4TU.NIRICT follow up of Workshop on Demand Flexibility in Cyber-physical Energy Systems

This document describes the results of the workshop that took place at the University of Twente, and was held on 22nd , 23rd, and 24th March, 2023 in Enschede on the topic "**Demand Flexibility in Cyber-physical Energy Systems**". The discussion started from the observation that the energy transition asks for a synergy between ICT and emerging technologies to keep a reliable energy system. However, innovative approaches combining ICT and electrical engineering are needed, demanding a stronger cross-functional collaboration and academia-industry bonding. This workshop brough together individuals from several backgrounds, primarily electrical engineers and computer scientist, to learn and further discuss key concepts in the energy transition domain.

Organizing committee:

Dr. Nataly Bañol Arias, EEMCS, University of Twente
Prof. Dr. Johann Hurink, EEMCS, University of Twente
Dr. Gerwin Hoogsteen, EEMCS, University of Twente
Dr. Juan C. López, EEMCSM, University of Twente
Dr. Juan S. Giraldo, TNO

1. Introduction

The energy transition (transformation from fossil-based to zero-carbon) relies on the electrification of society and is a key driver to achieving environmental goals. This process entails moving from a traditional energy system to a Smart Grid with multiple demand/generation sources, which asks for a synergy between ICT and emerging technologies (electric vehicles, solar panels, batteries, etc.) to keep a reliable energy system. However, this transition involves inherent (technical) issues such as e.g., congestion problems and vulnerability of the system due to potential cyber-security threats. To tackle these challenges, innovative approaches combining ICT and electrical engineering are needed, demanding a stronger cross-functional collaboration and academia-industry bonding.

This workshop introduced key concepts in the energy transition domain such as demand flexibility, optimal energy management, cyber-security, and digital twins. This event was an opportunity to disseminate current research topics, promote research collaboration between academia and industry, and strengthen the 4TU.NIRICT community. The workshop pursued the following goals:

- To provide an overview of the state-of-the-art research on demand flexibility in cyber-physical energy systems.

- To foster networking and collaboration among researchers and practitioners from different disciplines and sectors.

- To identify challenges and opportunities for future research and innovation on demand flexibility.

2. Workshop materials

The event covered theoretical discussion sessions, hands-on experiences, a poster session and a real demonstration of the SlimPark pilot project. All the material and presentations were made available after the event.

2.1 Keynote speeches

Experts from academia and industry came together to discuss the synergy between EE and ICT solutions, and the need for collaboration among different sectors towards achieving sustainability. The specific topics discussed during the meeting are shown below:

- Smart grids need power systems with ICT training or ICT systems with power system training!

  Prof. Dr. Ir. Geert Deconinck (KU Leuven and Energyville)

- "From exception to rule: Lessons learned from large-scale public EV charging optimization".

  Ir. Jules Van Dijk (Total Energies)

- Flexible charging: from pilot to standard

  Dr. Ir. Marisca Zweistra (ElaadNL)

- Cyber physical systems: concept and applications

  Prof. Dr. Pedro P. Vergara (TU/Delf)

- "Decentralized and end-users centric energy trading"

  Prof. Dr. Tarek Alskaif (Wageningen University)

- Cyber-security in energy systems

  Prof. Dr. Anne Remke (university of Münster)

- Digital twins: concept and applications

  Prof. Dr. Peter Palensky (TU/Delf)

- Introduction to DEMKkit

  Dr. Ir. Gerwin Hoogsteen (University of Twente)

2.2 Hands on sessions

The hands-on session introduced the participants to the basics of mathematical modeling, mathematical programming using Pyomo, a Python-based open-source software for modeling and solving optimization problems. The session consisted of four parts:

- A theoretical session on mathematical modeling of flexibility in energy systems.

- A tutorial on how to install and use Pyomo for optimization problems.

- A case study on how to model and solve a demand response problem for a residential consumer with flexible appliances and battery storage.

- A challenge for the participants to extend the case study with additional features or constraints, such as time-varying prices, renewable generation, or thermal comfort.

The hands-on sessions were led by Nataly Bañol Arias, Juan Camilo López Amézquita from the Energy Group at University of Twente and by Juan S. Giraldo from TNO.

2.3 Panel discussions

During the registration process, we asked the participants to share their thoughts about:

- What issues do they expect when developing solutions to provide flexibility in energy systems?

- What issues do they expect when developing solutions to implement cyber-physical energy systems and digital twins?
- What external factors limit the implementation of their research ideas in the real life? What would they change about it?

Based on their responses, two discussion sessions were conducted, which led to the following conclusions:

- **Expected issues to provide flexibility in energy systems**
  - Standardization, interoperability, security
  - Modeling uncertainties - energy forecasting
  - Grid modeling/integration into algorithms for flexibility provision
  - Computational resources, scalability & robustness
  - Human behavior/user acceptance
- **Expected issues to implement cyber-physical energy systems and digital twins**
  - Convince stakeholders
  - Interoperability
  - Computational resources
  - Lack of cyber-physical simulation platforms
  - Privacy issues
  - Lack of infrastructure
  - Regulations
- **External factors that limit the implementation of research ideas in real life**
  - Regulations, business models
  - Data availability and privacy
  - Maturity of technology
  - Standards & interoperability
  - Mismatch between real-life and theoretical models
  - Economic & social/human factors
  - Computational resources

The discussion sessions were led by Leoni Winschermann and Aditya Pappu, both PhD candidates from the energy group at the University of Twente.


3. **Outcomes**

- The workshop was attended by almost 50 participants from academia and industry, with different backgrounds (mathematicians, electrical and electronic engineers, computer scientists), primarily from different universities across The Netherlands, as well as a few from outside.
- Participants gained valuable insights into basic, intermediate, and advanced concepts on demand flexibility, digital twins, and the need for cooperation among academia, industry, and government towards the energy transition.
- Participants learnt how to use the tool Pyomo, a Python-based, open source optimization modelling language, to solve energy related problems: energy contracts and energy management system for smart homes and smart energy communities.
- We had extremely positive reactions on the workshop. Participants expressed their desire for more events like this in the future. They believe that there is a lack of communication/collaboration across different sectors, such as mathematics, computer sciences, and electrical engineering to address energy issues and to provide solutions.

4. Additional information

The following pictures provide a glimpse into the workshop and its activities.

Discussion sessions
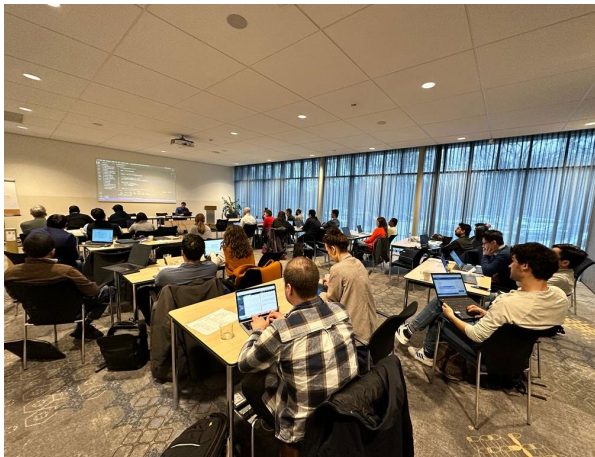
Hands on sessions

Visit to the EV parking Lot at the University
(SlimPark project)

The workshop was advertised on the websites of the university of Twente and the 4TU NIRICT Community, as well as through social media channels.

- https://www.utwente.nl/en/eemcs/energy/events/workshop-demand-flex/
- https://www.4tu.nl/nirict/events/Workshop%20on%20Demand%20Flexibility%20in%20Cyber-physical%20Energy%20Systems/
- https://www.linkedin.com/posts/nataly-ba%C3%B1ol-arias-5b273b1ab_academia-industry-collaboration-activity-7051122806247313409-4qBq?utm_source=share&utm_medium=member_desktop
- https://www.linkedin.com/posts/nataly-ba%C3%B1ol-arias-5b273b1ab_events-workshop-on-demand-flexibility-in-activity-7029391171822968832-v9fC?utm_source=share&utm_medium=member_desktop

During the workshop, the announcement of **DEMKit**, a new open-source toolkit for *Decentralized Energy Management,* was made under the Apache version 2.0 license. This tool can be used for both simulation and real-world demonstration of energy systems, making it a valuable resource for researchers and industries of all sizes worldwide who are working towards accelerating the energy transition. For further details, please visit:

https://www.utwente.nl/en/eemcs/energy/news/2023/3/559989/demkit-now-publicly-available-open-source