrid control methods mixing hard and soft control techniques are also proposed. Even so, a classical control approach based on an on/off, P, PI, or PID controls with a schedule is still used in to control HVAC systems (Vaccarini 2016). The main cause of the extended use of the classical approach is that nowadays most building energy management systems (BEMS) available on the market are reactive rule-based (Pantazaras 2016); this means that when an event occurs an action is produced.

Reactive control systems do not allow to evaluate future situations, and therefore anticipate control actions. Thus, the control cannot consider different domains (e.g. cost, air quality or user comfort), and apply control policies based on the minimization of a cost function (Vaccarini et al., 2016). These systems are also not capable of analysing the data they collect and learn over time (Costa et al., 2015).

The implementation of predictive and adaptive controls allows to increase the efficiency of the control systems, considering external environmental factors, occupation factors or the electricity market (Vaccarini et al., 2016). To be more specific, a predictive system could optimize the operation of the facilities taking into account the weather, occupation and the price curve of the energy planned for a given day. On the other hand, an adaptive system would allow to learn from past events to improve its functioning in future situations.

The consortium has expertise in the implementation of neural networks to optimize the heating and cooling systems and demonstrated the usability of this technology in relevant environment (see Macarulla et al., 2018). However, this type of controls requires a big number of data to configure the system, being this fact a clear barrier in the implementation of this type of controls.

In other hand, the consortium also has experience in the implementation of predictive controls for ventilation systems. Members of the consortium implemented successfully predictive controls to manage the ventilation in metro stations (see Casals et al., 2016). In this case the barrier is the need of models that reduce the computation effort to determine the optimal control policy.

Advances

The ARYES project will use reduced-order building models to lower the technological barriers for the implementation of predictive and adaptive controls in the management of HVAC systems. On the one hand, the reduced-order thermal building models will be used to generate required data to configure a neural network to optimize the heating and cooling. As a consequence, the historical data required to implement a neural network based

control will be reduced and its implementation will be more suitable. On the other hand, the reduced-order ventilation building models will reduce the computation effort to solve the optimization problem arised due to predictive control implementation. Then, it will be more suitable to implement predictive controls in the ventilation systems.

1.4.4 Weather and climate data prediction

Review

Many energy actors such as energy traders, energy producers, plant operators, grid operators have traditionally used climatology (weather conditions averaged over a period of time) to anticipate renewable energy sources and electricity demand for situations 15 days or more into the future (Dubus et al., 2010). However, assuming that future conditions will be similar to average past conditions has several inherent shortcomings. Climate predictions including both seasonal (for the forthcoming months) and decadal predictions (forthcoming years) have witnessed considerable improvements in the last decade demonstrating that probabilistic forecasting can inform better decision making at some temporal scales and regions (Soret et al., 2019). As a consequence, improved energy production and demand can be achieved.

At building level, the literature recognises that building energy consumption prediction is essential for energy planning, management, and conservation (Amasyaly 2018). However, all efforts are focused on obtaining methodologies to reproduce the building energy consumption with known inputs with different types of modelling (see section 1.5.2). No studies were found in the literature mixing climate predictions and building models. This unexplored interdisciplinary field can be very promising because other fields such as the agriculture started develop studies to explore the use of decadal predictions with interesting results (Turco et al., 2017). In the other hand, in the building operation, practitioners use very basic tools to estimate the building energy demand. For example, building managers usually use the average historical bills to plan the energy costs for the coming months. This leads to high inaccuracies in the building energy demand estimation.

Advances

ARYES project will deploy a weather and climate forecast intelligent service exploring the frontiers of seasonal and decadal predictions and their synthesis with weather forecast to provide robust forecast for decision making process. The project will develop state of the art techniques for forecasting distributed renewable generation (e.g. small scale solar systems) and building energy demand at different temporal scales (from days, to months and years) facilitating renewable energy integration and electricity demand management. In addition, cutting-edge techniques for improving the accuracy of forecasts will be deployed to enhance model skill and forecast reliability.

As the best of our knowledge, it is the first time that services for seasonal and decadal predictions and their synthesis with weather forecast taking into account the building market segments needs are offered. This will be achieved by co-developing methodologies to maximize the use of the forecasts systems for the building sector to design a real-time tailored forecast system. It will result in the detection of windows of opportunity for the different time scales (from days, to months and years).

1.4.5 Innovation potential

The innovation potential of the proposal can be summarized as:

- Increasing the viability of the end energy services through a servitisation process. This process should lead to very specific services that can generate new business opportunities (e.g. the seasonal predictions can be used to predict energy consumption, but also to manage the sales management in retail buildings).
- Supporting existing and future energy services by means of a robust and scalable service-oriented framework. The project will also contribute to improve the framework itself and its potential for interoperability with different protocols and third-party frameworks.
- Reducing the barriers for the implementation of predictive controls in HVAC systems using reduced-order building models: (I) Using the reduced-order building models to generate data to reduce the number of data required to configure a neural network based control; (II) Using reduced-order building models to solve the optimization function when a predictive control is applied.
- Using an interdisciplinary and novel approach to carry out forecasts for building energy demand and energy distributed renewable generation predictions. The approach consists into use reduced-order building models, that are easy to calibrate and are able to obtain good prediction performance, and novel weather and climate prediction methodologies (e.g. seasonal or decadal predictions) to estimate the building energy demand in different time scales.

2 Impact

2.1 Expected impacts

Expected impacts delivered by the ARYES project (including those set out in the work programme), corresponding measurement indicators, objectives and procedures, and target groups that need to be addressed for achieving them are summarised below.

I1 - Primary Energy savings triggered by the project (in GWh/year)	
Impact indicator	Primary energy reduction achieved in the buildings involved in the demonstration and market replication activities using the HVAC optimization services proposed in the project
Objective	25% of final energy savings in HVAC systems equivalent to a primary energy savings of: 1.75 GWh/year in the ARYES demonstrators; 5 GWh/year in the buildings from ARYES market replication activities; and the asymptotic potential amounts to 1,351,691 GWh/year in the whole Europe
Target groups	Buildings involved in the demonstration actions Other buildings with centralized HVAC systems
How to reach this impact	The objective will be achieved by implementing predictive and adaptive controls in the buildings HVACs through the ARYES ecosystem, and measured during task T5.2. Although outside of the current programme topic, the service ecosystem that will be developed in the ARYES project could also be deployed in other buildings further expanding the potential for energy consumption reductions beyond the project lifetime.
Impact justification	In Europe, buildings are responsible for 40% of final energy consumption and 36% of CO_2 emissions (European commission, 2019). About half of the building energy consumption in operational stage is devoted to HVACs systems (Bianchini et al., 2019). Building HVAC systems usually work inefficiently (Domínguez et al., 2015), and the implementation of energy management systems leads to savings of around 14% (Lee et al., 2016). These energy savings performances are correlated with the technology implemented and the building efficiency before the implementation. As reported in the literature, in some cases savings reached 46.9%. In the other hand, members of the consortium had previous experiences implementing predictive controls achieving savings around 20% (Macarulla et al., 2017). Taking into account that ARYES project aims to control the HVAC systems as a whole and will improve our previous results, and it is fair to assume that the ARYES solution will deliver an energy reduction around 25% of the final energy. Using the data presented in Table 7 from section 1.3.4 savings achieved in the 4 demonstrators will be 1.75 GWh/year. Assuming an average saving of 0.25 GWh/year per demonstrator (we disregarded the Tivoli complex in the calculation since it is a very large building and it would have provided too optimistic values), savings achieved in the market replication will be 5 GWh/year. Considering that the final energy consumption in Europe is 13,516,911 GWh (Eurostat, 2017), assuming that in Europe buildings are responsible for 40% of final energy consumption (European commission, 2019), HVAC systems consume 50% of the building energy, and the aforementioned 25% of savings, the asymptotic energy savings triggered by the project could amount to 675,845.55 GWh. Considering a primary energy factor (PEF) of 2 for the whole European energy system (Eurostat, 2017), the estimation of the potential primary energy savings triggered is 1,351,691 GWh per year if the proposed services are applied to all Europe.

I2 - Investments in sustainable energy triggered by the project (in million Euro)	
Impact indicator	Investments in sustainable energy of the proposed business models
Objective	26.13 million Euro
Target groups	Investors, financers, ESCOs and building owners
How to reach this impact	The energy prediction service family will provide a set of services that will contribute to lower the barriers of the small scale solar systems: services for investors, financers, ESCOs and building owners, providing tools to assess the investment and analyse the risks; aggregators and traders, provide intraday prediction tools in order to carry out actions in the intraday market.

<table>
<tr><td>Impact justification</td><td>Solar-generated electricity cannot be forecast exactly, since variable meteorological processes introduce a significant timing variability in production (Belusi et al., 2019). This leads to a set of barriers regarding the investment process and operational management (Hu et al., 2018). The services provided by ARYES ecosystem will help to reduce the aforementioned barriers. As a consequence, industrial partners expect that they can promote investments in small scale solar systems in commercial and housing buildings. In fact, although the focus of the ARYES projects is non-residential buildings, the project partners cover also that application area and thus will consider to apply ARYES results in residential scenarios. The following table forecasts sales per year:
<table>
<tr><td>Partner</td><td>Housing buildings (num)</td><td>Commercial buildings (num)</td><td>Investments in housing (€)</td><td>Investments in commercial (€)</td></tr>
<tr><td>COM</td><td>10</td><td></td><td>750,000</td><td>0</td></tr>
<tr><td>BED</td><td>-</td><td>3000</td><td>0</td><td>15,000,000</td></tr>
<tr><td>ADV</td><td>5</td><td>-</td><td>375,000</td><td>0</td></tr>
<tr><td>SLX</td><td>10</td><td>-</td><td>750,000</td><td>0</td></tr>
<tr><td>NEO</td><td>10</td><td>-</td><td>750,000</td><td>0</td></tr>
<tr><td>BA partners</td><td>100</td><td>200</td><td>7,500,000</td><td>1,000,000</td></tr>
<tr><td>Total</td><td>135</td><td>3200</td><td>10,125,000</td><td>16,000,000</td></tr>
<tr><td colspan="3">Investments in sustainable energy</td><td colspan="2">26,125,000</td></tr>
</table>
BA partners are buildings related with the business organizations involved in the project (VIA and CCB).
The average investment of small scale solar systems in housing is 6,000€ per building, considering an average of 5 kW installed and 1300€/kWh of investment. Regarding the commercial building the average investment of small scale solar systems is 75,000€, considering an average roof area of 400 m^2, 7 m^2/kWh, and 1300€/kWh of investment.</td></tr>
</table>

I3 - Improved viability of innovative energy services	
Impact indicator	I3.1 – Number of buildings were the system is deployed in market conditions. I3.2 – Number of stakeholders from all the construction value chain interested by the solution during various workshops organised on the “integration of ARYES in business models of construction industry”.
Objective	I3.1 – Market replication action successfully deployed in 20 buildings. I3.2 – 30 external stakeholders interested in the ARYES solution participating in our workshops.
Target groups	Buildings involved in the replication market actions Other buildings with centralized HVAC systems Construction industry
How to reach this impact	The objective I3.1 will be achieved assessing the market replication of the proposed HVAC optimization service family during task T4.3 and will be reported in D4.3. The objective I3.2 will be achieved by carrying out workshops, with presentation of the solution and co-creation activities to develop services, business models and energy performance contracts. CCB and VIA will be in charge of those activities.
Impact justification	Many barriers exist in order to implement predictive and adaptive controls. Those barriers depend on the technology used. For example, neural networks need large number of historical data to be configured (Afram et al., 2017), in the other hand, model predictive has high computation complexity (Bianchini et al., 2019). ARYES ecosystem aims to lower the aforementioned barriers by the implementation of reduced order models increasing the viability of the proposed energy services. Another relevant barrier regards interoperability and reusability aspects of data and mechanisms. Many BEMS do not make use of predictive and adaptive control systems and cannot interact with them, and the strong interoperability capabilities of the Arrowhead Framework can help towards the reuse of the techniques developed in the project.

I4 - A growing offer and up-take of services that combine energy efficiency with other energy services, technologies and non-energy benefits		
Impact indicator	I4 – Number of services that combines energy efficiency with other energy services, technologies, and non-energy benefits	
Objective	10 services	
Target groups	Demonstrators and buildings involved in the project Financers and investors Building owners Facility managers	ESCOs Technical support service providers Aggregators and energy traders Constructors and installers
How to reach this impact	These objectives will be achieved in WP2 after a co-creation process. The co-creation will involve the whole actors in the construction value chain. Later on the services will be developed in WP3 and implemented and tested in WP4 and WP5.	
Impact justification	ARYES HVAC optimization services aim to provide an optimization of the energy use but also comfort, peak shaving and reduction of costs among others. The proposed optimization services will need reduced order models for different purposes (see section 1.5.3). In order to increase the viability of the energy services it is planned to find other applications for the reduced order models. First, the combination of reduced order models with different weather and climate predictions will enable to carry out more accurate predictions of energy consumptions for buildings. Moreover, reduced order models will be used to create baseline to certify energy savings. Finally, it will be analysed the possibility to reuse the reduced order models for other purposes. Reduced order models combined with statistical methods offer a good opportunity to develop non energy applications such as measuring ventilation flows (Macarulla et al. 2018) or occupancy (Wolf et al. 2019) in a building. A reduced order model needs "n" inputs to be calibrated (examples of inputs are occupancy or CO_2 level). When the model is calibrated it can be estimated one input if "n-1" inputs are known. For example, to calibrate a reduced order indoor air quality model is required the occupancy and the CO_2 concertation of the room along the time. The calibration of the model enables to obtain the ventilation of the room and the volume of the room. Then if the CO_2 concentration along the time is known, it is possible to estimate the occupancy of the room along the time (see Wolf et al. 2019).	

I5 - A growing up-take of innovative data gathering and processing methods in the monitoring and verification of energy savings and flexibility		
Impact indicator	Number of energy savings and flexibility impact certifications done during the whole project	
Objective	100 certifications	
Target groups	Demonstrators and buildings involved in the project Financers and investors Building owners	Facility managers ESCOs Technical support service provider
How to reach this impact	During the project is expected to test the HVAC optimization services in 24 different buildings (4 demonstrators and 20 buildings to experiment with market replication) and use the certification service family to determine the amount of the energy savings. In addition, the certification service family will be made available and promoted to be used by the general public. Therefore, the scope for the implementation of the energy certification service family is the entire European building sector.	
Impact justification	The energy saving certification service family will use reduced order modelling, information regarding the building and data collected on the building to calibrate a building model. This approach improves the existing methods to certify energy savings. It has been demonstrated in the literature to be easy and quick to use, with low computational requirements and with a good accuracy (see Giretti et al., 2018). Developing an operational service that uses the aforementioned method will introduce in the market a new viable service to certify energy savings.	

I6 - The application of methods and concepts to ensure that: (i) innovative energy services are reliable and verifiable, (ii) service providers are trustworthy and accessible		
Impact indicator	Service to assess and label the developed services	
Objective	Service to assess and label the developed services operational and validated by external stakeholders	
Target groups	Demonstrators and buildings involved in the project Financers and investors Building owners	Facility managers ESCOs Technical support service providers Aggregators and energy traders
How to reach this impact	Task T5.1 will develop the monitoring and evaluation methodology (D.5.1). This will be the starting point for the development of service(s) that will assess and label the quality of the ARYES services themselves (Task T6.5), and of service providers. Data collected on the usage of the ARYES services will be used to assess the benefits provided by each ARYES service. Moreover, service providers will be evaluated in terms of their trustworthiness and accessibility. As a title of example, a service could be used to make available the feedback collected on each service provider, its downtime, etc. The aforementioned service(s) will be developed using a co-creation methodology in order to ensure that all stakeholders needs are satisfied. A link will be made with existing labels such as SRI-Smart Readiness Indicator (in development) or Ready to Service-R2S (Smart Building Alliance, already in the market) that certify the smart readiness of a service. ARYES should be compatible with the principles of such labels. This impact is related to the effect of the ARYES services on energy savings, green investments, etc. Impact 12 is focused on the platform supporting the ARYES ecosystem, which aims to be robust, secure and scalable.	
Impact justification	The project will develop a methodology to enable ARYES users to know the quality of the ARYES services themselves. The aim is to give confidence to the construction sector to implement and use the proposed services. Moreover, a web service will be created to search services and display its performance.	

I7 - Reduction of the greenhouse gases emissions (in tCO2-eq/year) and/or air pollutants (in kg/year) triggered by the project	
Impact indicator	Reduction of the greenhouse gases emissions in the buildings involved in the demonstration and market replication activities using the HVAC optimization services proposed in the project
Objective	213 tCO2-eq/year in the demonstrators; 1,420 tCO2-eq/year in the market replication buildings and an asymptotic potential of 367 million tCO2-eq/year in the whole Europe
Target groups	Buildings involved in the demonstration actions Other buildings with centralized HVAC systems
How to reach this impact	The objective will be achieved by implementing predictive and adaptive controls in the buildings HVACs through the ARYES ecosystem, and measured during task T5.2. Although outside of the current programme topic, the service ecosystem that will be developed in the ARYES project could also be deployed in other buildings further expanding the potential for reduction of the greenhouse gases emissions beyond the project lifetime.
Impact justification	The final energy consumption in Europe is 13,516,911 GWh (Eurostat, 2017) and the greenhouse gas emission are 4.300 million tonnes of CO_2-equivalents (Eurostat, 2019). Assuming that in Europe buildings are responsible for 40% of final energy consumption and 36% of greenhouse gas emissions (European commission, 2019), the emissions for energy consumed are 0.29 million kg of CO_2-equivalents/GWh. Transforming the energy savings indicated in impact 1, the reduction of the greenhouse gases emissions triggered by the project in the demonstrators will be 213 tCO2-eq/year and in the market replication buildings 1,420 tCO2-eq/year. If the proposed technologies are implemented in the whole building sector the reduction of the greenhouse gases emissions could be 367 million tCO2-eq/year.

The proposal will contribute to archive other impacts not mentioned in the work programme but substantial:

I8 – Economic impact: reduction in building energy bill	
Impact indicator	Reduction of the building energy bill
Objective	30% of cost savings
Target groups	Buildings involved in the demonstration actions Other buildings with centralized HVAC systems
How to reach this impact	The objective will be achieved by implementing predictive and adaptive controls in the buildings HVACs through the ARYES ecosystem, and measured during task T5.2. Although outside of the current programme topic, the service ecosystem that will be developed in the ARYES project could also be deployed in other buildings further expanding the potential for reduction of the greenhouse gases emissions beyond the project lifetime.
Impact justification	In the literature many examples exist on the use of model predictive controls and its benefits. Energy costs reductions depends on the control policy applied (Gangolells et al., 2016), but are around 25% (Bianchini et al., 2019). Those savings can be higher in ventilation systems, accounting more than 30% of cost savings (Vaccarini et al., 2016). Taking into account, that ARYES project aims to reduce 25% the HVAC final energy consumption, and the project will introduce flexibility services, it is fair to assume that the ARYES solution will deliver a cost reduction around 30%.

I9 – Improvement of the indoor air quality in buildings	
Impact indicator	I9. CO2 concentration in the buildings involved in the demonstration and market replication activities
Objective	CO2 concentration under 1,200 ppm during the working hours.
Target groups	Buildings involved in the demonstration and market replication actions Other buildings with centralized HVAC systems
How to reach this impact	The objective will be achieved by implementing predictive and adaptive controls in the buildings HVACs through the ARYES ecosystem, and measured during task T5.2. Although outside of the current programme topic, the service ecosystem that will be developed in the ARYES project could also be deployed in other buildings further expanding the potential for energy consumption reductions beyond the project lifetime.
Impact justification	Commercial BEMS usually are schedule-based (Vaccarini et al., 2016). As a consequence, HVAC system do not work efficiently. In ventilation systems this means that the fans could be turned one when nobody is in the room and turned off when the air is exhausted. ARYES project will implement model predictive controls and will use them to ensure a constraint of "never reaching 1,200 ppm", to guarantee indoor air quality.

I10 – Improvement of the facility management practices in buildings and increase the productivity of those actors	
Impact indicator	Developed control strategies do not require any action from the building energy manager
Objective	No daily, weekly or monthly actions carried out by building energy managers to control the HVAC systems
Target groups	Building energy managers of the buildings involved in the demonstration abd replication market actions Other building energy managers of buildings not involved in the demonstration and replication market actions planned Technical support service providers
How to reach this impact	The objective will be achieved by implementing the ARYES services regarding predictive and adaptive controls in the buildings HVACs and measured
Impact justification	BEMS available on the market are reactive rule-based (Pantazaras et al., 2018). This means that building energy managers should setup the working conditions of the HVAC systems (e.g. indoor temperature), and then they should use a time schedule for turning on and off the central HVAC systems such as boilers or fan (Vaccarini et al., 2016). This implies that building energy

	managers should manage the scheduling regularly in order to optimize the energy use according to the surrounding environment (e.g. weather conditions in the case of heating and cooling systems or building occupation in the case of ventilation systems). The proposed control systems will automatically turn on and off the heating and cooling systems in order to achieve and maintain the indoor temperature indicated by the energy manager during the building working hours. In the other hand, the proposed control systems for ventilation will automatically regulate building fans according to the occupancy of the building. Therefore, human actions to manage the building HVAC systems will be reduced and the productivity improved.

I11 – New weather and climate services to the retail sector	
Impact indicator	Conclusions in DB 2.2 workshop M5
Objective	Explore the potential use of seasonal predictions in the definition of sales management in retail buildings and logistics management between different centers and stores.
Target groups	Retail and logistics sectors.
How to reach this impact	Create a specific subgroup during the servitization process (WP2) that explores the possibility to use seasonal predictions in retail buildings.
Impact justification	During the preparation of the proposal we interacted with companies residing into the buildings target who were interested to use seasonal predictions to define their sales strategy. For example, if they know that the winter will be shorter and warmer than expected, they will not reduce the production of warm clothing. During the project we will explore how this information can be provided to those companies in order to help them defining sales strategy.

I12 – A robust and secure platform to support the viability of the service ecosystem		
Impact indicator	Reports on formal verification (D5.3 and 5.4) and on market replication (D4.3) of the ecosystem	
Objective	Increasing the trust of stakeholders in the ARYES approach, by both proving its properties (scalability, robustness, security, etc) and that it can be easily replicated on new deployments	
Target groups	Demonstrators and buildings involved in the project Financers and investors Building owners	Facility managers ESCOs Technical support service providers Aggregators and energy traders
How to reach this impact	Task T5.5 will develop the monitoring and evaluation methodology (D.5.1), which will define both the data to be collected when the ARYES services are provided and used, and the set of properties to be proved/monitored on the ecosystem. This set of properties can comprise formal timing properties to be verified with model checking tools, scalability properties to be tested using automated testing tools, robustness and security ensured by means of automated ICT risk assessment. An analysis of the process of replicating ARYES during the development of its beta version will provide best practices to facilitate future market replication.	
Impact justification	This impact complements the goals of impact 6 to ensure that the innovative energy services are reliable and verifiable and service providers are trustworthy and accessible. Impact 6 monitors the behaviour of the ARYES services, thus measuring the benefits provided by the services on energy saving, green investments, etc; and ensures that the service providers in the best possible way. This impact considers the technical aspects of the service oriented architecture itself and on the issues encountered while performing market replication during the deployment of the beta version of ARYES.	

2.2 Barriers and obstacles

With the aim to identify barriers, obstacles and other framework conditions that may influence the achievement of the aforementioned impacts, a PESTLE analysis focused on Political, Economic, Social, Technological, Legal and Environmental aspects will be conducted along the project.

Table 9. Barriers and obstacles for the ARYES project

Barriers and obstacles	Impact affected	Measures to overcome it
Existing buildings and current design and construction practices for HVAC systems are not compatible with the developed services	I1, I2, I3, I4, I5, I6, I7, I8, I9, I10, I12	The project will involve the whole construction value chain in the definition of ARYES services, business models and energy performance contracts using co-creation activities. This will result in the creation of viable and add value services for the building sector. In addition, the involvement of two business organizations, and specific communication channels and tools such as newsletters, workshops, and ARYES handbook will ensure to disseminate best practices to implement energy and non-energy services in building sector. Finally, the consortium will be in contact with relevant smart buildings associations and projects that are developing smart readiness indicators for buildings (e.g. SRI project).
Resistance to change of the construction industry	I1, I2, I3, I4, I5, I6, I7, I8, I9, I10	The project methodology is based on co-creation activities and this will ensure that services developed add value to the building industry and its implementation is viable. In addition, the consortium includes CCB that is a business organization for contractors who its aim is to activate the innovation in the building sector.
End energy users lack of awareness about the energy flexibility services	I4	The communication activities will include a set of documentation to justify the need of the project and the technologies proposed.
Proactive attitude of customers to implement weather and climate services in the retail sector	I11	The retail sector has a special interest to implement new management tools to optimize the sales. In this sense, the project will take advantage of this opportunity, and highlighting the benefits to have integrated services.
Data access related to problems in real-time climate prediction forecasts	I3, I4, I7 I8, I11, I12	The problems in accessing to the data for decadal models initialisation could compromise part of the weather and climate services, and limit the number of services in the ARYES ecosystem. The project tasks have been defined according to the plans of the Copernicus Climate Change Services to provide real-time operation seasonal forecasts.
The climatology of the years when the project will carry out the demonstrator activities is not relevant or interesting to test the developed services	I1, I7	The unexpected and rare climatic events such as warmer-than average winters or hot waves, can affect the promised savings because the proposed services mainly have the aim to optimise the HVAC systems. For this reason we selected different locations in order to have reliable climatological conditions and obtain consistent conclusions.
Local regulation not allow the flexibility services at demand side	I3, I4, I5, I8	The impossibility to fully exploit the benefits of flexibility services may compromise the implementation of the services related with energy flexibility. For this reason, we selected different locations in different countries. One of these locations is in Denmark, one of the countries with most advanced legislation in energy flexibility.

2.3 Measures to maximise impact

The ARYES consortium is aware about the importance of the communication activities not only to report the project results to experts and non-experts in the field, but also to explain the reasons behind the project as well as the project journey. In addition, the use of strategic communication can also help publicise the project work and create opportunities to increase the success rate of the project, draw the attention from public authorities and private entities, attract novel service providers, encourage talented students and scientist to join the project, enhance the project reputation, increase the opportunities to exploit the project results and generate market demand. Being aware of the importance of the communication activities as a tool to maximise the project impact, the ARYES communication activities will start from the beginning of the project. Impact covers issues that directly address call of proposals such as climate change, energy efficiency. Also impact addresses other societal challenges such as poverty, social inclusion

through introduction of new services and new business models into public buildings (see Section 1.3). The communication actions will address those issues as well through round tables, videos, newsletters, publications, presentations and other activities. In addition, as the proposal is built on co-creation, all stakeholders groups including end-users will be actively involved in workshops, feedback sessions and other kind of actions (see task T2.2, T6.2 and T6.5).

2.3.1 Communication and dissemination plan

Although ARYES project includes in the implementation plan the development of a detailed and fully adaptive communication, dissemination and exploitation plan (task T7.1) in WP7 (Ready-to-sign market uptake strategy and dissemination), in this proposal an initial communication, dissemination and exploitation plan is developed in order to define the communication and marketing activities. Although the dissemination regards the project results and the communications regards all the project interactions, we present them together since in our case they share objectives and channels. However during the execution of the project, separate plans should be developed. The methodology used to define this plan was: (I) Identify the communication objectives, (II) Identify the target audience, (III) Determine the information to be provided (message), (IV) Identify the dissemination and communication activities, and (V) Define the KPIs to monitor and evaluate the high quality of the communication strategy.

Communication objectives

The communication objectives for ARYES project are:

- **COBJ 1.** To inform the project reason, advance and results.
- **COBJ 2.** To capture and develop knowledge from different stakeholders in the construction value chain.
- **COBJ 3**. To transfer knowledge to academia for scientific purposes and education and training activities.
- **COBJ 4**. To transfer knowledge to the construction industry.
- **COBJ 4**. To persuade the construction sector to use/incorporate in its building management activities the ARYES ecosystem.
- **COBJ 5**. To inform policy makers the necessity to adapt the legislation to make possible implementation of the developed services and business models.
- **COBJ 6.** To share data generated by the project in order to facilitate its access, re-use and preservation.

Target and customer audience

For the ARYES project, 13 target groups have been identified. The target groups to be addressed are presented and assessed in Figure 5 according its power and interest in the project. Analysing Figure 5 is possible to see that 4 target groups have a strong interest and power in the project. Those groups are considered **key players for the project** and should be managed closely.

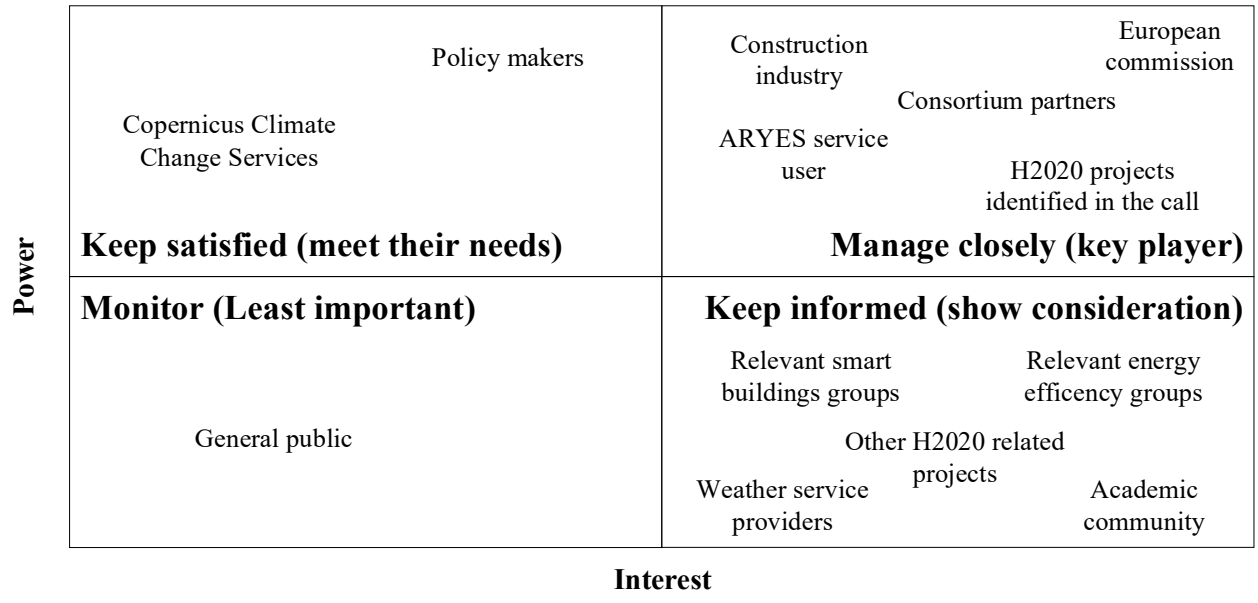

Figure 5. Analysis of ARYES target groups

- **TG1. European commission.** Is principal funder of the project and it has a strong interest and power in the project.
- **TG2. Consortium stakeholders.** This target group includes all ARYES consortium partners.

- **TG3. ARYES service user.** ARYES users are identified in Figure 5. Analysis of ARYES target groups. The identified users are not limited to the end energy users of a specific market segment. The results of the project aim to be applied across several market segments (Building office, retail, schools), and to be used by different actors: (i)Financer and investors; (ii) Building owners or facility managers; (iii) ESCOs; (iv) Technical support service provider; and (v) aggregators and energy traders. This target group has a strong power and interest in the project because they will benefit from the project results, using the services, but also because the project is based on a co-creation methodology.
- **TG4. Construction industry** installers, contractors, designers, engineering consultants… This target group is involved in the physical installation of ARYES services. ARYES concept can also help them enrich their business models, and they can become indirect customers of the platform.
- **TG5. H2020 projects identified in the call.** The collaboration of H2020 projects identified in the call we be used to find synergies between project results and increase the interoperability of ARYES project and increase the chances of commercialization of ARYES service ecosystem.
- **TG6. Relevant energy efficiency groups.** European and international networks related to energy efficient buildings such as ECEEE-European Council for an Energy Efficient Economy, EERA-European Energy Research Alliance, BUILD UP-energy solutions for better buildings, H2020-Bridge, IEA-Energy in Buildings and Communities Programme, as well as other relevant entities in the partner countries (e.g. NERN-National Energy Research Network, TEDDINET) provide unique opportunities for maximising the impact of the ARYES project.
- **TG7. Relevant smart buildings groups**. European and international networks related to smart buildings and its labelling, such as Smart Building Alliance and the Smart Readiness Indicator (SRI) https://smartreadinessindicator.eu/.
- **TG8. Other H2020 related projects.** Usually exists a good relationship between the different H2020 related projects in order to search liaisons and maximise the impact. To find related projects the BRIDGE (the initiative which unites Horizon 2020 Smart Grid and Energy Storage Projects) will be used.
- **TG9. Weather service providers.** Weather service providers are currently offering commercial solutions but are not specially adapted for the building sector. In addition, the predictions usually are from days to one or two weeks. No commercial services regarding seasonal predictions or decadal predictions are on the market. Weather services providers can be interested in the project results in order to increase the number of services that offer. Those weather services can be public ones such as national agencies (Agencia Estatal de Meteorologia-AEMET, http://www.aemet.es/) or private ones such as METEOBLUE (https://www.meteoblue.com/).
- **TG10. Academic community**, or scientific society is seen as an important target group to spread the results and get feedback on the conceptual and technological solutions.
- **TG11. Policy makers.** This target group has a power as they have a power to open opportunities and foster using new services for public building through support of energy efficient solutions. They also could be interested when understanding that new services designed during the project have impact no only on climate change and energy efficiency but also on dealing poverty, migration and other societal challenges through increasing access of energy to local communities centers and social support institutions.
- **TG12. Coopernicus CCS.** This target group has a high impact of the proposal because it provides the information to initialize the sessional and decadal predictions. However, is a big organization and possibly its interest in the project is low.
- **TG13. General public.** This target group has low impact and power in the project. However, consider them is a moral obligation because they tax funds indirectly the project.

Key messages

This section identifies the key messages of the ARYES project. Those messages will be revised during the project execution, once the work packages deliver their goals and deliverables will be completed. This messages will be used from the beginning of the project and until the first deliverables will be accessible and ready to disseminate.

ARYES users, policy makers and general public pillar key messages:

- **KM1.** Due to the building impact on global energy consumption, the current building characteristics and the new paradigm in energy market, implementing controls in HVAC building systems can reduce the global energy consumption and the stress to the electricity grid.
- **KM2.** The implementation of predictive and adaptive controls in HVAC building systems can help to reduce the building energy demand and reduce the energy bill.

- **KM3.** The weather and climate predictions combined with appropriate modelling tools is a useful tool to carry out building energy consumption predictions for energy planning, management, and conservation, but also to plan investments.

Technical expertise pillar key messages:

- **KM4.** Co-creation activities will be used to involve ARYES service users and other relevant stakeholders in the service developments.
- **KM5.** ARYES project contributes to the standardisation related to middleware protocols.
- **KM6.** Servitization process increases the viability of the end energy services and create new energy and non energy services.
- **KM7.** Generated data regarding monitoring is available for transparency purposes.

Business expertise pillar key messages:

- **KM8.** Co-creation activities will be used to involve ARYES service users and other relevant stakeholders in the business models definition.
- **KM9.** The ARYES services are sustainable along the time with reliable business models.

Ethical, legal and socioeconomic expertise pillar key messages:

- **KM10.** ARYES contributes to identify the needs and gaps in the regulatory framework applicable to energy market.
- **KM11.** ARYES contributes to define improved energy performance contracts (EPC) in order to facilitate the implementation of next-generation of smart energy services in buildings using co-creation activities.

2.3.2 Communication and dissemination channels, tools and activities

The communication and dissemination channels, tools and activities are defined according to the key messages defined in previous section. The internal project communication is described in section 3.2.2. Table 10 presents the relationship between the key messages and the communication and dissemination channels, tools and activities. In addition, the communication and dissemination channels, tools and activities should be adapted to the target group, adapting the language (e.g. technical, scientific or political) in order to achieve the expected benefits (e.g. inform, enhance collaboration). For this reason, Table 11 presents the relationship between the communication and dissemination channels, tools and activities and the target groups.

Table 10. Relationship between communication and dissemination channels, tools and activities

Communication and dissemination channels, tools and activities	**Key Messages**										
	KM1	**KM2**	**KM3**	**KM4**	**KM5**	**KM6**	**KM7**	**KM8**	**KM9**	**KM10**	**KM11**
ARYES logo, slogan and report and slides templates	+	+	+	+	+	+	+	+	+	+	+
ARYES website	+	+	+	+	+	+	+	+	+	+	+
Web 2.0 tools and services (social pages)	+	+	+	+	+	+	+	+	+	+	+
A series of short videos or photos (stories) on ARYES topics for Youtube	+	+	+						+		
A series of presentations on Shareslide, LinkedIn and similar	+	+	+	+	+	+	+	+	+	+	+
Project reports	+	+	+	+	+	+	+	+	+	+	+
Press notes	+	+	+	+	+	+	+	+	+	+	+
Brochures, leaflets and roll-up banners	+	+	+	+	+	+	+	+	+	+	+
E-newsletters	+	+	+	+	+	+	+	+	+	+	+
Demonstration events		+	+						+		
Co-creation activities (workshops, round tables or others)				+				+			+
Physical mini games for presentation				+				+			+
Presentations and participation in industry and scientific fairs and conferences	+	+	+	+	+	+	+	+	+	+	+
A series of scientific publications in scientific journals (OpenAccess) on findings of researches		+	+								

The communication and dissemination channels, tools and activities can be grouped into three four of actions:

- ARYES identity. Actions regarding to build a recognisable and identifiable visual identity for the project. This includes the design of logo, slogan, template for report and slides templates and the website layout.
- ARYES support material. These actions include all necessary activities to create content for the different communication and dissemination channels, tools and activities such as web content or presentations for participation to conferences.
- Co-creation activities. Project methodology is based on co-creation activities. For these reason during the project a series of interactive (co-creation workshops, round tables or others) in the cities and local communities involving all the stakeholders. Those activities will be supported by **innovative gamification** tools in order to serve as an excuse to initiate the discussion about ARYES related topics.
- Show cases and presentations. Those actions are related to communicate the project reason and progress and disseminate the results in on-site demonstrations events, conferences or face-to-face meetings.

Table 11. Communication and dissemination channels, tools and activities for each target group

Communication and dissemination channels, tools and activities	**Target groups**												
	TG1	**TG2**	**TG3**	**TG4**	**TG5**	**TG6**	**TG7**	**TG8**	**TG9**	**TG10**	**TG11**	**TG12**	**TG13**
ARYES logo, slogan and report and slides templates	+	+	+	+	+	+	+	+	+	+	+	+	+
ARYES website	+	+	+	+	+	+	+	+	+	+	+	+	+
Web 2.0 tools and services (social pages)	+	+	+	+	+	+	+	+	+	+	+	+	+
A series of short videos or photos (stories) on ARYES topics for Youtube		+	+	+		+	+			+			+
A series of presentations on Shareslide, LinkedIn and similar		+	+	+	+								
Project reports	+	+											
Press notes		+	+	+	+	+	+	+	+	+	+	+	+
Brochures, leaflets and roll-up banners		+	+	+	+	+	+	+	+	+	+	+	+
E-newsletters		+	+	+	+	+	+	+	+	+	+	+	+
Demonstration events		+	+	+	+	+	+	+	+	+	+		
Co-creation activities (workshops, round tables or others)		+	+	+	+						+		
Physical mini games for presentation		+	+	+	+								
Presentations and participation in industry and scientific fairs and conferences		+	+	+	+			+		+	+		
A series of scientific publications in scientific journals (OpenAccess) on findings of researches				+	+			+		+	+		

ARYES logo, slogan and document and slides template. In order to be recognisable and identifiable the project will develop a visual identity for the project to make every document and actuation identifiable, have a bigger impact, and make trackable the storyteller and the evaluation of the project. This includes the project logo development, the slogan and creative arts and the templates for reports and slides. Due to its experience, VGT through its Creativity and Innovation Center will develop communication tools with the resources established in WP7.

All ARYES identity tools will be used in all project communications.

ARYES website. Static / not time sensitive information will be published on a first version of the website at the beginning and along the project. When the service ecosystem will be ready to be used, a new version of the website will be launched mainly devoted to the ARYES service ecosystem promotion but incorporating inside the information of the project but in such a manner that potential ecosystem users not be bored by this static information and under specific pathways. The website will provide a prime online access point to the project, promoting information sharing and making the website a public dissemination tool with content derived from the research output (such as presentations, publications and demonstrations). It will also provide updated news on the progress of the project updated periodically when deemed necessary, information about project events and a private access to a collaborative work environment, where members of the consortium can build knowledge concerning the project to maximise the synergies between partners in the implementation of the different work packages. The ARYES project website will be kept active for at least five years after the end of the project, in order for it to act as a support tool for future dissemination and exploitation or, if it is the case, evolve to other marketing website even more focused to the releases of the game. The ARYES website will also be used as the main contact channel for any external stakeholder who

would like to retrieve additional information from the consortium, or is seeking guidance or establishment of partnerships. Contacts for partners will also be provided in the public website for any technical enquiry related to the ARYES services that will be deployed in the project's demonstrators. This action will be mainly be managed by VGT because of its own abilities and expertise, although other partners will also contribute in the creation of content. Specific consortium partners will also take the responsibility of managing enquiries from specific countries to provide multi-lingual assistance, for instance, UPC will manage contacts from Spain, AAU from Denmark, VGT from Lithuania, BED from Turkey and CCB from Belgium. Companies' own websites will also include references and the link to the ARYES website. This activity will be done with the PM assigned in WP7.

The indicator measuring the impact of the ARYES website will be the average number of monthly visits and their average duration, the objective being set on 500 monthly visits with an average duration of 2 minutes. In case this indicator is not properly reached, the website will be promoted using newsletters, social networks, etc. and/or reorganised to easily find relevant information and updated with more attractive content.

Web 2.0 tools and services. ARYES Web 2.0 communication systems will be an active node in global networks related with energy efficient buildings, using social networking (i.e. Facebook, Twitter, Flickr, Instagram, etc.) as the main driver in order to make it easier to reach multiple audiences. The ARYES online communities created by the project will provide real time / entertaining information and social news through social networking platforms for users to discuss energy efficiency, share interests and activities. The communities will be developed using existing Web 2.0 tools, such as those for blogging and micro blogging posts, podcasts, documents, videos, bookmarks, presentations and photos. The ARYES website will aggregate the information generated by the Web 2.0 tools and ARYES communities through widgets, RSS feeds, links, add-ons and embed applications or multimedia resources to provide a single source of information about the project for external stakeholders. Also mass and specialised social networks will be used as channels to communicate (e.g. www.crowdhelix.com for research and academia, network for Industries, etc.) This action will be mainly be managed by VGT because of its own abilities and expertise, although other partners will also contribute in the creation of content.

The indicator measuring the impact of the web 2.0 tools and services will be the average number of followers in the social networks, the objective being set at 100 followers yearly. The number of posts in the main social networks will also be used as an indicator, the objective being set at 20 posts by a users interested in the project or involved in the demonstration activities. In case these indicators are not properly reached, contacts, newsletters, social networks will be used to promote the project.

A series of short videos or photos (stories) on ARYES topics for Youtube. A series of original short videos and photos will be created and distributed through social media through communities or channels followed by specific groups of end-users and stakeholders. The videos will be produced to ease the comprehension of the message we want to communicate. In order to provide the right message to the right people, more than one video is planned. For dissemination at the local level, a video showing images of the pilot implementation strategy will be developed. For dissemination at international and EU level, the video will respond and provide answers to the overarching questions of the ARYES project. Videos will be accessible on both the main website as well as in each industrial partners' website amongst others. Videos will be also used as a method for users' engagement or trust building initiatives for initiating the discussions and debates. VGT will take the responsibility to produce these videos due to its experience in the field with its Creative Industries LAB and the budget considers the PM required to produce these videos.

The amount of produced videos and the average number of views (extracted from YouTube or Instagram statistics) will be used as main indicators for this communication tool, the objective being set at 3 videos and 10,000 views for each one. In the case this is not achieved, videos and photo stories will be promoted through events, newsletters and social networks.

A series of presentations on Shareslide, LinkedIn and similar. Slides providing answers to the overarching questions of the ARYES project will be generated and adapted to provide the right message and language to the right people. This questions will be: What is ARYES project about and why is it important?; What makes this project different to other projects?; What will be the "wider" benefits and impacts?; Who will it benefit? (directly and indirectly); Who should be interested? Media, industry, local and national authorities, service users; How does it fit and how it will contribute to the EU Energy Efficiency Policy at local, regional, national and European levels? Living Lab and co-creation methodology; Demonstrator creation and implementation; Demonstrator case; Market replication experience. VGT due to its expertise and experience will lead this action but all partners will contribute creating content for the presentations. The PM required to carry out this action are considered in WP7.

Slides will be used in every event in which presentation is needed. In addition, this slides will be uploaded to Shareslide, LinkedIn and similar. Is expected to generate 8 presentations with 20 slides each, the objective is to achieve 10,000 views.

Press notes. The project partners will produce a continuous stream of publications throughout the duration and beyond the project's lifetime addressing different dissemination channels. These will include mass media (e.g. newspaper, TV news), and specialised magazines. Publications of the research results will be available at appropriate venues, as well as on the project's website. A final compilation of all publications produced by the ARYES project will to be released towards the end of the project.

Indicator measuring the impact is the number of press notes but also the number of times the ARYES project is on the mass media. The target is set at releasing 3 press notes per year.

Brochures, leaflets and roll-up banners. The ARYES brochure will support the promotion of the project, including its vision, concept and objectives. The brochure design will be adaptable, whilst having a consistent high quality and engaging cover, loose single pages within will allow the brochure to modify to the ARYES audience and events at which it is used. In addition, leaflets and roll-up banners will be designed in order to support the promotion activities in conferences and industry fairs.

The number of distributed brochures and leaflets will be the main indicator for this communication tool, the target being 1,500 units. Attendance at conferences, workshops, industrials fairs will help to achieve this objective. In addition, 4 roll-up banners will be printed and used in conferences, workshops, industrials fairs.

E-newsletters. Two newsletters per year will be produced by the ARYES project and published on the project's website, with the first being published 3 months after the project start date. The newsletters will highlight the progress of the ARYES work plan, providing insight into the research, development, innovation and demonstration activities. A newsletter distribution list will be collected by each partner in its own country and used to notify to the distribution list when the first newsletter is published online. In this first email, there will be an option for users to subscribe online if they want to continue to receive the next issues of the newsletter (mailing list). As the project evolves, contacts gathered through the website, at conferences, will be added to the database. A printed version of the latest newsletter will be provided for promotion at organised events.

Partners will also be asked to disseminate the content developed in this action through their own communication tools, e.g. by including one article from ARYES newsletter in their own newsletters and promoting them through their own social media, in order to better reach all target groups.

The number of subscribers to the newsletter will be used as main indicator, the target being set at 500. In case that this target is not achieved, promotion of the project and its newsletters will be done through events and social networks. In addition, 18 articles from ARYES newsletters available to publish in the partners communication tools.

Demonstration events. In order to carry out promotion activities, two demonstrator events are planned in each demonstrator site and one in each market replication building. The aim is to invite potential ARYES service users/customers and other stakeholders into the demonstration sites in order to show how it works the developed services in a real environment. These events will be carried out after milestone 4 (month 18) and the partners in charge of the demonstrator will be responsible to carry out this action. The innovation manager will coordinate this actions. This communication action does not need specific founds.

The number of attendees in the demonstrator event will be used as a main indicator, the target is to achieve 20 attendees per event. In order to ensure this target, a confirmation mail will be asked, if one week before we do not reach the target number of attendees we will use social networks and we will send personal invitations.

Co-creation activities (workshops, round tables or others). The project will use a set of interactive actions to define the services to be developed, the business models and the type of contracts to be used to implemented the ARYES services. These interactives sessions will use gamification techniques in order to initiate the discussion about ARYES related topics (see Physical mini games). These activities will be carried out in Belgium and Lithuania, with a total number of 20: 2 for the servitization process; 8 for the business models; 8 for the service contracts and energy performance contracts; and 2 for the development of the labelling system to assess the quality of demand side service providers. In addition, an additional workshop regarding the servitization process will be done in Spain to analyse the use of seasonal predictions in retail buildings. Due to its experience in organizing this kind of events CCB will lead the coordination of this action. The budget considers specific budget to cover the costs of these activities (e.g. rent of equipment, small stationary and catering at the events).

The number of attendees in each event will be used as a main indicator, the target is to achieve 10 attendees per event. In order to ensure this target, a confirmation mail will be asked, if one week before we do not reach the target number of attendees we will use social networks and we will send personal invitations.

Physical mini games for presentation. Physical mini games for presentation of Project related topics, e.g. business model canvas for new services in an ecosystem. Examples of mini games can be a small card set, for people to be

kinaesthetically involved in the process of presentation and discussion. Mini games serve as a demonstration and an excuse to initiate discussions especially when different groups of end-users and stakeholders with different levels of power, understanding of the topic and skills to debate meet. Mini games will be produced VGT Creative Industries LAB by 3D printing or using other technologies. The budget considers the costs of physical mini games production.

The indicator measuring the impact of the physical mini games for presentation will be the development of 1 table game, with a set to each country involved in 18 activities.

Presentations in industry and international scientific conferences. Construction industries and related participants in the value chain besides other activities will be reached through presentations in the industry events such as industrial fairs or conferences. The aim of these presentations will be to present the results and encourage different stakeholders to invest in the development of services for ARYES ecosystem, exploit the new developed services or use the services of the ecosystem. The task will be coordinated by the innovation manager (CCB), although other partners will also contribute. Specially the industrial partners of the project (ADV, NEO, BED, COM) and the VIA as an association to promote the innovation in the industry. Examples of potential **industrial fairs and conferences** relevant to ARYES themes to be attended by the consortium partners include: RESTA, the annual exhibition of construction industry of Baltic states for construction industry professionals and end-users interested in construction and renovation; Batibouw, the annual fair for construction industry in Belgium; Digital Construction Brussels (annual fair); Smart Building for Smart Cities, the annual conference of SBA.

Regarding the **scientific conferences**, the coordinator will be the responsible to coordinate all actions. These actions will include the participation in scientific conferences and workshops, relevant European and International conferences/workshops on the use of ICT for energy efficiency, focusing on, but not limited to the topics of, smart grids, smart metering, energy efficiency, Co-creation and Living Lab methodologies, building simulation, etc. Examples of potential conferences relevant to ARYES themes to be attended by the consortium partners include: ECEEE/ACEEE Summer Study on Energy Efficiency, European Group for Intelligent Computing in Engineering (EG-ICE), BEHAVE, Building Simulation, Building Simulation and Optimisation, European Conference on Product and Process Modelling (ECPPM). Regarding the ICT techniques developed in the solution, and the high-performance and interoperability aspects targeted by ARYES, relevant conferences comprise the International Conference on Emerging Technologies and Factory Automation (ETFA) and the International Conference on Computer as a Tool (Eurocon). Regarding the business models, relevant conferences comprise Contemporary Issues in Business, Management and Economics Engineering, Business and Management, VISUALITY 2023. Finally, regarding the weather and climate aspects, the most relevant conference is ICEM. The project partners will promote parallel sessions in relevant conferences in order to increase the project impact. The budget includes the costs to attend to different conferences.

The indicator to measure the impact of this communication tool is the number of industrial fairs and conferences where the project is presented and the number of scientific papers presented in conferences. The target is set at 6 industrial fairs and conferences and 6 papers published in international and national conferences. If this is not achieved or there are no plans for being achieved at the end of the project, the project coordinator together with the innovation manager will assign this responsibility to the most suitable partner contributing in WP6, according to his point of view, at the beginning of the third year of the project.

A series of scientific publications in scientific journals (OpenAccess) on findings of researches. The project will address some scientific challenges such us the use of seasonal climate predictions or decadal predictions, but also the use of reduced order models and the implementation of adaptive controls for HVAC systems. In this sense some project results will be suitable to be published in high ranked scientific journals. Articles will be submitted to high impact scientific journals. Articles will be published in open access mode and they will be archived by the author, or a representative, in an online repository, when possible (i.e. UPCommons, UPC institutional repository). Project coordinator will have the responsibility to take care about this action. The budget considers the costs of the publication in *'green'and 'gold' open-access*.

The indicator to measure the impact of this communication tool is the number of scientific papers published. The target is set at 6 'green' or 'gold' open-access papers published in high impact journals. If this is not achieved or there are no plans for being achieved at the end of the project, the project coordinator will assign this responsibility to the most suitable partner contributing in WP7, according to his point of view, at the beginning of the third year of the project.

2.3.3 Communication and dissemination action plan

The following table summarizes the communication and dissemination channels, tools and activities and stablish the scheduling for each group. A detailed plan will be developed during the project.

Table 12. Communication and dissemination action plan

Communication Action	Year 1												Year 2												Year 3											
ARYES identity																																				
Website maintenance																																				
Web 2.0 tools and services																																				
Videos, presentations, brochures, leaflets, roll-up banners																																				
E-newsletters																																				
Demonstrator events																																				
Co-creation for service definition																																				
Co-creation for business models																																				
Co-creation for EPCs																																				
Co-creation for labelling system																																				
Gamification tools																																				
Presentations, conferences and publications																																				

2.3.4 Exploitation plan

In this section it will be explained the main commercial outputs of the ARYES project, and the exploitation plan for each of them. Figure 4 identify the main outputs of the project and how the different stakeholders can use does results. However, it is expected that during the servitization process new energy and non-energy services arise. Exists the possibility that the new services do not fit in the business focus of the industrial partners. For this reason, the strategy to carry out the project results exploitation will be done in two ways. Those services that fits in the business activities of one of the partners will be exploited for them. When a service created do not fits in any business activity of one of the project partners, **CCB** and **VIA** will carry out activities to find companies interested in those services. Both associations have in its mission drive the innovation into the industry and create new business opportunities, in this sense are the perfect actors to do this action. In the following lines it is specified how each industrial ARYES partners will exploit the project results according the main expected outputs:

Output 1. Tools for financers and investors. The main goal of this tool will be the prediction of renewable energy production at midterm horizon (5-10 years). This will help to develop investment risk analysis and to develop financial instruments linked with energy performance contracts. In addition, the energy saving certification service family will support the new energy performance contracts. **COM** and **BAM** as companies focused towards the creation of innovating and cost-effective technologies to be applied in the building industry are interested in these results in order to drive the investments in small scale solar systems in non-housing buildings. **BED**, as utility is looking for new services to offer to its customers, for this reason is interested in the same results, however with a focus on the housing sector.

Output 2. Tools for building owners or facility managers. The results of ARYES will also provide tools for building owners or facility managers (or building energy managers). Those services will be focused on the use of adaptive and predictive controls to improve the performance of building's HVAC system, prioritize building investments, and for energy planning, management, and conservation. **COM** and **BAM** within their division in facility management are interested into the aforementioned services in order to increase its service portfolio and increase its competitiveness with the automatic HVAC optimization systems, developing services to plan the building's energy buying and to provide services to verify which savings are achieved.

Output 3. Tools for ESCOs. Some ARYES results will be based on developing more reliable energy performance contracts in order to predict energy savings with more confidence and to obtain reliable services to verify and certify energy savings of the offered energy performance contracts. **COM** and **BAM** have a division that works in the ESCOs field. They will use the knowledge gained to the project in order to offer more reliable energy performance contracts.

Output 4: Tools for technical support service providers. ARYES contributions and specific exploitable outcomes for the technical support service providers will be essentially focused on building systems integration, field data collection and processing (device management and data acquisition), use of advanced technologies to perform monitoring and control activities, supporting management strategies and planning, as well as security solutions. **ADV NEO,** and **SLX** are strategically placed with respect to the potential commercial exploitation of the project results, and can fully exploit them in order to improve **ADV's IoT & Cloud solution**, **NEO's PreHEAT cloud energy management platform,** and **SLX's Seluxit IoT platform** capabilities and develop the own business on monitoring (data aggregation, devices management) and control (AI, analytics and optimisation) solutions applied to the building management sector market, IoT products and energy services for the energy management industry. This, in terms of

technological innovation in ARYES, is reflected in the improvement of services and IoT devices by expanding their functionalities (i.e., protocol agnostic enhanced adaptors and micro-services) based on opportunities that arise from the experiences gained in the project and relationships built with potential end customers or collaborators.

Output 5: Tools for aggregators and energy traders. The ARYES services will be also useful for aggregators and energy traders. The developed services will enable the introduction of energy flexibility services. **NEO** and **BED** will use the HVAC optimization systems to introduce and increase the flexibility services. They are also interested in the energy prediction service family in order to offer services in the energy market. The challenge in this last issue is to see if the accuracy of the services enables to develop consistent business models that enables services in the intraday electricity market.

Taking into account that **research partners** such as UPC, BSC, AAU and VGT have a twofold mission, (1) to create and disseminate scientific knowledge and (2) to form professionals both at graduate and postgraduate levels, scientific research gained within the ARYES project will serve to expand their research portfolio and the possibility to invest in future research, to increase their teaching capabilities, and to improve the competitiveness of national industries through future high-skilled professionals. Consultancy related to this topic is also a clear exploitation objective for these partners.

2.3.5 Business models

The project aims at servitising business functions (WP2), and a great deal of effort is focused on defining a business plan for each service (WP6). Some services will inherit the business model of the business functions it provides, for other ones part of the innovation will reside in the definition of a novel business model.

With regards to the Arrowhead Framework, which supports the service ecosystem, it is released as open source, however, it is important to remark that its maintenance will require raising resources, possibly by means of fees to the companies that will leverage on the framework to provide their own services.

2.3.6 Data management plan

The project considers a specific task (T7.1) to develop a data management plan (D7.2). This plan will be executed using the tool provided by the Consortium of University Services of Catalunya called Research Data Management Plan in order to fulfil the H2020 data management requirements.

The metadata standard used in the ARYES project to describe the different dataset generated or captured will be the Dublin Core Schema, as it is a flexible and common used standard and is also the one adopted by the European OpenAIRE repository. It will in some way include references to the ARYES project (through the grant identification number), to the deliverables of the project (also deposited in the repository and linked to the platform code), and to the EC and H2020 program. In addition, some keywords will be used for the description of the different dataset when being deposited. Same actions will be taken for project deliverables.

The preservation of the different datasets and deliverables will be through the use of OpenAIRE's Zenodo catchall repository. This repository is free if the datasets uploaded are lower than 50GB. As a consequence, the project preservation costs are null. In case that the OpenAIRE's Zenodo catchall repository was not available, or a fee should be payed to use the service, the UPC will provide the institutional repository (UPCommons. Portal del coneixement obert de la UPC, which is linked into the Open AIRE archive.

The Table 13 includes an initial identification of the datasets generated or collected by the project. The deliverables and the level of dissemination are defined in section 3.1.3 Detailed work description.

Table 13. Type of data generated and collected during the project and actions to be exploited and shared

Type of data generated/collected	Data exploitation/sharing
Data regarding energy consumption, indoor temperature, indoor CO2 levels, weather and climate data, and possibly other data, collected on buildings instrumented as demonstrators and during market replication activities[1]	This data will be used for operational demonstrations. At the end of the project this data will be anonymised and uploaded to the OpenAIRE's Zenodo catchall repository.
Weather and climate predictions (weather forecasting, seasonal forecasting , decadal prediction climate projections[2]	ARYES will collect essential climate variables from external sources (ECMWF-Copernicus Climate Data Store, NCEP) according to their sharing policies. All collected data will be pre-processed and quality-controlled before being ingested into a reputed data repository.

Demonstrator energy predictions	This data will be used for operational demonstrations. At the end of the project this data will be anonymised and uploaded to the OpenAIRE's Zenodo catchall repository.
Results from co-creation activities (e.g surveys or focus groups)	This data will be anonymised and uploaded to the OpenAIRE's Zenodo catchall repository

[1] Data will be also stored in the databases of the building energy management systems of each demonstrator. In this case, data will be only available for the service provider and the customer.

[2] Weather and climate predictions will be also accessible to the general public using the APIs developed in task T3.6. The first version of the APIs will be available in milestone ML3 (First feedback to business models development & ARYES ecosystem alpha version) in M13. The aim is to make accessible the service for potential users and make possible that they evaluate how the weather and climate predictions can be used.

2.3.7 Knowledge management and protection

In order to facilitate the results exploitation, Innovation Property Rights (IPR) protection strategy will be defined according to the partners' interests and stated in the Consortium Agreement to be signed along with the Grant Agreement. Recognising the importance of an appropriated management and protection of the knowledge generated in the project, WP1 will further work on intellectual property protection issues as part of the overall management of the project. An Innovation Manager (IM) will oversee managing and helping to exploit the Intellectual Property in order to ensure the innovative character of the ARYES ecosystem and its competitiveness in the European and worldwide markets. The IM will take care of: (i) Identifying any existing IPR that are held by the project partners and that are needed to implement the action and exploit the new results; (ii) Helping the partners to agree on the identified background and to access them on a royalty free basis; (iii) Managing the ownership of results generated by each partner during the project and conclude, if applicable, a joint ownership agreement; and (iv) Helping the partners to examine the possibility of protecting their results with a patent for an appropriate period and with appropriate territorial coverage.

At the early possible stage, every ARYES project partner should appoint a responsible person for their IPR-related tasks and questions. Those persons will have the responsibility to take all the required measures to guarantee that all rights needed for exploitation purposes will initially be collected and secondly transferred to the IM. The IM will collect this information, will manage all data, and will transfer relevant information to the Steering Committee. In order to do this, an all-embracing documentation search on the legal situation of all research results will be done. The documentation should include all documents, which are necessary for contracts, licenses and acquisitions relating to IPR, and will be more outlined during Consortium Agreement preparation and signature. The IPR management has to follow the legal requirements that can be found in the participation rules and contracts.

Basically, if ownership of knowledge (e.g. a patent or a utility model) is transferred to the project by a participant, the participant has to take steps or conclude agreements to pass on his obligations under the participation rules and the contract, in particular: (i) the granting of access rights; and the dissemination and use of knowledge.

If the participants do not pass their ownership to the project, they have to operate with licenses. Participants, which grant licences to the project, should ensure - as the case may be done by contract - that the other participants keep their access rights in accordance with the participation rules and the contract.

Simultaneously, patents filed in the areas of interest of ARYES will be revised continuously, in order to be aware of any protected technologies related to the activities of the project. This activity has started during the preparation of the proposal at the time of devising the technical scenarios. The dissemination of results will also be monitored by stimulating and facilitating the process of patent filing and giving green light to publications related to IPR going processes at the right time and with the proper notification.

Regarding the scholarly paper that will be produced by the consortium in order to explain the project results and share the scientific knowledge gained, will be accessible to general public for no charge. To attain this goal, the scientific project publications will be published in open access (also called 'gold' open access). Publishing papers under this model is more expensive than traditional closed access publication, since the costs are shifted away from the readers to the author. A positive effect of this paradigm is that authors will focus on fewer publications, but of a higher quality, and the slower paper production will be matched by better impact of the published papers. We will include in the project budget a reasonable amount for the project coordinator, who will manage the money to be used to this end. Other publications arising from ARYES will be self-archived in institutional open access repositories (e.g. 'green' open access), subject to any embargo periods imposed on the authors.

3 Implementation

3.1 Work plan — Work packages, deliverables

Following the servitization methodology and the user-centred service development approach, the project will be undertaken as an iterative process traversing two different but interconnected themes, a technological one and a financial and societal one. The first theme concerns the bundling of energy service, which will influence in the design of service families, followed by the implementation and demonstration in real life conditions, and the monitoring and evaluation of the impact of the proposed approach. The second theme is related to the economical and societal impacts of the project. Following is a brief overview of the project's work package structure and the work to be performed within each work package.

WP1: Project Management – WP1 is responsible for the coordination of scientific, technical, administrative, and financial activities for the entire project lifetime.

WP2: Servitization – WP2 is responsible for a comprehensive definition of the proposed approach as a whole, and of each service family.

WP3: Service developments – WP3 is responsible for the design and development of the different services of the ARYES ecosystem. Based on requirements defined in WP2, this work package involves the design and development of the different service families. In addition, the services will be tested in controlled environments. Finally, the services will be documented with the aim to provide concise information to integrate the different services in composed services.

WP4: Field tests: Validation of ARYES services in real life conditions – in WP4 the ARYES service ecosystem will be implement in real demonstrators. This involves the design of the pilot implementation methodology followed by the deployment of the services in the demonstrators.

WP5: Monitoring and Evaluation – In WP5, primary energy savings and other impact indicators (e.g. cost reduction, reduced order building model accuracy, robustness of the approach) will be monitored and evaluated by means of a pre-post comparison, and by means of formal methods.

WP6: Market uptake and transformation, privacy and regulatory framework – WP6 is responsible for conducting a comprehensive analysis of the existing barriers to implement the ARYES service ecosystem in the market. This work package will address different aspects such as technical barriers, types of contracts, issues regarding privacy and other regulations. The main outcome of this work package will be to provide instruments and incentives to implement ARYES ecosystem in market conditions.

WP7: Ready-to-sign market uptake strategy, communication and dissemination – WP7 will deliver a dissemination and exploitation plan, and drive all communication actions.

Work packages are carried out in parallel, but present inherent dependencies for their work, as depicted in Figure 6. WP1 coordinates the overall project work and as consequence has impact on all other work packages. WP2, WP3, WP4 and WP5 present a forward dependency, since they can be mapped to usual engineering processes (design -> development -> deployment -> evaluation), and will cooperate with WP6 that takes care of studying the effects of ARYES innovation with regards to economic and societal aspects. The results of all work packages will be communicated and disseminated through the WP7, which takes also care of identifying exploitable results and interact with regulations and standardization bodies.

Moreover, four loops between work packages are expected to influence what is done in the project: (1) between service development -WP2- and business models development -WP6- since work packages are carried out in parallel, but the servitization and the business models development are interconnected and require convergence points when they are aligned with each other; (2) the service development -WP3- and business models development -WP6- will both be influenced by the feedback received during the first test of the isolated services and then implemented in the demonstrators -WP4-; (3) from the demonstrator implementation -WP4- to the services development -WP3-, to allow the latter to consider the feedback obtained from the initial tests during the implementation stage; (4) between the monitoring and evaluation of the experimentation -WP5- and the demonstrators implementations -WP4- and business models development -WP6-, where mid-term evaluation results will provide information of the impact of the implementation in order to improve the business models and the end user tested services.

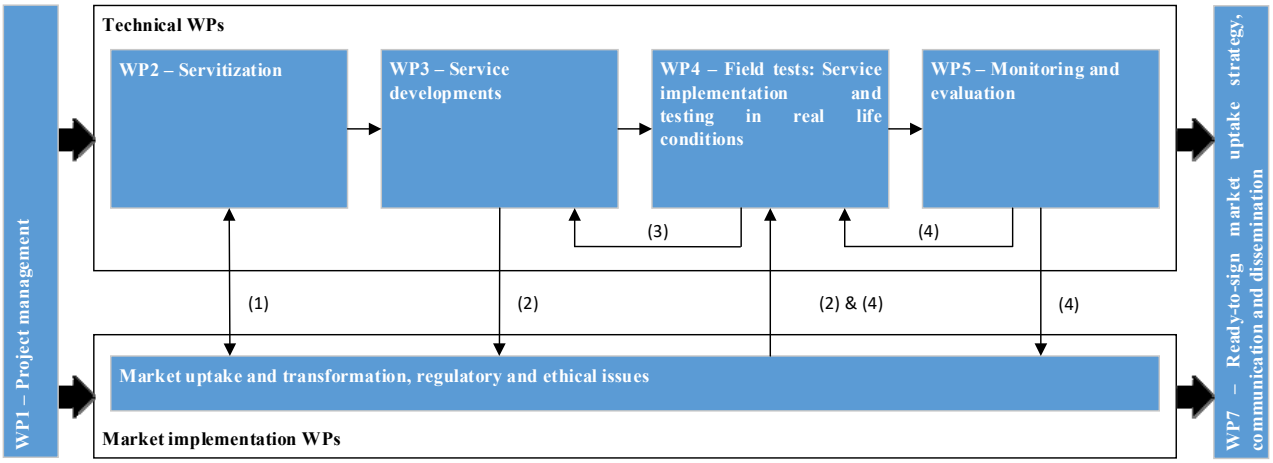

Figure 6: Graphical presentation of the ARYES project components showing how they inter-relate

Table 14 presents the overview of the work packages with the total person-month and the lead partner.

Table 14. Overview of the work packages

WP No.	WP Title	Lead Partner No	Lead Partner Name	PM	Start month	End month
WP 1	Project Management	1	UPC	34	M1	M36
WP 2	Servitization	3	NEO	65	M1	M7
WP 3	Service developments	2	AAU	75	M1	M26
WP 4	Field tests: Service implementation and testing in real life conditions	9	COM	115	M5	M36
WP 5	Monitoring and evaluation	1	UPC	66	M8	M36
WP 6	Market Uptake and Transformation, regulatory framework and ethical issues	6	VGT	101	M3	M36
WP 7	Ready-to-sign market uptake strategy, communication and dissemination	7	CCB	74	M1	M36
				530		

A Gantt chart that summarises a detailed timeline of the project's work packages and tasks is provided in Figure 7. A detailed description of the project's work packages and tasks and related deliverables are presented in tables of the following pages.

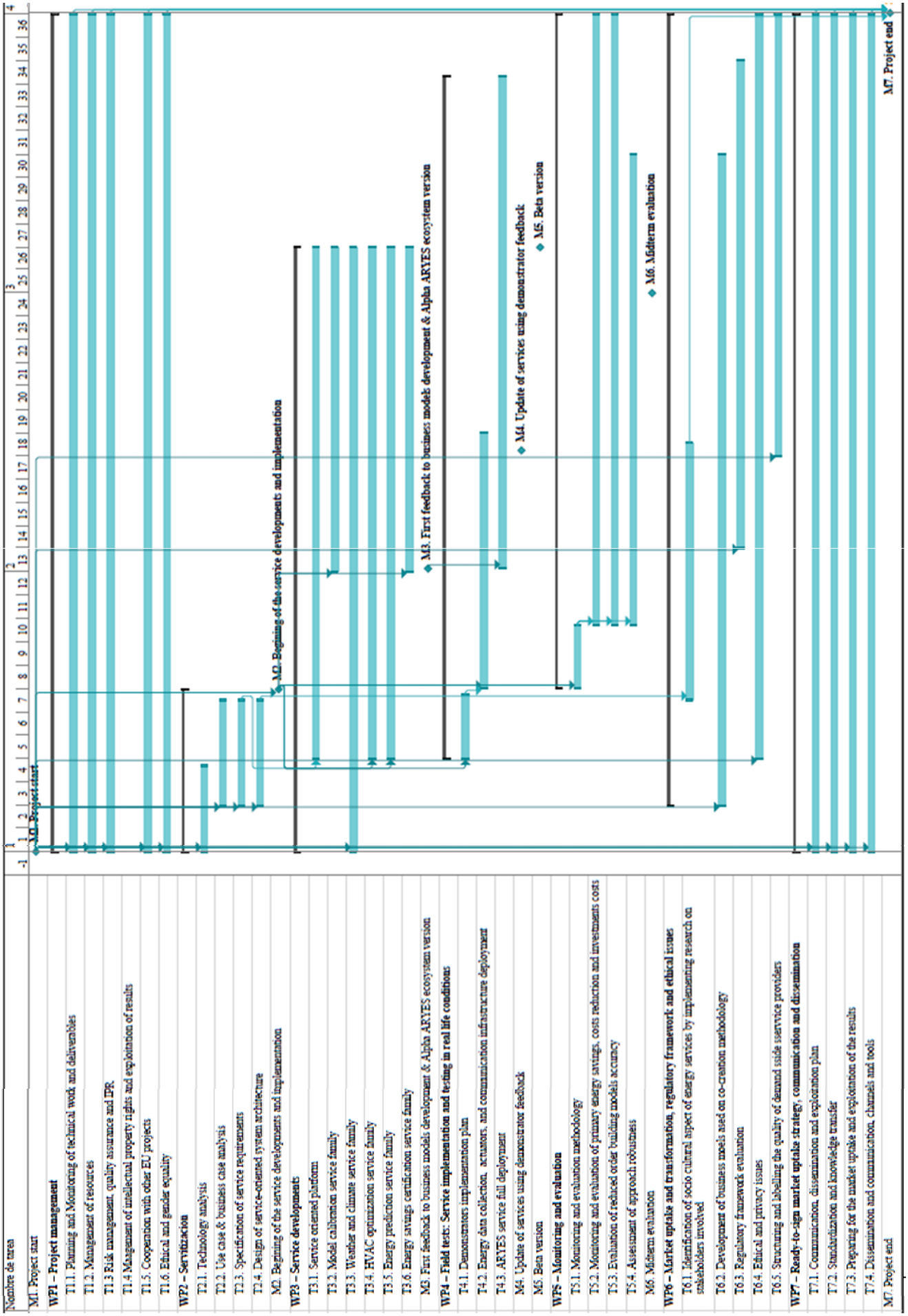

Figure 7. Gantt Chart for the ARYES project

WP1 – Project management

Work package number	WP1					**Lead beneficiary**			UPC			
Work package title	Project management											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	15	4	1	4	1	3	1	1	1	1	1	1
Start month	1					**End month**			36			

Objectives

The overall objective of this work package is the implementation of a sound project and financial management plan including, reporting to the European Commission (EC), ensuring delivery of ARYES results on time and within budget, and maintaining a high level of quality of the deliverables. The specific objectives of this work package are the following:

- Managing the project according to EU Grant Agreement provisions and conformingly to the respective.
- Monitoring the project planning and execution.
- Managing the overall legal, financial and administrative aspects of the consortium.
- Representing the project and the consortium towards the European Commission.
- Risk and quality management related to the project implementation
- Creating liaisons with other related EU projects.

Description of work

Task T1.1. Planning and Monitoring of technical work and deliverables [M1-M36] (lead: **UPC,** participants: ALL)

This task will include all planning and monitoring of the technical work and deliverables:

- Setting up and updating the project management plan according to the EU Grant Agreement provisions. The plan includes a schedule per task, responsible partner, related deliverables and dependencies with other tasks, etc.
- Overseeing the timely submission of deliverables and reports within each work package.
- Organisation of the consortium and the advisory board meetings (technical and market).
- Guaranteeing the cooperation between partners and interconnection between work packages and tasks.
- Acting as the intermediary for all communications between the partners and the EC.

Task T1.2. Management of resources [M1-M36] (lead: **UPC,** participants: ALL)

This task will manage the project resources, including:

- The overall legal, financial and administrative management
- Follow-up the management of resources allocated per partner and work package.
- Guarantee the submission of the financial reports to the EC.
- Ensure that all payments are made to the partners without unjustified delay.

Task T1.3 Risk management and quality assurance [M1-M36] (lead: **UPC,** participants: ALL)

This task will manage the risk and quality of the project, including:

- Managing any potential risk and minimising their impact during project execution. A risk assessment report will be compiled and maintained by periodical revision.
- Setting up and updating the quality plan according to the Grant Agreement.
- Risk and quality monitoring throughout regular meetings and teleconferences.

Task T1.4: Management of innovation, IPR and knowledge transfer [M1-M36] (lead: **CCB,** participants:ALL)

An Innovation Manager (IM) from CCB will be appointed at the beginning of the project (see section 3.2.1). The IM will be responsible to define and monitor the guidelines for the management of IPR and for knowledge transfer. More specifically, the current background regarding the ARYES services will be described, the access rights to the results for each partner will be clarified and the objectives of exploitation or commercialization of the project results will be defined. In addition, The IM will also coordinate the measures regarding knowledge transfer between the project Consortium and the private sector. The IM will also participate actively in the definition and revision of the Data Management Plan (DMP) and in the management of the results exploitation, and it will

produce a Plan for the Exploitation and Dissemination of Results as planned in Task 7.1. In addition, IM will be responsible of all innovation activities: identifying effective innovation approaches, monitoring the ARYES activities and its target markets, and defining correction activities. The IM will meet regularly with the steering committee and the work package leaders to coordinate the tasks.

Task T1.5. Cooperation with other EU projects [M1-M36] (lead: **AAU,** participants: ALL)

A Cooperation Leader (CL) (see section 3.2.1) will be appointed by AAU at the beginning of the project, to lead activities in this task. Its role will comprise:

- Setting up and updating the Cooperation Plan with other research activities and laboratories, comprising the ones specified in section 1.3.3.
- Uptake actions designed to facilitate cooperation, across Europe, with other research projects; to enhance interoperability; and to ensure the accessibility and reusability of the outcomes of the project.
- Multilateral meetings and specific workshops with other research projects, carrying out collaborative activities along the project and sharing best practices.

Task T1.6. Ethical and gender issues [M1-M36] (lead: **VGT,** participants: ALL)

An Ethical and Gender Issues Observer (EGIO) from VGT will be appointed at the beginning of the project (see section 3.2.1). The EGIO will be responsible to define and monitor the guidelines to ensure the appropriate ethical and gender balance in the project execution, and overseeing the promotion of gender equality in the project.

Role of participants

1. **UPC**, as the project coordinator, will lead this work package. UPC will support the specific management tasks involved with the Management team and Research team. The tasks are specifically formulated to ensure the implementation of the management approach and structures described in Section 3.2. Management structure and procedures. UPC is the intermediary between the Commission and the Consortium and responsible for the project controlling, in particular for the administrative and financial reporting, project time controlling, coordination issues and overall activities. It is also responsible for the correct application of all EU rules, the overall technical management and coordination within and between work packages. UPC will coordinate all relations with the EC.
2. **AAU**, as the CL, will have the responsibility to assess the viability of the cooperation actions with the projects funded under the topics specified in the call.
3. **CCB**, as the IM, will take care about the IPR management, and will manage the market advisory board.
4. **VGT**, as the EGEO will be the responsible to ensure that the project is carried out considering properly ethics and gender equality.
5. **ALL**, specific activities will be carried out by the partners under their respective work package efforts and responsibilities. Specific roles according to the individual partners' expertise and skills, such as Data Management, etc., will be also assigned during the kick off meeting.

Deliverables

D1.1 Project Management Plan (M3, updated when needed): It will be a formal and approved document that will define how the project will be executed, monitored, and controlled.

D1.2 Quality management plan (M3, updated when needed): This plan will define the acceptable level of quality and will describe how the project will ensure this level of quality in its deliverables and work processes.

D1.3 Risk assessment and implementation of the contingency plan (M6, updated when needed): Document to foresee risks, estimate impacts, and define responses to risks. In addition will contain the mitigation strategies.

D1.4 Innovation and IPR management plan (M6, updated when needed): Document defining how will be managed the IPR of the project.

D1.5 Cooperation plan with other EU projects (M5, updated when needed): This document will include all cooperation activities with other EU projects.

D1.6 Ethical and gender equality plan (M6, updated when needed): This document will define the guidelines to ensure the appropriate ethical and gender balance in the project execution.

WP2 – Servitization

Work package number	WP2					**Lead beneficiary**			NEO			
Work package title	Servitization											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	4	5	8	8	4	8	4	8	4	5	4	3
Start month	1					**End month**			7			

Objectives

The overall objective of this work package is to develop the servitization process of the proposed services. Use cases will be identified taking into account both technological and economic aspects. In addition, the specific requirements of each service will be determined. The specific objectives of this work package are the following:

- Analyze the available technology in order to identify possible risks and opportunities for innovation, and to define available functionalities that can be offered by the ARYES ecosystem
- Develop the use case and business case to be implemented and tested in the project
- Define the requirements for each use case and service family
- Design a proper architecture for the use cases, considering which service families are involved in each of them

Description of work

Task T2.1. Technology analysis [M1-M4] (lead: **NEO,** participants: AAU, ADV, BSC, UPC, CCB, BED, VGT, COM, SLX, BAM)

This task will perform a thorough analysis of technologies currently used in fields related to ARYES. In particular, given the objectives of ARYES, the analysis will get through:

- Service oriented middleware used for industrial applications
- Protocols used to transport data related to HVAC control
- Algorithms and techniques used to improve HVAC performance and energy saving
- How climate is predicted, and related data is communicated and stored
- How energy saving is predicted for existing and new buildings
- How current labelling practices address energy producers and consumers
- Techniques for formal analysis of middleware scalability, robustness, security, etc

Task T2.2. Use case & business case analysis [M3-M7] (lead: **VGT,** participants: All)

This task will identify and analyse the use cases that will be the focus for the ARYES project. From the definition of use cases in natural language, use case requirements will be extracted and prioritized. Particular care will be taken to identify which requirements are common to most use cases, and which ones are of more specific interest. Then, the list of requirements will be then prioritized by technical partners. The list will become a reference when specifying the business cases and the potential revenue streams for the use cases. Finally, this task will consider which service families are required for each use case. Co-creation activities will be carried out in the context of this task, one in Lithuania and another one in Belgium, to support the definition of use cases and business cases. This task will be executed in cooperation with T6.2.

Task T2.3. Specification of service requirements [M3-M7] (lead: **ADV,** participants: NEO, AAU, UPC, BSC, COM)

The work done in Task T2.2 will be refined in this task to the level of service families. In fact, this task will define the requirements of each service family. Such definition will define the data format, timing requirements and other properties required for each service family, and allow to identify which additional support services are needed to implement them. The definition of specific service requirements will be done with service family granularity, according to the service families initially identified:

- Building model calibration services.
- Weather and climate services.
- Support services
- HVAC optimization services
- Building energy prediction services
- Energy saving certification services

Task T2.4. Design of service-oriented system architecture [M3-M7] (lead: **AAU,** participants: NEO, BSC, COM, ADV, SLX)

Description of the reference architecture for the ARYES project, and the concrete architectures of the demonstrators. By leveraging on the analysis of the use cases, which identified which service families are required for each of them, it will be possible to provide an architecture for each use case. One step further will be performed to create a reference architecture for the ARYES ecosystem in general. Thus the result of this Task will be the architecture for the service ecosystem, and architectures for the demonstrators, the latter necessary to specify which further hardware and software elements are involved for each demonstrator.

By defining and describing the architecture using standard patterns, best practices, and inputs from other projects such as INTERCONNECT (see section 1.3.3), it will be easier to make the architectures understandable by other engineers.

- The process and activities can be defined by means of applying industry standards such as ISO15288 on System of Systems (ISO/IEC/IEEE, 2018b).
- The theory useful to define and document the architecture can be aligned with Design Science (Hevner et al., 2004).
- The concrete architecture can be defined using the techniques and the artifacts defined in ISO42010 (ISO, 2011)

Role of participants

1. **NEO**, will lead WP2 and will provide expertise in energy services development and market solutions for energy management in building sector. Its experience will be used to analyse the available technology, develop the use case and business case analysis, define the Specification of service requirement, and to design the architecture of the ARYES ecosystem.
2. **AAU**, will provide expertise in the servitization process, will lead the definition of the reference architecture and will work towards the integration of the Arrowhead framework in the ARYES ecosystem.
3. **CCB,** as a business organization, will develop the co-creation activities with relevant stakeholders, and will provide expertise in the building sector representing the traditional stakeholders (designers, contractors,…).
4. **VIA,** as a business organization, will develop the co-creation activities with relevant stakeholders.
5. **BED**, will make available knowledge on electricity market, consumers and IT solutions for the final energy consumers to support the definition of the use cases and business case analysis and the ARYES services.
6. **BSC,** as a weather and climate predictions expert, will provide knowledge about merits and caveats of climate prediction systems to propose potential use cases and services. In addition, BSC will work for the convergence of traditionally accepted models for climate prediction to data formats that can be used in service-oriented applications.
7. **VGT**, as an expert in co-creation methodologies will provide knowledge about the methodologies used to define the use cases and business cases that will lead to the definition of services. VGT will lead the aforementioned task.
8. **COM**, will provide knowledge in the ESCOs market, contributing to define the use cases and business case analysis and the ARYES services.
9. **ADV,** will provide knowledge in sensors and communication networking in order to develop feasible services, and design a proper architecture.
10. **UPC**, will contribute in the use case & business case definition providing expertise in reduced-order models.
11. **SLX,** as a technical service provider will contribute with its expertise in the analysis of the technology and will support the definition of the architecture.
12. **BAM,** as a contractor company will provide knowledge to define properly the use case and business case.

Deliverables

D2.1 Technology analysis (M4): This report analyses the technologies that can be used for the service ecosystem implementation, and the functionalities that can be offered by the service ecosystem.

D2.2 Use case and business case definition (M7): This deliverable will provide the definition of the use case and the business models and a list of functional and non-functional requirements.

D2.3 Service requirements (M7): This deliverable reports on the requirements for each service families that will be part of the ARYES ecosystem.

D2.4 ARYES architectures (M7): This report will contain the reference and the concrete architectures of the ARYES ecosystem, and a concrete architecture for each demonstrator.

WP3 – Service developments

Work package number	WP3					**Lead beneficiary**			AAU			
Work package title	Service developments											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	12	22	9	0	0	0	0	20	0	12	0	0
Start month	1					**End month**			26			

Objectives

The overall objective of this work package is to develop all ARYES services and populate the ARYES ecosystem. The specific objectives of this work package are the following:

- Design the service families, based on the requirements from WP2
- Provide a concrete design for the services pertaining to each service family
- Develop and document the services of the ARYES ecosystem
- Develop interfaces to enable general public access to the energy prediction services and the energy savings services
- Provide feedback to other work packages, and in particular to WP4, regarding the status of each service within the context of the ARYES ecosystem alpha and beta versions

Description of work

This task will create all ARYES service families considering the use case and business models identified in task 2.2 and the service family requirements identified in task 2.3. All services will be designed, implemented and documented. Two versions of the platform are planned to be delivered. The first one is the *alpha* version, which includes support service family, weather and climate service family, HVAC optimization service family, energy prediction service family. This version will be implemented in the demonstrators and feedback on them will be collected (D4.2), to support the development of the *beta* version of ARYES. The beta version comprises improved versions of the services provided by the alpha version, and the model calibration service family and energy saving certification service family. To accomplish the aforementioned work, this task was broken in 6 tasks.

Task T3.1. Service oriented platform [M5-M26] (lead: **AAU,** participants: ADV, NEO)

This task covers the support services (see section 1.3.2) used in the ARYES ecosystem:

- Improve the deployment of services related to security and service registration.
- Implement orchestration logic for the particular use cases.
- Design protocol translation functionalities and implement them as a translation service, to allow for interoperability between the ARYES ecosystem and other solutions in the construction industry.

The Translation service will be instrumental to provide compatibility with innovation actions in ARYES' same application area, for example by allowing for interoperability with INTERCONNECT's architecture, for the co-existence in the ARYES ecosystem of services created in the context of the INTERRFACE project, and to allow ARYES services to be accessed through INTERRFACE markets. The developed support services will be able to both empower the ARYES ecosystem with an advanced service oriented architecture, and fortify the collaboration with compatible research activities, such as INTERCONNECT to and ones described in section 1.3.3.

Task T3.2. Model calibration service family [M13-M26] (lead: **UPC,** participants: AAU, ADV)

This task will develop necessary activities to have the building model calibration service family operative, that includes:

- Identify the different reduced order models to be used and define a set of suitable reduced order models to be used to simulate the whole building and the subsystems of heating (thermal models) and ventilation (indoor air quality models).
- Define the automatic building model calibration service (do not need user interface)
- Define the manual building model calibration service and its user interfaces
- Register the services in the ARYES ecosystem.
- Create the service documentation.

Task T3.3. Weather and climate service family [M1-M26] (lead: **BSC,** participants: AAU, UPC)

Task T3.3 will develop the weather and climate service family for the ARYES ecosystem. They are some activities of this task that can be developed from the beginning of the project because are related to how to obtain the necessary data from the global forecast services, and how to post-process the obtained data to obtain the predictions for the regions of the project interest taking into account user needs. On the other hand, there are other activities that should be executed after the definition of the business cases of the ARYES project because it will implement the weather and climate services defined in the developed business case. For this reason, task T3.3.1 will develop all activities related to obtain data from global forecast and prediction services and post process it to be used in ARYES project; and task T3.3.2 will develop all those activities related to implement the services defined in the ARYES business case definition (task T2.2). This task will be divided in two subtasks:

Subtask T3.3.1. Developing the service and mapping uncertainty and skill in weather and climate data
This subtask will develop the methods to implement short term weather forecast, seasonal and decadal climate predictions over Europe with a special focus for the 5 regions of interest (Spain, Denmark, Lithuania, Belgium and Germany) and assess how the skill changes as a function of the forecast lead time. Different existing models will be used to generate the predictions:

- The MONARCH model will be initialized with data from a large scale numerical predictions system, the Global Forecast System (GFS), to provide short-term weather forecast for each location.
- The Copernicus Climate Change Service will be used to provide real-time robust seasonal information. Seasonal climate predictions are affected by biases; as a consequence, this data should be post-processed in order to obtain similar statistical properties as found in observation.
- Regarding decadal predictions, the European community Earth-System Model (EC-Earth) will be used. Decadal climate predictions are affected also by biases, as a consequence model outputs will be post-processed to obtain similar statistical properties as found in observed variables.

The forecasts will be delivered in deterministic (short term forecast) as well as probabilistic formats (seasonal and decadal predictions), which will be co-defined with end-users in a view of delivering actionable information for the decision support system and therefore to enable a better building operational management. The weather forecasts will cover a large temporal extent, starting from short term (up to 3 days in advance) up to seasonal and decadal predictions (monthly and multi-year).

Subtask T3.3.2. Weather and climate service family implementation
This subtask will create all required services to make available for the ARYES ecosystem the data generated in subtask T3.3.1 (short-term weather forecast and seasonal and decadal climate predictions), but also observation data and climatology.

- Identify the services comprising this service family. One service that is identified in the proposal stage is the service to convert the probabilistic data coming from seasonal and decadal predictions into a timeline to be used in building models.
- Create the services according to their requirements and design.
- Register the service in the ARYES ecosystem.
- Create the service documentation.

Task T3.4. HVAC optimization service family [M8-M26] (lead: **NEO,** participants: ADV, AAU, UPC)

This task will integrate in the ARYES ecosystem the energy services described in section (1.4.1). Then it will be developed a service that orchestrates the model calibration services and weather and climate services in order to create data required to configure a neural network to manage the thermostat setbacks. At the same time the predictive control for ventilation systems will use the model calibration service family to obtain a model and then using a cost function will optimize the use of energy in ventilation systems taking into account costs, consumed energy and comfort among others. This service will provide also the possibility to implement flexibility services, introducing into the cost functions the desired variables. Finally, the developed systems will be registered in the ARYES ecosystem, and it will be generated the service documentation.

Task T3.5. Energy prediction service family [M13-M26] (lead: **UPC,** participants: AAU, ADV)

This task will develop necessary actions to have the energy prediction service family operative, that means:

- Define the logic of the service, and the interconnections between other services. Specially with model calibration and weather, seasonal and decadal predictions
- Implement the service in the ARYES ecosystem
- Register the services in the ARYES ecosystem
- Generate the service documentation

This task will also include the development of an interface to enable general public to use the aforementioned service and assess the viability of the proposed prediction services.

This task will also cooperate funded under the call LC-SC3-ES-6-2018-2020 due to the aim of those proposal should be develop tools for predict energy consumption at grid level.

Task T3.6. Energy saving certification service family [M8-M26] (lead: **ADV,** participants: UPC, AAU)

This task will develop necessary activities to have the energy saving certification service family operative, that includes:

- Develop the logic of the service, and the interconnections between other services. Specially with model calibration and weather observations.
- Implement the service in the ARYES ecosystem
- Register the service in the ARYES ecosystem
- Generate the service documentation

This task will also include the development of an interface to enable general public to use the aforementioned service and assess the viability of the proposed measurement and verification service.

Roles of participation

1. AAU, as expert developer in Arrowhead-compliant services, will lead this work package and the task related with support service family. In addition will give support to the rest of the tasks in order to implement the services in the ARYES Ecosystem under the Arrowhead framework. In the context of T3.3, it will take data provided by BSC, and make it available by the ARYES Ecosystem services through an Arrowhead-compliant service.
2. BSC, as a weather and climate predictions expert, will explore the frontiers of climate predictions to be implemented in a service.
3. NEO, will contribute to develop the support service family and will lead the task from HVAC optimization services. Its expertise as aggregator will enable to implement flexibility services in HVAC optimization service family.
4. ADV, will contribute to implement the service logics in the service ecosystem.
5. UPC will develop the functional part of 4 service families (model calibration, HVAC optimization, energy prediction service family, energy certification), and contribute to transform data from weather and climate predictions into data be used in the reduced order modelling domain.

Deliverables

The deliverables of this work package will comprise instructions about how to effectively use and integrate each service family, and a concise reference manual with all the information required to work with the services, supported by tutorials and examples. In particular: manual with all the information required to work with the services, supported by tutorials and examples. In particular:

D 3.1 Support service family (M13, M26): This deliverable is focused on the support service family.

D 3.2 Model calibration service family (M26): This deliverable is focused on the model calibration service family.

D 3.3 Weather and climate service family (M13-26): This deliverable is focused on the weather and climate service family. In addition, this deliverable also includes a report benchmarking skill assessment of weather and climate forecasts and their appropriateness for use in weather and climate services in Europe.

D 3.4 HVAC optimization service family (M13-M26): This deliverable is focused on the HVAC optimization service family.

D 3.5 Energy prediction service family (M13-M26): This deliverable is focused on the energy prediction service family. It will also include an interface to promote that general public can test these services.

D 3.6 Energy saving certification service family (M26): This deliverable is focused on the energy saving certification service family. It will also include an interface to promote that general public can test this services.

WP4 – Field tests: Service implementation and testing in real life conditions

Work package number	WP4					**Lead beneficiary**			COM			
Work package title	Field tests: Service implementation and testing in real life conditions											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	10	10	14	5	0	10	14	5	14	12	11	10
Start month	5					**End month**			36			

Objectives

The overall objective of this work package is the implementation of ARYES ecosystem in real environments. The specific objectives of this work package are the following:

- Definition of a demonstrators plan for the deployment and validation of the ARYES ecosystem
- Deployment and functional testing of the energy data collection, actuators and communication infrastructure to operation working in the four demonstrator
- Deployment and functional testing of the ARYES service ecosystem alpha and beta version in four demonstrators
- As part of an iterative design process, address the technical needs identified in the deployment and functional testing of both ARYES alpha version, and ARYES beta version
- Carry out market replication of the ARYES ecosystem in 4 buildings (different from the demonstrators)

Description of work

Task T4.1. Demonstrators implementation plan [M5-M7] (lead: **NEO,** participants: ADV, VIA, VTU, UPC, AAU)

Task T4.1 will focus on the definition of the demonstrators, which will include actions to be carried out during the demonstrators' implementation and proposed timeline according to the progress of the other work packages and the calendar limitations. It will also involve an energy audit of the demonstrators, which will involve the identification of the specific building characteristics (floor area, building type, etc), the energy infrastructure (existing BEMS, power supply, and meters and their technical characteristics). The energy audit will provide the researchers with specific guidelines to design the most cost-effective energy data collection, actuators and communication infrastructure in each demonstrator (T4.2). This task will also include the risk assessment of the demonstrator implementation and the definition of the most suitable methods of information and communication with the building owners and managers.

Task T4.2. Energy data collection, actuators and communication infrastructure deployment [M6-M18] (lead: **ADV,** participants: NEO, VIA, VGT)

Based on the energy audits carried out in T4.1, a tailored cost-effective energy data monitoring, actuators and communication infrastructure will be designed and deployed in the 4 demonstrators. All demonstrators have an existing infrastructure, but to implement the ARYES ecosystem it may require additional meters or actuators. The aim of this task is to prepare the building energy management system to be deployed into the ARYES ecosystem by developing all required plugins and interfaces to test the proposed services and business models. The installation of the energy metering sensors, actuators and communication devices, as well as the plugins and interfaces, will be carried out in the period defined by the implementation plan (T4.1).

Task T4.3 ARYES service full deployment [M13-M36] (lead: **COM,** participants: NEO, ADV, VIA, VTU, UPC, AAU)

Task 4.3 aims at implementing the alpha and beta version of the ARYES ecosystem in the demonstrators and carry out the market replication actions.

Task T4.3.1 Implementation of alpha version of ARYES ecosystem

When the alpha version of ARYES ecosystem will be developed, all services will be implemented in the 4 demonstrators with the appropriate interfaces according the stakeholders involved in the demonstration activities. The alpha version will be ready when support service family, HVAC optimization service family, prediction energy services and weather and climate service family will be ready to test. In this stage the models required (e.g. building energy models, building indoor air quality models) will be calibrated manually by UPC. This task will reach completion with the demonstrators' implementation and evaluation (D4.2), which will be used to improve

the ARYES ecosystem as a part of the iterative process. This task will also include the orchestration of services in order to generated new non-energy benefits (such us occupancy calculation, or maintenance activities).

Task T4.3.2 Implementation of beta version of ARYES ecosystem in demonstrators
When all services will be developed and the improvements detected in T4.3.2 under D4.2 the ARYES ecosystem beta version will be ready. Later on, all services will be implemented in the demonstrators and then tested during 10 months. The completion of this task will result with the evaluation of the improved demonstrators (M36).

Task T4.3.3 Market replication activities
In conjunction with the implementation of the ARYES ecosystem beta version in the demonstrators, the ARYES ecosystem will be implemented in 20 buildings in order to test the market replication and the scalability. Before implementing the ARYES system, the buildings should be selected from the building stock of the industrial partners, and deploy the required energy data collection, actuators and communication infrastructure. This task will start four months before milestone 5 (ML5 – ARYES ecosystem beta version). It is expected that 6 months are required to select and carry out the implementation of required IT infrastructure. At least, the services of the ARYES ecosystem will work for 8 months, thus covering both winter and summer seasons.

The cooperation with other projects, and especially with INTERRFACE and CordiNet projects, will be explored in order to carry out market replication activities in their demonstrators (see section 1.3.3).

Role of participants (see also Table 8 in section 1.3.4)

1. COM, will lead this work package and will lead the market replication activities using its building stock to implement the ARYES ecosystem, and will provide 4 building to test market replication.
2. NEO, will be responsible of deploying alpha and beta versions of ARYES ecosystem in 1 demonstrator and 2 building to test the market replication.
3. VIA, will be responsible of deploying alpha and beta versions of ARYES ecosystem in 1 demonstrator and 4 building to test the market replication
4. ADV, will be responsible of deploying alpha and beta versions of ARYES ecosystem in 1 demonstrator and 4 building to test the market replication.
5. SLX, will be active in the market replication task providing 2 buildings.
6. BAM, will be responsible of deploying alpha and beta versions of ARYES ecosystem in 1 demonstrators and 2 building to test market replication.
7. VGT, will support the technical implementation of ARYES ecosystem in the Lithuanian demonstrator and the market replication activities.
8. UPC, will carry out the model calibration activities during the testing of ARYES alpha version and will support the demonstrators' implementation plan.
9. AAU, will support the implementation of the different versions of the ARYES ecosystem.
10. BSC, will support the deployment of the weather and prediction service family in the demonstrators.
11. CCB, will be active in the market replication task providing 2 buildings.

Deliverables

D4.1 – Demonstrators implementation methodology (M7): Report including demonstrators' implementation plan, results from energy audit, design of the tailored energy data collection, actuators and communication infrastructure, description of the information and communication methods used with the building owners, and risk assessment.

D4.2 – Demonstrators implementation evaluation (M20, M36): Report describing operational matters experienced during the demonstrators' implementation (regarding all service tested) and the technical solutions used.

D4.3 – Market replication results (M36): Report presenting the results of the market replication actions.

WP5 – Monitoring and evaluation

Work package number	WP5					**Lead beneficiary**			UPC			
Work package title	Monitoring and evaluation											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	15	12	3	0	0	5	4	10	5	6	3	3
Start month	8					**End month**			36			

Objectives

WP5 aims at defining and developing impact indicators and methods used to monitor, evaluate and verify the impacts resulting from the demonstration deployment of the ARYES service ecosystem. The specific objectives of this work package are the following:

- Definition of a monitoring and evaluation plan that includes a set of impact indicators that allow the assessment of the impact of the ARYES service ecosystem intervention on the demonstrators.
- Assessment of the primary energy savings, peak reduction, costs reduction and investments costs.
- Evaluation of the energy predictions accuracy
- Formal, analytical and experimental evaluation of properties of the support services and of the ecosystem itself, such as their robustness, scalability and security

Outcomes of WP5 will be disseminated in WP7 and will form an integral part of the guidelines for project replication in the ARYES service ecosystem Handbook (Deliverable 7.7).

Description of work

Task T5.1. Monitoring and evaluation methodology [M8-M10] (lead: **UPC,** participants: AAU, BSC, ADV, COM, VIA, VGT, NEO, SLX, BAM)

This task aims at defining a monitoring and evaluation methodology that will define the appropriated indicators to assess the impact of the ARYES service ecosystem usage. The project proposes using three main indicators families: energy and costs; reduced order building models accuracy; and approach robustness. Prior to making a decision on which measurement and impact methodologies to develop, due consideration will be given to what parameters and definitions need to be considered. The ARYES consortium will dedicate grate effort to this task, and propose and interchange if ideas with other project funded in similar H2020 calls. These indicators will need to be collected pre and post deployment of the ARYES service ecosystem. The final indicators defined will influence the energy certification service family T3.6.

In addition, this task will develop a new methodology based on reduced order modelling in order to verify energy savings and flexibility. These results will be used to develop the energy certification service family (T3.6).

Task T5.2. Monitoring and evaluation of primary energy savings, costs reduction, investments costs and business models [M9-M36] (lead: **VGT,** participants: COM, ADV, VIA, NEO, UPC, SLX, BAM, BSC)

Task 5.2 aims at monitoring and evaluating the energy consumption (gas and electricity) and identify energy savings derived from the implementation of the ARYES ecosystem. Data used in this task will include: continuous energy consumption data collected using a combination of existing infrastructure in the demonstrators; meters installed as part of WP4 (if are required); energy bills supplied by the demonstrator owners. In order to gather objective and accurate energy savings data, the ARYES project will apply the common Methodology for European Projects (eeMeasure), which is based on the International Performance Measurement and Verification Protocol (IPMVP). eeMeasure will enable the ARYES project to calculate and record energy saving results using a consistent methodology. This will allow the European Commission and other interested parties to produce a better quantitative analysis of the energy savings potential of predictive and adaptive controls solutions in buildings.

Outside temperature data collected in each demonstrator will be used to adjust the heat energy consumption results to the different heating periods monitored, in order to account for climatic effects on the energy consumption. The standard practice used by EU member states, a heating degree day calculation model (HDD), will be applied. Then the proposed method in T5.1 will be used to calculate the energy savings. In this sense it will be possible to assess the accuracy of the proposed energy saving certification method.

The reduction of peak demand will be assessed using 4 main methods: Load factor metric, baselines profile mode (10 day time model), baseline profile model (top 3 of 10 day model) and baseline profile model (top 3 of 10 day model with morning adjustment factor)

Finally, the cost reduction and the investments costs will be assessed to determine the economic viability of the proposed services in conjunction with the business models proposed.

Task T5.3. Evaluation of reduced order building models accuracy [M9-M36] (lead: **UPC,** participants: BSC)

Task 5.4 aims at evaluating the accuracy of the reduced order building models. It involves assessing whether the different inputs in the models impacts on the accuracy of the reduced order building models. Especially care will be taken in the influence of the uncertainty produced by weather and climate predictions affect the accuracy of those models. This task will specially evaluate the quality of the outputs of the energy service family and building calibration service family.

Task T5.4. Assessment of approach robustness [M9-M30] (lead: **AAU,** participants: NEO)

This Task will analyse the ARYES service ecosystem to measure its robustness, scalability, security and other useful properties, to increate trust in its technological aspects. Techniques applied here comprise formal methods such as model checking (Behrmann et al., 2004); security analysis such as automated ICT risk assessment (Baiardi et al., 2014); stress tests on the ecosystem using a mix of real and synthetic / simulated service providers and consumers. The goal of this task is to prove that the ARYES ecosystem is robust, highly scalable and secure; that each demonstrator is secure, and robust and scalable enough for the related use case.

Role of participants

1. UPC, will provide expertise from previous projects in energy in buildings in the definition of the monitoring and evaluation methodologies, will also calculate the specific indicators, analysing the results and establishing the learned lessons by the use of reduced order models in demonstrators.
2. AAU, will help with building the monitoring infrastructure for the ARYES ecosystem, and will perform the analysis of the ecosystem and of the support services.
3. BSC, will collaborate defining indicators to assess the weather and climate predictions performace compared to observations, will analyse model simulations performance for the selected case studies and periods, and will help to determine how the uncertainties in the weather and climate predictions affects the performance of the reduced-order building models predictions.
4. ADV, will collaborate with UPC providing support with the data regarding its demonstrator.
5. COM, will collaborate in the evaluation of the.
6. NEO, will collaborate with UPC providing support with the data regarding its demonstrator, and also in the assessment of approach robustness.
7. VIA, will collaborate with UPC providing support with the data regarding its demonstrator.
8. VGT, will support the analysis of the demonstrators' performance in Lithuania, and coordinate the evaluation activities regarding the benefits of the ARYES techniques.
9. SLX, will support the analysis and evaluation of the performance of ARYES techniques applied in the buildings in Germany.
10. BAM, will support the analysis of the Belgian demonstrator.

Deliverables

D5.1 – Monitoring and evaluation methodology (M8): Report describing the impact indicators necessary to assess the impact of the ARYES service ecosystem implementation, together with the calculation methods and interpretation guidelines.

D5.2 – Baseline monitoring and evaluation report (M12): Report presenting the results of the assessment of the impact indicators at the end of the baseline period of the demonstrator implementation.

D5.3 – Middle-term monitoring and evaluation report (M24): Report presenting the results of the assessment of the impact indicators at the end of the middle-term period of the demonstrator implementation.

D5.4 – Final monitoring and evaluation report (M36): Report presenting the final results of the assessment of the impact indicators at the end of the demonstrators implementation.

WP6 – Market uptake and transformation, regulatory framework and ethical issues

Work package number	WP6					**Lead beneficiary**	VGT					
Work package title	Market uptake and transformation, regulatory framework and ethical issues											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	4	0	4	13	15	22	12	4	9	4	5	9
Start month	3					**End month**			36			

Objectives

The overall objective of this work package is to define all aspects related to the market uptake and transformation, regulatory framework and ethical issues in order to enable full exploitation of ARYES services. The specific objective of this work package are the following:

- Identify the stakeholders: users, direct and indirect customers
- Identify and analyse market barriers for the implementation of ARYES ecosystem (including socio cultural aspects, legal framework and ethical issues).
- Define sustainable and suitable business models to exploit the ARYES ecosystem.
- Define contracts for ARYES services, energy performance contracts when ARYES services are involved, and recommendations to amend current regulatory practice at European and national level to enable full exploitation of ARYES services.
- Define protocols to ensure that demonstrator and market replication actions are executed considering ethical and privacy issues, and give recommendations about how to address this issues in the real market roll-out.
- Develop a methodology to structure and label the quality of demand side service providers and implement it in the project to evaluate the proposed services

Description of work

Task T6.1. Identification of socio cultural aspect of energy services by implementing research on stakeholders involved [M13-M24] (lead: **VGT,** participants: CCB, VIA)

The task aims to catalogue the socio cultural and socio-economic factors, to assess and identify importance and impact of the factors to successful implementation of new proposed services and new business models. The index will show the impact of the socio cultural and socio economic factors in a numeric value that expresses statistical relation between dimensions of the same phenomenon. Socio-cultural and socio economic factors to be considered:

- Geographical aspects (climate zone, climate changes, changes in temperature during the period of time)
- Cultural aspects (traditions and competencies in energy saving, awareness level about importance of energy saving, level of digital skills to use technologies, acceptance of novelties and risk avoidance, decentralization of communication, acceptance of individual responsibility, etc)
- Demographical aspects (gender, age, nationality, level of education)
- Economical aspects (differences in ways of standard living and working, purchasing power, GDP, investment trends, etc)
- Social aspects (impact of social environment, new professional profiles, etc.)

The catalogue of socio cultural and socio-economic factors will be identified, the significance of each factor will be researched as each factor can have a different weight due to end-users habits, technological education, traditions of energy usage, etc. Later the index valuing the impact of factors will be developed and validated in Project countries. The research methods will involve stakeholders and end-users through round tables, co-creation workshops, etc., during the whole process from collection of data and to validation of impact model.

Project countries will be explored as pilot models. The conclusions drawn from the research will be used as a basis for recommendations to be used in all the EU countries.

Task T6.2. Development of business models based on co-creation methodology [M3-M30] (lead: **VIA,** participants: CCB, BED, VGT, ADV, COM, NEO, BAM, SLX, BSC, UPC)

The task aims to map the emerging new business models together with new services in the energy sector (task T2.2), clarify elements of business model and link them with the value chain. The value proposition, possible revenue stream model and cost structure change, ways to communicate with customers and partners become more decentralized. The key challenge is to understand that the success of new business models depends on a combination of technological and non-technological innovations, and both of them are to be well balanced in the new business models developed in this task.

This task will explain the scenarios of possible business models of new services with special focus on above mentioned challenges on meso level in energy industry and also with attention to macro trends like changes in global economics ecosystem.

In order to meet the challenges co-creation methodology will be used through involvement of all the stakeholders and end-users as well as wider communities. They will be involved in empirical researches and experiments. The total number of co-creation activities such as focus groups, workshops or round tables will be 8, half of them in Lithuania and the other half in Belgium. The planning of those activities will be: 4 activities from M3 to M6, during the definition of the business models; 2 activities from M13 to M16 after the first feedback to business models (milestone 3-M13); and the last 2 from M25 to M28 after the midterm evaluation report (milestone 6-M24). See Table 12 and related text for the planning of co-creation activities. Those activities will be designed by VGT and carried out by CCB and VIA.

The output of this task will be a set of business models with analysis and explanations, that meet the above mentioned and new emerging challenges for new services for energy industry. Guidelines for business models will be based on business model canvas by A.Osterwalder and consist of: identification of perfect business model, explanation of the implication of the above mentioned trends and challenges into implementation of business models, good practices and case studies. Those will be based on the explorations and research conducted during the co-creation process and described below.

Identification of the stakeholders. Identify all potential customers for the ARYES solution, direct or indirect and define their specificities.

Identification of the most relevant business models of ARYES services. Business model canvas developed by A.Osterwalder will be used to describe the full version of business models of new services.

- Describe key business models for each of the service family to different industries
- Prepare the guidelines to use the Business Model Canvas to target groups
- Use the co-creation workshops with the target groups to co-create the business models by filling the Canvas
- Analyse the barriers and opportunities including not only market but also legal, data security, behavioural and consumption issues for implementation plans of new business models proposed by ARYES, using a SWOT methodology analysis
- Refine the business models descriptions using a multicriteria evaluation
- Conduct real environment experiments with 4 demonstrator buildings in different countries making the full scale research, business model development and implementation plan analysis
- Aggregate and analyse the data collected during all the previous steps to create a realistic "ready to be implemented" methodology for ex ante evaluation of alternative business models and implementation plans
- Verify the developed business models against the market replication experiments, to ensure that the ARYES ecosystem is viable in market conditions

Implementation plan of business models. Decision making process for Implementation of new business model meets several challenges: new business model risk assessment, need for balance between uncertainty in the market, wish for efficiency growth, other challenges. The following steps will be used:

- Risk to implement each of business model assessment. Risk heat map, scenario analysis, stress testing and other risk assessment methods will be used to evaluate possible risks in advance.
- Economic efficiency assessment. Economic efficiency ratios and indicators will be used for statistical analysis.
- Evaluation of impact on energy consumption in the building, economic and social issues. Cost-benefit analysis will be used to do ex ante evaluation of alternatives of business models. Analysis will use data from previous two steps: risk assessment and efficiency assessment and will be added up with the information from PESTEL analysis.

Multicriteria decision making methods, statistical data analysis and other research methods will be used. Involvement of different stakeholders forming focus groups, hackathons, workshops, round tables, video social media groups will be used.

Task T6.3. Regulatory framework evaluation [M13-M34] (lead: **BED,** participants: VGT, VIA, CCB, COM, SLX, BAM, NEO)

The objective of this task is to identify the global regulation that affects ARYES at the partner countries scale and at the EU scale.

The developed services will need specific contracts to enable full exploitation of ARYES services. In addition, the development of energy performance contracts will be also required because, in some cases, small investments will be required to adapt the building in order to implement de proposed services. On the other hand, changes in the current legislation will be also addressed to ensure that all proposed services with its contracts can be implemented in the market (e.g. flexibility energy services). This task aims to cover both, contractual aspects and changes in the current legislation, this implies:

- Defining either specific service contracts and energy performance contracts for the ARYES services. It will be also analysed the difference between the proposed contracts and other types of contracts in the construction sector.
- Assessing the legal framework governing contracts involved in the ARYES project.
- Defining the elements for improving regulatory framework.

To support the aforementioned actions a total number of co-creation activities such as focus groups, workshops or round tables will be 8, half of them in Lithuania and the other half in Belgium. The planning of those activities will be: 4 activities from M17 to M20 after the business models co-creation activities that will start on milestone 3-M13; and the last 4 from M29 to M32 after business models co-creation activities that will start on milestone 6-M24. See Table 12 and the related text for the planning of co-creation activities. Those activities will be designed by VGT and carried out by CCB and VIA.

The main outputs of this task will be the types of contracts to implement in the market the ARYES ecosystem and the recommendations to amend current regulatory practice at European and national level in order to enable the ARYES contracts in the market.

Task T6.4. Ethical and privacy issues [M5-M36] (lead: **VGT,** participants: VIA, BED, CCB)

The proposed services will require access to sensible building data such as occupancy or building scheduling to full exploitation of ARYES services. It is important that the usage of data is transparent and that building owners involved in the demonstration and market replication activities understand what happens with their data and why those data is need. Furthermore, building owners needs to be able to restrict exploitation of its data and needs full power to request deletion of the entire data set. This may lead to a set of ethical and privacy issues that the project will have to deal with. This task aims to cover the aforementioned aspects including:

- An analysis of the required data, and how should be properly stored and protected.
- Define the protocols for data accessing by ARYES service providers.
- Ensure that all data protection and consumer rights issues will be handled in the most careful manner during the runtime of the demonstration and market replication activities.
- Give recommendations on how ethical and privacy issues should be addressed in a real market roll-out.

Legal experts in the consortium will have to report their results to the EGIO.

A report will be delivered on M7 of the project and will be updated during project execution and at the end of the project identifying all data sources and how to ensure their privacy, including GDPR issues.

Task T6.5. Structuring and labelling the quality of demand side service providers [M18-M36] (lead: **COM,** participants: BED, CCB, VGT, BSC, ADV, SLX, BAM, UPC, NEO)

This task will match the ARYES service or services to the customer's demand. For example, the customer can indicate that his objective is energy consumption reduction and that he can produce data such as: localization, affluence, etc,: the interface will then indicate which ARYES service is the most convenient, with what % of energy reduction, with what accuracy. The interface will indicate the parameters needed from the users to work properly.

This task could include an analysis of the main labels being currently developed: SRI and R2S and identify the label requirements best suitable for ARYES (such as energy savings, comfort, convenience, …) so that the interface assesses the % of SRI or R2S-compatibility of the ARYES solution chosen.

Within this task, 2 co-creation activities will be carried out in order to support de development of the labeling system: 1 in Lithuania and 1 in Belgium. Those activities will be done between M18 and M21. VGT as expert in co-creation activities will design it, and CCB and VIA will carry out those activities. This activity will cooperate with other projects in order to find synergies in the definition of the labeling system and make compatible the information with their APPs market (see section 1.3.3).

The main output of this task will be a web service where potential user can search for services and see its labelling. This service will be ready to test at M25 in order to test it during the market replication activities.

Role of participants

1. VGT, will lead WP6 and will provide knowledge on co-creation activities, in socio cultural and socio-economic analysis, and ethical issues.
2. CCB, will carry out co-creation activities in Belgium to support the development of business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers. CCB will take at advantage of its business organization to ensure the participation of relevant stakeholders in the co-creation activities.
3. BED, will provide expertise in the electricity market in order to develop the business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers.
4. VIA, will carry out co-creation activities in Lithuania to support the development of business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers. CCB will take at advantage of its business organization to ensure the participation of relevant stakeholders in the co-creation activities.
5. COM, will provide expertise in the construction sector to develop the business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers.
6. BAM, will provide expertise in the construction sector to develop the business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers.
7. SLX, will provide expertise as technical service provider to develop the business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers.
8. ADV, will provide expertise as technical service provider to develop the business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers.
9. NEO, will provide expertise in the energy market and as technical service provider to develop the business models, the contracts and legal framework, and the labelling system to assess the quality of demand side service providers.
10. UPC, will provide expertise in the definition of labelling systems in addition will support the development of business models
11. BSC, will provide expertise in how to label weather and climate services.

12.

Deliverables

D6.1 – Socio-economic analysis (M17, M24): Report presenting socio-cultural and socio-economic aspects having influence on the implementation of the ARYES ecosystem.

D6.2 – Description of business models for ARYES services (M7, M17, M36): Report presenting business models suitable for ARYES market uptake.

D6.3 – Regulatory framework evaluation (M36): Report describing the types of contract and the changes in the legislation in order to enable full exploitation of ARYES services.

D6.4 – Ethical and privacy issues (M7, M36): Report describing how will be ensured the ethical and privacy issues during the project, and recommendations to deal this aspects during the exploitation of ARYES results.

D6.5 – Labelling system (M25, M36): Web service to display the labelling system and report describing the labelling system to assess the quality of demand side service providers.

WP7 – Ready-to-sign market uptake strategy, communication and dissemination

Work package number	WP7					**Lead beneficiary**		CCB				
Work package title	Ready-to-sign market uptake strategy and dissemination											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12
Short name of participant	UPC	AAU	NEO	CCB	BED	VGT	VIA	BSC	COM	ADV	SLX	BAM
PMs per participant	6	6	2	14	10	18	2	2	4	2	3	5
Start month	1					**End month**			36			

Objectives

The overall objective of this work package is to carry out all dissemination, exploitation and communication activates in order to take advantage of the project results and ensure a proper communication. The specific objectives of this work package are the following:

- Definition and delivery of the project communication and dissemination plan.
- Exploitation of the project results and definition of the market uptake strategy
- Establishment of the management plans for the intellectual property right and knowledge ownership.
- Development of project results communication tools and channels (i.e. project website, web 2.0 tools and services, videos, brochures, newsletters, scientific papers, press notes, etc.)
- Preparation of the ARYES ecosystem handbook that establishes best practises in end energy user services development, tutorials and scenarios, methodology for replication and guide for creation and management of co-creation in the building service development.
- Transfer of knowledge to targeted audience.

Description of work

Task T7.1. Communication, dissemination and exploitation plan [M1-M36] (lead: **CCB,** participants: All partners)

The ARYES project has the aim to bring the services from an average TRL 6 to TRL 9, ending up the project with market outreach. The main objective of this task is to develop an effective plan for the dissemination and exploitation of the results achieved within the ARYES ecosystem. This plan will be continuously updated taking into account the evolution of the business environment that may influence the exploitation of the project results. Long-term adoption and exploitation will also be considered, while taking into account the management of data protection (GDPR). The concrete action of this tasks will be:

- Create a visible and distinguishable visual identity of the project to make it easily recognisable in a way that all the communicative action undertaken during the project are traceable.
- Identify established networks, organizations, and individuals involved in similar activities, as well as other sectors, that could also benefit from ARYES ecosystem.
- Define the dissemination and exploitation plan of the project results
- Define the project data management plan
- Deploy a media planning to ensure that all the milestones of the project have an accurate broadcasting and reach the targeted audience having the expected impact
- Monitor the communication plan deployment in order to ensure the correct implementation and the accomplishment of the expected impacts making the necessary corrections when it is needed.
- Define the communication activities between all partners in order to ensure a correct deployment of the strategy
- Coordinate with external stakeholders (e.g. institutions, related projects and media) to ensure a high outreach of the communication activities

Task T7.2. Standardization and knowledge transfer [M1-M36] (lead: **CCB,** participants: All partners)

The main objective of this task will be to promote the standardization and transference of the knowledge gained during the project targeting all target groups identified in section 2.2.1. In order to exploit project outcomes according to the rest of the task of this work package, this task will use the dissemination and exploitation plan developed under Task T6.1 and the communication channels and tools elaborated in Task T6.4. This task will include:

- Interaction with standardization bodies
- Interaction with policy makers

- Liaisons with initiatives uniting research actions, such as H2020 bridge, which is uniting Horizon 2020 Smart Grid and Energy Storage Projects

Task T7.3. Preparing for the market uptake and exploitation of the results [M1-M36] (lead: **CCB,** participants: All partners)

The ARYES project has the aim to bring the proposed services from an average TRL 6 to TRL 9, ending up the project with market outreach. The aim of this task is to carry out all those activities for the results exploitation. As indicated in task T7.1, a detailed exploitation plan for all ARYES results will be made. To guarantee its execution, the Innovation Manager will regularly review and update this plan that will also consider the IPRs. The specific activities within this task will be:

- Develop a detailed market analysis and work
- Implement all those activities planned in the task T7.1.
- Manage the intellectual property
- Definition of the agreement on the IPR, confidentiality agreement and revenue sharing
- Commercial exploitation of the global results of ARYES knowledge: benchmarking for public institutions or research institutes, data exploitation…

Task T7.4. Dissemination and communication, channels and tools [M1-M36] (lead: **VGT,** participants: All partners)

In order to guarantee a full dissemination of the project results, several communication channels and tools will be developed within this task, combining the passive approach with the proactive approach. The following activities will be carried out within the project:

- Development and maintenance of the ARYES website. The website will be created in order to disseminate the ARYES project progress, and will also hold the description of the consortium members and the day-by-day obtained results. A first version of the website will be launched at the beginning of the project. When the different services will be ready to be distributed, a new version of the website will be launched. This version will mainly be devoted to ARYES ecosystem promotion although it will incorporate a link to the information of the project. The ARYES website will aggregate the information generated by the Web 2.0 tools and ARYES communities through widgets, RSS feeds, links, add-ons and embedded applications or multimedia resources to provide a single source of information aobut the project for external stakeholders.
- Creation of the accounts and maintain the Web 2.0 tools and services such as social networking sites (e.g. Facebook, Twitter, Linkedin, Researchgate, Instagram,…), blogs, video sharing sites, hosted services, etc. The project will benefit from the enormous potential of those tools to communicate research findings more rapidly, broadly and effectively. Thus, online communities will have a prominent role within the dissemination of the obtained results providing real time / entertaining information and social news.
- Production of videos. In order to support the dissemination of the project a will be produced. The aforementioned videos will be tailored to the target groups identified in T7.1 dissemination and exploitation plan. Three videos are planned to be produced: (I) the first will focus on the overarching questions of the ARYES project; (II) the second one will focus on the demonstrators' presentations; (III) the last one will focus on the dissemination of the final results explaining the impacts achieved.
- Development of media tools such as brochures and newsletters for specific target groups in accordance with the dissemination activities planned (i.e. events, workshops, seminaries and conferences). Brochures will support the awareness and promotion of the project, dissemination its vision concept and objectives. Periodic newsletters will be produced, every six months and, anyway, in line with each important event or milestone. Newsletters will be produced in order to provide timely information about the state of the research and it will be disseminated on the web portal, via email and through major events, such as conferences, exhibitions and workshops
- Submission of scientific papers to high impact scientific journals and national and international conferences. In all cases, gold and green open access will be used.
- Realization of press notes. This tool will be used to disseminate the results through several communication channels, including mass media (e.g. newspaper, TV news) and specialised industry journals and magazines.
- Creation of slides. Slides providing main information related to the ARYES project will be produced and adapted to each target audience and purpose.
- Organisation of conferences and workshops to present the results of ARYES project to the different target groups. This task will be connected with the co-creation activities in T2.2, T6.2 and T6.4 and T6.6.

- Demonstrator events: In order to carry out promotion activities, two demonstrator events are planned in each demonstrator site and one in each market replication building, mainly addressed to potential ARYES service users/customers.
- Physical mini games for presentation. Development of physical mini games to support co-creation activities.
- Participation in fairs and conferences, scientific and industrial.

This task will also create the ARYES handbook, the aim of this document will be gathering best practices for both the design of buildings suitable for participating into the ARYES ecosystem, and for the integration of existing business processes, services and building into the ARYES ecosystem. The information of the handbook will comprise at least:

- The definition of the target groups.
- Detailed indication on how to implement and use the ARYES ecosystem
- Results of the demonstrators and market replication activities
- Recommended business models, service contracts and energy performance contracts.

Role of participants

1. CCB, will coordinate the work package, and will be the innovation manager. In addition, CCB will carry out dissemination actions.
2. VGT, will design and develop the Web Portal and 2.0 spaces (Facebook, Twitter, etc.), as well as coordination of their content management, with the contributions of other partners to the animations. VGT will also participate in the definition of the marketing and exploitation plans, bringing its expertise in games exploitation and promotion.
3. BED, will exploit the results and will disseminate the project results in the electricity sector.
4. UPC, organisation of conferences and workshops, dissemination among future professionals, publication of scientific papers and production of slides.
5. AAU, organisation of conferences and workshops, dissemination among future professionals, publication of scientific papers and production of slides.
6. NEO, will exploit the results and will disseminate the project results in the construction sector.
7. VIA, will exploit the results and will disseminate the project results in the construction sector.
8. BSC, organisation of conferences and workshops, dissemination among future professionals, publication of scientific papers and production of slides.
9. COM, will exploit the results and will disseminate the project results in the construction sector
10. ADV, will exploit the results and will disseminate the project results in the construction sector.
11. SLX, will exploit the results and will disseminate the project results in the construction sector.
12. BAM, will exploit the results and will disseminate the project results in the construction sector.

Deliverables

D7.1 – Plan for communication, dissemination and exploitation of the project results (M6, M12, M24): Development of the plan that will drive the exploitation and dissemination aspects in the project. This plan will be periodically updated according to market evaluation.

D7.2 – Data management plan (M6): Development of the plan that will outline and define the specific data management strategy for the project according to H2020 rules.

D7.3 – Preliminary project web site (M6): Development of the project web portal that will be regularly updated containing main project information, deliverables and dissemination events.

D7.4 – Final project web site (M26): ARYES ecosystem web portal integrating the project web site previously developed and the ARYES ecosystem, including web 2.0 and media tools. This web site will be maintained during and beyond the execution of the project.

D7.5 – Preliminary, mid-term and final marketing plan and exploitation plans (M12, M24, M36): This deliverable will describe the marketing and exploitation plans. This deliverable will present also the business models proposed to introduce the services in the market. Economic and environmental cost-benefit analysis will be added in deliverables corresponding to M24 and M36.

D7.6 – Preliminary, mid-term and final report on dissemination activities (M12, M24, M36): This deliverable will report dissemination activities carried out during the period and those planned for the following period, including targeted audiences, methods, timings, indicators and impact measurements.

D7.7 – ARYES handbook (M36): Handbook including guidelines to implement ARYES ecosystem in new and existing buildings.

Table 15, List of project deliverables

No	Deliverable name	WP	Lead partner	Type	Dissemination level	Delivery date
D1.1	Project Management Plan	WP1	UPC	R	CO	M3, UWN
D1.2	Quality management plan	WP1	UPC	R	CO	M3, UWN
D1.3	Risk assessment and implementation of the contingency plan	WP1	UPC	R	CO	M6, UWN
D1.4	Innovation and IPR management plan	WP1	CCB	R	CO	M6, UWN
D1.5	Cooperation plan with other EU projects	WP1	AAU	R	CO	M5, UWN
D1.6	Ethical and gender equality plan	WP1	VGT	R	CO	M6, UWN
D2.1	Technology analysis	WP2	NEO	R	PU	M4
D2.2	Use case and business case definition	WP2	VGT	R	PU	M7
D2.3	Service requirements	WP2	ADV	R	PU	M7
D2.4	ARYES architectures	WP2	AAU	R	PU	M7
D3.1	Support service family	WP3	AAU	DEM, R	PU	M13, M26
D3.2	Model calibration service family	WP3	UPC	DEM, R	PU	M26
D3.3	Weather and climate service family	WP3	BSC	DEM, R	PU	M13, M26
D3.4	HVAC optimization service family	WP3	NEO	DEM, R	PU	M13, M26
D3.5	Prediction energy service family	WP3	UPC	DEM, R	PU	M13, M26
D3.6	Energy saving certification service family	WP3	ADV	DEM, R	PU	M26
D4.1	Demonstrators implementation methodology	WP4	NEO	R	PU	M7
D4.2	Demonstrators implementation evaluation	WP4	ADV	R	PU	M24, M36
D4.3	Market replication results	WP4	COM	R	PU	M36
D5.1	Monitoring and evaluation methodology	WP5	UPC	R	PU	M8
D5.2	Baseline monitoring and evaluation report	WP5	VGT	R	PU	M12
D5.3	Middle-term monitoring and evaluation report	WP5	UPC	R	PU	M24
D5.4	Final monition and evaluation report	WP5	AAU	R	PU	M36
D6.1	Socio-economic analysis	WP6	VGT	R	PU	M17, M24
D6.2	Description of business models for ARYES services	WP6	VIA	R	PU	M7, M17, M36
D6.3	Regulatory framework evaluation	WP6	BED	R	PU	M36
D6.4	Ethical and privacy issues	WP6	VGT	R	PU	M7, M36
D6.5	Labelling system	WP6	COM	DEM, R	PU	M25, M36
D7.1	Plan for communication, dissemination and exploitation of the project results	WP7	CCB	R	PU	M6, M12, M24
D7.2	Data management plan	WP7	CCB	R	PU	M6, UWN
D7.3	Preliminary project web site	WP7	VGT	DEM	PU	M6
D7.4	Final project web site	WP7	VGT	DEM	PU	M6
D7.5	Preliminary, mid-term and final marketing plan and exploitation plans	WP7	CCB	R	CO	M12, M24, M36
D7.6	Preliminary, mid-term and final report on dissemination activities	WP7	VGT	R	PU	M12, M24, M36
D7.7	ARYES handbook	WP7	CCB	R	PU	M36

UWN - Update when needed

3.2 Management structure, milestones and procedures

3.2.1 Organisational structure

The practical managerial framework, organizational structure and decision-making mechanisms, have been custom-tailored to the project size and complexity. The general structure of the project management structure is shown in Figure 8. The ARYES project's management structure and supporting procedures have been designed to specifically deal with the strategic and operational management requirements of a multidisciplinary research project. ARYES project implements the project management activates along these guidelines in WP1.

The project management activities will ensure that the project properly coordinates its multi-party approach and that the work is completed within the terms of the contract with the European Commission. This will include ensuring that:

- Appropriate agreements and management framework are in place between the partners.
- All the project activities are properly coordinated with appropriate levels of legal, contractual, ethical, quality, financial and administrative management of the Consortium.
- Proper operational project management is provided throughout the project and the project's work is completed to the expected timescales, resource usage and quality levels.
- Appropriate reporting to the European Commission is undertaken.

UPC will undertake the management of the project through its European Projects Office (EPO) inside the UPC Technology Transfer Center. This office holds an extensive management expertise in EU-funded research projects. Since 2007, the EPO has been managing more than 170 project participations plus more than 47 project coordinations of the 7th Framework Program. The other partners involved in the ARYES project have successfully run many other European Research projects and National Research Projects in their respective roles, and have many years of research and management experience.

According the reduced number of partners and small size of the project, the structure of the project will be simple to allow flexible and rapid response to situation or challenges as they arise (Figure 8). To ensure optimal performance in the project, the quality control of project management will play an important role.

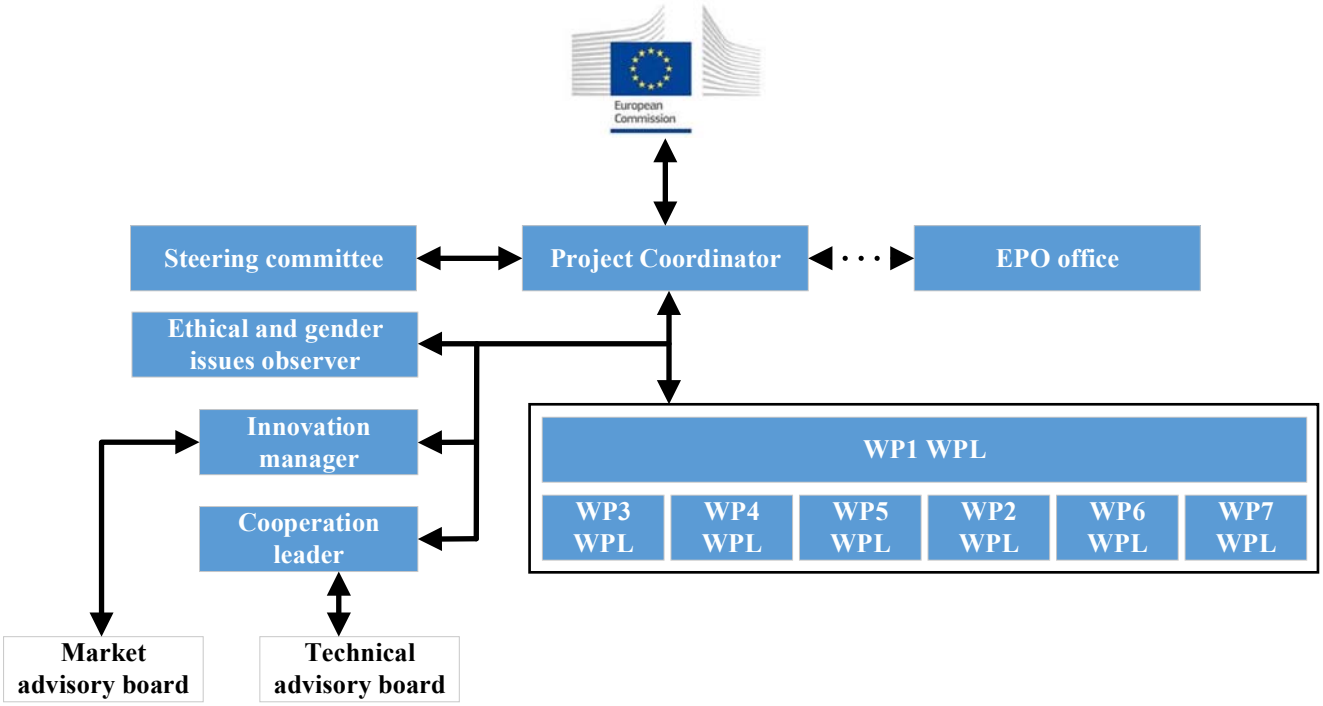

Figure 8. Project organisation

The consortium has designated Prof. Marcel Macarulla from UPC as Coordinator of the project. He has more than 10 years' experience in research activities also management activities both research and professional focused. The Project coordinator will be responsible for liaison with the European Commission, coordinating the project activities of the Consortium members and for producing deliverables to time, quality and budget. Day-to-day operational project control will be ensured primarily by the Project Coordinator supported by the Steering Committee at an operational level.

The Project Coordinator will be supported by UPC European Projects Office (EPO) who will assist him with a wide range of functions: liaising with the partners and the Project Officer working together with the involved professors and departments, assisting in drawing up Consortium Agreements, supervising and proceeding legal documentation for the EC, supporting the drafting and follow up of project budgets, filling in administrative documents etc. The UPC EPO is also in charge of the financial reporting and work monitoring. UPC EPO is responsible for solving any other managerial issue that might arise during the project such as audits and bank transfers towards the Commission and the partners.

UPC EPO will also nominate an Administrative Manager responsible for the administration of the internal Consortium structure and the financial administration of the project, ensuring the proper completion and consolidation of the cost claims. The Administrative Manager will act as a support to the Steering Committee and will attend its meetings.

The **Project Coordinator** will be responsible for delivery of the overall project objectives through:

- Definition and implementation of the management structure and procedures to be adopted throughout the project and maintenance of detailed project plans.
- Coordination at Consortium level of the management, legal, contractual, administrative, technical and quality activities, working closely with the project's Steering Committee, and ensuring co-operation among partners, anticipating and managing potential conflicts.
- Consideration of the state-of-the-art scientific and technical issues tackled and covered by the project and monitoring of results of other European projects and the establishment of contacts with other relevant projects and clusters in cooperation with the Steering Committee.
- Project reporting and coordination of management material, managing change control and provision of appropriate guidelines for each of the participants.
- Coordination of financial information from the partners (cost statements and audit certificate), provision of the regular financial reports to the Commission, revision and proposal of budget transfers in accordance with the Contract and the annual implementation plan.

Multi-disciplinarity is a key feature of the project and therefore coordination needs a team approach. Whilst the Project Coordinator's role is to ensure the operational management of the project, he also needs support from the team to ensure achievement of the project's objectives through strategic and tactical management. Each partner will work very closely with the Project Coordinator on all the project's matters and will be responsible for work and resource allocation at the partner level under the specific tasks.

The **Steering Committee** will be the executive authority for the overall management and running of the project, the resolution of any major problems that may arise and will decide on the use of the common knowledge resulting from the project. The Steering Committee will be also responsible for ensuring a high level of commitment from key members of the consortium, make recommendations to the Consortium in the case of redirection of project strategy or in the case of escalation, coordinate and monitor the scientific developments, technical activities and quality of the relevant deliverables, support project reporting, prepare and approve the annual implementation plan, alteration of the consortium agreement, restructuring work packages, budget-related issues and premature completion/termination of the project.

The Steering Committee will comprise one executive member from each partner and it will be chaired by the Project Coordinator. Each partner represented on the Steering Committee will have an equal say in the project. Where necessary, decisions will be taken by voting, when each of the members will have one vote. In cases of equal numbers of votes, the Chairman' decision will prevail. The Steering Committee will meet regularly.

The role of the **Cooperation Leader (CL)**, appointed by AAU, will be to assess the technical viability of the cooperation actions with the projects funded under the topics specified in the call, and advice the project coordinator and the overall project which actions are feasible in the technical domain. The cooperation leader will have a **Technical Advisory Board**, formed by EU projects identified in the call, other relevant EU projects and relevant scientists. This board will not have more than 10 participants. The budget will cover the cost for the CL to participate in the general assembly of the other projects, to invite technical advisory board members to the ARYES general assembly, and for the expenses for other liaisons activities.

The **Ethical and Gender Issues Observer (EGIO)**, appointed by VGT, will monitor these aspects and report periodically in the project meetings. The process is about ensuring that project is executed with an appropriated ethical approach and the appropriate gender balance in the project bodies (work packages, Quality Assurance Group, dissemination team) and in the project trajectory about decision making, conflict resolution and daily work of the researcher, where gender aspects have to be taken into account.

The **Innovation Manager (IM)**, appointed by CCB, will take care of the innovation management, the IPRs and the communication and exploitation of the ARYES project results during the project execution (to see the specific roles and responsibilities see section 2.2.7 and 3.2.6). The innovation manager will have the support of a market advisory board formed by companies that will be interested on the project results. Initially by the companies that provided a support letter, and the IM will be in charge to find more companies or organizations to be invited to the board. The budget will comprise the expenditures for the periodic meetings and workshops to be held in this context.

Strong emphasis on work package autonomy and management will be enforced. Clear objectives have been established for the outcome of each of the work packages and interfaces to other work packages have been made as simple as possible in order to create transparency and promote responsibility among project partners. The work in each work package is under the responsibility of a single partner who designates a **Work Package Leader (WPL)** to lead the work. The WPL organises the work on the tasks between the concerned partners and is responsible for achieving the objectives and producing the work package deliverables on time. Every WPL will be in charge of the soundness and overall quality of the related reports. The main responsibility for each main task will reside in the **Task Leader (TL)**. The WPL organises workshops and meetings within the work package in close liaison with the Project Coordinator. Meetings will be called as often as needed for ensuring effective work progress; however electronic conferencing facilities will be used as much as possible to limit travel expenses and carbon dioxide production. Other meetings will be organised at task level by participants involved in the task. The Project Coordinator continuously oversees that integration of the different components of the overall ARYES ecosystem is progressing according to plan and that overall project objectives are achieved.

The project roles will be maintained throughout the project and their effectiveness reviewed with the Steering Committee on an on-going basis. Any changes found necessary to the established roles or any changes arising in the Consortium participants, if is the case, will be appropriately reflected in the management organisation of the project. The Consortium Agreement will set out the basis upon which changes may be made.

3.2.2 Project internal communication

Personal contact among the participants is essential to ensure good communication flow and good collaboration. Interpersonal contacts will be realised through several workshops and project meetings. Regular general assemblies (minimum twice a year) will be organised by the Project Coordinator in close collaboration with the participants, who will take responsibility for local arrangements, when in their home country. Other smaller meetings and workshops on specific topics will be organised as required. The Steering Committee meetings will take place in conjunction with the regular general assemblies at least twice per year.

Electronic conferencing facilities will be arranged in order to enhance the communication among the partners. The frequency of the videoconferences will be in accordance with the needs of the project progress, weekly if needed. UPC will provide a virtual meeting room powered by Acrobat® Connect™ Pro.

The ARYES partners will install a web-based project extranet to support collaborative working. It will contain workspaces for partners to share materials and knowledge and a web-based Wiki space, allowing participants to work cooperatively, to report and to monitor progress. The extranet, together with the project website, will provide the focal point for project management and co-ordination activities including the project's library with all deliverables and documents, the wiki space for collaborative working and sharing, and the website with forum, news groups, and meetings and events planning for project discussions and planning of key topics and issues.

3.2.3 Decision making and conflict resolution

Conflict resolutions and discrepancies occurring during the development of the project tasks must be anticipated and reported immediately to the corresponding WPL. The WPL will solve the conflicts and will communicate every incidence to the Project Coordinator. The conflict resolutions will follow three steps:

1. **Open discussion:** The preferred method for dealing with conflicts is an open discussion and dialogue by the conflicting parties.

2. **Internal Mediation:** Parties whose disputes are not resolved in step 1 may utilise mediation through the appropriate WPL or Steering Committee. Here, the aim is to facilitate communication between disputants with the goal of assisting them to reach a resolution. The conciliation meetings are attended by all of the involved parties. The Coordinator must be informed of the nature and status of the conflict in order to bring it to the attention of the Steering Committee, if necessary. If the conflict is not resolved at this stage it moves to step 3.

3. **External Resolution:** In the case of failing to reach an agreement, as a last resort the conflict will be referred to an external arbitration procedure. In general, attempts at external arbitration will be enlarged with the responsible European Commission Project Officer. Adequate records of the nature of the conflict will be kept for reporting purposes and for planning future activities. Note that, at any time, the Steering Committee will organise a conflict resolution meeting within 15 days following the reception of a written request transmitted by any of the project partners. Requests for meetings must include hints for solutions.

3.2.4 Quality management and progress control

The Project Coordinator will be responsible for maintaining a high quality standard for the project as a whole. Quality assurance will be applied in both project results and project administration. UPC, as project coordinator, and the Steering Committee will supervise the quality management and quality control of the project deliverables and outcomes. Quality control methodologies and tools will be applied to all deliverables and other material intended for external use. A particular focus will be put on the quality of the main output of this project, the ARYES service ecosystem. At the beginning of each work package, the Steering Committee will collaborate with every WPL to indicate needs (requirements, standards, regulations) for maintaining quality assurance. The Steering Committee will verify that correct procedures and outputs result from preliminary work steps. A brief work package quality management plan containing a check list of all the expected results will be implemented by the Steering Committee in collaboration with the work package responsible. WPL will be responsible for ensuring the quality of their respective work package activities.

A short and operative Quality Plan will be produced at the start of the project and this document will govern the quality procedures for the whole project. It will define a set of rules for the organisation of the day-to-day work, including the procedures to be used, the reporting mechanisms, the organisation of meetings, and the preparation of documentation for submission to the Commission. It will also contain a process description for project deliverables, with the procedures for internal review and the quality criteria against which the deliverable will be assessed.

A Data Management Plan will be produced before M6, to make clear the procedures that the consortium will implement devoted to fulfil with all the H2020 Guidelines established for data management.

General assemblies will allow the revision and checking the contractual obligations with the work progress in view of the promised deliverable and milestones set up. This review will be accompanied by detailed planning for the next period and review of the associated deadlines for deliverables and milestones. Progress of work and decisions concerning alterations or additions to the work plan are on the agenda of each Steering Committee meeting. In case of major, but necessary changes, escalation or redirection of project strategy, the Steering Committee is the decision-making instrument.

For each period, the Project Coordinator in close coordination with the Steering Committee will submit a detailed progress and financial report to the European Commission together with cost statements and audit certificates as required under the contract. The delivery of major technical deliverables in the project has been aligned with the expected external project reviews. These reports will be submitted two weeks after completion of the related deadline to permit meaningful and timely feedback to the Project Coordinator by the European Commission. A first review will be held at month 12 by which time a number of key technical deliverables will have been produced. Further reviews will be held every 12 months. The Final Report will summarise the project's goals and objectives, intended outcomes, as well as provide an objective assessment of the project's success in achieving these. Furthermore, the Final Report shall provide an accounting for the actual expenditure of funds compared with the funding plan as originally proposed.

3.2.5 Milestones

The project milestones are summarized in the following table:

Table 16. List of milestones

Milestone number	Milestone name	Related WP(s)	Due date	Means of verification
ML1	Project start	All project	M1	Signatures of agreement by all partners
ML2	Beginning of the service developments and implementation	WP2, WP3	M7	All services developed, working and proper documented
ML3	First feedback to business models development & ARYES ecosystem alpha version	WP2, WP6	M13	(1) Document validated by SC (2) ARYES ecosystem released and validated by demonstrator owners
ML4	Update of services using demonstrator feedback	WP2, WP5	M18	Document validated by SC
ML5	ARYES ecosystem beta version	WP5	M26	ARYES ecosystem released and validated by demonstrator owners
ML6	Midterm evaluation	WP2, WP5, WP6	M24	Document validated by SC
ML7	Project end	All project	M36	Formal communication from EC

3.2.6 Innovation management

ARYES project aims to finalize with the market uptake. For this reason, the innovation management is a key aspect for the project. The consortium defined the role of an innovation manager. This role is not limited to the management of IPRs before and after the project but also includes: (i) Identification and dynamic management of the innovation management approach; (ii) Understanding of the landscape, including market, key stakeholders, trends, technologies, needs and opportunities; (iii) Continuous monitoring of the landscape; (iv) Assessment of the innovation potential of research results; and (v) Take corrective measures if needed, to ensure that market needs are best met. His/her responsibilities will be:

- Establishment of processes to maximize exploitation of the results by ARYES partners.
- Identification of ARYES innovations.
- Undertake the necessary actions to ensure favourable conditions for innovation and for the effective exploitation of innovations during and after the end of the project.

During the project a set of co-creation activities will be carried out: the servitization process, the definition of models and contracts and also to define the labelling system. Those activities will be monitored in order to complement the understanding of the landscape and detect business opportunities. The IM will define protocols to identify and share these aspects with the whole consortium and increase the opportunities to the develop innovation outputs.

3.2.7 Project risks and mitigation measures

A number of risks that could affect the full accomplishment of the objectives may arise during the ARYES project due to its multidisciplinary and complex characteristics. The risks have been identified in advance and preventative actions and contingency plans have been arranged for each case (see Table 17). However, the organisational structure of the consortium is prepared to deal with these risks by applying proactive risk management.

Table 17. Critical risks for implementation. LoL: Level of likelihood: L=low; M=medium; H=high

Description of risks	LoL	WP	Proposed risk-mitigation measures
Project coordinator could leave the project due to incompatible scientific or technical views with other partners	L	All	Other partners in the consortium have previous project management expertise and skills. AAU has an extensive experience and excellent reputation in project management of EU funded research projects.
Some delays experienced during work progress reporting, not in line with the planned milestones	L	All	The coordinator will avail himself of the help from the Steering Committee to analyse and remove delay causes and re-schedule the project. Many units involved in the work packages, to favour reciprocal help.
Tasks cannot be implemented within allocated budget and/or schedule	L	All	Appropriate managerial procedures and monitoring mechanisms have been set up in order to ensure that through periodic validation this risk will be mitigated.
A partner fails to meet the obligations laid down in this proposal, becomes non-performing or even defaulting	L	All	Each partner has the necessary expertise, professionalism and high commitment. If a partner will be non-performing, established managerial procedures (dictated by the Consortium Agreement) will be put into force. Alternative organisations with similar expertise will be brought to carry out the assigned work or alternatively, the remaining partners undertake this work in case there is appropriate expertise
Expertise risks (e.g. a key person with a specific expertise leaves the project, or key partner leave)	L	All	Proper documentation through reporting can mitigate this risk, though depending on the profile, work may need to be rescheduled in order to bring a new person up to speed. Clear communication channels will allow to inform. On the other handle, the technical/domain partners have several competences and could cover responsibilities from other partners, if needed.
Unavailability to recruit relevant stakeholders to participate in the co-creation activities	M	WP2, WP6	The project involves two associations that groups many companies from Belgium and Lithuania. The project will use its contacts to recruit companies for the co-creation activities

ARYES ecosystem requirements obtained by the co-creation process are not feasible within the scope of the project	H	WP2	The requirements and users' expectations will be analysed to ensure that they are realistic, cost-effective and essential to achieve the project impact
A new IT communication standard quickly penetrates the market	L	WP3, WP4	Special attention will be put into the design of the ARYES service family to ensure interoperability and flexible integration of new technologies
The components required to deploy the ARYES services are not available in the market	L	WP4	The project aims to reuse existing BEMS sensors and actuators. In fact, the demonstrators are selected to reduce the investment in the demonstrators near to 0. The technology partners are confident that developed services will be implemented in the demonstrators without major problems
The integration of the ARYES solution with existing infrastructure fails	L	WP4	Demonstrators are selected in the proposal stage carefully in order to ensure that is suitable to implemented the developed technologies during the project
Unavailability to obtain feedback from ARYES users in order to carry out the continual improvement process	M	WP2, WP6	Demonstrators are selected in the proposal stage ensuring its motivation in the project results. Other actors that can use ARYES services (different from the) will be ensured by the pool of contacts of the two associations of companies involved in the project
The developed business models,EPCs, and labelling service are not suitable in the market	M	WP6	The co-creation methodology will enable to involve all relevant stakeholders in the definition of business models, EPC and service making ensuring it market suitability
The ARYES ecosystem is interesting but it lacks dependability/ reliability features to allow its deployment under real-world conditions	L	WP6	The domain and technology experts of the consortium have indisputable expertise and knowledge in the domain fields of this proposal to ensure dependability/reliability features to the system

3.3 Consortium as a whole

The ARYES consortium is made of 12 high-profile European partners carefully selected for their acknowledged excellence as well as both their complementarity and trans-nationality (Figure 9) in order to provide the necessary knowledge, expertise, and state-of-the-art background required to ensure the success of the ARYES project as well as the sustainability of the proposed research and expected results. The reach of the ARYES consortium is not limited to the countries where the partners are based. An example is SEL, which is going to perform market replication to 2 buildings located in Germany (see Table 8).

The consortium brings together leading academics with scientific capacity in the field of energy consumption simulation, energy efficient technologies, computer science and energy market and business development; IT developers and technology integrators with expertise in developing building energy management systems and capacity to exploit the project outcomes; an energy supplier with access to a global electricity market and the capacity to exploit the project outcomes to a large scale; an aggregator that is looking for new energy flexibility services; an ESCO and facility/energy manager with experience in the development energy performance contracts and building operations and maintenance activities. Therefore, the consortium covers the value chain of energy, from the energy supply to the final consumers, including the IT tools to manage the building energy demand. In

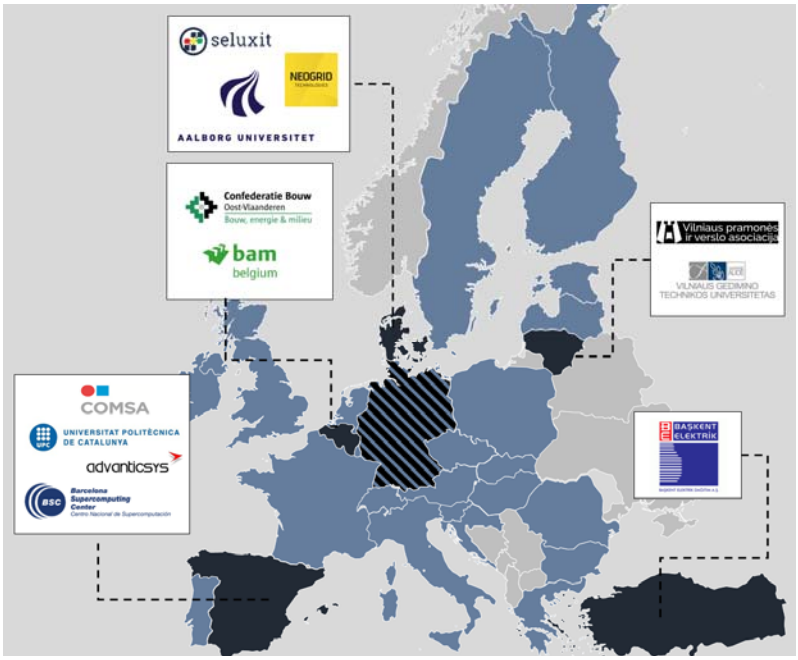

Figure 9. Distribution of partners around Europe

addition, the consortium covers the view of the traditional actors in the construction value chain with the view of a global infrastructure company and a construction confederation (Figure 10).

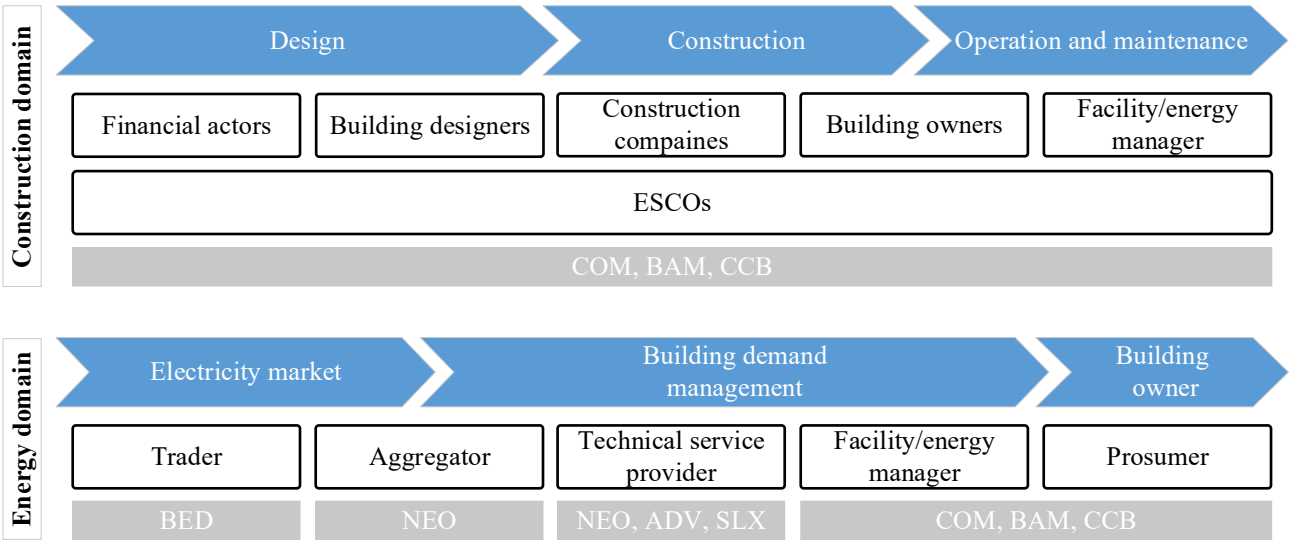

Figure 10. Construction value chain

Partners' expertise and role in the consortium

Five categories are used to classify the partners' expertise and role in the consortium (each partner belonging to one or more of them): (1) Domain experts; (2) Technology experts; (3) Exploitation and dissemination partners; (4) Research partners; and (5) Management partner.

The (1) domain experts includes an inter-disciplinary team covering all areas identified in section 1.3.1:

- **Energy market experts**, BED as an energy supplier and NEO as aggregator will provide an invaluable knowledge of the energy market and energy consumers.
- **Energy efficiency in buildings and building science experts,** UPC will provide the knowledge and expertise in energy efficient solutions in buildings, building modelling and building energy requirements analysis needed for the development of the HVAC optimization services as well as the measurement of the energy savings derived from the implementation of the services. COM as a large enterprise specialized in design, construction and maintenance of buildings will provide knowledge in energy efficient solutions in buildings and energy performance contracts current trends.
- **Service oriented middleware experts,** AAU, ADV, SLX and NEO have a long experience in developing service-oriented architectures and applying them to a plethora of use cases, comprising smart grids, monitoring of industrial machines, energy flexibility exchange in virtual markets of energy, weather and pollution monitoring.
- **Business model experts**, VIA and VGT will contribute with knowledge and expertise regarding the creation of innovative business models.
- **Weather and climate prediction experts**, BSC will provide expertise in weather and climate prediction
- **Construction domain experts,** COM and BAM, as global construction-service firms will provide expertise in the construction sector. In addition, CCB as a business organization focused on the construction sector will contribute also with his knowledge in the construction sector.
- **Co-creation and stakeholders involvement**, VIA, VGT and CCB will contribute with knowledge and expertise in the application of novel methodologies to involve stakeholders in the development process.

The **(2) technology experts** mainly will be technology integrators (NEO, ADV, SLX), with expertise in development and deployment of building energy management systems.

With regards to the **(3) exploitation and dissemination partners**, all partners in the consortium have previous expertise in disseminating project results and will actively participate in the communication and exploitation of ARYES findings as explained in section 2. However, it is worth mentioning the role of the innovation manager and of a cooperation leader, which will support reaching out to industry and academia alike.

The **(4) research partners** category will consist of the academics (UPC, AAU, VGT), researchers (BSC),IoT industry partners (NEO, ADV, SLX), energy market partners (BED), global construction companies (COM and BAS) and business organizations (CCB, VIA), which will contribute with their research skills and expertise to ensure the

delivery of innovative solutions and methods relevant not only to the international academic community but also to the global industry.

Finally, UPC will be the main **(5) management partner**, i.e. the coordinator of the ARYES consortium. All partners in the consortium have also good management and coordination skills acquired from previous projects; these will be put into practice following the leadership from UPC to ensure the success of the ARYES project

Since all partners have considerable experience in large European projects, they know, respect and trust each other, and have already developed a good team spirit. This will facilitate a smooth start of the project and ensure that the partners will collaborate, efficiently and in a positive atmosphere throughout the project period.

Industrial/commercial involvement

The ARYES consortium presents a good balance between academic and industrial/commercial involvement. In particular, the consortium consists of three academic partners (UPC, AAU, VGT), one research center (BSC), three commercial SMEs (ADV, NEO, SLX), three industrial partners (BED, COM, BED), and two business associations (CCB, VIA).

The industrial and commercial partners will work closer to the market to ensure the exploitation of the ARYES outcomes by means of different strategies suitable for their own business models and target markets, as explained in detail in Section 2. In general terms, ADV, NEO and SLX are expected to be able to develop and commercialise cutting-edge products (including energy optimization and flexibility services) related to the outcomes of the project in their respective target markets. COM and BED are expected to be able to use the developed EPC and energy prediction services in his activities. BED is expected to use the energy prediction services for its operation activities and to introduce new services in the market. And CCB and VIA will help to find investors to create spinoffs with the project outcomes that do not fit within the business of the ARYES consortium partners.

3.4 Resources to be committed

The ARYES project total eligible costs are 4,234,250 €, and the EU contribution that the project requires is 3,725,675€. The distribution of the budget is 55.3 % for companies and business organizations, 37.3 % for universities and 7.4 % for research centres. The distribution of resources by partner, activity and category of cost has been carefully thought over, to allow for efficient and effective implementation of the overall ARYES actions.

3.4.1 Staff resources

The ARYES project will mobilise a total of 530 person-months of partners' efforts (see Table 18). The distribution of effort is allocated mainly to develop, deploy and evaluate the ARYES ecosystem (WP2, WP3, WP4 and WP5), for a total of 321 PM (60.6 %). The second major effort is directed at developing instruments for the market uptake such as business models or EPC (WP6) with a total amount of 101 (19.1 %). The communication, dissemination and exploitation activities (WP7) accounts for an effort of 74 PM (14.0 %). Finally the management activities (WP1) are allocated 34 PM (6.4%). UPC is the partner with highest allocation of PM due to is coordinating the proposal, followed by AAU that is leading the development of services and liaisons activities, and VGT that coordinates all co-creation activities. BSC is planned to receive a large amount of resources due to its contribution in the development of services, particularly in weather and climate service family. The resources allocated to the rest of partners are approximately equally distributed and are ranged around 30-40 PM.

3.4.2 Other direct costs

Travel costs: Despite electronic means of communication and collaboration the consortium will heavily use, a certain amount of travelling is needed to participate in consortium meetings, workshops, training and pilot evaluation activities, dissemination events and EC review meetings. We however carefully planned these events in order to minimise travel costs while ensuring regular face-to-face meetings. We consider to have 2 general assemblies per year, and 1 review meeting per year collocated with one of the general assembly. Thus, we consider a total cost of 3 * (1000+1500) = 7500€ per partner.

Moreover, we consider that academic partners aim at disseminating our project results in a total of 2 conferences located in Europe and 2 conference outside Europe each, the first having an approximate cost of 500€ for the registration + 1000€ for the trip, and the second having an approximate cost of 500€ for the registration and 1500€ for the trip, amounting to a total of 7000€. We consider that the industrial partner will incur in some costs to travel to the demonstration / market replication sites and/or to attend industrial events and participating to co-creation activities, for a total of 7000€. Thus, for both academic and industrial partners, we consider travel costs of 14500€. Exceptions will be made for UPC (coordinator) and AAU (cooperation leader) since they are both expected to take part in dedicated communication and cooperation activities during the project execution, such as presentation of the

project in other actions' general assemblies and in research and innovation forums. The total travel expenses amount to 195,000 € (4.6%), which is reasonable considering the number and duration of the envisaged face-to-face meetings and liaisons activities.

Equipment: The costs for equipment are 16,500 € (0.4%) and are mainly dedicated to the acquisition of laptops and computers for the personnel that will be involved in the project.

Other goods and services: These costs consist in supplies of consumables and small equipment for the demonstrators and buildings used for market replication, auditing costs (only for those partners who will need to undertake an audit, i.e. UPC, AAU, VGT, CCB), 'Gold' and 'Green' open-access fees, expenses to carry out co-creation activities (e.g. small physical mini games), and communication issues (e.g. brochures). The total amount of these costs are 190,700 € (4.5 %). Although the big effort allocated to demonstrators and market replication activities, the project will have an emphasis on developing services and deploying them in buildings with existing BEMS, leading to low equipment and other goods and services costs. The rationale is that the ARYES ecosystem aims to create best practices for its deployment over existing BEMS platforms to maximise its market uptake.

Table 18. Summary of staff effort

Participant	WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total Person-Months per Participant
Participant 1 / UPC	**15**	4	12	10	**15**	4	6	66
Participant 2 / AAU	4	5	**22**	10	12	0	6	59
Participant 3 / NEO	1	**8**	9	14	3	4	2	41
Participant 4 / CCB	4	8	0	5	0	13	**14**	44
Participant 5 / BED	1	4	0	0	0	15	10	30
Participant 6 / VGT	3	8	0	10	5	**22**	18	66
Participant 7 / VIA	1	4	0	14	4	12	2	37
Participant 8 / BSC	1	8	20	5	10	4	2	50
Participant 9 / COM	1	4	0	**14**	5	9	4	37
Participant 10 / ADV	1	5	12	12	6	4	2	42
Participant 11 / SLX	1	4	0	11	3	5	3	27
Participant 12 / BAM	1	3	0	10	3	9	5	31
Total person- months	34	65	75	115	66	101	74	530

Table 19 and Table 20 describe the other direct costs for those partners that exceed 15% of the personnel cost.

Table 19. 'Other direct cost' items (travel, equipment, other goods and services, large research infrastructure) for BED

Participant 5/BED	Cost (€)	Justification
Travel	14,500	We consider to have 2 general assemblies per year, and 1 review meeting per year collocated with one of the general assembly. Thus, we consider a total cost of 3 * (1000+1500) = 7500€ per partner. Moreover, we consider that BED, as industrial partner, will incur in some costs to travel to attend industrial events and participating to co-creation activities, for a total of 7000€.
Equipment	2,000	We assigned the same amount of money of the rest of the partners for one computer
Other goods and services	0	
Total	16,500	

Table 20. 'Other direct cost' items (travel, equipment, other goods and services, large research infrastructure) for VIA

Participant 7/VIA	Cost (€)	Justification
Travel	14,500	We consider to have 2 general assemblies per year, and 1 review meeting per year collocated with one of the general assembly. Thus, we consider a total cost of 3 * (1000+1500) = 7500€ per partner. Moreover, VIA, as industrial partner will incur in some costs to travel to the demonstration / market replication sites and/or to attend industrial events and participating to co-creation activities, for a total of 7000€.

Equipment	2,000	We assigned the same amount of money of the rest of the partners for one computer
Other goods and services	20,000	We assigned this amount of money to implement ARYES system in the demonstrator and buildings from market replication activities.
Total	36,500	

3.4.3 Direct cost of Subcontracting

No subcontracting costs are foreseen at this proposal stage. All the work done in the tasks is covered by the partner's expertise and competences.

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