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EU Support for Innovation and Market Uptake in Smart Buildings under the Horizon 2020 Framework Programme

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Abstract: At the end of November 2016, the European Commission tabled the Clean Energy for All Europeans package, which represents a large set of proposals for several key directives related to energy. The package included proposed revisions to the Energy Performance of Buildings Directive (EPBD) which seek to update and streamline the Directive in several areas, including provisions to ensure buildings operate efficiently by encouraging the uptake of Information and Communication Technologies (ICT) and smart technologies. Although it can be argued that there is at present no commonly accepted definition of a "smart building", the Commission's proposed revision refers to three key features of a possible indicator of "smartness" in buildings: the technological readiness of a building to (1) interact with its occupants; (2) to interact with the grid; and (3) to manage itself efficiently. Using these three pillars of "smartness" as a methodological starting point, this paper identifies and analyses recent and ongoing Horizon 2020 research, innovation and market uptake projects which are investigating "smart buildings". The research maps and examines the tasks, scope and innovations in areas that include building automation and control systems, demand response, energy management, ICT and user interfaces for energy efficiency.

Keywords: smart buildings; energy efficiency; EPBD; Horizon 2020; demand response; building energy management; BEMS

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1. Introduction: Purpose of the Research

This paper seeks to answer the following question: "How is Europe's Horizon 2020 framework programme supporting research, innovation and market uptake of smart buildings?" This apparently straightforward question is in fact relatively difficult to answer, partly because the term "smart buildings" is a frequently used but ill-defined [1] term that cuts across several themes including ICT (Information and Communication Technologies), energy efficiency, renewable energy technologies, design and construction techniques, and the dynamic interaction of a building with its occupants. A simple answer to the question might be to express the amount of grant funding allocated to projects working on smart buildings, or to count the overall number of projects supported. However, statistics such as these would in practice be relatively difficult to obtain, for several reasons. First, it would require projects across Horizon 2020 to apply a common and precisely defined understanding of the term "smart building", with the added complication that in this context we are only concerned with energy efficiency-related smartness. Second, it would depend on databases of projects being searchable using this commonly agreed indicator. The third reason why statistics would not be easy to come by is that one aspect of a smart building might be investigated in a particular task or work package within a larger project, which might not identify itself (for the purposes of a database search) as a "smart buildings" project. The research problem to be tackled in this paper is therefore to define the "smart building", to search for and find projects that match this definition across the Horizon 2020 programme, and to analyse those results in a mapping exercise.

The overall purpose of this research is to generate new data that will be useful for both researchers and policymakers. Horizon 2020 projects can sometimes be large and complex, and it can be difficult for persons outside of the project consortium itself to appreciate the precise scope of work and the nature of individual tasks, from publicly available information such as abstracts. This is especially the case when projects are ongoing and results are yet to be published. Potentially useful data such as lists of deliverables and detailed breakdowns of tasks are not normally publicly available. Because of this, it can be difficult to establish the scale and extent of research efforts being made across the programme on any particular subject, beyond relatively simplistic estimations. Therefore in order to discern the extent of research and funding efforts in smart buildings it is necessary to generate new data, analyse it and place it in the public domain. This kind of mapping should offer a more precise picture, enabling better understanding of the status quo, more effective prioritisation of future research needs, and potentially help align EU funded research and innovation with national and private sector efforts.

2. Policy Context

The European Union (EU) has long pursued strategies to improve the energy performance of buildings, and these have been steadily increasing in ambition and scope. The Energy Performance of Buildings Directive (EPBD) [2] was published in 2002 and followed earlier EU legislation in the previous decade on energy efficiency measures in buildings [3] and their technical systems [4]. In March 2007, EU Heads of State and Government agreed on Europe's 2020 Strategy for smart, sustainable and inclusive growth [5]. This strategy set EU-wide targets on greenhouse gas emissions (a reduction of at least 20% by 2020, from a 1990 baseline), energy efficiency (savings of 20% by 2020, expressed in absolute) and uptake of renewable energy (achievement of a 20% share of renewable energy in EU energy consumption by 2020). In the same year, the European Commission also published the Strategic Energy Technology (SET) Plan [6] which aimed to coordinate EU, national and private funding efforts in technology research and development in order to accelerate the EU's transformation to a low-carbon energy system [7]. In this context, the European Commission proposed in 2008 a recast of the EPBD which was adopted by the European Parliament and Council in May 2010 [8]. The European Commission stepped up its efforts in January [9] and July [10] 2014 by proposing more ambitious energy efficiency targets by 2030, which were adopted by the European Council in October of that year [11]: a 40% reduction in greenhouse gas emissions from the 1990 baseline, a 27% share of renewable energy consumption, and a 27% improvement in energy efficiency, which would be reviewed by 2020 having in mind an EU level of 30%. In February 2015, the Commission adopted the Communication on the European Energy Union [12] which highlights energy efficiency, especially in buildings, as well as research and innovation as key "dimensions" that would drive Europe through an energy transition leading to greater energy security, sustainability and competitiveness [12].

More recently, in November 2016 the European Commission published a large package of legislative proposals under the umbrella title "Clean Energy for all Europeans" [13]. Taken together, the proposals would adapt several directives relating to energy efficiency, energy security, renewable energy, electricity market design, and energy governance. Among the Directives put forward for review was the EPBD, with proposals to encourage the use of ICT and smart technologies to ensure that buildings operate as efficiently as possible [14]. For the first time, European legislation was being squarely aimed at encouraging the uptake of "smart buildings". Specifically, the EPBD proposal opened the possibility of using building automation and control systems as an alternative to physical inspections of technical buildings systems [14]. It also sought to facilitate the uptake of electric vehicles by ensuring that buildings would be ready to connect with them [14] and it introduced an indicator that would assess the degree to which a building can be deemed 'smart' [14]. This 'Smart Readiness Indicator' would enable assessment of the "technological readiness" of buildings to manage their own energy performance, to interact with users and with the wider grid [14].

3. The Horizon 2020 Programme and Buildings' Energy Performance

In parallel with policy developments, the European Commission has over a number of years supported research, innovation and market uptake projects that help Europe use energy more sustainably [6]. The current Horizon 2020 framework programme (2014–2020) [15] brings together research and innovation in an effort to ensure that scientific and technological breakthroughs lead to innovative products and services that tackle "the urgent challenges society faces" [15]. These "Societal Challenges" sit alongside "Industrial Leadership" and "Excellent Science" as the three overarching priorities of Horizon 2020 [15]. First, the "Excellent Science" priority includes support to scientists via the European Research Council; funding for specific "Future and Emerging Technologies"; and provisions for researchers to develop their careers through the Marie Skłodowska-Curie actions [15]. Secondly, the "Industrial Leadership" priority aims to "build leadership" in specific "enabling and industrial technologies" as well as providing support for innovation in SME's and facilitating access to risk finance [15]. Thirdly, the policy priorities of the Europe 2020 strategy [16] are reflected in a challenge-based approach to bring research results to the market according to "Societal Challenges", one of which is "Secure, clean and efficient energy" [16]. This particular Societal Challenge aims to "support the transition to a reliable, sustainable and competitive energy system" [17]. In the Work Programme this has been expressed in three priority "focus areas" for research, innovation and market uptake, namely "Energy Efficiency", "Competitive Low-Carbon Energy" and "Smart Cities and Communities" [18]. Calls for proposals to receive funding are described in the work programme, and each call contains a number of specific topics [18]. Work Programmes for the Societal Challenge "Secure, Clean and Efficient Energy" have been published for two-year periods, hence there is a Work Programme for 2014–2015 [18] and a separate Work Programme for 2016–2017 [19].

In practice, support is mobilised via several different types of funding schemes (grants for research and innovation; training and mobility; co-funding including public-private partnerships; grants to public procurement of innovation; support grants; debt finance and equity investments; prizes; and procurement) [20]. The specific programme [21] for implementation of Horizon 2020 was approved by the Council in 2013. The Horizon 2020 programme has now reached its halfway point and the European Commission published an interim evaluation of its results at the end of May 2017 [22]. This research paper therefore comes at an opportune time, although it does not form part of the Horizon 2020 Interim Evaluation, and the timing of this research was not influenced by the evaluation.

One particular development that coincided with the Horizon 2020 programme was the launch of the contractual Public-Private Partnerships for research (cPPP) in December 2013 [23]. These partnerships aim to leverage private funds alongside EU grant funding [23] and are based on roadmaps that were developed together with industry stakeholders in an open consultation process [23]. In total there are ten Public Private Partnerships [24], including the Energy-efficient Buildings Public Private Partnership (EeB PPP) which under Horizon 2020 continues activities that it began in 2009 [23]. In 2010, the European Commission, through the EeB PPP, published a multi-annual roadmap and strategy for the years 2011–2013 [25] and it followed this up in 2013 with an updated roadmap for the years 2014–2020 [26].

4. Methodology

One advantage of having a single research and innovation programme for Europe is that this also offers the possibility to search and compare projects across all thematic priority areas in a single database. For smart buildings this is an important point, since the subject could be expected to involve projects funded under a variety of topics and types of action. The principal publicly accessible source of data on Horizon 2020 projects is the CORDIS database (Community Research and Development Information Service) [27]. It contains data on signed grants and beneficiaries, abstracts, and certain publishable reports produced by projects [27]. For individual projects, data is given on the names and addresses of the coordinator's organisation and any other project partners, and the EU funds they have received, the call topic, and the start and end dates [27]. CORDIS enables searches to be carried out using keywords or free text, or by searching for project acronyms and reference numbers, or by topic, by type of action, or by a number of other criteria [27]. It can also find projects that were funded under the same call for proposals as those found in an initial set of search results [27]. For staff of the European Commission there is also a closed internal database called CORDA (COmmon Research DAtawarehouse), which is the European Framework Programmes' central repository of data [28]. CORDA contains data concerning signed grants and beneficiaries and enables the preparation of statistical overview data with a degree of sorting according to filters such as thematic priorities, activities and countries [28].

In order to search effectively for projects, or for tasks within projects that are relevant to the development of smart buildings, one first needs to define what is understood by the term "smart building". Arguably, there is at present no single commonly accepted definition of this term [1]. Various interpretations exist, including the term "Intelligent Building", which itself can be understood differently in different contexts [1]. In its proposals for a revision of the EPBD [14], the European Commission refers to three key features of a possible indicator of "smartness" in buildings: the technological readiness of a building to (1) manage itself efficiently; (2) interact with its users; and (3) interact with the wider energy environment. For the purposes of this research, these three features are taken as a methodological starting point. Within these three features, further refinement and sub-division is necessary in order to form a practical basis for a comparative search and mapping exercise. A total of 16 features of energy-related smartness in buildings have therefore been set out and explained here below.

4.1. Features of Energy-Related Smartness in Buildings

4.1.1. The Building's Ability to Interact with Its Users

- Full automation—the automatic centralised control of a building's energy-consuming technical building systems.
- User interface—the interface by which the user can view, understand and control the building's energy consumption. This can be located either within the building or it can be remote (e.g., a hand-held device).
- Control of entire building—the ability to control all of the energy-consuming systems and appliances in the entire building, including systems that might exert an influence over the building's energy consumption such as motorised windows and shading devices.
- Control of individual appliances—the user's ability to control individual energy-consuming appliances within the building, other than via the appliance itself.
- Implicit Demand Response—the ability of consumers to be "exposed to time-varying electricity prices or time-varying network tariffs (or both) that partly reflect the value or cost of electricity and/or transportation in different time periods and react to those price differences depending on their own possibilities" [29].

4.1.2. The Building's Ability to Manage Its Own Energy Consumption

- On-site storage—the storage of energy within a building's plot boundary.
- Heating and cooling—the management of a building's heating and cooling systems.
- Lighting—the management of a building's lighting systems.
- Domestic Hot Water—the management of a building's domestic hot water systems.
- Domestic appliances—the management of energy-consuming appliances situated within the building.
- Self-learning and Artificial Intelligence—the ability of a building energy management system to apply decisions that influence the building's energy consumption without being explicitly programmed to do so.

- Optimization—the building energy management system's ability to optimally balance the building's energy loads including for generation, storage or consumption.

4.1.3. The Building's Ability to Interact with the Wider Energy Environment

- Interoperability and communication—the ability of different technical building systems and appliances to share data and work together.
- Electro-mobility and smart charging—the interaction on-site electric vehicles with the building's energy system.
- Data privacy and protection—measures to ensure secure storage, management and use of data that is generated or used by technical building systems and appliances.
- Explicit Demand Response—"the control of aggregated changes in load traded in electricity markets, providing a comparable resource to generation, and receiving comparable prices" [30].

In reality, although the 16 features are grouped under three principal headings, the divisions between them may not always be clear-cut and a degree of overlap can be expected. For example, self-learning or Artificial Intelligence could be expected to apply to a building's interaction with its users just as much as to the building's ability to manage itself. Nevertheless, for reasons of practicality these 16 features are felt to be the most appropriate to map the tasks that Horizon 2020 projects might be carrying out. The mapping exercise has therefore taken the form of manual searches, primarily using the CORDIS public database [27], for projects that are carrying out research, innovation and market uptake activities according to this list of 16 features that are relevant to smart buildings. The result has been a table matrix (Appendix A) which identifies the projects and their respective tasks corresponding to each of the 16 features. A simple list of the projects that were found to be relevant is also presented in Appendix B.

Three overarching criteria have also been applied to filter out irrelevant search results:

1. Projects must be funded under the Horizon 2020 programme. This is to exclude other programmes such as FP7 which also appear in CORDIS [30]. Although similar work may be ongoing under those programmes, this research covers the Horizon 2020 programme only.
2. Project tasks must relate to the building level. This excludes, for example, tasks which relate to smart power grids at the district or city level but which are not directly related to the ways in which they might interact with buildings.
3. Project tasks must relate to the sustainable use of energy in buildings. For example, some projects might include tasks relating to the Internet of Things and connected devices, but these would only be included in the study if those devices were energy-consuming appliances or technical systems that related to the building's energy use.

In addition to manual searches, some cross-referencing has been carried out. First, the outputs of the Horizon 2020 project EEBERS have been analysed [31], specifically the "Energy Efficient Buildings Projects Map" which aims to identify synergies between ICT related research and development in energy efficient buildings [32]. Secondly, it has been possible to take advantage of unpublished research work by EASME staff members who had used the CORDA database to identify, for internal purposes, energy-related projects funded under the Horizon 2020 SME Instrument. These are typically two-stage projects where the first stage is a short study that might lead, depending on success with the second stage application, to a more detailed phase of real innovation activity. Many SME Instrument Phase I projects never go further than the first stage feasibility study. For this reason, only Phase II projects from the SME Instrument have been included in this research.

5. Searching and Mapping of Projects: Results

The database searches were carried out on several occasions during April and early May 2017, and included all Horizon 2020 actions that were either ongoing or completed by that date, since the start of the programme in 2014. Within the CORDIS database, the "Advanced Search" facility was used, which includes an ability to look for "Projects only" and exclude other potential results such as individual reports, news items and events [30]. Filters were applied to restrict the "Programme" to Horizon 2020 only [30]. Search terms were inserted into the "Search Terms" box and all other filters were kept open in order to avoid unwittingly restricting the results. The actual search terms used were "Smart Buildings", "Building Energy Management", "Energy Storage", "Demand Response", and "Optimization". Following these searches, further searches were deemed unnecessary as the results did not return any projects that had not already appeared. In addition to manual searches, CORDIS enables identification of all projects funded under the same Call as a single search result—hence, which also facilitates manual cross-referencing [30]. This final act of cross-referencing was carried out in early July 2017 and resulted in modification of the results: two projects that had been funded under Smart Cities and Communities calls, which had been missed, were added.

The initial results produced a list of 65 Horizon 2020 projects, funded across a variety of thematic priorities, which might be carrying out relevant tasks based on the limited project information that is available from CORDIS [30]. In order to verify and refine these results it was also necessary to analyse the individual project tasks, which required a level of information that is not available using CORDIS alone. CORDIS is a useful tool to gain a broad overview including project abstracts, overall budgets and publishable summary reports, but it does not at present allow detailed scrutiny of work plans down to the level of specific tasks and deliverables [30]. The project websites were also analysed where these were available, but although they usually contain greater detail than the CORDIS entries, in most cases they still contain insufficiently detailed information for such an exercise. In any case, Horizon 2020 project websites are rarely online from the very beginning of a project, therefore actions which have only recently been funded can appear in CORDIS without yet having a project website in place. It was therefore necessary to identify and contact the individual European Commission staff members who were responsible for overseeing each project, and to make use of their in-depth knowledge to identify relevant project tasks. This was made possible by the European Commission's internal project management tools. In many cases, the project coordinators were also contacted after having obtained the permission of the relevant officer. Where the relevant officer or coordinator was unavailable, a detailed analysis of project tasks was carried out against the criteria set out in Section 3 above, using the Commission's internal tools which also offer full access to project documentation. As a result of this exercise, the initial list of 65 projects was refined and about one third were excluded as being out of scope.

The final results of the research have found 42 relevant Horizon 2020 actions. These are funded across 28 topics, the majority of which are Research and Innovation Actions (RIA) and Innovation Actions (IA). Four projects have been funded under the SME Instrument Phase 2. The search also revealed one action for research and innovation staff exchange (RISE) under the Marie Skłodowska Curie action, one European Research Council (ERC) proof of concept grant, and one Coordination and Support Action (CSA) funded under the Energy Efficiency call of 2015. The total budget costs for these 42 actions add up to 367.9 million Euros, of which the EU grant contribution is 304.1 million Euros. These statistics are presented here below in Table 1 and Figure 1.

Table 1. Numbers of projects which contain tasks that directly relate to the energy smartness of buildings, and their total budgets and European Union (EU) contributions. Source: author.

Funding Scheme [1]	No. of Projects	Total Budget Costs (EUR)	EU Contribution (EUR)
RIA	12	€ 49.5 M	€ 48.1 M
IA	23	€ 308.9 M	€ 248.7 M
CSA	1	€ 1.1 M	€ 1.1 M
MSCA	1	€ 1.0 M	€ 1.0 M
ERC	1	€ 0.1 M	€ 0.1 M
SME Inst	4	€ 7.3 M	€ 5.1 M
Total	**42**	**€ 367.9 M**	**€ 304.1 M**

Notes: [1] "IA" = Innovation Action; "RIA" = Research and Innovation Action; "CSA" = Coordination and Support Action; "MSCA" = Marie Skłodowska-Curie Research and Innovation Staff Exchange; "ERC" = European Research Council Proof of Concept Grant; "SME Inst" = SME Instrument Phase 2.

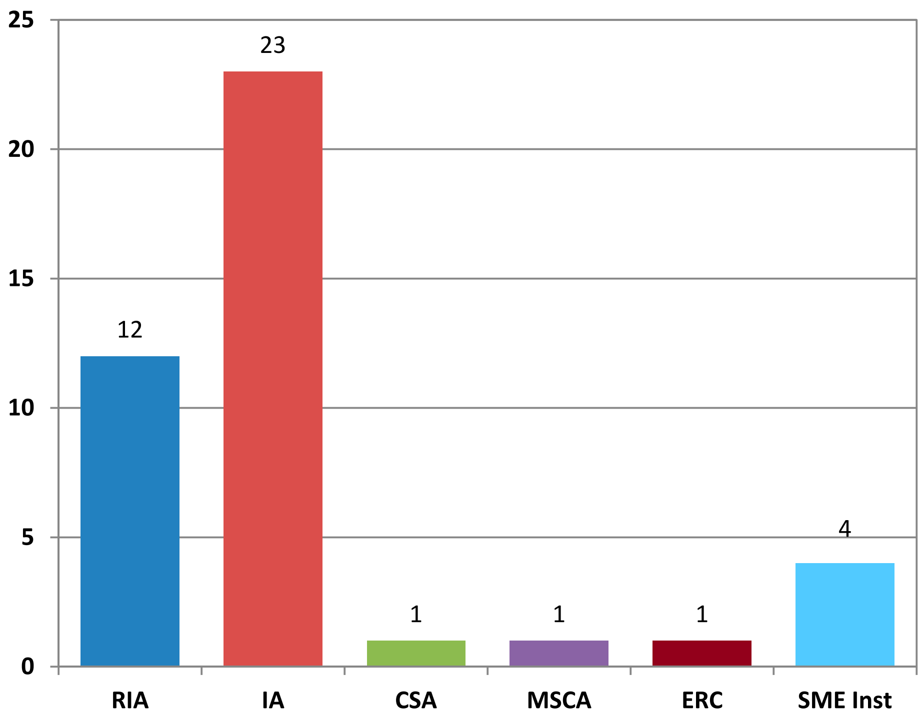

Figure 1. Number of projects per funding scheme. Source: author. For explanations of abbreviations see Table 1.

6. Comparative Analysis

Figure 1 shows the number of projects supported by the different funding schemes while Figure 2 shows their total budget costs and the corresponding EU grant contribution. The majority of the projects are Innovation Actions (IA) and Research and Innovation Actions (RIA). However, when one looks at the allocation of funds, there is a large dominance of Innovation Actions accounting for some 82% of the EU grant contributions. This can be explained by the fact that the Innovation Actions include several projects funded under the Smart Cities and Communities calls, and these tend to have far larger budgets than other Horizon 2020 projects. Likewise, the almost negligible proportion of funds allocated to CSA, MSCA and ERC actions relates to the inherently smaller size of this kind of project.

The 42 projects have been funded across 28 topics within 23 calls for proposals from the years 2014, 2015 and 2016 (see Figure 3). Of the 42 projects, 15 have been funded under the Energy Efficiency calls; seven are from the Smart Cities and Communities calls; seven from the Low Carbon Energy

(LCE) calls; six from the Energy-efficient Buildings (EeB) calls; four from the SME Instrument (second phase); and one each are funded under the ICT call 2015 and from the European Research Council (ERC) and Marie Skłodowska-Curie actions (MSCA). A total of 20 projects, almost half the total, have been funded under the contractual Public-Private Partnerships (cPPP). The majority of these (14) come under the Energy Efficiency calls, with the remaining six being funded under EeB calls.

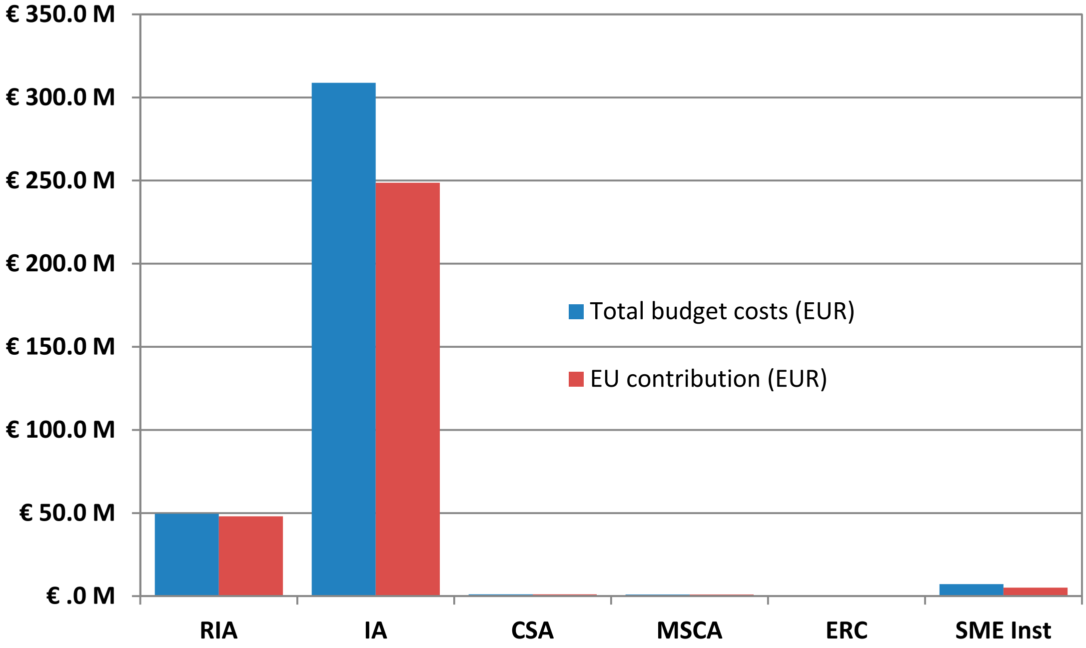

Figure 2. Total budget costs and EU contribution per funding scheme. Source: author. For explanations of abbreviations see Table 1.

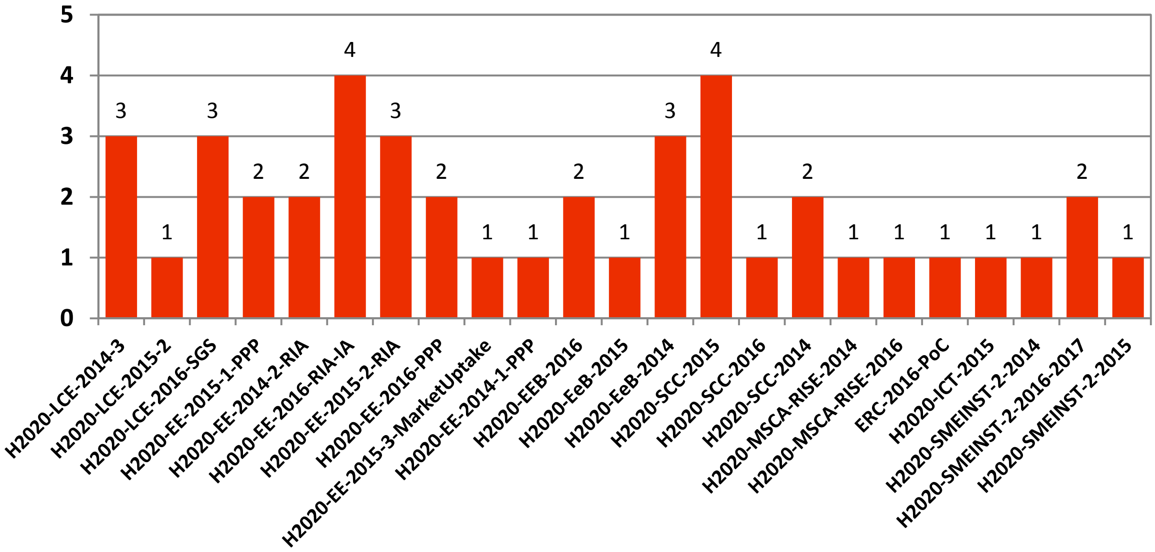

Figure 3. Number of projects funded per Call. Source: author.

The coordinators of the 42 projects are situated in only 13 countries, which are shown in Figure 4. Nine projects are coordinated from Spain and five each from the UK, Netherlands and Italy. France is next with four projects and the remainder are shared between Germany and Belgium (three each), Greece and Ireland (two each), and one each in Switzerland, Portugal, Sweden and Israel. Therefore, none of the projects is coordinated from former Eastern Bloc or so-called "EU13" [33] countries. Of the two coordinators who are based in non-EU countries, the Swiss one is an SME Instrument project (POWERCLOUD: a cloud energy management solution for office equipment and smart devices) which is therefore acting alone rather than in a consortium, and the Israeli one is a European Research Council Proof of Concept grant (ERC PoC) for "Intelligent Control of Energy Storage for Smart Buildings and Grids". All of the remaining projects that include relatively large consortia are therefore coordinated from Western European countries.

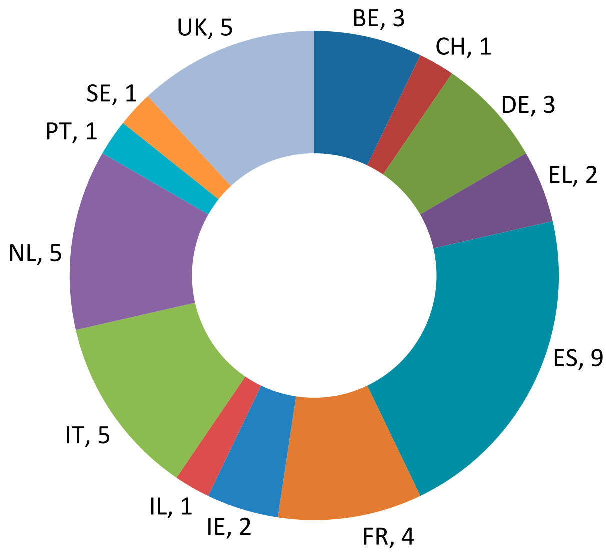

Figure 4. Number of projects per coordinator's country. Source: author.

Figures 5–7 illustrate the extent to which tasks related to the various aspects of a smart building, as previously explained in Section 4 above, are spread across the identified projects. It is possible to conclude that 29 projects are exploring the user interface for control of a smart building, 25 projects deal with on-site storage, and 11 projects are investigating the links between smart buildings and electro-mobility and smart charging. If one considers the three main features of the proposed Smart Readiness Indicator that was referred to earlier, the results show that 39 out of the 42 projects are investigating the building's ability to interact with its users, 38 out of the 42 are investigating the building's ability to manage itself, and 32 out of the 42 projects are investigating the building's interaction with the wider energy environment. Thus, the three principal features are relatively equally represented across the range of projects. Nevertheless, within these totals it can also be said that the areas that are investigated by the fewest projects are electro-mobility and smart charging (12 projects), domestic appliances (11 projects) and self-learning/artificial intelligence (14 projects).

It should be stated that the budget and EU grant contribution figures quoted here represent the overall costs and contributions for the projects as a whole. In many cases, projects are working on a variety of tasks, not all of which are related directly to the advancement of smart buildings for sustainable energy. For example, actions funded under the Smart Cities and Communities (SCC) calls are very large and complex projects with a wide range of tasks that typically include developing digital networks and services for citizens, which may sometimes be related to smart use of energy in buildings, but not always. Likewise, projects working in the area of Demand Response may include tasks relevant to the energy consumption of buildings (which are included in this exercise) but they may also include tasks that focus on the wider energy grid outside of the building's plot boundary. Although such tasks do not feature in the mapping exercise, they nevertheless appear in the overall project budget costs.

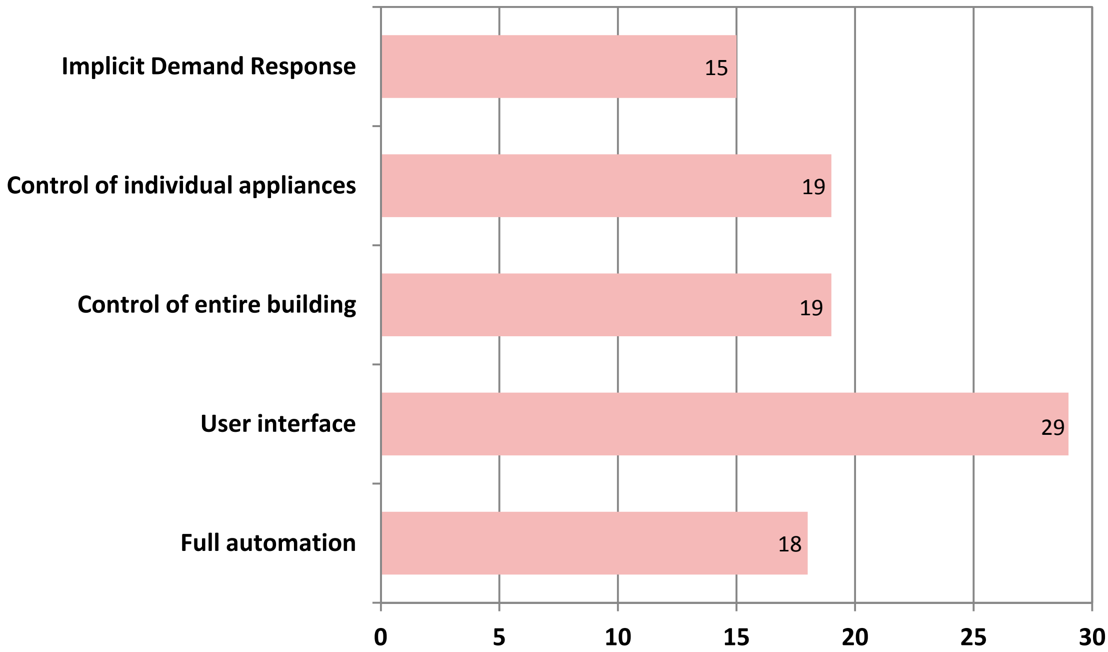

Figure 5. Number of Horizon 2020-funded projects that include tasks related to the ability of a building to interact with its users. Source: author.

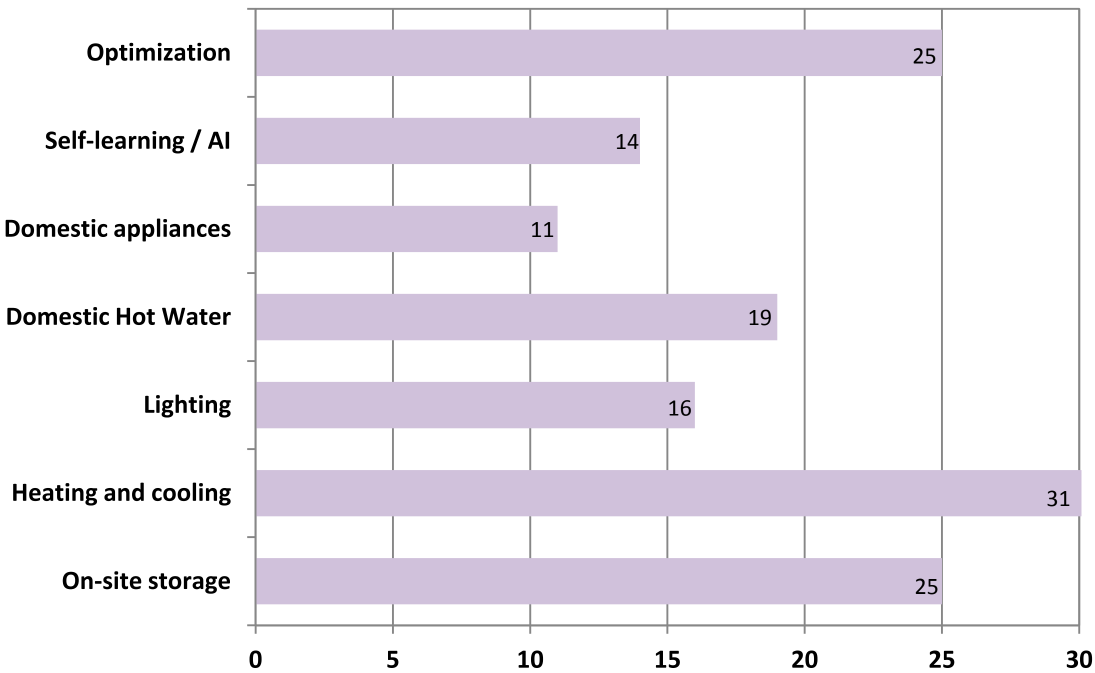

Figure 6. Number of Horizon 2020-funded projects that include tasks related to the ability of a building to manage itself. Source: author.

There are a number of reasons to challenge the results here presented. A manual database search is inherently open to human error. It is possible that requests for information that were sent to project coordinators and officers of the European Commission were not sufficiently clear and that they therefore could have been misinterpreted. It is also possible that the relevance of some project tasks was missed, or misunderstood, when analysing the project tasks. Some of the project documentation is very long and complex, and it is not always straightforward to extract simple yes/no answers. It is also possible that some projects were missed entirely in the search, for example if the search terms used did not appear in the data, including the abstracts, which are available on CORDIS. The results should therefore be treated with some caution. It is more likely that projects or individual tasks were missed, rather than being included in error. Because of this, one conclusion that can be stated with a fair degree of certainty is that, by early May 2017, at least 42 projects that included tasks related to research, innovation and market uptake of smart buildings had been funded under Horizon 2020.

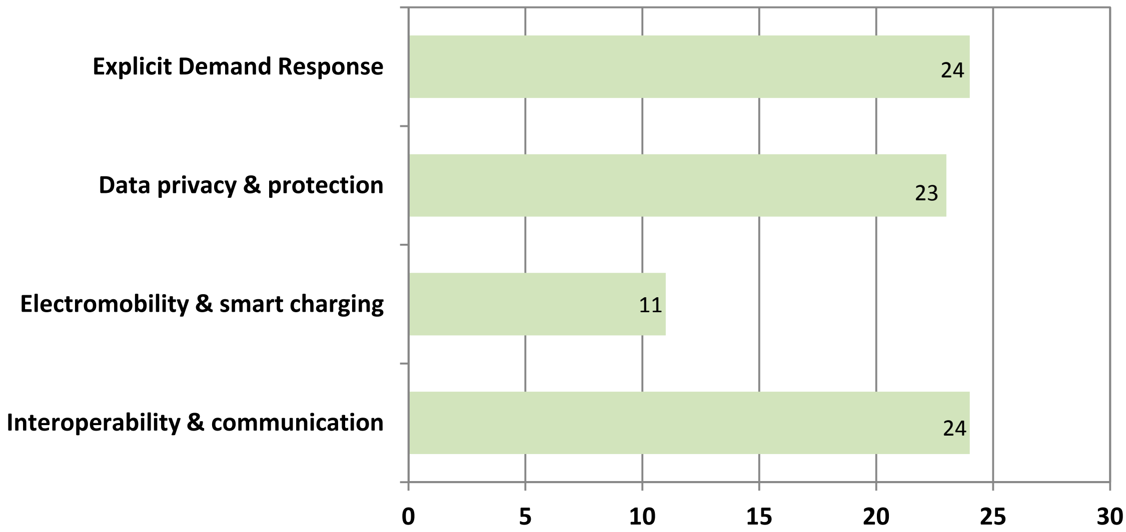

Figure 7. Number of Horizon 2020-funded projects that include tasks related to the ability of a building to interact with the wider energy environment. Source: author.

New Horizon 2020 grant agreements continue to be signed on a regular basis. It is therefore quite likely that new projects that might be relevant to this exercise have been funded and have begun work during the period in between the search for projects and the subsequent analysis and writing of this paper. The results here presented should therefore be understood as a snapshot in time of the support given by Horizon 2020 to smart buildings research, innovation and market uptake from the beginning of the programme in 2014 until roughly its mid-way point in early May 2017. During the search for data it became apparent that a number of ongoing projects funded under the EU's 7th Framework Programme (FP7) [34], the predecessor of Horizon 2020, were also carrying out tasks related to smart buildings, but these were excluded from this exercise. The total level of EU financial support for smart buildings is therefore likely to be significantly greater than the figures that are presented here, especially when one considers the other possible sources of EU funding such as regional development [35] and Cohesion funds [36].

The analysis of data finds that no single Horizon 2020 project identified in this study includes tasks that comprehensively investigate all aspects of a smart building, according to the table with 16 features adopted by this study. However, a small number of projects do come close to comprehensive coverage. For example, projects GrowSmarter [37], AnyPLACE [38] and ELSA [39] are found to include tasks covering 14 out of the 16 aspects of smart buildings.

7. Conclusions

This research work has found that the Horizon 2020 programme has supported 42 different actions that relate to smart buildings, between its beginning in 2014 and early May 2017. About half of these are Innovation Actions. The total budget costs for these 42 actions add up to 367.9 million Euros, of which the EU grant contribution is 304.1 million Euros. A number of these projects are only indirectly addressing smart buildings, for example through individual tasks or work packages within a large and complex project. In theory it would be possible to add up the budgets of all the relevant individual tasks and work packages to arrive at a precise figure for the funding of research, innovation and market uptake related to smart buildings in Horizon 2020; however, in practice such an exercise would be very complex and time consuming.

Despite the usefulness of central IT tools such as CORDIS, there is no automated way to identify projects working on smart buildings, a subject that cuts across Horizon 2020 topics and priority areas, and manual searches have been necessary. Similar efforts would be required to carry out an equivalent exercise in a separate cross-cutting discipline covered by Horizon 2020. The research has found that no single project is comprehensively investigating every aspect of smart buildings. However, three projects contain tasks that relate to 14 out of the 16 aspects of smart buildings that have been set out in this study.

This research could potentially lead to follow-up action, including policy discussions and further research. For example, it could potentially provide input to discussions at the level of the EU's Strategic Energy Technology (SET) Plan [7] which promotes alignment and cooperation in energy technology policies and funding priorities between EU countries, businesses and research bodies as well as the EU itself [7]. More specifically, it could inform the SET-Plan Action 5 on new materials and technologies for buildings [40] and Action 3 on new technologies and services for consumers [40]. The research could also potentially provide input into the Energy-efficient Buildings Public-Private Partnership [23], for example by providing data that could inform the next multi-annual roadmap and longer term strategy [26]. In terms of the Horizon 2020 programme itself, the research might inform the remainder of the work programme and its possible successor EU programmes [41], as well as national funding programmes. Finally, individual research and innovation projects, as well as potential proposers of future projects, will be able to better understand the scope and scale of current efforts in this area. The research should help the project identify and make contact with others that are carrying out similar work, with the result that dissemination of results could be aligned for maximum impact.

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Conflicts of Interest: The author declares no conflict of interest. This article reflects the view of the author and neither the European Commission nor the Executive Agency for Small and Medium-sized Enterprises can be held responsible for any use which may be made of the information contained therein.

Appendix A

Table A1. Matrix of Project Activities.

Project Data Extracted from CORDIS												Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	Project Reference	Funding Scheme [1]	Project Title	Call Identifier	Topic Reference	Topic Title	Coordinator Country	Start Date	End Date	Duration (Months)	Total Cost	EU Contribution	Full Automation	User Interface	Control of Entire Building	Control of Individual Appliances	Implicit Demand Response	On-Site Storage	Heating and Cooling	Lighting	Domestic Hot Water	Domestic Appliances	Self-Learning/AI	Optimization	Interoperability & Communication	Electromobility & Smart Charging	Data Privacy & Protection	Explicit Demand Response
4RinEU	723829	IA	Robust and Reliable technology concepts and business models for triggering deep Renovation of Residential buildings in EU	H2020-EE-2016-PPP	EE-10-2016	Supporting accelerated and cost-effective deep renovation of buildings through Public Private Partnership (EeB PPP)	IT	01/10/2016	30/09/2020	48	EUR 4,627,954	EUR 3,999,962		X					X					X				
AnyPLACE	646580	IA	Adaptable Platform for Active Services Exchange	H2020-LCE-2014-3	LCE-07-2014	Distribution grid and retail market	PT	01/01/2015	31/12/2017	36	EUR 2,974,264	EUR 2,534,389	X	X	X	X	X	X	X	X	X	X			X	X	X	X
BRESAER	637186	RIA	Breakthrough solutions for adaptable envelopes for building refurbishment	H2020-EeB-2014	EeB-02-2014	Adaptable envelopes integrated in building refurbishment projects	ES	01/02/2015	31/07/2019	54	EUR 5,849,107	EUR 5,849,107	X	X	X	X			X	X			X	X	X			X
ChArGED	696170	RIA	CleAnweb Gamified Energy Disaggregation	H2020-EE-2015-2-RIA	EE-11-2015	New ICT-based solutions for energy efficiency	BE	01/03/2016	28/02/2019	36	EUR 2,220,313	EUR 2,220,313		X		X			X	X		X		X			X	
CHESS-SETUP	680556	IA	Combined HEat SyStem by using Solar Energy and heaT pUmPs	H2020-EE-2015-1-PPP	EE-02-2015	Buildings design for new highly energy performing buildings	ES	01/06/2016	31/05/2019	36	EUR 3,703,706	EUR 3,364,315	X			X		X	X		X			X				
DOMINO	696074	CSA	DOMINO—Connecting Europe, Saving Energy	H2020-EE-2015-3-Market Uptake	EE-10-2015	Consumer engagement for sustainable energy	DE	01/03/2016	31/10/2018	32	EUR 1,099,590	EUR 1,099,590		X		X						X			X			
DR BOB	696114	IA	Demand Response in Block of Buildings	H2020-EE-2015-2-RIA	EE-06-2015	Demand response in blocks of buildings	UK	01/03/2016	28/02/2019	36	EUR 5,136,770	EUR 4,274,500		X	X			X	X	X	X			X	X	X	X	X
E2VENT	637261	RIA	Energy Efficient Ventilated Façades for Optimal Adaptability and Heat Exchange enabling low energy architectural concepts for the refurbishment of existing buildings	H2020-EeB-2014	EeB-02-2014	Adaptable envelopes integrated in building refurbishment projects	FR	01/01/2015	30/06/2018	42	EUR 3,402,789	EUR 3,402,789	X	X		X		X	X					X	X			X

Table A1. *Cont.*

Project Data Extracted from CORDIS												Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	Project Reference	Funding Scheme [1]	Project Title	Call Identifier	Topic Reference	Topic Title	Coordinator Country	Start Date	End Date	Duration (Months)	Total Cost	EU Contribution	Full Automation	User Interface	Control of Entire Building	Control of Individual Appliances	Implicit Demand Response	On-Site Storage	Heating and Cooling	Lighting	Domestic Hot Water	Domestic Appliances	Self-Learning/AI	Optimization	Interoperability & Communication	Electromobility & Smart Charging	Data Privacy & Protection	Explicit Demand Response
ELSA	646125	IA	Energy Local Storage Advanced system (ELSA)	H2020-LCE-2014-3	LCE-08-2014	Local/small-scale storage	FR	01/04/2015	31/03/2018	36	EUR 13,144,250	EUR 9,861,613	X	X	X	X	X	X	X	X	X	X		X	X		X	X
enCOM PASS	723059	IA	Collaborative Recommendations and Adaptive Control for Personalised Energy Saving	H2020-EE-2016-RIA-IA	EE-07-2016-2017	Behavioural change toward energy efficiency through ICT	IT	01/11/2016	31/10/2019	36	EUR 3,309,375	EUR 2,000,350		X					X	X	X	X	X	X	X		X	X
FHP	731231	RIA	Flexible Heat and Power, Connecting heat and power networks by harnessing the complexity in distributed thermal flexibility.	H2020-LCE-2016-SGS	LCE-01-2016-2017	Next generation innovative technologies enabling smart grids, storage and energy system integration with increasing share of renewables: distribution network	BE	01/11/2016	31/10/2019	36	EUR 3,823,606	EUR 3,801,998	X	X	X		X	X	X				X	X	X		X	X
GOFLEX	731232	IA	Generalised Operational FLEXibility for Integrating Renewables in the Distribution Grid	H2020-LCE-2016-SGS	LCE-02-2016	Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system	IE	01/11/2016	31/10/2019	36	EUR 11,234,125	EUR 6,826,393					X	X							X	X	X	X
Grow Smarter	646456	IA	GrowSmarter	H2020-SCC-2014	SCCC-01-2014	Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration—first of the kind) projects	SE	01/01/2015	31/12/2019	60	EUR 34,635,913	EUR 24,820,974		X	X	X	X	X	X	X	X	X		X	X	X	X	X
Heat4Cool	723925	IA	Smart building retrofitting complemented by solar assisted heat pumps integrated within a self-correcting intelligent building energy management system.	H2020-EEB-2016	EEB-03-2016	Integration of advanced technologies for heating and cooling at building and district level	IT	03/10/2016	02/10/2020	48	EUR 7,934,578	EUR 5,703,013		X		X		X	X		X		X	X	X		X	X

Table A1. *Cont.*

Project Data Extracted from CORDIS													Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	Project Reference	Funding Scheme [1]	Project Title	Call Identifier	Topic Reference	Topic Title	Coordinator Country	Start Date	End Date	Duration (Months)	Total Cost	EU Contribution	Full Automation	User Interface	Control of Entire Building	Control of Individual Appliances	Implicit Demand Response	On-Site Storage	Heating and Cooling	Lighting	Domestic Hot Water	Domestic Appliances	Self-Learning/AI	Optimization	Interoperability & Communication	Electromobility & Smart Charging	Data Privacy & Protection	Explicit Demand Response
ICE	755445	ERC-POC—Proof of Concept Grant	Intelligent Control of Energy Storage for Smart Buildings and Grids	ERC-2016-PoC	ERC-PoC-2016	ERC-Proof of Concept-2016	CH	01/03/2017	31/08/2018	18	EUR 149,720	EUR 149,720						X							X			X
Innova MicroSolar	723596	RIA	Innovative Micro Solar Heat and Power System for Domestic and Small Business Residential Buildings	H2020-EE-2016-RIA-IA	EE-04-2016-2017	New heating and cooling solutions using low grade sources of thermal energy	UK	01/09/2016	31/08/2020	48	EUR 3,999,384	EUR 3,999,384		X				X	X	X	X			X				
INSITER	636063	RIA	Intuitive Self-Inspection Techniques using Augmented Reality for construction, refurbishment and maintenance of energy-efficient buildings made of prefabricated components	H2020-EeB-2014	EeB-03-2014	Development of new self-inspection techniques and quality check methodologies for efficient construction processes	NL	01/12/2014	30/11/2018	48	EUR 5,999,885	EUR 5,999,885	X	X	X	X			X				X		X		X	
LOWUP	723930	RIA	LOW valued energy sources UPgrading for buildings and industry uses	H2020-EE-2016-RIA-IA	EE-04-2016-2017	New heating and cooling solutions using low grade sources of thermal energy	ES	01/11/2016	30/04/2020	42	EUR 4,086,245	EUR 3,735,595						X	X		X			X				
MORE-CONNECT	633477	IA	Development and advanced prefabrication of innovative, multifunctional building envelope elements for MOdular REtrofitting and CONNECTions	H2020-EE-2014-1-PPP	EE-01-2014	Manufacturing of prefabricated modules for renovation of building	NL	01/12/2014	30/11/2018	48	EUR 5,557,263	EUR 4,364,749	X		X		X		X	X	X			X	X			X
MPC-. GT	723649	RIA	Model Predictive Control and Innovative System Integration of GEOTABS;-) in Hybrid Low Grade Thermal Energy Systems—Hybrid MPC GEOTABS	H2020-EE-2016-RIA-IA	EE-04-2016-2017	New heating and cooling solutions using low grade sources of thermal energy	BE	01/09/2016	31/08/2020	48	EUR 4,263,701	EUR 3,989,951	X	X	X		X	X	X	X			X	X	X		X	

Table A1. *Cont.*

Project Data Extracted from CORDIS													Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	Project Reference	Funding Scheme [1]	Project Title	Call Identifier	Topic Reference	Topic Title	Coordinator Country	Start Date	End Date	Duration (Months)	Total Cost	EU Contribution	Full Automation	User Interface	Control of Entire Building	Control of Individual Appliances	Implicit Demand Response	On-Site Storage	Heating and Cooling	Lighting	Domestic Hot Water	Domestic Appliances	Self-Learning/AI	Optimization	Interoperability & Communication	Electromobility & Smart Charging	Data Privacy & Protection	Explicit Demand Response
OrbEEt	649753	RIA	ORganizational Behaviour improvement for Energy Efficient adminisTrative public offices	H2020-EE-2014-2-RIA	EE-11-2014	New ICT-based solutions for energy efficiency	ES	01/03/2015	28/02/2018	36	EUR 1,776,625	EUR 1,776,625		X					X	X								
P2Endure	723391	IA	Plug-and-Play product and process innovation for Energy-efficient building deep renovation	H2020-EE-2016-PPP	EE-10-2016	Supporting accelerated and cost-effective deep renovation of buildings through Public Private Partnership (EeB PPP)	NL	01/09/2016	31/08/2020	48	EUR 5,318,600	EUR 3,999,992	X	X	X	X		X	X				X		X	X	X	
POWER CLOUD	672278	SME-2—SME instrument phase 2	Cloud Energy management solution for Office It equipment and Smart devices	H2020-SMEINST-2-2014	SIE-01-2014	Stimulating the innovation potential of SMEs for a low carbon energy system	IL	01/08/2015	31/07/2017	24	EUR 1,534,577	EUR 1,074,204		X		X												
PVSITES	691768	IA	Building-integrated photovoltaic technologies and systems for large-scale market deployment	H2020-LCE-2015-2	LCE-03-2015	Demonstration of renewable electricity and heating/cooling technologies	ES	01/01/2016	30/06/2019	42	EUR 8,490,473	EUR 5,467,612		X			X	X					X	X				
RealValue	646116	IA	Realising Value from Electricity Markets with Local Smart Electric Thermal Storage Technology	H2020-LCE-2014-3	LCE-08-2014	Local/small-scale storage	IE	01/06/2015	31/05/2018	36	EUR 15,413,331	EUR 11,987,430	X	X		X		X	X		X	X	X	X	X		X	X
REMO URBAN	646511	IA	REgeneration MOdel for accelerating the smart URBAN transformation	H2020-SCC-2014	SCC-01-2014	Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration—first of the kind) projects	ES	01/01/2015	31/12/2019	60	EUR 23,791,530	EUR 21,541,954		X		X	X	X	X	X	X		X	X				
Rennovates	680603	IA	Flexibility Activated Zero Energy Districts	H2020-EeB-2015	EeB-08-2015	Integrated approach to retrofitting of residential buildings	NL	01/09/2015	30/08/2018	36	EUR 6,847,730	EUR 5,087,238	X	X			X	X	X		X		X	X	X		X	X

Table A1. *Cont.*

Project Data Extracted from CORDIS													Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	Project Reference	Funding Scheme [1]	Project Title	Call Identifier	Topic Reference	Topic Title	Coordinator Country	Start Date	End Date	Duration (Months)	Total Cost	EU Contribution	Full Automation	User Interface	Control of Entire Building	Control of Individual Appliances	Implicit Demand Response	On-Site Storage	Heating and Cooling	Lighting	Domestic Hot Water	Domestic Appliances	Self-Learning/AI	Optimization	Interoperability & Communication	Electromobility & Smart Charging	Data Privacy & Protection	Explicit Demand Response
REPLI CATE	691735	IA	REnaissance of Places with Innovative Citizenship and Technolgy	H2020-SCC-2015	SCC-01-2015	Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration—first of the kind) projects	ES	01/02/2016	31/01/2021	60	EUR 29,250,564	EUR 24,965,263	X		X	X	X									X		
Ruggedised	731198	IA	Rotterdam, Umea and Glasgow: Generating Exemplar Districts In Sustainable Energy Deployment	H2020-SCC-2016	SCC-1-2016-2017	Smart Cities and Communities lighthouse projects	NL	01/11/2016	31/10/2021	60	EUR 19,562,868	EUR 17,692,858			X			X	X						X	X	X	X
SABINA	731211	RIA	SmArt BI-directional multi eNergy gAteway	H2020-LCE-2016-SGS	LCE-01-2016-2017	Next generation innovative technologies enabling smart grids, storage and energy system integration with increasing share of renewables: distribution network	UK	01/11/2016	31/10/2020	48	EUR 4,611,041	EUR 3,789,869	X					X	X				X	X			X	X
SHAR-LLM	691895	IA	Sharing Cities	H2020-SCC-2015	SCC-01-2015	Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration—first of the kind) projects	UK	01/01/2016	31/12/2020	60	EUR 28,068,094	EUR 24,753,945						X		X		X		X		X		X
Sim4Blocks	695965	IA	Simulation Supported Real Time Energy Management in Building Blocks	H2020-EE-2015-2-RIA	EE-06-2015	Demand response in blocks of buildings	DE	01/04/2016	31/03/2020	48	EUR 5,563,356	EUR 3,729,056		X	X		X	X	X		X						X	X
SMART GEMS	645677	MSCA-RISE—Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)	Smart Grids Energy management Staff	H2020-MSCA-RISE-2014	MSCA-RISE-2014	Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)	EL	01/09/2015	31/08/2019	48	EUR 958,500	EUR 958,500	X	X	X			X	X	X			X	X				X

Table A1. *Cont.*

Project Data Extracted from CORDIS													Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	Project Reference	Funding Scheme [1]	Project Title	Call Identifier	Topic Reference	Topic Title	Coordinator Country	Start Date	End Date	Duration (Months)	Total Cost	EU Contribution	Full Automation	User Interface	Control of Entire Building	Control of Individual Appliances	Implicit Demand Response	On-Site Storage	Heating and Cooling	Lighting	Domestic Hot Water	Domestic Appliances	Self-Learning/AI	Optimization	Interoperability & Communication	Electromobility & Smart Charging	Data Privacy & Protection	Explicit Demand Response
SMARTCIM	684086	SME-2—SME instrument phase 2	Smart interoperable electronic active valve, control eco-system and service to achieve superior building efficiency and user awareness	H2020-SMEINST-2-2015	SIE-01-2015	Stimulating the innovation potential of SMEs for a low carbon energy system	IT	01/08/2015	31/05/2017	22	EUR 2,302,000	EUR 1,611,400		X		X			X		X			X				
SmartEn City	691883	IA	Towards Smart Zero CO2 Cities across Europe	H2020-SCC-2015	SCC-01-2015	Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration—first of the kind) projects	ES	01/02/2016	31/01/2021	60	EUR 32,201,606	EUR 27,890,139		X	X	X			X		X	X		X	X	X	X	X
SMARTER TOGETHER	691876	IA	Smart and Inclusive Solutions for a Better Life in Urban Districts	H2020-SCC-2015	SCC-01-2015	Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration—first of the kind) projects	FR	01/02/2016	31/01/2021	60	EUR 29,119,448	EUR 24,742,979	X		X	X		X							X	X	X	X
SMARTHE	733426	SME-2—SME instrument phase 2	Smart thermostat evolution	H2020-SMEINST-2-2016-2017	SMEInst-09-2016-2017	Stimulating the innovation potential of SMEs for a low carbon and efficient energy system	FR	01/08/2016	31/10/2017	15	EUR 1,691,088	EUR 1,183,761		X					X		X		X	X				
Socials martgrid	739264	SME-2—SME instrument phase 2	Boosting Energy Efficiency Trough Social Smart Grid Network	H2020-SMEINST-2-2016-2017	SMEInst-09-2016-2017	Stimulating the innovation potential of SMEs for a low carbon and efficient energy system	IT	01/01/2017	31/12/2018	24	EUR 1,750,098	EUR 1,225,068		X			X								X		X	X
THER MOSS	723562	IA	Building and district thermal retrofit and management solutions	H2020-EEB-2016	EEB-03-2016	Integration of advanced technologies for heating and cooling at building and district level	UK	01/09/2016	29/02/2020	42	EUR 8,796,474	EUR 5,658,244			X	X			X	X	X	X					X	X

Table A1. *Cont.*

Project Data Extracted from CORDIS													Building's Ability to Interact with Users					Building's Ability to Manage Itself							Building's Ability to Interact with the Energy Environment			
Project Acronym	**Project Reference**	**Funding Scheme** [1]	**Project Title**	**Call Identifier**	**Topic Reference**	**Topic Title**	**Coordinator Country**	**Start Date**	**End Date**	**Duration (Months)**	**Total Cost**	**EU Contribution**	**Full Automation**	**User Interface**	**Control of Entire Building**	**Control of Individual Appliances**	**Implicit Demand Response**	**On-Site Storage**	**Heating and Cooling**	**Lighting**	**Domestic Hot Water**	**Domestic Appliances**	**Self-Learning/AI**	**Optimization**	**Interoperability & Communication**	**Electromobility & Smart Charging**	**Data Privacy & Protection**	**Explicit Demand Response**
TRIBE	649770	RIA	TRaIning Behaviours towards Energy efficiency: Play it!	H2020-EE-2014-2-RIA	EE-11-2014	New ICT-based solutions for energy efficiency	ES	01/03/2015	28/02/2018	36	EUR 2,000,033	EUR 2,000,032		X			X										x	x
VICINITY	688467	RIA	Open virtual neighbourhood network to connect intelligent buildings and smart objects	H2020-ICT-2015	ICT-30-2015	Internet of Things and Platforms for Connected Smart Objects	DE	01/01/2016	31/12/2019	48	EUR 7,499,008	EUR 7,499,008	X		X		X		X	X	X	X			x	X	X	
ZERO-PLUS	678407	IA	Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology	H2020-EE-2015-1-PPP	EE-02-2015	Buildings design for new highly energy performing buildings	EL	01/10/2015	30/09/2019	48	EUR 4,171,948	EUR 3,468,983	X		X			X							X			

Notes: [1] "IA" = Innovation Action; "RIA" = Research and Innovation Action; "CSA" = Coordination and Support Action.

Appendix B

Table A2. List of Projects in Alphabetical Order.

Acronym	Project Reference	Funding Scheme [1]	Project Title
4RinEU	723829	IA	Robust and Reliable technology concepts and business models for triggering deep Renovation of Residential buildings in EU
AnyPLACE	646580	IA	Adaptable Platform for Active Services Exchange
BRESAER	637186	RIA	Breakthrough solutions for adaptable envelopes for building refurbishment
ChArGED	696170	RIA	CleAnweb Gamified Energy Disaggregation
CHESS-SETUP	680556	IA	Combined HEat SyStem by using Solar Energy and heaT pUmPs

Table A2. *Cont.*

Acronym	Project Reference	Funding Scheme [1]	Project Title
DOMINO	696074	CSA	DOMINO—Connecting Europe, Saving Energy
DR BOB	696114	IA	Demand Response in Block of Buildings
E2VENT	637261	RIA	Energy Efficient Ventilated Façades for Optimal Adaptability and Heat Exchange enabling low energy architectural concepts for the refurbishment of existing buildings
ELSA	646125	IA	Energy Local Storage Advanced system (ELSA)
enCOMPASS	723059	IA	Collaborative Recommendations and Adaptive Control for Personalised Energy Saving
FHP	731231	RIA	Flexible Heat and Power, Connecting heat and power networks by harnessing the complexity in distributed thermal flexibility.
GOFLEX	731232	IA	Generalised Operational FLEXibility for Integrating Renewables in the Distribution Grid
GrowSmarter	646456	IA	GrowSmarter
Heat4Cool	723925	IA	Smart building retrofitting complemented by solar assisted heat pumps integrated within a self-correcting intelligent building energy management system.
ICE	755445	ERC-POC—Proof of Concept Grant	Intelligent Control of Energy Storage for Smart Buildings and Grids
Innova MicroSolar	723596	RIA	Innovative Micro Solar Heat and Power System for Domestic and Small Business Residential Buildings
INSITER	636063	RIA	Intuitive Self-Inspection Techniques using Augmented Reality for construction, refurbishment and maintenance of energy-efficient buildings made of prefabricated components
LOWUP	723930	RIA	LOW valued energy sources UPgrading for buildings and industry uses
MORE-CONNECT	633477	IA	Development and advanced prefabrication of innovative, multifunctional building envelope elements for MOdular REtrofitting and CONNECTions
MPC-. GT	723649	RIA	Model Predictive Control and Innovative System Integration of GEOTABS;-) in Hybrid Low Grade Thermal Energy Systems—Hybrid MPC GEOTABS
OrbEEt	649753	RIA	ORganizational Behaviour improvement for Energy Efficient adminisTrative public offices
P2Endure	723391	IA	Plug-and-Play product and process innovation for Energy-efficient building deep renovation

Table A2. *Cont.*

Acronym	Project Reference	Funding Scheme [1]	Project Title
POWERCLOUD	672278	SME-2—SME instrument phase 2	Cloud Energy management solution for Office It equipment and Smart devices
PVSITES	691768	IA	Building-integrated photovoltaic technologies and systems for large-scale market deployment
RealValue	646116	IA	Realising Value from Electricity Markets with Local Smart Electric Thermal Storage Technology
REMOURBAN	646511	IA	REgeneration MOdel for accelerating the smart URBAN transformation
Rennovates	680603	IA	Flexibility Activated Zero Energy Districts
REPLICATE	691735	IA	REnaissance of Places with Innovative Citizenship and Technology
Ruggedised	731198	IA	Rotterdam, Umea and Glasgow: Generating Exemplar Districts In Sustainable Energy Deployment
SABINA	731211	RIA	SmArt BI-directional multi eNergy gAteway
SHAR-LLM	691895	IA	Sharing Cities
Sim4Blocks	695965	IA	Simulation Supported Real Time Energy Management in Building Blocks
SMART GEMS	645677	MSCA-RISE—Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)	Smart Grids Energy management Staff
SMARTCIM	684086	SME-2—SME instrument phase 2	Smart interoperable electronic active valve, control eco-system and service to achieve superior building efficiency and user awareness
SmartEnCity	691883	IA	Towards Smart Zero CO2 Cities across Europe
SMARTER TOGETHER	691876	IA	Smart and Inclusive Solutions for a Better Life in Urban Districts
SMARTHE	733426	SME-2—SME instrument phase 2	Smart thermostat èvolution
Socialsmartgrid	739264	SME-2—SME instrument phase 2	Boosting Energy Efficiency Trough Social Smart Grid Network
THERMOSS	723562	IA	Building and district thermal retrofit and management solutions
TRIBE	649770	RIA	TRaIning Behaviours towards Energy efficiency: Play it!
VICINITY	688467	RIA	Open virtual neighbourhood network to connect intelligent buildings and smart objects
ZERO-PLUS	678407	IA	Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology

Notes: [1] "IA" = Innovation Action; "RIA" = Research and Innovation Action; "CSA" = Coordination and Support Action.

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