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# User experience inquiry to specify COFFEE: a Collaborative Open Framework For Energy Engineering

Sacha Hodencq – Fabrice Forest – Théo Carrano - Benoit Delinchant – Frédéric Wurtz

**Abstract** The aim of this article is to introduce COFFEE, a concept of open and collaborative platform in the field of electrical engineering. The platform intends to make energy research accessible, and improve collaborations between researchers, public authorities, design offices and citizen collectives. The COFFEE concept is presented supported by a literature review on open energy modeling and collaborative platforms. Following a "user experience" inquiry conducted with a representative panel, the results are used to specify a first implementation of the COFFEE concept, and can serve as guidelines for the implementation of open energy modelling platforms. These platforms could become the spearheads of electrical engineering laboratories, promoting reproducibility and collaborations between energy stakeholders.

## 1 Introduction

In the current context of climate change, the transition to energy systems combining the three pillars of sufficiency, efficiency and consistency [1] represents a major challenge for the scientific research. The electricity field can face this challenge with energy modelling, in order to understand and size new sustainable energy systems, taking into account cross-sectoral interactions. While the study of sustainable energy systems is essential, this major challenge of the energy transition invites scientists to open up and pool their research. Collaborative platforms incorporating open energy modelling principles can be the place for this shift.

In this article, we introduce COFFEE (Collaborative Open Framework For Energy Engineering), a collaborative open platform that aims at making research works accessible to peers as well as public authorities, design offices and citizen collectives. We first present the interests of open energy modelling and the characteristics of collaborative platforms, before introducing the concept of COFFEE. Finally, we present the associated main conclusions of a user experience inquiry that was carried out to design the platform, in the form of 12 recommendations.

## 2 Collaborative platforms for open energy modelling

### 2.1. Interests of open energy modelling

Institutions such as the European Union [2] and the UNESCO [3] are increasingly asking for transparency and open science practices. Yet, historical and current mainstream approaches in energy modelling are proprietary solutions and lack transparency [4]. Rather than being subjected to coming binding jurisdictions, researchers could embrace open energy modelling that comes with many interests. Here, we refer to "open" as models, code, and data that can be freely accessed, used, modified, and shared by anyone for any purpose [5].

First, openness and transparency facilitate peer reviewing and models comparison in the scientific community, as well as the identification of biases, errors or even fraud [6]. It also improves collaboration and reduces parallel efforts in the research field, but also with other stakeholders such as public authorities through a share of both methods and quantitative work [7]. When it comes to designing sustainable energy systems in a variety of contexts, open-source enables to easily add and discuss specific features [8]. Open energy modelling tools meet high standards [9]: they are highly maintainable as well as continuously

improved [10], and their source code remains available over time with respect to proprietary software.

Openness also lowers barriers for adoption relative to conventional proprietary solutions [11], and improves comprehensibility [12]. Since the outcomes of energy systems studies can shape energy policies and affect the public, opening up these studies can enable the affected stakeholders to participate in the decision-making process [13], which has been identified as a key for the success of energy transition projects [14]. Furthermore, transparency provides reliability to scientific arguments in public debate of energy transition and enable public engagement [15] that can lead to virtuous behaviours. Finally open collaborations favours user-centred innovation with faster development cycles, increased interoperability and cost savings [16].

The main interests of open energy modelling by audience are presented in Table 1.

**Table 1** Main interests of open energy modelling by audience

Researchers	Public authorities and design offices	Citizen collectives
Reducing parallel efforts Useful, accessible and sustainable models with specific features Peer review, identifying and reducing biases, errors	Tools for the study of energy projects with low barriers for adoption Education, awareness and involvement, that can lead to virtuous behavioural responses	
Improved collaboration between science and policy makers. Transfer, valorisation, innovation		Equipping and accompanying citizens
Scientific credibility in the public debate, comprehensibility of energy studies Linking science and society		

### 2.2. Including human actors in the design process

The previously mentioned interests of open energy modelling reflect the importance of taking human actors into account to improve design processes, in addition to technical considerations alone. I.e., going from a positivist epistemology to a constructivist one, where knowledge and especially models, depend on the objective and context of the modeller [17].

In addition to making energy modelling accessible in legal, financial and technical terms with free and licensed open workflows, these workflows should also be accessible in terms of understanding for the human actors. This includes user-friendliness features such as intelligibility and debatability of knowledge, graphical user interfaces, and abstraction levels close to the stakeholders' understanding when developing energy models [18]. Such features can answer particular issues in the field, such as the lack of permanence of methods and tools following their developer departure from a research team.

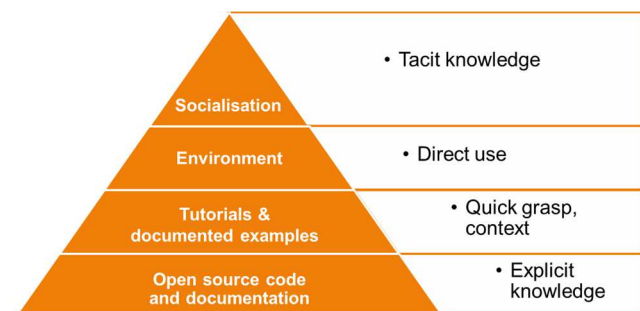
More generally, this accessibility need can be answered with online collaborative platforms.

### 2.3. Characteristics of online collaborative platforms in the energy field

Online collaborative platforms enable scattered researchers to cooperate and share research objects as well and ideas and experiences. Collaborative platforms are usually online services ranging from extensive virtual research environments (VREs) that include various features to facilitate sharing and collaboration (accessing data, software, and processing resources), down to single specific tools that enable researchers to work together on specific aspects of research [19].

In the energy field, online collaborative platforms can address the issues of transparency and replicability [4], by making open energy modelling principles the norm and facilitating transfers of knowledge.

Figure 1 presents essential concepts for the dissemination of an online collaborative platform in the field of open energy modelling. Documented and versioned open source tools form a basis, where tutorials will allow to quickly grasp the functionality and uses of the models [4]. Documented examples including the context and workflow of the use case from raw data to open access results improve knowledge capitalisation through context understanding [20]. A runtime environment will allow direct use of the tools [21]. Finally, synchronous or asynchronous socialisation means such as forums, if used by a sufficiently large community, can connect communities of energy model developers and users, and thus capture and disseminate both explicit and tacit knowledge [22]. Such platforms enable community building, transparency and legitimacy of studies and participation. Community of actors can then form between these platforms, such as *openmod* [23].



**Fig. 1** Basic concepts for the dissemination of online collaborative platforms. Source: Author

### 3 Collaborative Open Framework For Energy Engineering (COFFEE)

#### 3.1. COFFEE concept

COFFEE (Collaborative Open Framework For Energy Engineering) is a concept of online platform with the double objective to create a link between open energy modelling functions, and between energy stakeholders. It can be seen as a showcase for laboratories to present their energy research in an open and accessible way for stakeholders. The stakeholders include researchers of course, but also public authorities, design offices and citizen collectives. Many tools and platforms already exist in the energy field such as the Open Energy Platform (OEP), EMP-E [24] or besos [25]. COFFEE is a platform concept focusing on user experience and collaboration between stakeholders. It is a simplifying proposal that plays a role of integrator to bring coherence and legibility to the different functions. These functions include open data access and management, open energy modelling tools, open access papers as well as socialisation to improve synergies, and potential additional features such as open teaching materials or open hardware. COFFEE main functions are displayed in Figure 2.

The core of COFFEE is a use cases library, since use cases are thought as an intuitive way of accessing research work and improving reproducibility. Each use case is developed following Open and Reproducible Use Case for Energy principles [20], that is to say from raw data source and management to results interpretation and article in open access, developed with open source models. Use cases also explicitly indicate the study context with its objectives and assumptions. The use cases are presented in Jupyter Notebooks that can be directly understood, adapted and used online [26]. Thus, a use case can be used as an intermediary object to explore energy scenarios with an intermediate level of complexity for the workflow and results. It is also a gateway to collaborate and exchange with professionals, tackling information asymmetry.

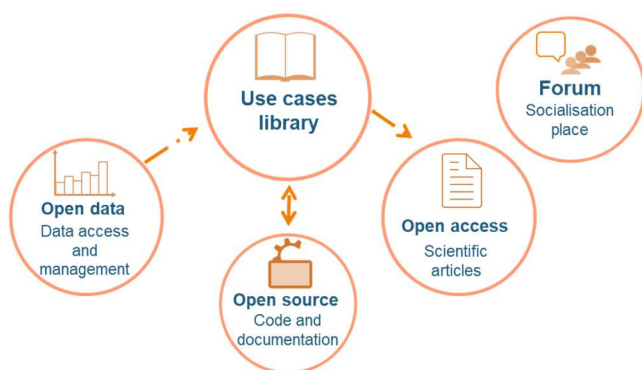


Fig. 2 COFFEE main functions. Source: Author

#### 3.2. COFFEE implementation

While the implementation of a first version of COFFEE platform is underway, previous work presented the use case of a dwelling photovoltaic self-consumption [20] that can be translated in the functions of COFFEE.

The library would include this dwelling PV self-consumption use case with a directly usable notebook (available in the Supplementary Materials section). The notebook presents the sources and management of the load profile, PV profile and greenhouse gas data, the main assumptions and methods for the energy modelling with the use of the Mixed Integer Linear Programming modelling tool, OMEGAlpes [18], as well as the results and interpretation. A user can also directly find the open data and open access article in the associated sections. The use case and the tools such as OMEGAlpes will be presented in summary forms based on the Open Energy Platform *fact sheets* and on interdisciplinary research work from the Eco-SESA program<sup>1</sup>. The introduction of forms, presenting a clear, understandable and available representation of the models, can significantly improve transparency [27]. Moreover, developers can add their own use case, tools or data sets through these forms to contribute. Derived teaching materials are also accessible, such as an introduction to open energy modelling taught to architecture students. Finally, the model developers and users can exchange asynchronously on the online forum about the use case with its specific functions, or general issues about self-consumption.

#### 3.3. CAUTIC inquiry: method and results

A study was led to qualify the relevance of the COFFEE platform concept for the stakeholders, and to contribute to the research on collaborative open platforms in the energy field. In other words, the aim was to ensure future COFFEE platform instances would be usable, used and useful, going beyond the authors common sense. An inquiry was carried out using the CAUTIC method [28]. CAUTIC is a user experience qualitative method that is used to explore criteria for the meaning of use. These criteria are divided in 4 categories:

1. Banalisation (*how does it work?*): assesses the possibility for the user to assimilate the innovation into his customary technical know-how
2. Hybridisation (*what does it do?*): assesses the possibility for the user to associate the innovation with his existing practices.
3. Active identity (*who is it for?*): evaluates the possibility for the user to appropriate the innovation to his private and professional identity.

<sup>1</sup> Eco-SESA research program website:  
<https://ecosesa.univ-grenoble-alpes.fr/>

4. *Integration in the social environment (how does it fit in?):* evaluates the possibility for the user to adapt the innovation to his private or professional environment.

The method first consisted in the formalisation of the use value for the COFFEE concept and presentation of usage scenarios, before carrying out 15 interviews (in addition to two test interviews) with energy stakeholders including:

- researchers (4 interviews),
- public authorities (3 interviews) and design offices (3 interviews),
- citizen collectives (5 interviews).

While the sample group is not as representative as it is in quantitative surveys, the twenty hours of interviews with representative user profiles enable to identify and to characterise the decisive factors for COFFEE adoption but not to quantify their weight in the expected success.

After the interviews analysis, the results consist in the identification of the attractors of use and the conditions for the use of COFFEE. Based on this, recommendations for improvements. The overall assessment of the inquiry reveals very few barriers to the adoption of the COFFEE platform. The points of tension are more related to conditions of use and not to barriers. Researchers are the most likely to use COFFEE, while members of collectives are the ones who have the most conditions of use. In general, the aggregation function of COFFEE makes sense but raises the question of potential duplication with existing systems. The library of case studies is a relevant approach but encouraging the user input is a real issue. Animation is an interesting perspective to develop collaborations. Finally, the question of the economic model of COFFEE is not to be underestimated, as users need visibility in order to engage in a contributory logic. This also raises the question of the human resources that would need to be made available to run the network and manage the data on the platform.

Twelve thematic recommendations have been built at the end of the analysis, based on the matching between the users' expectations and conditions to use:

1. *Improve communication on the integrator role of COFFEE:* adopt a partnership approach with the actors who are already carrying out initiatives, proposing new resources only to create added value to what already exists (e.g., through openness), and offer guidance features in the complex ecosystem of energy modelling for the access to resources to be inclusive.
2. *Position COFFEE in an open science dynamic for energy transition stakeholders:* positioning the platform as providing existing scientific knowledge and highlighting the reciprocity of the research carried out in the field, thus sharing the operational benefits for the territories. An interesting trail could be to identify future challenges and locks arising in the field in the short and long term.

3. *Strengthen COFFEE's perspectives in terms of its economic model:* reassure on the minimum means of perpetuation of the platform, and on the open model of research results, so that the user has sufficient confidence to contribute.

4. *Unlocking the stock of individual resources:* prospecting to uncover a pool of both formal and informal scientific resources for collaboration, and encourage sharing by raising awareness on open science practices.

5. *Organising data:* offering a standard formalisation framework to ease inputs and to make resources identifiable and usable, according to various criteria such as peer rating, Technology Readiness Level, level of difficulty, etc...

6. *Propose verification and certification of data provided:* positioning as a trusted network through its neutrality, to guide and make energy studies reliable.

7. *Facilitate the COFFEE network:* promotion of new contents and facilitation of thematic workshops, thus bridging the gap between communities on operational issues and concretising the transfer of research.

8. *Clarify the positioning between proven vs. innovative solutions:* positioning the platform according to the solutions level of maturity. It can be key for the implication of actors such as design offices, in accordance with their open or closed model strategy.

9. *Support the development of the skills of novices in the groups,* with entry-level resources. Also, offer collaborative skills building for professionals.

10. *Supporting the relationship between the conurbations and small local communities:* while urbanised conurbations usually already benefit from an expert network linked to the research field, small local communities could benefit from the platform to access resources for new projects or citizen actions.

11. *Balancing socio-economic resources and technological solutions:* solutions related to socioeconomic issues are tough to find for stakeholders and often more relevant than technological solutions. An interdisciplinary link with social, economic and legal research, as well as feedbacks on financial and organisational models should be welcome on the platform.

12. *Implement a search engine and/or human resources:* given the high quantity of resource and the variety of level of expertise, either a dedicated search engine and/or human resource could help in the indexation and mediation.

These results and recommendations will be used for the implementation of a first version of COFFEE instance to be as relevant as possible for stakeholders. The order in which the recommendations are presented corresponds to the order

of priority given for this first implementation in the Grenoble Electrical Engineering laboratory (G2Elab). The Table 2 presents the details of occurrences by profile for each recommendation: that is to say the volume of occurrences of an expression of need or improvement to COFFEE by respondents.

**Table 2** Occurrences of recommendations by audience

Recommendations	Research (4)	Public authorities and design offices (6)	Citizen collectives (5)	Tot. (15)
<b>1. Integrator</b>	2	3	4	9
<b>2. Positioning</b>	2	4	2	8
<b>3. Economic model</b>	-	5	1	6
<b>4. Unlocking</b>	3	1	-	4
<b>5. Organising data</b>	2	4	3	9
<b>6. Verification</b>	1	5	1	7
<b>7. Facilitation</b>	3	5	5	13
<b>8. Innovative?</b>	-	2	2	4
<b>9. Support</b>	-	2	3	5
<b>10. Local communities</b>	1	4	2	7
<b>11. Balancing</b>	2	3	5	10
<b>12. Human resource</b>	2	1	5	8

#### 4 Discussion and perspectives

First, a distinction should be made between the COFFEE platform concept on the one hand, which is fed by literature, authors work and the inquiry results, and implementations of COFFEE platform on the other hand.

The first implementation of COFFEE platform will obviously not cover all the recommendation from the CAUTIC inquiry but rather be used as a first operational version of the COFFEE concept and a showcase for open energy modelling use cases. The order of priority of recommendations for this implementation was made according to our objectives and resources. Even if most improvements are expected from citizen collectives, public authorities and design offices, the recommendations aimed at improving the user experience of the researchers' profile was first prioritized. It is of strategical importance for the development roadmap of an open science platform to ease the inputs coming from scientists. The next step will be to consider the expectations of the citizen collectives, public authorities and design offices. So the recommendations feed the G2Elab's strategy to design COFFEE.

For other use of the COFFEE concept, other priorities could be given to the recommendations depending on the context. Table 2 can help regarding the representativeness of recommendations in the targeted audiences. Regarding these results, biases exist given the low number of participants and the way it gives a weight to each

recommendation. The role of a user centric method such as CAUTIC is to reveal the expectations of the user profiles to the designer but the user needs are not the design strategy. Regardless the weight of the recommendations, it shows what the designer has to improve depending on the targeted profile.

If the analysis of the inquiry and the recommendations represent first results, further validations need to be addressed. Methodologies exist [12] and have been applied to quantify the transparency, reproducibility and quality of open science approaches: self-assessment is indeed essential in this field. The durability of the platform implementations is also an important matter since it is related to the users confidence in the solution. This will be addressed on the long run, with community development around the platform. An additional challenge is the effort of digital sufficiency in the development and use of online platforms [29], to ensure that the progress made in energy transition projects is not wasted. Finally, short-term perspectives include the development of forms for the use cases and tools, and the implementation of a first version of COFFEE. Such a platform will enable to experience actual user feedbacks, and to develop collaborative design, methods and models with users from the various audiences. Including the user from the early steps of the design phase makes it possible to take into account his habits, with systems that are adapted, adopted and not too complex. It can also foster virtuous energy behaviours and be a source of innovation.

#### 5 Conclusions

This article presents the interests of online collaborative platforms in the energy field, with a focus on open energy modelling practices. It introduces COFFEE, a concept of energy modelling platform that aims at making studies and associated resources accessible for stakeholders. A qualitative user-experience inquiry was carried out to qualify the user experience of the platform, and the analysis results and recommendations are presented. Beyond the single implementation of a platform in the G2Elab; the COFFEE concept and associated inquiry results are intended to be used for the dissemination of open energy modelling platforms.

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#### Supplementary materials

To access the notebook discussed in section 3.2:

[https://gricad-gitlab.univ-grenoble-alpes.fr/omegalpes/omegalpes\\_examples/-/blob/846814ba1c42309642f1032c188d2bbb94ca2435/not\\_ebooks/article\\_2021\\_BS\\_ORUCE.ipynb](https://gricad-gitlab.univ-grenoble-alpes.fr/omegalpes/omegalpes_examples/-/blob/846814ba1c42309642f1032c188d2bbb94ca2435/not_ebooks/article_2021_BS_ORUCE.ipynb)

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