









Deliverable 5.3.1.1

REQUIREMENTS FOR THE IMPLEMENTATION OF NFDI4ENERGY
USE CASES

14.09.2024

D5.3.1.1 Requirements for the Implementation of NFDI4Energy Use Cases

Corinna Seiwerth ¹, Michael Niebisch ¹, Jan Sören Schwarz ^{2 3}, Laura Fuentes Grau ⁴, Reinhard German ¹, Sebastian Lehnhoff ², Astrid Nieße ³, Antonello Monti ⁴

¹ Friedrich-Alexander-Universität Erlangen-Nürnberg, Chair of Computer Science 7 (Computer Networks and Communication Systems), Martensstraße 3, 91058 Erlangen

² OFFIS, Institute for Information Technology, <https://ror.org/003sav189>, Escherweg 2, 26121 Oldenburg

³ Carl von Ossietzky University of Oldenburg, Department of Computing Science, <https://ror.org/033n9gh91>, Ammerländer Heerstraße 114-118, 26129 Oldenburg

⁴ RWTH Aachen, Institute for Automation of Complex Power Systems, Mathieustraße 10, 52074 Aachen

Published by

Friedrich-Alexander-Universität Erlangen-Nürnberg, Chair of Computer Science 7 (Computer Networks and Communication Systems), Martensstraße 3, 91058 Erlangen

Acknowledgements

The authors of this article have used various preparatory works from the NFDI4Energy to create this portrait, and references have been made where possible. Thanks to all those who are not named.

The authors would like to thank the German Federal Government, the German State Governments, and the Joint Science Conference (GWK) for their funding and support as part of the NFDI4Energy consortium. The work was funded by the German Research Foundation (DFG) – 501865131 within the German National Research Data Infrastructure (NFDI, www.nfdi.de).

License

This document is published under the [Attribution 4.0 International \(CC BY 4.0\)](https://creativecommons.org/licenses/by/4.0/). This license allows users to distribute, remix, adapt, and build upon the material in any medium or format, so long as attribution is given to the creator. The license allows for commercial use.



Table of Contents

General Information.....	3
Summary	3
Deliverable within NFDI4Energy.....	3
Introduction.....	4
Requirements Analysis	4
List of requirements	5
Conclusion and Future Work.....	8
References.....	8

General Information

The following describes the goal of this deliverable and how it fits into the development of the NFDI4Energy platform.

Summary

Simulation is becoming increasingly crucial in energy system research. Measure 5.3 aims to provide a Simulation-as-a-service (SimaaS) on the NFDI4Energy platform. This service will integrate the three simulation middlewares: mosaik, DaceDS, and VILLASframework. We conducted a comprehensive requirements analysis based on exemplary use cases from Task Area 6 to ensure that the simulation service meets the user's needs. We interviewed the measure leads of Task Area 6 and subsequently drew up the initial and comprehensive list of requirements for the SimaaS.

Furthermore, we fostered a collaborative environment by organizing an internal workshop to gather additional requirements. The question, "What features would you expect when using a SimaaS containing multiple frameworks?" was thoroughly discussed using the 1-2-4-All method. We then analyzed the workshop results, adding them to the list of requirements. To ensure the requirements for the SimaaS remain up to date during the platform development, we uploaded them to a GitHub repository where users can propose changes.

Deliverable within NFDI4Energy

The activities in NFDI4Energy are divided into seven task areas, each with its unique scope. Task Area 5 is dedicated to simulation software for energy system research. It aims to develop two primary services for the NFDI4Energy platform: the provision of a software registry and a SimaaS. Measure 5.3 focuses on the conceptualization and implementation of the SimaaS. The first task is "5.3.1 Conduct requirements analysis" to ensure the SimaaS fits the user's needs. This deliverable, "5.3.1.1 List of Requirements", presents the results of Task 5.3.1.

Introduction

The simulation of energy systems is critical to understand complex interactions within interconnected components and dynamic factors. Simulation allows predicting future scenarios, optimizing system performance, and mitigating risks in a rapidly changing energy landscape to ensure a reliable, efficient, and sustainable energy future [1]. Accordingly, Simulation-as-a-Service (SimaaS) has gained traction, providing a seamless and accessible platform for researchers, practitioners, and policymakers to integrate simulation in their work [2]. SimaaS refers to delivering simulation software and tools through a cloud-based platform [3]. Similar to other as-a-Service approaches, SimaaS enables users to access and utilize simulation capabilities without needing local installation or dedicated hardware resources [4]. Therefore, we aim to provide a SimaaS with the NFDI4Energy platform as a front-end to improve the understanding and management of energy systems.

Analyzing user requirements is a necessary step to develop innovative software and services that truly meet their needs. However, extracting these requirements is not a trivial task [5]. This document lists the initial requirements for the NFDI4Energy platform's simulation service. The overall goal of this service is to ease the use of simulation in the energy domain, both for experts and interested non-experts.

Requirements Analysis

As part of this study, we analyzed the requirements for the NFDI4Energy simulation service using the predefined use cases from Task Area 6. As part of Task Area 6, Measures 6.1 and 6.3 in particular deal with simulations. Measure 6.1 focuses on Hardware-in-the-Loop simulations and Measure 6.3 on co-simulations. As a result, the measure leads were asked the following fourteen questions, from which a list of initial requirements for our SimaaS was drawn up:

1. Which input factors are considered in the development of each simulation?
2. Which domains are to be considered in the simulation?
3. What are the top 3 requirements for the use case?
4. What types of distributed simulation will be used?
5. Which simulation tools/frameworks will be utilized?
6. Is special hardware needed or are there prerequisites for it?
7. Which data/data formats will be used?
8. What are the data sizes that need to be inputted for the simulations?
9. How many sub-models must be coupled simultaneously?
10. Are there any runtime limitations?
11. Are there real-time requirements?
12. Which model paradigms will be combined?
13. Which features would be particularly useful for the use case?
14. What are additional requirements for the simulation service that have not been queried so far?

In order to find further common requirements for the SimaaS, we organized a workshop at our Task Area 5 Quarterly. We used the 1-2-4-All method [6] to brainstorm and prioritize ideas for the simulation service. According to the 1-2-4-All method, each person has one minute to write down their ideas on a specified question. The participants are then assigned to groups of two persons and have two minutes to discuss and refine their ideas. Then, two groups are put together and have four minutes to discuss and prioritize their ideas. Finally, the results are presented to all participants shortly [6]. Our internal workshop focused on the question: "What features would you expect when using a SimaaS

containing multiple frameworks?” The features that were mentioned the most by the end of the workshop were as follows:

- Running example scenarios
- Common dashboard
- Export results
- Easy comparison of results
- Running a general scenario on all frameworks
- Import and export scenarios
- Provide resource allocation

After discussing the workshop results, we extracted some requirements from the most relevant and, in our view, feasible features within the project's scope.

List of requirements

From the answers to the previous questions and the results of our internal workshop, we have compiled the following initial list of requirements with the ID representing the TA6 use case the requirement is needed for:

Req. ID	Requirement Name	Description	Priority
6.1.1	Coupling real laboratories	Enable coupling of distributed real-time simulations and real laboratories using VILLASframework	high
6.1.2	HIL-Simulation	Enable hardware-in-the-loop simulations using VILLASframework	high
6.1.3	Automated configuration of VILLASframework	Provide a possibility to configure simulation setups with VILLASframework automatically	low
6.1.4	Geographically distributed simulation	Enable co-simulation on geographically distributed devices	high
6.1.5	Real-Time Simulator	Integrate a real-time simulator (RT-LAB/RTDS) into the simulation setup to enable real-time simulation	high
6.1.6	HIL-Interface	Provide access to Xilinx FPGAs and ADC/DAC	middle
6.1.7	QoS	Optimize communication between different simulation components	middle
6.1.8	Complex simulation VILLASframework	Enable a simulation where RTDS, FMUs, and InfluxDB are	high

		coupled over VILLASframework	
6.1.9	Different step sizes	Enable time domain simulation with different step sizes	low
6.1.10	Multi-energy-simulation Energy Domain	Enable multi-energy-simulation, that couples models of electric energy and thermal energy	high
6.1.11	Input data and models	Enable simulations with the following input data and models: <ol style="list-style-type: none"> 1. Time series database / time series for PV system 2. RTDS low voltage model 3. RTDS model for controllable load (possibly with OpalRT behind it but this is a black box) 4. Adjustable hardware load 5. Model of a building as FMU 	high
6.1.12	Hardware Requirements	Enable simulations with incorporating the following hardware: <ol style="list-style-type: none"> 1. RTDS real time simulators (2x) 2. Hardware Load 3. Lab infrastructure 4. OpalRT hardware interface 	high
6.3.1	Agent Based Simulation	Enable distributed simulation of energy systems using agent-based simulation	high
6.3.2	Multiple domains	Enable a co-simulation with simulators from the communication and traffic domain	high
6.3.3	Power Plants	Enable simulations of power plants, like wind turbines,	middle

		photo voltaic, combined heat and power, and battery	
6.3.4	Flexibility and self-healing	Enable simulations of flexibility and self-healing mechanisms using agent-based models	high
6.3.5	Agents	Enable agent-based simulations, supporting the following agents: <ol style="list-style-type: none"> 1. Unit agents 2. Aggregator agents 3. Grid agents 	middle
6.3.6	Communication simulator	Integrate a communication simulator into a co-simulation framework	high
6.3.7	Traffic simulator	Integrate a traffic simulator into a co-simulation framework	high
6.3.8	Input data	Read in data from csv and hdf5 files with a size of 1-5 MB	high
6.3.9	Standardized protocols	Use standardized protocols like json and protobuf	low
6.3.10	Low delay	Keep delay caused by framework/middleware low	low
Other.1	SimaaS	Enable the automated execution of energy simulations based on a predefined configuration	high
Other.2	MaaS	Enable the assisted creation of a simulation scenario for an energy simulation, similar to a Modeling as a Service (MaaS) approach	middle
Other.3	Scenario Ontology	Enable the configuration of simulation scenarios via the scenario ontology developed in TA 5	high
Other.4	Run example scenario	Provide some example scenarios for each framework and enable running them in the simulation service	middle

Other.5	Common results-format	Enable exporting the results in a common specified format	high
Other.6	Common dashboard	Provide a dashboard that shows the progress and previous results of the running simulation. The Dashboard should be the same for each framework	low

Conclusion and Future Work

In summary, we have comprehensively outlined the requirements for the simulation service of the NFDI4Energy platform. This platform is designed to support both experts and non-experts in the energy domain and aims to offer SaaS. Therefore, it is essential to have a detailed understanding of various use cases, as explored by TA6. We have addressed several important questions regarding input factors, domains, requirements, distributed simulations, tools, hardware, data formats, sub-model coupling, runtime limitations, real-time needs, and modeling paradigms, resulting in robust requirements.

However, this list of requirements is initial, and we will expand and refine the list as the work in TA6 becomes more concrete. This continuous development will ensure that the simulation service evolves to meet the specific and emerging needs of the energy research community, thereby enhancing simulation capabilities and fostering innovation in the energy sector. We have created a GitHub repository [7] to facilitate a structured expansion of this list. The latest version of the list is available in this repository, and suggestions for changes can be submitted via issues.

References

- [1] J. Priesmann, L. Nolting, C. Kockel, and A. Praktijnjo, "Time series of useful energy consumption patterns for energy system modeling," *Sci. Data*, vol. 8, no. 1, p. 148, May 2021, doi: <https://doi.org/10.1038/s41597-021-00907-w>.
- [2] T. Hong, J. Langevin, and K. Sun, "Building simulation: Ten challenges," *Build. Simul.*, vol. 11, no. 5, pp. 871–898, Oct. 2018, doi: <https://doi.org/10.1007/s12273-018-0444-x>
- [3] K. Kritikos and P. Skrzypek, "Simulation-as-a-Service with Serverless Computing," in *2019 IEEE World Congress on Services (SERVICES)*, Jul. 2019, pp. 200–205. doi: <https://doi.org/10.1109/SERVICES.2019.00056>.
- [4] S. Shekhar, H. Abdel-Aziz, M. Walker, F. Caglar, A. Gokhale, and X. Koutsoukos, "A simulation as a service cloud middleware," *Ann. Telecommun.*, vol. 71, no. 3, pp. 93–108, Apr. 2016, doi: <https://doi.org/10.1007/s12243-015-0475-6>.
- [5] M. Maguire and N. Bevan, "User Requirements Analysis," in *Usability: Gaining a Competitive Edge*, J. Hammond, T. Gross, and J. Wesson, Eds., Boston, MA: Springer US, 2002, pp. 133–148. doi: https://doi.org/10.1007/978-0-387-35610-5_9.
- [6] K. M. Lipmanowicz Henri, "Liberating Structures - 1. 1-2-4-All." Accessed: Sep. 09, 2024. [Online]. Available: <https://www.liberatingstructures.com/1-1-2-4-all/>
- [7] "NFDI4Energy/simulation-service-requirements: Requirements and Use Cases for Simulation in Interdisciplinary Energy Research (TA5)." Accessed: Sep. 09, 2024. [Online]. Available: <https://github.com/NFDI4Energy/simulation-service-requirements>