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|  | **Statens Byggeforsknings Institut**AC Meyers Vænge 152450 København SVDanmarkKontaktperson:Kirsten Gram-HanssenTelefon: 9940 2291E-mail: kgh@sbi.aau.dk |

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 Dato: 15.09.2017

**Skabelon - komplet projektforslag (fase 2) (max. 13 sider i alt ekskl. CV’er og referencer)**

1. **Ansøgningsskema (max. 1 side)**

Udfyld venligst nedenstående skema.

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| Projektets titel og akronym: | Intermittent energy - Integrating Households, Utilities and Buildings Akronym: InterHUB |
| Forskningstema og tilknytning til andre temaer | *Intelligent, bæredygtig og integreret energiudvikling og –forbrug* |

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| Videnskabelige emneord (max 5): | Smart grid; intermittent energy; user practices; smart buildings |

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| **Ansøgningsansvarlig /Principal Investigator** |
| Ansøgningsansvarliges navn  | Kirsten Gram-Hanssen |
| Stilling  | Professor |
| Institut/Center  | ENG/Statens Byggeforskningsinstitut/Byer og boliger |
| Adresse  | A.C.Meyers Vænge 15, 4. sal. 2450 København SV |
| E-mail  | kgh@sbi.aau.dk |
| Telefon  | 9940 2291 |
| Mobil  | 2360 5653 |

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| Projektets varighed i måneder\*: | 36 måneder |

\* Projektet forventes at starte primo 2018. Projektets varighed må ikke overstige 36 måneder.

1. **Projektbeskrivelse (maks. 10 sider)**
2. ***Background and project idea***

Transition to a low-carbon future calls for lowering energy demand and an increased use of intermittent energy sources, such as wind and solar power. Buildings account for roughly 40% of all energy use (for heating-cooling) and have, therefore, a prominent role in this transition. Buildings should, however, not be seen in isolation. There are several reasons for considering buildings as part of the energy system. First, energy savings in buildings may be balanced by related energy systems’ initiatives; second, building technologies should be developed related to specific local infrastructures; and third the inclusion of buildings into the energy infrastructure may deliver flexibility services if buildings can be used to store energy as heating. Buildings can thus serve as distributed system generators, and improvements in building design can furthermore contribute substantially to energy savings. To realize these potentials, technical developments within smart energy systems and buildings technologies are needed. However, if substantial advances are to be made, then these technological developments must be based on a greater understanding of the residents’ social practices, i.e. how they interact with and understand heating technologies and indoor comfort. The integration of buildings into the energy infrastructure will impact building design, existing modes of heating/cooling, and affect relations between energy providers and buildings owners/residents. Successful integration of residential buildings into the energy system to achieve energy savings and flexibility requires, therefore, new knowledge of the changing relationships between energy providers and households and of the roles different buildings technologies can play in this.

This calls for interdisciplinary research involving social sciences to understand everyday household practices and the complex changes in energy infrastructure, humanistic research to understand the involved actors’ sense-making and communication patterns, and technical research and development in building technologies. The InterHUB project will be dedicated to providing this knowledge, and we will argue that the question of integrating buildings into the energy systems represents a very strong case for why interdisciplinary research is needed. Interdisciplinary research is always a challenge. The InterHUB consortium is well positioned to address this challenge, having collaborated successfully in the five-year UserTEC project that also involved extensive collaboration with actors from both building industry and energy provision. Integrating buildings into the energy system is a more challenging issue than the ones studied in the UserTEC project, as this will entail new roles for all involved actors. However, the UserTEC project serves as a strong base for further developing the interdisciplinary research needed, and will do so utilizing mixed methods to collect and analyze data. This will include statistical analysis of register based data, qualitative interviews with households and professionals, conducting future workshops, and document analysis. The project will also entail and contribute to the development of engineering systems, including new methodologies in building modeling, performance evaluation and design methods.

InterHUB will contribute to AAU’s strategy by developing a strong interdisciplinary and problem-oriented approach within an area of major societal relevance; an area where substantial research funding is expected in the future both nationally and at EU level. The project will engage a number of young(er) researchers and assist them in developing this kind of research. This will be done in close collaboration with actors from within the energy and building sectors.

1. ***Aim, vision and research question***

The vision of this project is that in the future buildings will be an active and integrated part of the energy system. This will require rethinking the building both as a residential project and as part of the energy infrastructure in order to achieve the cross-sectorial integration that energy planners call for (Lund et al., 2017). If this is to happen successfully, our argument is that not only a technical and cross-sectorial integration is needed. It is imperative that this cross-sectorial and technical integration build on mutual understandings from the involved professionals, as well as that these professionals understand what constitute households’ practices and meanings. InterHUB focuses on three important dimensions for the integration of buildings into the energy system: building systems design, household practices, and changing models for energy provision, and on how these dimensions are interrelated. The project addresses the technical, communicative, organisational and social challenges associated with buildings’ changing role in the energy system. *Thus, the purpose of InterHUB is to deepen our understanding of the challenges involved in realising an integration of buildings and households in a future integrated and flexible energy system.* Given the indeterminacy of this, the project will be explorative in its approach. The project will also develop ideas for addressing these challenges, i.e. suggestions regarding the development of new technologies and business models, new types of collaborations and new ways of communicating, all of which will be based on understandings of how householders will be affected by and react to these new solutions in their everyday lives.

The project has three key success criteria: One is to develop an interdisciplinary approach to socio-technical transitions that can move the international research frontier and attract the attention of international scholars. The second is to further develop our collaborative relations with actors in the field to develop an empirically relevant knowledge that can be used in future service and technology development. The third success criteria is that upon completion of the InterHUB project, the research team will be in a position to initiate larger nationally and internationally (EU) funded research and development projects and that we are a preferred partner in other researchers’ projects, both nationally and internationally.

1. ***Project content***
	1. *AAU research theme*

Reducing carbon dioxide emissions to ensure a future with “Intelligent, Sustainable, and Integrated Energy Production and Consumption” calls for changing the existing energy system to include an increased share of fluctuating renewable energy sources. Integrating these energy sources in the energy system will call for developing more flexible energy systems, and overall reduction of consumption. This can be achieved by integrating buildings into the energy system, making them part of the energy infrastructure. This will have implications for everyday household practices, the ways in which buildings and their associated technologies are designed and for the ways in which energy providers operate. The InterHUB projects focuses on changes within and across these three domains.

With an increased reliance on intermittent energy sources, the technical, institutional and organizational configuration of the energy system is in a state of flux. The roles of the involved actors are also changing, e.g. utilities becoming service providers rather than energy providers, consumers taking roles of prosumers (both providing and consuming energy), and buildings serving as energy storage units and energy producing units. Although the extent and implications of these changes are far from certain, it will, however, call for increased collaboration and an aligning of practices across each of these domains, as indicated in figure 1. Thus, central research topics to be investigated are: how households interact with and understand different types of building technologies, how households relate to utilities providing different services, how different types of professionals communicate with each other and with households on energy issues, and how developments within buildings and provision systems influence each other. Each of these topics has implications for the chances of lowering energy demand and for the ways in which buildings will be integrated into the energy infrastructure.



*Figure 1. Three key domains in integrating buildings into energy systems*

The lack of interdisciplinary research on the integration of buildings into the energy system is a major scientific challenge for transitioning to a low carbon future. There are substantial bodies of research within each of these three domains in relation to intermittent energy, particularly with regard to technology and systems development. There is also a growing amount of humanistic and social science research on infrastructure development and households practices. What is missing, however, are studies focusing on the integration of all three domains and the interrelations between them, where insights from the humanities and social science can help form the development of new technological solutions, and insights from building engineering can provide input to developments within energy provision.

InterHUB is an interdisciplinary research project that combines expertise from engineering, social sciences and the humanities, and has an action approach to conducting research that involves engaging with actors in the field. This is not only valuable for developing alternatives to existing practices, technologies and systems but also for feeding insights into each of our respective disciplines.

* 1. *Content of the project*

The InterHUB project’s major contribution is its interdisciplinary approach to a societal problem where a deeper understanding of the actors’ different interests and priorities is absolutely needed for being able to deliver solutions that will work in real life. The project provides new insights by integrating different types of data and research approaches from different disciplines, and by working together on the same research topics. This is in contrast to much research on energy systems transition, which often has a strong sectorial focus, e.g. on building construction, energy provision or influencing household behavior. InterHUB looks across these sectors and specifically addresses the interactions between key actors involved in the transition processes.

The project investigates three areas, as depicted by the shaded overlaps in figure 1:

* The *interactions between household practices and building system designs*. The requirements and performance of future building system designs must accommodate new needs related to the energy system as well as to household comfort needs. The research will be carried out in collaboration between engineers modeling flexible energy use in buildings and social scientists investigating how norms of comfort develop together with the introduction of new smart building technologies. This will be combined with humanistic research on the communication practices amongst designers and households, the aim of which is to bring these actors together and increase their understandings of each other’s respective priorities/interests.
* The *interactions between utility provision systems and household practices*. This research examines how changes in utility services affects households with varying socio-economic backgrounds, and how buyers and sellers of energy, including prosumers, attribute value to energy provision and seek to create new businesses or community developments in relation to new energy services. Multi-stakeholder communication is important for the ways in which these relations evolve. Drawing on insights from the humanities this research will analyze professional-household communication with the aim to improve communication amongst households and professionals
* The *interrelations between utility service provision and building system designs*. This research addresses the challenges facing utilities in developing new business models as consumers become more ‘mobile’ and as new buildings technologies/designs re-define the building as part of the energy system infrastructure that can provide energy savings, flexible use and storage facilities. The research will be conducted by engineers and social scientists in collaboration with humanists. The research will focus on how system requirements of the utilities and changes in building structures/designs can be mutually accommodated. This research will be supported by communication research on language, values and arguments made by different types of professionals.

Aalborg University has a strong national and international research position within the built environment as well as within energy studies, including the role of users and households. By combining these approaches, and by drawing on insights from the humanities, InterHUB will place AAU in a very strong position nationally as well as internationally as regard energy research on the role of buildings in an energy system with intermittent energy. The project will be able to develop new synergies and utilise these to influence future calls from EU and national research bodies, and subsequently be in a strong position to respond to these calls.

* 1. *State-of-the-art and beyond*

Given that much of the research on energy system transition is discipline-based, the following begins by highlighting state-of-the-art within each of the involved disciplines in the InterHUB project, and then describes how the InterHUB project seeks to go beyond this.

*Communication in green transition efforts*

In the wider area of scientific research on green transitions, communication has hitherto played an instrumental role as part of behavior change initiatives rooted in economic psychology and environmental psychology, or analytically in mediated environmental communication and public engagement initiatives (Phillips et al., 2012; Whitmarsh et al., 2011). More recent research on green transition in energy systems in residential buildings has opened a new venue of research. Based on thorough in-depth studies of expressed dilemmas in cross sectorial communication concerning household agency and energy efficient technologies, this research shows that communication in multi-stakeholder communication about green transitions has a double nature: it moves towards solutions before the problem formulation has been negotiated, and it seeks closure before diverging values and worldviews have been exchanged (Andersen, 2016), thus, making it difficult to enable the necessary transitions. The InterHUB project will follow this line of research further by deploying future workshops (Junk and Müllert, 1987) as its main method for providing more robust multi-stakeholder interaction that can provide the stakeholders with a better understanding of the other actors’ interests/priorities and guide development of communication strategies and tools in the project. Future workshops have for many years proven their value as instrument for communication about planning and developing visions and scenarios of the future within education, software design, and health (Greenbaum and Kyng, 1991; Müller and Druin, 2012).

*Building System Design*

Although the electrification of energy demand in buildings and local renewable energy integration in buildings impose additional stress to energy networks, buildings are at the same time considered to be part of the solution in low carbon energy transitions because of their ability to deliver flexibility services. Research, focusing on the building level, i.e. impact on the residents’ thermal comfort, energy and/or cost savings (Arteconi et al., 2012; De Coninck and Helsen, 2016; Lopes et al., 2016; Xue et al., 2014); on the local energy infrastructure, e.g. power imbalance compensation, voltage deviation, cover factors (Kim et al., 2016; Marszal-Pomianowska et al., 2017; Nuytten et al., 2013); and on increased use of intermittent renewable energy production (Hedegaard et al., 2012), has shown, that buildings potentially can offer considerable heating energy flexibility services to the smart energy system. Different building designs and building energy system solutions have different characteristics and capabilities in relation to their heating flexibility potential, energy efficiency and provision of indoor environmental quality levels (Arteconi et al., 2014; Le Dréau and Heiselberg, 2016; Reynders et al., 2015, 2013; Široký et al., 2011). Currently applied methods in building design and performance evaluation focus on minimizing the building energy use. They do not address the new features of future buildings, i.e. their active participation in the energy market (Lopes et al., 2016), the contribution to improve grid capacity or on the impact of flexibility services on user perception of comfort. By bringing control of energy demand in buildings, the electric grid perspectives and user practices and perception of comfort together, a new building design and evaluation framework including new design and modelling methods can be developed.

*Challenging business as usual – new roles for utility companies*

With buildings being responsible for a large part of society’s overall energy use, heating/cooling is of strategic importance for reducing energy consumption. The electrification of heating/cooling (through the use of large heat pumps and electric boilers) is also means for providing flexible consumption and storage, which is currently hampered by the existing tariff and tax structure (Skytte et al., 2017). Actors engaged in making heating sector investments need to find ways in which to move forward in providing flexibility services (Jensen et al., 2017). A common suggestion for re-considering the role of utilities is to focus on service innovation (PWC, 2013; Richter, 2012, 2013a), i.e. the offering and optimization of energy services rather than just selling units of energy (Apajalahti et al., 2015; Hannon et al., 2013; Sorrell, 2007).This transformation of a capital-intensive sector involves a number of challenges, notably the development of new business models (Nair et al., 2013; Richter, 2013b), the value dilemma stemming from a lack of customer trust, demand and willingness to pay for the ‘new’ services and, notably the managerial difficulties of simultaneously managing a utility and service company while leveraging stakeholder relationships (Hannon and Bolton, 2015; Helms, 2016; Marino et al., 2011). More research is needed to better understand what implications the integration of buildings into the energy system will have for households living in the buildings and for actors in the heating/cooling sector (Apajalahti et al., 2015; Hannon and Bolton, 2015). Although the call for new business models abound, less attention has been given to the development processes, i.e. to the business modeling and what this entails in terms of collaboration with other actors, e.g. housing associations, individual households and the building industry, and in terms of aligning interests.

*Household practices and energy consumption*

Households consume energy to accomplish social practices, and not because they are interested in consuming energy (Shove and Walker, 2014). In seeking to understand households’ energy consumption for heating we should, thus, focus on the practices related to indoor climate and hot water use and by that to understandings of cleanliness and comfort (Shove, 2003). Studies have shown how norms of comfort (Hansen et al., 2017; Madsen and Gram-Hanssen, 2017) and cleanliness (Gram-Hanssen, 2007) co-evolve with the introduction of new technologies. New, more efficient technologies may thus invoke higher norms of comfort, which means that the expected energy savings are not realized despite the efficiency gains (Gram-Hanssen et al., 2017, 2012). Policy-makers often see feed-back and smart home control of energy as a means to engage households. However, research on energy feedback show modest reductions (Darby, 2010) and that smart home technologies not are that easily adopted in households (Hargreaves et al., 2017, 2013). Related to smart grid approaches, the time of use of energy has also been investigated, and this study emphasizes how practices are interrelated (Friis and Haunstrup Christensen, 2016). Much of smart grid research has hitherto focused on electricity for appliance use, and smart grid research related to heating buildings is thus scarce. New research questions related to intermittent energy include how comfort norms are dependent on the control of heating, including issues of whom is in control; how being a prosumer affects practices under different business models, as well as how different policies and incentives are received differently among households according to social class.

*Combining efforts into new approaches*

The InterHUB project will build upon the state-of-art from each of the abovementioned research areas and will seek to provide insights to further develop these disciplinary domains. However, InterHUB will primarily go in new directions by combining insights from across disciplines and developing an interdisciplinary approach to understanding transitions in energy production and consumption. Our interdisciplinary approach is based on two principles – interdisciplinary teams and co-supervision of all PhDs. First, the work packages are designed so different disciplines will work together in addressing the research questions. Second, the PhDs will receive supervision from researchers from different disciplines. Bi-annual, working-seminars where all researchers meet for a couple of days to assure aligned approaches and understandings will be used throughout the project to support our interdisciplinary collaboration.

* 1. *Results*

The InterHUB project will provide new understandings of how household practices can be utilized in developing new energy services, building technologies and designs, and of the influential role communication plays in constituting new practices. This research will contribute to the on-going scientific and policy debates as to how to ensure a sustainable, efficient, flexible, stable and affordable balancing of energy supply and demand.

The project will develop new knowledge on households in the changing energy system, on new buildings solutions and on how different utility services impact both households and the energy system. The project will also provide new knowledge about and methods to enhance communication amongst actors involved in these transition processes.

The project will produce four PhDs and support three post docs from different disciplines, all of whom will be trained in interdisciplinary collaboration. The main scientific output will be in the form of scientific papers for peer-review journals (app. 20 articles). The project will provide practitioners within utilities, construction and building component production with insights into the dynamics of user practices and the implications this can have for them. The future workshops will provide them with insights as to various actors’ assessments of status quo and their visions for the future. Results will also be disseminated as the senior researchers in the project are frequent speakers at professional meetings in a Danish context, and are frequently cited in public media related to their research.

* 1. *Future applications and activities*

The aim of the project is to support junior scholars and develop applications for both the Innovation Fund Denmark and future H2020 energy calls within the emerging field of smart energy use in buildings and energy systems. International cooperation will be an integral part of the project, thus laying the groundwork for future H2020 applications. This will be based on nurturing and extending existing international research networks with researchers at Oxford University (Dr Sarah Darby), University of East Anglia (Dr. Tom Hargraeves), RWTH Aachen University (Prof. Dirk Müller)

University of La Rochelle (Ass. Prof Jerome Le Dreau), and University of Edinburgh (Dr Ronan Bolton). These international contacts will serve as a reference group for InterHUB, meeting once a year during the project, laying the ground for future international (EU) research applications.

1. ***Implementing the project***
	1. *Work packages: structure and content*

InterHUB is organized into three different work packages, each dealing with a specific aspect of the overall vision of actively integrating buildings into the future energy system, facilitating energy savings and an increased use of intermittent energy. The overarching research aim is to analyze the changing roles and challenges that arise from this at the intersection between building systems design; household practices, and energy provision as shown in figure 2. Each WP will involve interdisciplinary collaboration on specific research questions pertaining to each of these three intersections.



*Figure 2. Location of the three WPs, as well as the future workshops, at the intersections between the three dimensions identified as those relevant for the integration of buildings into the energy system.*

Given the importance of communication in attending to the challenges of energy transitions and the need to actively engage with the involved actors, InterHUB has selected *future workshops* as the means for interdisciplinary interaction across the three WPs. Running through all three WP, future workshops will help integrate and bring different disciplinary understandings and preferences to the forefront in InterHUB, when directions for the integration of buildings in energy systems are discussed, negotiated, evaluated and proposed implemented. The first future workshop will feed information for staging the next, and so on. Each future workshop runs over three phases – critique, envisioning and realisation – and will engage utility representatives, building designers and households in discussing technical solutions and household agency. Future Workshops have been chosen as a means to move beyond examining current practices. The future workshops will be supplemented with interviews with building technology designers and utility representatives, as well as with analyses of key documents. The analytical approach will identify different actors’ understandings of the future role of the householder in the new energy system. This will be based on semantic and conceptual coding of documents and on analyses of how different perspectives are exchanged and negotiated at the future workshops. Outcomes of the future workshops include a map of stakeholder perspectives on the household’s future role and analyses of how to improve cross-sectorial communication.

*Work package 1: Buildings and Households*

Research in this WP will focus on the relation between the household and the building systems design and how this interaction takes place depending on the type of technologies and buildings used in new smart grid settings. Focus will include understanding how new routines and practices related to buildings and technologies are developed and how these influence householders’ understanding of comfort. The study will localize new and existing buildings with different types of control systems related to heating and cooling and will investigate how indoor climate control is perceived by householders, and how this varies with different types of heating systems and different types of housing. The study will also investigate the implications of control being performed by households, utilities or other actors. The study will include qualitative interviews with householders as well as data from the integrative future workshops, especially with regard to improving technology developers’ understandings of household practices. The work will also focus on the development of a new design and evaluation framework including appropriate modelling methods, that allow for the optimal design and operation of energy flexible buildings – both existing and future buildings and building energy systems – while taking into account the impact and consequences for user practices and user acceptability of different design solutions identified in this WP. On-going work in EU H2020 project (EU H2020 Mobistyle, n.d.) on motivating end-users behavioral change by combined use of ICT based tools and information services on energy use, indoor environment, health and lifestyle will also be included to support this development work.

*Work package 2: Households and Utilities*

WP 2 will focus on what impact the changing relations between households and the energy supply system may have in terms of social and environmental sustainability. Although new business models are expected to lead to energy services, attention should also be on what social consequences they may have. What types of households are capable of reacting to and benefitting from different business models, and will this produce new social inequality in terms of e.g. comfort and health? Taking the value dilemmas of utility companies as a point of departure, this WP will also address the question of value, and the ways in which energy provision and services are made valuable for households. The study will use results from the integrative future workshops to identify focus groups with householders as well as with actors from the utilities to discuss how new services can be made valuable for the householders. Furthermore, we will utilize the extensive and unique data possibilities that we have in DK, combining the Data-hub and its hourly electricity consumption for all households with socio-economic and building data. This data will be utilized to model how different business models and pricing structures will provide different situations for different types (social classes) of households. The same data will focus on households with heat pumps, with and without own PV production, to reveal people’s willingness to adjust heat consumption to production. Finally, this data possibility will also be related to an on-going development project deploying ideas of gamification to engage households to relate their consumption to different signals of production. Results can reveal new knowledge on what type of consumers are more likely to be interested and capable of responding to this type of communication.

*Work package 3: Buildings and Utilities*

The introduction of buildings into the energy system changes ‘the system’ boundaries, and this will affect both the energy system and the ways in which building systems are designed. It is important to study both aspects and the relation between them. Hence, the overarching aim is to investigate the implications that integrating buildings into the energy infrastructure of heating and cooling can have for building design and evaluation framework. One study in WP3 will extend the developed design and evaluation framework from WP1 to include optimal building design solutions and operational strategies in providing the best flexibility services for the energy system depending on different possible approaches to utility/building interaction and on different developed business models for provision of energy flexibility. The work will include analysis of the sensitivity of optimal building design and operation to different flexibility needs of energy grids, different business models for provision of energy flexibility. The research work and outcome of an on-going IEA project (EBC annex 67, n.d.) on Energy Flexible Buildings will be integrated into this study. WP 3 will also draw on literature studies, interviews and results from the integrative future workshops to analyze how integrating buildings into the energy system challenges the utilities’ existing modes of operation, business models, and investment decisions. Special attention will be given to points of contention as these will provide important insights to how existing roles and responsibilities can be changed. The purpose is to identify new, emergent modes of operation/BM, and go into depth on how they are being developed. This will entail in-depth, interview-based studies with the aim of clarifying how utilities, e.g. district heating, in such instances create and appropriate value. The study will also investigate what influence heating system configuration has on the flexibility services being provided by buildings.

* 1. *Project management*

The project is organised with a project leader (PI), prof. Kirsten Gram Hanssen, who is supported by a management team (MT) consisting of prof. Per Heiselberg, Prof. Susse Georg, Prof. Ellen Christiansen, and Dr. Anders Horsbøl. PI will be responsible for all practical and day-to-day management, in close cooperation with the MT. MT will meet every half year during the working retreat seminars, and will furthermore have two skype-meetings a year in between the seminars.

The project is designed to creatively combine insights from the research team’s different disciplines and each WP will include the following senior researchers, with the first mentioned as main responsible for this WP:

WP1: Anders Horsbøl, Kirsten Gram-Hansen, Per Heiselberg

WP2: Susse Georg, Kirsten Gram-Hansen, Anders Horsbøl,

WP3: Per Heiselberg, Susse Georg, Anna Marszal, Ellen Christiansen, Anders Horsbøl

* 1. *Ethics*

The research of InterHUB includes empirical data collection that involves human participants. All participants will be adults, who will be asked for their voluntary participation and informed consent, based on relevant information provided to them about the project. When data about individuals’ private matters is processed, the project must notify and obtain authorisation from the Danish Data Protection Agency, which according to recent agreements will be done through Aalborg University. The Danish Data Protection Agency imposes a number of conditions in addition to the general provisions of the law that must be observed when conducting a project, including ways of collecting and storing data of both qualitative and quantitative art. InterHUB will follow all national rules as well as sound scientific guides for collecting, storing and analysing data as well as for publishing results.

* 1. *Research partners*

The InterHUB project consists of the following four research groups:

*Research Group on Urban and Housing Studies, Danish Building Research Institute.* The research group’s focus is on social and environmental aspects of housing and urban issues. A strong international agenda has been the study of households’ everyday practices related to energy consumption based on theoretical approaches from sociology of consumption, including theories of practices.

*Architectural Engineering, Department of Civil Engineering.* The division’s main research field includes analysis, design, construction, and operation of engineering systems for energy efficient buildings. It focuses on an integrated, multidisciplinary approach to achieve optimal building designs and pays special attention to building impacts on the indoor climate as well as the surrounding environment. Research has in the past 10 years been targeted analysis, design and operation of near zero energy buildings, including their interaction with users and energy systems.

*The Sustainable Transitions research group* conducts research on the organizational, institutional, and economic challenges that sustainable transitions involve in different empirical domains, e.g. energy systems, construction and the built environment. With a strong base in science and technology studies, emphasis is given to analyzing the involved actors’ actions in relation to existing governance arrangements and attempts to change them.

*Department of Communication.* Since 2005 a group of researchers has done research regarding user and citizen involvement concerning green transition and sustainability. Focus is on dilemmas in design, implementation, innovation and evaluation of digital technologies from the point of view of the end-user experience. Methodologically, communication theory, text and action is the subject for investigation, and data is collected in situ of action and analysed with actors.

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