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# Increase sustainability in buildings through Public Procurements: the PROLITE project for lighting retrofit in schools

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**Abstract**

The Public Procurement has always been a demand-side policy measure with great opportunities in terms of spurring innovation at the scale of products and/or services. A support for a sustainable development in the field of energy and buildings may came from different types of Public Procurement: Green Public Procurement (GPP), Sustainable Public Procurement (SPP) and Public Procurement of Innovation (PPI). Within this framework, the paper presents a case study where PPI has been used to promote the development of innovative solutions for upgrading school buildings in terms of increased energy efficiency and sustainability.

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*Keywords:* Lighting retrofit; Energy efficiency; Schools; Public Procurement; Performance specification

## 1. Introduction

The Public Procurement, that is "the process whereby public authorities – including all levels of government and public agencies – buy goods and services or commission work" [1], has always been a demand-side policy measure with great opportunities in terms of spurring innovation at the scale of products and/or services. In the past, government procurement programs have been the driver for projects that led to major innovations and technological developments such as the Internet, the Global Positioning System (GPS) or the semiconductors industry. Nowadays,

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the main goal of policy initiatives in this field is to determine a broader innovation impact, not limited to new technologies or products, but which includes the development of new market capabilities or the innovation in mature markets. Public procurement is more and more intended as horizontal policy measure, able to encourage market innovation, to involve small and medium-sized enterprises and oriented to promote the economic development. [2],[3].

The great potential of public procurement in boosting the innovative and sustainable development of products and services is related to the total government expenditure on works, goods and services that, in European Countries, is estimated as much as about 19% percent of the Gross Domestic Product (GDP) [1],[4].

In the last decade, several measures, at European or national level, have been adopted to link public procurement and political objectives like innovation and sustainability. From a regulatory point of view, it is worth to be mentioned the new European Directive on public procurement [5]- and consequent national legislation – which identifies a strong link between procurement and innovation, hence defining new procurement procedures such as the "Innovation Partnerships" [6].

A support for a sustainable development in the field of energy and buildings may came from different types of Public Procurement set out in the last decade: Green Public Procurement (GPP), Sustainable Public Procurement (SPP) and Public Procurement of Innovation (PPI). More recently, an upcoming debate is growing on the link between the circular economy and the procurement, and targeted national and local policies are growing around this issue.

Decarolis and Frey [7] defined the Green (or environmental) procurement as: "the purchase of products and services which have less impact on the environment and human health compared with competing products or services that serve the same purpose". The aim is to incorporate green performance among the goals of the procurement process, accounting for energy and material consumption, production of polluting or waste emissions, etc.. The goals of GPP are also included in the ones of Sustainable Public Procurement, which is defined as "a process whereby organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst minimizing damage to the environment" [8]. In addition to the environmental aspects, SPP entails paying attention to elements related to social aspects in order to foster societal well being.

A further available measure to increase the buildings' sustainability is the Public Procurement of Innovation. PPI occurs when public authorities act as a launch customer for innovative goods or service that are typically not yet available on a large-scale commercial basis [9]. The procurement of innovation is driven by the demand of public customers and targets the development of concrete solutions to meet these needs. PPI can provide an early 'reality check', helping suppliers to better anticipate demand for solutions and shorten the time to bring them to the market. Procurers can compare competing solutions and get the best price for an innovative solution that fit-for-purpose, avoiding unnecessary costs or suppliers lock-ins and taking into account longer-term public sector requirements. [10].

In the field of buildings sustainability, PPI can be used to introduce, in public buildings, innovative products, services or management approaches, which can both increase the building's energy efficiency and the overall users' well-being.

Several funding programs have been recently launched at European level to foster the adoption of GPP, SPP or PPI: in the period 2007-2013 the Competitiveness and Innovation program first piloted innovative PPI procedures. Now this policy is strongly supported within Horizon 2020, which co-fund the preparation and realization of PPI and Pre-Competitive Procurement (PCP) projects in several sectors (energy, security, ICT, etc.) [11]. PPI and PCP are intended as horizontal measures for the policies of open innovation and innovation for smart cities and they are being included in the policy agenda of many of the European Countries. In Italy, the Minister for the Economic Development has recently launched an initiative to support the development of smart cities, giving favor to PCP of digital solutions to respond to the urban challenges, including the energy one.

Within this framework, the paper presents a case study where PPI has been used to promote the development of innovative design solutions, for the upgrading of school buildings in the perspective of increased energy efficiency and sustainability. The case study is part of a European Project named "Procurement of Lighting Innovation and Technology in Europe" (PRO-LITE) [12], whose scope was to demonstrate how public sector authorities can

consolidate their procurement power to create economies of scale, procuring innovative products/technologies, while driving the European economies.

PRO-LITE focused on the procurement of innovative lighting technologies and solutions that will offer improved social, environmental and economic benefits. The aim is to use the lever of public demand to stimulate – through demand assessment and pre-procurement market sounding activities, as well as through the study and definition of ad hoc procurement documents and contract formulations – innovation in three main areas of the lighting sector: outdoor public lighting, indoor lighting, lighting of underground facilities. Among these domains, the project presented in this paper is the one developed by the Municipality of Turin, the partner of the project that decided to focus on the study and acquisition of innovative solutions for the indoor lighting of school buildings. Indoor lighting was considered a critical aspect because of the large dimension of the public building stock (more than 700 buildings, half of which schools), and of the high expenditure for electric lighting. Furthermore, the choice of school buildings is also grounded on the potential it has in terms of replicability and educational value.

## 2. The PRO-LITE project for lighting retrofit in school buildings in Turin

The working group that carried out the project for the procurement of innovative solutions for lighting in school buildings in Turin was composed by several Departments of the Municipality, IREN Servizi e Innovazione, that is the service provider of the City and contracting authority of the tender, the Energy Department of the Politecnico of Torino and the Management Department of the University of Torino. Politecnico of Torino and University of Torino were involved, the first one, to support the definition of lighting requirements and the second one for the legal advice during the definition of the procurement strategy.

The process for the public procurement was organized in different phases:

- Pre-procurement actions
- Demand-side analysis
- Design workshop and open-day
- Definition of the tender specifications
- Launch of the tender.

The European project was an opportunity to promote an investigation into the perceived needs expressed by the school communities inside three building complexes already been assigned of high priority levels in the lists of extraordinary maintenance tasks to be managed by IREN, representing also a good sample (different building ages, locations and plant characteristics) and thus providing scope for wider replicability of solutions in the future. At the end of pre-procurement phase (described in the following section) it was decided to launch the procurement only on two of the analysed schools for budget constraint linked to the will to find integrated solutions affecting all comfort variables for the final user, not just the replacement of existing lighting technologies. The defined object of the tender was: “Integrated contract for the final and executive project design and extraordinary maintenance works of 2 school buildings” (Dal Piaz Primary School, and ex-Meucci Middle School, both in Turin). Fig. 1-2.

Fig. 1. - Dal Piaz primary school.

Fig. 2. – ex-Meucci middle school.

### 2.1. Pre-procurement action

On February 2014 the Municipality of Turin published the Prior Information Notice of the future tender. In order to spread as possible the news, the City organized an event in March, in collaboration with the Chamber of Commerce of Turin, inviting all the market operators potentially interested in receiving additional information on the buildings that were object of the tender and participating to the early market activities planned for the next months.

Soon afterwards, the partnership produced a "Common Prospectus" outlining common strategic objectives and detailed description for each pilot and an online submission form set up to gather information from suppliers.

As a result 30 submission, in the field of indoor lighting, were gathered, from different European Countries (Italy, Great Britain, Finland, Norway, Switzerland), and also from USA and China.

### 2.2. The demand-side analysis

To develop the analysis of the demand-side requirements, the City of Turin, together with ITER (Educational Institution of the City of Torino), adopted an innovative approach whereby technical analysis activities were carried out in parallel with a user involvement program. The aim was twofold: build up an exhaustive picture of current conditions with the contribution of students, teachers, school officers and administrative personnel; use the opportunity offered by the European project to develop educational contents, which, through practical work, might help enhance the awareness of the school community with respect to the key theme of energy saving.

The analysis carried out in this phase can be summarized as follow:

- Analysis of the functional distribution and conditions of artificial and natural lighting as determined from the building plans and by simulating actual lighting conditions as a function if the orientation and intended use of the different rooms: classrooms, laboratories, circulation areas, offices, teacher rooms, lavatories, canteen, gym, storage rooms, utility rooms.
- Definition of an Audit model and selection of ad hoc indicators to monitor real and perceived environmental quality. The proposed Audit model is integrated, i.e., it encompasses all the factors that determine environmental comfort (light, indoor air temperature, noise, colors) and all the ergonomic factors (organization of space, functions and design).
- Development of a technical analysis, focused on the lighting systems (type of lighting systems, measurements of maintained illuminance, scheduled maintenance, etc.)
- Involvement of the users to evaluate the perceived environmental comfort. Teachers, administrative staff, etc. were interviewed by means of participatory techniques: questionnaires, discussions, direct experimental experiences.

The overall description of the demand-side analysis and the obtained results can be consulted online [13]. As an example, the results obtained from the survey on the lighting conditions and lighting systems use are presented in Fig. 3.

The results of this analysis has become a key element for the identification of the innovation needs and the following project activities.

**1) How do you rate the level of daylighting perceived in the classroom ?**

| | Teachers | | Students | |
|---|---|---|---|---|
| | dal Piaz | ex-Meucci | dal Piaz | ex-Meucci |
| Good | 32% | 27% | 51% | 33% |
| Sufficient | 46% | 40% | 46% | 53% |
| Insufficient | 21% | 33% | 3% | 14% |

**2) How do you rate the level of artificial light perceived in the classroom?**

| | Teachers | | Students | |
|---|---|---|---|---|
| | dal Piaz | ex-Meucci | dal Piaz | ex-Meucci |
| Good | 64% | 27% | 50% | 33% |
| Sufficient | 29% | 40% | 47% | 53% |
| Insufficient | 7% | 33% | 3% | 14% |

**3) In your opinion how many hours is artificial light switched on in a classroom on a typical day?**

| | Teachers | | Students | |
|---|---|---|---|---|
| | dal Piaz | ex-Meucci | dal Piaz | ex-Meucci |
| Up to 1 hour | 0% | 0% | 3% | 1% |
| 2 to 3 hours | 11% | 53% | 8% | 13% |
| 4 to 5 hours | 59% | 14% | 19% | 63% |
| 6 to 8 hours | 30% | 33% | 70% | 23% |

**4) Are glare phenomena observed during classroom activities?**

| | Teachers | | Students | |
|---|---|---|---|---|
| | dal Piaz | ex-Meucci | dal Piaz | ex-Meucci |
| Never | 25% | 60% | 25% | 35% |
| At times | 61% | 20% | 55% | 53% |
| Often | 7% | 13% | 17% | 8% |
| All the time | 7% | 7% | 3% | 4% |

**5) In your opinion are the following factors important to comfort and can they help improve the quality of classroom activities?**

| | Teachers | | Students | |
|---|---|---|---|---|
| | YES | NO | YES | NO |
| Colour | 81% | 19% | 70% | 30% |
| Light control | 94% | 6% | 60% | 40% |
| WI-FI | 92% | 8% | - | - |
| Furniture arrangment | 59% | 41% | 42% | 58% |

**Characteristics of the lighting systems**

| | DAL PIAZ | EX-MEUCCI |
|---|---|---|
| LAMPS | fluorescent 38 mm | fluorescent 38 mm |
| LUMINAIRES | prismatic diffuser | prismatic diff. / mirror louvre |
| CONTROLS | manual on/off | manual on/off |
| PERFORMANCES | barely sufficient | barely sufficient |

**Energy consumption [kWh]**

| | DAL PIAZ | | EX-MEUCCI | |
|---|---|---|---|---|
| Year | 2011 | 2012 | 2011 | 2012 |
| Jenuary | 5318 | 6128 | 2640 | 2882 |
| February | 5887 | 5839 | 2569 | 2814 |
| March | 5488 | 5299 | 2596 | 2672 |
| April | 7872 | 4366 | 1650 | 2090 |
| May | 3719 | 3936 | 1584 | 1741 |
| June | 2689 | 2612 | 898 | 1021 |
| July | 2160 | 1760 | 557 | 623 |
| August | 1899 | 1770 | 453 | 519 |
| September | 3143 | 3243 | 1355 | 2014 |
| October | 4629 | 5880 | 2068 | 4355 |
| November | 5635 | 5870 | 2576 | 2371 |
| December | 5615 | 5990 | 2366 | 2393 |
| Annual | 54054 | 52693 | 21312 | 25495 |

Fig. 3. – Results of the demand-side analysis.

### *2.3. The design workshop and open day*

The third phase of the project was dedicated to a 'Design Workshop' organized in collaboration with Turin Foundation of the Order of Architects. This working seminar was aimed to co-develop innovative and integrated solutions for the refurbishment of lighting systems in the selected school buildings. Conceived as a "project atelier" lasting about 2 weeks the workshop involved up to 30 volunteered professionals subdivided into 3 groups, led by a tutor and supported by a group of local technical expert. In order to best carry out innovative solution also interested

enterprises were invited to take part to the workshop as technical observers to be involved during the working group sessions. Eleven enterprises sent their application and provided information on their own innovative solutions.

Some examples of the results obtained from the workshop are shown in Fig. 4.

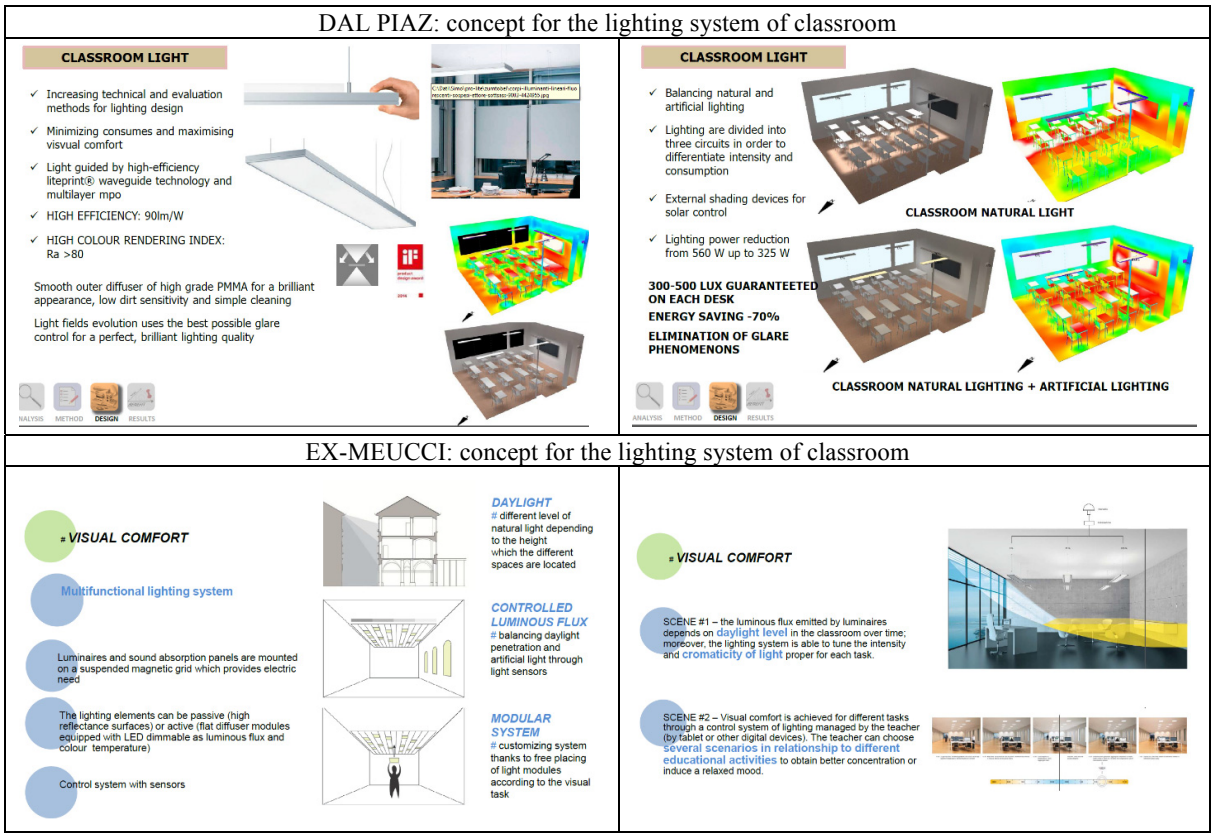


Fig. 4. – Examples of design solutions for the new lighting system arisen from the design workshop.

The closing activity of the Early Market Engagement was the Market Engagement Event, organized by the City of Torino and Iren (the open day). The focus was on integrated solutions - including lighting appliances, ICT supporting devices - as well as other complementary elements - able to improve the overall lighting efficiency and comfort conditions in the school environment. Participation was open to any market operators able to present innovative products/services/systems connected to the project focus and that wished to dialogue with the local technical staff. Twenty-four companies (including two suppliers form outside Italy) participated to one to one meeting, with a slot of 20 minutes to present their solution, including its performances and estimated costs.

The whole data and information acquired during the preliminary phases of the project were used as basis for the definition of the tender specification.

### *2.4. The tender specification*

Subject matters of the tender were the final design, supply and works for the lighting system, lighting control and finishing of the aforementioned two school buildings (Dal Piaz and ex-Meucci). Two types of items were expected, the mandatory ones: electrical systems, special systems, light fixtures system, monitoring and control systems, integrated color scheme and measures to reduce noise discomfort in certain rooms. Bidders had to offer further improvements too, considered as automatic re-investments of discounts, within these domains:

- Wi-Fi systems for teaching and administrative activities;
- Additional functions for the control and monitoring system, such as heating and ventilation system control functions, or sensors for the detection of indoor environmental conditions;
- Shading devices to control daylight penetration and solar radiation;
- Control of acoustic discomfort and reduction systems in other rooms;
- Furnishing solutions and/or new concepts making for enhanced visual comfort and a more efficient use of space
- Systems for routing the light in the rooms, to improve the levels of indoor comfort and energy saving, by making optimal use of daylight.

No technological pre-choice were made. In addition to a set of more traditional technical specifications for standard system, performance based specifications were designed for the different "components" of the thought innovative solutions and collected in a separate volume of tender documents.

Contrary to prescriptive specification, which details the design characteristics, the materials that must be used and to a certain extend the methods or procedures to achieve the end result, the performance specification states requirements in terms of required results with criteria for verifying compliance, but with no accompanying restrictions on material, or component solutions proposed by contractors. Prescriptive specification gives the client more certainty about the end product, but can also limit the contractor innovativeness, while performance specification gives contractor and suppliers more scope to innovate and adopt cost effective methods of work.

The performance-based specification includes requirements related to:

- Technical innovation;
- Environmental performance;
- Energy consumption;
- Ease of use,
- Maintenance costs;
- Integration and interoperability with other building's systems and functions.

Specification was divided in sections, which were referred to each item object of the tender. Each designed system (lighting system, lighting controls and finishing) should respond to a set of requirements, which were organized in different fields: environmental requirements, energy performance requirements, ease of use and maintenance requirements. Fig. 5 shows an example of the performance specification structure.

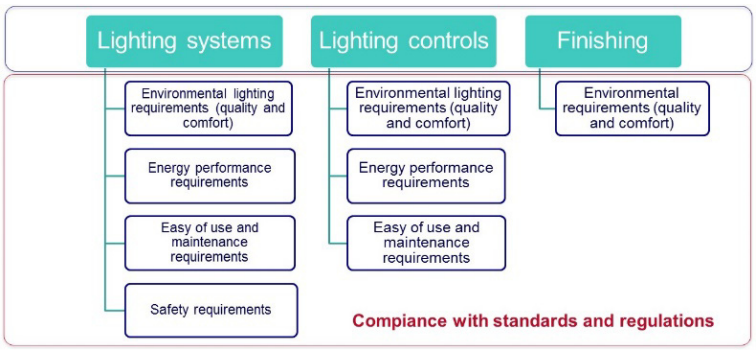


Fig. 5. Fields of requirements for the main systems/objects of the tender

For each field of requirements several quantitative and qualitative performance indicators were included in the specification and, when possible, two levels of requirements were formulated: "basic" performance requirements and "awarding" performance requirements. The first should entail a "sufficient" environmental quality, energy efficiency and systems operation, and correspond to Standards prescriptions, the latter correspond to an awarding

required level, specified for the improvement of the performance and therefore associated, in the evaluation phase of the tender to higher evaluation scores.

The environmental requirements have been defined around the main user's needs, which, in terms of lighting environment, are referred to visual performance, visual comfort, safety and well being. Requirements were expressed for: average maintained illuminance and illuminance uniformity, luminance distribution, glare, modeling, light chromaticity, color rendering index, flickering and photo biological risk. For illuminance distribution and color rendering index both "basic" and "awarding" requirements were defined. The required performance level are mainly drawn from the European Standard EN 12464-1/2011 on lighting for indoor workplaces [14].

The environmental requirements were not only referred to the lighting performances, but embraced a larger "environmental" comfort performance concept (e.g. reduction of $CO_2$ emissions; reduction of energy use; classrooms acoustics; quality of air; thermal conditions, etc.).

In the specification, great emphasis was given to the energy performance requirements, as innovation in the lighting field is nowadays strictly connected to the reduction of energy consumption and in general to the control of the systems operational costs. Within this field, performance indicators were included for each component of the lighting system: lamps, luminaire and ballasts. Requirements were concerned with the energy efficiency class of lamps and ballasts and the efficiency of luminaires. For these indicators both "basic" and "awarding" requirements were given.

For the maintenance costs of the lighting system minimum levels of lamps' lifetime, lumen maintenance, survival after switching cycles, start time and run-up time were required. Most of the indicators and performance values for the requirements related to the lighting systems components are in agreement with the ones defined in the European and National Directives on energy-related products and in the European and National documents for Public Procurements of LED lighting. [15][16][17].

A further indicator included in the specification to assess the energy performance of the overall lighting system and controls solution is the energy demand for lighting. The parameter used is the LENI (Lighting Energy Numeric Indicator) as defined in the European Standard EN 15193/2008 [18]. The use of this parameter for the procurement of buildings' lighting system is quite new, as only recently the LENI has become part of the calculation approach to evaluate the overall energy performance of buildings in accordance with the EPBD Directive. To simplify the estimation of the parameter, which depends on both building's feature and lighting system characteristics, the calculation procedure was explained in the specification document, and a number of required parameters (the one related to the building's features) were pre-calculated and provided. LENI requirements were defined for classrooms (base and awarding requirements equal to 13 $kWh/m^2y$ and 8 $kWh/m^2y$ respectively) and corridors (base and awarding requirements equal to 6 $kWh/m^2y$ and 4 $kWh/m^2y$ respectively).

Further qualitative requirements were specified for the lighting control system and for the finishing solutions and, in general, a great importance was given to level of integration of the proposed solution (integration with the building and among the different items object of the procurement).

## 3. Tender's launch and results

The tender was launched by Iren on the 5th of August 2014. Object of the open procedure was: final design and extraordinary maintenance work for innovative and integrated solutions in 2 school buildings owned by the City of Torino. The MEAT (Most Economically Advantageous Tender) criteria for the evaluation was chosen, with 45% weight for the technical part and 55% for the economic one. The technical criteria was divided in:

- quality of the technical solution proposed for core works, to be evaluated through quantity indicators: lighting quality – energy sustainability – functionality and management characteristics of the different technology solutions and namely lighting appliances; ICT; finishing;
- quality of the technical solution proposed for the additional works with ad hoc quantity indicators;
- integration level of the innovative solution proposed to be evaluated by "Energy Need" reduction (through LENI indicator), the quality of the proposal in terms of comfort of the integrated solution and by the aesthetic – formal coherence of the proposed solutions.

Only one lot has been awarded, because of lack of minimum requirements of the bid presented for the Dal Piaz School. For the Dal Piaz School a further negotiated procedure has been later implemented. Only one competitor has answered to the invitation, and the second lot has been awarded. At present, the awarding companies are working inside the schools to implement the proposed solutions. The tender procedure enabled innovation by:

- using performance based specifications - not prescribing the final solution or technology to be deployed but binding minimum performances (prescribed by National Regulations and/or International Technical Norms)
- leaving the bidders the possibility to provide the final design;
- opting not for supply of solutions but for the concept and realization of fully integrated solutions within the building context;
- needing multi-sectoral expertise, enabling cross fertilization among different professionals/business areas.

## 4. Discussion

The PRO-LITE project has been a great opportunity to test PPI procedure inside a public entity, allowing to recognize the main barriers, to design the possible solutions and to define some important lessons learnt for future applications. One of the basic idea of PPI is to work on procurement needs at an early stage in the view to improve the innovation demand analysis – through a deep involvement of final users and the interactive dialogue with the market to identify the innovation potential. Open innovation methodologies have been tested in the current projects putting together all the relevant internal and external key actors to define the innovation demand as well as to identify the market capacity to respond to it at the pre-procurement phase. All this influenced the drafting of procurement documents which do not necessarily prescribe solutions but – being most preferably expressed in functional terms - allow the market to propose innovations (technological or not, even organizational or including integration) for the expressed challenges.In terms of lessons learnt, first is it important to underline the relevance of pre-procurement phase to plan and implement PPI;

- open approaches should be used to gather needs and intelligence from outside (users, building managers, market operators and designers);
- the supply chain must be studied and mapped to best plan market engagement activities;
- a constant communication channel with market operators must be created until the launch of the tender in order to best understand and trigger the innovation potential in the thought sector;
- the procurement strategy is then to be designed accordingly, also taking into consideration since the beginning the possible deployment of innovative contractual strategy such as in the construction field energy performance contracting models.

Regarding the procurement implementation phase, it is useful to stress the following aspects:

- performance based specifications and a coherent evaluation set based on objective and measurable criteria developed in accordance are necessary to attain the innovation thought
- to simplify internal approval and publication procedures, and to simplify procurement documents is a key element to keep an high interest of the market on the tender.

In the last phase of the procedure, that includes evaluation, contracting and operation, it could be difficult to assure a complete alignment between the quality/innovation/integration of the solution offered and the real performances of the new solutions. For this reason, it is useful to implement monitoring activities to verify real performance and also to consider the possibility to deploy innovative contractual models based on energy performance. In addition to this, it is important to stress that the involvement of the final user in the operation phase is not foregone, so it is important to define a way to include within the procurement an educational programmer as an accompanying tool for a renovation project.

More in general, PPI has proved to be an impactful demand side tool to deliver innovation at the benefit of local authorities, its territories and citizen. However, to get most advantages from this tool, there is a need to make a step forward from testing to impact. This means that there is a need to define targeted policies and practices to systematize the strategic use of public procurement, for instance:

- aligning strategic planning with procurement programming,
- work with the market at an early stage on impactful procurements, hence federating demand at territorial level,
- not take a unique receipt but work on BUSINESS CASE to find the right procurement and/or contractual model,
- provide scope for replicability and systematization: organizational models, training and dissemination.

All this has also to be re-interpreted in the context of the regulatory changes related to the Procurement Directives exploring the new possibilities for leveraging innovation through public demand.

## 5. Conclusions

The paper presents the approach that was adopted for the public procurement of innovative technologies and solutions for the retrofit of indoor lighting in school buildings. The conceived approach, based on pre-procurement actions (demand side-analysis and the design workshop and open day), and on the use of a performance based specification, was aimed at increasing the indoor and energy performance, while enhancing the social, environmental and economic benefit.

In conclusion, the whole procedure, starting from the demand side analysis, allowed to obtain a fully integrated concepts for improved energy efficiency of lighting appliances and overall comfort at the benefit of final users. Although at the beginning, the project was only focused on lighting solutions; all users' comfort variables were faced allowing to obtain a new intervention model for lighting retrofit with impact on the overall building user experience, which will be widely replicable for other Administrations. To this scope an evaluation on impacts and effects on the 2 procurement procedures will be finalized in order to identify the business case for replication with a focus both on economic gains and on comfort advantages of the proposed innovative mix.

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