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Abstract:

This report provides and overview of the key innovations developed in the FINESCE trials of FIWARE for Smart Energy and places the innovation in the context of changing business conditions and models in the Energy Sector.

Keyword list: FI-PPP trials, Smart Energy, Business models, Business transformation, customer-centric energy networks

Executive Summary

Since the start of FINECSE, evidence that many of changes expected, by project participants, to happen in the Energy sector, is appearing more and more frequently. Energy markets are showing the strains caused by the availability of energy from renewable sources in Europe and from the availability of cheap shale oil in the US. Traditional energy producers are re-structuring their operations as power production using fossil fuels, and in Germany also from nuclear fuel, becomes a loss making business.

In the midst of this change, the consumer is looking for energy services rather than products and consumers have become pro-sumers in many parts of Europe.

Start-up companies in the energy sector have rapidly increased in number and FINESCE took many energy focused SMEs into the consortium as a result of its' Open Call. The accelerators of Phase III of the FI-PPP demonstrate the high level of activity of the start-up scene in the energy sector, and FINESCE has been supporting start-ups whenever possible.

In this context, the technical achievements and learnings from the individual trials have developed a body of knowledge and experience on a set of critical use cases for transforming the energy sector in Europe into a vibrant eco-system generating economic growth and creating a more sustainable environment for everyone.

This report provides a short overview of the transformation underway towards customer centric energy services based on renewable energy, and the role that FINESCE has played in it during its' 30 month life as a project. The FINESCE trial learnings, the FINESCE platform and the Utility 4.0 concept provide a large body of publicly accessible knowledge on how to build and run a customer-centric energy service business based on renewable energy sources.

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Table of Contents

1. Introduction

The purpose of this report is to give an overview of the changes in the business environment for Energy and the places the innovations developed by FINESCE in that context.

Chapter 2 summarises changes in the energy market during project life time and how they are related to the projects trial sites. Chapter 3 covers the progress made in the project paying attention to the experience gained with integrating FIWARE GE's into the trial software infrastructures. It describes how the project adapted its' initial plans to the market changes and the also the key benefits and learnings of the trials. This is followed by a summary of the efforts made in disseminating and preparing exploitation and commercialisation of results, with a particular focus on the FINSCE trial site Open Days.

The report concludes with an overview of the business models which were investigated in the trials and sustainability plans for further exploiting trial achievements and continuing of the trial activities beyond the FINESCE project timeframe.

2. Changes in business environment and trends in the energy market

Since the FINESCE project started in 2013 the energy market has changed rapidly. Climate change and global warming concerns are driving increasing renewable energy sources. In particular, the:

- Use of and switch to renewable energy grew faster than expected (Energiewende in Germany – reduction in use of Nuclear power),
- Transformation in the energy sector is happening faster than many in the industry expected, and the
- Trend towards energy as a customer-centric service is now established in Europe.

These changes in particular benefit the exploitation of the FINESCE results as they have increased interest in our results on how to run and build customer centric energy services based on renewable energy sources.

Other changes in markets that have taken place during the project lifetime include:

- The European Commission is requiring the member states to reduce the dependency on fossil fuels and the expensive energy imports while reducing the consumption of primary energy by 20 % compared to the forecast consumption (EU guideline 2012/27).

- Renewable energy will play a fundamental role in the transition towards a more competitive, secure and sustainable energy system.

- A developing trend shows the increasing tendency of the manufacturing industry to change to eco-friendly manufacturing. Induced from the customers who are showing a rising interest on sustainable eco-friendly products, companies start to show the energy consumption and usage of renewable energies in their production.

- Another challenge is presented by the anticipated growing penetration of electric mobility leading to a constant and high energy demand.

- The rapid deployment of renewable energy already poses challenges for the electricity system.

These changes lead to an increased interest in private and commercial users being empowered to take an active role in the energy arena as prosumers. The energy flow is changing from uni-

directional to bi-directional as an increasing number of users install renewable energy sources in their own properties and in their own buildings.

A more intelligent and efficient system is needed to operate the energy network with a new architecture, particularly at the distribution and regional network levels.

The integration of the renewable energies, the electric mobility, the involvement of prosumers feeding energy into the grid and the increased involvement of the customers while leveraging their energy consumptions flexible are changing the architecture of the energy grid.

To ensure the stability and the security of the grid more intensive monitoring and controlling systems are needed using communication, metering and monitoring systems based on ICT and cloud technology. Future smart grid concepts such as demand side management and demand site response systems will help to control and guarantee the stability of the grid.

3. Progress and key benefits of the project trials during project time

3.1 Planned work and changes of plans during project time

The planned work of the FINESCE Project has been carried out successfully with only minor deviations which didn't affect the final results. Many extra results, not in the original project plan, were developed.

During the project duration, an increased focus on FIWARE and the validation of the GEs from the stakeholders was met by increased effort and the joint work on a coherent evaluation scheme for GEs.

3.2 Key results

A detailed description of the WP key results is given in the Deliverables Dx7 Trial Results

Overall results for all Work Packages

- Successful integration of a large number of GE's
- Development of the FINESCE API

Results WP1

- Development of a robust and flexible trial infrastructure which will be further developed and trailed post the FINESCE project
- Executed use cases around data processing and energy optimization
- Experienced positive and engaged building owners in the trial
- Development of a CO2 signal forecast regression model based on historical district heating production
- A seasonal three-day model performs best in terms the sum squared error
- Development of a grey box building model for assessing the building's thermal characteristics based on measurement data and basic building information
- Derivation of the thermal flexibility per different building types to assess the Demand Side Management potential
- An evaluation of the building thermal flexibility based on a 2 capacity grey box model shows that the building can maintain a comfortable indoor temperature (less than 1 K temperature decrease) over 20 hours for an average outdoor temperature

of 3°C and a heating reduction of 70%. These results are in agreement with measurement data form a step test result in the corresponding building

- Integration of GE's Identity Manager KeyRock, Authorization PDP AuthZForce, and PEP Proxy Wilma
- Implementation of the application for visualising the Smart Building data

Results WP2

Horsens

- Development of a software platform collecting and distributing data form all installed platform, using internet technologies.
- Shifting energy consumption by controlling the charging of the trials EV's. Online measurements of the trial site users' power consumption for EV charging and the EVs batteries state-of-charge are used as input parameters for an optimised charging schedule.
- Comparison of a controlled group of EVs with the reference group for the full two months period demonstrated that: it is possible to reduce the peak load on the 400 V power grid by controlling the charging of EVs without reducing the users comfort and in addition, controlled charging can reduce CO2 footprint and cost of electricity for the individual user.
- For the users, unsolved challenges remain related to the management and optimisation of the new technologies. We see that nearly all participants actively engage in "hands-on" optimising guided by common sense.
- With their new equipment, and in particular the production of their own energy, we see that the families adjust towards "more rewarding" consumption practices.
- The users emphasise the importance of issues like transparency, level of security of energy supply and shared control when asked about a future partnership with an external control service supplier.

Madrid

- The main result is the integration of 4 different building subsystems (BMS with remote control functionalities through the Building Control Centre (BCC), energy generation and storage control system, smart metering system and external forecast services)
- Acciona plans to offer three advanced energy services commercially
  - energy demand management of buildings, which purpose is to optimize the day-to-day operation of industrial and tertiary buildings equipped with a BMS.
  - optimized management of the energy generation and storage capabilities of a building in order to match its energy demand, taking into account as well the prices of the energy purchased from the grid, thus considering the building as a microgrid.
  - delivery of energy efficiency services targeting the diagnose of the use of energy in a building, the definition of a strategy for improving the energy efficiency of the building (either through the upgrade of building installations and/or the improvement of the facility management strategies), and the verification of the energy savings obtained through the application of this strategy.
  - The main interaction with stakeholders enabled in the trial has been the increase in awareness about energy consumption through the display of information through a dedicated web graphical interface, as well as enabling the access to this information through the trial API.

Results WP3

- Development of the system to balance the energy between the VPP and the Smart Factory in the energy eco system with Future Internet technology based on FIWARE and GEs.
- Implementation of a stack for data aggregation, refinement, enrichment and visualization to better connect various services Future Internet technology services into new synergies.
- Having an energy driven factory at disposal for testing new methods and software systems is a strong value proposition for big industry players from a variety of fields. This was strongly confirmed by larger enterprises visiting the architecture during the project.
- In the Aachen/Cologne trial site the infrastructure for a demand response system was created which is available for testing and business innovation. This includes the web interfaces for the communication of the different parts of the trial.
- The impact of B2B balancing approach on electrical grid operation is evaluated based on simulation platform that utilizes real-time digital simulator. The simulation infrastructure allows for easy interaction of simulated trial and applications. Furthermore, it enables realistic validation and demonstration of a cloud-based VPP platform.
- The graphical user web interface applications for Smart Factory and VPP use cases improve visibility into the data and enable the operators' regular workflows without the user interface getting into the user's way.

Results WP4

- a G3-PLC based AMR2AMI solution has been designed and then implemented
- In order to implement the IT solution for the designed marketplace, software components (DSEs and others) and services (FINESCE WP4 API) have been developed
- The DSEs put in place the integration between the marketplace and its different data sources (metering data, weather forecast, social events, etc.). DSEs have got the following distinctive features:
  - source code is publicly available on FINESCE Github (https://github.com/FINESCE), royalty free and has been released as open source (mostly under Apache 2.0 license);
  - DSEs are "pieces of software" developed in Java but are different in nature (Timer application, client/server application, web services);
  - the web services are all based on RESTFul technology (Jersey/XML);
  - most of the DSEs represent a way of "publishing" data to an instance of ORION Context Broker GE (which can be considered the centric "piece" of the marketplace architecture)

Results WP5
Stream 1

- Balancing of electricity supply and demand, in time and geographically.
- Users' energy demand (when they may charge EVs) tracks the supply of energy from renewable sources.
- Fully operational charging optimisation system (COS), serving real customers implemented.
- Communications aspects have been studied for LTE and WiMAX:
- how quickly COS responds to a grid emergency event
- how quickly EV charging can be turned on/off,
- large-scale tests have been done using simulations

- LTE delivers adequate performance for the tested use cases.

Stream 2

- Distributed storage system for Utility data, with high-availability, low latency in acquiring data and secure solution for sharing data with external stakeholders.
- Flexible approach targeting distribution networks is to replace Utility systems with:
- Sensors
- Software on low cost computers
- Advanced L2 networks
- Replication of data between storages using TRILL Layer 2 protocol has been tested.
- TRILL allows easy deployment and interconnection of new nodes, but difficulties in large scale deployment have been found.

3.3 Key learnings

Below follows key results for the involved partners. Further details are available in deliverable "Trial Results".

Key learnings WP1

- Thanks to E.ON's involvement in the FINESCE project under the FI-PPP program, the E.ON organization has started to understand the power of the FIWARE capabilities and cloud as a concept
- Open API's to support new business models as well as delivering models for new services
- The developed trial infrastructure has proven to be a very flexible system with regard to handling different use cases and business models.
- Promising optimization results have been found and will be explored further.
- The potential for shifting loads without significant impact on the customer's comfort has been shown to be bigger than initially expected
- The infrastructure is capable to shift load according to defined use cases
- The evaluation of the trial building's flexibility indicated good potential as high thermal inertia
- The CO2 model performs well for shifting purposes but to decrease the sum squared error both the seasonal approach should be used and further training data is required
- Novelty of technology could help the users adopt it, but to actually use it regularly it also needs to be informative and useful
- A pleasing design has to follow the functional requirements
- Flexibility of the visualisation framework enables relatively quick reiterations of the data shown in an application and the functionality available

Key learnings WP2
Horsens

- An overall learning from the trial implementation is that smart energy solutions can be built on standard components. To ensure the stability and amenability needed to scale a solution the setup should be as simple as possible and use components that are prepared for external interfacing and preferably the same type

- Insights from the end user co-operation have generated extensive data about the end user in everyday interaction with new technology. With focus on smart grid services, there are at least three recommendations with respect to human insights:
  - Well-designed support and instructions should accompany the delivery of intelligent, green technology – both hardware and software – to encourage and empower end-users in the transition and to prevent old habits from counteracting the full potential of their investments.
  - Users ask for easy means to interact with external control services, and system interfaces must invite the users to easy-accessible, shared control features with clear feedback on "who" has control, and for how long.
  - In the case of offering control as a service, the services must be open to accommodate clear local motivators. This means that intelligent control services must be flexible and adaptive in order to meet the present price and payment conditions, as in the case of profiting from free solar energy.

Madrid

- The main learning obtained from the Madrid trial experimentation has been to understand how FIWARE technologies can help to enable and/or enhance energy services delivered for industrial and tertiary buildings.
- Another key learning has been the FIWARE GEs evaluation process itself, as it has been useful for providing a set of metrics with which it is possible to assess in an objective manner the adequacy of each GE to the envisaged application, and compare it with other commercial alternatives.
- The trial experience has been very useful to obtain key learnings about how to enhance the interaction with the different stakeholders in industrial and tertiary buildings, addressing both an increase of energy awareness, which may lead to a reduced consumption, and an optimization of the building maintenance routines.

Key learnings WP3

- A key result from the trial in Cologne and Aachen is the finding that the global balancing problems can be executed efficiently without interference of the normal business operations of the involved partners. Hence, this means that
  - a cross-border VPP can be set up and controlled using Future Internet-technologies and that
  - a discrete production offers sufficient flexibility in their energy consumption to be a valuable partner for an energy optimization.
- The efficient balancing between the energy generation of the VPP and the consumption of the Smart Factory has to be based on the forecast of both partners for the next day and has to be controlled with an event-oriented architecture to identify deviations from the plans and enable fast responses from the partners.
- The energy monitoring infrastructure and the data collected can also offer additional benefits and services like e.g. predictive maintenance for the machines based on their energy consumption data.
- The complexity of the integration of factories in the eco-system should be transparent for the factory operator.
- The graphical user interface needs to provide a good balance between a number of available features and simplicity. Fixed views set to show a small subset of live data work best for continuous monitoring, while customisable views with additional visualisations are suitable for occasional analyses. Data needs to be displayed in its context, such as on a map or in a floor plan.
- Using FIWARE and GEs improve the portability of the developed solutions to similar, yet different use cases. We demonstrated this by using the WP3's

FINESCE presentation layer for developing the web application for the WP1's Smart Building trial.

Key learnings WP4

- Learning how to use FIWARE technologies (installation, customization, etc.)
- Learning how to integrate software components with FIWARE GEs and how to collect data from the "real world"
- Playing the role of "infrastructure maintainers" from an operational point of view (solving bugs on DSEs, upgrading GEs, managing unexpected issues on cloud resources and private instances of GEs)
- Finally, teaching SMEs how to use the technology and replying to their questions

Key learnings WP5

- eCar batteries as interruptible loads demonstrated to work fast in the trial balancing and protecting the grid – to be scaled up and involve more load types
- Software defined utility concept for the distribution network demonstrated the low cost and flexibility offered in the trial

3.4 Trial site open days

FINESCE organised six Open Days at the trial sites across Europe to offer interested parties an insight into what has been accomplished in FINESCE in the last years.

The six locations gained an insight to the FINESCE trial sites and showed the key elements of a smart energy system. Examples for a successful implementation of applications and services in the energy sector based on an open infrastructure developed from Fi-WARE within FI-PPP were shown. They gave the participants the chance to meet stakeholders from the energy and the ICT sector and information on the funding possibilities to come up in the FI-PPP programme's phase 3 with altogether 80 million euros for SMEs developing IT solutions by using FI-WARE standard internet components.

Trial Site	Date and Location	Participants	Audience	Focus
Madrid	10.03.14 in Madrid, Spain	30	Entrepreneur, SMEs, incubators and others	First open day The experience gave the basis for the organisation of the successful following events
Aachen	12.06.14 Aachen, Germany	90	Start-ups, SMEs, students	Focus on the FIWARE open calls
Irland	22.09.14 Portlaoise, Ireland		SMEs and entrepreneurs	Information on FIWARE Acclerator Programme
Horsens	02.12.14 Stenderup, Denmark	60	SMEs, start-ups, universities, accelerators, project partners	Upcoming call Visit to the trial site houses to see the equipment and hear about the energy and home management system
Terni	09.03.15 Terni, Italy	80	SMEs , entrepreneurs	Information about funding possibilities within Incense
Malmö	22.04.15 Malmö, Sweden	150	Start Up's, SME's, FINESCE	Networking opportunities Information on FI-PPP

			Partners, authorities such as Swedish Energy Agency	Programme and FIWARE

4. Business innovation

4.1 New business models of the FINESCE project

FINESCE has further the development of new business models for energy services to end users (in our Horsens trials), to building owners (in our Malmő and Madrid trials), to power producers (in our VPP trial), to distribution network operators (in our interruptible loads trials in Ireland).

4.2 Sustainability plans

The sustainability of the FINESCE results is being pursued by partners, at trial sites and in the context of the FEN initiative of RWTH and in the context of further Research and Innovation projects. The FEN initiative has already secured 20 industry partners to privately fund further development of the FINESCE platform and has held two workshops in Aachen, Germany in June 2015.

All trial sites plan to provide services to interested SMEs beyond the end of the project. In particular,

- Data have been archived and are available via the FIWARE Lab Data,
- Commercialisation of project results will continue, including the development of the FINESCE platform,
- GE experiences reported in public documents on our web site (www.finesce.eu),
- DSE's continue to be available and are published on GitHub as Open Source,
- Trial sites will continue to be active after the project ends depending on demand,
- The FINESCE API will be supported for at least a year after the project ends, and
- Further development of project results will continue in 3 spin-off companies, a range of projects and in business development activities

5. Conclusion

The FINESCE project has benefited from the many changes which took place in the political context of energy provision following the Fukushima disaster in Japan, resulting in a shift in public opinion towards sources of renewable energy and the operation of smart grids required to support the large scale use of renewable energy sources.

The innovations developed in FINESCE target the growing need for knowledge and reports on experiences of planning, building and running customer centric energy services based on renewable energy sources. We have been able to make a considerable contribution to the body of public knowledge available on this topic. Our learnings and results have raised the interest of many players in the energy sector in Europe, the US and in Japan. They are being taken to commercial maturity in our partner organisations and the organisations investing in their further development through the FEN consortium.