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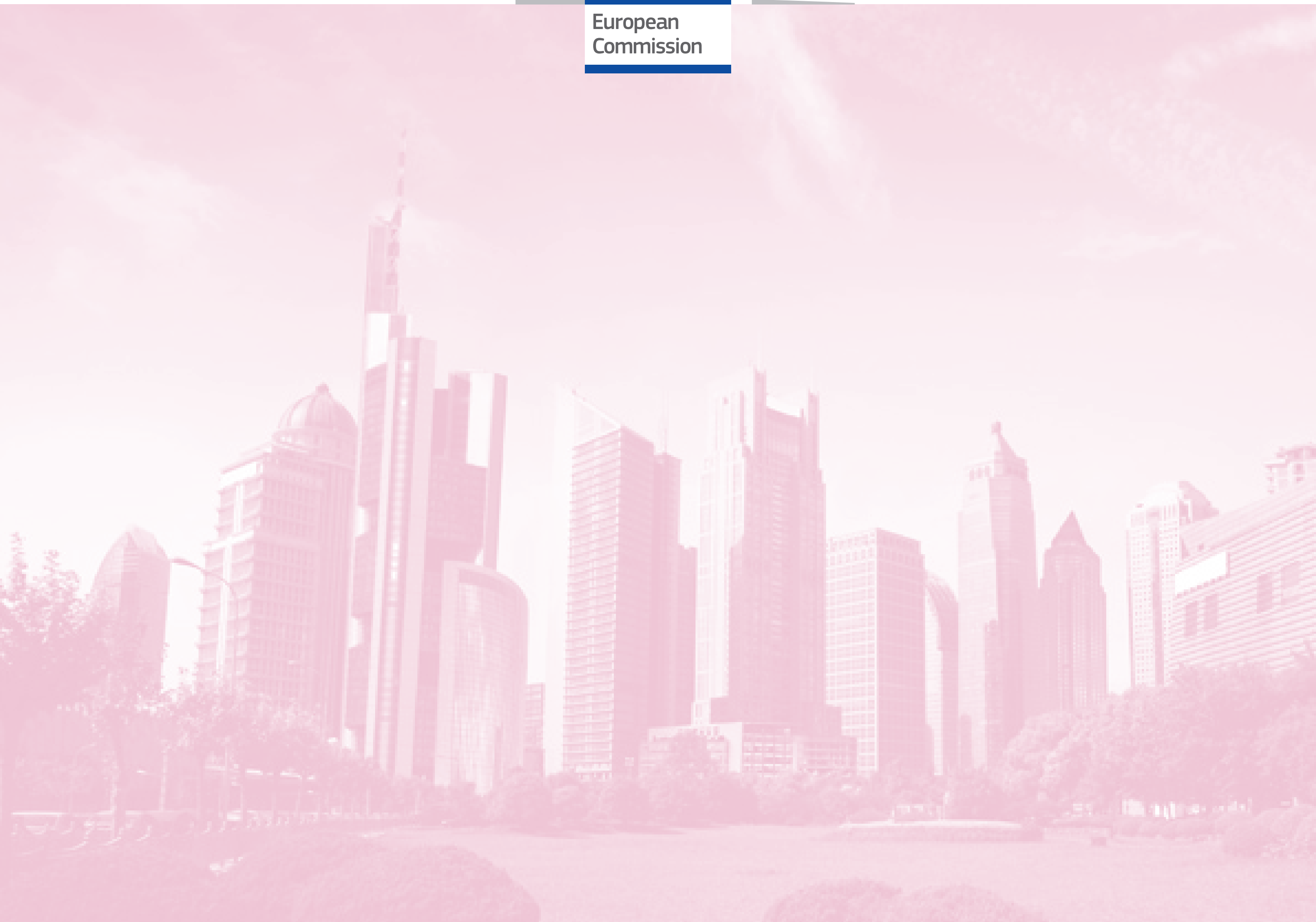

Smart Cities
Stakeholder Platform

Integrated Urban Energy Governance

Key to Innovation Integrated Solution

Integrated Urban Energy Governance

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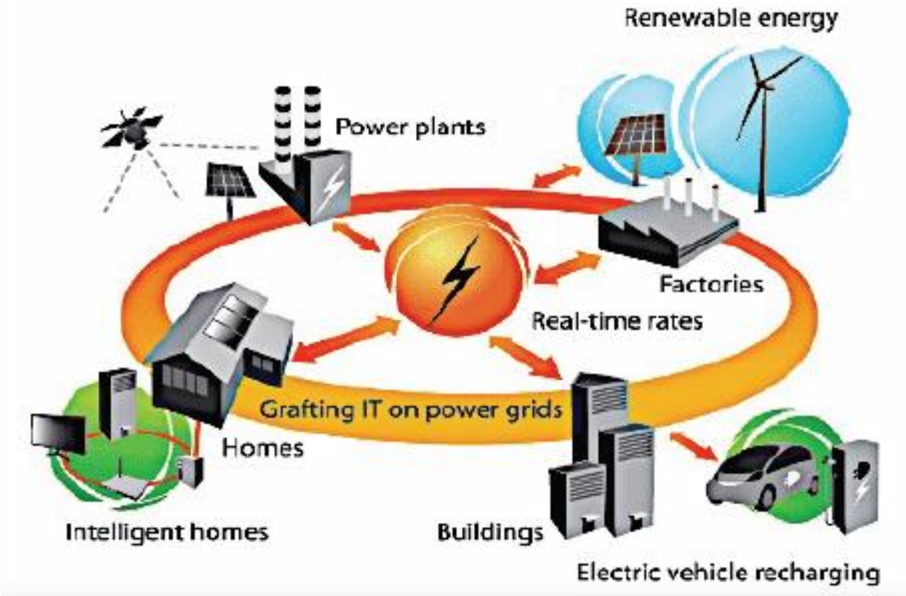
ABSTRACT



Integrated energy management and governance capabilities are essential for implementing Smart Cities initiatives successfully. They support cities in realising and coordinating measures for improving energy efficiency, and create economic value for both cities and businesses by integrating distributed renewable energy power plants, in both urban and rural areas.

The integrated approach described is to create a business and environmental advantage for the entire system, based upon the direct and active involvement of private entities and investors. Real-life implementation of innovative systems and technology involves a range of stakeholders in a bottom-up process, so that governance matches the innovative business models of different parties. The participation of local authorities, energy producers, energy distribution and transmission operators, storage systems manufacturers, financial entities, and others, also ensures a broad base of support.

This Key Innovation is based on a project in the Autonomous Region Friuli Venezia Giulia. This project builds clusters of private enterprises for energy management, using the potential for renewable energy production of the Friuli Venezia Giula region. It is an inclusive initiative open to all interested stakeholders to define jointly innovative business models and financial mechanisms. Together, private and public stakeholders create new markets for innovative energy services including smart grids, energy storage systems, distributed intelligence and a virtual power plant for integrating and optimising the different systems. The initiative also supports the growth of testing facilities for emerging energy technologies, enabling “Smart cities” approach and interoperability between different energetic systems.

Complementing the activities within the Friuli Venezia Giula region, the project aims for replication in neighbouring Austria and Slovenia, creating trans-boundary cooperation to create links with the Balkan Area. Cyber security of ICT infrastructures is central to this international aspect of the project. The project in Friuli Venezia Giula thus builds a smart cross–border community, in which energy represents the key factor for value creation.

INTRODUCTION

The Key Innovations (KIs) are a key output of the Smart Cities Stakeholder Platform. The Platform promotes innovation and is part of the Smart Cities and Communities European Innovation Partnership of the European Union. It aims to accelerate the development and market deployment of energy efficiency and low-carbon technology applications in the urban environment. The emphasis will be on their integration, which is a key challenge particularly for Smart Cities' technologies. The Platform aims to bring together technology providers, financiers and specialists in implementing smart city strategies at local level.

The expert Working Groups of the Platform on Energy Efficiency and Buildings, Energy Supply and Networks, ICT, as well as Mobility and Transport select from the spectrum of Solution Proposals (SPs) submitted by stakeholders[1] the *most promising and fundamental* solutions to accelerate the development of smart cities. The focus is on specific promising innovations, considered pillars or technical leapfrogs for integrated solutions in smart cities, thus promising, but standalone solutions, will not be developed into key innovation files and toolkits.

Regardless, if an SP will be part or not of a key innovation document, all solution proposals will be published in the Platform and linked to city profiles. The Platform is not an evaluation body and is open to all relevant smart solutions, large or small scale for cities and their inhabitants.

The aim is to promote through the preparation of a detailed document, a guide for cities on the performance of the innovation, including in some cases wider impacts on city life (such as change of behaviour, environment, social inclusion etc.). For each innovation, this key innovation document will describe the methodology to deploy it, including the technical requirements and the necessary framework conditions, such as existing infrastructures, technical expertise, regulatory requirements as well as the financial costs involved. The document aims to promote the adoption of the key technology and to identify barriers to deployment to assist relevant authorities in developing solutions to remove them. The document will list the technology providers as well as information of a number of potential financial sources by the EU and other bodies which have supplied information to the platform.

The information in the Key Innovation documents will become an integral part of the recommendations of the Smart City 10 Year Rolling Agenda document the Platform will draft for the European Commission. This document will highlight identified actions at European level required to promote the adoption of key innovations, such as the removal of regulatory barriers or recommendations on the focus of the Horizon 2020.

It is important to stress that this document is not a set of technical proposal or a full evaluation of the innovation, but aims to assist for cities to identify potential solutions and understand their context and implementation needs. It does not exempt or substitute a detailed cost/benefit analysis and implementation plans for cities that wish to introduce the innovation. The Stakeholder Platform cannot take any responsibility for inaccuracies or missing information or specific problems in the implementation of the proposed Key Innovations or other Solution Proposals.

[1]Solution proposals are published on the web site: www.eu-smartcities.eu/ solution-proposals

Description of a Key Innovation

A key objective of the Smart Cities Stakeholder Platform is to identify Key Innovations (KIs) for the development of Smart Cities. The selection of an SP as KI is based on the following criteria: **applicability, simplicity, affordability**, **usability** the extent to which it addresses technology integration and if the potential impact is significant. Selected SPs will then be enhanced by the Platform's technical Working Groups (WGs) to develop KIs, adding the following aspects:

- Premises for the technology development and up-take (e.g. problems, what the technology is intended to achieve, other unforeseen benefits for the smart cities);
- Potential integration with other technologies and sectors, including use of ICT;
- If necessary, enhancing the information from the SP on the urban environment in which the technology can be applied;
- Key pre-requisites for the applicability of the key innovation, such as the required enabling environment;
- Instruments and market conditions needed to reach commercial viability.2

KIs will be completed by the technical WGs in collaboration with the Finance WG. This group will analyse the financial needs of the KI as well as their financial viability and bankability. The members of the WG will provide information on funding sources. The result will be published as a Key Innovation Toolkit.

The Toolkits thus provide practical solutions that can create an enabling environment for the application and replication of key innovations in a smart city.

[2]This includes a description of the main EU support instruments, such as the Risk Sharing Financing Facility

1. PRESENTATION OF THE KEY INNOVATION

This key innovation is based on the following solution proposal(s):

	Date of submission	Solution Proposal Submitted by	IP right holders	Maturity	City	Stakeholders involved
Integrated system for the energy governance in Friuli Venezia Giulia region, "smart cities" approach and interoperability in the energetic system	12 October 2012	Maurizio Trevisan	NA	Pilot Project	The main cities of Friuli Venezia Giulia region	BIC INCUBATORI FVG S.p.a., SiTI
Scarcity of resources and infrastructure security, in a rural environment	15 October 2012	Thierry Gallet	NA	Pilot Project	Alpes de Haute Provence	Conseil général des Alpes de Haute Provence
Innovative integrated and optimized energy systems for high performance-energy districts		Jorge Molina-Martinez	Project Idea	Zaragoza	FP7 Aragon Network (Red Aragon 7PM)	

1.1 Description of the innovation and rationale for selection

The energy sector is an important element of local and regional development policy. This includes addressing energy generation, plant profitability maximisation, resources optimization, , involvement of public and private stakeholders, and consumption reduction. Smart design of related infrastructure is an important driver for a sustainable development and growth of the territory.

Renewable Energy Sources (RES) are an element of many local and regional energy strategies. However, RES are typically spread over the territory and have complex issues related to intermittent and uncontrollable power production. Integrating RES therefore requires new energy management strategies. These strategies include re-organization of energy infrastructure , aiming to reduce the average distance and time-gap between energy generation and consumption, when possible. The associated complex technological and managerial challenges can be addressed by developing smart infrastructures (e.g. smart grids) and implementing technological improvements.

In addition, many cities wish to introduce electric vehicles in the urban environment. Electric mobility infrastructure has requirements that current energy infrastructures cannot satisfy on a large scale. These requirements ranges from the provision of substantial amounts of energy at the right time to time-dependent energy pricing to incentivize consumers to adjust their consumption profiles to market price and available network capacity. This challenge also requires an integrated framework, using real-time management of consumption data and production profiles, coupled with the management of energy storage devices.

Improvements can be structured at three different levels:

- On **small-scale networks**, where the distributed generation from RES has to be adapted to local consumptions, if any; it means, for example, to use energy locally whenever possible by connecting producers with consumers, in order to avoid at the same time the losses in the grid;

- On **sustainable urban systems**, in which all urban infrastructures is managed in a coordinated way on the basis of innovative energy efficiency protocols, providing services to the population. These services can relate to mobility and intermodal transport, incentives for people to become “prosumers” (i.e. producer/consumers), improvement of energy efficiency in public and private buildings (also in the historical centres, while maintaining their artistic value), deployment of domestic storage (e.g. in electric vehicles) and, not last, the mobilisation of citizens to encourage changes in unconscious unsustainable behaviour;
- On **distribution and transmission grids**, at local, regional and national level, dealing with the intermittence of RES and integrating storage appliances in order to provide energy needs effectively and efficiently.

1.2 Deployment status

Various European cities have been implementing strategies for Smart integrated management of distributed generation. Agenda 21 provided a much-needed impulse for supporting local efforts in sustainability all around the world, including the development of city networks for urban energy projects. In Europe a number of city networks with specific sustainability-related scopes were founded from 1989 to 1994, for example on climate (Climate Alliance); culture (Les Rencontres); urban policy (Congress of Local an d Regional Authorities of Europe, Eurotowns); communication and technology transfer (TeleCities); transportation (POLIS); urban development (QeC-ERAN); and energy (Energie-Cités, Brundtland City Energy Network, etc. etc.).

A look at the geographical spread of cities active in integrated urban energy projects and networks in Europe shows a concentration in industrialized areas in Western Europe but also an even distribution across Eastern Europe. While the City Energy network tends to concentrate around Germany and Scandinavia and Eastern Europe, urban energy projects are more dominant in the Benelux countries, France and UK.

Evidentially, energy network membership is regionally defined, which leads one to conclude that cultural factors come into play. It is also interesting to note that smaller to mid-sized cities dominate in these networks - the regional capitals as opposed to the global metropolises.

After the adoption of the European climate and energy package in 2008, the European Commission launched the Covenant of Mayors to endorse and support the efforts made by local authorities in the implementation of policies in the field of sustainable energy. Local governments, in fact, play a decisive role in the mitigation of the effects of climate change, especially when you consider that 80% of energy consumption and CO_2 emissions is associated with urban activities.

Because of its unique characteristics - being the only movement of its kind to mobilize local and regional actors in order to achieve the European objectives - the Covenant of Mayors is considered by the European institutions as an outstanding model of multilevel governance.

Friuli Venezia Giulia (IT)

The project in the Friuli Venezia Giulia region will apply best practices to improve the energy efficiency and the integration of the RES in the urban areas, following some European examples.

The local authority of Friuli Venezia Giulia aims to implement a Virtual Power Plant (VPP) and has been evaluating the proper area for its application. RES plants have been identified and their energy production reported. Those suitable will be connected to the VPP, giving priority to hydroelectric plants). Furthermore the transmission and distribution grid has been studied, taking into consideration cross-border power/energy flows and the consequences of the installation of energy storage in the cross-border regions. The VPP is being tested on a relatively small number of heterogeneous plants, aiming at replicating the approach on a wide area and, eventually, at covering the entire region.

Groningen (NL)

Groningen is the major city in the North of the Netherlands. With circa 170.000 inhabitants, Groningen offers many top facilities: university, academic hospital, a historic city centre. Groningen is bursting with energy: traditional sources of power (oil and natural gas), alternative forms of energy, as well as a concentration of knowledge on energy and energy-related activities.

The Municipality of Groningen has expressed the ambition to become the most sustainable city of The Netherlands. The policy on sustainability for 2006-2010 focuses on energy and quality of the environment. A "Guide towards energy-neutral+ in 2025" is the symbol for the cooperation between the municipality with inhabitants, knowledge institutes, developers and other firms to reduce CO_2 emissions.

In 'Build with CaRe', the municipality of Groningen seeks to realise energy-efficient building and behaviour, by using expertise of the other partners and offering the results of pilots in Groningen:

- Integrate energy-efficiency in improvement of neighbourhoods;
- Overcome financial problems after improvements;
- Implement sustainable design of houses and energy solutions in new living areas;
- Broadly implement inventions that influences consumer behaviour;
- Construct an effective information centre on sustainable houses for inhabitants.

Göteborg (SE)

Gőteborg in the South of Sweden (county of Västra Götaland) with 500.000 inhabitants represents an important example for the efficient recovery of the heat from industrial processes. The the majority of consumers (domestic and industrial) are connected with a district heating network, which leads the heat, recovered from industrial processes.

The 33% of the heat derives from two refineries, the 26% from a waste incinerator, equipped with a CHP plant (rated power 165 MW). The 16% of the heat is recovered through heat pumps, which use the waste-water, because its temperature is higher than that of the sea, caused by the human uses (e.g. washing machine, shower). The 7% of the heat derives from CHP plants; supplied with fossil fuels, whereas the 4% derives from a CHP plant, feed with biogas. Biogas is obtained in the anaerobic digestion of the mud, residual from the treatment of the urban waste-water.

1.3 Technical feasibility and viability

The selection and coordination of diverse technical solutions requires an integrated approach to energy governance and management at territorial level, linking technology capabilities to entrepreneurial, organization and business potentials, dealing with both electric and thermal energy, and including various technical elements[3]. Key elements of the system are the VPP, data collection and management infrastructure, energy storage and an Energy Management Agency (EMA).

RES technologies

Present status: fossil-fuel based energy production still dominates most energy systems, though RES can represent a significant share locally. However, distributed RES generation is increasing in many places; a trend that is likely to continue. This will result in greater variability of supply, and more complex flows in energy networks. Often, local distribution and supply infrastructure is not able to accommodate this without investment of more efficient operation.

[3]The project in the Friuli Venezia Giulia region takes this approach.

The situation of the project in Friuli Venezia Giula is a good illustration. In the region there are already several RES generation plants (i.e. hydroelectric, biomass, biogas, solar photovoltaic), and others are planned. The energy production from RES is near the objective to 2020: RES make up 11.9% of total energy consumption, and 20.1% of electricity consumption. There is a fully functional energy distribution and transmission grid and investments for new lines are already planned by the system operators: one OHL 380 kV “Udine Sud-Redipuglia” and some merchant lines (110 kV “Redipuglia-Vrtojba”, “Zaule-Dekani” Italy-Slovenia, 132 kV “Paluzza-Mauthen” Italy-Austria).

Furthermore the FRIULI VENEZIA GIULA region has many abandoned military areas; an estimated 1.3% of the regional territory (7.842 km2). These areas are being assessed for commercial use, providing potential sites for energy storage.

Emerging Smart City solution: many RES systems are already commercially available, and being deployed at significant scale. Assessing the different options in terms of potential and economic viability through a cost-benefit analysis allows for identifying the most suitable options.

Virtual Power Plant

Present status: currently, there is usually little coordination in the development of RES generation with each other ,and with local places of demand. Deployment of these resources and flexibility of demand, while considering limitation of the energy infrastructure is also often not fully integrated. This can lead to situations in which the available RES generation or demand-side efficiency is not used to its full potential.

Emerging Smart City solution: A VPP[4] connects and coordinates several plants based on different RES (e.g. biomass, hydroelectric, photovoltaic, wind, geothermal), that are managed in a coordinated way, aiming at optimizing the resource exploitation both from the economical and the environmental points of view.

The smart paradigm for coordinating the different resources is based on four pillars:

1. Definition of management policies in case of great amount of inconstant energy coming from several generation points based on RES spread over a wide area;
2. Support for electric mobility diffusion, paving the way for a new distribution network able to cope with the specific requirements of electric cars and recharging stations;
3. Identification of the best energy storage solutions to store the surplus energy coming from renewable sources and use it when needed, taking advantage of energy price variations;
4. Promoting energy efficiency to improve the management of domestic consumptions.

In addition to the energy generation plants based on RES, the VPP includes industrial, commercial and residential buildings equipped with ICT technologies that enable them to act as “smart buildings”, being able to adjust demand and to supply on-site generated energy back to the network. The aim is to evaluate how the system can deal with the presence of prosumers acting as both energy producers and consumers inside a smart infrastructure.

Data collection and management infrastructure

Present situation: in the absence of smart meters and with little monitoring systems in local energy networks, there is often little knowledge of conditions of decentralized supply, local demand and the state of the distribution network. Consequently, there is little information available for designing planning and operational strategies to better coordinate the local energy system.

Emerging Smart City solution: Integrated energy management must be based on data about the conditions of the whole local energy system, and exchange of this information between all the actors involved (e.g. energy producers, distributors, end-users). For

[4]See also the dedicated Key Innovation document on Virtual Power Plants.

this reason a proper ICT infrastructure must be implemented to collect data. Involving local telecommunication system operators can help to define the right communication infrastructure to collect data in a reliable and secure way. As decision makers will use such data to define energy management policies, data reliability and integrity is a priority. Moreover, the ICT infrastructure needs to adhere to principles of privacy and cyber-security.

In an integrated scenario, energy consumers play an important role in the definition of proper management policies5. Data on consumption profiles need to be collected in order to define the energy required to satisfy the demand. Such data also helps users to get insight in their energy consumptions and to identify possible measures for improving energy efficiency. The implementation of a secure ICT infrastructure guarantees the privacy of collected consumption data, encouraging full participation of end-users in the VPP.

Energy storage

Present status: currently, market prices are central in determining the deployment of different generation sources. This generally ensures that the most cost-effective generation is mobilized first, but it is not necessarily sufficient to exploit RES to their full potential, as it cannot always manage the variable nature of RES production. Additionally, it does not account for congestion in the energy distribution infrastructures.

Emerging Smart City solution: integrating energy storage locally in the system allows for optimizing supply and demand and mitigating infrastructure limitations. They do this by storing the produced energy when not required and releasing it when the production systems are not able to fully satisfy the demand, exploiting variations in energy market prices. Furthermore, storage can also help reduce network congestion during peak hours, contributing to the mitigation of the immediate need for an improvement of current infrastructures.

Various energy storage technologies can be adopted. The VPP pilot case of the project in the region Friuli Venezia Giula, for instance, considers pumped hydro (PHES), compressed air (CAES), battery farms, flywheels. The most suitable options can be identified based on technical-economic criteria in a cost-benefit analysis, using software simulation, in conjunction with technology manufacturers.

Important factors to consider in the evaluation are the economic viability and GHGs emissions saving, also in the framework of LCA analysis, current data to assess the expected impacts of different option.

The economic viability will give information about potential investors, identifying the investment costs and the payback period of the investments. Since these indicators can have very different values (from several million € up to some hundreds M€) and paybacks can be long (up to more than 18 years), the investors could be public for the biggest ones, private companies for the smallest ones. In Fruili Venezia Giula, for example, each option can be classified as “suitable for public sector investment” (for instance, those investments with a payback exceeding 10 years) or as “suitable for private sector investment” (for instance, those investments with a payback less than 10 years).

The GHGs emissions saving depends on the quantity of saved electricity and on its emission factor, which varies in different regions. Energy efficiency include those resulting from reducing the distance between producers and consumers, decreasing network losses

[5] The project specifically uses a bottom-up process to involve local stakeholders in designing the integrated system, as opposed to a technology-driven top-down approach. Each tested intervention is analysed in terms of economic viability and potential investors. Consequently the evolution of the electricity grid is studied with an approach, which is able to integrate and harmonize the intervention by different stakeholders.

1.4 Financial analysis

Regional energy governance can be achieved through investments of different size by different stakeholders, both public and private. Through the VPP of the economic viability of different interventions can be evaluated, using the usual indicators: net present value, internal rate of return, and payback period. This is illustrated below for energy storage, one of the core elements of the integrated strategy.

Energy storage can be a catalyst for economic and financial optimization of production and sale profiles for distributed generation (power plants are connected through a VPP paradigm and integrated governance of energy clusters is a major asset). With this approach the initial investments in setting up the whole system can be recovered through the optimization of energy provision services and the reduction of energy production costs.

The results of the simulations performed in the VPP allow to estimate the economic benefits for the regional governance, because the economic viability of each technology option can be analysed on economic grounds (i.e. net present value, internal rate of return, payback period).

The investment costs depend on the type of energy storage and on the performance (Table 1), ranging from about 400 US$/kW for lead-acid batteries and lithium-ion systems to around 1,200 US$/kW or more for pumped-storage hydropower plants. For example the pumped hydropower plant of Kozjak on the Drava river in Slovenia (rated power 220 MW) has an investment cost estimated in 323 M€, translating into 1,468 €/kW[6].

Table 1 Costs and performance of various electricity storage technologies[7].

Technology	**Cycles**	**Power subsystem costs (US$/kW)**	**Energy subsystem costs (US$/kWh)**
Advanced lead-acid batteries	2,000	400	330
Sodium/sulphur batteries	3,000	350	350
Lead-acid batteries with carbon-enhanced electrodes	20,000	400	330
Lithium-ion batteries (large)	4,000	400	600
Compressed air energy storage	25,000	700	5
Pumped-storage hydroelectric	25,000	1,200	75
Flywheels	25,000	600	1,600
Supercapacitors	25,000	500	10,000

The economic viability also depends on the kind of use: some technologies are more attractive for long-term storage/frequent discharge, while others are more suitable for long-term storage/infrequent discharge, short-term /frequent discharge or short-term /infrequent discharge storage. For example,

- For advanced lead-acid batteries the present-value cost of 10 year operation in year 1 is 2,840 US$/kW if used for long-term storage/frequent discharge, and 704 $/kW if for short duration/infrequent discharge.
- For flywheels he present-value of 10 year operation in year 1 t is 966 $/kW for short-term/frequent discharge storage, and 923 $/kW for short-term duration/infrequent discharge.
- CAES and PSH are only suitable for long-term storage/frequent discharge.

[6] Source: www.eles.si; Development Strategy of the electrical power system of the republic of Slovenia.

[7] Source: www.smartgrid.gov; www.dnvkema.com; ENI-Ente nazionale Idrocarburi: Innovations in the near future, 2013.

The benefits of the investments in energy storage derive from the optimisation in the selling of electricity, made possible by the storage of electricity in different forms (e.g. chemical, mechanical) when demand (and therefore prices) are low. The revenues are correlated with the capacity of storage, and for a single technology, therefore with the size of the plant and the investment.

Paybacks can be long for emerging storage technologies, for example higher than 15-18 years for technologies such as pumped-hydropower storage and compressed air energy storage. The typical payback is shorter for others, in some cases lower than 10 years, like for lead acid battery systems and flywheels.

Depending on the payback, some investments may be suitable for financing by private parties, while others would require partial or full public-sector funding. The project in Friuli Venezia Giula, for example, makes the division at a payback period of 10 years - those project with a higher return are deemed suitable for public investments (this could be the case of great interventions for the energy storage (e.g. PHES, CAES) or for the implementation of the electric grid). Project with a payback time under 10 years could be made by private sector, including, for instance, smaller energy storage plants (e.g. batteries, flywheels).

The Finance group was deemed necessary to better specify the kind of information the innovation providers should provide, to help the financial group to find solutions. The financiers look at the following points when considering to finance a KI.

- An estimated timescale for the proposed technology to be available in the market commercially (e.g. now; 2 years time, 5 years time)

- An example of some key timetable aspects: Initial project design and feasibility study; Financing; Planning, consenting and agreements with other organisations that must be involved; Implementation; System testing; System life – Other aspects are relevant but highly depend on the location. Any knowledge on permits required, Environmental Impact Assessment needs, consultations and procurement rules are welcome[8].

- Analysis of the key risks - technical, financial, other as far a possible, including differences depending on the city type.

- Some information on he scale of financing required (for example using three example projects - e.g. a small scale pilot covering 30,000 people; a city of 400,000 people; a city of 1,000,000 people). If this is too difficult the proposers could to suggest a range of example types of projects and estimate costs for these.

1.5 Suitable city context

The area where the approach can be applied in order to fully exploit the potential benefit should have the following characteristics:

- A diverse mix of energy generation plants based on RES located in an area able to serve different types of final users (industrial, commercial and residential);
- Biomass plants located near buildings in order to also exploit the heat generated through district heating networks;
- An ICT infrastructure able to connect the plants and the user should already existent, to reduce the investments required;
- The presence of natural or man-made infrastructure able to be transformed in energy storage systems, like artificial lakes, caves, or the proper space to host battery farms and flywheels, like abandoned military areas, which in Friuli

[8] For guidance on impact assessment, urban planning and procurement please refer to the guidance documents published by the Platform **"Foundations for an Urban Investment Planning Logic – The EU case"** and the **"Guidance document on public procurement for smart cities".**

Venezia Giulia are very frequent (1.3% of the regional territory); these sites should be near to the transmission and distribution grid;

- A suitable transmission and distribution grid, with sufficient capacity and monitoring and controlling systems.

2. EXPECTED IMPACTS

2.1 Energy supplied or savings expected

There are different ways in which integrated energy management can help achieve energy savings.

Firstly, the development of an optimized energy exploitation strategy based on generation from RES and real consumption data will reduce the global amount of energy produced as only the necessary energy will delivered. The use of storage systems will help achieve this goal, as they will store the surplus of produced energy and will return the energy when needed and the operational plants are not able to satisfy the demand. This avoids the need for having (fossil-fuel) generation units on standby, reducing energy input. This saving has to be balanced against the energy losses within the storage system.

Secondly, it helps reduce electricity network losses by increasing the proximity between producers and consumers. This is particularly important in local low-voltage networks; the value of network losses is 1.8% in transmission networks, 4.7% in the medium voltage network and 10.4% at low voltage[9].

Lastly, the collection of real-time data on energy consumption will help develop specific energy efficiency policies. Also consumers will be more aware of their consumptions and will be encouraged to change their habits in order to save energy (and consequently money).

2.2 Expected impact on GHG emissions

The optimal exploitation of RES, as well as energy efficiency measures by end-users that the integrated approach aims to achieve, will reduce the amount of energy produced by fossil fuels, thus reducing the greenhouse gases emissions. As with the energy savings, reductions in GHG emissions result from different effects.

- Better balancing of supply and demand, thereby reducing the need for stand-by (fossil-fuel) power plants;
- Reduction of network losses;
- Energy efficiency measures by end-users.

In addition, the VPP can support GHG emissions savings in other areas, for example by supporting new mobility infrastructures.[10]

The GHGs emissions savings in a certain region depend on the CO_2-intensity of the electricity that is displaced. This is determined by the energy sources used to generate the electricity in the conventional system.

For example, in Italy the grid electricity has an average emissions factor of 0.503 tCO_2/MWh[11]. The saving for each measure in the Friuli Venezia Giulia region can be calculated based on this figure.

Life-cycle assessment (LCA) can provide a more comprehensive evaluation of the GHG emissions effect for different measures or technologies throughout the whole supply chain, if desired. This is a much more detailed and elaborate process, that may not be feasible for all projects or all proposed measures.

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[9]Source: www.terna.it - Grid development plan.

[10]See also the dedicate Key Innovation documents for Virtual Power Plant and Smart Grids.

[11]Data for the year2010; source: AEEG - The Regulatory Authority for Electricity and Gas (Aeeg): is the independent body which regulates, controls and monitors the electricity and gas markets in Italy (http://www.autorita.energia.it/).

2.3 Interfaces with other technologies/ transport modes

Links with End-User Energy Efficiency technology and measures: ICT infrastructure not only connects the energy production centres, but also consumers, giving access to flexible demand and on-site generation. Industrial, commercial and residential buildings equipped with building energy management ICT technologies and able to act as “smart buildings”, supporting the transition toward “near-zero emissions” buildings. In addition, the broadband communication infrastructure can be the backbone for the provision of other services to the population, with potential benefits on the energy efficiency.

Building-based energy hubs are central to this interaction. These systems monitor energy consumption in real time, in conjunction with providing customized tariffs based on user energy needs, which can help users change their habits reducing their consumptions and using energy more efficiently. It also supports consumers or clusters of smart buildings to produce their own energy, and potentially provide this back to the network.

Links with Transport & Mobility technology and measures: The energy management policy and VPP take into account the requirements of an electric mobility infrastructures (recharging stations, energy pricing). With this approach, electric mobility solutions can be successfully adopted with a minimal impact on the whole energy infrastructures as it becomes smart enough to effectively adapt to new consumption or production profiles.

2.4 Waste generation

Not applicable.

2.5 Wider potential benefits for cities

The VPP will foster the creation of an Energy Management Agency (EMA), with the goal to support public and private investors in the energy field at regional level. This agency will foster a regional economic system able to support technical and economic innovation process. The agency can establish and participate in public-private partnerships that create a favourable environment for the whole regional economy, including industrial system, but also agricultural sector thanks to the exploitation of biomasses.

Furthermore the activities of the EMA could coordinate different parts of the energy system, such as mobility and in the intermodal transport, the diffusion of “prosumers”, the improvement of energy efficiency in public and private buildings, the diffusion of the domestic storage (e.g. electric vehicles) and the engagement and involvement of citizens.

2.6 Other expected impacts

The definition of an integrated energy management policy that takes into account the requirements of electric mobility will have potential benefits on the whole transport sector, with an increased mobility efficiency. Not only private cars, but the public transport can be integrated.

Furthermore, other interventions could improve the sustainability in urban areas: improvement of the energy efficiency in public and private buildings, diffusion of the domestic storage (e.g. electric vehicles) and engagement and involvement of citizens.

3. ADDITIONAL REQUIREMENTS ON DEPLOYMENT

3.1 Governance and regulation

The successful deployment of an integrated approach to energy management through a VPP and EMA benefits from:

- A regulatory framework providing rules and commitments for energy producers and consumers to share their data, while respecting privacy and guaranteeing cyber security;
- Insight in energy demand services to stimulate their uptake by stakeholders;
- Evaluation of different approaches for guaranteeing cyber security and data privacy, as this is a key issue to enable private stakeholders to make sensitive information available and shared;
- Interoperability standards and protocols for technological solutions from different vendors, to reduce risk of system incompatibilities;
- Rigorous selection of the storage systems to integrate in the VPP, in order to ensure the right choice in each context and to facilitate replication of the approach elsewhere.

Strong involvement of the local government in the VPP deployment and establishment of the EMA is important to ensure full support from the local authorities for the implementation of the energy solutions proposed and implemented, as well as the proper legal framework. Particularly important is the installation of smart meters to monitor user real-time energy consumptions. Smart meters are the next generation of gas and electricity meters and they can offer a range of intelligent functions. For example they can tell you how much energy you are using through a display in your home. They can also communicate directly with your energy supplier meaning that no one will need to come and read your meter in future. Smart meters bring a wide range of benefits. For example: Smart meters give near real time information on energy use – expressed in money. You will be able to better manage your energy use, save money and reduce emissions. Smart meters will bring an end to estimated billing - you will only be billed for the energy you actually use, helping you budget better.

The use of smart metering represents one of the interventions on the distribution grid to improve the electricity service and it is complementary to the other ones, which will be considered in the VPP. They allow for measuring the savings achieved as a result of upgrading the efficiency, making it possible to evaluate fuel consumption and energy losses before the implementation of specific measures, during the implementation phase, and afterwards. This gives good insights into the size of the benefits, and when and how they were achieved.

The EMA is responsible for data collection and management, thus a proper legal framework must be developed to identify its organizational framework and remit. Furthermore, its effects on the market needs to be investigated, so as not to interfere with the energy market.

Regulation must also create a framework for providing new energy services to end-users. An example of such a service is the definition of customized tariffs. These tariffs can be defined on the basis of user energy needs, requiring that data need to be secure. Regulation needs to guarantee integrity, reliability and privacy of data collected. If regulation on these issues already exist, it will be updated and integrated to meet the new requirements, taking into account social impacts.

3.2 Stakeholders to involve

The main stakeholders that must be involved to introduce integrated energy management policy in a smart city or community are:

- Local Authorities, responsible for the creation of the EMA and for providing the legal framework that permits a secure data exchange between the involved actors;
- Energy producers, responsible for energy generation from RES and for data exchanging to identify the optimal production profile;
- Energy distribution and transmission operators, responsible for the grid which energy producers and storage systems are connected to;
- Storage systems manufacturers, responsible for the installation of the proper storage system solution identified;
- Telecommunication providers, responsible for the ICT network that enables data exchange between the actors;
- Electric mobility authorities, responsible for the definition of electric mobility and recharging stations requirements that have to be met by the distribution grid;
- Householders, that needs to actively participate to the energy consumption measurements and to the adoption of energy efficiency measures identified.

Communication to all stakeholders' categories is a major issue, and an integrated approach seems fit to create a good communication environment.

Stakeholder	Role/ how to be involved
Mayors, politicians	High-level support for the initiative and dissemination of the results, in order to support their application
City administration	Application of the measures and dissemination of the results, in order to apply them in the urban areas Providing financing for measures requiring partial or full public-sector financing.
Utilities, energy service companies, network operators (electric, thermal, sewage, etc.)	Obtaining data for the simulations and helping design the most suitable measures. Providing financing for technologies and measures with payback periods suitable for private-sector investment.
Developers, architects, planners	Helping design and coordinate the selected measures
Construction companies	Helping to implement the selected measures
Industries	Helping to design and implement the technologies and measures, as end-users, and by providing energy-saving technology Providing financing for technologies and measures with payback periods suitable for private-sector investment.
Component manufacturers (windows, facades, HVAC components, …)	Helping to implement the selected measures by providing and installing energy-saving technology
Renewable energy industry (PV, solar thermal, heat pumps, …)	Helping to implement the selected measures by providing and installing RES technology
ICT companies	Helping to implement the selected measures by providing and installing ICT components of the VPP and monitoring systems.
Financial Institutions	Providing financing for technologies and measures with payback periods suitable for private-sector investment.
R&D institutes and universities	Helping to identify, select and design suitable technologies and measures

Inhabitants (life-long horizon)	Helping to design and implement the technologies and measures, as end-users. Providing financing for technologies and measures with payback periods suitable for private-sector investment. Dissemination of the results, in order to improve the behaviour of other users

3.3 Supporting infrastructure required

The introduction of the innovation is easier if the generation plants are already connected to a ICT network supporting a fast and reliable data exchange with a remote control centre (that will become the EMA). Similarly, users should have a connection to the same control centre to communicate their consumption data.

3.4 Other specific needs

The successful deployment of an integrated approach to energy management through a VPP and EMA benefits from:

- A regulatory framework providing rules and commitments for energy producers and consumers to share their data, while respecting privacy and guaranteeing cyber security;
- Insight in energy demand services to stimulate their uptake by stakeholders;
- Evaluation of different approaches for guaranteeing cyber security and data privacy, as this is a key issue to enable private stakeholders to make sensitive information available and shared;
- Interoperability standards and protocols for technological solutions from different vendors, to reduce risk of system incompatibilities;
- Rigorous selection of the storage systems to integrate in the VPP, in order to ensure the right choice in each context and to facilitate replication of the approach elsewhere.

4. FINANCIAL MODELS AND POTENTIAL FUNDING SOURCES

The Finance Group of the Stakeholder Platform has prepared documents on funding models and the use of EU Funding instruments, either from the EU budget or from the European Investment Bank. The documents are freely downloadable from the Stakeholder Platform's website.

- For funding models please refer to the **"Financing models for Smart Cities"** guidance document.
- For EU supported funding instruments please refer to the guidance document on **"Using EU Funding mechanisms for Smart Cities"**.

This section presents specific recommendations for financing models and potential sources suitable for this KI.

4.1 Financing models suitable for the innovation

This KI is a highly complex endeavour with many independent but separate actions, each of which requires a different intervention. The costs are large and there is a need for finance with long-term repayment periods.

As revenue generating project, it does not necessarily need grant support, but not all parts of the project have the same revenue and risk profile. One of the main barriers is the lack of financial products and tested business models for such an investment. This project is thus also an experimental area for financial engineering. This KI needs tailored financial instruments from the financial sector which are often absent in member states. There is a need to develop models for such projects that can be introduced across the European Union (and beyond).

This project is overall bankable and under realisation with prospects for duplication. The financial mechanisms developed should be replicated. In addition to the financial mechanisms, key barriers are administrative and regulatory and these need also to be tackled. The implementation process of this KI and similar projects elsewhere need to be analysed and tailored technical assistance prepared for cities across Europe.

4.2 Specific sources of funding for the KI

No single source of project can handle such a large project. However, there is a need to provide finance by institutions like the EIB. Cities can also raise bonds, but public banks could offer guarantees for loans and bonds for such large projects.

The information in this KI will be further developed as the project advances.

Smart Cities Stakeholder Platform

…brings together people, industry and authorities from across Europe to make our cities more energy efficient, better to live in and growth-friendly.

…is about developing concrete innovative solutions for cities through tailored innovations.

…facilitates the exchange of knowledge and best solutions across smart cities in Europe.