Towards a Research Agenda for Digital Twins of the Netherlands' Energy Systems

Our “Towards a Research Agenda for Digital Twins of the Netherlands' Energy Systems” proposal, promised to host two national workshops around the vision of the research agenda to achieve the development of a national digital twin of the Dutch energy system. Both workshops were successfully held at the Van der Valk Hotel Utrecht on the 18th of February, 2025, and the 8th of March, 2025. Participants of both workshops included Dutch researchers, industry partners, and research and innovation stakeholders (i.e., NWO).

The first workshop was focused on developing a common understanding of digital twins in the energy sector. As a result of an extensive co-creation session, a common definition was proposed by the participants, stating that “*A digital twin (DT) is a virtual representation of a physical system, process, or entity, connected through real-time or historical data, with capabilities to simulate, analyze, and optimize its performance*.” In different working groups, participants discussed perspectives and aspects of DTs, including their functionality, purpose, data and connectivity requirements, application and use cases, and levels of detail and fidelity. During this first workshop, the presentations by Matija Naglic (Business Developer, System Operations, TenneT TSO) and Bedir Tekinerdogan (Full Professor and Chair of Information Technology, Wageningen University) generated 117 questions, some of which were answered during the Q&A. The essence of the questions for Matija revolved around the design, implementation, governance, and impact of DTs in the energy sector, particularly for Transmission System Operators (TSOs) and energy infrastructure. The essence of the questions for Bedir revolves around the technical, theoretical, and practical evolution of DTs, particularly in the context of AI, scalability, validation, and future research directions. Additionally, participants identified 139 stakeholders required to develop a national DT. For 49 of them, we identified “What problems do Digital Twins solve for them?” and “How do they use these tools?”. A clustering of the stakeholders in broad groups based on their roles and interests was also developed.

During the second workshop, participants were asked to draw their favorite piece of architecture and name the components. After identifying and discussing the architecture's attributes, the participants shared their key insights. The second workshop featured a presentation from Tony Xiang (Alliander) and Robert Vrancken (CEO, Gradyent). After the presentation, Tony answered 27 questions. These questions revolve around several key themes, spanning technical, organizational, cultural, and strategic concerns. After the presentation, there were 27 questions directed to Robert Vrancken (Gradyent). They touch on several core themes related to DTs, particularly from technical, architectural, and strategic perspectives. Finally, the second workshop closed with a reflection on the societal impact of DTs in the energy sector.

After this summary, we consider that we have successfully achieved the objectives of the proposal. We have sat down with Dutch researchers, industry, and stakeholders to discuss in depth what DTs can bring to the energy sector and how these tools can impact society. We also identified scientific challenges that universities and research institutions can help address. By inviting NWO representatives, we have ensured that the output of our workshops is incorporated into their research agenda. Currently, a research call by NWO and TenneT1 is open. This research call aims to fund researchers who address DT's scientific challenges. As deliverables, we promised a report including a summary of the workshop (including an

1 https://www.nwo.nl/en/calls/kic-unlocking-digital-twin-capabilities-for-electricity-utilities is open.

infographic). Unfortunately, due to the fast-approaching deadline of the NWO-TenneT call, in which the applicants of this call are leading a consortium, it has not been possible to prepare this report. A draft is available, but it is not at the level required for publication. Nevertheless, the knowledge and networking resulting from this funding have been primordial to support the careers of the applicants.

Workshop 1

Workshop 2

1 https://www.nwo.nl/en/calls/kic-unlocking-digital-twin-capabilities-for-electricity-utilities is open.