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Smart Grid Interoperability Laboratory

Annual Report 2021

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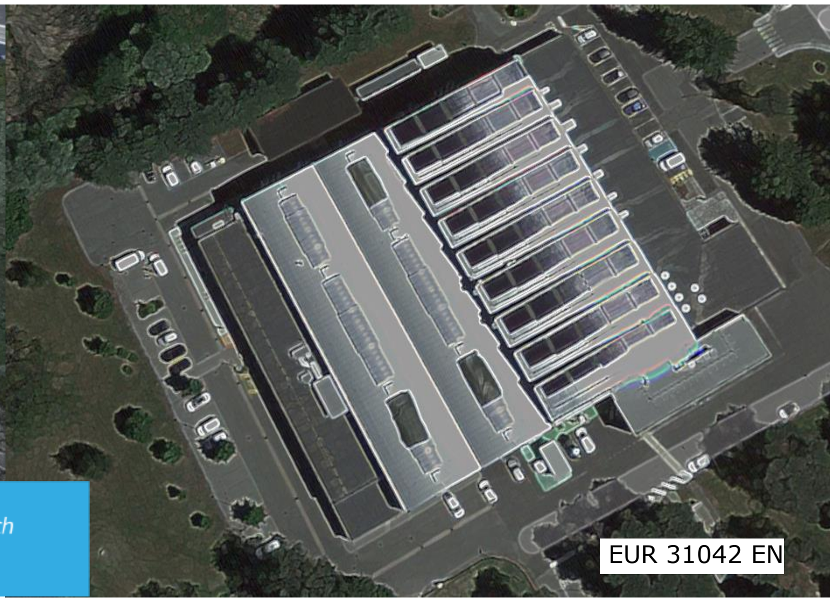

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Abstract

The Joint Research Centre's Smart Grid Interoperability Laboratory is situated at two sites, Ispra (IT) and Petten (NL). It is designed to foster a common European approach to interoperable digital energy, focussing on the smart home, community and city levels. The Smart Grid Interoperability Laboratory is part of a larger activity of the JRC, the science and knowledge service of the European Commission, encompassing electric vehicles, smart grids and batteries. The activities in 2021 are highlighted in this report.

Executive summary

Smart homes are growing into smart communities and smart regions – even smart cities. In the future, we will live in an intelligent digital eco-system, where virtual power plants connect up sustainable energy systems, where electric cars behave as intelligent batteries, and where citizens produce energy as well as consuming it.

In order to achieve an intelligent digital eco-system, all systems need to be able to communicate with each other. They need to be interoperable. After the opening of the House of the Future as part of the JRC Smart Grid Interoperability Laboratory (SGIL) in Petten, NL, at the end of 2018, scientific activities started. With that scope the first test series had been undertaken in 2019/20. The continuation in 2021 is reported under chapter 4.

As a continuous activity the Laboratory is updated with new innovative digital products when needed. The tailor-made energy management system software is also further developed on a continuous base.

Policy context

The Energy Union in 2015 set the scene for an ambitious EU's positioning concerning energy, climate and clean mobility. Key objectives are the strengthening of the position of citizens while paving the way for innovative business. This approach is necessary to achieve the commitments of the Paris Agreement and the 2030 Energy Strategy, but also to enable the EU e-industry to be at the forefront of the global market. It recognizes the need for an integrated, coordinated and streamlined approach of EU policy and industrial R&D and business development with a global reach.

From the technological viewpoint, one major change is the massive introduction of ICT solutions in the energy field. This process of digitalization will result in an energy system characterised by extensive interconnections and exchanges of data between stakeholders, systems and devices. In this context, the potential of the market cannot be effectively realised if interoperability is not a cornerstone of efforts. Proprietary solutions, mainly if imposed by foreign companies, can greatly hamper the prospects for EU companies, and the empowerment of consumers.

The Tallinn e-Energy declaration ([1]) of 2017, signed by all Member States, asserted the vast potential for digital solutions in the energy sector and the requirement to ensure full interoperability between systems. The European Commission services are currently preparing both policy initiatives (DG CONNECT and DG ENER) in support of the 'Digitising European Industry' (DEI) strategy ([2]) and of the Clean Energy for All Europeans package (CEP) ([3]), and support to interoperability standardisation and testing with a hub of dedicated laboratories by JRC.

More recently, in 2019 the Green Deal ([4]) was launched by President Ursula von der Leyen. It is about making Europe climate-neutral and protecting our natural habitat, which will be good for people, planet and economy. The related initiatives are decarbonisation of the energy sector and renovation of building to cut energy bills and use.

In 2020, the New European Bauhaus ([5]) initiative was launched, which connects the European Green Deal to our living spaces. It intends to look at our green and digital challenges as opportunities and an approach to finding innovative solutions to complex societal problems. In line with these aims the JRC SGIL is prepared to contribute to the interoperability testing of digital solutions for the energy sector.

From e-mobility, to resilience of the energy grid passing via smart homes and grid integration, the SGIL is able to independently assess and support industry developments with respect to interoperability.

Key conclusions

Since the SGIL inauguration more and more interoperability use cases are and will be developed based on co-operation with industry, academia and research, such as RWTH Aachen, AIT, ERIGrid, Interconnect, Maesha,

([1]) https://www.eu2017.ee/tallinn-e-energy-declaration
([2]) https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry
([3]) https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans
([4]) https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
([5]) https://ec.europa.eu/commission/presscorner/detail/en/AC_20_1916

EEBUS. The need for a common European interoperability testing methodology had been recognized and was taken on board by the SGIL, backed and recognized more and more by industry. The test results are described in detailed use-case testing descriptions.

The SGIL published a smart grid inventory.

The SGIL produced several publications in its field of expertise.

The SGIL validated the basic models for the residential electricity load simulation (resLoadSim) of households and developed an improved e-vehicle charging method.

Related and future JRC work

In fact, the SGIL is part of a broader set of interoperability labs. It is connected with many other research facilities, including the Battery Energy Storage Testing facility in Petten (NL) and the European Interoperability Centre for Electric Vehicles in Ispra (IT). Interoperability testing is carried out following an in-house developed European interoperability testing methodology. A common European repository for dissemination and open access is envisaged. The SGIL aims to attract external researchers with their use case, in order to build up the repository. For a better dissemination participation to related fora and consortia are envisaged, in order to spread and promote the application of the European interoperability testing methodology. By this, the database for use cases will continuously grow. On top of this, two new documents are in discussion: Interoperability standards following a new approach and a benchmarking process for defining the maturity in interoperability of devices, processes and services.

Further plans are to intensify our collaboration with EEBus with the objective to validate the EEBus interface against our interoperability testing methodology, which will require real hardware testing experiments. For this purpose, an experimental setup was designed jointly which will be delivered in early 2022.

A 3-dimensional virtual tour of the SGIL (Ispra and Petten) is in preparation to be online in 2022.

Quick guide to this report

Chapter 1 gives a short introduction to the theme.
Chapter 2 describes the EC policy relevance, the motivations and the benefits for all stakeholders.
Chapter 3 describes the laboratory.
Chapter 4 reports about the activities related to the laboratory
Conclusions are drawn in Chapter 5.
Finally, Annex 1 reports aspects relevant to developing Interoperability for Europe

1 Introduction

Smart homes and communities are benefiting EU citizens mainly by optimized energy consumption and therefore energy bill reduction. Our houses are quickly becoming smart homes, with smart thermostats, domestic appliances and security systems activated by apps on our smartphones. However, this is just the beginning. Smart homes are growing into smart communities and smart regions – even smart cities. In the future, we will live in an intelligent digital eco-system, where virtual power plants connect sustainable energy systems, where electric cars behave as intelligent batteries, and where citizens produce energy along with consuming it.

In order to achieve an intelligent digital eco-system, all systems need to be able to communicate with each other. They need to be interoperable. But as citizens, how do we know if the appliances we buy are compatible; as investors and producers, what gives us the confidence to invest in specific products and to design new components?

The European Commission has launched several initiatives for making interoperability a reality, such as:

— Mandate to the European Standardization bodies on standards for smart grids and smart meters ([6]);

— Energy Union and Clean Energy for All Europeans policy packages ([7]);

— High level Meeting "Interoperability to create the Internet of Energy ([8]);"

— Calls in Horizon 2020 in the Pillar of Industrial Leadership ([9]);

— Common international smart grid standards initiatives within the Transatlantic Economic Council (TEC) ([10])

Developing common standards, test procedures and tools to promote universal compatibility and interoperability between electric vehicles, e-vehicles supply equipment, and the electric power supply infrastructure. The successful bilateral working relationship has led to an expansion of collaboration to include smart energy management;

Advancing work towards international standards on interoperability of patient health summaries, creating a common education programmes to support jobs in the health-IT workforce, and fostering transatlantic partnerships with regions/cities to solve similar health IT challenges and identify potential trade and commercial opportunities; and

Promoting opportunities for small and medium enterprises (SMEs) to increase exports. At the JRC in Petten, we offer to stakeholders a laboratory facility to evaluate interoperability in smart homes and communities, fostering the adoption of a common testing methodology. The work is carried out in conjunction with other JRC facilities supporting the interoperability of smart grids and electric vehicles. With these actions, JRC will contribute to the implementation of EU policies aiming at the clear energy transition and the digitalisation of energy.

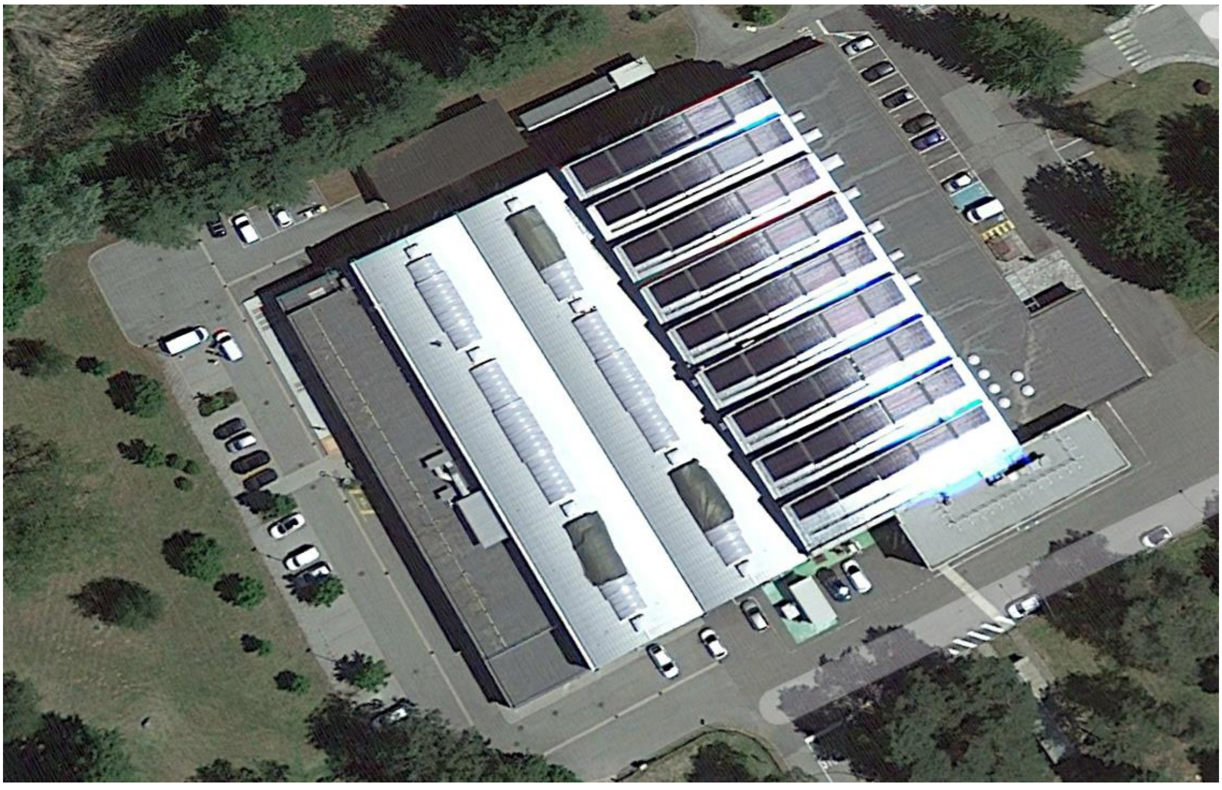
In 2021, we specifically investigated the application of the European Interoperability Testing Methodology in use cases and developed further our modelling and programming activities.

([6]) http://pr.euractiv.com/pr/european-standards-organisations-drive-international-cooperation-smart-grids-electricity-networks
([7]) https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en
([8]) https://digital-strategy.ec.europa.eu/en/events/high-level-meeting-interoperability-create-internet-energy
([9]) https://ec.europa.eu/programmes/horizon2020/en/h2020-section/industrial-leadership
([10]) https://trade.ec.europa.eu/doclib/press/index.cfm?id=1591

Figure 1. Aerial view of the JRC in Petten

Source: JRC, 2021

Figure 2. Aerial view of the JRC SGIL in Ispra



Source: JRC, 2021

2 Policy background

The Energy Union set the scene in 2015 for an ambitious EU's positioning concerning energy, climate and clean mobility. Key objectives are the strengthening of the position of citizens while paving the way for innovative business. This approach is necessary to achieve the commitments of the Paris Agreement and the 2030 Energy Strategy, but also to enable the EU e-industry to be at the forefront of the global market. It recognises the need for an integrated, coordinated and streamlined approach of EU policy and industrial R&D and business development with a global reach.

From the technological viewpoint, one major change is the massive introduction of ICT solutions in the energy field. This process of digitalization will result in an energy system characterised by extensive interconnections and exchanges of data between stakeholders, systems and devices. In this context, the potential of the market cannot be effectively realised if interoperability is not a cornerstone of efforts. Proprietary solutions, mainly if imposed by foreign companies, can greatly hamper the prospects for EU companies, and the empowerment of consumers.

The Tallinn e-Energy declaration of 2017, signed by all Member States, asserted the vast potential for digital solutions in the energy sector and the requirement to ensure full interoperability between systems. The European Commission services are currently preparing both policy initiatives (DG CONNECT and DG ENER) in support of the 'Digitising European Industry' (DEI) strategy and of the Clean Energy for All Europeans package, and support to interoperability standardisation and testing with a hub of dedicated laboratories by JRC.

More recently, in 2019 the Green Deal ([11]) was launched by President Ursula von der Leyen, It is about making Europe climate-neutral and protecting our natural habitat, which will be good for people, planet and economy. The related initiatives are decarbonisation of the energy sector and renovation of building to cut energy bills and use.

In 2020, the New European Bauhaus ([12]) initiative was launched, which connects the European Green Deal to our living spaces. It intends to look at our green and digital challenges as opportunities and an approach to finding innovative solutions to complex societal problems.

In line with these aims the JRC SGIL is prepared to contribute to the interoperability testing of digital solutions for the energy sector.

From e-mobility, to resilience of the energy grid passing via smart homes and grid integration, the SGIL is able to independently assess and support industry developments with respect to interoperability.

2.1 Why is interoperability important?

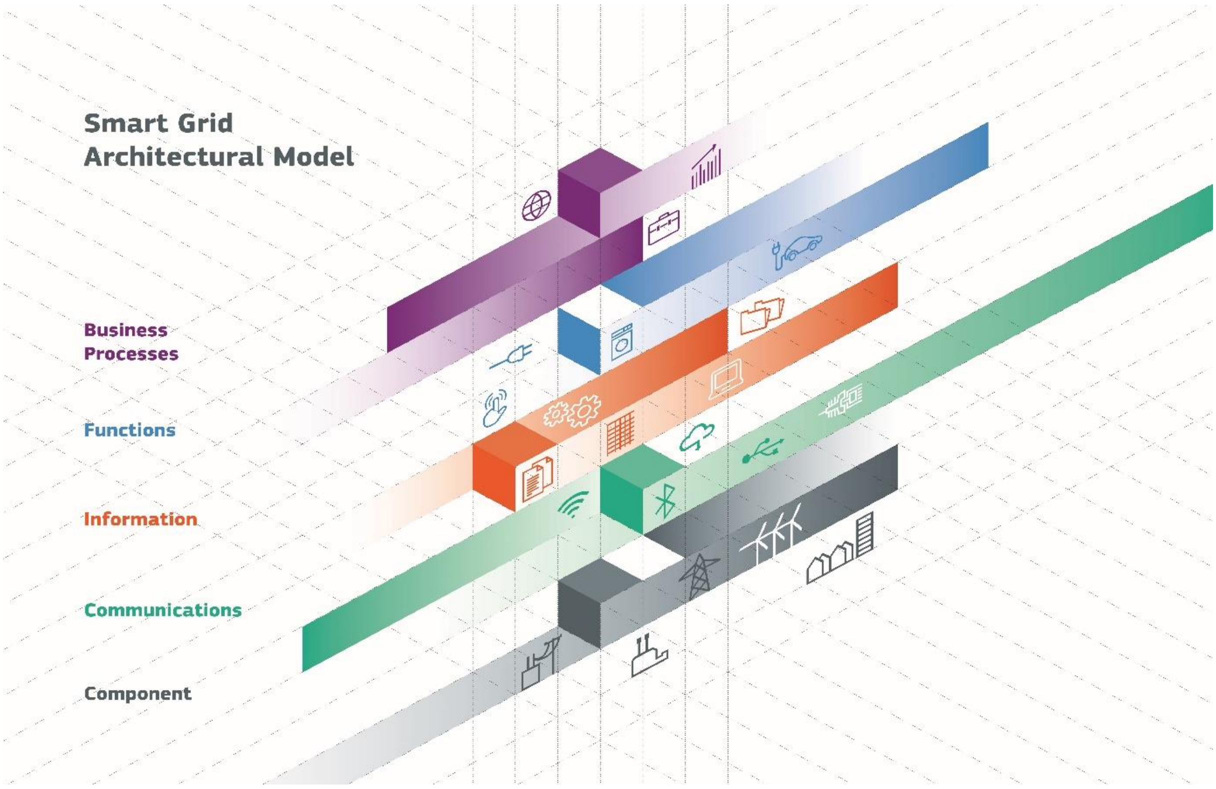
The digital transformation of the energy sector is already changing the way energy is produced, distributed and consumed, affecting not just industry, but also consumers and local communities. This revolution is characterised by the conjunction of renewable sources, smart grids, smart houses and electric vehicles, and is enabled by widespread application of information and communication technologies. The introduction of "internet of things" solutions in homes and buildings, for example, can interconnect appliances and devices to achieve energy efficiency.

A key challenge for digital energy, especially from the consumer's point of view, is the interoperability of all the components, systems, applications and information involved. Interoperability is the ability of two or more items to work together, which is key to the creation of a single digital energy ecosystem. But digital energy results from the convergence of many different industrial sectors – electricity, power electronics, home appliances, telecoms and internet – all with their own standards, cultures and technical backgrounds.

Interoperability will not happen spontaneously and needs to be supported with dedicated policy, standardisation and technical instruments.

([11]) https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
([12]) https://ec.europa.eu/commission/presscorner/detail/en/AC_20_1916

Figure 3. The different interoperability layers based on the Smart Grid Architectural Model (SGAM)



Source: JRC, 2018

2.2 What is the issue for the EU consumer?

Consumers (at all levels: citizens, private companies, public organisations) would benefit substantially from the certainty that the goods they purchase can be integrated without major inconvenience and that they are not locked-in by vendors. This is particularly significant in the case of smart houses, where commercial offers can hide the perils and shortcomings of proprietary solutions. Lack of interoperability will fragment markets and damage consumers.

2.3 What is the EU doing about interoperability?

The European Commission has identified interoperability, based on open standards, as an essential requirement for the fostering of markets for innovative energy products and services. The European standardisation bodies (CEN-CENELEC and ETSI) have been working to develop an approach that can guarantee the interoperability of solutions. This work is complicated by the vast range of standards used and the lack of a common methodology to demonstrate interoperability (annex 1).

It is in this context that the JRC SGIL was conceived to contribute to the interoperability testing of digital solutions for the energy sector.

2.4 Why a laboratory for the interoperability of smart homes?

The above mentioned policy decisions made it the right moment to launch the Smart Grid Interoperability Lab and to demonstrate the House of the Future in JRC's Petten site. Smart Homes and communities are central to the energy transition. They set the pace for the connection of renewable energy sources (RES), the promotion of energy efficiency, the smooth management of distributed generation and the charging of electric vehicles, as well as the adoption of new services based on local storage solutions, smart appliances and Internet of Things (IoT).

With a similar approach, the laboratory in the Ispra site focuses on the integration of renewable energy and electro-mobility into the power system, analyzing the key technologies available at a distribution level to enable and facilitate the energy transition. The focus of the lab is on testing the ability to interwork, and to exchange and use information in new electric power grids architectures, including heterogeneous and microgrids. The lab activity in Ispra focuses on the interoperability of technological (hardware/software) implementations according to proposed standards used in conjunction with applicable reference architectures.

Interoperability is the crucial element, not just enabling the overall integration of energy and ICT components, but unblocking open and fair markets based on seamless access to data and communication interfaces. Interoperability, building on existing standards, paves the way to an innovative digitalisation of energy.

This demonstrates the political emphasis placed on interoperability for Europe and provides the impetus to translate political goals into workable solutions.

Indeed, it is now timely for the work of the European Commission towards interoperability of solutions and standardisation for smart energy grids, smart homes and smart meters to benefit consumers and industry. The "Clean Energy for All Europeans" package presented in November 2016 clearly stated that the development of more interoperable systems was required "in order to stimulate the further development and uptake of low-carbon, energy-efficient solutions across all sectors."

Additionally, the High-Level meeting organised by DG CONNECT and ENERGY in 2017 highlighted the need for aligning the standards regarding smart homes and smart grids, as a way for promoting the broad introduction of smart technologies and appliances. The link with public policies is clear: there is the collective interest of not fragmenting the internal market, of promoting European solutions worldwide, of sustaining public procurement and of empowering the end-users.

Nevertheless, policies, technologies and standards by themselves cannot secure the flourishing of the digital energy market. Policymakers, market players and consumers require a solid basis upon which to build up trust. Interoperability needs evidence and only systematic tests can provide it.

The work to be accomplished in the JRC Interoperability lab represents an important novelty: it will propose and disseminate the first complete and actionable interoperability testing methodology for digital energy and smart homes ([13]). The approach to this issue has to be pan-European. A common approach to testing and reporting will facilitate the openness of information and the development of markets.

The creation of the lab thus represents a substantive step towards a more thorough European approach to interoperability. The future use and implementation of the common testing methodology by other laboratories and industry in Europe will secure a homogeneous and consistent reporting of the state-of-the-art of interoperable solutions.

Moreover, access to open and trustworthy information will reinforce the engagement of citizens. The vision is that of Interoperable digital energy systems for All Europeans, where each citizen can benefit with new products and services.

This is also an opportunity for Europe to play a leading role in the global scene. By unlocking the potential of interoperability and demonstrating its application, Europe's standards, technologies, solutions and industrial actors can gain markets and pioneer the worldwide adoption of clean and smart energy.

([13]) Papaioannou I., Tarantola S., Lucas A., Kotsakis E., Marinopoulos A., Ginocchi M., Olariaga Guardiola M., Masera M., Smart grid interoperability testing methodology, EUR 29416 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-96855-6, doi:10.2760/08049, JRC110455

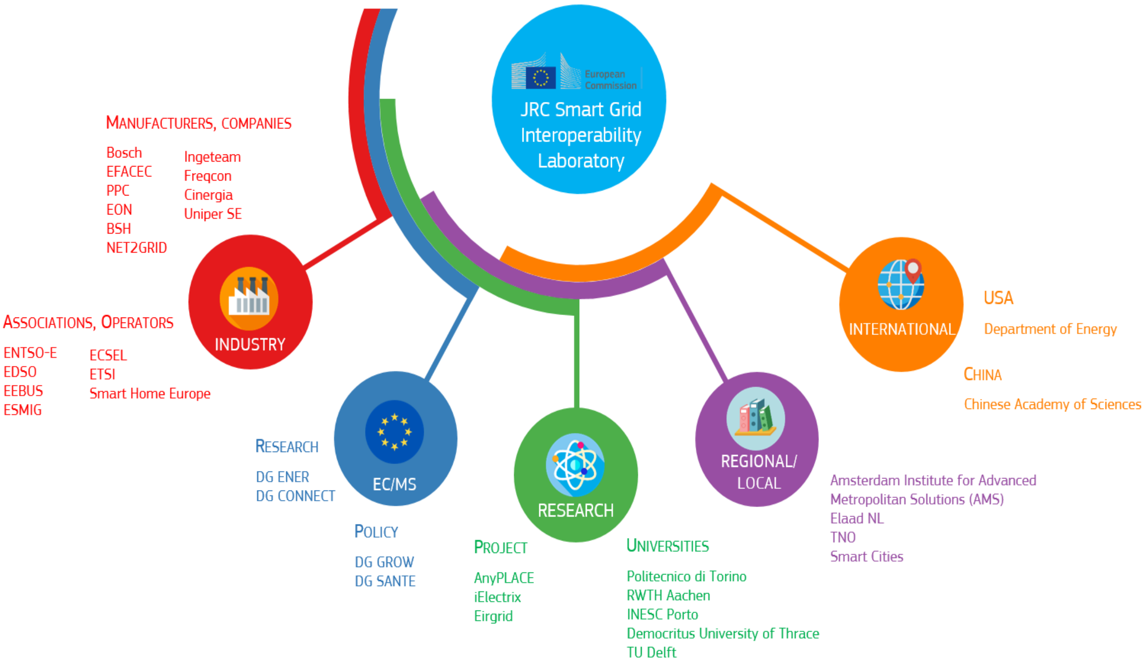
2.5 Smart Grid Interoperability Laboratory (SGIL) at JRC: What do we do and for whom?

The SGIL at Petten has a clear objective: to promote the interoperability of digital energy in the interface between smart homes and smart grids. In order to do this, SGIL does:

- Test the interoperability of solutions, from the market and from research projects.
- Promote the use of a common interoperability testing methodology based on the CEN-CENELEC-ETSI framework.
- Network with other European laboratories and research centres for common initiatives.
- Network with European industrial actors in various sectors.
- Disseminate the results of testing campaigns.

Figure 4 shows an overview of stakeholders addressed by the SGIL.

Figure 4. Stakeholders beyond the EU citizen addressed by the SGIL



Source: JRC, 2019

The SGIL at Ispra supports the development of innovative solutions for the decarbonization of energy systems and promotes the interoperability of digital energy, with a specific focus on distribution network technologies and electric mobility. For this purpose, the following key activities are conducted at the Ispra site:

- Scientific support to other Directorates of the Commission
- Collaborations with universities, research institutes and industrial companies for the development of new technological solutions in the energy sector
- Research activities in the areas of renewable energy sources integration, network design and simulation

— Testing and promotion of hardware/software interoperability solutions for the electricity network

Box 1. Some concrete examples of problems to solve for consumers or businesses

a) Carla wants to make her home in Italy smarter. She is looking for products to buy, but feels lost in the jungle of EU products and standards.

By making use of the results of the JRC lab, Carla will be able to speedily select among products with demonstrable interoperability.

b) George works in a retail company and would like to offer smart services, but finds the wide range of standards confusing.

Taking advantage of the database of use cases and testing results carried out at JRC's and other European facilities, George will be able to select interoperable services and the related products.

c) Pat and Ken are young entrepreneurs with an idea for a start-up, but the market is blocked by proprietary solutions.

Pat and Ken can benefit from the Interoperability labs in several ways: by testing their idea for qualifying their solution and accelerating the innovation cycle; by browsing the database of testing cases for examining the technical state of the art; and by being part of an ecosystem that defends open standards vs monopolies.

2.6 Who is benefitting from SGIL activities?

Consumers

— Access to reliable information on interoperable energy-related products and services.

— More certainty about plug-and-play digital energy solutions.

— Proof that applications can enable energy efficiency and participation in the energy market.

Manufacturers

— Less market fragmentation, opening up global market opportunities.

— Lower production costs due to economies of scale.

— Benefits of using open standards.

Operators

— Better integration of distributed energy resources.

— Opportunity for new business models and services.

— More consistent approach to a comprehensive digital energy framework.

Standardisation

— Identification of gaps and misalignments in current standards.

— Recommendations for further global harmonisation.

3 Layout and equipment of the SGIL

Accommodated in a new tailor-made building, the lab features a testing space for the future components of smart homes – where apps can regulate the fridge temperature according to your energy saving preferences for example, or the energy left over in the electric vehicle battery can be used to power your washing machine at a time of your choosing.

On one floor, simulators and technical apparatus set the testing environment. They are used to analyse the electricity and data flows between the grid and the smart home components.

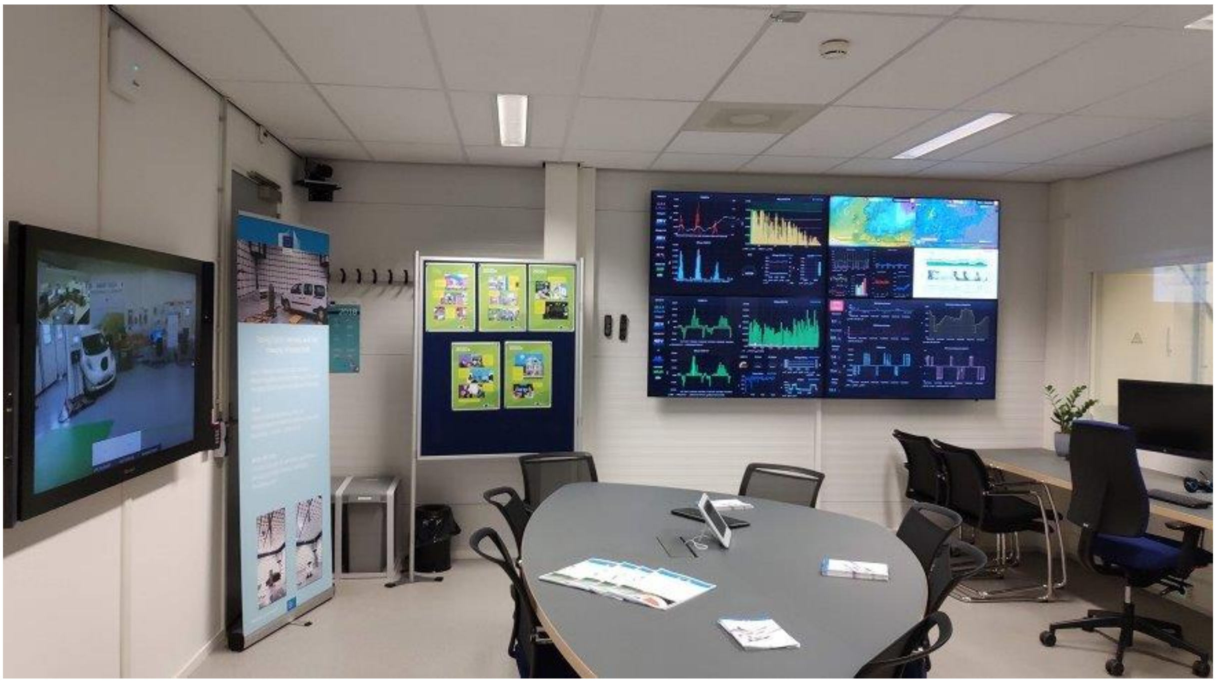
Figure 5. SGIL from the air

Source: JRC, 2019

Figure 6. Smart kitchen SGIL, first floor

Source: JRC, 2018

Figure 7. Control room SGIL, first floor



Source: JRC, 2018

Figure 8. SGIL, ground floor

Source: JRC, 2018

Figure 9. Battery containers SGIL

Source: JRC, 2018

The SGIL is structured and composed according to figure 10.

Figure 10. Structure SGIL

SMART HOME	BATTERY ENERGY STORAGE SYSTEMS	MICROGRID	REAL-TIME SIMULATION	E-MOBILITY	MONITORING
SMART APPLIANCES	BESS 1: 15KW/45KWH WITH LEAD ACID BATTERIES	BATTERY ENERGY STORAGE	OPAL-RT REAL-TIME SIMULATOR	PHV	OPEN SOURCE SYSTEM FOR CONTROL, AUTOMATISATION, ON-THE-FLY RECONFIGURATION, ETC.
HEAT PUMP	BESS 2: 75KW/150KWH WITH LI-ION (LFP) BATTERIES	PV	SPEEDGOAT	BEV	DATA COLLECTION AND STORAGE
HOME AUTOMATION SYSTEMS	BESS 3: 75KW/150KWH WITH LI-ION POLYMER BATTERIES	LOAD EMULATOR/LOADS	AMPLIFIERS TRIPHASE	EV CHARGING POLES	VISUALISATION
VARIOUS SMART DEVICES		DIESEL GENSET		ELECTRIC BIKES	

Source: JRC, 2018

Some examples are shown hereunder.

Figure 11. 3 Large energy storage units (batteries)

Source: JRC, 2018

Figure 12. Microgrid SGIL

Source: JRC, 2018

Figure 13. Electric vehicles SGIL

Source: JRC, 2019

Figure 14. Real time simulation SGIL

Source: JRC, 2018

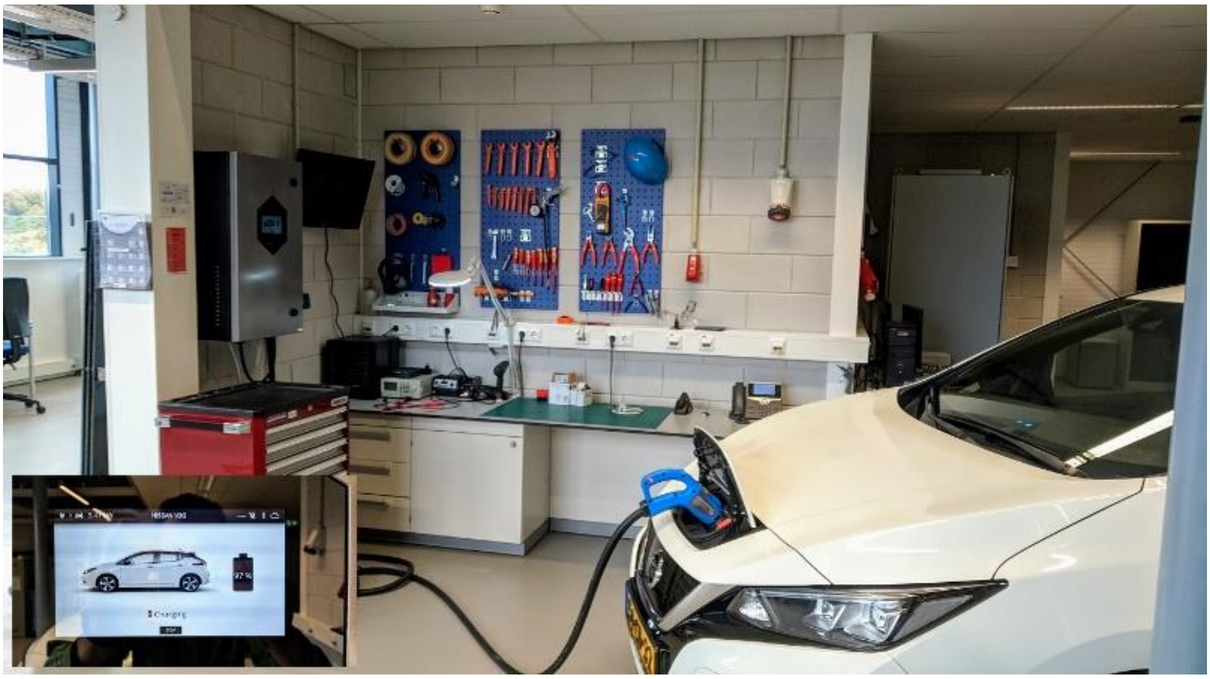
Figure 15. Smart Home appliances SGIL, first floor

Source: JRC, 2018

Figure 16. Diesel generator for uninterruptable power supply in the SGIL

Source: JRC, 2018

Figure 17. Vehicle to Grid (V2G) Charger, bidirectional flow of energy possible



Source: JRC, 2019

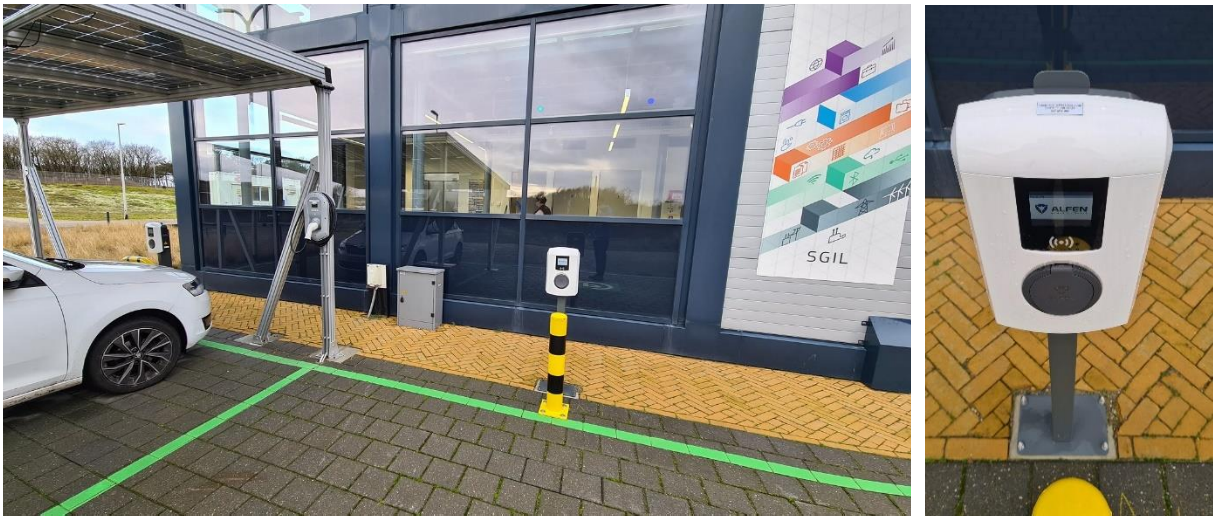
Figure 18. Prototype of Dutch Solar Design solar panels

Source: JRC, 2019

Figure 19. Revised extended electro cabinet

Source: JRC, 2020

Figure 20. New car charging infrastructure:



Source: JRC, 2020

Figure 21. Home battery and a hybrid solar inverter

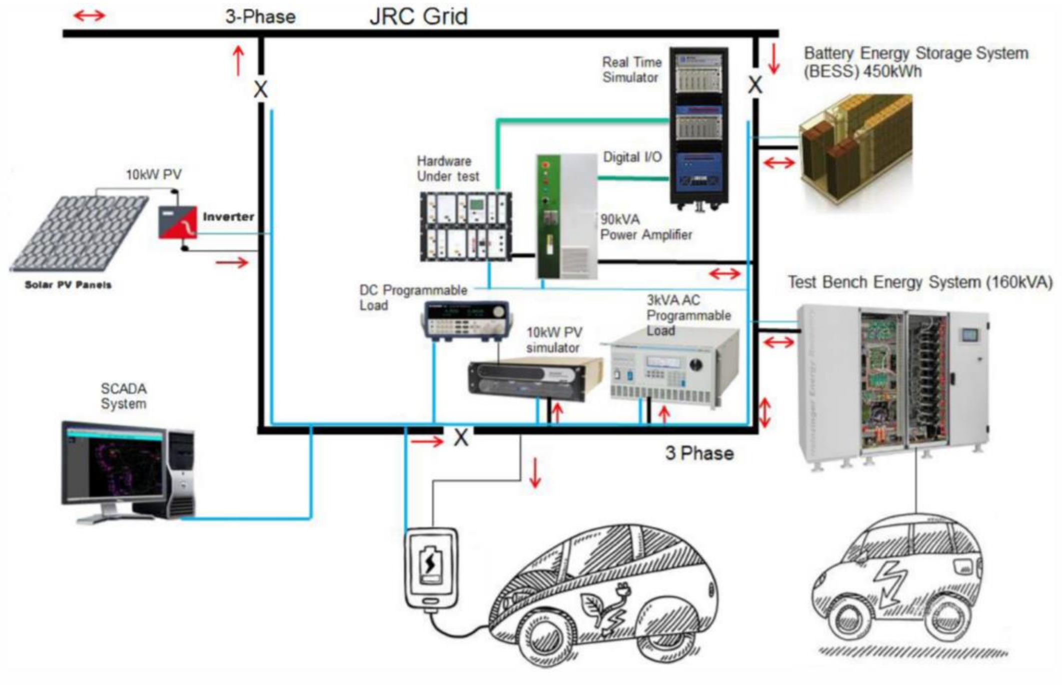
Source: JRC, 2020

Figure 22. PRISM

Source: JRC, 2021

The SGIL of the JRC site in Ispra is situated in building 18 and a general overview of its main equipment is provided in **Error! Reference source not found.**. Externally, the lab is endowed with a battery energy s torage system of 550 KWh and photovoltaic panels for a total power of 60 kW are installed on its roof. Indoor, the large technical hall contains the most relevant equipment for simulations and testing: an electric vehicle (Nissan Leaf), an Energy Recovery System (ERS), a smart meter panel, a power amplifier and an education power system workstation. The server room at the back of the building hosts the information and communications control center, together with the real-time digital simulator. In addition, a conference space is reserved for meetings and a control room has been set up to design, execute and monitor the different experiments.

Figure 23. Laboratory equipment



Source: E. Kotsakis et al. (2016) *"Smart grid interoperability lab at the Joint Research Centre (JRC) of the European Commission"*

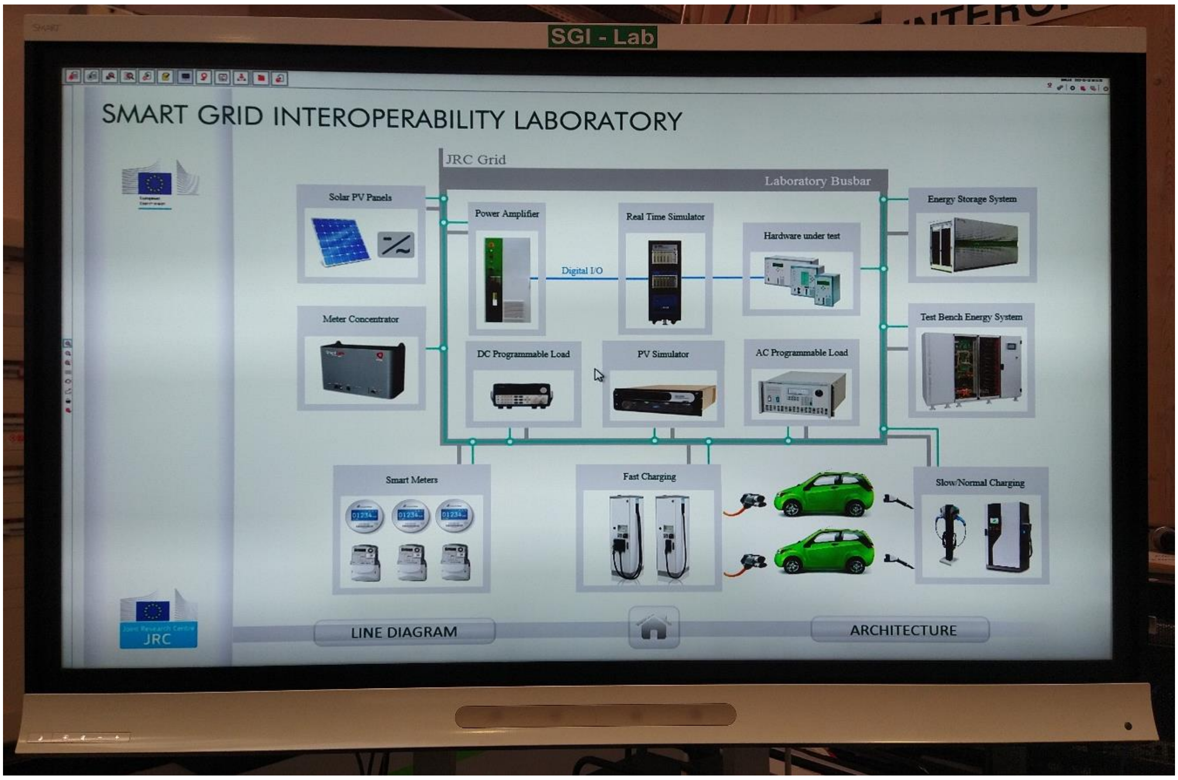
Figure 24. Smart Grid Interoperability Lab in Ispra

Source: JRC, 2021

Figure 25. Panoramic view of the laboratory

Source: JRC, 2021

Figure 26. SCADA system



Source: JRC, 2022

Figure 27. Battery energy storage system

Source: JRC, 2022

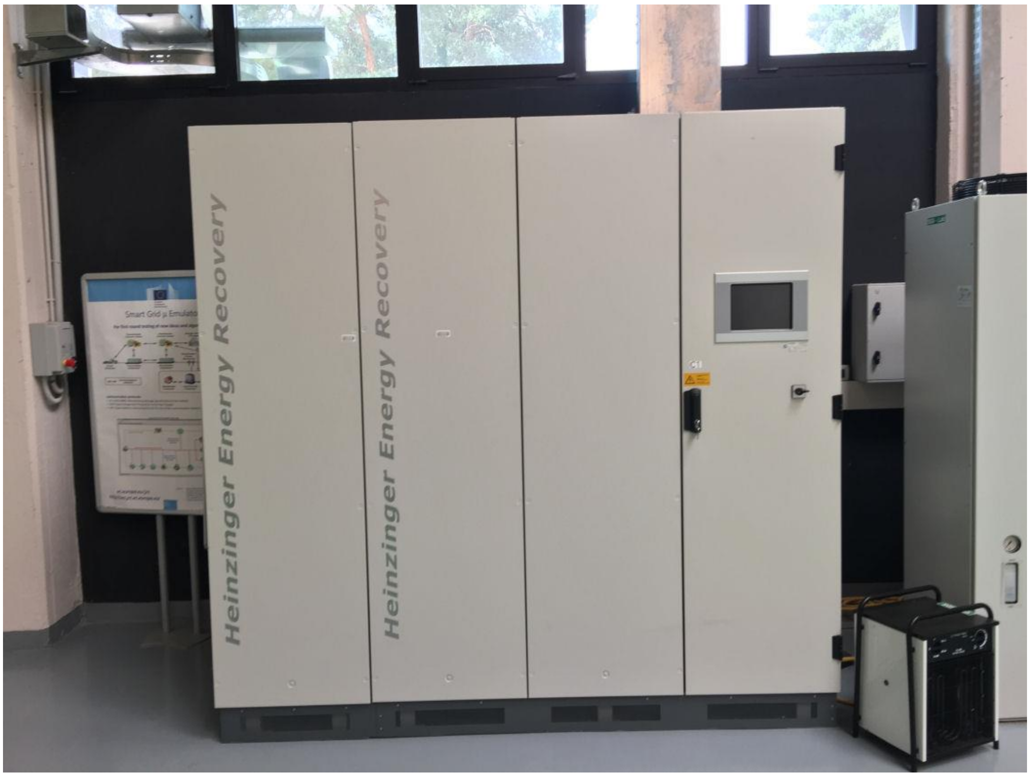
Figure 28. Energy storage cells

Source: JRC, 2022

Figure 29. Nissan Leaf electric vehicle

Source: JRC, 2021

Figure 30. Energy recovery system



Source: JRC, 2021

Figure 31. Smart meter panel

Source: JRC, 2022

Figure 32. Triphase 90 kVA power amplifier

Source: JRC, 2021

Figure 33. Panoramic Education power system work station

Source: JRC, 2021

Figure 34. Real-time digital simulator

Source: JRC, 2022

Figure 35. Conference space

Source: JRC, 2021

4 Scientific and experimental achievements in 2021 and planned activities in 2022

4.1 European Research Infrastructure supporting Smart Grid and Smart Energy Systems Research, Technology Development, Validation and Roll Out (ERIGrid 2.0)

Authors: Evangelos Kotsakis, Antonio De Paola, Dimitrios Thomas, Antonios Marinopoulos

Since April 2020, the team of the JRC Smart Grid Interoperability Laboratory is taking part in a new Horizon 2020 EU project, ERIGrid 2.0 (https://erigrid2.eu/). The project runs from April 2020 until September 2024, comprises 20 partner organisations from 13 countries, including Universities, Research Institutes, and a Grid Operator, and has a total budget of 10 million Euros.

ERIGrid 2.0 will further expand the research services and tools of research infrastructures, previously developed in ERIGrid project (2015-2020), for validating smart energy networks with the electric power grid as the main backbone. Committed to the holistic and cyber-physical systems-based validation approach, ERIGrid 2.0 will foster system-level support and education for industrial and academic researchers in power and energy systems research and technology development.

The JRC SGIL team participates in most of the ERIGrid 2.0 Network activities and the Joint Research Activities of the project, as well as in the Transnational Access Activity for Facilities for Smart Energy Systems Integration and Validation.

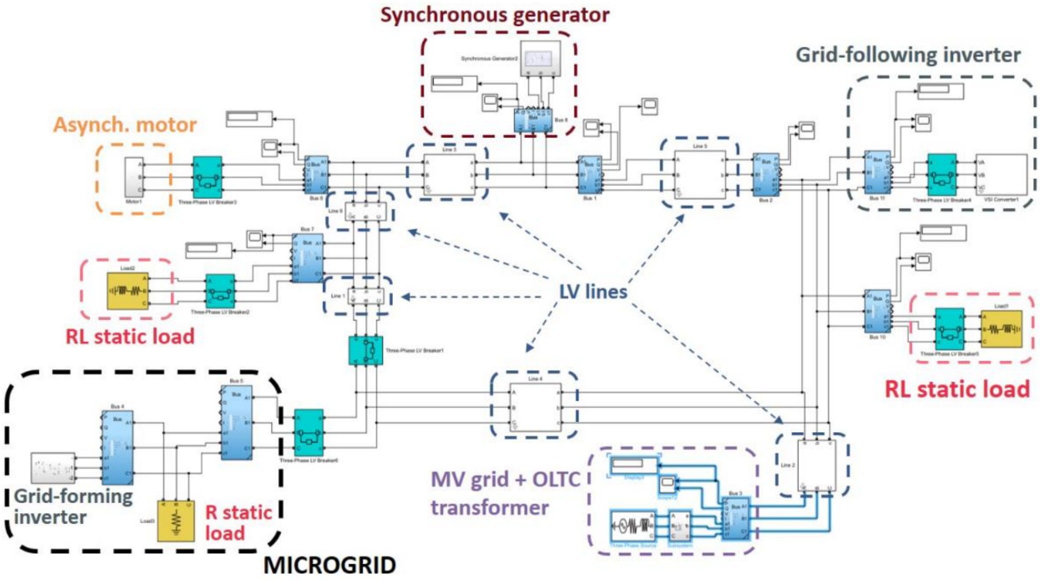
In 2021, the activity of the SGIL has focused on the following tasks:

— Development of network benchmark models for low-voltage networks with high penetration of power electronics and renewable energy sources

  The SGIL team has developed comprehensive benchmark network models that can support the research community in the design, analysis and simulation of new paradigms of distribution grids, accounting for the effect of power electronics devices (e.g. inverters) and modelling the impact of storage devices and renewable sources. The models of the single power system components have been collected from other project partners (Tecnalia, RSE, NTUA, Ormazabal) and then merged together, leading to the development in a MATLAB environment of two distinct network models, specifically tailored for dynamic transient studies and power flow analyses, respectively. A schematic representation of the benchmark network for transient simulations is provided in **Error! Reference source not found.**. In order to facilitate the u tilization and tuning of these models, an open source approach has been followed: the simulation files have been made available online in the Erigrid 2.0 project repository ([14]), together with a detailed and comprehensive documentation aimed at facilitating the utilization, tuning and testing of the models by external users. The outcomes of this work have been discussed in a conference paper which has been submitted to the "1st International workshop on Open Source Modelling and Simulation of Energy Systems" and should be presented there in April 2022.

(14) https://doi.org/10.5281/zenodo.5707769

Figure 36. Benchmark network model for dynamic transient studies



Source: JRC, 2021

— Sensitivity analysis for Power-Hardware-In-the-Loop (PHIL) *simulations*

The SGIL team has contributed to the development and testing of a general setup for sensitivity analysis in PHIL experiments. The overall purpose is the improvement in the performance of Hardware-in-the loop simulations, which represent a fundamental resource for the testing and analysis of new power system components. In this context, the SGIL has developed a theoretical framework that provides clear metrics for the sensitivity of different PHIL interface algorithms, through the definition and evaluation of different sensitivity transfer functions. These functions allow to quantify in a rigorous and consistent manner the impact of disturbances within the PHIL setup and to compare quantitatively the performance of the different hardware solutions. The framework has been validated in the SGIL with Software-In-the-Loop simulations and then further corroborated by tests with real equipment performed by other project partners (NTUA, University of Strathclyde). The outcome of this study are being collected in a journal research paper, whose submission is expected by January 2022.

— Transnational access activities

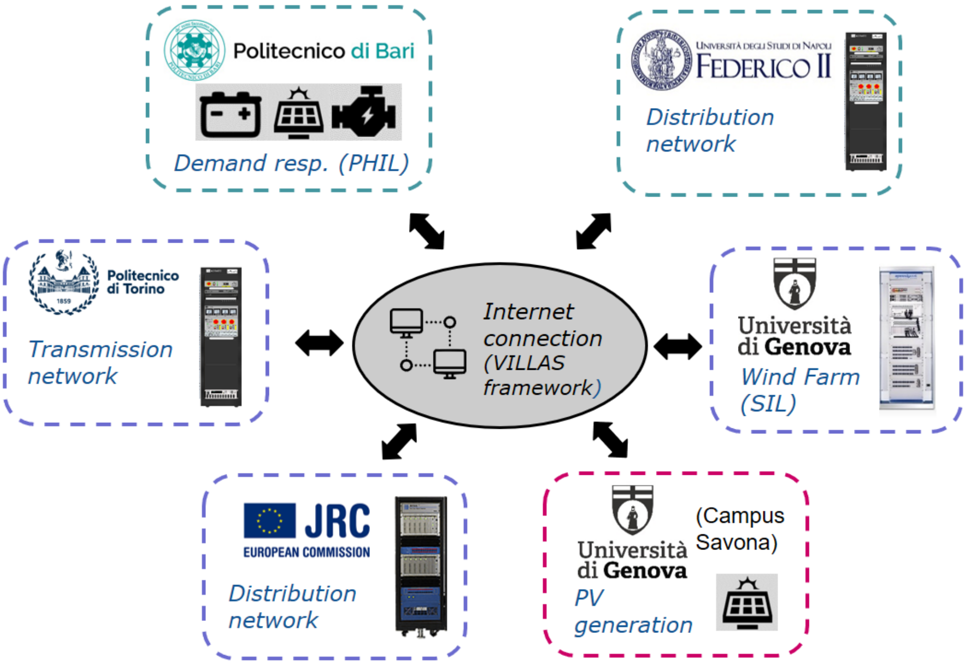
The SGIL is actively involved in the laboratory access activities of Erigrid 2.0, with the objective of sharing its expertise and equipment with other engineers and researchers in the power system community. After a rigorous selection process, the team of the Magliano Alpi Renewable Energy Community (REC) will be the first user group to be hosted in the Ispra lab, starting from February 2022. The Magliano Alpi team manages a network of interconnected smart buildings equipped with photovoltaic panels. The buildings are operated in order to share the energy produced by their renewables assets, reducing the energy costs for the users and possibly supporting the operation and security of the distribution network. During their visits to the lab, the Magliano Alpi team will be supported in the filtering and analysis of the large amount of data that is being collected in their infrastructure, determining the most suitable protocols for accessing the relevant information and evaluating the key performance metrics of the energy community. The activity will also test and validate with real measurements the theoretical demand/generation forecast models developed by the REC team, with the objective of estimating the potential benefits of an extended aggregation perimeter for the energy community, in preparation of expected regulatory developments in such sense.

The activity of the SGIL within the ERIGrid 2.0 project will continue in 2022: in addition to the dissemination of previous work (discussed in the points above), the lab will participate to new joint research activities aimed at facilitating the integration of different lab infrastructures, with a particular focus on the development of extended services for integrated real-time environments. Compatibly with the evolution of the COVID-19 situation, the access activities will continue throughout 2022: periodical calls are currently in place to select the next user groups that will visit the lab facilities.

4.2 Collaboration with the Ensiel consortium for the design and realization of geographically-distributed Real-Time Digital Simulations (RTDS)

The SGIL has initiated a new collaboration with the Ensiel consortium ([15]), an organization of Italian universities that aims to promote and coordinate innovative studies in the energy and power system sector. The collaboration has focused on real-time simulations and in particular on the design and realization of geographically-distributed RTDS experiments. The objective of the partnership has been the creation of a "network of connected simulators", in order to test and showcase the potential advantages of distributed real-time simulations in terms of increased overall computational capacity of the assets, reduced equipment redundancy and facilitated remote collaborations.

Figure 37. Setup of the Geographically-Distributed RTDS experiment



Source: JRC, 2021

The general layout of the distributed simulation network is displayed in Figure 37. In addition to the SGIL, four university and five distinct sites have participated to the experiment. Communications and data exchange have been performed through the internet network, adopting a UDP protocol for data transmission and relying on the VILLAs framework ([16]) (an ad hoc software tool developed by the University of Aachen) to handle data synchronization and conversion. After the creation and testing of the relevant communication channels between the participants, the network of simulators has been utilized to test the behavior of a power system with a large penetration of Renewable Energy Resources (RES), with the objective of assessing the capability by the RES to displace traditional synchronous generator in the provision of ancillary services and in the preservation of grid security. Consistently with the proposed geographically-distributed approach, each site has either simulated or replicated the behavior of a part of the power system. For example, the SGIL has been responsible for the simulation of the network at the distribution level, whereas the Politecnico di Bari has implemented a Power-Hardware-in-the-Loop setup for the integration of demand response. To make the

(15) http://www.consorzioensiel.it
(16) http://new.villas.fein-aachen.org

distributed simulation possible, the sites have exchanged between themselves, in real time, the values of relevant electrical quantities of the simulated grid (e.g. consumed power or voltage levels), so that each node of the simulation is able to emulate or reconstruct the behavior of the other parts of the system.

The first internal test of the network of simulators has been successfully completed in December, analyzing the corrective actions of the flexible assets and the resulting frequency response of the system in the case of unexpected oscillations in the generation from renewables. At the beginning of 2022, the distributed setup will be demonstrated publicly, with the involvement of the major stakeholders of the Italian electricity sector. In parallel, the research activity will build up on these promising preliminary results, pursuing two main objectives: scaling up simulations to systems of increased size and complexity and refinement of the communication interface between nodes in order to increase accuracy and robustness of the simulation.

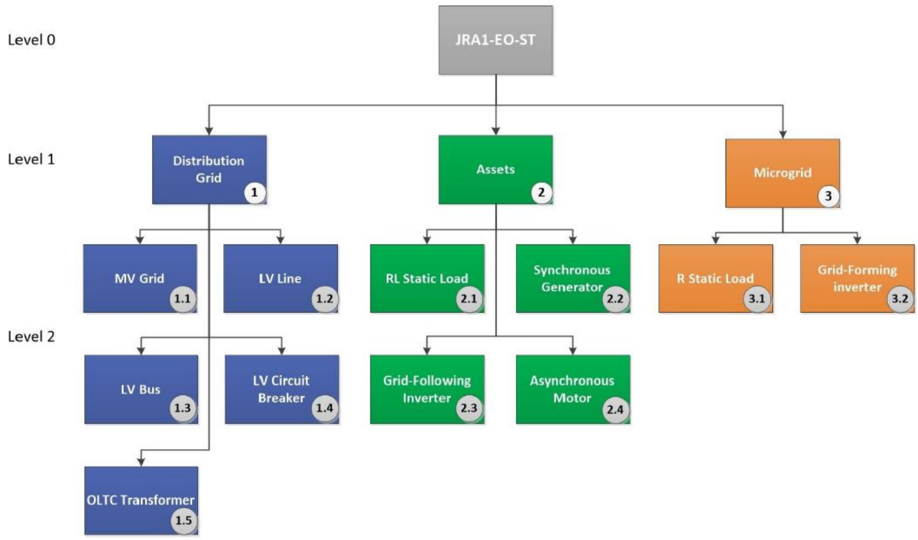
4.3 Benchmark Models for Low-Voltage Networks: A Novel Open-Source Approach

Authors: Antonio De Paola (JRC), Alexandros Paspatis (NTUA), Dimitrios Thomas (JRC), Evangelos Kotsakis (JRC), Antonios Marinopoulos (JRC), Marcelo Masera (JRC), Alkistis Kontou (NTUA), Panos Kotsampopoulos (NTUA), Nikos Hatziargyriou (NTUA)

Conference paper developed in collaboration with the National Technical University of Athens and submitted to the 1st International workshop on "Open Source Modelling and Simulation of Energy Systems". The paper is the outcome of the Erigrid 2.0 project activity for the development of novel benchmark systems for the simulation of low-voltage networks. The modelling of the grids has considered the impact of new technologies and devices, accounting for the presence of grid-forming and grid-following inverters while considering also the increasing relevance of photovoltaic generation and the potential for storage installations at low voltage levels. Updated and detailed models of the individual components have been provided by the project partners and the design and implementation of the general network model have been carried out in a Matlab/Simulink environment. In order to enable a wide range of different network studies, two different versions of the grid, tailored respectively for transient dynamic simulations and power flow studies, have been developed. The model development has been accompanied by the production of a comprehensive open-source documentation, in order to facilitate the utilisation, tuning and expansion of the model by external users. Following the PreCISE methodology, one of the key steps in preparing the documentation has been the development of a block representation of the grid (see example in Figure 38), where the different components are indexed and presented in a hierarchical structure. A comprehensive description is then provided for each block, specifying for example the general modelling equations that have been utilized and the validation and testing procedures that can be followed for tuning and potentially modifying the single network blocks. The full documentation, containing the model implementation files and the detailed description of the network and its components, is available in the Zenodo Erigrid 2.0 repository[17].

(17) https://doi.org/10.5281/zenodo.5707769

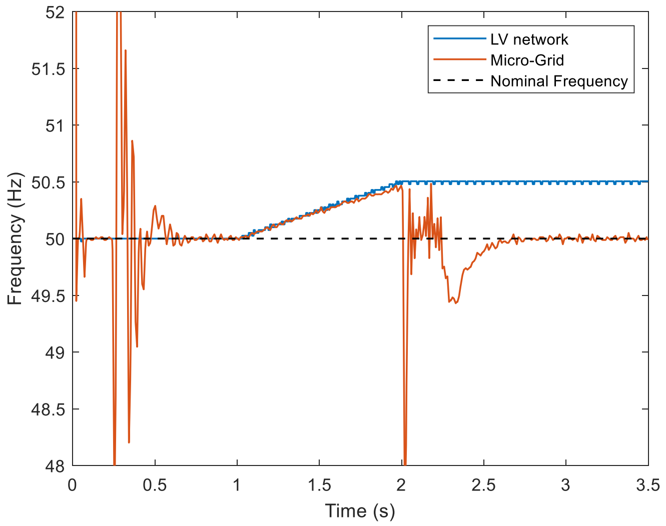
Figure 38. System breakdown of the benchmark model (dynamic version)



Source: JRC, 2021

In order to validate the models, the paper also presents comprehensive simulations, considering two distinct test cases from the Erigrid 2.0 test case library ([18]). For example, the network benchmark system for transient studies has been utilised to test the capability by a grid-forming inverter to set and maintain the nominal frequency within a microgrid operating in islanded mode. To this purpose, an ad hoc scenario has been built to emulate critical system conditions and the resulting microgrid disconnection, The simulation results, summarized in Figure 39**Error! Reference source not found.**, **Error! Reference source not found.**show that the grid-forming inverter is able to satisfactorily restore the nominal frequency in the islanded microgrid after a transient of about 500 ms.

Figure 39. Frequency profile of the LV network (blue) and of the microgrid (red) after its disconnection at time t=2 s.



Source: JRC, 2021

(18) https://doi.org/10.5281/zenodo.5588212

In order to extend and consolidate the activity presented in the paper, future work will focus on improving the level of detail and modularity in the models, with the inclusion of additional components (e.g. heat pumps) and the possibility of selecting modeling blocks of varying complexity for the same component, so that the user can achieve the desired trade-off between accuracy and simulation time.

4.4 European Interoperability Testing Methodology's further Developments

Authors: Ioulia Papaioannou, Evangelos Kotsakis, Sotirios Moustakidis

The European Interoperability testing methodology in a portal:

The Smart Grid Design of Interoperability Tests (SG-DoIT) is a web based application which will be used to store the intermediate and final products of the interoperability testing process but also to automate some of the activities. The system is available to be used by laboratories. The application is based on the JRC Smart Grid Interoperability methodology. The methodology with the application is utmost automated (with less possible human intervention) so that all the objects can be replicated and under the same conditions and testing environment shall provide the same evidence. In this way SG-DoIT serves as a knowledge hub for the Smart Grid Interoperability community. The first version of the web-based application was launched in October 2021 where three basic objects of the methodology can be created facilitating the user to design and evaluate his/her interoperability test specifications

In the SG-DoIT the user proceeds to create the tests through the use of special forms. These forms will constitute the interoperability objects which under the same Use Case may interact which each other automating thus the procedure, facilitating the user in the design and minimizing the possibility of inconsistencies or errors. After the creation and before the publication of the respective test, the user is able to evaluate the test he created through a voting system. The user, therefore, invites existing system users or external users to evaluate the test.

The link for SG-DoIT is here : https://smart-interoperability.jrc.ec.europa.eu/ and registration is needed.

A manual has been written and and can be used as a guidance for the users of the portal:

SG-DoIT - Smart Grid Design of Interoperability Tests. Technical manual to the web-based application

Moustakidis S, Papaioannou I., Kotsakis E. (to be requested to the authors, before being online early 2022, request No JRC125123)

The portal has already gained the attention of the European Commission's policy DGs (especially DG ENER and DG Connect). The Horizon 2020 project MAESHA ([19]) is currently using it to create the Interoperability testing objects for the tests they want to run within the project. (https://cordis.europa.eu/project/id/957843)

The SG-DoIT has been presented to the Data Management meeting of BRIDGE ([20]) and there was an expression of interest from CEN/CENELEC/ETSI to collaborate with the JRC. They are interested on the portal as they see it as a way to tackle issues on standardization gaps. (https://www.h2020-bridge.eu/, https://www.cencenelec.eu/)

There is also a database of Use Cases developed within the Data Management and it will be part of the EIRIE platform. There are discussions to find ways to include also the SG-DoIT. The agreement would go towards adapting the SG-DoIT as a branch of the Use Case database for projects which are specifically looking at interoperability testing.

(19) deMonstration of smArt and flExible solutions for a decarboniSed energy future in Mayotte and other European islAnds
(20) Cooperation group of Smart Grid, Energy Storage, Islands and Digitalisation H2020 projects

Further developments on the JRC Interoperability testing methodology:

A paper under the title "A Use Case using the Joint Research Centre Smart Grid Interoperability Testing Methodology " has been accepted by the Guest Editors. The abstract has been submitted and accepted while the manuscript submission will be done early 2022

A paper submission and presentation in the COMFOREN conference http://www.comforen.org/ with the title: ICT interoperability and architectures for energy communities. Smart Grid Interoperability Testing (http://www.comforen.org/Program/)

A presentation with the title: Interoperability: a key element for Smart Energy Storage integration at the Energy Storage Global Conference https://ease-storage.eu/easeevents/energy-storage-global-conference/ (https://www.accelevents.com/e/u/checkout/EnergyStorageGlobalConference/tickets/order, https://www.accelevents.com/e/EnergyStorageGlobalConference#agenda)

Co-operation with RWTH Aachen is ongoing and resulted in formulating the Bachelor/Master-Thesis "Implementation and interoperability analysis of a distribution system automation in real time application" where one of the major tasks is the design and analysis of the experiments based on the JRC developed European Interoperability Testing Methodology.

Networking activities and dissemination of the JRC Interoperability testing methodology has been resulted in the following references to the methodology:

- Accompanying the document "REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL Progress on competitiveness of clean energy technologies 8 & 9 - Smart Grids and Renewable Fuels" {COM(2021) 950 final} - {COM(2021) 952 final}, published in Brussels 26.10.2021. The reference of the methodology can be found on page 226. https://eur-lex.europa.eu/resource.html?uri=cellar:bdd70525-3658-11ec-8daf-01aa75ed71a1.0001.02/DOC_5&format=PDF
- In the call: Sustainable, secure and competitive energy supply (HORIZON-CL5-2021-D3-01), Type of action HORIZON-CSA HORIZON Coordination and Support Actions. The call was open 24/6/2021 with a closing date of 20/10/2021. The reference of the methodology was made in the Topic description as a suggested Harmonised Interoperability testing procedure
- The project TDX- ASSIST project and the CyberResilienceLab project that has received funding from the Federal Ministry for Economic Affairs and Energy under grant agreement No 0350008 has published a paper by Schütz J., Uslar M. and Meister J. A case study research on interoperability improvement in Smart Grids: state-of-the-art and further opportunities Europe 2021, 1:33 https://doi.org/10.12688/openreseurope.13313.1
- In the Interoperability of digital (ICT) systems in the energy sector: How to Improve the Interoperability of Digital (ICT) Systems in the Energy Sector. Discussion paper ISGAN Annex 6 Power Transmission & Distribution Systems Focus area "System Operation and Security" , 31-03-2021 https://www.iea-isgan.org/how-to-improve-the-interoperability-of-digital-ict-systems-in-the-energy-sector/

4.5 Residential Electric Load Simulation

Authors: Heinz Wilkening

resLoadSim ([21])([22]) is a tool for residential electric load simulation developed within the Smart Electricity Systems and Interoperability project. The tool allows prediction of residential electric loads with a time resolution of 1 minute. It uses a probabilistic approach based on statistics to predict the electric load profiles of individual households by summing up the consumption of individual household appliances. Besides using the tool for load prediction, it is also possible to study the potential for load shifting in private households by implementing different control mechanisms, for example, based on variable pricing. The objective is not to develop a specific technology in detail than rather to evaluate the potential of certain technologies and concepts for the energy transition such as demand side management.

(21) https://ses.jrc.ec.europa.eu/power-system-modelling
(22) http://files.messe.de/abstracts/85152_GB_2404_1620_Wilkening_Heinz.pdf

As resLoadSIM has been made public-domain available under the GNU licence in 2020 several research organizations began using the tool in 2021 of which some are worth mentioning. The DLR Institute of Networked Energy Systems in Oldenburg is using resLoadSIM in a German founded research project, where resLoadSIM will be used to evaluate the potential of Demand Response in the German Energy Transition. At the Institute of Electronics and Computer Science resLoadSIM is used to study the change of energy consumption and use in private households in Latvia. The Information Technologies Institute – CERTH in Thessaloniki wants to use resLaodSIM for testing Home Energy Management Systems in a controller in the loop environment. Finally at the Teeside University in Middlesbrough an automated optimization algorithm for resLoadSIM is developed allowing easy validation of the code. This will make it possible to use resLoadSIM for various country applications as energy use can differ quite a lot between countries. All these partners are supported when they get started in using the code and we plan to extend the number of users even further in 2022.

4.6 Collaboration with the EEBus Initiative

Authors: Ioulia Papaioannou**,** Heinz Wilkening

The EEBus ([23]) Initiative e.V. is a non-profit association with leading manufacturers from the sectors of networked building technology, electromobility and energy. EEBus is a communication interface for typical smart home devices based on standards and norms. Although the main application of EEBus is the energy demand management, it also can be used for Home automation in general. As such, EEBus is an ideal test case for use to apply our interoperability testing methodology to it. This is even facilitated as already many use cases have been already defined within EEBus. Therefore, we decided to intensify our collaboration with EEBus with the objective to validate the EEBus interface against our interoperability testing methodology, which will require real hardware testing experiment. For this purpose, an experimental setup was designed jointly and an order for construction was placed and will be delivered in 2022.

4.7 Smart Grid Laboratories Inventory 2021

Authors: Nikoleta Andreadou, Ioulia Papaioannou, Antonios Marinopoulos, Marcello Barboni

Reference: to be requested to the authors, before being online early 2022, request No JRC128001

This report sheds light to the smart grid research being conducted by scientific and industrial communities worldwide. Whereas the concept of realizing this report remained the same with the one used for the previous releases, meaning that a questionnaire has been prepared and participants have been invited to fill it in, there has been a change with respect to the structure of the information obtained.

This time, we have joined our forces under the EIRIE ([24]) platform, and we obtained an updated database containing information in coherence with the ETIP SNET (European Technology and Innovation Platforms Smart Networks for Energy Transition) concept. EIRIE, the European Interconnection for Research Innovation & Entrepreneurship is a living dynamic multi-functional platform for all the energy system stakeholders and for all EU citizens to benefit of a series of services: (a) Research and Innovation exchange including the results of all EU and National funded projects; (b) Synergetic affiliations for R&I, entrepreneurship, etc.; (c) Education &training and (d) other extra functionalities. EIRIE connects the R&I community of EU to enhance collaboration with a wider interest and use of the project results, avoids duplication and optimizes investments, fosters and facilitates entrepreneurship and strengthens the participation of all Member States in support of the fifth pillar of the Energy Union (RIC) and the energy transition.

Under the EIRIE initiative the ETIP SNET group of technologies has been created, in an effort to categorize the broad concept of smart grid research. Thus, the categories of smart grid research according to ETIP SNET are five and these are as follows: Integrated Grid, Customers and Market, Storage, Generation, Digitalization, Communication and Data. Our team, has adopted this concept to maintain a homogeneous way of smart grid

(23) https://www.eebus.org/what-is-eebus/
(24) https://ses.jrc.ec.europa.eu/eirie/en

research definitions and facilitate the work of researchers. As a result, the categories of smart grid research have been adapted to the aforementioned ones, whereas a careful matching has been made with the categories defined in the previous three releases of the Inventory. The approach followed for this fourth release is summarised as follows: An updated questionnaire has been created that follows the concept of ETIP SNET group of technologies; Labs that have been conducting research in the broad area of smart grid worldwide have been conducted and invited to fill in our survey; Results have been obtained in an aggregated manner; Information has been used for our online Tool, which intends in increasing visualisation among smart grid lab researchers.

The smart grid research groups in Europe have been working in order to cope up with these policy efforts and laboratories are built in order to support such research activities. On many occasions, consortia and collaboration efforts among lab facilities are sought in order to gain leverage in shared infrastructure and knowledge and reduce the burden of having a single facility covering all areas. Such examples are: The Smart Grid International Research Facility Network (SIRFN) of the International Energy Agency (IEA) Implementing Agreement for a Co-operative Programme on Smart Grids (ISGAN), DERlab, the European Network for cyber security (ENCS) and Futured.

This report presents information about the smart grid lab research, thus revealing the trends in scientific research and on the other hand, identifying the gaps and guiding further actions to be made. It is worth mentioning, that although the policy context for us remains at European level, the Inventory covers research carried out by laboratories worldwide, in an attempt to depict the worldwide trends and enhance collaboration activities beyond European borders.

To complete the work of the Inventory, an Online Tool has been created in order to enhance visibility of the smart grid lab activities, to foster collaborations between research organisations, policy making bodies and all relevant smart grid stakeholders. It is intended to improve the already existing Online Tool, making it more dynamic, in the sense that laboratories that work on a specific field of smart grids can be found in a straightforward way.

The fourth release of the Smart Grid Laboratories Inventory shows information from 86 labs worldwide. Whereas in previous versions of the Inventory the focus was to find new participants, this year the main focus has been to obtain updated information of the already existing laboratories, especially since the new concept of ETIP SNET smart grid fields has been introduced. As secondary goal, it has been set to find new participants.

Information from 50 labs was collected during autumn 2021, where most of these labs provided an update of the information they had given in previous releases of the Inventory. In addition, the information of other 36 labs was merged from previous releases, including however, only information that did not date longer than 5 years back. Some of the conclusions of this fourth release of the survey are:

Around 43% of the labs operate with personnel up to 10 people and occupy an area up to 250 m2.

The 86% of labs performs R&D on hardware and software research activities, whereas the 91% of them carries out research about the distribution grid.

Exactly half of the labs have had investments of up to 1,000,000 euros. The period in which these investments are spanned varies; however, half of the labs have had their investments for a period of up to 4-5 years.

It is interesting to see that funding sources for labs are almost equally split into three parts: own funding (34.38%), national funding (31.25%) and EU funding (34.38%). Given the fact that also non-EU labs are taking part in this survey, it becomes clear how important EU funding is for smart grid research. Indeed, EU funding for European labs, results to 38.4% of all funding sources, with national and own funding being 25.6% and 36% respectively.

Every lab is specializing in more than one research category. Thus all the research categories attract more than 70% of the labs like: Integrated Grid: 84%, Customers and Market: 76%, Storage: 70%, Generation: 79%, Digitalization, Communication and Data: 77%.

For the Integrated Grid, 70% of the labs work on microgrids, 47% work on AMI and the most popular standard is IEC 61850

For Customers and Market, the active labs in the field work on the following sub-categories: Distributed Flexibility (86%), Smart Buildings (68%), Electric vehicles (68%), energy communities (58%), Electricity market (52%), Smart appliances (51%), Lighting (22%).

For Storage, the most popular energy storage technology is: Storage electric (87% of the active labs in the field)

For Generation, the most popular standards are IEC 61850 and IEC 61400, while the most popular areas of research are Solar generation (81%), flexible generation (78%) and wind generation (62%)

For Digitalization, Communication and Data the active labs in the field work on the following sub-categories:

Communication networks including devices and systems for signals and data connectivity and solutions (85%), Digital twins (61%), Data and Cyber security including repositories (58%), Artificial intelligence (54%)

Simulations are very popular for smart grid research, with 65% of labs performing real-time simulations and 61% of labs performing Hardware-in-the-Loop simulations. On the other hand, Matlab is the most popular tool used for simulations, particularly for grid simulations (44% of the labs).

The most common major infrastructure is: power amplifier, battery energy storage system, grid emulator.

Finally, the most popular services offered by labs are: Integration and testing of devices (hardware testing, meter, relay testing, high voltage products tests, etc), (33%) and Research and Development support (29%).

The Smart Grid lab Inventory gives a complete picture of the smart grid research carried out by labs not only in Europe, but also worldwide. It gives detailed information about the categories of research, points out the sub-categories and standards used and it also gives an insight on the infrastructure used by labs. The Inventory is a valuable tool in identifying trends in the smart grid research and getting important information about the state-of-the-art in the field.

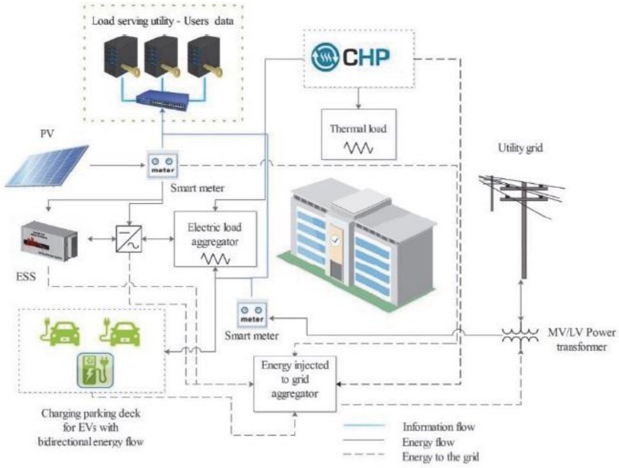
4.8 Energy Management and Optimal Power Scheduling in a Smart Building under Uncertainty*

Authors: Dimitrios Thomas**,** Evangelis Kotsakis

Reference: published in the form of a chapter with the title: *D. Thomas and E. Kotsakis, "Energy management and optimal power scheduling in a smart building under uncertainty," in Smart Cities, IntechOpen, 2020.*

In this work, we consider a microgrid with a certain number of distributed energy resources (DER) components connected to an office building (in a university campus) provided with electricity by a utility company. We develope the initial version of the energy management system which is responsible for the optimal energy scheduling of the microgrid's distributed energy resources. These resources include a photovoltaic (PV) installation, a Storage Energy System (ESS), a small Combined Heat and Power (CHP) unit, and a fleet of electric vehicles (EVs) used for work-related trips. The mobility behavior of the EVs fleet is modeled considering deterministic realizations of the probabilistic distributions used for the arrival/departure, and the time EVs remain parked. To investigate the impact of renewable generation and load unpredictability on the energy management system (EMS) operation, PV production and electric load are modeled under uncertainty using actual smart meters data for the scenarios formulation. We also assume that each DER component, through an EMS, can communicate and control the power exchange from and towards this component and that, two way communication with the utility company can be reached through aggregators using advanced metering equipment. We also consider a simplified thermal model that provides a specific level of thermal comfort to the building's occupants, by meeting the predicted heating load. The energy produced by the DERs can be sold back to the grid by the microgrid manager and/or it can be stored for future utilization.

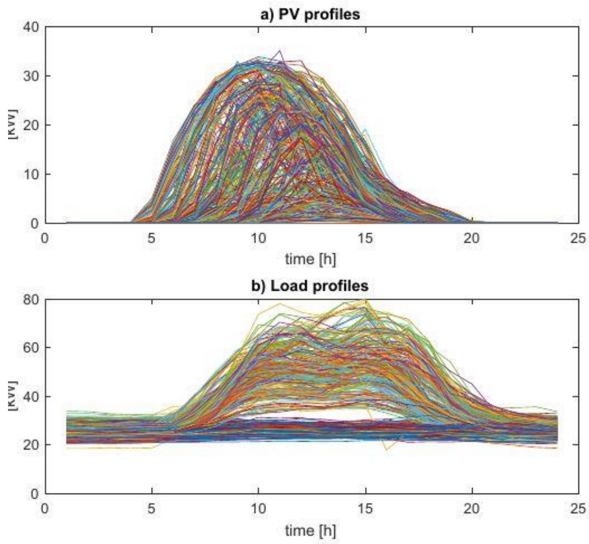
Figure 40. Energy management system configuration



Source: JRC, 2021

To classify PV and electric load production, yearly data-measurements from smart meters installed in Walloon region, Belgium, have been used. The smart meters communicate with the utility company server every 15-min providing the updated PV and load measurements. The 15-min datasets were merged to formulate 8,760 hourly readings (365 24-hour PV generation and load profiles). The total PV capacity is 50 kVA. The original datasets are shown in 41.

Figure 41. The 365 original profiles for a) PV production, and b) electric load demand



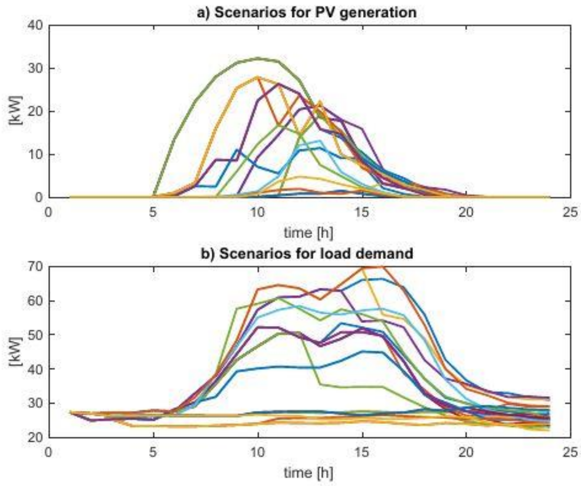
Source: JRC, 2021

We use a scenario reduction technique ([25]) introduced in to construct the scenarios. A script developed in Matlab is utilized to aggregate the two sources of uncertainty into one. That is, a discrete probability has been assigned to each one of the generated scenarios. Every scenario comprises two 24-hour vectors where each vector corresponds to a specific profile (one vector for PV production and one for load demand). Moreover, this scenario construction technique considers the potential correlation within the data. The latter is very important as, for example, a sunny day with increased PV production is expected to affect the load demand

(25) N. Growe-Kuska, H. Heitsch, and W. Romisch, "Scenario reduction and scenario tree construction for power management problems," in 2003 IEEE Bologna Power Tech, Bologna, Italy, pp. 152–158

downwards and vice-versa. The 24 probability-weighted scenarios for PV generation and load demand are illustrated in 42

Figure 442. The 24 representative scenarios for a) PV production, and b) electric load demand



Source: JRC, 2021

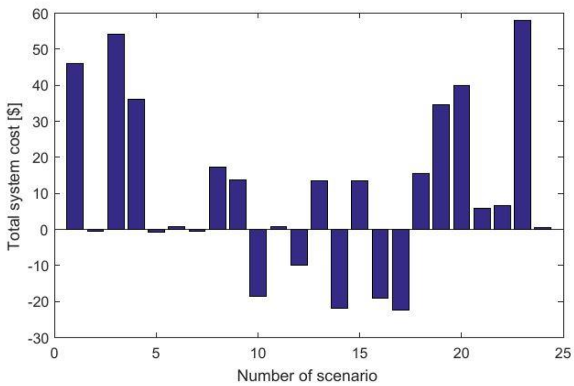
The importance of considering an EMS in microgrid's operation is depicted in the TSC results across all cases, as shown in **Error! Reference source not found.**.

Table 1. Total system cost across all cases [$]

Case	Description	Total system cost
1	No EMS in operation (average of all historical data)	59.47
2	With EMS in operation (average of all historical data)	13.51
3	Expected mean of all 24 scenarios	16.68
4	Most probable scenario of the 24 (prob. 9.3%)	58.11

A cost distribution for all scenarios considered in case 3 is shown in **Error! Reference source not found.**43.

Figure 43. Total system cost distribution for the 24 scenarios



Source: JRC, 2021

The transition to the new "smart" era requires the utilization of smart technology through comprehensive and efficient energy management functions. We propose in this study, a two-way communication energy management framework for a microgrid in a university campus including local renewable energy sources, a storage system, a combined heat and power small turbine, and a fleet of EVs used for work-related trips. Two-way energy exchange is allowed using net metering technology. The developed MILP framework incorporates an optimizer which decides the power exchange among the DER components of the microgrid and the grid, exploiting the V2B and V2G capabilities of the distributed energy resources. It also provides a specific level of thermal comfort to the building's occupants by meeting the predicted heating load. The formulation of an EMS model which takes into account the PV and load variability is very important if we want to consider the impact of planning for one scenario, and having another scenario occurs. To overcome this challenge, actual smart metering data for a period of one year have been used to construct a number of potential scenarios. The PV and load demand data are classified using a scenario construction technique, leading to the formulation of 24 different PV and electric load scenarios, each one represented by a designated probability. The importance of considering an EMS in microgrid's operation is depicted in the total system cost across all cases. Results confirm that the EMS substantially decreases the total system cost by optimally coordinating and scheduling the microgrid operation. An additional significant remark is that the majority of the total daily system's cost is due to the natural gas expenses required for the operation of the CHP microturbine. Finally, we compare the optimal scheduling of the microgrid's DERs under the deterministic case and the most probable scenario. The most probable scenario assumes a lower PV production and a higher building electric load demand than the average values considered in the deterministic case, resulting in a substantially different energy scheduling for the DERs. It is worth noting that under the deterministic approach and the current design, the microgrid seems to be self-sufficient in terms of covering its energy demand. However, this is not the case under the most probable scenario approach, where the microgrid relies also on grid energy to meet its load demand, on top of the energy production of its own DERs. Suggestions for future work include the introduction of additional stochasticity parameters (e.g., electricity price) and the integration of power flow constraints into the optimization problem.

4.9 Towards Smart Cities: An Analysis of Innovative European Case-studies*

Authors: Dimitrios Thomas et all.

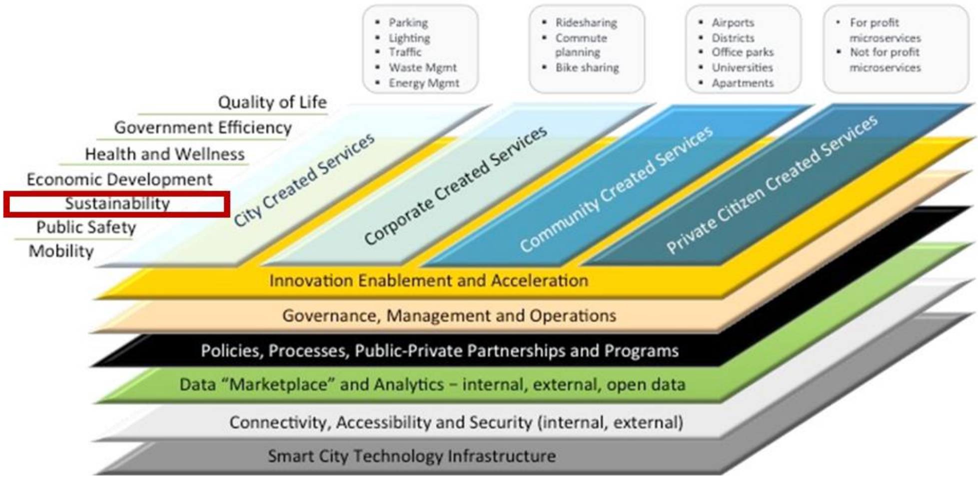
Reference: Published in Sustainability Journal under the title: *R. Taratori, P. Rodriguez-Fiscal, M. A. Pacho, S. Koutra, M. Pareja-Eastaway, and D. Thomas, "Unveiling the Evolution of Innovation Ecosystems: An Analysis of Triple, Quadruple, and Quintuple Helix Model Innovation Systems in European Case Studies," Sustainability, vol. 13, no. 14, 2021, doi: 10.3390/su13147582*

Despite the rising interest in smart city initiatives worldwide, governmental theories along with the managerial perspectives of city planning are a great lack in the literature. It is definitely understandable that the adoption of configurational pathways towards the 'smart' 'governance' models is required as key factor and smartness' facilitator in modern cities. In this manuscript, we display an exhaustive analysis on the importance of the n-Helix models along with a bench-marking critical approach through selected European case-studies. The study, through the literature review, revealed the lack of exhaustive analyses for the methodological investigation, identification and adoption of the most appropriate governance model and collaborative approaches per project and collaborative approaches and create modular frameworks to address efficiently the continuous urban challenges, such as the rapid urbanization or the climate change.

Figure 44. The 'smart city' model in layersFigure **44**44 represents the 'smart city' model in 'layers' organization, in which each has a particular role for the accelerating integration of the technology to mutate the ecosystem. This process is usually supported by the synergies between stakeholders, while a key factor for its success is undoubtedly the 'governance'.

The evolution of innovation ecosystems models (i.e., from Triple to Quintuple Helix) yields for the parallel evolution of smart urban governance approaches. The state-of-the-art review reveals that research is already being done towards this direction, yet the complexity imposed by the emerging innovation ecosystems demands the perpetual reinforcement of governance mechanisms and definition/conceptualization of most appropriate, modular/dynamic and customized frameworks to the smart city transitions or even to the specific smart project to be envisaged.

Figure 44. The 'smart city' model in layers



Source: Chan, B. Planning Sustainable Smart Cities with the Smart City Ecosystem Framework. 2018. Available online: https://strategyofthings.io/smart-city-ecosystem

The selected case-studies revealed various findings. To begin with, the Triple Helix case revealed that depending on the nature and the scope of the project, public participation might not be necessary for securing the success of the project. Nevertheless, we high-light that public participation is recommended both for its dynamic for innovation and value creation (e.g., via open participation, open innovation schemes), as well as for the general elevation to a knowledge society (and knowledge economy, knowledge democracy) with 'smart' citizens. In doing so, however, it is crucial to engage the public as early as the planning stage of the project to raise their awareness and to ensure their continued involvement. This must be done through consistent and transparent communication between citizens and all stakeholders involved to build trust and credibility. Failure to do so may negatively impact the realization of the project, as demonstrated in the Flottsund bridge renovation project. Finally, the Quintuple Helix case study confirmed the maturity of the whole framework and suggested that perhaps of the time and the holistic approach it offers to sustainable development, smart city governances are learning from past literature and empirical mistakes and adapting to new global conditions and addressing urban challenges efficiently and effectively. Nonetheless, and as a future work, it is highly recommended to undergo a more extensive and exhausting literature review on stories of success and failure per Helix and create a roadmap of the empirical evolution of the Helix concept. We furthermore suggest that the smart city governance 'ecosystems' should not be examined only internally, but also externally with their interoperability with other urban cases as the knowledge, innovation and creativity are only accelerated by sharing and interacting within complex networks that strive for the same long-term goals (e.g., open innovation 2.0).

The power of innovation ecosystems was complementary elaborated from the perspective that they allow the emergence of multiple potential solutions where strengths, weaknesses, opportunities, and threats of smart governance mechanisms can be orchestrated for ameliorating the design and implementation of smart city projects towards sustainable development. Even though the authors chose to focus on the so-called key drivers for smart city development for the purposes of this review, it is suggested that the multiple relationships between the different areas of the SWOT analysis should be furthermore explored and the case studies analysis will become exhaustively investigated.

The smart city field may be studied at each level and scale from the regional to the more global emerging the rising demands of the cities' populations. In this manuscript, we emphasized on the role of the organization, while given its reviewing character, an analytical process of the n-Helix models with a critical angle is identified as a powerful lever for innovation. Keywords, such as 'governance', 'ecosystem', or 'collaboration', enabled to display the role of 'smart ecosystems' for solutions against challenging phenomena, such as the rapid urbanization or the climate change. The study, through the literature review and the benchmarking process of selected and successful European projects of the models' applied, revealed the lack of exhaustive analyses for the methodological investigation, identification and adoption of the most appropriate governance model and collaborative approaches per project and collaborative approaches and create modular frameworks; nonetheless, more evolutionary frames based on the development of synergies of stakeholders are required to prioritize their importance in the smart city planning.

4.10 Development of an Energy Baseline Estimation Tool

In the context of Drimpac project, our lab developed a machine learning-based tool to predict the energy baseline of residential/commercial buildings based on a number of predictors.

The first step was to retrieve the data using a dedicated Application Programming Interface, which communicated all the data received from the installed smart boxes and smart meters across the pilot sites. Afterwards, the useful data points had to be filtered, cleaned, and put in the right form for the data analysis.

The second step was to perform an exploratory data analysis for all cases (before running the actual models) to reveal the structure of the data and detect empirical phenomena. For example, in more than one case, the exploratory data analysis "warned" us that the results of the multivariate regression analysis will not be sufficient.

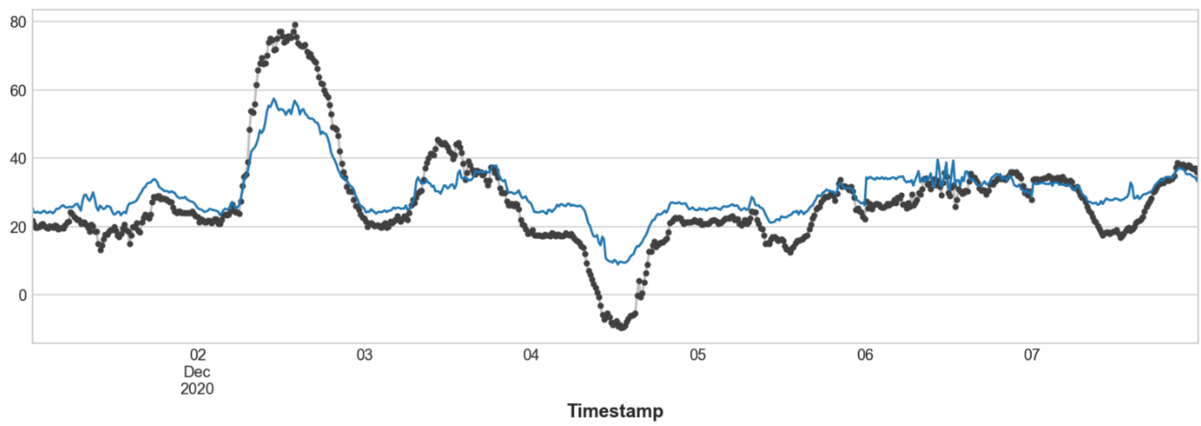
Finally, in the third step we tested our models using actual data and compared their performance. The three different models we developed are: (i) a multivariable linear regression model which predicts the baseline energy consumption based on several independent variables, (ii) a univariate linear regression model with time series using the lag (time-shift) feature and, (iii) a deep learning Convolutional Neural Network model. The root mean squared error has been chosen as the main metric to compare the performance of each model. The root mean squared error is more punishing of forecast errors and its main advantage is that its units are the same as the value that is predicted.

The quality and the number of available data were the two main factors affecting the quality of the results. The multivariate regression analysis model was reliable only for one case. The obtained results for the rest of the cases were not satisfactory as in general the multivariate regression analysis failed to capture the time-dependency, which is the main feature of a time-series variable. The univariate regression analysis using the time-shift feature is a good alternative to the multivariate analysis, especially when data availability is limited. On the other hand, the convolutional neural networks models outperformed the regression analysis models in all cases. Especially for the pilot sites for which a significant amount of data was available, this deep learning technique achieved remarkable results.

For demonstration purposes, we present the results of two different baseline estimation approaches for the pilot site located in Cyprus: i) the univariate linear regression model with time series using the lag (time-shift) feature and, ii) the deep learning Convolutional Neural Network model.

Figure 45 shows how the forecasts respond to the behaviour of the series for a period of one week (672 15-min time intervals). The dots represent the actual data points, while the blue lines the predicted ones.

Figure 45. Time plot of actual and predicted energy values for a period of one week at the Cypriot pilot



Source: JRC, 2021

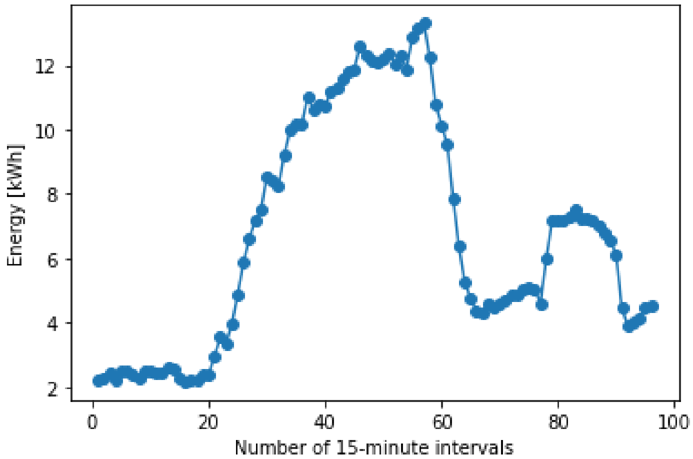
The coefficient of determination (R^2) for the model is 0.388 or 38.8%, while the root mean square value is 10.52.

For the second approach, we used a deep learning model applied to time series forecasting (CNN model). The energy consumption data points (15-min granularity) are 54336 (566 days) for this specific case of the Cypriot pilot. The size of the dataset is considered adequate to train the CNN deep learning algorithm.

To evaluate this neural network, we used 51648 datapoints (538 days) as our train set, while 2688 datapoints (28 days) were used as the test set. The plethora of the datapoints allowed us to predict this longer period (4 weeks).

The RMSE across all 96 forecast 15-minute intervals is 2.368 kWh. This is a very satisfactory result and implies that the predicted values for the 96 15-min intervals have on average only a 2.368 kWh difference compared to the actual values of the test set (the mean energy consumption for the 15-min time interval is 31.24 kWh). A plot of the 15-min RMSE across all 96 forecast intervals is given in Figure 46.

Figure 46. Line plot of RMSE for the 96 (15-minute) predicted intervals for the Cypriot pilot



Source: JRC, 2021

As the dataset starts from 12:00 am, the first step corresponds to this time, with the final 96th step corresponding to 11:45 pm. The higher RMSE values show that in general these specific time intervals are harder to predict. Thus, the results indicate that from midnight to around 5:00 am, the forecast is more accurate. The period from 5:00 am to 2.30 pm is the harder to predict, as the RMSE is gradually increased during this period. Afterwards, a sharp drop to the values of the RMSE occurs, until around 7.15 pm. The RMSE starts increasing again from 7.15 pm onwards, reaching a second peak (much lower however compared to the first one) at around 9:00 pm, before starting to fall again.

4.11 Policy Support

2021 Competitiveness Progress Report

For the 2021 CPR we provided contributions to three different key technology areas. These are:

1. Home energy management systems (HEMS)
2. Smart electric vehicle charging and virtual power plants
3. LV distribution and substation automation

For the aforementioned areas we provided for each topic:

— A technology maturity summary based on the technology readiness level (TRL)

- Public R&I funding (27 EU Member States and EU funding)
- Private R&I funding (EU-27) (and compared with other major economies to the extent possible); (and to the extent possible data on venture capital (value and number of deals), including sources backing VC)
- Patenting trends - including high value patents
- A brief global market analysis
- Value chain analysis

More specifically, in the context of value chain analysis we provided:

- An overview of the technology's entire value chain
- A selection of the most relevant value chain segment(s) for EU-27 competitiveness (based on attractiveness and current/projected EU-27 positioning).
- Information on the turnover, the compound-annual growth and the EU market leaders for each technology

For the Smart electric vehicle charging and virtual power plants part, there is a technical report (JRC127004) available with the title: "*Smart charging for electric vehicles: Technology analysis and market overview (2021)*", where additional information and material has been added.

Science for Policy Report on Blockchain for the European Parliament

The SGIL has also contributed to the writing of a science for policy report on blockchain technology for the European Parliament based on the Enerchain administrative arrangement. Among others, we developed the following sections:

- How Digitalisation Reshapes Energy Sector
- Impact of Digitalization on energy demand (transport, buildings, industry, markets, etc.)
- Impact of Digitalization on Power Supply
- Digitally interconnected systems
- Blockchain in the energy sector (smart metering, flexibility, e-mobility, green certificates, etc.)
- Blockchain Challenges and Current Limitations
- The role of Standards in relation to Blockchain and distributed ledger technology
- Technical use case: Flexibility services

5 Conclusions

The construction of the Smart Grid Interoperability Laboratory at the JRC in Petten (NL) is an additional piece in the JRC support to EC policy in the area of Digital Energy. Interoperability has received a high level of attention. JRC developed a widely accepted European Interoperability Testing Methodology based on the Smart Grid Architectural Model, which serves as a basis for testing use cases of interoperability in future smart homes. Next to the enlargement of the laboratory testing capabilities, new use cases will be continuously defined and carried out. These use cases are of interest for or result directly from networking with European industry and research consortia. First tests were carried out in 2019 and 2020 mentioned in the respective Annual Reports of the SGIL. Activities carried out in 2021 are reported here, of which the biggest impact was made by the broad recognition of the JRC developed European Interoperability Testing Methodology, as well by industry as by policy.

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List of abbreviations and definitions

AIT	Austrian Institute of Technology
ANL	Argonne National Laboratory
BAP	Basic Application Profile
BAIOP	Basic Application Interoperability Profile
BESS	Battery Energy Storage System
BMS	Battery Management System
BRIDGE	Cooperation group of Smart Grid, Energy Storage, Islands and Digitalisation H2020 projects
CHO	Combined Heat and Power
CEN	European Standardisation Committee
CENELEC	European Committee for Electro technical Standardization
CEP	Clean Energy for all Europeans Package
DEI	Digitising European Industry
DER	Distributed Energy Resources
DES Lab	Digital Energy Solutions Laboratory
DoE	Department of Energy (USA)
DUTH	Democritus University Thrace
EIRIE	European Interconnection for Research Innovation & Entrepreneurship
EMS	Energy Management System
ERS	Energy Recovery System
ESS	Energy Storage System
ETSI	European Telecommunications Standards Institute
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GGIP	Global Grid Integration Project
HA	Home Automation
HEMS	Home Energy Management System
Interconnect	Interoperable solutions connecting smart homes, buildings and grids
IoT	Internet of Things
LED	Light-emitting Diode
MAESHA	deMonstration of smArt and flExible solutions for a decarboniSed energy future in Mayotte and other European islAnds
OCPP	Open Charge Point Protocol
OpenDSS	Open Distribution System Simulator
PHIL	Power Hardware in the Loop
PQ	Power Quality
PV	Photovoltaic
PyEMS	Python based Energy Management System

RCD	Residual Current Device
REC	Renewable Energy Community
RES	Renewable Energy Sources
SGAM	Smart Grid Architecture Model
SGIL	Smart Grid Interoperability Laboratory
SOC	State Of Charge
SOH	State of Health
TEC	Transatlantic Economic Council
UC	Use Case
V2B	Vehicle to Building
V2G	Vehicle to Grid

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Annexes

Annex 1. Developing Interoperability for Europe

The digitalisation of energy integrates components from different sectors: electricity, heating and cooling, information, communications, business processes and home appliances. The interconnection of those different systems, designed and developed according to different standards, brings about the problem of their interoperability. All those elements have to work together in order to have workable solutions in the market.

The lack of interoperability obstructs and delays the implementation of the digital energy solutions, affecting also the deployment of –among others– distributed renewable energy sources, smart homes and electric vehicles.

For tackling this conundrum, the European Commission set up the ***Smart Grids Task Force*** in 2009 for receiving advice on relevant issues regarding the deployment and development of Smart Grids. Based on the work of this expert group, the European Commission issued mandates in 2011 to European Standardisation Organisations (ESOs) –CEN, CENELEC and ETSI– to develop and update technical standards: M/441 'Standardization Mandate of Smart Meters', M/468 'Standardization Mandate concerning the charging of electric vehicles' and M/490 'Standardization Mandate for Smart Grids'.

The ***Mandate M/490*** had the precise goal of accelerating the standardisation process required for the deployment of Smart Grids in Europe. The Mandate 490 explicitly stated:

> *The objective of this mandate is to develop or update a set of consistent standards within a common European framework that integrating a variety of digital computing and communication technologies and electrical architectures, and associated processes and services, that will achieve **interoperability** and will enable or facilitate the implementation in Europe of the different high level Smart Grid services and functionalities as defined by the Smart Grid Task Force that will be flexible enough to accommodate future developments.*

To work on mandate M/490, the ***Smart Grid Coordination Group (SG-CG)*** was set-up in July 2011. After work on standards, in 2014 the group produced a report on Smart Grid Interoperability, highlighting the urgent need for a shared European approach to its testing. The report ([26]) sketched a first set of methodologies for including interoperability requirements during system design, and then ascertaining them through testing. The report states:

> *As more and more ICT components are connected to the physical electrical infrastructure, interoperability is a key requirement for a robust, reliable and secure Smart Grid infrastructure. The way to achieve Smart Grid system interoperability is through detailed system specification, through use of standards, and through **testing**.*
>
> *...*
>
> *Although the majority of Smart Grid equipment is based on (inter)national standards, this does not automatically result in an interoperable Smart Grid infrastructure. This is partly due to misunderstanding of what interoperability means, what can be expected from it and what should be done to realize it.*

In 2015 the European Commission set up a ***Smart Grid standards expert group*** with the aim of supporting the work on interoperability, standards and functionalities applied in the large scale roll-outs of smart metering in EU Member States. The work included an extensive survey (and responses by the Member States.

An important aspect has been the link between the European Union and USA. In successive dialogues in the context of the Trans-Atlantic Economic Council (TEC), and ratified by the EU-US Energy Council, both parties ratified the importance of cooperation in interoperability. A TEC Joint Statement in November 2011([27]) called for "*working jointly towards the objective of common or compatible* standards" and launched a cooperation pilot project, agreeing on the establishment of two Electric Vehicle/Smart Grid Interoperability Centres, one at Argonne National Laboratories and one at JRC. This was complemented with a Letter of Intent (LoI) between JRC and the US Department of Energy (DOE) declaring the interest on closer co-operation on interoperability

(26) https://www.cencenelec.eu/media/CEN-CENELEC/AreasOfWork/CEN-CENELEC_Topics/Smart%20Grids%20and%20Meters/Smart%20Grids/4_sgcg_methodology_sgamusermanual.pdf

(27) https://www.state.gov/p/eur/rls/or/178419.htm

matters. This cooperation was later confirmed during the inauguration of the Argonne National Lab interoperability facilities for electric vehicles in 2013.

In parallel, the Trans-Atlantic Business Council identified e-mobility and smart grids as a key growth sector in both USA and EU where collaboration in standards, regulation and interoperability could be of great value.

In 2015, the TEC meeting reiterated the shared interests for EU-US cooperation on e-vehicles and smart grids, highlighting that the work on interoperability and the joint work between the labs in DOE and JRC was a priority. This demonstrated the high political support to the initiative. One relevant phrase of the TEC facilitators says (27 March 2015):

> *In view of this success in the field of charging devices, facilitators encouraged Argonne National Laboratory and DG JRC to continue their active cooperation towards implementation of the Letter of Intent between the DG JRC and the DOE to test and verify equipment, connectivity technologies, communication protocols, and standards.*

Other relevant activities in Europe

⇒ DG CNECT/ENER - High level Meeting "Interoperability to create the Internet of Energy"

On 11 May 2017 DG ENER and DG CNECT organised a high-level meeting on how interoperability of communication and data exchange can ensure that Europe will benefit from the new opportunities that the IoT will create in the energy transition. The main questions were around interoperability, such as: What can public authorities do to ensure interoperability? What interoperability is needed to develop the smart home of the future that is for the benefit of consumers? What interoperability is needed for an efficient smart grid that fosters innovative energy services?

⇒ DG ENER - Smart Grids Task Force Expert Group 1 Electricity and Gas Data Format and Procedures

Following the decision of the Smart Grids Task Force on 17/02/2017, a Working Group on Energy Data Format and Procedures was formed with the overall task to collect information and investigate the potential for setting up a common format and procedure for energy data exchange in the EU-28. There have been some first reflections on this issue captured in a recent study on "My Energy Data" drafted as an interim report by an ad-hoc group of the Expert Group 1 (EG1) of the Smart Grids Task Force.

The main objective of this Group is to work towards a common interoperable energy data format and procedures at European level, achieve consensus among key stakeholders on best practice, and propose what should be the scope and coverage of further and more specific secondary EU legislation (i.e. implementing act) to set such common arrangements.

Uniting the existing various arrangements into a common data format and procedure at EU level will bring together diverging national practices, facilitate interoperability and uptake of new services, boost internal market competition and keep administrative costs under control.

The tasks were divided into four ad-hoc working teams (subgroups) dealing respectively with three processes – change of supplier, billing, emerging services – and the horizontal issue of interoperability. JRC takes part in the latter.

The final aim is to achieve consensus among key stakeholders on best practices, and finally frame recommendations to propose what should be the scope and coverage of a secondary EU legislation to set-up such common arrangements ensuring interoperability. The outcome of this work will also facilitate the discussions of the Council with the Parliament for the Article 24 "Interoperability requirements and procedures for access data" of the Recast of the Electricity Directive, and will directly feed into testing requirements.

⇒ DG CNECT/ENER - H2020 Call Interoperable and smart homes and grids

Within H2020 a Call is dedicated to the topic 'Interoperable and smart homes and grids where the aim is to exploit the Internet of Things (IoT) architectures models that allow for combining services for home or building comfort and energy management, based on platforms, that enable the integration of relevant digital technologies. With deadline on 14 November 2018, the project is planned to begin in the 2Q 2019.

The envisaged architecture should allow for third-party contributions that may lead to new value-added services both in energy and the home/building domain. This shall be done by developing interoperability and seamless data sharing, through aligning existing standards from the utility and ICT domains, across the devices and systems to enable innovative building energy management services, with the aim to save costs to consumers, to facilitate the integration of renewable energy from distributed intermittent sources and to support energy efficiency.

The JRC SGIL in Petten, in agreement with DG ENER/CNECT, intends to provide technical support to the selected project consortium.

⇒ DG CNECT/DG SANTE – Health

Smart or digital health will become more and more of importance in patient's diagnostic and therapeutic methods. New approaches have as central components telemedicine and remote care, with dedicated appliances and services that rely on reliable energy and communications. The security and interoperability of health data and devices are key issues. Interoperability is explicitly requested in the Medical Device Regulation EU 2017/745, as well as in the Medical Device Directive 98/79/EC 'in-vitro diagnostic medical devices ".

In this respect, DG CNECT animates the Digital Health and Care Task Force and sponsors different research activities in H2020, planning to continue with them in the future for facilitating the sustainability and quality of health and care provision, as a consequence of demographic change and improvements in medical treatment.

The JRC SGIL considers providing support to these initiatives at different levels:

- Interoperability testing of devices;
- Participating in the JRC Transversal Activity on Evidence-based Health Project;
- Setting up collaboration with leading European digital health/Telehealth research institutes and clinics;
- Information exchange on interoperability issues in digital health with DG DIGIT and DG ENER.

⇒ DG GROW – Smart Grid flagship studies

At the end of 2015, the Executive Agency for Small and Medium-sized Enterprises, under coordination of DG GROW and supported by the JRC, launched a tender grouped into two lots for studies on: 1) smart grid lighthouse projects; and 2) barriers and opportunities for smart grids deployment.

The purpose of the studies was twofold: 1) to identify what makes smart grid projects attractive to investors with the aim of stimulating investment towards this industry; and 2) analyse existing obstacles and opportunities for deployment of these technologies in EU to help identify where support is most needed and most relevant for smart grid deployment and European industrial competitiveness and growth.

The basis for the studies was the JRC inventory of smart grids projects and the main findings were presented in the context of the Expert Group on smart grid industrial policy of the EC Smart Grid Task Force. Amongst them, as also stated by the European Economic and Social Committee (2017), the objectives of the Clean Energy Package highly depend on the value the interactions between operators, service providers and consumers, and the availability of interoperable solutions.

⇒ CEN-CENELEC-ETSI - Coordination Group on Smart Energy Grids (CG-SEG)

After the dissolution of the Smart Grid Coordination Group in 2015, CEN-CENELEC-ETSI set up the CG-SEG for continuing with the work on standardisation. CG-SEG complements work of the European Commission Smart Grid Task Force (SGTF) Expert Groups.

CG-SEG identified some legislative proposals from the Clean Energy Package (CEP) with the highest impact on standardisation. Of these 'priority topics', two refer to interoperability:

5. Data Management, format and interoperability (CEP-EMD-1)

7. Interoperability with Consumer Energy Management systems (CEP-EMD-3)

In addition, the European Parliament (EP) amendment to Article 24 (Data format) of the Proposal for a revised Electricity Market Directive explicitly requests that interoperability standards for a common European data format be drawn up by the relevant European standards organization.

JRC takes part in the CG-SEG, taking into consideration their technical positions, and providing feedback from the work in the laboratory, mainly regarding the testing procedures. It is expected that CG-SEG will formally endorse the testing methodology and tools developed by JRC.

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