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The Electricity System Improvement Canvas (ESIC):

A New Tool for Business Model Innovation in the Energy Sector

Jordi Vinaixa, ESADE Business School, Spain*
Winnie Vanrespaille, ESADE Business School, Spain
Hasan Muslemani, ESADE Business School, Spain

ABSTRACT

This paper addresses the complexity of commercially exploiting technical solutions in ecosystems with many stakeholders or in ecosystems that are highly influenced by regulatory issues. It does so by introducing a new tool, called the electricity system improvement canvas (ESIC). The ESIC allows for an efficient design, visualization, analysis, and/or validation of innovative system solutions and their implementation. Moreover, the ESIC helps to focus on the benefits that the solution provides for the system as a whole and for certain stakeholders. It is normally used together with the value creation ecosystem (VCE), a tool previously developed by the authors, providing more concretion and detail to it. To better portray its functionality, the ESIC and the VCE will be applied to one of the demo projects explored within EU-SysFlex, a project that has to do with congestion problems in the German electricity grid.

KEYWORDS

Business Model Design, Business Model Innovation, Ecosystem, Electricity Sector, Energy Business Innovation, EU-SysFlex, System Improvement Canvas, Value Creation Ecosystem

INTRODUCTION

While developing innovative business models and exploitation plans for demo solutions of the Horizon2020 EU-SysFlex project[1], the authors of this paper encountered different issues. Most of these issues originated from the complexity of the ecosystems around those solutions, which made it difficult to exploit them beyond their demo stages. Problems can occur in the exploitation of diverse types of technical solutions in complex ecosystems, due to the need to consider many stakeholders and/or important local regulations. Moreover, these types of solutions are often influenced by public entities and can depend on future regulations. Therefore, it is very important to not only consider all the actors and beneficiaries involved, but also the regulators and other stakeholders whose buy-in might be needed. Moreover, the authors (Vinaixa et al., 2022) previously developed the Value Creation

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*Corresponding Author

Ecosystem (VCE), a visual and practical tool to deal with some of these problems. However, a further level of concretion and detail was still needed. Hence, a new tool was developed to cope with these issues and to better exploit and/or replicate technical solutions. In other words, there was a need for a new tool to perform business model innovations in complex and/or highly regulated ecosystems.

Osterwalder and Pigneur (2010) define business models as the 'fundamental structures for how companies create, deliver and capture value'. More simply put, a business model defines the solution that a business aims to take to the market and how it can do so in a *profitable* manner. However, the definition of the term 'business model' and what fundamentally constitutes business model innovation remains ambiguous (Amit & Zott, 2012; Bocken et al., 2014), as the concept is considered at different levels by different researchers in the literature (Stewart & Zhao, 2000; Morris et al., 2005; Zott & Amit, 2008).

Different tools for designing innovative business models have been developed recently and applied broadly by researchers, entrepreneurs, and business managers (Keane et al., 2018). Specifically, Osterwalder and Pigneur's Business Model Canvas (BMC), introduced in 2010, defined business models in a structured manner whereby a model consisted of nine key elements, or 'building blocks'. The BMC gained popularity for its simplicity in visualizing the individual characteristics and offerings of a particular business, effectively representing a business strategy in a box (Aure, 2014).

Building on this BMC, a number of new business modelling tools – or 'canvases' – took shape. The reasoning behind their divergence from the initially-prescribed BMC is that Osterwalder and Pigneur's BMC focused specifically on businesses which are financially driven, and would not always be able to capture value that goes beyond generating financial revenue (Burkett, 2013; Coes, 2014; Yang & Wu, 2016). Examples of this include designing business models for social enterprises and regulated entities (Qastharin, 2016; Carter & Carter, 2020; Timeus et al., 2020). The BMC is not the most appropriate tool for these types of entities since they normally do not necessitate generating profits to reward shareholders, nor are they concerned with how to commercialize this value. Moreover, while the emphasis of any business model definition has traditionally been centred around value capturing, the introduction of value creation into the most recent definitions made the concept shift somewhat from value capturing towards value creation (Simberová & Kita, 2020; Climent & Haftor, 2021). This opened the door to use the concept with non-for-profit entities and other situations where value is created but not necessarily captured (commercialized). This is especially the case for businesses in highly regulated sectors, such as energy, infrastructure, or healthcare, which tend to require complicated business models, with different regulatory frameworks in different countries or local areas.

To address the complexity of designing, visualizing, and analyzing the values added by new sustainability-oriented businesses, particularly those whose value can be multi-faceted, this paper introduces a new conceptual instrument, the 'Electricity System Improvement Canvas' (ESIC).

BACKGROUND

Due to the limitations of Osterwalder and Pigneur's (2010) BMC in capturing value for different types of businesses (Coes, 2014), various versions of 'socially-oriented' business modelling tools emerged in the literature. These include the Social Entrepreneurship Canvas (Aure, 2014), the Triple Layered Business Model Canvas (Joyce & Paquin, 2016), the Mission Model Canvas (Osterwalder & Blank, 2016), the Social Enterprise Model Canvas (Sparviero, 2019), the Creative Business Model Canvas (Carter & Carter, 2020), and the City Model Canvas (Timeus et al., 2020). The canvas developed in this paper has its roots in the Mission Model Canvas, the Triple Layered Business Model Canvas, and the City Model Canvas.

The Mission Model Canvas (MMC) differs from the BMC in that it contains the blocks 'Beneficiaries', 'Deployment', 'Buy-In & Support', and 'Mission Achievement' instead of 'Customer Segments', 'Channels', 'Customer Relationships', and 'Revenue Streams'. The Triple Layered Business Model Canvas (TLBMC) specifically addresses the lack of a sustainability dimension in the MMC. The

TLBMC contains three different canvas layers: The economic BMC (i.e., equivalent to Osterwalder and Pigneur's BMC), the environmental lifecycle BMC, and the social stakeholder BMC. Although the TLBMC significantly serves to analyze or visualize business models of firms or organizations that need to be profitable while also creating environmental or social value, it is not the most appropriate tool to analyze system improvements in regulatory or social sectors that are not as concerned with capturing value. Moreover, using three different canvases does not simplify the visualization of the value created, and neither does it make it easier to obtain a holistic view of system improvements.

A last canvas that inspired us while developing the ESIC was the City Model Canvas (CMC) as developed by Timeus et al. (2020). This canvas departs from a combination of the MMC and the TLBMC by adding two sustainability layers (environmental costs/benefits and social costs/benefits) from the TLBMC to the MMC. Moreover, Timeus et al. changed the 'Key Resources' block to 'Key Infrastructure and Resources & Key Regulatory Framework'. The CMC is very well suited for designing, analyzing, and deploying smart projects for smart cities. As such, the CMC was the most adequate existing framework to treat system improvements in regulated sectors.

Regarding research on stakeholder value creation, Freudenreich et al. (2020) developed a stakeholder value creation framework that links the business model perspective with the stakeholder theory, while Attanasio et al. (2021) developed a stakeholder value flow model. Although both models consider stakeholder relationships as a key element of business models, the models fall short when discussing other aspects of the 'businesses', or 'solutions'. Furthermore, as a conclusion of the research of Fobbe and Hilletofth (2021), in stakeholder literature there remains a lack of attention to the role of stakeholder interactions in developing collaborative business models. Lastly, Dembek et al. (2018) state that there is an untapped potential to create value for multiple stakeholders beyond just products and services by combining multiple value creation logics in one business model.

Thus, the authors considered that a new model or canvas, which would not only show different forms of stakeholder value creation, but also the most important (sustainable) aspects of a system solution or improvement, could be very useful.

DEVELOPMENT OF THE ESIC

The authors' job on the Horizon2020 EU-SysFlex project was to design innovative business models for solutions to electricity grid problems. However, the authors noticed early in the process that the BMC was not an appropriate tool for developing business models for the project . This was mainly because electricity grids are publicly regulated, and while dealing with governmental regulation there is usually no need to 'capture' new customers through channels and customer relationships, although there is value created for clients. Therefore, the authors began verifying alternative canvases (MMC, TLBMC, and CMC); but important elements of the electricity system solutions were missing, especially when it came to developing good and viable innovative solutions for all system stakeholders.

One of the main flaws that the authors encountered when using the MMC, the TLBMC, or the CMC for solutions in the energy sector, was that each of them focus on the entity addressing the problem that underlies the improvement. While this is a good approach that is useful to understand and analyze the role of that entity in developing a solution, it falls short of fully understanding all the requirements (buy-ins, regulatory framework, infrastructure, etc.) and the possibility of successfully deploying a solution. The authors consider that in complex and highly regulated systems, a more holistic approach is needed. In these cases, it is critical to explicitly state from the outset what problem the improvement(s), or mission, aim(s) to solve, and to identify the key stakeholders required, together with the role they will play and the benefits they will receive from their contribution to the improvement.

Hence, the authors started developing a new canvas with the main aim of designing a better tool for understanding, presenting, analyzing, and validating innovative solutions for the electricity system. This new canvas started from the main problem that the system improvement was tackling, and the solution (mission statement). Further, for the energy sector, the authors considered that the regulatory framework should be included in the 'Buy-In' block, since the proposed solution should consider the existing regulations, and, in some instances, a regulatory change might be needed. Further, when analyzing system improvements, the authors considered it of critical importance to include the different enhancements that are created to obtain a sustainable system, since they are not only profit-driven but also bring about important environmental and social impacts.

Within the EU-SysFlex project many technical solutions, Exploitable Results (ERs), were developed, and the authorship team selected five of them for the job. The selection was based on a handful of variables, such as the market potential, and the countries and project partners involved (EU-SysFlex, 2022a). The five selected ERs were:

1. Development of Virtual Power Plant packages to reduce electricity system imbalances of the Portuguese Transmission System Operator. Main project partners: Siemens and EDP.
2. A Traffic Light Qualification system for Distribution System Operators to validate Distribution Network Replacement Reserve bids before activation, avoiding congestions in the Distribution Network. Main project partners: InescTec and EDP.
3. Cost-efficient aggregation of flexibilities from battery energy storage systems and electric vehicle charging stations in Finland to solve the higher expected need of ancillary services. Project partner: Helen.
4. The Data Bridge Alliance's development and operation of a cross-border Data Exchange Platform to make energy data hubs interoperable to reduce the fragmentation of European energy markets. Project partner: Elering.
5. A solution to the German grid congestions, by using a coordinated redispatch mechanism for system operators. Project partner: MITNETZ-STROM.

The very first thing the authors did for each ER was to have a meeting with the project partner(s) to fully understand the problem addressed and the proposed solution. Based on the gathered information, they developed a first draft of the VCE, another tool developed by the authors of this paper (Vinaixa et al., 2022), to represent the key stakeholders involved in the solution, together with their main value exchanges. After having developed a first draft, the authors organized iterative meetings with the partners until they agreed on a final VCE for the proposed ER.

Based on the validated VCE, the authors got to better know the role of the key stakeholders participating in the generation of the solution. Taking the BMC as a starting point, the authors tried to allocate all the key elements of the solution (ER) within the nine blocks of the BMC, and realized that they were not getting a good enough 'picture' to figure out how to successfully bring the solution to the market. Then, the authors started to introduce changes into the original BMC and finally developed a first draft of a template for what they called the 'Electricity System Improvement Canvas' (ESIC). Together with the ER's project partner(s), the authors then designed a first version of the canvas for each of the ERs, and held more iterative meetings for improving both the ESIC template and the ESIC for each ER, until all parties agreed on a final version.

Lastly, the authors validated the VCE and ESIC tools developed for the five results (ERs) by presenting them to all the other EU-SysFlex consortium partners, either in plenary sessions or in workshop meetings.

Based on all the feedback, the authors made some adaptations to the ESIC, such as the addition of a 'Leader' block, to include the leading stakeholder for the solution. This latter point was important for the consortium partners since it shows who is the most appropriate partner for bringing the proposed improvement to fruition.

Most of the partners confirmed the usefulness of the tool in comparing and developing business models for the selected solutions. Especially when looking at how to implement and even scale up these solutions, they saw usefulness in applying the ESIC.

THE ESIC CONCEPT

The ESIC is a one-page canvas that can be used for any project or mission that aims to improve a system, and the authors define it as follows: The ESIC illustrates how a proposed improvement, addressing an important problem in a particular system (e.g., energy, health, education, etc.), can be deployed or exploited, taking into account the regulatory framework, while creating sustainable (economic, environmental, and social) value for different beneficiaries and highlighting the critical resources, infrastructure, partners, and activities required for its successful implementation. As such, there can be many purposes for using an ESIC, including:

- To obtain a holistic view of the system improvement so as to design, analyze, discuss, or present it.
- To validate proposed system improvements, similar to how the BMC is used as a tool to identify and validate business model hypotheses. Identifying and validating what is critical for the successful implementation of an improvement will help it to materialize.
- To analyze innovations in systems: Introducing changes in one of the elements of a block can open doors to better or new improvements. As such, the ESIC can be used to introduce changes to systems and analyze the impact and/or the viability of the new solutions.
- To discuss and approve changes in the system with the stakeholders involved.
- To explore, analyze, and create innovative solutions in complex systems and also in sectors that involve public entities or that are highly dependent on regulation.
- To examine the specific benefits that each stakeholder could gain if certain system improvements were deployed, as well as the requirements from each of them for the successful implementation of the improvements.
- To analyze and compare the economic, environmental, and social sustainability of different improvements, by evaluating the three pillars of sustainability (economic, environmental, and social).

The ESIC is a static tool and might need to be adapted to different deployment stages: 'Demo Stage', 'Full Exploitation', etc. An ESIC template is presented in Figure 1. This template can be used directly by third parties to create the ESIC for a system improvement, as explained in the following section.

After developing the tool, the next step for any entity using it for the deployment of a solution would be to identify the most important elements in the blocks that are crucial for the viability of the improvement and should be validated. Similar to the business model validation when working with the BMC for developing a new business, this validation step would be performed by defining hypotheses and validating them with potential stakeholders (beneficiaries, partners, etc.).

HOW TO DESIGN AN ESIC

The guidelines for third parties to construct the ESIC are given here so that they can develop exploitation models for complex system improvements or missions. Moreover, this explanation method also serves as a guideline to present ESICs, since the order of the described steps is also the order in which an ESIC is recommended to be presented.

Add Problem, Mission, Beneficiaries, and Their Specific Benefits

The first step to develop an ESIC is to define the main problem, or 'pain', that the system improvement is tackling. Once this is defined, the mission, or the main goal, of the improvement should be described and added to the upper blocks of the ESIC, as shown in Figure 1. Moreover, if the leader, or the responsible entity for the implementation and exploitation of the system improvement is already defined, it is added following the mission block. However, if this is not the case, this block can be left

Figure 1. Electricity system improvement canvas template

<table>
<tr><td colspan="5">Problem: The primary problem of the system that should be addressed by the project.</td></tr>
<tr><td colspan="5">Mission Statement: The ultimate goal to be achieved with the system improvement, thus resolving the problem.</td></tr>
<tr><td colspan="5">Leader: The person, organization, or entity that is responsible for the deployment of the project.</td></tr>
<tr>
<td rowspan="2">Key Partners
The most important partners that are needed to deploy the system improvement.</td>
<td>Key Activities
The most important activities that must be performed to deploy the system improvement.</td>
<td rowspan="2">Specific System Benefits
The specific gains that the system improvement creates for each of the beneficiaries and/or the ones that the beneficiaries might need to participate and to attain the final mission.</td>
<td>Buy-In & Regulatory Framework
To deploy the system improvement, whose buy-in is needed (legal, policy, etc.) and/or regulations:
• To be considered
• Must be adapted
• Will help to deploy</td>
<td rowspan="2">Beneficiaries
The actors or entities of the system that will benefit directly from the improvement.</td>
</tr>
<tr>
<td>Key Resources & Infrastructure
The most important resources and/or infrastructure required to deploy the improvement:
• Existing
• To be created</td>
<td>Mission Deployment
The steps to follow to deploy and/or exploit (replicate and scale up) the system improvement.</td>
</tr>
<tr><td colspan="3">Mission Costs
The costs of the creation, delivery, and exploitation (replication and scaling up if required) of the proposed system improvement.</td><td colspan="2">Economic Benefits
The profits and/or savings on certain operational costs of some of the beneficiaries that can be generated by the system improvement.</td></tr>
<tr><td colspan="3">Environmental Risks
The negative environmental impacts that the system improvement can cause.</td><td colspan="2">Environmental Benefits
The environmental benefits that the system improvement can deliver.</td></tr>
<tr><td colspan="3">Social Risks
The social risks that the system improvement can cause.</td><td colspan="2">Social Benefits
The social benefits that the system improvement can deliver.</td></tr>
</table>

blank until defined. The authors highlight the importance of finding this leader as soon as possible so as to expedite their participation in the entire ecosystem designing process.

Next, all the relevant stakeholders of a system are identified, and the main value exchanges between them are mapped. To do this, the VCE, developed by the authors of this paper (Vinaixa et al., 2022), is used.

Next, the main beneficiaries (actors or entities) of the mission should be numbered and added to the righthand column of the ESIC. Then, the description of the specific system benefits that each of them will receive once the improvement has been realized is included in the specific system benefits block. Each stakeholder (or beneficiary) should gain something to secure their participation in the system improvement. These specific system benefits should be numbered accordingly and added to the middle block of the ESIC. Normally, the most directly involved beneficiaries are added first and the ones that are not immediately involved, or that do not have a central role in enabling the improvement, are added next. It is important to state here that not all the stakeholders that appear in the VCE of a certain system improvement will be included in this column, since some of them will only benefit indirectly from the innovation, as key partners (key suppliers, etc.), or will be stakeholders whose buy-in is needed.

Define Buy-In and Regulatory Framework

The next step is to define the buy-in and regulatory framework. This block consists of two parts: 1) The buy-in needed to deploy the mission (from the regulator, a legal entity, and/or another stakeholder) and 2) the regulatory framework needed to be able to exploit the improvement, which can include three types of regulations: Some to be considered by the mission, some that will need to be adapted, or others that will help the deployment. It is important to be concise in this block, especially for the regulatory framework, and to include the most important regulations only.

Define Key Activities, Key Resources and Infrastructure, and Key Partners

Next, the key activities that must be undertaken to deploy the system improvement should be described. Often these activities are specific elements required by different beneficiaries of the system, in which case it should be clearly indicated who needs to perform what activities by using corresponding numbers as used for those particular beneficiaries.

Once the activities are described, the key resources and infrastructure should be defined. This block contains the most important resources and/or infrastructural items that the system improvement needs, whether already existing or in need of being created. Also, these items are often specific to different beneficiaries of the system and should in that case be numbered accordingly. Then, the key partners or main stakeholders needed to deploy the mission are added. Usually, these partners would have already been identified and included in the VCE.

Define Mission Deployment

Next, it is suitable to define the mission deployment, including all the main necessary steps for the deployment and/or exploitation of the system improvement. This block usually contains a sequence of steps to follow to be able to completely deploy the improvement (often starting from a demo phase) up to the final scaling up (and even replication, if possible) of the solution.

Add Sustainability Layers

Lastly, the bottom layers of the ESIC should be defined and added, containing the three sustainability layers: Economic, environmental, and social. On the left side, the costs, negative sustainability impacts, or risks are added, while the right side shows the positive impacts, either real or expected. The authors recommend defining and describing them in the following order:

- **Mission Costs:** The costs of the complete deployment (creation, delivery, and exploitation) of the system improvement. In some cases, these costs should be allocated to some of the beneficiaries, which must then be indicated by corresponding numbers. This is the downside of the economic pillar of sustainability.
- **Economic Benefits:** Including both the profits and the cost savings. These are often specified for each beneficiary.
- **Environmental Risks:** The potential negative environmental impacts of the system improvement.
- **Environmental Benefits:** The main environmental benefits of the mission for the whole system.
- **Social Risks:** The potential negative social impacts.
- **Social Benefits:** The social benefits of the improvement for the whole system.

As an ultimate guideline when constructing an ESIC, the authors advise brevity. It is critical that the canvas remains a one-page summary that easily portrays the innovation and improvement offered by the solution. Therefore, it is essential to only include the key elements and to describe them in bullet points. Nevertheless, as the canvas is either used as supporting material in a public presentation or in a document, everything included on any of the blocks can be further explained.

ESIC IN PRACTICE: A CASE STUDY

To illustrate the applicability of the ESIC, an example of this canvas from a case study that the authors worked on as part of the EU-SysFlex project is presented, here referred to as the 'German demo' (see 5th ER above).

The German Demo: An Overview

A paradigm shift driven by the implementation of a carbon trading scheme and increasing penetration of renewables into the German electricity grid forced the electricity system to undergo significant changes. The combination of these two factors pushed conventional power plants out of the energy mix (Oei et al., 2020), to the extent that some of these plants had already been shut down and others were expected to follow suit in the following years. These conventional generators retained redispatch[2] potential to adjust their production in advance and help the Transmission System Operator (TSO) prevent congestion in the Transmission Network (TN).

The variable renewable energy sources (vRES) with which those conventional plants were replaced, however, could not participate in redispatch. It followed that the TSO had lesser capacity for preventing congestion. Additionally, because of structural grid challenges, the Distribution System Operator (DSO) would also face more instances of congestion and voltage-related issues. However, at least at the time of writing of this paper, a DSO did not have the ability to perform redispatch in Germany. Hence, both TSOs and DSOs were sometimes forced to adopt last-minute measures, namely emergency curtailment (i.e., temporary shutdown) of vRES, for which the generators had to be compensated. These curtailment compensation costs were entirely transferred to final grid users accordingly, and thus constituted an important part of their energy bills.

To address the lack of redispatch potential when grid congestions occurred, in October 2021 the German regulatory authorities adapted its NABEG[3] law, originally introduced in 2011, to allow vRES[4] to participate in redispatch activities. To implement this, new TSO-DSO coordination mechanisms became necessary, so that both system operators could continuously exchange data. Moreover, DSOs required tools to estimate and anticipate the grid state for optimal grid operation. Within the EU-SysFlex project, the German demo tested and demonstrated new redispatch and curtailment scenarios that were meant to significantly reduce curtailment costs. Fraunhofer IEE was the Research Centre that developed the beeDIP toolbox, the corresponding software tools for the DSO.

The German Demo: ESIC Applicability

The above-described project is used to provide an example of the use of the ESIC. To do this, the authors first define the main problem:

Increasing shares of RES cause congestion for system operators and a shortage of redispatch potential for TSOs due to the shutdown of conventional power plants, exacerbated by manual, inefficient communication between TSOs and DSOs.

Then, the mission, or solution, as proposed by MITNETZ-STROM, leader of this EU-SysFlex project demo is defined:

Developing TSO-DSO automated coordination methods to solve problems related to congestion management, by using active power flexibilities from the Distribution Network.

Next, the VCE, as shown in Figure 2, is developed so as to define the key actors and value exchanges needed for this solution (or mission) to work.

Lastly, the ESIC (see Figure 3) is developed, by following the steps explained in the section "How to Design an ESIC" above.

Since the EU-SysFlex demos worked with Key Performance Indicators (KPIs) to validate and follow up on the proposed improvements, the authors added these KPIs next to the corresponding items (see Appendix B).

The authors elaborate on the different ESIC blocks as discussed with MITNETZ-STROM:

- **Problem:** The main problem at the base of the TSO-DSO congestion coordination is the increasing share of variable RES in the German electricity grid, which causes higher requirements for congestion management and, in turn, shortage of TSO redispatch potential. Congestion in the Transmission Network is mostly caused by an uneven geographic distribution of RES (e.g., wind farms) and their corresponding loads. This congestion problem is worsened by inefficient and manual communication (through telephone calls) between the TSO (50Hertz) and the DSO (MITNETZ-STROM).
- **Mission Statement:** Developing fast and effective TSO-DSO coordination methods to solve problems related to congestion management, when using active power flexibilities from the Distribution Network (DN).
- **Specific System Benefits:** As defined for the five different categories of Beneficiaries:
    - The TSO (50Hertz in the case of the demo) would obtain increased redispatch potential by including the DSOs (and their connected RES) in the redispatch process and as such reducing last-minute curtailment to solve congestion problems. Therefore, a change in German regulation would be necessary (see Buy-In & Regulatory Framework). Moreover, by automating the coordination process, the TSO would waste less time due to inefficient communication with the DSO.
    - The DSO (MITNETZ-STROM) would have less congested lines by being included in the schedule-based (day-ahead and intra-day) redispatch process, thus minimizing the necessity to perform last-minute curtailment. Moreover, a DSO would also waste less time by using the new, automated coordination tool (see Resources & Infrastructure block).
    - RES would benefit from the system improvement since they would be included in the redispatch process so that their corresponding managers would know upfront (i.e., scheduled)

Figure 2. Value creation ecosystem of the TSO-DSO coordinated redispatch solution as developed together with the German demo partners

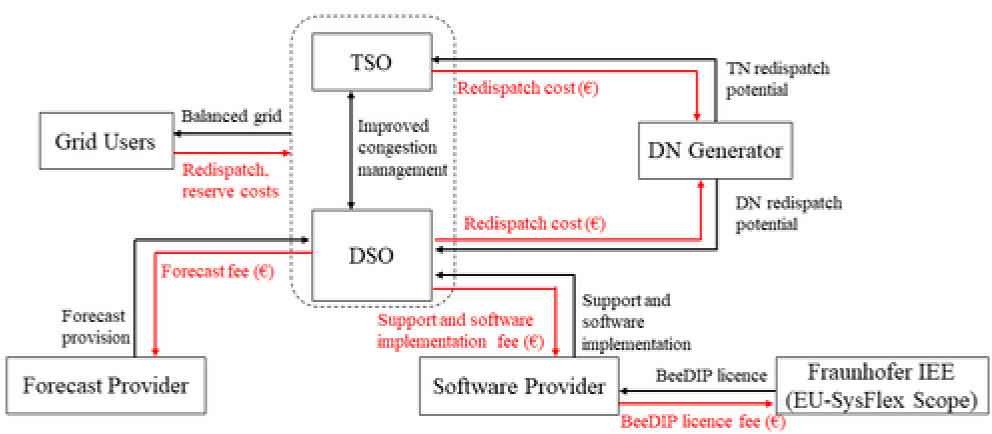

Figure 3. The electricity system improvement canvas of the German EU-SysFlex Demo

Problem: Increasing shares of RES, causing congestion for system operators and shortage of redispatch potential for TSOs due to shutdown of conventional power plants, exacerbated by manual, inefficient communication between TSOs and DSOs.

Mission Statement: Developing TSO-DSO automated coordination methods to solve problems related to congestion management, by using active power flexibilities from the Distribution Network.

Leader: MITNETZ-STROM

Key Partners
- European Commission (demo)
- Research center (Fraunhofer IEE)
- Other DSOs and TSOs
- Consumption and generation forecast provider

Key Activities
1) Call for active power flexibility to DSO
2) DN-redispatch and support TN-redispatch: Grid state estimation, P-flow forecast (KPI10-11), send info to TSO (KPI2, 3, 7) and to distributed energy resources (KPI4)
Improved forecast (generation & load)
3) Build up a schedule (incl. outages)
4) Communicate contracted reserves

Key Resources & Infrastructure
- Communication infrastructure
- beeDIP toolbox (to integrate in DSO Grid Control Center):
  - Grid topology analysis and state estimation to forecast network states
  - Active power optimization and coordination
  - Network congestion management

Specific System Benefits
1) Increase redispatch potential by including DSOs (and RES) in new automated processes
2) Avoid congestion by including DSO in schedule-based redispatch process
3) Optimize their portfolio/schedule
4) Reduce penalties (for BRP) by including RES in redispatch
5) Potentially lower grid tariffs (through more efficient redispatch)

Buy-In & Regulatory Framework

Buy-In:
- National regulatory authorities

Regulation (German):
- NABEG-law change (2021) includes RES in redispatch
- New efficiency factor (2026)

Mission Deployment

Demo (EU-Sysflex)
↓
Application in DSO-area
↓
Application in whole country
↓
Potential replication in other countries

Beneficiaries
1) TSO
2) DSO (MITNETZ-STROM)
3) RES
4) Energy traders / Aggregator
5) Grid Users

Mission Costs
- Demo costs (paid by EC)
- Forecasts (paid by DSO)
- Costs of communication infrastructure (paid by RES/aggregators)
- Costs of applying the new mechanisms (paid by TSO/DSO)

Economic Benefits
1) Savings on congestion management, extra reserves, and operation (KPI1)
2) Savings on congestion management and operation (KPI1)
3) Savings depending on redispatch compensation and extra energy sold (optimized schedule)
4) Reduced penalties for aggregators (BRP)
5) Potentially lower electricity bills due to lower grid tariffs

Environmental Risks
- None

Environmental Benefits
- Lower CO_2 emissions (less curtailed RES and grid losses (KPI9))

Social Risks
- Conventional generators (at TN level) will lose money/jobs

Social Benefits
- Job creation of flexibility participants (DER, etc.)
- Better grid efficiency (KPI8) and more stable electricity supply

if they had to reduce their generation and could accordingly optimize their schedule. In 2021, only RES >10MW could participate in redispatch, but it was expected that by 2022 all RES >100kW would be able to do so.

- ◦ Energy traders or flexibility aggregators that were Balance Responsible Parties (BRP), and thus had to pay for any imbalances (amongst others caused by curtailment), would enjoy reduced penalties due to less curtailment.
- ◦ Grid users could potentially benefit from lower electricity bills because the TSO-DSO congestion coordination method would lead to savings on operating costs of system operators and thus to lower grid tariffs, which could be transferred to the grid users.

- **Buy-In and Regulatory Framework:** The change in regulation added to this block is in this case only applicable in Germany, which means that if similar regulations existed in other European countries, the solution could be potentially replicated or scaled up across borders. In this case, the change in the German NABEG law to include RES (of >10MW in the beginning, and later of >100kW) in the redispatch process (enforced beginning in October 2021) was necessary for the solution to work. Although this law already included large RES, it remained important for smaller RES. Moreover, it was expected that by 2023, this law would also test the introduction of a new 'efficiency factor' that would limit the curtailment costs that DSOs could forward to grid users. DSOs would thus need to prove that they had no alternatives for curtailment and that it was an absolute emergency measure. In Germany, the National Regulatory Authority (NRA) put an upper limit on the profits that the DSOs could share with their stockholders, and this limit was calculated every five years with many (between eight and twenty) efficiency factors (European Commission, 2016). In 2026, the new calculation, using this new efficiency factor, was expected to be enforced. Based on these upper limits, DSOs then calculated what the grid tariffs would be for each year.

- **Key Activities:** For the German demo, all key activities had to be performed by some of the beneficiaries and include:
    - The TSO had to include Distributed Energy Resources (DERs) in the German and EU redispatch process. Next, they needed to hold call(s) for active power flexibility with the DSO.
    - The DSO had to perform the DN redispatch process and provide support to the TN redispatch by undertaking grid state estimation, active power (P) flow forecasts (day-ahead and intra-day, as measured by the demo's KPIs 10 and 11), and send forecast data to the TSO (demo KPIs 2, 3, and 7) and to the DER (KPI 4). Moreover, the DSOs would need an improved forecasting of generation and loads (whether outsourced or not), and a disaggregated forecast for each connection point.
    - RES would have to build up a generation schedule that included their outages. This was very important for the solution to work, because if RES did not undertake this appropriately (as was the case then), the entire schedule-based redispatch method would not work, especially for RES that did their own activation/control of generation, and that were thus not being activated/controlled by the DSO (smaller RES often did not have the competence for control/activation and thus left this responsibility to the DSO).
    - With the NABEG law change, aggregators and energy traders had to communicate the contracted reserves to the DSO so that they knew which of their DER (95% RES) would be activated.
- **Key Resources and Infrastructure:** For the solution to work, a communication infrastructure between the DSO and the RES was required so that the DSO could activate or communicate the final redispatch schedules to the RES. Moreover, the beeDIP toolbox, which included three important software parts all developed by Fraunhofer IEE (see Key Partners), had to be included in the DSO's grid control centre.
- **Key Partners:** Some of these were only applicable during the demo phase (such as the European Commission and Fraunhofer IEE). The other TSOs and DSOs could lobby to help to further deploy and replicate the solution, while the forecast provider (as a key supplier) enabled the solution.
- **Mission Deployment:** This starts at the EU-SysFlex demo stage, followed by regulatory changes that would allow the system improvement to be applied in the DSO's region (MITNETZ-STROM here), before the improvement was scaled up to the entire country. In the German case, this scaling up would occur following the regulatory change. The last step is added in grey (Figure 3) since at the time of writing this paper, it still had to be appraised whether this exploitable result could be replicated in other EU countries, depending on the similarity of the coordination/congestion problems, and the regulatory framework.
- **Mission Costs:** These are divided into four categories of important costs: The (EU-SysFlex) demo costs were paid by the European Commission (see Key Partners), the new generation and load forecasts needed for the solution (should be paid by the DSOs), the communication infrastructure (paid by either the aggregator or the RES), and other costs of applying the demo in the DSO/TSO regions.
- **Economic Benefits:** These are also allocated to each type of beneficiary:
    - For TSOs, certain savings on congestion management would be created by the new system due to less curtailment and redispatch costs attributed to better forecasts and optimization

of the electricity system. Moreover, there would be other operational savings due to the automation of the communication system (instead of relying on manual telephone calls) with the DSO. Lastly, TSOs would also save on reserves contracting since there would be fewer reserves needed due to last-minute curtailment.

  - For DSOs: The same savings apply, except for the reserves contracting, since it is only a duty of TSOs.
  - For RES, the economic benefits depend on the compensations (redispatch compared to curtailment) which were still to be defined. However, the Balance Responsible Parties would very likely benefit from lower penalties.
  - For aggregators, the same applies as for the RES.
  - Lastly, the grid users should benefit from lower grid tariffs since the congestion management costs were expected to decrease, depending on whether TSOs and DSOs choose to pass down cost savings to end users. Even if grid tariffs did not ultimately decrease, with the proposed solution they would at least not be expected to increase considerably.
- **Environmental Benefits:** Lower CO_2 emissions are expected due to less curtailment, which in turn leads to less balancing energy needed for the activation of conventional plants and hence lesser grid losses (as measured by KPI 9).
- **Social Risks:** It is expected that conventional generators at the TN would suffer losses since the solution improved the inclusion, and hence the competitiveness, of RES. However, this new method was merely enhancing this process in Germany, since it had already been decided that by 2038 all coal power plants would shut down.
- **Social Benefits:** These may include job creation by flexibility participants (RES, aggregators, forecast suppliers, etc.). Moreover, decreased congestion was expected to lead to better grid efficiency and a more stable electricity supply. This grid efficiency was measured by demo KPI 8.

The tool helped MITNETZ-STROM to deploy their solution in the development phase by identifying which parts should be defined or analyzed better and which parts of the solution were missing.

After having the ESIC completely filled in, the next step was to figure out if all the elements included in the ESIC (Stakeholders, System Benefits, Key Activities, Key Resources & Infrastructure, Key Partners, etc.) were available and/or worked as expected. That is, the most critical elements included in the ESIC (most important hypotheses) should be validated. In an ESIC there are two types of elements to validate: Technical, and business/managerial. For the validation of the first, the technical ones, MITNETZ-STROM defined the main KPIs (see Appendix B) that were validated during the demo development. One of the blocks which was validated as part of the demo included savings on costs due to congestion management (KPI 1), resulting in an estimation of more than 50,000 €/month savings on grid losses for the MITNETZ-STROM region. Another was the process duration (KPIs 2, 3 and 7), resulting in five to six minutes for data processing, which was sufficient to meet the TSO's needs. Also, the accuracy of optimization and schedule adjustment from the TSO was included as a demo result with no deviation found in the demo (KPI 4). Moreover, impacts on grid efficiency (KPI 8) were measured, with grid efficiency improving by 4–7%. Lastly, the percentage of curtailment (KPI 9), and the technical capability for grid state estimation and P-flow forecasting (KPIs 10 and 11) were measured (EU-SysFlex, 2022a).

For the validation of the second, business/managerial categories, a similar approach to the validation of the BMC elements of a start-up should be used: 1) The most critical elements are identified and analyzed according to its impact and to its probability; and 2) a specific approach is designed for the validation of each of the previously identified critical elements, mostly interviews and experimentation using Minimum Viable Products (MVP). To illustrate this, two examples of the German demo case are used:

- In the German demo, the RESs were expected to obtain an economic benefit from savings depending on redispatch compensation and extra energy sold (optimized schedule). For further validation of these economic benefits – a task which is beyond the scope of this paper – a set of interviews with some RES owners would be appropriate in the future to evaluate how great these benefits should be in order for them to be willing to participate in the system improvement.
- The aggregators that are BRP are expected to obtain an economic benefit by reducing penalties. Here, an MVP experiment combined with interviews could also be used to check if there were real savings and if they were large enough for the aggregators to participate in generating this solution.

DISCUSSION OF THE FINDINGS AND DIRECTION FOR FUTURE STUDIES

The goal of the ESIC is to design, analyze, or communicate system improvements in the energy sector, by illustrating how they can improve the entire system while creating sustainable value for its beneficiaries and highlighting how they should be deployed.

The ESIC is useful for designing system improvements since it contains the main points that should be considered. As such, it is a good basis for defining what and who is needed to solve problems. Moreover, in a further step, the ESIC serves to design a proposed solution to the problems. This definition stage should be completed together with the team of the 'leading' entity that proposes the solution, and often also with the most important stakeholders (beneficiaries, buy-in entities, and/or key partners).

When using the ESIC to analyze the system around a company or organization, it can aid in clarifying different business models or innovating businesses in complex ecosystems. The tool can especially help to explore new businesses that involve public or regulated entities, and/or other stakeholders from which something is required or whose buy-in is needed, since it can serve to identify important risks (hypotheses) that should be identified and validated prior to starting these businesses. Additionally, the ESIC is an appropriate tool to analyze and compare the sustainability of different innovations, by evaluating the three pillars of sustainability (economic, environmental, and social).

Moreover, when using the ESIC to communicate business ideas, during discussions or presentations to different types of audiences, its advantage lies in its ability to simplify and to offer a holistic view of a system improvement. As such, it can be very useful to present and thus obtain approval for certain innovations, showing the benefits for both the key beneficiaries and for the entire social and environmental ecosystem around the proposed improvement, and at the same time highlighting what will be required from each party for the improvement to succeed. However, this research was limited to the EU-SysFlex project and should be replicated with other electricity system–related entities. Similar studies should be conducted in other fields or industries to ascertain the full potential benefits of the tool.

Finally, the use and applicability of the ESIC is expected to go beyond the electricity sector, to be applied in other sectors. Thus, as an evolution of the ESIC the authorship team proposes the use of 'SIC', the System Improvement Canvas, as a tool to design, analyze, or communicate system improvements in other highly complex and/or regulated sectors. In this context, the tool could be especially useful for solutions in sectors such as finance, transportation, and health. Regarding the health sector, the authorship team has already applied the tool to analyze the design of an ecosystem for the commercial deployment of a vaccine for the prevention of post-weaning diarrhea in piglets in Europe. Furthermore, the authors suggest that the ESIC can have great use when the concept of business ecosystems is used, such as for financial ecosystems in the digital era (Hacioglu & Aksoy, 2021), or for analyzing value creation in public services (Strokosch & Osborne, 2020). Moreover, when looking for new business opportunities by business model innovation and/or ecosystem innovation (Cohendet et al., 2021) the tool could also be of great impact. The ESIC is especially useful for designing sustainable solutions to problems in multi-stakeholder complex ecosystems. In these contexts, the authorship team advises using the tool in combination with the VCE tool, another tool developed by the authorship team.

LIST OF ACRONYMS

BMC: Business Model Canvas
BRP: Balance Responsible Party
CMC: City Model Canvas
DER: Distributed Energy Resource
DSO: Distribution System Operator
DN: Distribution Network
ER: Exploitable Result
ESIC: Electricity System Improvement Canvas
KPI: Key Performance Indicator
MMC: Mission Model Canvas
MVP: Minimum Viable Product
NABEG: *Netzausbaubeschleunigungsgesetz* (Grid Expansion Acceleration Act)
NRA: National Regulatory Authority
RES: Renewable Energy Source
SIC: System Improvement Canvas
TLBMC: Triple Layered Business Model Canvas
TN: Transmission Network
TSO: Transmission System Operator
VCE: Value Creation Ecosystem
vRES: variable Renewable Energy Source

CONFLICT OF INTEREST

The authors of this publication declare there is no conflict of interest.

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ENDNOTES

1 The EU-SysFlex project introduced new types of services that would meet the needs of an electricity system with more than 50% renewable energy sources. It explored the right blend of flexibility and system services to support secure and resilient transmission system operation, including different technical solutions and demonstrations (EU-SysFlex, 2022b).

2 Redispatch, also called schedule-based congestion management, is the adaptation of production schedules of generators to the grid's demands by the TSO and/or the DSO.

3 NABEG stands for *Netzausbaubeschleunigungsgesetz*, which translates to Grid Expansion Acceleration Act.

4 Around 95% of vRES are connected to the Distribution Network in Germany.

APPENDIX A: EXPLANATION OF ACRONYMS

BMC (Business Model Canvas): Is made up of nine building blocks showing the logic of how a company intends to deliver value and make money. The nine blocks cover the three main areas of a business: Desirability, viability, and feasibility (Osterwalder & Pigneur, 2010).

BRP (Balance Responsible Party): An electricity market participant, or its chosen representative, which must strive to be balanced in real time and is financially responsible for the imbalances to be settled with the connecting Transmission System Operator (Glowacki, 2022).

CMC (City Model Canvas): This canvas departs from a combination of the Mission Model Canvas and the Triple Layered Business Model Canvas by adding two sustainability layers (environmental costs/benefits and social costs/benefits) and changing the 'Key Resources' block to 'Key Infrastructure and Resources & Key Regulatory Framework' (Timeus et al., 2020).

DSO (Distribution System Operator): A personal or legal entity who is responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and its interconnections with other systems, as well as for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity (European Union, 2019).

ESIC (Electricity System Improvement Canvas): Illustrates how a proposed improvement, addressing an important problem in a particular system (e.g., energy, health, education, etc.), can be deployed or exploited considering the regulatory framework, while creating sustainable (economic, environmental, and social) value for different beneficiaries and highlighting the critical resources, infrastructure, partners, and activities required for its successful implementation.

MMC (Mission Model Canvas): Differs from the Business Model Canvas in that it contains the blocks 'Beneficiaries', 'Deployment', 'Buy-In & Support', and 'Mission Achievement' instead of 'Customer Segments', 'Channels', 'Customer Relationships', and 'Revenue Streams'.

MVP (Minimum Viable Product): The most basic version of a product which the company wants to launch in the market. By introducing the basic version to consumers, companies want to gauge the response from prospective consumers (The Economic Times, 2022).

TLBMC (Triple Layered Business Model Canvas): Contains three different canvas layers: The economic Business Model Canvas, the environmental lifecycle Business Model Canvas, and the social stakeholder Business Model Canvas.

TSO (Transmission System Operator): An entity operating independently from the other electricity market players, responsible for the bulk transmission of electric power on the main high voltage electric networks. TSOs provide grid access to the electricity market players (i.e., generating companies, traders, suppliers, distributors, and directly connected customers) according to non-discriminatory and transparent rules (ENTSO-E, 2022).

VCE (Value Creation Ecosystem): A tool developed by the authors of this paper to represent the key stakeholders involved in a solution, together with their main value exchanges (Vinaixa et al., 2022).

APPENDIX B: KEY PERFORMANCE INDICATORS (KPIS) OF THE GERMAN EU-SYSFLEX DEMO (EU-SYSFLEX, 2022A)

Table 1.

	KPI Name	Explanation
KPI 1	costs for congestion management	Costs for congestion management and curtailment should be less with the demo, or at least not higher.
KPI 2	process duration	The intra-day update process needs to be done in a certain time.
KPI 3	keeping deadlines	The day-ahead process begins and ends at certain times, plus there are different times in this process for information exchange; all these times have to be met.
KPI 4	meet TSO need in adjustment of schedule	The aggregated schedule adjustment from the TSO needs to be segregated for adjusting the schedule of single units, therefore the accuracy of optimization is important.
KPI 7	meet TSO need in delivering data	The needed data for the demo in amount, accuracy, and detail must be delivered.
KPI 8	grid efficiency	The KPI measures the optimization of the grid for the most efficient operation, considering the needs of connected parties, including the TSO.
KPI 9	percentage of scheduled flexibility	To prevent curtailment, a planning process is needed to address the needed amount of flexibility for congestion management in a schedule. The KPI measures the percentage of scheduled flexibility.
KPI 10	quality of forecast – day-ahead	An accurate forecast is needed for a satisfactory planning process in congestion management. The KPI measures the quality (accuracy/fit) of the adjusted schedule at 10pm for the next day.
KPI 11	quality of forecast – intra-day	An accurate forecast is needed for a satisfactory planning process in congestion management. The KPI measures the quality (accuracy/fit) of the adjusted schedule two hours before measurement.

Jordi Vinaixa is a lecturer in the Department of Strategy and General Management at ESADE Business School. He holds a PhD in chemistry from the University of Barcelona and an MBA from ESADE. He has engaged in postdoctoral research at the University of Sussex and in the postgraduate program in entrepreneurship-EECPCL at Harvard Business School. He is the director of the 'From Science to Business' program, and of the ESADE courses for the EIT InnoEnergy MSc and PhD Schools. He is currently teaching entrepreneurship courses in undergraduate, MBA, executive MBA, and executive education programs. He is also the project leader of the ESADE work package of the EU-SysFlex (H2020) project. Previously, he set up his own consultancy firm and has managing experience in the chemical, education, and service industries.

Winnie Vanrespaille completed a bachelor and an MSc in bio engineering between 2007 and 2012, and an MSc in management at K. U. Leuven (Belgium); from 2012 to 2017 she was the industrial project manager at Group IPS (Belgium and Spain); from 2018 to 2022 she conducted the research H2020 Project EU-SysFlex at ESADE Business School (Spain).

Hasan Muslemani is the head of carbon management research and a senior research fellow at the Oxford Institute for Energy Studies (OIES), and a postdoctoral research fellow at ESADE Business School in Barcelona. He has a multinational background and a career spanning multiple disciplines, including carbon markets, natural sciences, and climate and energy policy. Hasan holds a PhD in carbon finance from the University of Edinburgh Business School, with MSc degrees in carbon finance and in oceanography. He has taken up several roles in climate and energy consultancy, and academic and industry research. He has also published a number of articles on energy and clean technologies, and is a member of the British Institute of Energy Economics (BIEE), the International Association for Energy Economics (IAEE), and the European Association of Environmental and Resource Economists (EARE).