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WP7

Demonstration and impact assessment

Demo Characterization

D7.1



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Abbreviations and Acronyms

| ACRONYM / ABBREVIATION | Extensive form |
|------------------------|---|
| AMR | Automated Meter Readout system |
| API | Application Programming Interface |
| CGMES | Common Grid Model Exchange Standard |
| CIM | Common Information Model |
| DSO | Distribution System Operator |
| ERP | Enterprise Resource Planning system |
| EQ | Equipment profile of the CGMES |
| IEC | International Electrotechnical Commission |
| JSON | JavaScript Object Notation |
| SSH | Steady State Hypothesis profile of the CGMES |
| SCADA | Supervisory Control and Data Acquisition system |
| TRL | Technology Readiness Level |
| TSO | Transmission System Operator |
| WFM | Workforce management tools |

1. Introduction

This document describes and documents the activities planned for the execution of Croatian pilot of the Advanced Tools Towards cost-efficient decarbonisation of future reliable Energy SysTems (ATTEST) project.

The project principal delivery is a modular open-source toolbox composed of a suite of tools to support Transmission System Operators (TSOs) and Distribution Systems Operators (DSOs) operate, maintain, and plan the energy systems in year 2030 and beyond. This open-source toolbox has been developed in the scope of main work packages of this project and integrated into a consistent platform within the work package WP6, as illustrated in the picture below.

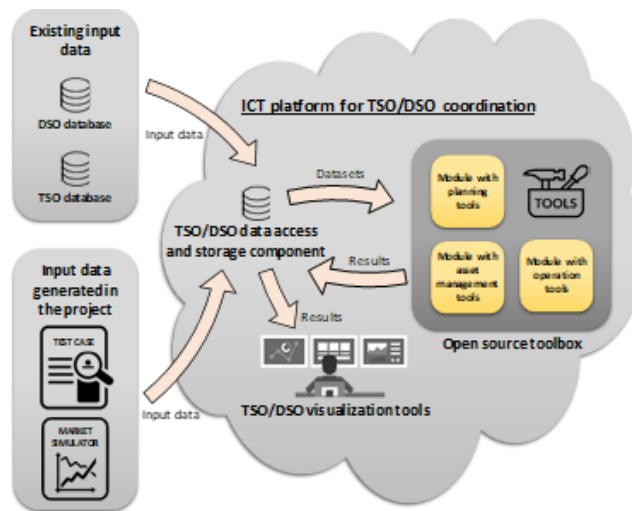


FIGURE 1 – OUTLINE OF THE ATTEST TOOLBOX CONFIGURATION

Within the WP7, this toolbox is deployed in an actual and operational business setting of Croatian transmission and distribution system operators. Implementing and integrating any new tools in day-to-day business of a system operator is a challenging task, even when these tools are fully production-ready. For the lower TRL tools, that are from the very start designed to run in the 2030 operational context, this is even more challenging. This document explains the setup of the Croatian pilot.

This document is organized as follows:

- Chapter 2 accompanies the deliveries and specifications of WP6, providing additional business and integration context for this deliverable and the rationale for setting the pilot up;
- Chapter 3 provides the documentation of the pilot configuration deployed in the Croatian HEP DSO distribution system operator;
- Chapter 4 provides conclusions of the document, including a summary of the challenges faced in the preparation and execution of the pilot.

This document will be accompanied by the deliverable D7.2 that will document the tools testing and validation results within the context of the Croatian demonstration.

2. Business Integration Context of ATTEST Tools

Over the course of the project, virtually all the ATTEST tools have been developed in a separate fashion, ending up with their own inputs and outputs specification. With ATTEST being a research and innovation action project, this enabled more focus of the tool developers on the tools themselves, instead of on the tool integration in the platform.

This trade-off increased the challenges of WP6 where these tools have been integrated in the platform, but this decision is fully in line with the expected technology readiness level of the tools after the project completion.

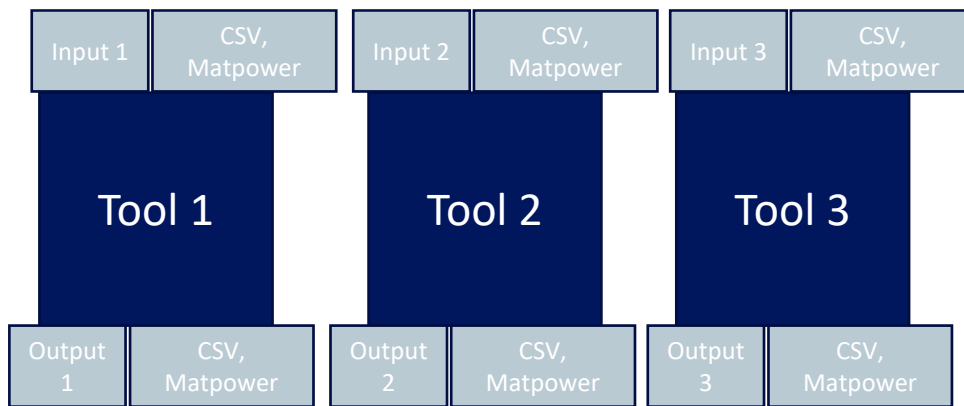


FIGURE 2 - ATTEST TOOLS - SEPARATE INPUTS AND OUTPUTS

In effect, no specific version of software environment has been enforced on the tool developers and consequently different tools use different development environments and libraries, such as Python¹, Julia², and optimization solvers such as IBM’s CPLEX³, AMPL⁴, and Ipopt⁵.

This gave the liberty to tool developers to focus on the main tool delivery. Effectively, as Figure 2 shows, each tool developed communicates with other tools via the tool inputs and outputs, and the ATTEST toolbox integration approach ensured that each tool runs in the correct environment. This is documented in more detail in the deliverable D6.2 [1].

¹ <https://www.python.org/>

² <https://julialang.org/>

³ <https://www.ibm.com/it-it/analytics/cplex-optimizer>

⁴ <https://ampl.com/ce/>

⁵ <https://coin-or.github.io/Ipopt/>

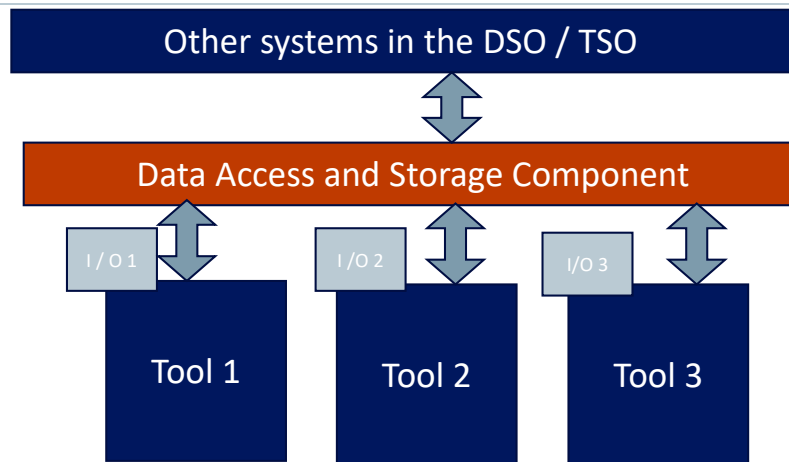


FIGURE 3 - DATA ACCESS AND STORAGE COMPONENT IN THE INTEGRATION CONTEXT

In the context of the Croatian pilot, the ATTEST tools have to be integrated within the business context and data sources of the two system operators: the HEP ODS, Croatian distribution system operator, and the HOPS, Croatian transmission system operator.

With the architectural approach of the toolbox illustrated above in Figure 3, the data access and storage component communicates with the other systems in the TSO and DSO, and orchestrates the data for the individual ATTEST tools. It performs the required format conversion, serves the input data to the tools and processes the tool outputs.

, Besides being the integration component of separate ATTEST tools into the ATTEST toolbox, the data access and storage component should also provide the integration of the ATTEST toolbox with the remaining systems within the system operator and with the rest of the business context. For that reason, this component is not monolithic but consists of several modules as shown below.

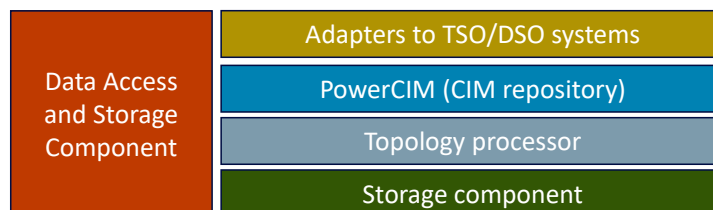


FIGURE 4 - DATA ACCESS AND STORAGE COMPONENT INTEGRATION BUILDING BLOCKS

The main functions of each module are described below.

The adapters to TSO and DSO systems harvest the data from other TSO and DSO systems and prepare these data for their use in ATTEST. These are the principal integration components for different data sources in the DSO. The real situation in the DSO, that may remain as such even in 2030, is that there is no single hub-like central data repository that would serve all types of data ATTEST tool needs. While it is expected this will change until 2030 as the DSOs consolidate their data-related operations, the very versatile nature of ATTEST tools would still very likely require different types of data and different data pathways. To correctly model this situation in the pilot, a solution being developed in KONČAR is utilized and extended for the ATTEST project.

The **PowerCIM** is KONČAR’s data harmonization, orchestration, and semantic integration tool, that allows multi-branch, bitemporal versioned handling and referencing of information on the electricity

networks. It relies on the IEC CIM (Common Information Model), which everyone can use to easily exchange information. The IEC CIM is described in the IEC 61968 [2] and IEC 61970 [3] series of standards and it is designed as an object oriented standard and is in practice a de facto ontological data modelling standard for the system operator and beyond. It is in widespread use in the system operators across Europe and we reasonably expect the usage of IEC CIM will become even more common across different business contexts by 2030, when ATTEST tools reach their full maturity.

While the PowerCIM is developed with the multiple data sources on the same objects in mind, it is not merely a CIM-enabled enterprise service bus that ties different data sources together. Its functionalities include handling non-CIM aware data sources and data sinks by using appropriate input and output adapters and converters. A key defining property of the PowerCIM solution is that it offers concurrent multi-branch and multi-temporal model handling, akin to versioning in source code control systems such as git. This allows different variants of the system model to be valid at the same time. This means different business contexts can handle different subsets of the system information. An example of the divided reality of data provenance in typical DSO is illustrated in the figure below.

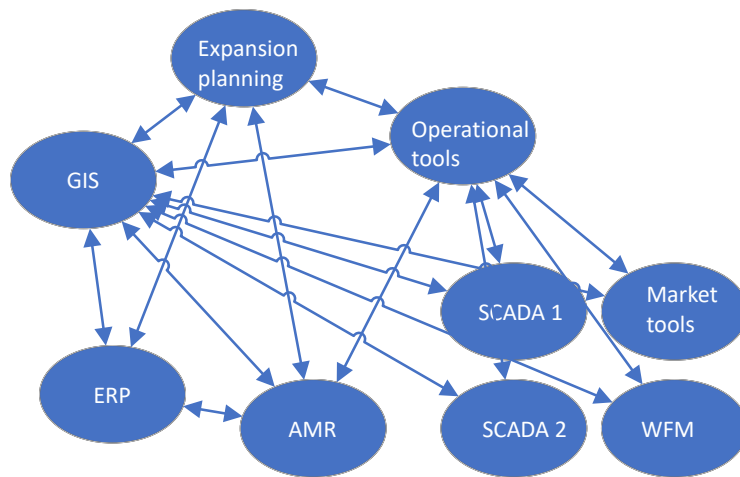


FIGURE 5 - DIFFERENT BUSINESS CONTEXTS AND THEIR PARTIAL SOURCES OF TRUTH IN A DSO

For many of the business needs, the system operators typically utilize different systems. These systems, in the best case, communicate with other system using CIM messages at its edges. As an example, virtually all recent versions of modern SCADA systems can build their internal network model from a CIM-compatible format. Similarly, tools often used in the DSO day-to-day operation often use CIM-compatible input data to interact with other systems – to the level of issuing work orders in more advanced cases common in Texas in the United States. The workforce management tools often rely directly on geographical information system data and outputs of the operational tools such as outage management tools. Simulation and analysis tools such as Neplan can also work with CIM data format. In effect, different and often legacy systems represent partial sources of truth on the same objects. Market-facing tools require yet another subset of the tools.

For the sake of completeness, it should be noted that some DSOs in Croatian region have implemented a bus-like solution for data exchange. This does not necessarily change the discussion above: the topology of communication between the system does change, but the challenge of orchestrating and referencing a full dataset on a particular object is still valid.

However, each business need such as automated meter readout, ERP and SCADA system effectively have their own set of referencing rules and the systems end up as only partially integrated. There is no

system that holds the ultimate truth on any of the objects. The object is also typically not holding the same identifier in all the subsystems.

Effectively, the same physical object has a subset of its attributes defined in one system, and the remainder in other systems. An electricity meter may have one identifier in the ERP system tied to its purchase, another one in the AMR system related to its firmware, and yet a third one in the asset management system and so on. In effect multiple loosely coupled sources of truth for the same object exist and are all valid across business contexts.

The PowerCIM therefore, provides a solution to integrate different business contexts within the DSO by allowing multi-branching to accommodate different business context.

For the ATTEST project, a derivative solution, which is in effect a special instance of PowerCIM, has been developed. The “main line” version of PowerCIM, namely, focuses primarily on the SCADA network models, and this coverage has been widened for ATTEST.

The adaptations tailored specifically for ATTEST are dealing with specific API interface to PowerCIM, and primarily with the type of the model ATTEST tools utilize. Namely, as described in [4], most of the ATTEST tools rely on the so-called bus-branch network model where a bus is actually a node in a graph model of the network: topological composition of the physical components directly connected via closed switches or breakers. On the other hand, in the business contexts in the DSO (e.g. GIS or SCADA) the dominant concept is to have data directly corresponding to the physical network equipment. Indeed, this is the case of the CIM EQ equipment profile that describes the node-breaker network model.

As the ATTEST tools and the ATTEST internal data model developed by Softlab are based on bus-branch model, a **topological conversion** is required that would essentially collapse, aggregate or merge the physical nodes connected together into a single bus. For the Croatian pilot, the topological processing is integrated into PowerCIM interface to the ATTEST toolbox. The topological model conversion happens transparently to the ATTEST toolbox and the model that the PowerCIM exposes to the ATTEST toolbox is already topologically processed and converted into a bus-branch model and stored into the storage component adequately. A more detailed description is provided in [1].

This way the specific PowerCIM instance serves as an interface of ATTEST tools to CIM-aware systems of the DSO, and its additional functionalities bridge the gap from the current reality in system operators at one side (towards the DSO systems), and prepares the data in suitable format for ATTEST at the other side (internally, towards the ATTEST toolbox). This way, the ATTEST toolbox gains a realistic and future-proofed interface towards the systems in the DSO and TSO, and conversely, the developments and experiences in ATTEST will serve as inputs for the further development of PowerCIM as a product.

3. Setup of ATTEST demo in HEP ODS

3.1. Server location and network interfaces

In the pilot, the ATTEST tools will work on the actual data of HEP ODS and HOPS. There have been several options evaluated on the server location, however as most of the data for the pilot will be coming from HEP ODS and there has been a server utilized for a previous project, it has been decided to repurpose this machine, with some hardware upgrades so it can handle the whole ATTEST toolbox. It is a Windows Server 2016 machine, running Hyper-V virtualization for the Ubuntu Linux virtual machine needed to run the PowerCIM backbone.

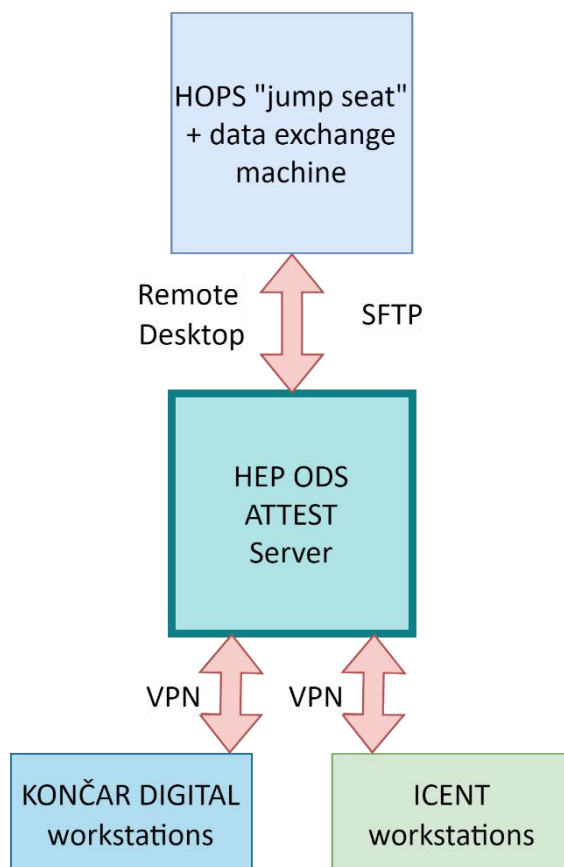


FIGURE 6 - NETWORK CONNECTIONS TO THE ATTEST PILOT SERVER

To communicate with HOPS systems, we have taken advantage of the existing VPN connection between HOPS and HEP ODS. Through that VPN connection, two types of data is tunneled: as the ATTEST tools run directly on the ATTEST server machine, their interface can be accessed and used by the HOPS team by means of remoting into a “jump-seat” machine, from where a remote desktop connection can be made to the ATTEST server. User connection is therefore via remote desktop, and the data connections use already established channels in HEP ODS and HOPS.

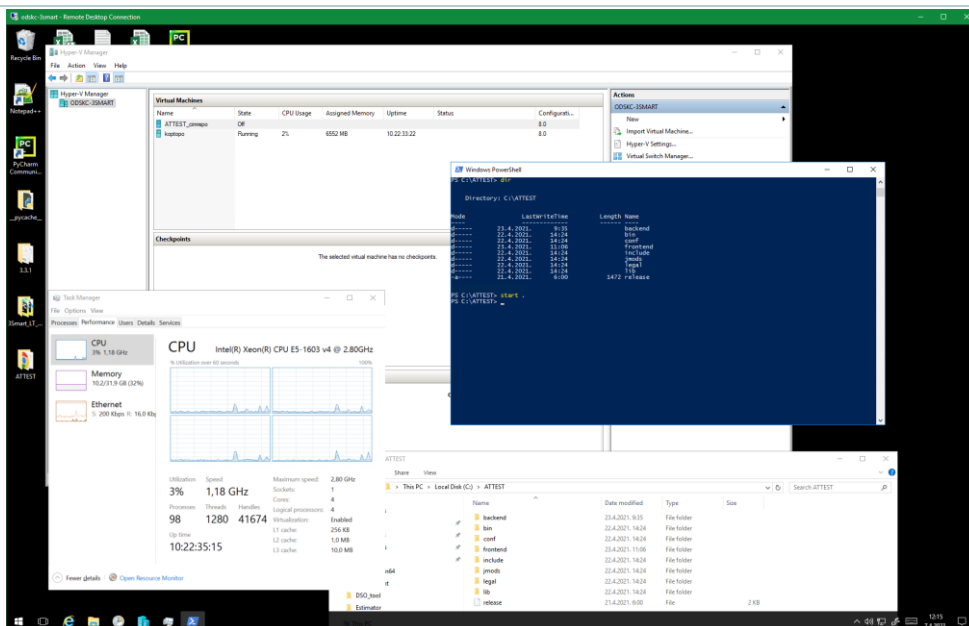


FIGURE 7 - REMOTE DESKTOP CONNECTION TO THE ATTEST SERVER

Access to the server from outside HEP ODS, required for KONČAR DIGITAL team and ICENT team, is resolved through personal on-demand VPN access credentials. These required administrative prerequisites such as signature of the terms and services of accessing the HEP ODS resources. While this is an expected administrative step as the actual network of the DSO is being accessed, it required a considerable amount of approvals and person-based paperwork. For this reason, there is no provision for the other partners to access the HEP ODS server directly. Instead, the coordination is done via KONČAR and ICENT teams and the deployment is staged from the INESC TEC server which all the project participants can access.

3.2. Software integration setup

The following figure illustrates the configuration of software modules installed at the server in HEP ODS.

The leftmost parts of the configuration are Croatian pilot specific, while most of the remaining configuration of the ATTEST toolbox directly follows the configuration where the tools have been tested and developed, at the server in INESC TEC premises, i.e. the configuration from the ATTEST internal database to the ATTEST tools is mostly unchanged for the pilot deployment compared to INESC TEC hosted development setting. This configuration and the integration of the ATTEST toolbox is described in detail in [1].

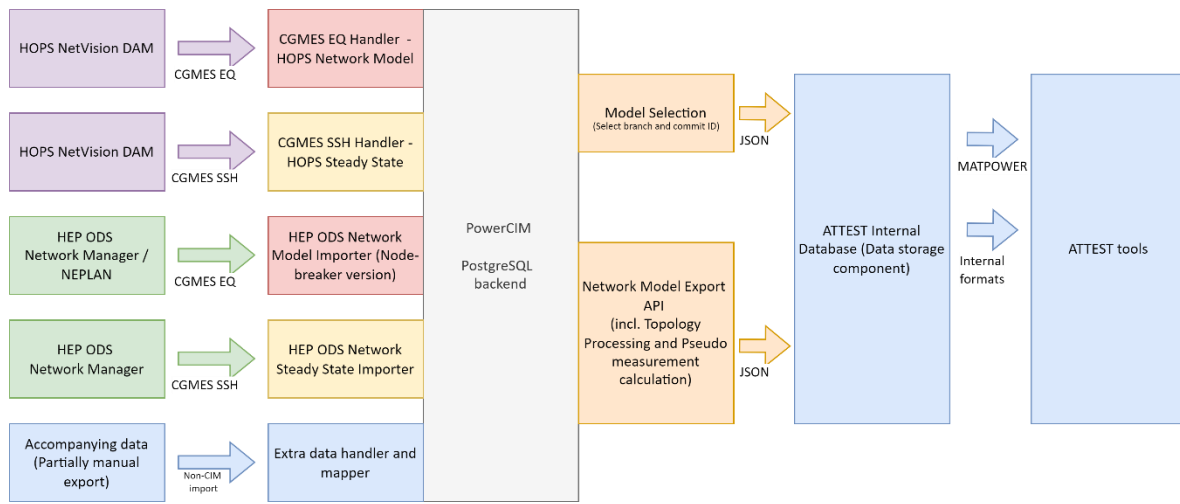


FIGURE 8 - SOFTWARE CONFIGURATION OF CROATIAN PILOT

The CGMES stands for Common Grid Model Exchange Standard [5] and in ATTEST, four profiles of CIM are utilized:

- **EQ** or **E**quipment profile, that holds the node-breaker model of the network equipment; it provides the identification of the network equipment and typically this is not updated often
- **SSH** or **S**teady **S**tate **H**ypothesis profile, that generally defines the network steady state, in a typical setting these values are gathered from a monitoring or management system and are exported periodically, typically each 15 minutes
- **TP** or **T**opology **P**rofile, that holds the topological network configuration and is essentially
- **SV** or **S**tate **V**ariable profile, that completes the SSH profile with a complete estimated state vector.

In case of Croatian pilot setup, HOPS NetVision DAM software is the source of the CGMES profiles. EQ profile is exported manually when needed, and the SSH profile is calculated each 15 minutes and stored on the specific folder of the ATTEST server from where the ATTEST pilot can process it.

The TP and SV profiles are the product of topological processing within the PowerCIM ATTEST-specific module. In that module, the topological processing is embedded into the TP creation. This way, the result of topological conversion can be the internal calculation result of the node-breaker to bus-branch conversion.

For HEP ODS integration, the CGMES SSH profile is sourced from the Network Manager SCADA system, while the EQ model can be gathered from Network Manager directly or via NEPLAN network modeling software.

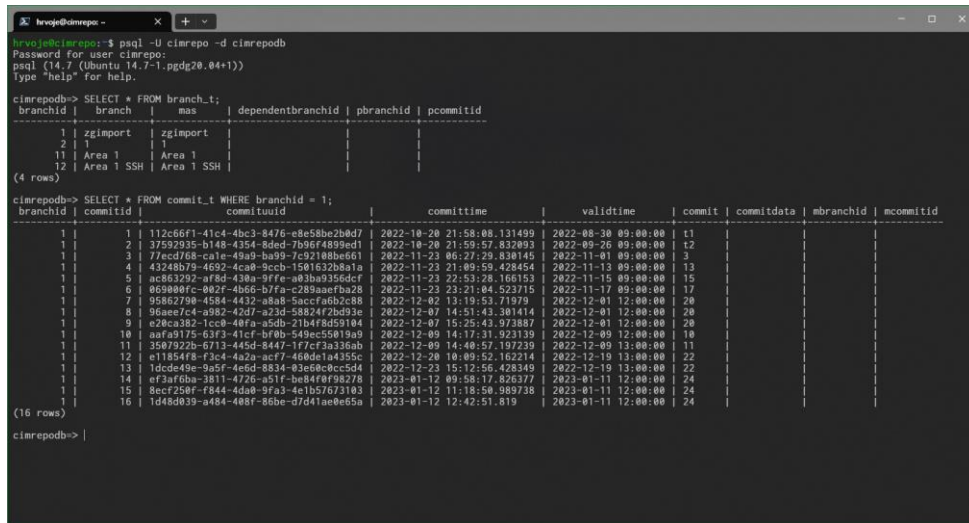


FIGURE 9 – SQL INTERNAL INTERFACE TO ATTEST POWERCIM

In the figure above, it is visible that the PowerCIM holds several branches of the Northern Croatia network data, and that there are several commits for the same branch.

| mrid | mridtext | rname | cmclassid | cmclass | pmrid | fulobject |
|--------------------------------------|--------------------------------------|--------------------|-----------|-----------------------|--------------------------------------|--|
| 006ecc6a-af68-a8a3-388c-3a03c94e02d | 006ecc6a-af68-a8a3-388c-3a03c94e02d | GR-L-1000639683 | 613 | cm:DiagramObject | (NULL) | ["cm:DiagramObject.Diagram": "fee0829-b42c-0329-54f0-3a03c94df6", "cm:Iden...] |
| 007178ce-aba5-7b35-0ef4-3a03c94df6 | 007178ce-aba5-7b35-0ef4-3a03c94df6 | GR-Busar-743843202 | 613 | cm:DiagramObject | (NULL) | ["cm:DiagramObject.Diagram": "fee0829-b42c-0329-54f0-3a03c94df6", "cm:Iden...] |
| 00894c6-13f2-41da-59d3-3a03c94e01d | 00894c6-13f2-41da-59d3-3a03c94e01d | GR-L-1024544195 | 613 | cm:DiagramObject | (NULL) | ["cm:DiagramObject.Diagram": "fee0829-b42c-0329-54f0-3a03c94df6", "cm:Iden...] |
| 01107367-993f-4896-9573-aa1daafdf7 | 01107367-993f-4896-9573-aa1daafdf7 | 140 | 138 | cm:ConnectivityNode | 891cc89e-0225-4cfb-9db0-2ded3d29df35 | ["cm:IdentifiedObject.mRID": "01107367-993f-4896-9573-aa1daafdf7", "cm:Iden...] |
| 01276700-e8e8-d740-56bf-3a03c94e02d | 01276700-e8e8-d740-56bf-3a03c94e02d | (NULL) | 570 | cm:DiagramObjectPoint | (NULL) | ["cm:DiagramObjectPoint.xPosition": "361.7", "cm:DiagramObjectPoint.yPosition": "...] |
| 0128a2cf-7d74-420a-986e-13aa327c5897 | 0128a2cf-7d74-420a-986e-13aa327c5897 | PATL | 432 | cm:CurrentLimit | a460c8b-5315-4ebb-8a61-9575f90491e6 | ["cm:CurrentLimit.value": "23.09402", "cm:IdentifiedObject.mRID": "0128a2cf-7d74-...] |
| 0129483a-4267-4807-80b1-6fac78c205e2 | 0129483a-4267-4807-80b1-6fac78c205e2 | (NULL) | 548 | cm:SVoltage | (NULL) | ["cm:SVoltage.v": "9.950634", "cm:SVoltage.angle": "0.2425418", "cm:SVoltage...] |
| 01575bc-8953-4f34-9e69-432ce858a7b0 | 01575bc-8953-4f34-9e69-432ce858a7b0 | TATL | 432 | cm:CurrentLimit | 886b2bf-0f1a-4f68-a78-7fa970bf7d3 | ["cm:CurrentLimit.value": "500", "cm:IdentifiedObject.mRID": "01575bc-8953-4f34-...] |
| 01a916f-743b-edae-37cf-3a03c94e00e | 01a916f-743b-edae-37cf-3a03c94e00e | (NULL) | 570 | cm:DiagramObjectPoint | (NULL) | ["cm:DiagramObjectPoint.xPosition": "328", "cm:DiagramObjectPoint.yPosition": "111...] |
| 01c1620b-eef4-457e-ba41-3c15324a4f60 | 01c1620b-eef4-457e-ba41-3c15324a4f60 | (NULL) | 944 | cm:SVStatus | 8a8014b-a945-4e78-9e67-153a4644c994 | ["cm:SVStatus.inService": "true", "cm:SVStatus.ConductingEquipment": "8a8014b-...] |
| 01c83a9-5a7e-4a2d-ba0a-507985d6e51 | 01c83a9-5a7e-4a2d-ba0a-507985d6e51 | (NULL) | 548 | cm:SVoltage | (NULL) | ["cm:SVoltage.v": "0.3993514", "cm:SVoltage.angle": "0.4016685", "cm:SVolta...] |
| 01d1a693-e3c8-490c-bd8c-77417591b14e | 01d1a693-e3c8-490c-bd8c-77417591b14e | Terminal | 519 | cm:Terminal | d598241-f2af-4f02-aa48-b2c-f367881d1 | ["cm:Terminal.phases": "http://ec.ch/TC57/CIM100#PhaseCode.ABC", "cm:Ident...] |
| 01e93322-93a8-409b-b071-d92fe437c17 | 01e93322-93a8-409b-b071-d92fe437c17 | 74 | 263 | cm:TopologicalNode | 891cc89e-0225-4cfb-9db0-2ded3d29df35 | ["cm:IdentifiedObject.mRID": "01e93322-93a8-409b-b071-d92fe437c17", "cm:Iden...] |

FIGURE 10 - EXAMPLE OF NORTHERN CROATIAN NETWORK EQ PROFILE (AS STORED IN POWERCIM)

| mrid | mridtext | rname | cmclassid | cmclass | pmrid | fulobject |
|---------------------------------------|---------------------------------------|--------|-----------|-----------------|--------|--|
| 0128a2cf-7d74-420a-986e-13aa327c5897 | 0128a2cf-7d74-420a-986e-13aa327c5897 | (NULL) | 432 | cm:CurrentLimit | (NULL) | ["cm:CurrentLimit.value": "23.09402"] |
| 01575bc-8953-4f34-9e69-432ce858a7b0 | 01575bc-8953-4f34-9e69-432ce858a7b0 | (NULL) | 432 | cm:CurrentLimit | (NULL) | ["cm:CurrentLimit.value": "500"] |
| 01d1a693-e3c8-490c-bd8c-77417591b14e | 01d1a693-e3c8-490c-bd8c-77417591b14e | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "false"] |
| 02081d79-e44a-4f80-a2e0-2f9a950d8851 | 02081d79-e44a-4f80-a2e0-2f9a950d8851 | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "true"] |
| 0233bcc9-1f79-4302-9b93-ddf88766eca | 0233bcc9-1f79-4302-9b93-ddf88766eca | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "true"] |
| 0233d603-eb3b-4cfe-bb80-f4d282dd0666 | 0233d603-eb3b-4cfe-bb80-f4d282dd0666 | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "true"] |
| 036bd619-37d0-4f78-8018-f08d2073bb4f | 036bd619-37d0-4f78-8018-f08d2073bb4f | (NULL) | 432 | cm:CurrentLimit | (NULL) | ["cm:CurrentLimit.value": "23.09402"] |
| 037156be-36b2-4197-8934-ade5a9e9d61 | 037156be-36b2-4197-8934-ade5a9e9d61 | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "false"] |
| 043c653c-b5b4-4a48-9051-be4fba1de4e9 | 043c653c-b5b4-4a48-9051-be4fba1de4e9 | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "true"] |
| 0441d40b-59fc-46f3-b695-c22d810fb591 | 0441d40b-59fc-46f3-b695-c22d810fb591 | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "false"] |
| 044557c0-f8dc-4de9-a0a7-7f9e8d9bdb89 | 044557c0-f8dc-4de9-a0a7-7f9e8d9bdb89 | (NULL) | 519 | cm:Terminal | (NULL) | ["cm:ACDCTerminal.connected": "true"] |
| 04639362-e950-44de-91e8-65a1a8d81932d | 04639362-e950-44de-91e8-65a1a8d81932d | (NULL) | 432 | cm:CurrentLimit | (NULL) | ["cm:CurrentLimit.value": "360.8441"] |
| 04a64216-3d33-411a-a350-41ca7a7119ae | 04a64216-3d33-411a-a350-41ca7a7119ae | (NULL) | 285 | cm:Equipment | (NULL) | ["cm:Equipment.inService": "true"] |

FIGURE 11 - EXAMPLE OF NORTHERN CROATIAN NETWORK SSH PROFILE

Figure 10 - Example of Northern Croatian Network EQ profile (as stored in PowerCIM) Figure 10 and Figure 11 illustrate the EQ and SSH profiles of Northern Croatia network, respectively. As there are EQ CIM models that originate from different companies (HEP ODS and HOPS in this case), the ATTEST specific PowerCIM version also includes a mapper which maps the connectivity nodes from HOPS network to the HEP ODS network so that an integral model can be generated for the scope of Croatian pilot, this mapping is performed manually.

The Northern Croatian network is selected to be the primary test within the project and the relevant network model is imported in PowerCIM from the CGMES format.

The backbone of the PowerCIM tool runs in the PostgreSQL database, but the PowerCIM proper also has a REST API based interface. For this project, a different instance of API has been developed and deployed to allow flexibility required for the project. A shim or a wrapper around PowerCIM exposes the API endpoints to the rest of the data integration component:

- **branches** – provides the list of branch_ids and their descriptions
- **commits**(branch_id) – provides the list of commit ids for a given branch id
- **cimclasses** – exposes the CIM class mappings to internal IDs of PowerCIM, a helper API call exposed for easier mapping
- **netdata**(commit_id, branch_id, class_id) –retrieves the data for a particular CIM class ID
- **netdataall**(commit_id, branch_id) – retrieves the network data in an integral form
- a set of APIs suitable for assembling a MATPOWER-like model, all taking branch and commit IDs as parameters and returning fields of a MATPOWER model:
 - o **topoislands** – topological islands
 - o **buses** – buses from a bus-branch model
 - o **lines** – line branches
 - o **trafos** – transformer branches (with tap changers and tap sizes)
 - o **esources** – all nodes with generators connected within the network
 - o **extinjs** – external injections to the network.

To improve the user experience and as desired, branch and commit IDs do not need to be exposed fully to the user. The user's experience can go from selecting a desired network instance and then the model date in a selector dialog.

All APIs return the data as a JSON array. There are three possible workflows for the client of PowerCIM to assemble the network model, after identifying the correct branch and commit:

- getting all the data from PowerCIM via netdataall API and processes the CIM model data in the client
- processing the data CIM class by CIM class using the netdata API or
- utilizing the APIs exposing the properties required to assemble the MATPOWER-like model.

The netdata and netdataall APIs allow additional flexibility, while the MATPOWER APIs dispense the client of the need to process all the CIM classes.

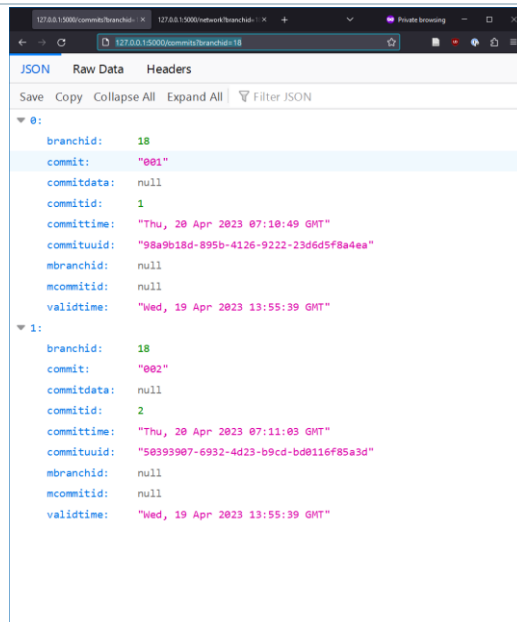


FIGURE 12 – EXAMPLE JSON RESULT OF BRANCH API CALL

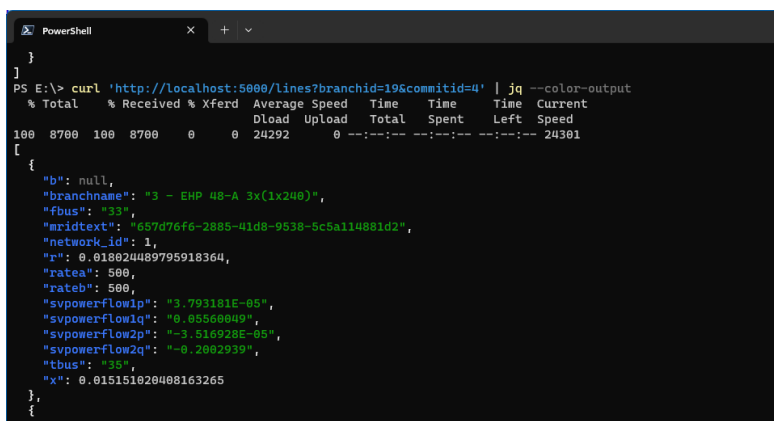


FIGURE 13 – EXAMPLE JSON RESULT OF LINES API CALL

In all the above cases, the topological processing happens transparently. As SCADA systems typically operate with physical equipment and the corresponding commands and signals, utilizing the network model directly corresponding to the network equipment, thus the EQ profile. This type of model is commonly called a *node-breaker* model. The principal benefit of a node-breaker model is that the signals directly correspond to the physical components of the industrial automation system being controlled. In a typical SCADA, there is little notion of entities semantically aggregating these commands and signals, while virtually all optimizations and calculations in the electrical grid require a correct network topology. The network topology can be determined from statuses of switches (breakers and disconnectors) and this creates an abstract model known as bus/branch network model, as opposed to the node-breaker model.

A switch is not an element which is a part of calculations such as power flows – a closed switch is effectively invisible to such calculations, and an open switch is a break in the network. A closed switch between the two physical nodes effectively aggregates these two nodes into the same abstract bus. An open switch means the two physical nodes must correspondingly be represented as two buses in the bus-branch model with no branch between them. The bus-branch model eliminates switches based on

their open/closed status and groups the so-called connectivity nodes, connected with closed switches, into a single topological node (bus). The other elements of electrical network are modelled as topological branches and this process of conversion is called network topology processing. More information and a detailed explanation on how the topological processing is implemented can be found in [4]. In the PowerCIM version dedicated to ATTEST, the ATTEST topological processor can create TP and SV PowerCIM profiles which then get exposed to the end user. These profiles can also be created by external tools such as NEPLAN – this way both workflows are supported, both using the ATTEST topology processing and relying on another software topological processing result. This way ATTEST tools can rely on, e.g. advanced distribution network management software if it is available in the DSO.

The ATTEST toolbox then instantiates a new network instance and fills in the database fields from the JSON packaged by PowerCIM. The JSON structure exactly corresponds to the internal database model of ATTEST, which for reasons of compatibility with the tools, follows the MATPOWER format specification. From there, the operational tools that tested in the Croatian pilot on the (mostly) live data are invoked as described in [1] - from the moment the network instance is created in the ATTEST internal integration component, the ATTEST tools operate exactly the same as in the development instance deployed in INESC TEC.

4. Demo Characteristics

The previous chapters outline the technical setup of the Croatian demo. Considering the network data, two principal network instances will be utilized from the DSO and their counterpart in the TSO:

- A 35 kV network of the Koprivnica city region, representing the network considerably well covered with measurements
- A 10 kV network of Koprivnica city region, representing a wider MV network with less available measurements
- Croatian transmission network segment overlapping with the Koprivnica city region

Both DSO networks have the connection points to the TSO network via the 110 kV transformer stations. The tools to be demonstrated are primarily the operational tools from the WP4 working package:

- T4.1 Tool for ancillary services procurement in day-ahead operation planning of the distribution network
- T4.2 Tool for ancillary services activation in real-time operation of the distribution network
- T4.3 Tool for state estimation of distribution networks
- T4.4 Tool for ancillary services procurement in day-ahead operation planning of the transmission network

The environment to demonstrate the above tools targeted for 2030 differs from the actual situation in 2023, so the tools would partially have to rely on simulated environment – for instance, there is no ancillary services activation in Croatian DSO.

The benefits of the above tools will be estimated through the calculation of performance indicators as follows: from the historical data, the indicators will be extrapolated to determine the baseline business as usual scenario. This will, for obvious case of e.g. the functionality of ancillary services in the DSO not being implemented, have to be an estimate. ATTEST tools would then be run on the actual collected data from the actual systems of the TSO and DSO, and a comparison will be made to determine the performance indicators comparing the business as usual with the scenario where ATTEST tools are used.

5. Conclusions and Future Work

In this deliverable the setup of the Croatian pilot and the integration of the tools with the Croatian pilot are described. When implementing any type of novel software solution within the business of an enterprise, there will always be technical, business and even legal challenges.

This is even more pronounced if the business in question is a regulated network operator, thus belonging to the critical system operators. Further yet, the challenge is harder if the tools that should be deployed are not at commercial level of maturity – which is the case of ATTEST toolbox.

The transmission and distribution system operators of the near future will have to handle increasing amounts of data and a standardized and well-organized data handling methodology will become essential. Furthermore, open data requirements and open data hub approaches, that are becoming common in Europe nowadays, would make the system operators even more exposed to the requirements of robust data handling. It is reasonable to expect the system operators to become the entities providing robust, correct and coherent data on the grids under their supervision. This is a very challenging and daunting task – and also the principal reason we faced many challenges in the implementation.

It is reasonable to expect that the existing common data handling formats such as CGMES will continue to be in use by 2030. For that reason, and for the reasons of interoperability, a version of the data integration and orchestration tool has been adapted to use in ATTEST. The Croatian pilot, designed as depicted, then closely resembles and follows the expected business operation of the DSO and TSO in 2030.

In other words, the described approach allows the ATTEST tools already, at their current level of maturity and the development stage within the project, to have the capability of embedding their added value in the business processes of the DSO. This will allow the testing of ATTEST operational tools on a dataset that very closely – albeit not perfectly – resembles the live data set available to the TSO and DSO, and fulfill the target of applying the ATTEST tools in the day-to-day operation of the system operators in Croatia.

In the months following the submission of this deliverable, the operational tools from the ATTEST toolbox will be tested in real-life grid operation in Croatia.

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