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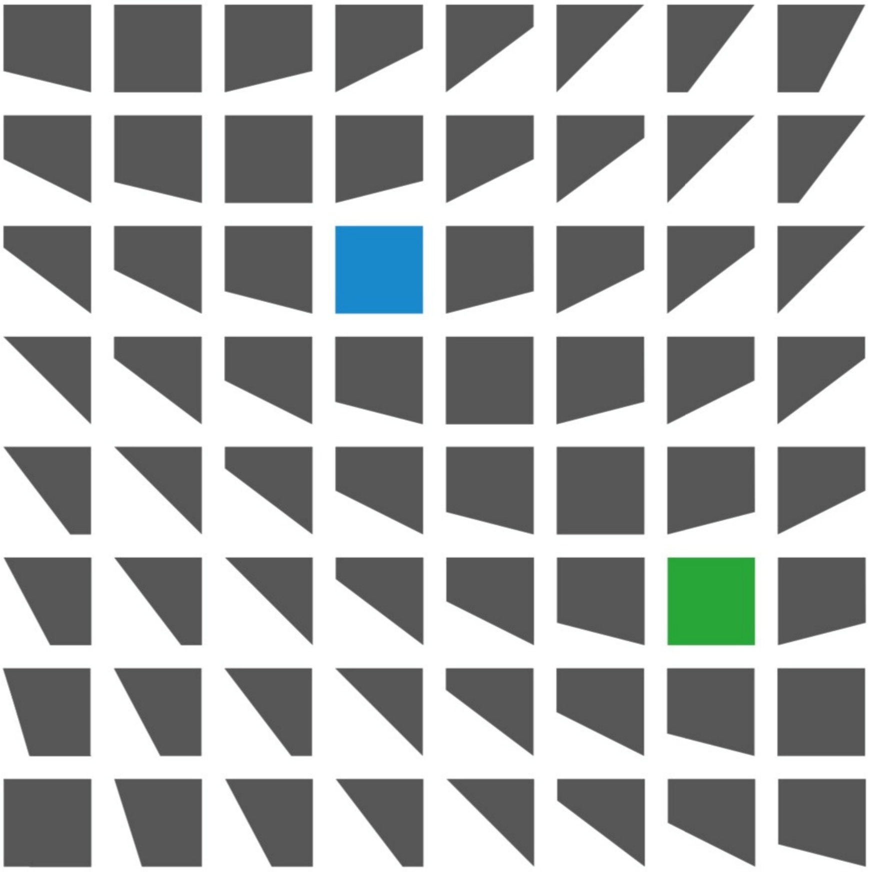
ReFlex

Replicability Concept for Flexible Smart Grids



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Résumé

Le projet Grid+ a permis d'identifier un manque de connaissances sur les moteurs et les méthodes de transfert d'un projet pilote de réseau intelligent ou d'un projet de démonstration à un autre endroit, compte tenu des différences en termes de constellations technologiques, de conditions du marché national et régional et d'acceptation sociale. Par conséquent, le projet ReFlex vise à développer un concept de réplicabilité et des directives pour le déploiement de solutions technologiquement réalisables, axées sur le marché et conviviales pour les réseaux intelligents avec un haut niveau de flexibilité.

L'accent est mis sur les réseaux produisant un niveau attendu élevé d'énergie renouvelable, qui doivent être utilisés de manière efficace et efficiente localement par une combinaison de mesures de régulation de la tension, de gestion de la demande et de stockage.
ReFlex est basé sur les pilotes de réseaux intelligents en évolution de grandes régions de démonstration (Salzbourg, Gotland, Hyllie, Rolle) et de régions de démonstration plus petites comptant moins de 15 000 habitants (Güssing, Hartberg, Biel-Benken et Wüstenrot), d'Autriche, de Suisse et d'Allemagne et la Suède.

S'appuyant sur l'expérience d'apprentissage des partenaires ReFlex, des directives de réplicabilité ont été élaborées pour aider les régions de démonstration et le groupe plus large d'acteurs du réseau intelligent européen à déployer et à faire progresser leurs initiatives de réseau intelligent. En tant qu'activité transversale au sein de ERA-Net, ReFlex contribue aux communautés de connaissances. Le projet a publié le ReFlex Guidebook, un guide contenant des instructions pour la réplication de solutions pour des réseaux intelligents flexibles, ainsi un Policy Brief, en résumant les principaux problèmes per les régulateurs.

Riassunto

Una mancanza di conoscenza dei promotori e dei metodi di trasferimento da un pilota di rete intelligente o da un progetto dimostrativo in un'altra località è stata identificata dal progetto Grid+. Particolare attenzione è stata data alle differenze nelle costellazioni tecnologiche, nelle condizioni del mercato nazionale e regionale e nell'accettazione sociale. Partendo da questa base il progetto ReFlex mira a sviluppare un concetto di replicabilità e delle linee guida per l'implementazione di soluzioni tecnologicamente fattibili, basate sul mercato e user-friendly per reti intelligenti con un elevato livello di flessibilità.

L'attenzione si concentra sulle reti con un livello elevato di produzione di energia rinnovabile, la quale deve essere utilizzata in modo efficace ed efficiente a livello locale attraverso una combinazione di misure in materia di regolazione della tensione, gestione della domanda e stoccaggio.
ReFlex si basa su progetti pilota di smart grid situati in grandi regioni demo (Salisburgo, Gotland, Hyllie, Rolle) e regioni demo più piccole con meno di 15.000 abitanti (Güssing, Hartberg, Biel-Benken e Wüstenrot) dall'Austria, Svizzera, Germania e Svezia.

Basandosi sull'esperienza di apprendimento tra i partner di ReFlex, sono state elaborate linee guida sulla replicabilità per supportare le regioni di dimostrazione e il più ampio gruppo di stakeholder europei nell'implementazione e nell'avanzamento delle loro iniziative di smart grid. Come attività trasversale all'interno di ERA-NET, ReFlex contribuisce alla diffusione della conoscenza.

Il progetto ha pubblicato la guida ReFlex, una documento che include linee guida per la replicabilità delle soluzioni per reti intelligenti flessibili e un breve documento, che riassume le questioni chiave per i responsabili politici.

Summary

A lack of knowledge about drivers and transfer methods from a smart grid pilot or demonstration project to another location has been identified by the Grid+ project, given the differences in technological constellations, national and regional market conditions and social acceptance. Therefore, the ReFlex project aims to develop a replicability concept and guidelines for the deployment of technologically feasible, market based and user-friendly solutions for smart grids with a high level of flexibility.

The focus is on grids with expectedly high level of renewable energy production which shall be effectively and efficiently used locally through a mix of measures in voltage regulation, demand side management and storage.
ReFlex is based on evolving smart grid pilots from large demo-regions (Salzburg, Gotland, Hyllie, Rolle) and smaller demo-regions with less than 15,000 inhabitants (Güssing, Hartberg, Biel-Benken, and Wüstenrot) from Austria, Switzerland, Germany and Sweden.

Drawing on the learning experience among ReFlex partners, replicability-guidelines were elaborated to support the demo regions and the wider group of European smart grid stakeholders in deploying and advancing their smart grid initiatives. As a cross-cutting activity within the ERA-Net, ReFlex contributes to the Knowledge Communities.

The project released the ReFlex Guidebook, a guidebook that includes guidelines for the replicability of solutions for flexible smart grids, and also a Policy Brief, summarizing the key issues for policy makers.

Main findings

- Legislators and Regulatory bodies can support innovation and replication of smart grids with new policy instruments for experimenting with regulatory framework conditions
- Replicability of smart grids can be supported through COPs between practitioners from existing and prospective for use-cases
- Replicability of smart grids can be supported through creating and strengthening networks connecting actors and stakeholder

Contents

Abbreviations

AIT	Austrian Institute of Technology
BaU	Business as usual
DB	Database
DG	Distributed Generation
DSM	Demand side management
DSO	Distribution system operator
DR	Demand Response
EIFER	European Institute for Energy Research
EV	Electric vehicle
LIU	Linköping University
PV	Photovoltaic
SFOE	Swiss Federal Office of Energy
SUPSI	University of Applied Sciences and Arts of Southern Switzerland
WG	Working group
WP	Work package
ZSW	Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg

1 Introduction

1.1 Background information and current situation

A lack of knowledge about drivers and transfer methods from a smart grid pilot or demonstration project to another location has been identified by the Grid+ project, given the differences in technological constellations, national and regional market conditions and social acceptance. Therefore, the ReFlex project aims to develop a replicability concept and guidelines for the deployment of technologically feasible, market based and user-friendly solutions for smart grids with a high level of flexibility.

The focus will be on grids with expectedly high level of renewable energy production which shall be effectively and efficiently used locally through a mix of measures in voltage regulation, demand side management and storage.

1.2 Purpose of the project

The ReFlex project aims at developing a replicability guideline for the deployment of technologically feasible, market based and user-friendly solutions for smart grids with a high level of flexibility. The focus was put on grids with expectedly high level of renewable energy production which are effectively and efficiently used locally through mixes of measures from voltage regulation, demand response, energy management and storage.

ReFlex is based on evolving smart grid pilots in eight demo sites in Austria (AT), Germany (DE), Sweden (SE) and Switzerland (CH). Four of them – Salzburg-Köstendorf (AT), Island of Gotland (SE) and Malmö-Hyllie (SE), Lausanne-Rolle (CH) – involved demo sites situated in larger areas with a distribution system operator (DSO) as main project partner. The other four of them – Biel-Benken (CH), Güssing (AT), Hartberg (AT) and Wüstenrot (DE) – are situated in smaller areas with less than 15,000 inhabitants involving private and public owned energy utilities, which did not have to unbundle grid operation from energy supply.

The **main objectives** of ReFlex are:

(a) **to establish a Community of Practice (CoP)** for among the Smart Grid demo regions across the participating countries, and

(b) **to develop a replicability concept and guidelines** for further deployment of Smart Grid solutions. As a crosscutting activity within the ERA-NET Smart Grids Plus, ReFlex directly feeds into its Knowledge Community.

1.3 Objectives

ReFlex Community of Practice (CoP)
The project aims to establish the **ReFlex Community of Practice (CoP)** for in depth knowledge exchange between regional Smart Grid demo regions across the participating countries, through providing workshops and demo site visits of practitioners, stakeholders and researchers.

Following the three-layer research approach of ERA-NET Smart Grid Plus (technology – business model – stakeholder adoption), the different technological solutions to real grid problems, customer acceptance and user-friendliness were to be inquired. Supporting action research and socio-economic analysis be based on a jointly agreed framework for technology review to enable comparative analysis, laying the ground for developing future replication scenarios. With the collected data, simulation models should be developed, advanced and tested for scalability assessment of technological flexibilities.

ReFlex Guidebook

The project also aims to elaborate a **ReFlex Guidebook** for the replication of technologically feasible, economically viable and user-friendly solutions for smart grids.

The replication concept and guidelines in the Guidebook are grounded upon a series of workshops and trans-disciplinary research from engineering and socio-economic disciplines, comprising technological solutions, new regulations, participatory processes, social acceptance and the exploration of business models. The guidelines for replicability are to support the industrial actors and other stakeholders in the ReFlex demo regions and the wider group of European smart grid stakeholders in deploying and advancing their smart grid initiatives.

2 Procedures and methodology

WP1: Replicability Concept and Socio-economic Research

The Work Package was led by LiU.

A key question for the future development of smart grids is how to move beyond pilot and demonstration projects and complete the transformation to a more active, flexible and sustainable grid system. Obviously, this is not only a question of 'getting the technologies right'. Energy grids and their functionality are deeply intertwined with regulations and other institutional structures (e.g. ownership structures, tariff systems), the types and networks of actors who operate the grid or supply electricity, the social practices and cultures of energy use, or the models and cognitive frames of actors and stakeholders, including the business models and interests of companies participating in the energy system. Studies of the scalability and replicability of smart grid technologies, i.e. the potential of implementing technologies from pilot projects for the whole electricity system or parts of it, even if carefully done and insightful, thus necessarily fall short of capturing the dynamics of electricity system transformation and the requirements of moving from limited smart grid pilot projects to a full-scale smart electricity grid.

This work package developed an outline of a replicability concept which extends the focus on technical replicability to the economic (market place) and further socio-technical dimensions, including user perspectives and institutional embedding. The work started on the conceptual background and links to other WPs (desktop research on upscaling & replicability). The concept was discussed in the Steering Group, approved in the CoPs. It represents a basis for the analysis of case studies and the structure of the Guidebook for the replication of Smart Grid projects. The replicability concept was discussed in Hartberg (and was again fed with input in Biel-Benken), structured along social and technical viewpoints and economical views.

WP2: Technology Assessment and Comparison

The Work Package was led by ZSW.

A frame of classified key technology parameters was developed and tried out with Wüstenrot (1st CoP Workshop), findings from the other ReFlex sites have been described among these technology parameters and compared with each other in order to feed into the discussion on replication and upscaling. The description of technologies has been finished and also included in the Guidebook.

On scalability, a ReFlex Simulation Tool was elaborated and tested for the demo site of Wüstenrot. The setup of a common technical framework has been initiated for the assessment of scalability. The tool uses existing models (technology & grid) developed by EIFER and makes use of collected data on demo sites. ReFlex project partners ZSW and SUPSI also provided their own simulation systems and grid topologies. The first simulation results have been discussed in the CoP in Malmö as well as with experts and stakeholders during the site visit. Furthermore, AIT and experts from demo sites have provided input on the user interface for the simulation tool.

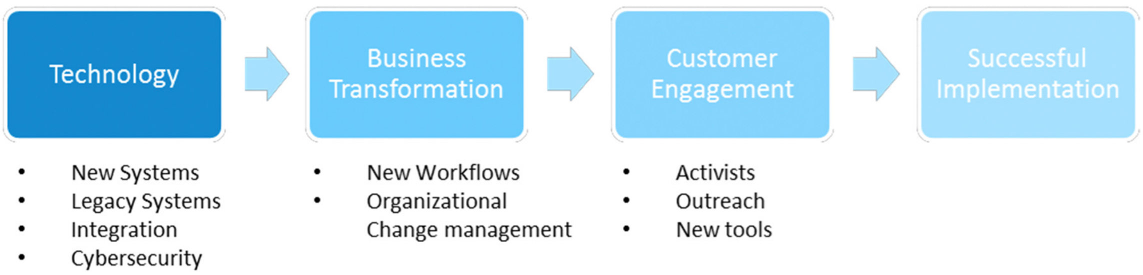


Figure 1 - Major elements of a smart grid implementation [1]

As shown in Figure 1 technology is the foundation of a successful smart grid project. All ReFlex demo-sites started with the idea having a sustainable, decarbonized and smart energy system. The transformation from old top-down infrastructure with large centralized power plants to decentralized infrastructure with renewable energy resources requires the implementation of devices with new technological features.

The *Guideline for implementation of "best-practice" technological features at demo-sites* will give

- an overview of used technologies at the demo-site projects and their readiness levels,
- lessons learned for technological synergy and functional interaction (Sector coupling),
- the assessment of flexibilities and
- best practice technologies for specific use cases.

The development of the technological part of the Guide has been based on the posters, interviews and reports produced by COP and the demo sites visits. The produced material was used to research and analyze the different sectors, technologies and boundary conditions.

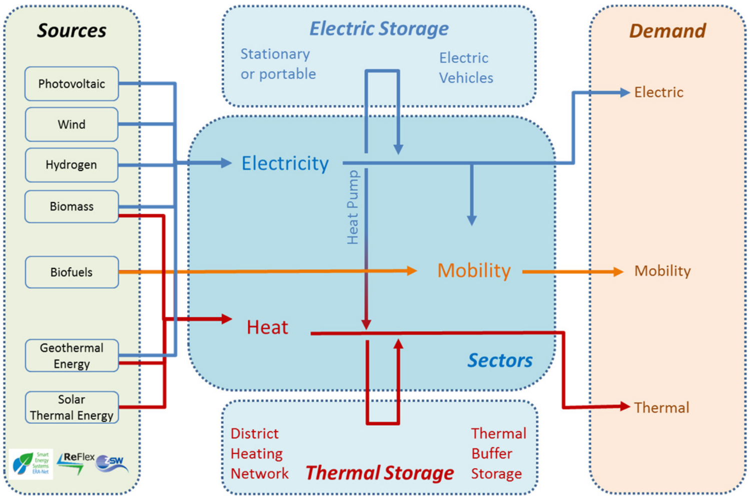


Figure 2 - Sector coupling of technologies

The result is the qualitative overview shown in Figure 2. With the technologies used in the individual sectors (power and heat generation, mobility, thermal and electrical storage) and their (sector) couplings.

The overall energy system should be considered as more than a random combination of different technologies. An optimized overall energy system utilizes synergies of different technologies and sectors (Electricity, Mobility and Heat) to increase the overall efficiency, sustainability and integration of renewable energy sources. A common example for single family houses is increasing self-consumption of PV with a heat pump and battery storage system. The surplus of PV generated electricity can be used to cover the heat demand by powering the heat pump or charge a battery-electric vehicle. It can also be fed to a battery storage system to use the energy whenever it’s needed.

✓ in use
O planned

	Technology	Wüstenrot DE	Köstendorf AT	Hartberg AT	Güssing AT	Hyllie SE	Gotland SE	Biel-Benken CH	TRL	SGRL
Electricity	Biomass	✓	✓	✓	✓	✓			9	9
	Photovoltaic Plants	✓	✓	✓	✓	✓	✓	✓	9	8
	Wind Power	o		✓		o	✓		9	8
Heat	Geo- / Agrothermal	✓							8	8
	Heat Pumps	✓	✓	✓	✓	✓	✓	✓	9	7
	District Heating Grid	✓		✓	✓	✓			9	8
	Solar Thermal	✓		✓	✓	✓			9	8
	Biomass Block-Type Thermal Power	✓	✓	✓	✓	✓			9	8
	Biogas / Biofuel	o		✓	✓	o			8	8
Mobility	**Electric Cars**	✓	✓	✓	✓	✓		✓	9	7
	Car Charger	✓	✓	✓	✓	✓		✓	9	7
Storage	**Electric Battery Storage**	✓	✓	✓		✓	o	✓	9	8
	Thermal Buffer Storage	✓	✓	✓				✓	9	8
Data Communication	Smart Grid With Data Communication		✓	✓	✓	✓	✓	✓	7	7
Buildings	**Building Energy Manager (DSM)**	✓	✓	✓	✓	✓	✓	✓	7	7
	High Efficiency Buildings	✓	✓			✓			9	-
Clients	**Residential Consumers**	✓	✓	✓	✓	✓	✓	✓	-	-
	Industrial Consumers	✓		✓	✓		✓		-	-

Figure 3 - Overview of used Technologies at Demo-Site-Projects

As shown in the previous table, photovoltaic and biomass are widespread for electricity generation and being used at all demo-site projects. Due to legal requirements, higher investment costs, inappropriate locations and lower public acceptance compared to solar energy, wind energy was only covered by half of the demo-site projects and successfully implemented by only two of the height. [2] Heat pumps are the only technology for heating used in all demo-sites. Especially because heat pumps are an easy and efficient technology for one-directional coupling from electricity to heat. Beyond that, for communal energy projects, biomass block-type thermal power plants connected to a district heating grid were the key technology for heat supply. Amongst all demo-sites Wüstenrot is the only project using geothermal or more precisely agrothermal energy in combination with heat pumps to feed a district heating grid in a new development area. Even though the mobility sector is part of nearly every demo-site, electric cars and charging stations are a subordinate part of the overall projects. One reason for that is that penetration of electric cars was low when these demonstration projects have been started years ago.

Based on site visits, interviews, and the experience of the Community of Practice (CoP), various technologies have been assigned a Technology Readiness Level (TRL). As shown in the previous table, all technologies have a very high TRL value (8-9).

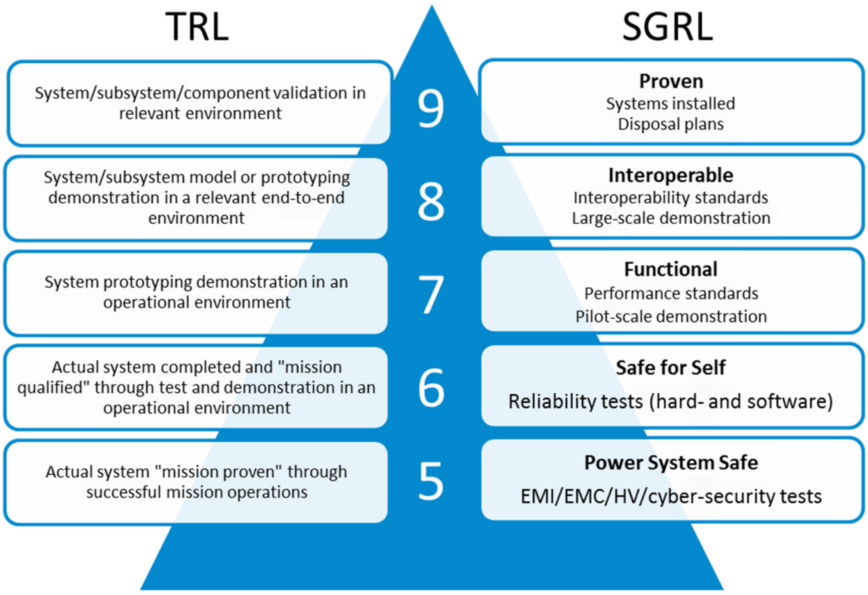


Figure 4 - From TRL to SGRL

We evaluated existing technologies not only in terms of their technology readiness level (TRL) but also by their “SmartGrid capability” (SGRL). The scoring has been derived from definitions of *Ruiz et al.* and *Kirkham* for the overall smart gird implementation of considered technologies. Although most technologies reached TRL 9 and all of them at least TRL 8, the SGRL of the majority of the technologies at the demo-sites is lower. Nevertheless, all technologies improved to at least SGRL 7 during the project duration.

Generation and Load shifting potential

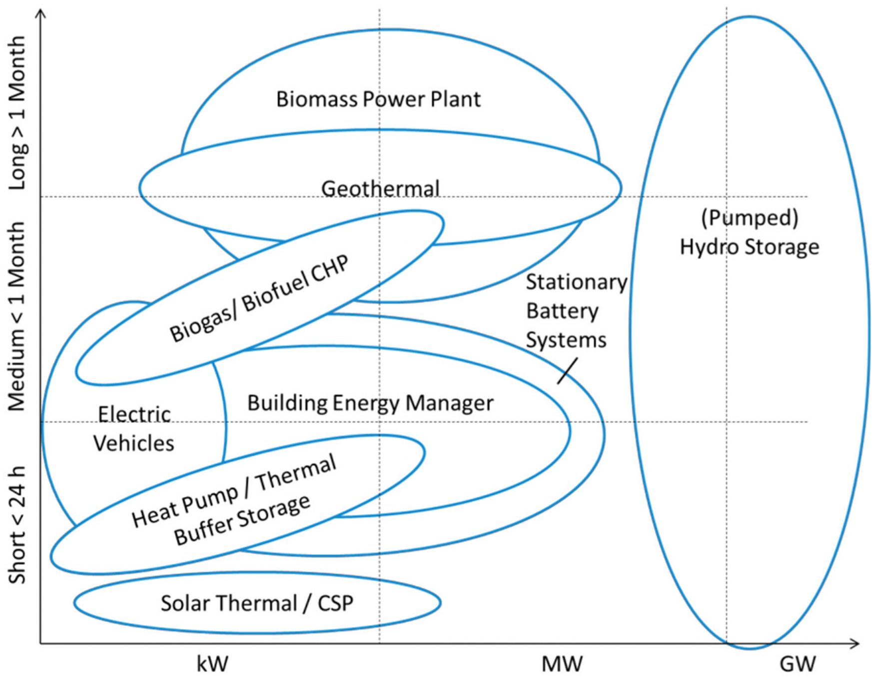


Figure 5 - Flexibility of generation and load shifting potential of different technologies

Available technologies for electricity, heat generation and storage systems can be classified with respect to their performance range, flexibility of power generation and shifting potential. The shifting potential of electric and thermal energy strongly depends on the used energy source. Figure 5 shows the time dependency plotted against the performance range of selected technologies qualitatively.

Renewable energy power plants such as solar and wind power plants are highly scalable in their performance range. But due to their weather dependency, they have no flexibility for power generation, apart from curtailment. In contrast, biomass power plants have a wide range of power levels and a long-term shifting potential due to the low storage cost for its chemical energy source. The same flexibility applies to hydro power plants.

Thermal and battery electric storage technologies need frequent cycling to amortize the initial invest, due to high investment cost compared to the amount of stored energy. Therefore, they need to be used for frequent short- and mid-term energy shifting. Pumped hydro storage plants cover the whole range from short up to long term load power and energy shifting potential.

Flexibility Assessment

Flexibility describes the ability of a technology to shift generation or load to another point of time. The technologies, we are looking at, provide flexibility for multiple purposes. Within the project we coined the following terms to categorizes the demo sites in two main purposes:

Flexibility of power
Flexibility of power has two main dimensions – time and power level. It enables the system to match generation and loads on time, within seconds and minutes.

Flexibility of Power aiming at
- maintaining quality of power,
- local grid voltage stability as well as
- availability of power supply for congestion management and operating reserve under changing conditions due to increasingly volatile energy generation.

The focus of this flexibility approach is more oriented on power and voltage aspects and related to short term periods.

Flexibility of energy-logistics
Energy generation and demand must balance across every period of time: minutes, hours, days and seasons to manage variability and uncertainty in the overall energy system.

The aim of *Flexibility of energy-logistics* is to
- manage the just-in-time feed-in and withdrawal of energy, to
- make locally produced renewable (access) energy available for optimal local energy-use and to
- optimize decarbonization of the energy system across weeks up to months.

The focus of this flexibility approach is more oriented on energy aspects and related from short to long term periods.

Use Cases for Replication

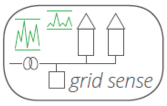
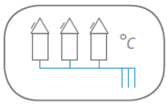
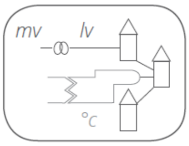
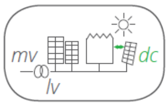
	Flexibility of Power	**Flexibility of Energy-Logistics**
Grid Management B2C with actively engaged energy end-user	Short-term voltage-stabilization in local electricity grid 	Shared use of local low temperature resources 
Load & Energy Management Services B2B without active engagement energy end-user	Load shifting for load-management of energy-utilities 	Energy Management for business parks 

Figure 6 - Use-Case Overview

Rather than describing all demo-sites themselves, four use cases for replication have been developed. Categories used are Flexibility of Power and Flexibility of Energy- logistics on one hand and business-to-customer (B2C) and business-to-business (B2B) on the other hand, leading to the four use cases shown in Figure 6. A detailed description of all use cases can be found in the ReFlex-Guidebook.

ReflexBox Tool

Based on a sketch of the most important technology parameters, since 2017 a ReFlex simulation tool was developed and tested on the example of the demo site of Wüstenrot and Biel-Benken. The tool uses the models developed by EIFER (Technology & Grid) as well as the data collected at the demo sites. The ReFlex project partners ZSW and SUPSI also provided their own simulation data. The first simulation results were discussed with experts and stakeholders at the CoP Workshop in Malmö. The final version of the simulation tool (ReflexBox) was introduced to a broader audience during the February 2019 ReFlex final conference.

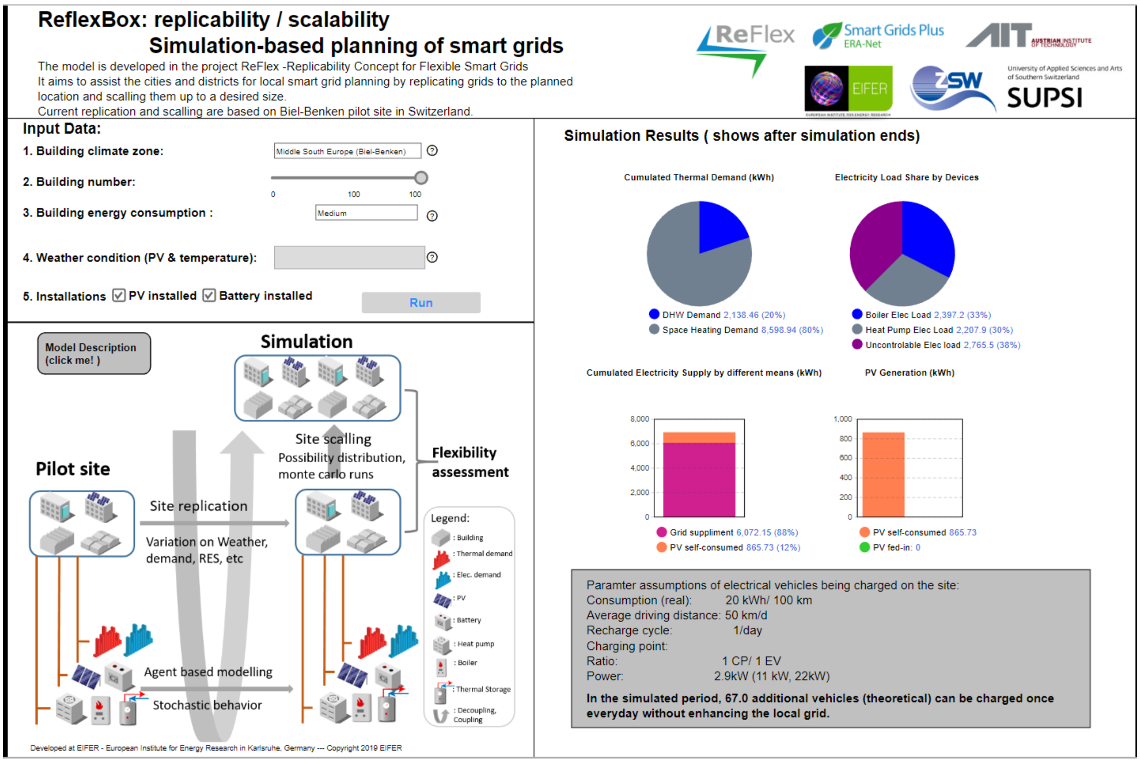


Figure 7 - ReflexBox User Interface

The tool helps decision-makers interested in smart grid projects to better understand the functioning of energy systems and the flexibility potential of simulated energy systems. With the "ReflexBox", energy systems consisting of individual single-family homes in a residential district can be displayed in a distribution network and, based on the reference project in Biel-Benken, Switzerland, replicated to different locations in Europe and scaled to a desired size.

A demo version makes it possible to simulate two pre-set cases. It is available at the following link: https://cloud.anylogic.com/model/1344a774-26c7-45f8-a259-96c95bcf5e4f?mode=SETTINGS.

A full version allows the user to customize the setup and replicate to other locations. This can be reached at the following link: https://files.eifer.kit.edu/nextcloud/s/FHpptyedfwebx0h.

WP3: Community of Practice - Knowledge Exchange

The Work Package was led by EIFER.

Three CoP Workshops were conducted by the local ReFlex partners in cooperation with AIT. Lessons from the field-testing experiments, including crosscutting issues (marketplace, stakeholders, and technology) were discussed and follow-up research questions agreed upon. In coordination with the CoP Workshop schedule, co-located demo site visits took place.

- The **First CoP Workshop (13-15 March 2017 in Wüstenrot, Germany)** provided insights into the EnVisaGe project, aiming at accelerating the transformation of the municipality towards a plus-energy community and discussed several questions on storage system issues including business models, demand side management from a technical perspective as well as the perspective of end users (prices, awareness, usability and the clarity of benefits). The workshop was complemented by a **demo site visit** to the plus-energy neighbourhood “Vordere Viehweide”.

- The **Second CoP Workshop (18-20 October 2017 in Malmö, Sweden)** focused on the field-testing experiments carried out in Hyllie, the largest urban development area in Malmö. Discussion tables were organized around (a) the integration of renewable energy sources in municipal multi-energy grid systems, (b) short-term (day and night) as well as long-term (seasonal) storage flexibilities, (c) opportunities and risks of peer-to-peer transaction platforms (blockchain), and (d) main characteristics and benefits of operating microgrids. Technical solutions and good practices specific for Malmö were discussed, e.g. the institution of a building energy manager, solutions beyond smart grids towards integrated energy systems coupling energy systems (heating and gas networks, electrical grid) and a successful cooperation between E.on and the municipality of Malmö. The **demo site visit** took place in **Hyllie**, a test bed for innovative smart grid and smart energy solutions. Some of the key questions which arose from the site visit were the future role of local energy communities and aggregators, the corresponding role of the DSO, and the tariff structure of storage systems change after the introduction of new regulations to acknowledge their role in providing flexibility to the grid.

- The **Third CoP Workshop (4-6 June 2018 in Lausanne, Switzerland)** focused on the economic viability of carrying Smart Grid solutions from an academic setting to real life, and the corresponding regulatory frameworks. Discussion topics focused on the identity crisis of DSO, the stakeholders driving the energy transition and the challenges related to the upscaling and downscaling of smart grid technologies. Local examples refer to the **demo site Rolle** (REel demo project) and EPFL Microgrid: The REel demo project is the largest interdisciplinary project of Romande Energie, the leading DSO in Western Switzerland, with the objective to test several smart grid technologies for grid management under real conditions. Among the current questions is the required sophistication of the measurement and control infrastructure. For example, the Commelec framework is reported to be a promising grid management control framework allowing to reduce energy resources to a minimum number of sets of metrics (energy profile, belief functions and virtual costs). The demo site visit was completed by a guided tour through the Smart Lab located at EPFL campus.

An initial demo sites survey has been done with specific questionnaires and telco interviews with demo site representative. After this data gathering phase **additional demo site visits** have taken place. Documentation and analysis have been uploaded to Sharepoint to distribute it among project partners, and on the ReFlex website.

- **Demo site visit in Hartberg, Austria (23-24 November 2016).** The site visit in Hartberg, organized by 4ward Energy, Stadtwerke Hartberg and AIT, gathered 20 participants from Austria, Germany and Switzerland, and gave insights into the Ökopark, on smart grids solutions in Hartberg. Replicability and scalability issues were discussed present as well as the future of the demo site. The format of the Hartberg site visit was endorsed and adopted for the following site visits.

- **Demo site visit in Biel-Benken, Switzerland (25-26 January 2017).** The ReFlex project team visited the Powergrid demonstration site in Biel-Benken. The event was hosted by EBM, the local distribution system operator running the trial of GridSense, a fully decentralized residential management system. The control algorithm has been developed by the Swiss University of Applied Science and Arts of Southern Switzerland (SUPSI) in cooperation with Alpiq, a leading Swiss electricity and energy services provider. The technology is validated locally in 4 residential houses and optimises the use of all suitably equipped power consumers, such as electric boilers, heat pumps, domestic batteries and charging stations for electric vehicles as well as decentralised power generators such as photovoltaic systems.

- **Demo site visit in Salzburg, Austria (26-27 June 2017).** The site visit was jointly organized by AIT, Salzburg AG and EIFER. The first day was devoted to visiting the Smart Grid community Köstendorf, a demo site integrating distributed renewable energy sources (PV) and electric vehicles in an efficient way in order to increase the hosting capacity of low voltage distribution networks. On the second day, a workshop held at the headquarters of Salzburg Netz GmbH, the regional multi-utility system operator for the city and the province of Salzburg focused on current projects conducted by Salzburg Netz, like Leaf, the 250 roofs program, *PV* Mieterstrommodell and DECAS. The projects cover the provision of ancillary services through distributed resources over the implementation of new programs and services to make renewables sources easily accessible to all consumers. DECAS (Demonstration of Coordinated Ancillary Services) explores aggregated prosumer response control reserve, individual voltage control and reactive power management concepts – like ReFlex – under the ERA-NET Smart Grids Plus initiative.

- **Demo site visit in Güssing, Austria (22-23 March 2018).** The site visit in Güssing, organized by 4ward Energy, Elektro Güssing GmbH and AIT, provided insights for the ReFlex project from field testing experiments carried out in Strem and Güssing, two municipalities belonging to the regional association ökoEnergieland Burgenland. Experience from the microgrid project in Güssing, 3Smart and SHAR-Q were discussed in the context of the overall objectives of ökoEnergieland, namely strengthening the regional economy of the border region, to create jobs and to maintain and increase the quality of life.

WP4 - Replicability Guidelines at 3 Research Layers

The Work Package was led by AIT.

Results from WP1 fed into the development of a draft structure for the **ReFlex Guidebook**. The ReFlex Guidebook on replicability follows the three-layer approach of ERA-NET Smart Grid Plus (technology / business model / stakeholder adoption). Municipalities and (bundled or unbundled) energy utilities have been identified as its main target groups. Moreover, policymakers and funding agencies are addressed with policy briefs subsuming the lessons learned regarding CoPs and transformative tools such as RTI-instruments, inclusion of new actors and stakeholders, cross-sectoral interaction and agenda setting. The structure of the ReFlex Guidebook was discussed among the Steering Committee as well as with experts from the ReFlex demo sites:

- Framework for the replicability concept
- Description of four to six use cases based on experiences from the demo sites
- Indication of the limits to upscaling in the case of replication

- Description of the requirements or preconditions for replication in the dimensions spatial structure, market structure, mission model, institutional framework and technological parameters
- Guidelines on replication of technologically feasible, economically viable and user-friendly solutions for smart grids (specific for target groups)

The ReFlex Guidebook addresses the specific roles and interests of target groups regarding replicability. The main focus is the integration of case studies, structured along the lines of technology – markets – users and the provision of a close link to CoP results. The ReFlex Use Cases, which are each based on a demo site case, are as follows:

- Biel-Benken: avoidance of load peaks and stabilization of the distribution grid
- Gotland: increase of hosting capacity, electricity quality and real-time pricing
- Güssing: feasibility of a micro-grid in a defined urban project region
- Hartberg: develop energy management system for electricity, heating and cooling of a business park
- Malmö: energy management of thermal and electricity grid on intelligent control of flexibility
- Salzburg: Volt-VAR Control and home storage integration
- Wüstenrot: shared use of local low-temperature resources (anergy) in neighbourhoods

The core messages from the ReFlex Guidebook, especially those targeting the policy level, are published in a Policy Brief. This document provides answers to the following question: **How can policy makers support the adaptive replication of flexibility use cases and smart solutions?** It compiles key issues from the ReFlex guidebook with relevance for policy makers in climate and energy policy and related research, technology and innovation policy at national, transnational and EU-level. More specifically, it addresses policy actors who are dealing with replication through new funding instruments, policy mix and regulatory changes in the energy field. Policy recommendations include **experimentation** (e.g.**Sandbox for replication)**, n**etwork & coalition Building (e.g in ReFlex Communities of Practice** (**CoP), Innovation Platforms, Stakeholder engagement in Visioning and strategy development (**example Hartberg**)** – as well as a **Transdisciplinary Co-creative Innovation Process** (Translation between electrical engineering, ICT-programming (cyberphysical systems), Collaborative business models)

Regarding the regulatory framework, DSOs need sufficient incentives to invest in smart grid solutions, e.g. like the energy act in Switzerland (2017), which creates incentives to install devices at household premises and introduce flexible tariffs. The storage question also needs to be addressed, e.g. in regulatory sandboxes, like on the island of Gotland in Sweden, where the DSO will be allowed to operate a regional storage system.

3 Results and discussion

WP1: Replicability Concept and Socio-economic Research

The aim of currently ongoing pilot and demonstration projects for smart grids and smart energy systems is to contribute to a transition towards a sustainable energy system. From a systemic perspective this requires a bunch of socio-technical solutions.

At the most basic level, the transfer of functionalities can mean the roll-out of standardized products developed in one or several smart grid projects. This type of transfer of solutions requires highly standardized conditions where the disseminated products function equally well in other parts of the electricity infrastructure (e.g. new smart meters). More challenging is an adaptive replication of smart solutions in other places which requires the adaptation to new socio-technical (e.g. geographic, regulatory, socio-cultural) contexts. An example would be the transfer of a smart grid solution, such as the use of energy management in households for grid stabilization, from one experimental site to another city or country. With a longer time-horizon, new smart grid solutions can contribute to transformative change, e.g. by linking experiment in households with new transport solutions or new business models, or by eventually becoming part of a new type of grid system.

The replication of experimental smart solutions in new locations and environments, i.e. the second of the above-mentioned categories of deployment in different socio-technical contexts, is the mid-range challenge for policies going beyond pilot projects. The aim is to make systematic use of the knowledge and experiences acquired in current projects and adapt it to new places and contexts.

We suggest ‘use cases’ to describe functionalities and actions related to specific smart solutions (e.g. the type of actors involved, their behavior and action etc.). For replication at other locations Table 1 outlines the dimensions, components of use-cases and socio-technical context factors along those dimensions, which should be considered when planning replication projects and when designing adequate policy instruments.

Table 1: Socio-technical Components & Context Factors of Use-Cases

Dimensions	**Use-case components**	**Socio-technical context factors of use-case**
Space and Geography	Physical Infrastructure Potential for local energy generation	Spatial and geographical environment: Size of replication site, climate conditions
Institutions and Regulation	Organizations and actor groups involved	EU and national legislation on competition and energy market regulation Energy market institutions Standardization
Social and political practices, networks and culture	Mission model (beyond economic benefits) Actor and stakeholder constellation	Cultural norms, Social practices of end-users Citizens’ acceptance and trust in institutions

Economic conditions	Business model of private and public actors Collaborative business model	Culture of cooperation and costs of coordination Macro-economic benefits

The replication concept elaborates how such a transfer requires a good understanding of the social, economic and geographical context of the current experiment as well as of the intended new place of implementation. Such an understanding allows to identify critical modifications and adaptations of the original smart grid solution if it is to function in the new socio-technical environment. It is crucial to ask: Which elements and solutions of the pilot project can be replicated somewhere else? Which context dimensions are critical for the replicability of these solutions? If these critical context conditions are not matched at the new place where a smart grid solution should be implemented, the solution in question is either not applicable, or in some cases framework conditions might need to be changed to accommodate the smart grid.

WP2: Technology Assessment and Comparison

For the simulation of energy systems, a hybrid multi-method approach is used, in which three major methodologies are applied: System Dynamics (SD), Discrete Event (DE) modelling and Agent Based Modelling (ABM). These three modelling methodologies give a relatively comprehensive way of representing complex systems.

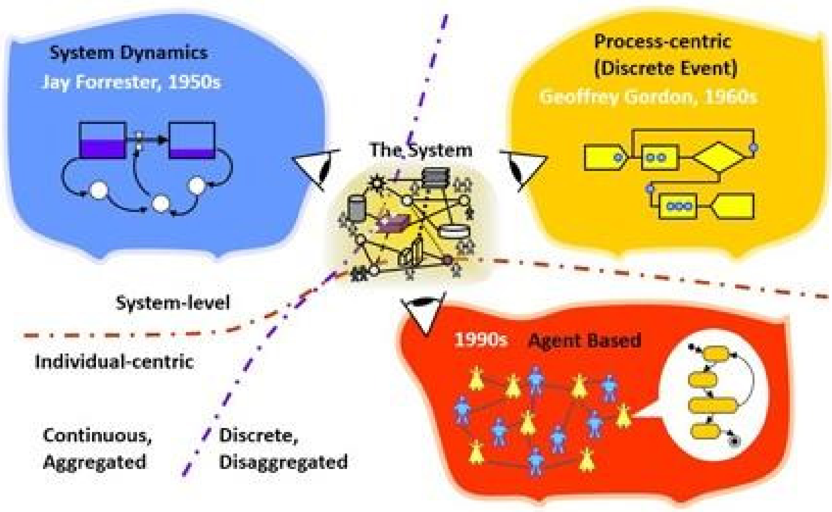


Figure 8 - Hybrid modelling methodologies (reference: AnyLogic)

The single-family houses are modelled with heat pump plus water tank storage system for supplying space heating, boiler and water tank for domestic hot water, battery + PV system and the rest electrical load including TVs, lighting, refrigerators etc.

With Agent Based Modelling (ABM), residential buildings in Biel-Benken are modelled individually, as so-called ReflexBox. ABM is used in decentralized, individual-centric or modular systems. The modeller identifies the agents and their behaviors, puts them in an environment, establishes their connections, and designs the control of system before running the simulation. The global behavior of the system is an emerging result of all the agents (population of agents). With ABM, objects of ReflexBox can be replicated in order to represent the system on a higher scale, building blocks or districts.

System Dynamic (SD) is a method to model the nonlinear behavior of complex systems over time using stock, flows, internal feedback loops, table functions and time delay. In case of processes with a continuous nature such as power flows, storage charging and discharging cycles, SD is a convenient modelling method.

Discrete Event (DE) allows to model control procedures of the energy system. DE modelling techniques should be used when the system under analysis can naturally be described as a sequence of operations.

Using multi-method modelling, we are capable to capture the complexity of a modern energy system, including a consistent representation of generation, demand, storage and their interactions. By modelling flexibility-related processes such as control strategies and rebound effects in a bottom up way, we are able reduce complexity and give a concise view on relevant KPIs of the system such as flexibility potential taking into account individual settings of system components.

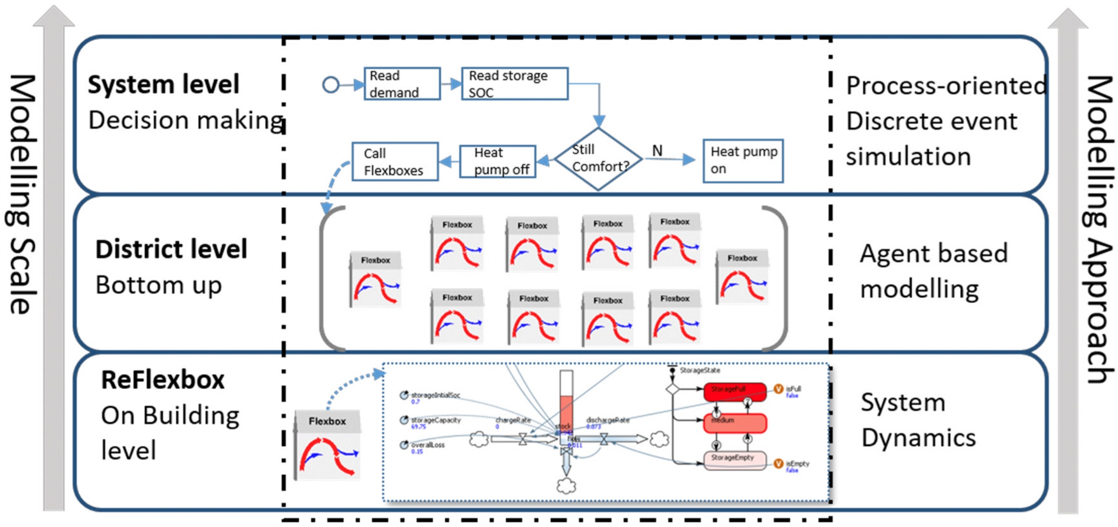


Figure 9 - Hybrid multi-modelling approach used for the simulation of energy system

Replicability and scalability assessment

Energy demand, system configuration defining the components of the energy systems and the system operation of a reference energy system (in this case, Biel-Benken) are decoupled and modelled respectively in the simulation environment. By creating new profiles of energy demand and PV generation according to the weather conditions of the planned location of replication and assigning stochastic behaviors to the system operation, a grid is replicated. Scalability is realized by increasing the number of building agents represented with “ReflexBox”. The simulation results show, as well as, the flexibility potential of the replicated or scaled up site.

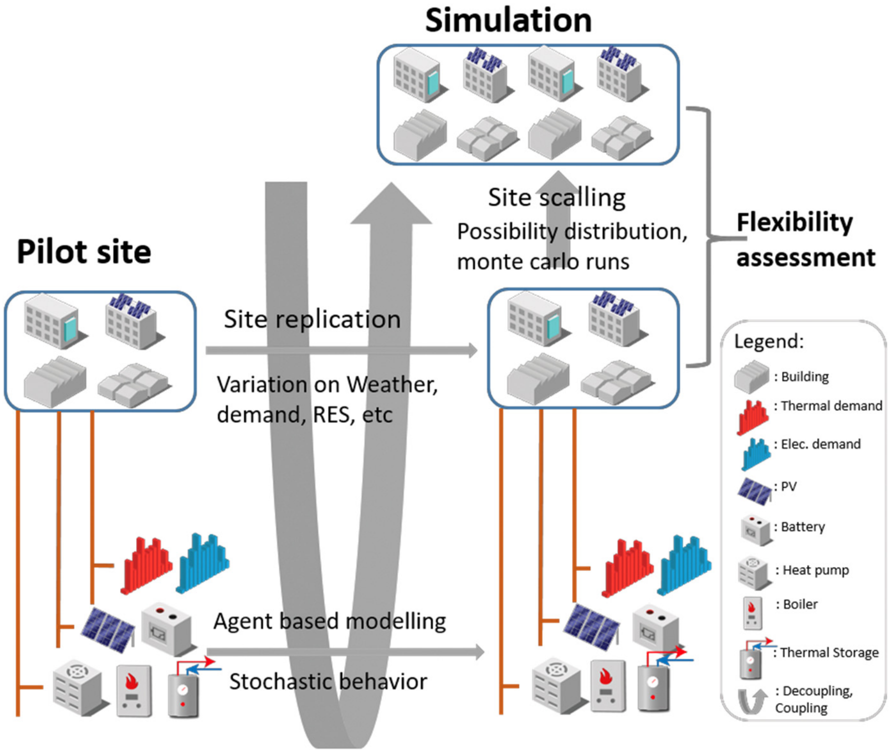


Figure 10 - Model architecture

Example: 100 houses replicated from Biel-Benken to Malmö

The energy system of 100-house district located in Biel-Benken is replicated to Malmö. Figure 11 and Figure 12 show that Malmö, Sweden has lower average temperature and solar radiation compared to Biel-Benken, Switzerland in winter 2017.

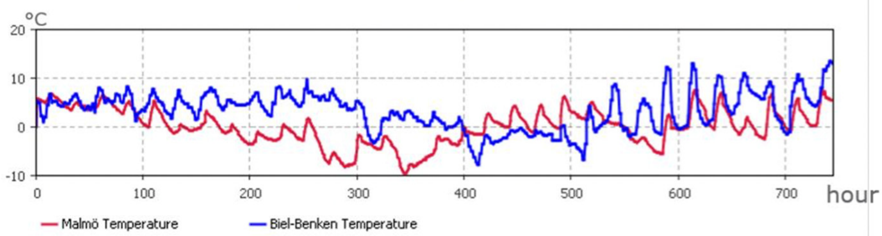


Figure 11 - Temperature comparison of Malmö and Biel-Benken in January 2017

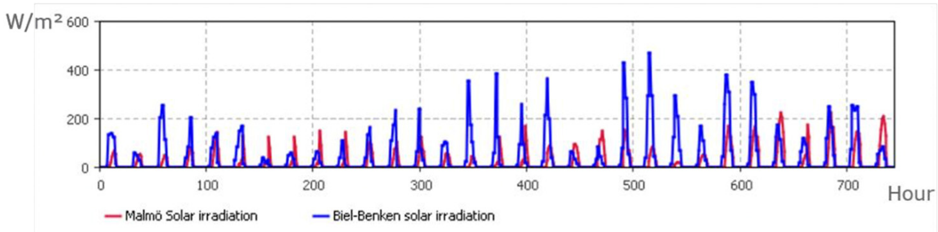


Figure 12 - Solar radiation comparison of Malmö and Biel-Benken in January 2017

Temperature difference results in different simulation results in terms of thermal demand and supply. The energy demand of the district in Malmö over one year is 140 MWh higher and the share of space heating is slightly higher compared to Biel-Benken. This results in a higher consumption of 45 MWh electricity in Malmö than in Biel-Benken.

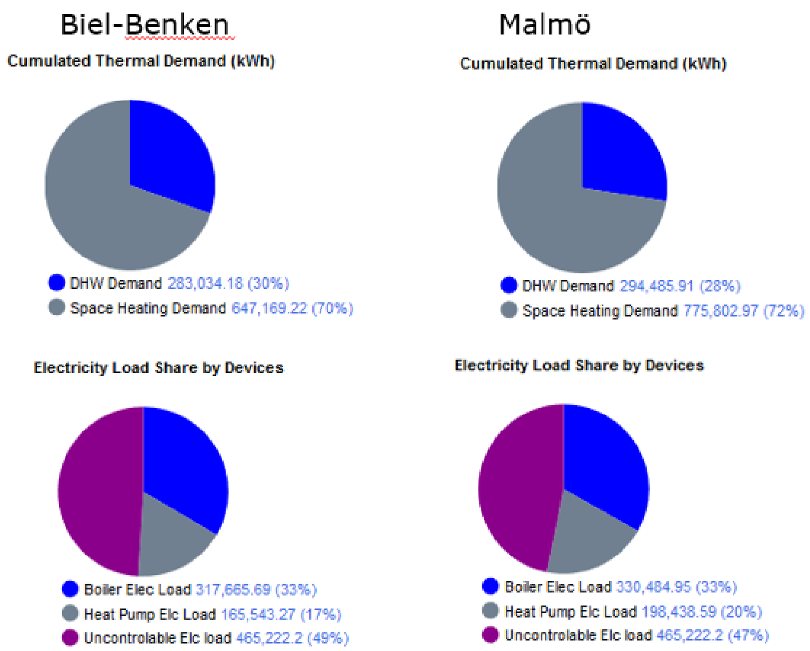


Figure 13 - Simulated thermal demand and electrical loads of Malmö and Biel-Benken

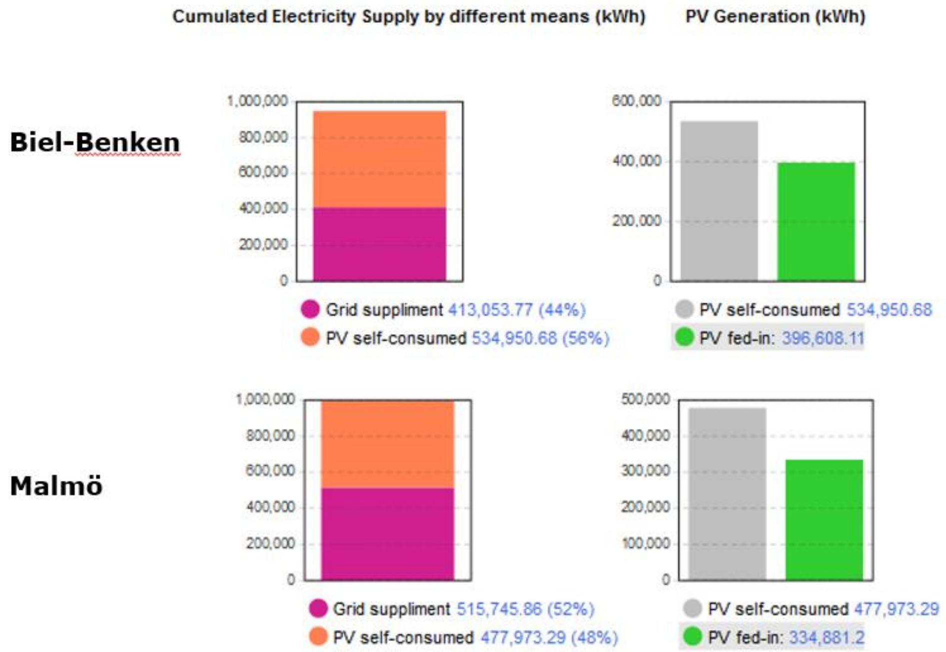


Figure 14 - PV generation and usage of Malmö and Biel-Benken

Compared to Biel-Benken, the PV installations in Malmö generate 118 MWh less electricity. PV supplies 48% electricity demand in Malmö, while the rest comes from the utility grid. In comparison, 56% of the electricity demand is supplied by PV in Biel-Benken.

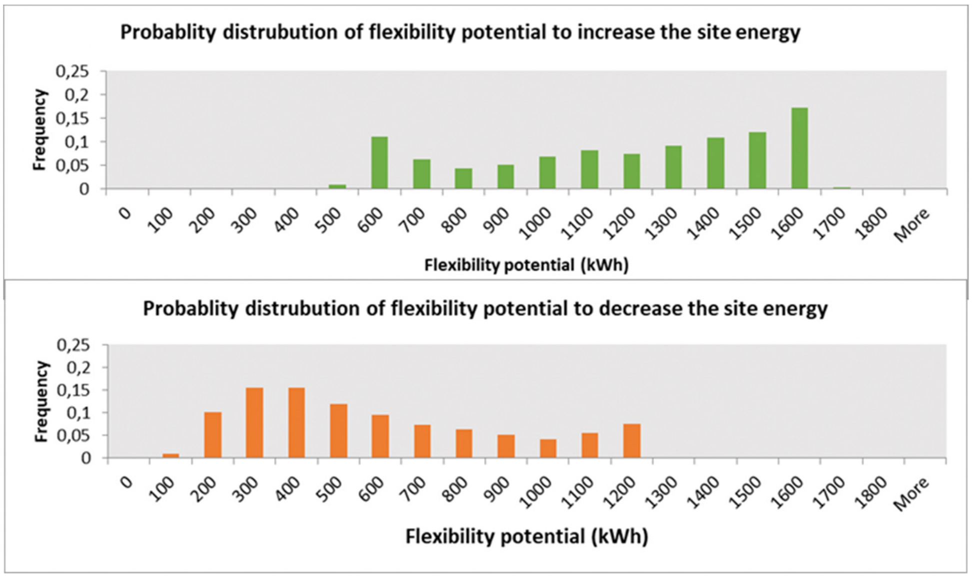


Figure 15 - Flexibility potential of the Biel-Benken site over a year

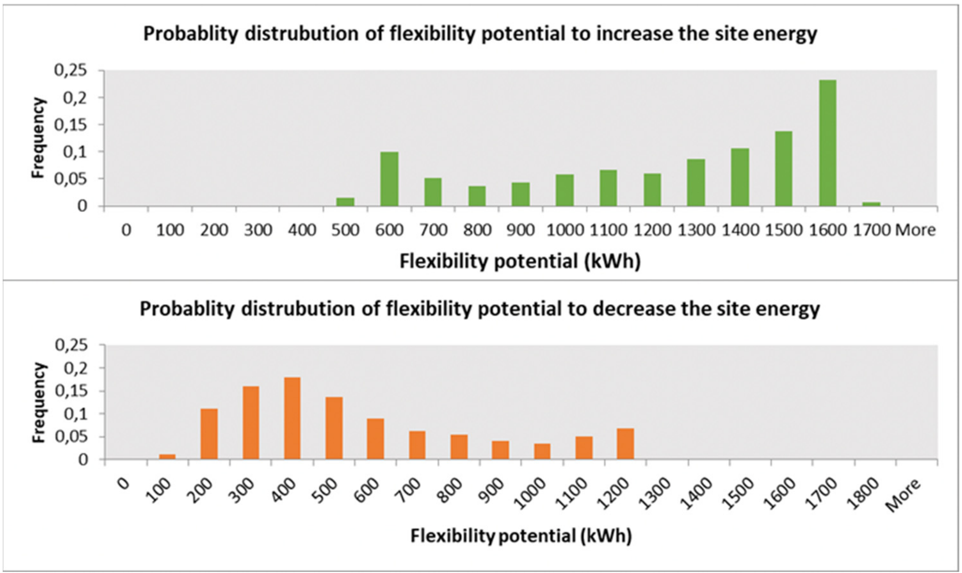


Figure 16 - Flexibility potential of the Malmö site over a year

Over one year, 100 houses located in Malmö have higher flexibility potential to increase the electrical load and lower potential to decrease the load, as compared with the site in Biel-Benken.

Location	Flexibility potential to increase the load (mean) (kWh)	Flexibility potential to decrease the load (mean) (kWh)
Biel-Benken	1128	540
Malmö	1176	514

Figure 17 - Average downward and upward flexibility potential over one year

From boiler and heat pump perspectives, the Malmö site is expected to have lower potential to increase load because of the more frequent usage of thermal devices in Malmö. However, the simulation result shows the opposite. The reason comes from batteries in Malmö, which tend to stay emptier than Biel-Benken, thus, have more potential to increasing load by storing more electricity from the grid.

Moreover, the better solar radiation results in a higher SOC level in batteries in Biel-Benken, therefore, Biel-Benken has a higher potential of decreasing its load by discharging batteries.
According to the quantified usable flexibility providers, site Biel-Benken allows to charge simultaneously 64 additional EVs without affecting grid stability while Site Malmö only 60 EVs. While replicating the smart grid solution to two different meteorological areas, we can still see a relevant flexibility potential in both, making the deployment of smart grid solutions interesting in the different countries.

WP3: Community of Practice - Knowledge Exchange

Lessons learned and feedback from CoP participants: Content-related feedback most prevalently dealt with the future role of DSOs and the regulatory barriers to innovations. The DSO appears to be in the best position to deploy and provide smart grid solutions. However, the current regulation – an incentive-based framework that set constraint on what type of services and assets distribution systems operators are expected to deliver and/or operate – does not create incentive for DSO to invest in smart grid solutions. An extended role of the DSO, allowing for more flexibility and including the issue of storage, will have to be rethought in the context of current changes in energy policy and should be addressed by the European Commission. In process-related feedback, many CoP participants stated to have learned a lot during the site visits and workshops, whereby provocative discussions caught the highest attention of the audience. Some participants suggested to give the local experts a wider participation in the workshops, include them more intensively in the discussion rounds and the CoPs in the other countries.

As a result of the ReFlex CoP, based on the feedback gathered during these events and desk research conducted by the ReFlex research team, main barriers to replication and scalability have been identified and ranked by importance. The main results are presented in the following paragraphs.

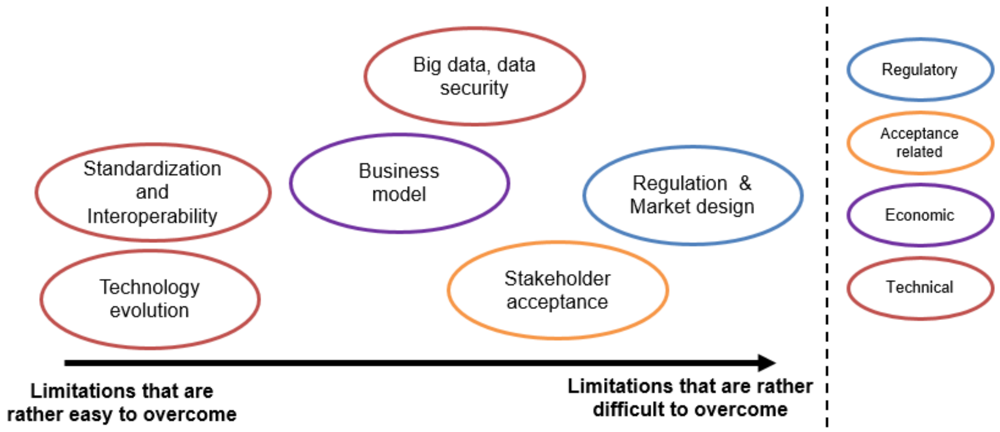


Figure 18 - *Own illustration based on Sigrist et al.: On Scalability and Replicability of Smart Grid Projects – A Case Study (2016)*

Regulation and market design

Regulation is seen as one of the main barriers to innovative smart grid solutions. The incentive regulation (regulation of TSOs and DSOs revenues) is a regulatory framework that encourages power operators to choose the most efficient solutions for the grid operation. Since innovative solutions such as storage systems or smart controllers have higher CAPEX, DSOs prefer invest in grid reinforcement measures than implementing and testing smart grid solutions.

ReFlex project partners advocate for Regulatory Innovation Zones as testbed for experimentations. This has already been implemented in some countries and should be further developed. In Switzerland for example it would be very interesting to experiment further on innovative tariffs. These tariffs could be very effective to indirectly steer the smart control agents that will diffuse "behind the meter". With these scenarios business models and technical aspects are tightly interconnected, and require experimentation and validation in pilot areas before a full rollout. Another interesting research topic is the "virtualization" of self-consumption community with a data driven approach enabling shared usage and ownerships between public and private entities. This kind of innovation requires a simultaneous piloting of technical, business and regulatory aspects that can be unlocked only thanks to Regulatory Innovation Zones.

Project partners also recommend adapting the regulatory framework to encourage investments in solutions that provide flexibility to the grid or to the energy system as a whole. The Clean Energy Package presented in November 2016 by the EU Commission will open space for new development regarding self-consumption communities and end-user solutions.

Stakeholder acceptance, big data and data security

An ongoing movement prioritizes the "local" and supports the local production and consummation of goods. This trend can be observed in the energy sector as well, where there is a push towards local energy systems and local optimization. An increasing number of individuals want to manage the electricity supply and consumption of their households. This trend is mainly driven by emotional and social aspects, supported in some aspects by economical reason, for example by local PV generation costs which reached and went below grid electricity costs in many European countries. The purely economic rational argument is not valid in all occasion however. For instance, individual are deciding to install home storage system where the return of investment (ROI) is clearly not reached with current market prices.

Participants of the ReFlex events reported that the benefits of smart grid solutions for users must be clearly explained and highlighted to ensure high customer acceptance. End-users usually want a complex control system with an easy interface. Transparency is a key element in winning the trust of customers. People tend to be less concerned about security and data protection when the benefit is clear and visible. It was observed that people perceptions vary a lot from one country to another: i.e. data protection and security is a much more sensitive topic in Germany than in Sweden.
To increase public acceptance of smart grid solutions, participations suggested two possible ways of action:

- Clear and detailed communication about the smart grid solutions and the services they can provide,
- People should get the opportunity to experience these solutions to make up their own mind.

There might be a move towards the creation of mixed ownerships structure in the future: people are increasingly going to invest in assets through crowdfunding while utilities and even DSOs are going to act as service provider. The simplification of contract and payment procedures is a prerequisite for this new ownership structure. Another important aspect is the creation of trusted platform, needed to run some assets and allow communication between market players. It is important to guarantee security and protection of personal data collected through smart meters and other measuring devices.
It was also reported that effort should be made to accompany local and regional authorities and small utilities that are in charge of the development and implementation of the regional strategy in order to compensate the lack of skills and knowledge in smart energy systems and services. Greater collaboration between research institutes and energy companies is also needed.

(Collaborative) Business model implementation

According to ReFlex' project partners and participants in the CoP workshops, the smart grid and smart energy markets are undergoing a transformation as a result of general trends such as digitalization and a rapid growth of renewables. An integrated energy system will consolidate in the coming years but there is still some way to go (between 10 and 30 years) before the institutional framework and the markets for flexibility provision are fully developed. In the future, collaborative business models based on cooperative solutions or mergers are expected to increase. A key success factor is to develop solutions with clear benefits for all involved actors and stakeholders, which are easy to understand, implement and operate.

Participants reported that many use cases have been implemented in the demo regions but only few were able to create value apart of the innovation project's context. Several reasons can be given for that: the regulatory framework is outpaced by technologies; there is a lack of innovative pricing schemes (dynamic tariffs) and there are cooperation difficulties between energy stakeholders due to the current market design (unbundling). Other barriers are the high system costs of smart grid solutions and the rather low revenues from these and the competition with current "conventional" services and solutions.

The goal of many smart grid projects is to save costs. Thus, these projects do not create much value for the stakeholders involved and therefore many companies are struggling to find viable business models. Nevertheless, there is a high value associated with the collection, treatment and processing of big data that still needs to be tapped.

Standardization and interoperability, Technology evolution and Modularity
The technologies are mostly mature and there are no major technological barriers. The lack of standard for the control interface/management of demand control solutions is one of the main technological obstacles to the uptake of demand response solutions.

Participants reported that every demo region and country has developed their own solutions and that European standards should be preferred over national ones to ensure interoperability of smart solutions. This would also lead to significant cost savings and foster replication and upscaling of smart grid projects across EU member states. A possible explanation of this observed behavior is that a lot of pilot projects are still led by researchers from universities. Researcher tends to give a bigger priority on research topics such innovative control algorithms and forecasting systems and lean to simple proprietary technologies for the implementation phase. Another possible explanation is that for specific use cases, i.e. demand side management, the current standards are still quite complex and heavy for very granular implementation. Moreover, the standards landscape for home automation is still very highly fragmented.

Blockchain and the related security and energy issues have been discussed intensively during the site visits and workshops. Blockchain is seen as a promising technology that can facilitate the participation of small players in the energy market. However, it still needs to be tested and validated under real conditions before being fully market ready. Its success relies on the strong commitment and support from hardware manufacturer as well as broad public acceptance.

WP4 - Replicability Guidelines at 3 Research Layers

Strategies and Instruments for Middle Range Policies

The aim of a transformative innovation strategy is to achieve fully integrated socio-technical solution, which are deployed in the whole energy systems, thus becoming components of a new energy regime. System transformation and full system deployment, however, are long-range strategy goals not yet at the horizon. More realistically to achieve, than to focus on long-range policies, are middle-range strategies (5-10 years) as a prior step. Middle-range policies thus can focus at speeding-up the adaptive replication of use-cases and the fast deployment of innovative solution in other regions and countries.

As can be seen from the figure below, use-cases for replication can be identified by searching for good-practice solutions in promising demo projects and reproducing the functionalities by adapting them to the geographical and socio-technical context of the location for replication. Middle-range policy instruments to support replication projects will therefore need to be designed considering a much higher degree of complexity than when supporting “conventional” demonstration and pilot projects.

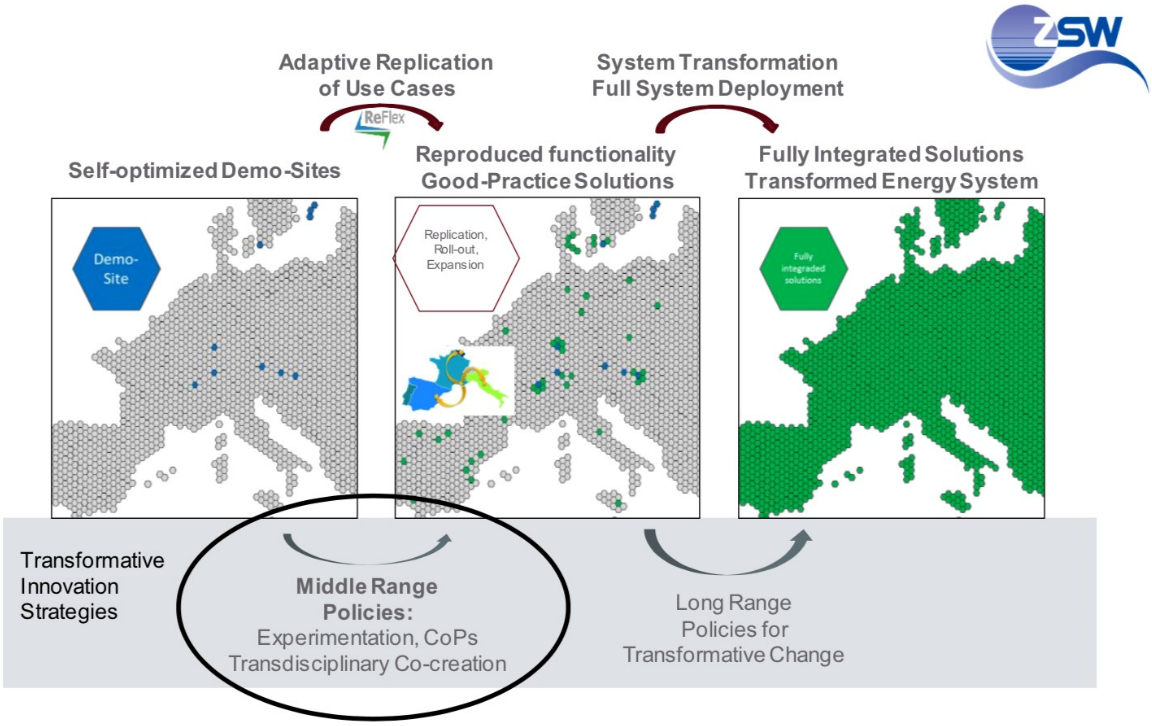


Figure 19 - Replication of use-cases in ReFlex and Middle Range Policies as part of Transformative Innovation Strategies

We conclude that middle-range policies are crucial for bridging the gap between demo projects and system transformation/change. Thus, the following final recommendations from the ReFlex project for policy makers aim at speeding-up and fostering the replication process and focus on experimentation, learning and co-creation.

Policy Recommendations for supporting the adaptive replication of flexibility use cases with Middle Range Policies

Recommendation #1:

Experimentation: *Legislators and Regulatory bodies can support innovation and replication with new policy instruments for experimenting with regulatory framework conditions*

As regulation is seen as one of the main barriers to smart grid solutions, experimenting with new regulatory environments would open new possibilities. As context conditions are critical for the replication of flexibility solutions, more and more policy makers recognize the need for new instruments to create room for experimenting. Latest developments include experimental innovation programs (e.g. for regulatory sandbox projects in UK and Singapore) or case-by-case derogations by regulatory bodies (e.g. in Norway and Spain). In some countries (like in Germany, Italy and The Netherlands) legal instruments are in place to provide regulatory space for exemptions under certain conditions (limited to specific projects and periods of time).

ReFlex project partners advocate for all kinds of regulatory experimenting as testbed for innovative flexibility solutions, which go beyond conventional pilot-projects following the logic of Technology Readiness Levels (TRL). When planning replication projects, those possibilities should be identified and considered as means for boosting innovation beyond the limits of current regulatory context conditions.

As various experimental measures have already been implemented in some countries, those instruments should be evaluated and further developed.

Recommendation #2:

Communities of Practice (CoP): *Supporting co-creation through COPs between practitioners from existing and prospective for use-cases*

Policy makers should support the formation of Communities of Practice among practitioners from existing and prospective use-cases in different locations and countries. This would facilitate co-creative replication of flexibility solutions between actors in projects facing similar challenges regarding technology, business models, and socio-technical context conditions.

Moreover, learning from the mistakes others already made is avoiding stranded R&D investments and thus is highly economic from a macro-economic viewpoint. As such CoPs will not likely emerge bottom-up, it is a clear matter of market-failure, which should legitimize the public support for such initiatives.

Recommendation #3:

Innovation-Ecosystem Platforms: *Supporting co-creation through creating and strengthening networks connecting actors and stakeholder*

As the energy system is in transition, so are the networks of actors and stakeholders constituting the innovation-ecosystem. An integrated energy system will consolidate in the long-term, but there is still some way to go (between 10 and 30 years) before the institutional framework and the markets for flexibility provision are fully developed.

Although many actors are involved in new innovative solutions in the energy field, a decisive role in adapting the context-conditions for replication will be played by those who can link between regionally, sectorial or disciplinary constituted networks. Moreover, the involvement of public, private and civic need-owners and stakeholders as well of experts from relevant research fields may foster co-creation.

However, the emergence of those innovation-ecosystems out of self-organization will take a long time. Thus, establishing or supporting the institutionalization of Innovation-Ecosystem Platforms, as networking space for actors and stakeholders will likely represent a policy measure to overcome systemic failure.

4 Conclusions

The results show that the project was able to fully realise this target. Establishing and sustaining a transnational CoP for in depth knowledge exchange between Smart Grid demo regions has been reconfirmed as an essential project asset. In accordance with the project plan, three CoP Workshops were conducted by the local ReFlex partners in cooperation with AIT (in Wüstenrot/DE, Malmö/SE and Lausanne/CH). Lessons from the field-testing experiments, including crosscutting issues (marketplace, stakeholders, and technology) were discussed and follow-up research questions agreed upon. In coordination with the CoP Workshop schedule, eight demo site visits took place – in Hartberg, Köstendorf and Güssing (AT), Gotland and Hyllie (SE), Biel-Benken and Rolle (CH), and Wüstenrot (DE). All CoP activities, outcomes and conclusions are documented in corresponding project deliverables.

A technology review across the demo sites followed a joint concept to gather stock of energy profiles, algorithms for electricity grid balancing and technological infrastructure. The ReFlex sites have been described among those technology parameters and compared with each other in order to feed into the discussion on replication and upscaling. Based on this empirical analysis, simulation tools for replicability were elaborated, advanced and tested for the German, Swiss and Austrian cases.

The ReFlex Guidebook represents the second main outcome of the project. The guidebook was developed based on the experience of the project partners and relevant stakeholders in the ReFlex demo sites on the one hand, and a conceptual framework integrating technical viewpoints and the socio-economic perspective on upscaling and replicability on the other. It provides theoretical background and links to the different (scientific) tasks and requirements of and has been formally approved by project partners and stakeholders from the demo sites as well as experts during the 3rd CoP Workshop. The guidebook comprises a number of use cases, e.g., load management on the part of the producer, low voltage stabilization in the local grid, shared use of low temperature resources and energy management for business parks. Moreover, the guidebook provides an assessment of replicability tools for specific target groups and gives recommendations for EU and national RTI policymakers and funding agencies.

5 Outlook

The project identified the following recommendations for the policy makers:

- Legislators and Regulatory bodies can support innovation and replication of smart grids with new policy instruments for experimenting with regulatory framework conditions
- Replicability of smart grids can be supported through COPs between practitioners from existing and prospective for use-cases
- Replicability of smart grids can be supported through creating and strengthening networks connecting actors and stakeholder

As we experienced first-hand during the project, the multi-disciplinary work required by smart grid projects can be challenging. There are significant perspective gaps between practitioners from social sciences, engineering and business. Moreover, the access to experts can be quite difficult, efforts are needed to convince business and legal experts from industry to participate to a broad knowledge exchange platform.
The results of this project resonate well with the goal of the national Swiss Competence Centers for Energy Research (SCCERs), which are looking for solutions to the technical, social and political challenges relating to the 2050 Energy Strategy, bringing together academia and industry, going a long way towards ensuring the transfer of knowledge and technology.

Therefore, as a possible next step, the smart grid replicability topic initiated within the ReFlex project could be further developed at national level as a joint work involving all SCCERs.

6 Publications

The ReFlex team published relevant research output, contributed content or promoted the project at various events and conferences as listed below.

- **IEA-ISGAN Workshop "Flexibility in future energy systems",** 11 October 2016, Paris, FR. Workshop in collaboration of the European projects ELECTRA, GRID+STORAGE and ERA-NET SG+. Moderation of the Session "What level of flexibility is needed?" Also, the Technology Experience group from AIT added their view on dimensions and applicable methodologies for measuring and realizing social acceptance and user experience in this concept.
- **Smart Energy Systems Week (SESWA)**, 16-19 May 2017, Graz, AT.
- **IEA Vernetzungstreffen**, 12 October 2017, Salzburg, AT. Keynote presentation entitled, „Die Rolle von Smart Grids in der Transition zu nachhaltigen Energiesystemen".
- **International Sustainability Transitions Conference (IST 2017)**, 18-21 June 2017, Gothenburg, SE. The session "From local experiments to large scale energy transitions" was held in collaboration with MATCH, another ERA-NET SG+ project. MATCH partners were invited to join ReFlex CoPs and site visits.
- **International Sustainability Transitions Conference (IST 2018),** 11-14 June 2018, Manchester, UK. A dialogue session on "Regulatory Innovation Zones as New Transformative Innovation Policy Instruments" was organized (https://app.oxfordabstracts.com/stages/329/programme-builder/submission/27618?backHref=/events/311/programme-builder/view/sort/author&view=published) and a paper on "'Replicating' smart grid

experiments: a socio-technical analysis” presented (https://app.oxfordabstracts.com/stages/329/programme-builder/submission/26168?backHref=/events/311/programme-builder/view/sort/author&view=published).

- **Smart Energy Systems Week Austria (SESWA 2018)**, 15-18 May 2018, Graz, AT. A Poster on “Replication of Smart Grid Solutions: Don’t Copy – Co-create!” was presented (http://www.seswa.at/poster.html).
- **Smart Grids Kongress 2018 – Smart Data for Smart Grids,** 3 December 2018, Fellbach, DE. Presentation on „Wie replizieren? - ´Reflex´ - ein EU ERA-Net Smart Energy Systems Projekt“ (https://www.smartgrids-bw.net/fileadmin/images/demo/mobifyjs/SMART_GRIDS-KONGRESS.pdf).

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8 Appendices

- ReFlex Guidebook