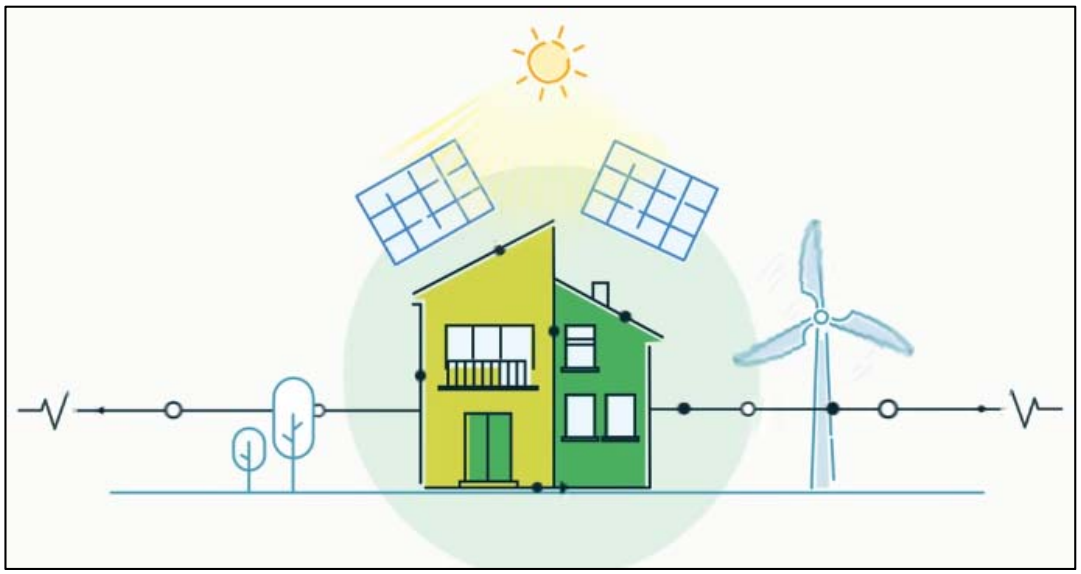
INCREASE

SEVENTH FRAMEWORK PROGRAMME



THE INCREASE SIMULATION PLATFORM

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1 INTRODUCTION

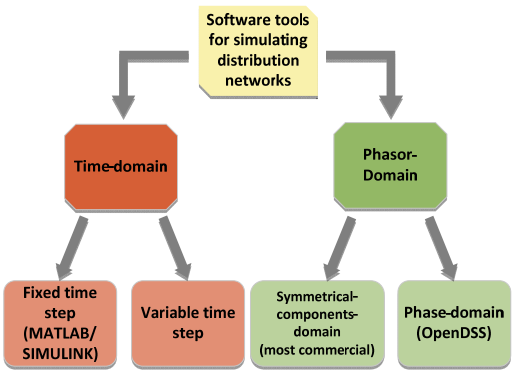
New challenges in the distribution network

Over the past decades, research has been focused on developing software tools to analyze, plan, optimize and simulate electrical networks. The advent of distributed generation (DG) has gradually changed power flow in the power distribution network from downstream unidirectional to a bidirectional scheme, introducing challenging technical issues, such as unacceptable overvoltages, voltage unbalances, line congestions, and protection issues. Although novel control schemes have been proposed for interfacing DGs to the grid and mitigating these issues, such controlled inverters need to be also efficiently incorporated in the simulation software packages.

Limitations of current software platforms

Most of the commercially available software platforms for power system analysis allow the use of customizable configurations covering almost all electrical aspects in generation, transmission and distribution, including steady-state calculations, power quality optimization and protection coordination. However, a major drawback is that they usually have a closed form architecture, not allowing the easy and efficient integration of user developed models, especially regarding control systems.

Considering the simulation of power system networks, the existing open source and commercial software products can be divided into two main categories as shown in the following figure.



Software tools based on time-domain solutions simulate the power system network by solving differential equations that describe all power system components. Although these simulation tools provide the ability to integrate DG control schemes in a very straightforward manner, they cannot be used for the simulation of extended networks, due to the prohibitive execution times.

Software platforms based on phasor solutions use algebraic equations for the simulation of power systems operating in steady-state condition. As a result, power flow and harmonic analysis calculations can be readily performed with small execution times, even in cases of extended networks. The major drawback of such models is that their core calculation routines may become cumbersome with the incorporation of DG droop controls or of other additional control schemes.

The INCREASE approach

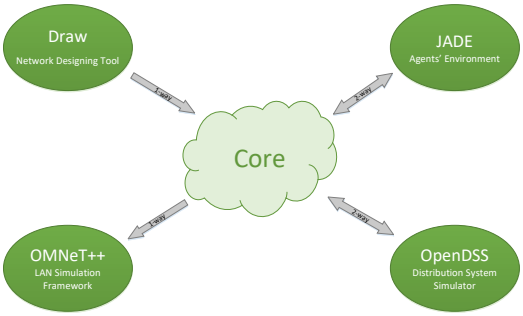
To overcome these issues, **a new simulation platform has been developed in the framework of the INCREASE project**, comprising the benefits of both software categories and allowing the efficient integration of several distributed renewable energy sources (DRES) control strategies. The new simulation tool has the following basic characteristics:

- Employs **phasor-domain** solutions, resulting in short execution times even in cases of extended distribution networks.

- Offers a **graphical user interface** (GUI) for the convenient input and configuration of the system under study.
- Can allow the efficient incorporation of any DG control scheme.
- Can be **interlinked** with other software platforms and tools to form a generic **co-simulation** platform, capable to simulate modern power system networks from both power, control and communication point of view.

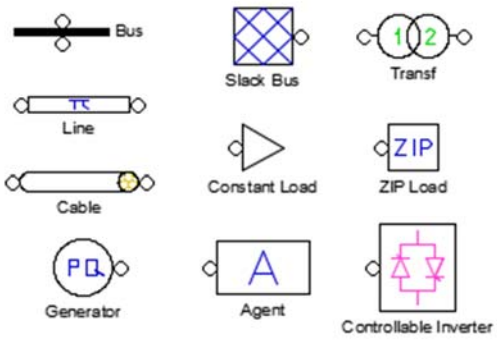
2 ARCHITECTURE

The INCREASE simulation platform is presented in the following figure. The developed software comprises **different open-source** tool components and their mutual interconnections. More specifically, the INCREASE simulation platform includes:



- The **Core** engine, which is the base of the simulation platform. The core is developed in MATLAB and implements the interconnections between the different components of the INCREASE simulation platform.

- The **Draw tool**, which is a **graphical pre-processor** with design capabilities to allow the user-friendly input and configuration of the distribution or transmission network under investigation. All elements work in a **drag and drop environment** by simply putting them in the design area, configuring their required data, and making the appropriate connections.



- The **OpenDSS** software, which is a phasor-domain grid simulator, capable of performing unbalanced power flow calculations. OpenDSS provides all the advantages of an open-source software, while it also offers highly accurate results, remarkable numerical performance, and vast communication abilities with external software tools.

- The **JADE software**, which is the tool integrating any intelligent multi-agent based control system (MAS) and the corresponding communication in the INCREASE platform for the implementation of high level control strategies.

- The **OMNeT++ simulator**, which is an open source LAN simulator, used for the analysis and the evaluation of the communication infrastructure of the examined smart grid.

3 FEATURES

The INCREASE simulation platform provides the user with a **co-simulation tool** that can be used to investigate the influence of DRESs on their distribution system. In general, the simulation platform offers the following major features:

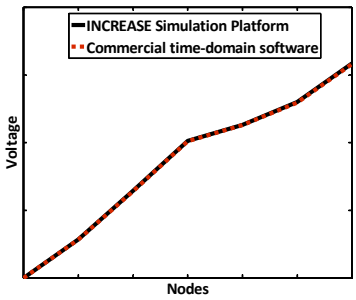
- **Detailed analysis** of MV/LV electrical power grids, including all potential DRESs, DGs, loads and control systems. Due to the required analysis, a **quasi-dynamic** solution is adopted.

- Incorporation of an adaptive **Multi-Agent System** (MAS) taking into account multi-objective control algorithms as well as the communication among the individual agents.

- Implementation of a **multi-layer** control strategy for the secure and optimal operation of active distribution grids. The distinct control strategies are coordinated by employing a user defined **timeslot concept**.

- Ability to simulate **balanced** as well as **unbalanced** distribution networks with **high accuracy**.

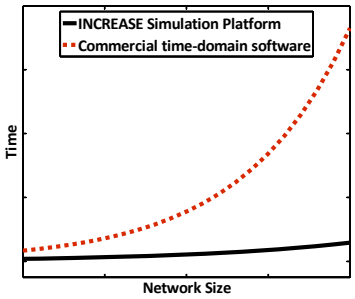
- A **near-zero** mismatch between the results obtained from the INCREASE simulation platform and most of the available commercial time-domain software platforms.



- Provides **reduced order equivalent models** for both passive and active parts of extended distribution grids.

- Can incorporate of the most **high-end** control schemes in DRESs for the effective overvoltage and voltage unbalance mitigation.

- Offers the ability to perform time-series simulation with **reduced** execution times.



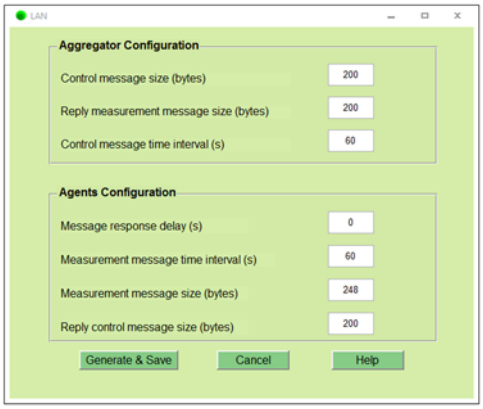
- Allows the **integration** of load and generation forecasting algorithms for short- and medium-term provision of reserve, focusing on the power loss reduction, maximizing active power injection and the **optimal** performance of DRES.

- Offers the ability to simulate **several control schemes** for the locally controlled inverter-interfaced DRESs. The $P(V)$ droop control is considered as the default control strategy. Other control schemes such as the $Q(V)$ and the $cos\varphi(P)$ control strategy can be readily incorporated into the simulation platform.

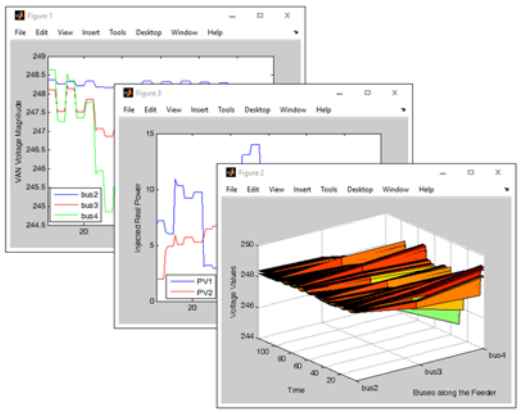
- Employs a discrete **LAN simulator** of communication networks to evaluate the communication performance and the vulnerability of the MAS control system.

- The LAN simulator is mainly used to analyze possible **contingencies** of the communication infrastructure on the operation of the MAS control system. However, it can also be used to investigate alternative options on the design of the necessary infrastructure and to examine the

communication system **vulnerability** and its impact on the control system performance.



- **Simple** GUI for the power system design with **user-friendly** post-processing tools for reporting and plotting results.



- **Built-in** import and export features for most common data and calculation formats.

- **Flexible** platform based on **open-source** software with **modular** architecture structure to readily integrate future packages, features and functions.

The above features and advantages, make the INCREASE simulation platform a **competitive** simulation program among other commercial and open-source software packages.

4 KEY STAKEHOLDERS

The key stakeholders that can make use of the INCREASE simulation platform include:

- **Distribution system operators** (DSOs). They can perform **long-term analysis** of the distribution grids to assess different control techniques of DRESs and their impacts.

- **Transmission system operators** (TSOs). The INCREASE simulation platform can be a valuable tool for developing and/or evaluating the provision of **ancillary services** for the TSOs.

- **Aggregators**. It can be used as a **powerful tool** for the aggregators to ensure the safe and reliable network operation, following certain interventions.

- **Power retailers.** The developed platform can be used to investigate **different pricing policies** for the prosumers, taking also into consideration the network operation from a power systems point of view.

- **Other regulatory authorities.** They can exploit the INCREASE simulation platform to develop new and/or assess existing **regulatory frameworks**.

- **Energy companies.** It can be used to investigate the **long-term performance** of the network from the grid side as well as from the economic point of view.

- **Universities or research institutes.** They can perform simulation studies to evaluate existing control techniques and/or to develop new control strategies.

5 OUTLOOK

The INCREASE co-simulation platform is a novel software platform for the analysis of smart grids. Offering some unique features like modular, flexible structure, an easy to use graphical user interface and open source architecture, it allows the easy integration of models of any novel smart grid component. It is compatible with existing commercial software packages, providing data portability and integration capabilities. Therefore, the INCREASE simulation platform can be considered as a tool for many stakeholders involved in the analysis and simulations of smart grids.

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PROJECT

This policy brief was created within the FP7 project INCREASE:

http://www.project-increase.eu/index.php

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