Laboratoire des Sciences de l'Ingénieur pour l'Environnement

Laboratory of Engineering Sciences for Environment

La Rochelle University Research Chair

"Low carbon and smart district development"

Context :

La Rochelle University is launching a new research program called LUDI «Littoral Urbain Durable et Intelligent » (sustainable and smart urban littoral). This multidisciplinary project aims at strengthen the research effort of the university on the various aspects of sustainable urban development or assessment in littoral zones.
In this aspect, the building and district energy and environmental management is one of the main issues. La Rochelle University has already a real expertise in this domain through the activity developed at LaSIE "Laboratoire des Sciences de l'Ingénieur pour l'Environnement" (https://lasie.univ-larochelle.fr) a joined laboratory with CNRS.

Objective :

In this context, it is appropriate to create as a basis for this ambition a chair of excellence to establish a dynamic between the actors and to achieve the objectives of visibility and quality. The main mission that could be entrusted to this Chair of Excellence would be to contribute to the definition of theories, methods and tools adapted to a multidisciplinary consideration of the issues related to Sustainable Urban Coastal Development.
In order to boost relations between stakeholders, a first action could be the implementation of a decision-making support platform (based on the concept of a workshop area) aimed at improving, through innovation, the development and provision of urban services to users, businesses and public and private managers.
This platform would be based on multi-polar urban ecosystem modelling and would provide services for simulation, structuring, data processing and analysis as well as event analysis. This tool, and the associated approaches, would make it possible to better understand and optimize their operation and anticipate their sustainable development and the transformations resulting from innovation proposals related to sustainable development.

The design of the platform would be based on a multidisciplinary and systemic approach based on the work of researchers, the contribution of business know-how from companies and local authorities, associated public and private data and solid methodological, mathematical and IT studies and developments.
This platform would contribute to creating the conditions for the emergence of sustainable urban experimentation and innovation dynamics based on simulations and data produced by ecosystem stakeholders. Thus, it would be a tool to facilitate the socio-economic development of the various related sectors. It would make it possible to assess risks a priori and to integrate a posteriori in vivo experiments with socio-economic actors as a means of moving from the laboratory stage to a size that allows technologies to be validated under real-life conditions.

Chair area:
As mentioned above, the problem of sustainable urban coastlines is based on many fields and is therefore a priori multidisciplinary, interdisciplinary and even transdisciplinary. The Chair should therefore above all have a coordinating role in the development of the platform with all the research actors directly concerned, in particular CESI, EIGSI, Sup de Co and the University of La Rochelle.
We propose four main axes of research for the Chair, the first being multidisciplinary and integrative, while the last three are more disciplinary and oriented towards energy management in coastal buildings.

Axis 1: Install the structure of the digital platform for modelling coastal urban areas

The approach adopted will be based primarily on modelling urban and coastal ecosystems to support decision-making and will provide simulation services and tools. The systemic approach will be necessary to be able to simulate the short-, medium- and long-term impact of the planned decisions at different levels, such as the management of structures and infrastructure, networks, waste, real estate, transport, risks of flooding and biodiversity loss. Based on the data collected and through defined, analysable, configurable and reproducible scenarios, the platform will make it possible to simulate the short, medium and long-term effect of the planned decisions at different levels. To this end, the research could be based in particular on the methodology adopted as part of the European project Science and Policy Integration for COastal System Assessment (SPICOSA) and named System Approach Framework (SAF).

Axis 2: Obtaining, managing and exploiting urban data for building energy

The various sources of available and useful external data must be scanned and gaps identified. In addition to the meteorological file traditionally used in energy simulation, other data can be used to enrich the simulation. For example, averaged Meteo France data are usually used in dynamic thermal simulation, but other external data sources exist, from international projects, in-situ measurements or intensification of heat waves related to global warming (data from warming scenarios).
Where only global data are available, models must be developed to move from global data to local data, adapted to the location studied, and in particular to adapt to modulations due to local configurations. If several different types of data and models are used, a thinking must be undertaken on how the data are collected in order to be used in simulation. A second side of urban data is related to the physical data needed to enable modelling of building components, which are often difficult or

even impossible to obtain. The collection, extrapolation and storage of these data - in a structured way to allow their use in simulation - must be studied. In this context, a link must be established with existing or future tools for representing urban data or buildings: GISs (Geographic Information Systems), BIM (digital model of the building). As such, a better understanding and exploitation of data exchange standards such as CityGML for 3D urban data or gbXML for high-performance buildings must be developed. In addition, the issue of validation at the neighbourhood level is an open question. To ensure the validity of the simulation results, it is necessary to establish a validation methodology for the bottom-up approach, which is based on the assembly of elementary models of buildings interacting directly or indirectly. Obtaining data from real neighbourhoods, measured or from existing databases, is an important step in the validation process. In addition, the opportunity to use data assimilation techniques to improve a model and the results produced using real data should also be investigated.

Axis 3: Modelling the envelope, radiation and aeraulics on an urban scale

We are first interested here in the articulation between the building's envelope models and the consideration of urban radiation and aeraulics.
The conventional way of modelling the building envelope must be reviewed so that it can take into account the new data related to its environment. Two main topics emerge:

- A new approach to the thermal building model reviewed in the context of the neighbourhood. In addition to the development of elementary models coupled with urban micro-climatology phenomena, thermal zoning must be reviewed in this context of larger-scale interactions. The division of the building into thermal zones to adapt it to external boundary conditions can be done according to several strategies, depending on the available data and the type of building. The relevance of redrawing a specific building depends strongly on the building under study and the objective of the study. Although traditional choices may be sufficient in a number of cases, new rules must be established to assist in the choice of zoning, if possible automatically ;

- Building envelope models must be able to exploit the full richness of new data provided by neighbourhood-scale modelling. Opaque and glazed wall models must be able to take advantage of these new boundary conditions in terms of convective or radiative heat exchange (adaptation of convection models to walls; separation of diffuse and direct radiative flows; consideration of multi-reflection...).

The study of the neighbourhood's airflow using specific tools can help guide building modeling choices. A large difference in behaviour is to be expected depending on the energy performance of the building under study as well as the types of construction, allowing the level of detail required for the intended purpose to be chosen.
Since simulation on a neighbourhood scale can no longer be carried out by a single tool, consideration must also be given to the notion of coupling between models (e. g. coupling between buildings via specific models: street, urban canyon, thermal inertia, vegetation consideration, etc.) and coupling between tools (weak coupling via file exchange, production of graphs that can be used in 0D simulation, or strong coupling via co-simulation). In addition, different temporal and especially spatial scales can be used in the modelling at the neighbourhood level, similar to the traditional building thermal approach (nodal, zonal approach, finite differences, etc.). A thinking must be carried out on multi-scale simulation, in particular the possible interfaces and couplings between 3D and 0D, passing if necessary through intermediate scales.

The air component must be taken into account both outside the building (for its energy impact, in particular by taking into account the effect of wind), and inside the building (for the study of indoor air quality or ventilation operation). The way to model the interface between internal and external airflow is still an open problem. In addition, the interest of taking into account the humidity in external aeraulics must be studied, in particular in the case of buildings with hygroscopic components.
Beyond the impact of its environment on the building under study, it also seems important to study the opposite problem, i.e. the impact of the building and its emissions (energy and mass) on the local microclimate, following its establishment in a block.

Axis 4: The building as a node of the energy network: heat exchanges at the district level, sensitivity and optimization

Buildings can be placed in the broader issue of energy transfers at the district level: in this perspective, they are nodes of the energy network, with consumption, decentralized production, energy storage or control capacities. These can be optimised in order to maximise the energy efficiency of the district or the exploitation of the energy resources available. Neighbourhoods are often conventionally represented by "energy well" buildings, connected by networks in a unidirectional way. In order to overcome these representations, which are no longer suitable for new/positive energy buildings and districts, this work is based on the new models and data described in axes 1 and 2, and then aims to complete these models with the elements necessary for a global energy simulation: system models, ventilation, storage, heating networks...