CHAPTER 13

Lessons Learned Establishing a Dialogue Between the Energy Industry and the Meteorological Community and a Way Forward

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Abstract Work at the nexus between energy and meteorology aims at integrating meteorological information into operational risk management and strategic planning for the energy sector, at all timescales, from

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long-term climate change and climate variability to shorter term local weather. Weather and climate risk management can be a powerful instrument for development—not only for building energy system resilience and thus mitigating the effects of adverse events but also for ensuring that opportunities for enhanced system efficiency are exploited. The collaboration between energy and meteorology has a long history but has recently been strengthening, particularly in response to the new challenges posed by climate change and the necessary development of low-carbon energy systems. An efficient integration of high-quality weather and climate information into energy sector policy formulation, strategic planning, risk management and operational activities now, more than ever, requires improved understanding and communication between energy and meteorology specialists and decision makers.

Keywords Climate change • Energy systems • Meteorology • Risk management • Strategic planning • Resilience • Weather and climate services

Lessons Learned in Energy and Meteorology

Examples and lessons learned have been presented in the preceding chapters. Here we attempt to summarize them, highlighting the key messages in the interaction between the energy sector and the meteorology community. The objective is to strengthen this relationship so as to achieve improved resilience and efficiency of energy systems, informed by weather, water and climate services, based on a strong scientific foundation.

Improving the Communication Between Providers and Users

As advocated by the UN's Global Framework for Climate Services[1] (GFCS) (WMO 2011, 2017), evaluating the benefits of a new meteorological product for the energy industry requires good understanding between all the actors along the energy systems value chain. But, even more importantly, a fluid communication is extremely important at the early stage of the process, to understand the needs, propose the relevant solutions and work in a co-design approach. This is a field that has been further explored in depth only in the last several years, through a range of initiatives and projects, in particular but not only via the development of climate services. The EUPORIAS project,[2] for example, developed semi-operational climate services underpinned by a co-design approach. The co-design of climate services, understood as the process through which the service is defined and developed together with the end users (and other relevant actors), is perceived as an essential step for delivering successful services that adequately respond to users' needs and requirements with regard to climate data and information (Mauser et al. 2013; Troccoli et al. 2010; WMO 2011, 2017). One essential component of the co-design approach is an effective engagement and communication between the providers and the users (Brooks 2013) alongside other critical aspects such as fully understanding the scope of the climate service, the involvement of all relevant actors, a degree of flexibility and iteration in the developmental process and the continuous evaluation of the service being developed (Buontempo et al. 2014).

In the last decade or so, the links between energy and meteorology have also been developed in several international conferences, with the organization of specific energy meteorology symposia. These are now established at events such as the American Meteorological Society annual meeting[3] and the European Meteorological Society conference,[4] where the energy meteorology session has been more and more popular in the last few years. But academics still represent the largest portion of attendees at these meetings, with fewer people from the energy industry. Some more specific conferences are successful in bringing together academic and industry people (Wind Europe[5] is one of them), whereas targeted working groups (e.g. the Utility Variable Integration Group, UVIG[6]) are very successful in getting scientists, private sector service providers and energy practitioners focused on specific problems.

To our knowledge, the International Conference on Energy & Meteorology[7] (ICEM) is at present the only sustained process within the last ten years aiming at bringing meteorology and energy experts together, with the goal to cover both weather, water and climate sciences and services, and all the fields of activity in the energy value chain, even if, due to the initial structure of the network, the wind and solar aspects of the power sector were dominant at the beginning. Since its first edition in 2011, a growing network of specialists working at the nexus between energy and meteorology (weather, water, climate sciences and services) such as energy regulators, economists, planning officers, water experts, financial and insurance brokers, utility engineers, transmission and distribution operators, meteorologists, climatologists, service providers, policy makers as well as energy industry executives, have been gathering every two years. Building on its successes, ICEM's sustained process is now providing a premium international platform with excellent networking opportunities amongst the ca. 200 participants at each conference as well as a source of the state-of-the-art in the science, policy, planning and operations in energy and meteorology. Based on the discussions during ICEMs, and parallel activities in between, an international, non-profit organization was established in 2015 to go one step further: the World Energy and Meteorology Council[8] (WEMC) is devoted to promoting and enhancing the interaction between the energy industry and the weather, water, climate and broader environmental sciences community as the stakeholders of a resilient energy services value chain under an ever changing climate. Both ICEM and WEMC were presented in Chap. 5 of this book.

Improving Decision-Making Processes

Improving decision-making processes is crucial and relates to the effective integration of improved data/forecasts/products developed operationally by the meteorology community. When the target is to improve the quality and accuracy of an existing product purely from a meteorological perspective, the improvement tends to be easier to achieve. This is the case, for instance, if an improved version of a weather model reduces the forecast error for air temperature. However, with the additional step of using the meteorological variable in a specific context (e.g. the use of air temperature to compute energy demand) or in a more complex manner (e.g. using a probabilistic forecast instead of a deterministic one), the improvement is more difficult to assess. Not only is the decision process changed, because different or additional information becomes available, but also decision-making tools may need to be adapted, or even fully redefined to be able to use the new information. Decision-making tools and processes then become more complex and in most cases the underlying meteorological product development or improvement represents only a portion of the final decision or outcome.

The first implication of the interplay between the meteorological input and the final decision is that more time is required to develop the meteorological product as it must fit the decision process in the best possible way, even if both sides—the meteorological product development and the energy decision—can be addressed in parallel, at least partially.

The second implication is that, prior to the adoption of the new product, its added value must be demonstrated, and hence the methodology to enable this demonstration needs to be defined at an early stage. This requires definition of the goal to be pursued and the objective criteria that will allow the assessment of the solution.

And then the third implication is that specific people and skills are required in the process. These experts must, collectively, be able to understand every component of the energy services value chain and must be able to interact with each other in a dynamic way covering the spectrum from the meteorological side to the final energy services at the user level. Most of all, there is a need for experts with skills to implement an objective method to evaluate the benefits of the new product. Evaluating a decision-making process, and if/how/why it should or should not be changed, is a specialist field in itself. In some companies, these skills do not exist and external experts are therefore required.

In particular, it must be shown objectively that the new decision-making process, and not only the new meteorological product, adds some value to the final decision. It requires a proof that the new approach is more beneficial than the existing one. This means that the evaluation process must be completed from the application point of view and not only from the meteorological perspective. A common mistake has been for meteorologists alone to evaluate a meteorological product from the meteorological point of view and to decide on its usefulness based solely on the meteorological performance assessment, as mentioned above. This can be misleading. Indeed, even small improvements in meteorological forecasts can result in significant added value from the end user point of view, as the transformation from meteorology to energy can be nonlinear. In addition, there is generally an asymmetry in weather-dependant processes: for instance, energy demand is very sensitive to cold temperature in France in winter, but not so much to mild temperatures (Dubus 2014). A slight improvement in cold temperature event forecasts can therefore be very valuable, while a larger improvement on mild temperature events might be irrelevant in this context.

Aside from asymmetries, and more generally nonlinearities, in the meteorology-energy transfer functions, an important consideration when focusing efforts in meteorological model improvements, is that the most benefit is not always where one would commonly expect it, such as in the performance of simulating extreme events. A case in point, in the context of construction and operations and maintenance of offshore wind farms, is that enhancements to the performance of wave models should be focused most usefully upon the narrow wave height range which determines whether work can or cannot be safely conducted, rather than on very large or very small waves (Dorling and Bacon 2017). As a generic principle, the evaluation should then always be made all along the chain, from the meteorological input to the final decision, and compared to the user's current practice. The final added value will be a mix of the meteorological value and how it enhances the user decisions. This approach has also recently been implemented more frequently in government sponsored projects (Haupt et al. 2017).

It becomes even more complex when the new meteorological solution changes in nature. Many times we have heard dialogues in which meteorologists, to answer a temperature forecast quality issue for two weeks ahead, emphasized that the user should move from deterministic forecasts to probabilistic forecasts because, due to uncertainties in the initial conditions and to nonlinear effects in the equations, and many other excellent scientific arguments, it does not make sense to use deterministic forecasts beyond three to four days' lead time. End of discussion. But moving from a deterministic temperature forecast to an ensemble prediction is not a mouse-click story when one considers the whole decision process. First there are computational issues, in particular in large companies, where there are often many dependencies between different models, decision tools and processes and reporting tools. But the most significant barrier often comes from the users' reluctance to adopt new kinds of information, especially if it is probabilistic rather than deterministic. Efficient and informed use of probabilistic weather and climate forecasts has significantly advanced in the energy sector, but there is still a natural mistrust, which is quite surprising as energy people are used to dealing with uncertainty for other variables, especially in finance and market operations. Therefore, training and education about probabilistic weather and climate forecasts must remain a key component for the effective integration of better weather and climate information in energy system decision-making processes.

Looking Ahead in Energy and Meteorology

As exposed above, energy and meteorology is an interdisciplinary area which offers exciting but complex challenges. Experts have been working and providing solutions for many years now (e.g. the ANEMOS' wind power forecasting system developed in the early 2000s by a European partnership). However, it is also clear that much more needs to be done. It is also becoming more evident that solutions, such as development of tools, require enhanced co-design and co-development between meteorologists and energy experts. In the context of climate services, the EU Copernicus Climate Change Service (C3S)[9] Programme is pioneering such an approach. Amongst the C3S projects, the European Climatic Energy Mixes[10] (ECEM) service is producing, in close collaboration with prospective users, a proof-of-concept climate service—or demonstrator. This C3S ECEM climate service demonstrator, comprising a set of tools, including an online web interface, for improved assessment of energy mix options over Europe, has been co-developed from scratch with extensive input from prospective users engaged through expert elicitation workshops and direct contacts. The main purpose of the C3S ECEM Demonstrator[11] is to enable the energy industry and policy makers to assess how well energy supply will meet demand in Europe over different time horizons, focusing on the role climate has on energy supply and demand. These are the types of activities that greatly enhance collaboration between energy and meteorology and at the same time produce valuable tools for decision making in the energy sector.

Other activities which foster collaboration, encourage critical thinking and promote innovative solutions are working groups within an organized environment. For instance, WEMC has recently launched its membership[12] which, as one of its core objectives, encourages meteorology and energy experts to engage in Special Interest Groups (SIGs).[13] The SIGs are vehicles leading to the production of reports, analyses and syntheses on key topics in energy and meteorology, which will ultimately assist the energy industry in addressing resilience, efficiency, mitigation and adaptation challenges.

Major Challenges to Be Addressed in a Co-design Approach

The Paris Agreement at COP21 has established a framework. Its impact depends on how the goals will be translated into real government policy actions. Nonetheless, the energy sector faces a critical need to transition from a carbon-based energy model to a decarbonized energy world. Low-carbon energy generation and energy efficiency are already key in this new paradigm. Hence, addressing the Energy Trilemma will require improved weather and climate information. A strong growth in renewables has already begun in electricity production and must continue; their contribution now needs to develop significantly in heat and transport (IEA 2016). As electricity is the easiest energy generation source to decarbonize, its share in the global energy production is expected to double in the next 50 years or so. The growth in solar and wind energy will continue. This will create new opportunities, for instance:

- The need for innovative solutions from start-ups and SMEs, in storage solutions and in smart management of energy systems at local to global scale;
- Job creation: the renewables sector is estimated to currently employ 8.1 million people (not including large-scale hydropower), plus an extra 1.3 million in large-scale hydropower (REN21 2016), and thousands of new jobs will be created by new projects;
- The development of distributed renewable energy will increase energy access, especially in the Asia-Pacific region and sub-Saharan Africa, where most of the 1.2 billion people who do not currently have access to electricity live.

But there will also be new or increased risks:

- The increasing share of wind, solar and hydropower is and will be reinforcing the dependence of energy systems on knowledge of climate variability and climate change. «Classical» energy systems need to become more flexible and to account for renewable variable generation (Cochrane et al. 2014). Hence, observational and forecasting capacities of the relevant variables need to be improved, on the necessary time and space scales. This includes local and high frequency wind and solar radiation forecasts, which are becoming more and more critical as the underlying variability poses problems to grid management, to ensure the real-time balance between consumption and production. Among the more specific challenges, one can (non-exhaustively) list:
  - Improved and more accurate characterization of past climate, especially in order to adequately assess wind, solar and hydropower resources. In addition to field campaigns during the due diligence stage of proposed projects, it is more than ever necessary to have multidecadal reanalysis at high spatial resolution, and at

least hourly time step, to correctly assess the future performance of wind and solar farms. This allows better shaping of plant characteristics, and assessment of project bankability, ensuring a good return on investment, which is essential to make the sector profitable, and finally to improve its competitiveness with respect to other production means.
    - Very short-term wind and solar radiation variations, on timescales of a few minutes to two to three hours. Ramp events, in particular, can destabilize power systems as they require a significant increase or decrease in production over short periods, to compensate renewables variability.

- Improved demand and generation forecasts on a few days to a few weeks, for optimized unit commitment planning and energy market operations. One key issue at the moment lies in the frequent jumpiness in successive weather forecasts, that is to say when consecutive forecasts give a different trend over the coming days. Reacting to these changes in real time often requires the buying/selling of energy in a sub-optimal way, leading to unnecessary expenditure.
- On longer timescales, from a few weeks to several months, improved sub-seasonal to seasonal forecasts would allow better planning of generation unit maintenance, and management of energy stocks, in particular hydropower capacity in large reservoirs.
- Of course, on longer timescales, energy companies and policy makers need improved information on the possible impacts of climate change on energy assets, and how future operations and systems management need to be adapted. This includes information on future means and extremes of different climate variables, together with the expected changes on the variability itself, as for instance a change in seasonality in precipitation will impact the yearly management of large reservoirs. Downscaling is of course a key issue because information is needed at a scale as close as possible to individual plants.

One could list many other examples of benefits arising from improving weather, water and climate information for the energy sector, and some of the other chapters of this book do so, building upon Troccoli et al. (2014). But, as mentioned in the previous section, improving weather and climate forecasts is not the only key to enabling more secure, more affordable and sustainable energy systems and services. Each component of the system needs to be taken into consideration in a global and integrated approach. For instance, the technical and economic analysis of the European electricity system with 60% Renewable Energy Sources study (Silva and Burtin 2015) shows the complexity of such an analysis, which requires many sources of information and different model components, with many interconnections between them. Improving the decision-making processes and the communication channels between energy and meteorology specialists is thus very important to ensure a coherent approach all along the chain. Therefore, a more effective integration of weather and climate information in energy systems requires:

- Improved communication between communities, at different levels (technical, managerial and decision/policy making). This should reduce the language gaps and enable a more rapid design of fit for purpose solutions.
- Common training programmes to inform energy people on weather and climate on the one side, but also, on the other side, for meteorologists to better understand how energy systems work, and how their inputs can be tailored to enhance operational models and decision chains.
- Closer and more responsive relationships between energy and meteorology people.

Among several other organizations, the World Business Council for Sustainable Development (WBCSD) emphasizes that pooling learning, exchanging best practice, sharing resources and encouraging mutual aid can benefit electric utilities and their stakeholders, as well as public authorities and consumers (WBCSD 2014). Increased sectoral and cross-sectoral collaboration is essential in moving forward and tackling the energy trilemma. Energy is now at the core of major programmes like the GFCS[14] and the C3S. Organizations with a strong interest in energy and in the role weather and climate have on it, such as WBCSD, the World Bank's Energy Sector Management Assistance Program (ESMAP), the International Renewable Energy Agency (IRENA) and WEMC, will play an important role in the future: to help develop science-based and user-driven solutions, for an effective integration of high-quality weather, climate and other environmental information into energy sector policy formulation, planning, risk management and operational activities; to better manage power systems on all timescales and strengthen climate change mitigation and adaptation.

Notes

1. http://www.wmo.int/gfcs/.
2. http://www.euporias.eu/.
3. https://www.ametsoc.org/ams/.
4. http://www.emetsoc.org/.
5. https://windeurope.org/.
6. http://uvig.org/newsroom/.
7. http://www.wemcouncil.org/wp/conferences/.
8. http://www.wemcouncil.org/.
9. http://climate.copernicus.eu/.
10. http://ecem.climate.copernicus.eu/.
11. http://ecem.climate.copernicus.eu/demonstrator/.
12. http://www.wemcouncil.org/wp/about/membership/.
13. Typical SIGs could focus on (1) Weather/Climate Forecast/Projections for Energy Operation and Planning; (2) Grid Integration; (3) Data Exchange, Access and Standards; (4) Energy & Meteorology Education.
14. http://www.wmo.int/gfcs/.

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