Platone

PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS

Platone

PLATform for Operation of distribution NEtworks

D7.5

Replicability at international level - application to Canada

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Abstract

This deliverable explores the replicability of Platone solutions in Canada. Key findings obtained by local field implementations in the demos indicate that the use cases tested in Platone could represent fundamental tools that will enable the Canadian energy system to achieve the long-term targets of the Canadian energy strategy, that foresees to achieve the complete decarbonization of the energy sector by 2035. However, in order to successfully deploy at a large-scale the most important solutions tested in Platone, namely, local energy communities, virtual power plants, flexibility-based reinforcement planning, and flexibility provision by distributed resources, significant barriers must be removed. Therefore, a survey was conducted to identify these barriers in the Canadian context. The questionnaire was developed considering the recommendations elaborated by past projects that performed a qualitative assessment of replicability potential of smart grid projects (similar to Platone). The questionnaire was distributed among a list of Canadian energy experts suggested by the University of Alberta.

The results of the survey were completed with a relevant literature review and provided the following insights. Regarding the stakeholder acceptance, the lack of methodologies to perform cost-benefit analysis and elaborate business of the above-mentioned solutions, differences in the regulatory systems implemented in the different Canada's Regions and Territories, and the need to significantly re-adapt the current approaches adopted in the utilities and energy companies to integrate these innovative functionalities into their daily operations were identified as the main barriers. Technology barriers included data privacy and lack of standards. Overcoming these barriers requires comprehensive analysis, data privacy improvements, and supportive policies. In this regard, the challenges that the utilities face and the advantages that they can gain by replicating Platone solutions help to overcome these barriers and ultimately pave the path towards Canada's net-zero greenhouse gas emissions by 2050.

Keyword list

Flexibility, Replicability, Canada, Local Energy Communities, Virtual Power Plant, Flexibility Based Reinforcement Planning, Flexibility provision

Disclaimer

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Executive Summary

The Platone project envisions "Innovation for the customers, innovation for the grid," aligning with the H2020 program's goal of a smart European electricity grid. Platone focuses on "Flexibility and retail market options for the distribution grid," as power grids transition from centralized TSOs to flexible DSOs managing renewable sources. Using blockchain, the Platone Open Framework facilitates modern DSO needs like data management, enabling secure distribution grid mechanisms and energy market models involving various actors. This open-source framework ensures secure data handling, easy integration, and links with traditional TSOs, promoting grid innovation and customer participation.

To analyse the potential replication of Platone solutions internationally, an overview of the scientific literature that describes the characteristics of the Canadian energy system was performed and a dedicated survey was conducted in collaboration with Canadian partners. The objectives of this exercise and the corresponding analysis were to disseminate Platone results within the Canadian stakeholder community and elucidate potential benefits for them.

In this regard, the technological, contextual, regulatory and stakeholder boundary conditions that can affect the potential of smart grid projects like Platone were defined. The contextual boundary conditions were identified thanks to an analysis of the relevant literature. Information regarding the other boundary conditions was identified by a survey specifically designed for this purpose. Additionally, Platone solutions were categorised under four main macro topics, i.e., local energy communities, virtual power plant, flexibility-based reinforcement planning, and flexibility provision by distributed resources. This was then followed by finalizing and conducting the survey with the inclusion of Canadian energy experts.

The analysis identified common barriers across all four solutions. Stakeholder engagement faces challenges due to the lack of methodologies for cost-benefit analysis of innovative solutions in Canada. Implementing changes in daily utilities operation necessitates internal approvals and maintaining service quality. Technological barriers encompass data privacy, security concerns, and a lack of non-proprietary standards.

Conversely, shared enabling factors include the Canadian Government's commitment to achieving net-zero greenhouse gas emissions by 2050. The challenges of accommodating distributed energy resources and regional energy price differences motivate investment. The favourable Canadian context supports the deployment of the four solutions, assessed individually:

Local Energy Communities: Minimal technical barriers are observed. Challenges relate to Advanced Metering Infrastructure deployment and regulatory disparities. Pilot projects provide insights.

Virtual Power Plant (VPP) as DSO Support: Technical challenges involve AMI deployment, and regulatory variations affect DER participation and energy trading. Regional energy price differences and pilot projects play roles.

Flexibility Based Reinforcement Planning: Enabling factors include the need to accommodate distributed renewables and manage grid upgrade costs. Barriers include utility familiarity and conventional remuneration schemes.

Flexibility Provision by Distributed Resources: Challenges stem from lack of utility familiarity and regulatory complexities. Varying electricity distribution charges and access conditions pose obstacles.

The analysis underscores the intricate interplay between technology, regulation, and context in the Canadian energy landscape. The established rules provide valuable insights into the potential for scaling-up and replication across the various solutions, offering a strategic guide to navigate challenges and harness opportunities in the pursuit of an innovative energy future.

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1 Introduction

The project “PLATform for Operation of distribution Networks – Platone” aims to develop an architecture for testing and implementing a data acquisition system based on a two-layer Blockchain approach: an “Access Layer” to connect customers to the Distribution System Operator (DSO) and a “Service Layer” to link customers and DSO to the Flexibility Market environment (Market Place, Aggregators, TSO, …). The two layers are linked by a Shared Customer Database, containing all the data certified by Blockchain and made available to all the relevant stakeholders of the two layers. This Platone Open Framework architecture allows a greater stakeholder involvement and enables an efficient and smart network management. The Platone platform is tested in three European demos (Greece, Germany and Italy). The Platone consortium aims to go for a commercial exploitation of the results after the project is finished not only in the countries that host Platone demos but also in other European and extra European countries. To support the dissemination and exploitation of Platone’s results, WP7 members, leveraging on a cooperation agreement with the Northern Alberta Institute of Technology, interviewed a selected panel of Canadian experts. These interviews were performed using an online survey tool and aimed to identify potential barriers and/or enabling factors that might impact on the replication in the Canadian energy sectors of a set of solutions that have been developed and tested in the Platone demos. These solutions include:

- Local Energy Communities.
- Virtual Power Plant (VPP) as a support for DSO.
- Flexibility Based Reinforcement Planning.
- Flexibility provision by distributed resources.

The list of interviewed experts includes representatives from: ATCO, Siemens, representatives from the Alberta regulatory agencies, from local manufacturing companies and DSOs.

This questionnaire was aimed at gathering information on the technical, regulatory and stakeholder acceptance issues that govern the Canadian energy system that might limit the replication of the solutions tested in the European project Platone. It is an adaptation of the questionnaire used for other European projects, such as GRID+, GRID4EU and SUSTAINABLE. The questionnaire consists of different sets of questions to address different aspects of distribution grids mainly those concerning the possible technical, regulatory and stakeholder acceptance barriers that might hinder the replication of the Platone concept in the Canadian energy system.

1.1 Task 7.5

The qualitative scalability and replicability analysis of the Platone solutions in the Canadian context is performed in the task 7.5 and is based on the guidelines that were suggested by past European projects that pursued a similar exercise. Based on these lessons learnt, the potential drivers and barriers that might affect the deployment of the any smart grid project in a different context w.r.t. the demo areas can be classified into two categories: technical and non-technical boundary conditions. Technical boundary conditions comprise aspects like; (i) distribution grid characteristics, performance indicators (continuity of supply, energy losses), smart metering status, and installed distributed generators (DG). These parameters have been compared with the data compiled from the project demos countries. (ii) Market models: i.e., comparison of the different market models for developing local flexibility with respect to the Canada market settings. Non-technical boundary conditions include regulatory and stakeholder acceptance issues. In the present analysis, the focus is mainly placed on the differential regulatory settings as compared to the EU context. Some noteworthy stakeholder issues have been incorporated in the analysis is when relevant. The topics analysed, include for example: distribution regulation, smart meter deployment, RES promotion policies, self-consumption, energy storage, incentives for smart grid demonstration projects and treatment of DG units.

1.2 Objectives of the work reported in this deliverable

The objective of the work reported in this deliverable is to perform a qualitative evaluation of the parameters that describe the scalability and replicability potential of the most important Platone solutions in the Canadian energy system. To evaluate this potential, the authors have identified the barriers and the enabling factors that can limit or support the large-scale deployment of the Platone solutions. The authors performed an overview of the most relevant literature and public information that describe the state of these parameters in the Canadian context. This overview was complemented by a survey that was circulated among the list of experts provided by the Northern Alberta Institute of Technology.

1.3 Outline of the deliverable

Chapter 2 illustrates all the factors that can have an impact on the scalability and replicability potential of the Platone solutions: technical, technological, regulatory and stakeholder acceptance parameters are identified and described. Chapter 3 describes the solutions investigated in the present deliverable, while chapter 4 reports the different sections of the questionnaire that was circulated among the Canadian experts. Chapter 5 presents and discusses the results of the survey. Finally, chapter 7 reports the conclusions of the study.

1.4 How to read this document

The reader shall find in the present deliverable a qualitative assessment of the scalability and replicability potential of the most relevant Platone solutions. Technical, economic, regulatory and stakeholders related factors that can impact on the potential roll out of the Platone solutions have been identified. Information was gathered to understand the characteristics of these parameters in the Canadian context. For each solution analysed the potential barriers and enabling factors are reported in the conclusions

2 Identification of the boundary conditions that impact on replicability potential

Platone includes three pilot projects testing several smart grid solutions. In order to evaluate the replicability potential of these solutions, a set of specific boundary conditions must be considered.

Boundary conditions are the technical, contextual, economic, regulatory and stakeholders related factors that can support or hinder the large-scale deployment of smart grid applications [1]. These boundary conditions have been identified based on the review of relevant studies that had proposed methodologies for the qualitative evaluation of the scalability and replicability potential of smart grids projects in non-European Countries like GRID+, Sustainable and GRID4EU [1], [2], [3].

Sustainable [2] project classified these boundary conditions in four major groups according to their nature, as illustrated in Figure 1.

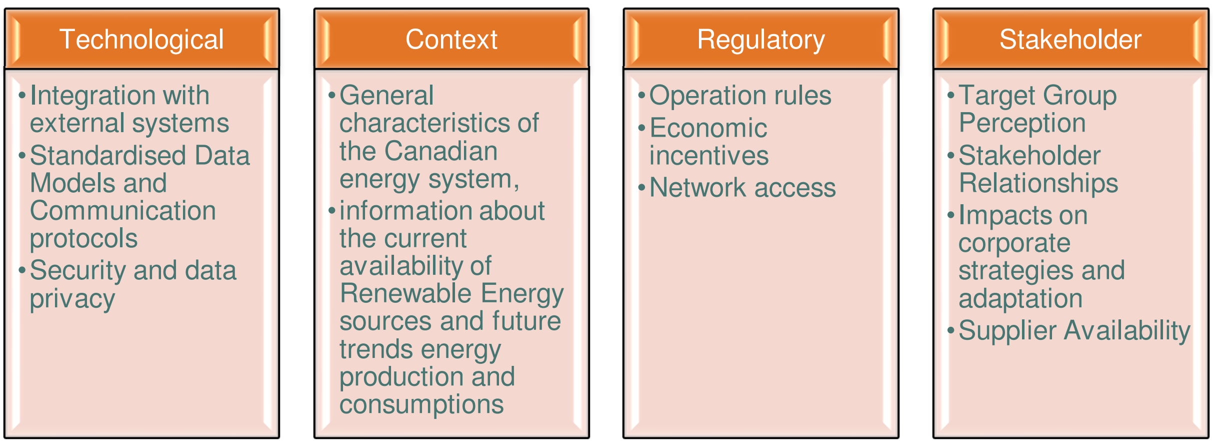

Figure 1 – Different types of boundary conditions that impact on the replication of smart grid project solutions (source: [1], [2], [3])

To perform a qualitative replicability assessment, all the boundary conditions identified in Figure 1 must be further detailed and the replicability assessment must describe their characteristics in the replicability domain (in this case, in Canada).

Sub chapters 2.2, 2.3 and 2.4 provide more detailed information about the boundary conditions listed in Figure 1 providing explanations regarding the parameters that shall be analysed to perform a sound qualitative SRA.

The analysis of the characteristics of the above-mentioned boundary conditions started with an extensive overview of the relevant scientific literature and with a detailed analysis of the information published by regulated Canadian companies, governmental agencies, etc. However not all the information needed to perform the qualitative replicability assessment could be found in the literature overview exercise. Thus, to analyse all recommended boundary conditions, a specific survey was designed, tacking the information that could not be obtained by the analysis of public documents (see chapter 4) because of the lack of availability of public sources: technological conditions, regulatory conditions and stakeholders' acceptance aspects.

The information that describes the context boundary conditions has been obtained by the analysis of the relevant literature in chapter 6 and therefore it was not necessary to include it in the development of the survey. Chapter 6 also summarizes the literature overview of aspects related to stakeholder engagement to complement the survey results. Table 1 summarizes the sources of information that have been used in the present report to analyse the characteristics of the above recommended boundary conditions in the Canadian context.

Table 1 – Mapping of the boundary conditions against the sources of information used in the present deliverable

Boundary conditions	Sources analysed	Results
Technological	Survey (described in sub-chapter 4.3)	Sub - Chapter 5.2
Context	Overview of the existing literature and public documents	Sub – Chapter 6.1
Regulatory	Survey (described in sub-chapter 4.2)	Sub – Chapter 5.3
Stakeholder acceptance	Survey (described in sub-chapter 4.1) Overview of the existing literature and public documents	Sub – Chapter 5.1 Sub – Chapter 6.2

2.1 Technological conditions

According to the recommendations elaborated by the GRID+ project [1], a core requirement for replicating the solution tested in a demo in a different environment is that a given solution can interwork with other systems. This translates into the analysis of the following boundary conditions:

- Integration with external systems: the innovative solution shall be integrated seamlessly into the existing networks. The implementation of open standards is a fundamental requirement to avoid that the DSOs would install proprietary solutions that can be applied only to limited contexts.
- The implementation of standardized data models and communication protocols guarantee that innovative solutions can be smoothly integrated into existing systems.
- Security and data privacy; these factors proved to be key elements to ensure that innovative technologies could be safely integrate in existing complex systems (like energy networks) without jeopardizing system security and stability.

These latest factors prove to be a fundamental requirement that shall be satisfied to ensure that all the information gathered by the different parties involved in the experimentation will be treated in a secure manner that complies with law requirements [1].

2.2 Context conditions

The present sub-chapter summarizes the main characteristics of the Canadian electricity sector with a particular focus on the area of Alberta region. According to the recommendations elaborated by Sustainable [2], the "context conditions" include the following aspects:

- General characteristics of the Canadian energy system.

- Information about the current availability of Renewable Energy sources and future trends energy production and consumptions.
- Expected growth of generation and demand.
- Characteristics of the transmission and distribution grids and finally elements of the national and regional legislative frameworks.

2.3 Regulatory conditions

This sub chapter summarizes the key regulatory elements that can hinder or support the large-scale deployment of smart grids innovations. These elements have been identified in the recommendations elaborated by GRID+ [1] and Sustainable [2]. For each of the regulatory element identified, a short description is provided.

2.3.1 DER participation in network services and relationship with DSOs

DER systems, which consist of generators and adaptable loads, have the capability to provide services to the grid such as regulating voltage and managing congestion at a local level. This has the effect of improving the efficiency of the entire system. However, the degree to which DER systems can participate in these services depends on the existing regulations. The capacity of decentralized resources and flexible loads to furnish these services to the DSOs is contingent on determinations undertaken by the country's Regulatory Agency.

2.3.2 Business model for purchase and sale of energy by DER Role of the aggregator

DG units generate power to meet specific consumption needs across various users within the electrical power network. Depending on prevailing regulations, this generated energy can be traded through various frameworks. Additionally, energy storage options like grid-connected batteries or electric vehicles equipped with Vehicle-to-Grid (V2G) technology can also engage in purchasing and selling energy during various time intervals.

2.3.3 Network tariffs

The fundamental tariff arrangement encompasses three main categories: volumetric (€/kWh), capacity-based (€/kW), and per connection (€/year) charges. Volumetric tariffs depend on energy usage, while capacity tariffs are based on contracted grid capacity or used power. Time-Of-Use (ToU) tariffs have fixed charges for different time segments, encouraging actions like peak shaving. Critical peak pricing (CPP) involves high rates during demand spikes. Dynamic network pricing adjusts prices for network conditions, aiming to balance revenue, cost reflection, efficiency, and energy goals. Tariff design should optimize revenue, cost accuracy, efficiency, and energy advancements. Impacts of DER and Active Demand on planning, operation, network losses, supply reliability, and costs are also considered.

The tariff structure should reflect variable and fixed costs, dependent on actual energy consumption, with network tariff costs hinging on the roles and responsibilities of Distribution System Operators (DSOs). These expenses typically encompass Capital Expenditures (CAPEX), linked to network asset investments, and Operational Expenditures (OPEX), which cover operations, network losses, customer services, and overheads. The energy sector's digital transformation necessitates revising tariff models, shifting towards value-oriented approaches such as the Total Expenditures (TOTEX) method, which combines operating and investment costs. TOTEX integrates regulation, service quality, and innovation support within an output-based logic [4].

2.3.4 Active demand response and smart metering

Tariff design should reflect the link between connection and use of system charges as well as network customer diversity. Self-generated electricity is one of the major factors contributing to the current decrease in the amount of grid-distributed electricity. However, self-generation per se does not necessarily reduce grid development/management costs. In fact, in many cases the opposite is true due to the need for connection and use of the distribution grid and sometimes further network extension, as well as increased automation investment.

2.3.5 DSO incentives for innovation

The integration of smart grids introduces fresh challenges for Distribution System Operators (DSOs) concerning network planning, operation, and control. Furthermore, initiating pilot projects often yields an unfavourable cost-benefit ratio. This outcome arises from the nascent stage of innovation and the substantial costs linked to addressing practical implementation hurdles or assessing potential and obstacles for novel technologies. The conservative approach of regulated DSOs towards risk restrains investments in less mature technologies. Additionally, European regulations commonly lack provisions to encourage network innovation, prioritizing cost and investment reduction. Several nations have introduced inventive mechanisms to stimulate innovation within regulated sectors through public-private collaboration. Regulatory experiments, like regulatory sandboxes, facilitate the trial of innovative products, services, and business models, with engagement from public stakeholders. This blend of innovative policy actions and initiatives driven by public, semi-public, and private entities has proven effective. It ensures a well-balanced mixture of innovation-focused legislative or regulatory measures, alongside project-specific support approaches and funding mechanisms [5].

During the development phase of the Platone survey all the recommended regulatory boundary conditions were considered. In order to improve the readability of the survey and to limit the complexity of the entire questionnaire, the recommended regulatory boundary conditions have been grouped into the following categories:

- DER participation in network services and relationship with DSOs.
- Business models for purchase and sale of energy by DER.
- Effects of DER on planning, operation, network losses, reliability of supply and incremental costs
- Active demand response and smart metering
- Incentives for innovation

2.4 Stakeholder boundary conditions

Based on the recommendation of the past projects, the impact of the deployment of the smart grid solution on the following stakeholder categories shall be addressed:

- Regulatory Authorities, Ministries, Grid regulators and energy agencies.
- Grid operators (DFO and DSO).
- Energy Producers and distributed Energy Resources owners.
- End Customers: Industrial customers, Retailers, Households.
- Manufacturers and Providers.

This part of the questionnaire addresses all the above-mentioned groups of stakeholders. In the development stage of the survey the questions were grouped into four sections, to allow each category of stakeholder to be able to reply to the same set of questions and compare the results.

- Target group perception: familiarity and importance of the analysed solution for the category of the respondents)
- Relationship between stakeholders: how the analysed solution impacts on the relationship between the respondent and the other stakeholders involved?
- Organizational perspective and other topics: how does the analysed solution impact on the current or future internal organizational aspects?
- Supplier availability (only applied to solutions if these were at least at lab test experimentation in the respondent’s firm): how does the analysed solution perform in the tests conducted so far?

the potential barriers that shall be encountered by the stakeholders listed above have been analysed in section 4.1 of the Platone questionnaire and are described in sub- paragraph 5.1. This information is complemented with the analysis of the relevant literature reported in sub paragraph 6.2.

3 Solutions tested in Platone demos and analysed in the survey

The 3 pilot projects developed in the in Platone had implemented innovative solutions aimed at addressing local challenges thanks to the implementation of the Platone Open Framework. Each demo had elaborated a general description of the set of solutions implemented in their own pilot project. These descriptions are reported in D1.1 [6].

The goal of task 7.5 is to identify the potential barriers or enabling factors that could impact on the possibility to replicate these innovations in the Canadian context. To simplify the descriptions of the innovations tested in the demos that are reported in the questionnaires, the innovations described in D1.1 [6] have been grouped in the following 4 macro categories or solutions.

- Local energy communities.
- Virtual Power Plant (VPP) as a support for DSO.
- Flexibility Based Reinforcement Planning.
- Flexibility provision by distributed resources.

The present chapter describes these macro categories and reports examples of their implementations in the Platone demos and WPs.

3.1 Local Energy Communities

Energy communities play a pivotal role in driving the transition to clean energy, empowering citizens, and enhancing public acceptance of renewables. They attract private investments, improve energy efficiency, cut electricity costs, and generate local job opportunities. By promoting citizen engagement, these communities provide grid flexibility through demand response and storage, contributing to a more flexible electricity system. Local Energy Communities (LECs) are operated by independent entities, with the local DSO ensuring safety and decision-making authority while enabling flexibility providers like prosumers, aggregators, and LECs to operate.

In the Platone project, digital tools were developed and tested to facilitate LECs in offering flexibility services to DSOs. This enhances DSO distribution network operations and provides information to aggregators and LEC operators. As described in D5.2 [7], the concept of LECs was applied in the German demo of the Platone project, featuring an Avacon Local Flex Controller (ALF-C) as the central Energy Management System. This system monitors local demand, generation, and available flexibility, aided by a large-scale energy storage setup. Through this architecture, the LEC participates in markets and contributes to grid balancing.

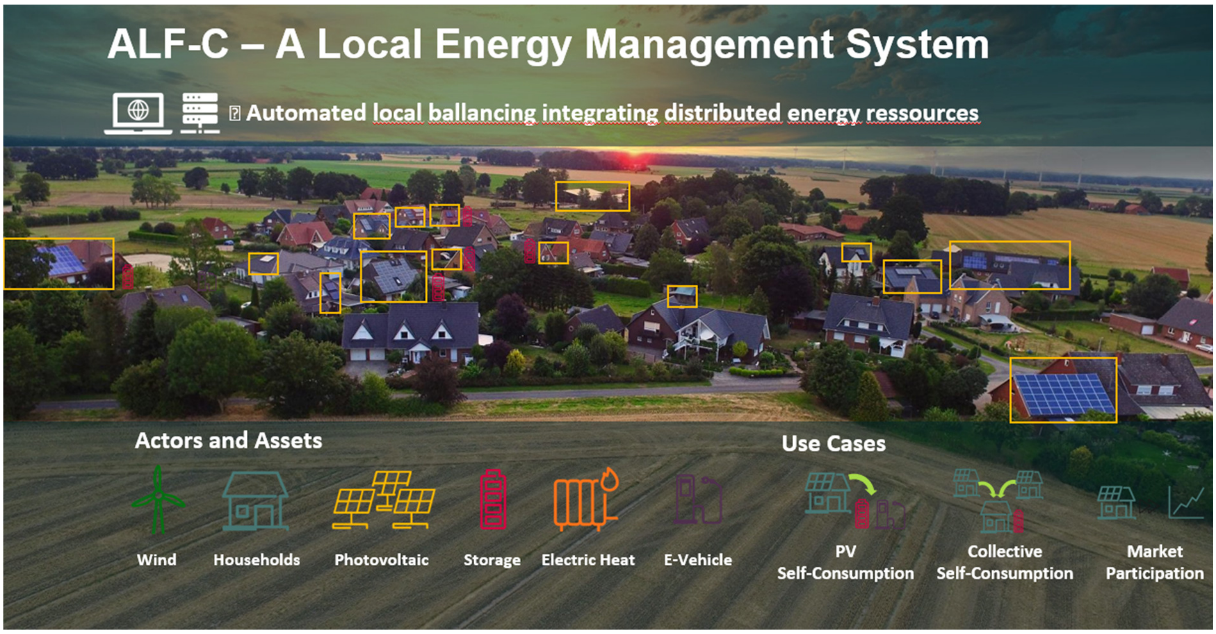

Figure 2 - Local Energy Community implemented in the Platone German demo (source: [8])

The objective is to support the DSOs in the daily operation of the distribution network . Further information about the local energy community implemented in the German demo are reported in [20].

3.2 Virtual Power Plant (VPP) as a support for DSO

To manage distributed generation and enhance its presence in power markets, researchers have introduced the concept of a virtual power plant (VPP). This involves combining smaller distributed generating units into a single virtual unit, operated by an aggregator (while the LECs could be operated by different aggregators). This setup allows the VPP to function like a traditional unit and be monitored individually. This approach was applied in the Italian and German demos of Platone, where various control strategies were used to manage power exchange at the MV/LV interface. The strategies included setting power exchange at a fixed value to provide flexibility and establishing fixed profiles for bulk power export/import. These methods aimed to replicate real-world VPP operation, supporting the DSO. The focus of the VPP analysis in the provided text is on technical and regulatory considerations relevant to implementing these mechanisms in Canada, rather than the economic aspects related to their compensation. For further implementation details, refer to D5.2 [20] and to D3.9 [9].

3.3 Flexibility based reinforcement planning

The rapid deployment of distributed generators and flexible loads in the distribution network is disrupting traditional planning procedures established by network operators. This situation adds complexity to managing electricity networks, which are facing growing uncertainty. Moreover, investing in grid infrastructure requires significant capital and has a long lifespan. By the time a new transmission line is operational, it could already be considered a sunk cost. These uncertainties surrounding grid investments are making decisions about new assets more intricate and uncertain. Additionally, public opposition to constructing new power lines is extending the planning process and introducing further uncertainty. The introduction of new types of users such as storage technologies and system flexibility offer support to DSOs not only in daily grid operations but also in the planning process. These innovative users help make overall generation behaviour more predictable and manageable. Various position papers and European Commission (EC) documents emphasize the need for new methodologies [10] [11]. Ongoing projects are developing innovative approaches to compare traditional grid investments, which address expected load and generation changes, with the potential of utilizing local flexibility sources [12]. These sources could mitigate peak loads and delay the need for new grid investments by harnessing flexibility services from local resources. Determining the best approach involves comparing grid reinforcement with utilizing existing system resources for flexibility. Short-term congestion might be effectively managed with flexibility activation, while prolonged or severe congestion could necessitate network reinforcement. The network development plan must showcase the use of demand response, energy efficiency, and energy storage as alternatives to expanding the system. The Platone Project, specifically within the Scalability and Replicability work package is crafting an approach and software tools to quantify the required flexibility to accommodate projected load and distributed generation growth without resorting to traditional reinforcements. Given uncertainties about how various loads and generators linked to each grid node might evolve, Platone's approach evaluates necessary flexibility across different scenarios representing potential grid developments (see D7.2 [13]).

3.4 Flexibility provision by distributed resources

Sub-chapter 3.2 focused on empowering end-users (LECs, aggregators, etc.) to offer flexibility services to DSOs. Conversely, sub-chapter 3.4 examines solutions allowing DSOs to acquire services (Local markets for flexibility services or dynamic tariffs). Flexible distributed resources offer DSOs services to address local imbalances, and compensation occurs through diverse market platforms, bilateral agreements, or dynamic tariffs as per local regulations. Energy storage like grid-connected batteries or V2G-capable EVs also engage in energy transactions across time periods.

The Platone project introduces the innovative Platone Open Framework, a multi-layered platform accommodating system operators, aggregators, and customers. This framework strives for full scalability and replication, facilitating distribution grid flexibility/congestion management via peer-to-peer market models. It engages various actors (DSOs, TSOs, customers, aggregators) and enables DSOs to utilize customer-provided flexibility services.

In Platone demos, customers receive compensation through two mechanisms:

- Local markets for flexibility services (Italian demo): A Market Platform (MP) is established in the Italian demo to facilitate local DSOs in procuring flexibility services from local sources. It manages a range of flexibility requests from TSOs and DSOs over a wide geographic area. The platform matches DSO flexibility demands with aggregator offers, using a clearing mechanism to ensure secure and cost-effective provision of required flexibility services. More details are reported in D3.9 [9].
- Dynamic tariffs (Greek demo): The Greek demo introduces advancements enhancing data exchange and visualization among energy value chain stakeholders. This innovation allows for dynamic distribution network tariffs, compensating end users for energy flexibility services. These innovative tariff models offer practical solutions for DSOs to leverage flexibility schemes under realistic market conditions and address technical issues tied to increased renewable energy penetration or network capacity. Further insights are reported in D4.3 [14] .

4 Questionnaire design and content

As described in chapter 2, the overview of the existing literature was not sufficient to identify all the information needed to describe the boundary conditions in the Canadian context. Therefore, to complete the analysis and to collect the missing details, a dedicated survey was developed and distributed among the list of Canadian experts. The questionnaire addresses the three boundary conditions that could not be fully described leveraging only on public information:

- Stakeholder.
- Regulation.
- Technology.

In the beginning, the above-mentioned mentioned 4 Platone solutions are introduced to the recipients of the survey to ensure a good understanding of the status quo of the Platone project.

4.1 Stakeholder engagement

4.1.1 Target group perception

- Do you think that these solutions will be necessary in the future energy system?
- Does one or more of the solutions have the potential to solve grid issues you are experiencing in your grid area?
- Is the solution or/and involvement of an organization offering solution specific services addressing a need that is sharply felt by you?
- Is there preexisting collaboration between an organization which offer tools/solutions/services (provider) and those who use their services/tools (user)?
- How familiar are you such solutions?
- Do you have any further comments, information or links to complement the above-mentioned question(s)?
- To which extent do solution that aim at improving the operation of your grid (and to reduce OPEX, e.g. investments in solutions aimed at improving grid observability) can be more efficient than the conventional grid development investments (CAPEX intensive e.g.: building new lines/transformers)?
- How to evaluate the costs and benefits for the solutions? Are existing methodologies known? If not, what do you need to evaluate the costs and benefits?
- In your opinion, which opportunities do you see in each solution as a solution?
- In your opinion, which potential risks arise with the solutions and products developed in your solutions?
- Do you have a proposal how to remunerate the solutions within the Canadian context? (Dynamic tariff, and bi-lateral contracts, local markets)
- Do you have any further comments, information or links to complement the above-mentioned question(s)?

4.1.2 Relationships between stakeholders

- Which stakeholders need to be involved with each other for the solutions to function?
- Are actor and stakeholder networks (and their tools) visible enough / have enough presence to replicate the solutions in the market?
- Is there support from eminent individuals (incl. initiatives) and institutions?
- How trusted are the solutions by the end users?
- How mature is the implementation of the solutions in your market?
- Do you have any further comments, information or links to complement the above-mentioned question(s)?

4.1.3 Organizational perspective / other topics

- How many customers do you serve?
- What are the main barriers in your own network (or part of the grid) to being able to implement the Solutions?
- Is your Research, Development and Innovation department testing/ implementing such solutions in pilot projects?
- How many decision makers are involved in authorizing or approving adoption/ usage?
- Do you have any further comments, information or links to complement the above-mentioned question(s)?
- How big is the change of implementation for your current practices in your company?
- Please describe the changes of implementation.
- Are the solutions in line with and/or adaptable to the values of the public?
- Please share further your view on adaptability and the public.
- Is your organization ready to accommodate solution-specific requests providing data/ support?
- Is data privacy a concern?
- Do you have any further comments, information or links to complement the above-mentioned question(s)?

4.1.4 Supplier availability (Applied to solutions if at least testing in labs)

- Is there robust evidence that the solution works in diverse settings and for diverse target groups addressing the shown dimensions?
- Has the solution been externally evaluated by an independent body?
- Does the solution deliver the promised quality of service / promised volumes / expected outcomes?
- How do you assure the delivery of service from your side? (e.g., certification, training...)
- Are the solutions of the solutions adaptable to different stakeholder preferences?
- Do you have any further comments, information or links to complement the above-mentioned question(s)?

4.2 Regulation

4.2.1 DER participation in network services and relationship with DSOs

- Can DER participate in provision of flexibility services to the DSO? Is there any specific requirement for the provision of these services?
- Can DER participate into local congestion management, provide flexibility services or any other services to the DSO?
- What is the reason for DER to provide services? Is that because they are obliged or incentivized by regulation? Or is because they can make contracts with DSOs to provide services and receive a payment?
- Can DSOs own DER under specific circumstances?
- Does the DSO have visibility of the DER generation/consumption profiles for grid operation purposes?

- Are there any plans to modify in the near future the current situation regarding DER as a provider of network services?

4.2.2 Business model for purchase and sale of energy by DER

- Are there agents, such as aggregators, virtual power plants (VPPs), EV charge management agents or EV supplier aggregators or other business arrangements that manage different loads (commercial and domestic consumers) and DER connected to the distribution network? What is the regulation concerning these agents and how can they interact with other agents?
- Is the figure of new energy service companies (ESCOs) contemplated by regulation? What kind of additional services do they offer to their clients?
- What is the regulation regarding the relationship between aggregators and DSOs? Can they interact and sign agreements?
- How can DER owners sell their energy and under what conditions (in the wholesale market, through contracts with suppliers or aggregators, etc.)? How is the production from RES remunerated (dynamic prices, feed-in tariffs, incentives, green certificates, etc.)?
- Are DER owners (mainly domestic consumers with DG and/or EV) obliged to have a separate metering for generation and consumption or are metering and tariffs based on net consumption? Is the figure of prosumer contemplated by regulation?

4.2.3 Effects of DER on planning, operation, network losses, reliability of supply and incremental costs

- What is the current scheme to recognize DSO costs (OPEX and CAPEX) when calculating DSO revenues in your country? Are CAPEX and OPEX equally remunerated? (passthrough or econometric benchmarking, engineering models, TOTEX approach...)
- Are incremental DSO costs (OPEX & CAPEX) due to the connection of DER taken into account when DSO revenues are calculated under the current regulatory scheme in your country? Is this mechanism consistent with the policy adopted on DER connection and use-of-system charges?
- Is DER explicitly considered by DSOs in order to postpone or reduce network investment?
- Are There any plans to include such impact on further regulatory developments? What kind of regulatory scheme in the opinion of the regulator is the most appropriate to deal with this problem?
- What regulatory mechanism is used in your country to compensate and provide incentives to DSOs for energy losses reduction?

4.2.4 Active demand response and smart metering

- Demand response may be regulated from the side of the DSO, having the possibility to switch of certain consumers. This is mostly regulated through a contract between DSO (and energy supplier) and consumer through lower electricity tariffs (or network tariffs). Is something introduced in your country (or in some regions?) For what kind of consumers (industrial, commercial, domestic)?
- Is there any kind of regulatory incentive for consumers to actively control their load pattern? Are regulated and competitive tariffs obliged to include an economic signal for consumers on time?
- Is it possible to enforce "time-of-use" tariff schemes e.g., price differentiation for peak/base periods, super-valley tariff, dynamic pricing, etc.?
- Is the implementation of smart metering regulated (is it mandatory or left to DSO or market initiative)? Are there any specific smart metering rollout programs?
- What is the infrastructure considered by regulation (just the smart meters at consumers' location, does it also include data concentrators, communication networks, etc.)?
- What are the functionalities considered for smart meters (remote reading, load limitation, etc.)?
- Who is in charge of Advanced Metering Infrastructure (AMI) operation and maintenance (the DSO, the supplier, an independent agent)?
- Who is in charge of reading, billing costs? (the DSO, the supplier, an independent agent)?
- Who bears the costs of AMI (investment, operation and maintenance, management)? How are these costs passed through to consumers (do consumers pay a fixed amount for AMI rental)?

- Are there any problems with confidentiality and data protection? What is the regulation on this topic? Who is the owner of consumers' data and who is allowed to access the information?

4.2.5 Incentives for innovation

- Do DSOs in your country have incentives for network innovation? Are there any specific terms to account for the implementation of smart grids technologies (e.g.: advanced operation and automation of the grid with self - healing, network diagnosis, remote operation, etc.)?
- What kind of mechanism, in the regulator opinion, is the most appropriate to promote DSO innovation in smart grid technologies?
- Are there any plans to provide incentives to DSOs in order to explore ways of how DER can contribute to improve network and system efficiency?

4.3 Technology

4.3.1 Integration with external systems

- Do you implement any specific interfaces between your own systems and other energy stakeholders (market operators, service providers, other system operators) or external systems?
    - If yes, can you specify more in detail those interfaces? Can you define them in terms of:
- Do you integrate any tool in your own system? (e.g., forecasting, data exchange, bid selection/optimization, pre-qualification, settlement, flexibility registers, state estimation, coordination, baseline calculation tools, etc.).
    - If yes, how do you integrate this tool?

4.3.2 Standardised Data Models and Communication protocols

- Did you define communication mechanisms and data models for the integration of external system?
- Are you using any standardised data model? (e.g., CIM) (Please list them)
- Which kind of standard communication protocols are implemented? (e.g., HTTP, MQTT) (Please list them)

4.3.3 Security and data privacy

- Are you considering any data privacy and security mechanisms for the integration of external system?
- Which kind of authentication/authorization mechanisms are used/supported? (Please list them)

5 Survey results

The survey was developed using the online survey tool *SoSciSurvey* (www.soscisurvey.de). 14 valid responses were recorded. The following paragraphs were elaborated considering the replies to the survey and the relevant literature suggested by the experts that participated to the survey. To assess the impacts measured by the survey, a qualitative scoring system was employed, classifying potential barriers as low, medium, or high. This approach allowed for a straightforward comparison of the overall functionality impact across the four solutions.

5.1 Stakeholders engagement aspects

Sub- chapter 5.1.1 investigate the perception of the 4 solutions among the different stakeholders. The perception was analysed considering the following aspects: perceived necessity of these solutions to resolve the current problems faced by the DSOs; their potential to solve the challenges that the DSOs must solve to plan and operate the grids in the future; the necessity to involve other stakeholders and to identify the optimal approaches to cooperate with them.

In this section, the necessity to elaborate new methodologies to estimate the benefits enabled by the solutions and to identify the optimal remuneration of these services is also investigated. Finally, the perceived risks are also analysed.

Sub – chapter 5.1.2 addresses the potential needs to develop innovative approaches to involve stakeholders and in particular end customers. Sub – chapter 5.1.3 investigates the changes that shall be introduced in the corporate structure to integrate the innovative solutions into the daily operation of the utilities. Sub – chapter 5.1.4 provides a summary of the main findings.

5.1.1 Target group perception

The respondents were requested to provide their opinion about the perceived importance of these 4 solutions:

- solution 1: Local Energy Communities.
- solution 2: VPP as a support for DSO/TSO.
- solution 3: Flexibility Based Reinforcement Planning.
- solution 4: Flexibility provision by distributed resources.

The totality of the respondents to the survey stated that solution number 2 represents a fundamental solution in the future energy systems, while only half of them stated that local energy communities are a fundamental solution. Half of the respondents also state that VPP and Flexibility Based Reinforcement Planning could also help the utility to solve congestions that are already happening in the grids. Regarding solutions 3 and 4, the respondents stated that there is not adequate information about their functionalities and the expected benefits. According to the respondents, no methodologies for performing cost benefit analysis of the innovative solutions that is adapted to the Canadian context exists. Consequently, it is also difficult to identify the optimal mechanism to remunerate these services. The maturity of the four solutions is currently very low: solutions 3 and 4 have been classified as “proof of concepts”; only solution 1 and 2 are currently tested in few pilot projects (see Figure 4)

The main barriers perceived by the respondents are technical feasibility and regulation.

5.1.2 Stakeholder engagement

According to the outcomes of the survey, DSOs, aggregators and end consumers must cooperate for ensuring a smooth implementation of the four solutions. However, there is a lack of tools that enable the DSOs to have visibility about the necessary data provided by all stakeholders that are associated with the analysed solutions. According to the respondents, there is still a limited trust by end users regarding the innovative solutions tested in the demo. In order to overcome this barrier, pilot projects involving real customers must be realized.

Based on past experiences and input provided by survey respondents, it has been observed that engaging with local customers during the planning and design phases of a proposed project can be mutually beneficial. Such engagement fosters relationship building, promotes trust, enhances the LECs understanding of the project, and allows the proponent to grasp the interests and concerns of the affected area's residents. By utilizing this understanding and information, project proponents that are willing to invest in the deployment of Platone solutions can develop practical strategies to maximize positive project effects while minimizing or mitigating negative impacts. Commencing discussions regarding project-specific matters and concerns with the community before formal project descriptions are submitted can significantly streamline the regulatory review process in a more efficient and effective manner. In certain instances, neglecting early engagement with Indigenous communities has led to unnecessary delays and amplified expenses for project proponents. A notable illustration underscoring the significance of early community involvement and consultation is the Gull Bay First Nation microgrid initiative. This microgrid, a collaborative effort between Gull Bay First Nation and Ontario Power Generation, employs solar panels, battery storage, and automated control technology to curtail diesel reliance. The triumph of this undertaking is attributed to the consistent backing garnered from the Chief, council, and community over the project's lifecycle. The engagement activities encompassed a range of interactions such as meetings, competitions, newsletters, and energy exhibitions. Furthermore, community members were actively engaged in project management, construction, and operational responsibilities [15].

5.1.3 Impacts on corporate strategies and adaptation

To implement changes needed to integrate the solutions into the daily operation of the utilities, considerable changes are required. According to the respondents, a lot of internal approvals within the corporate structure is needed to ensure to maintain the same level of quality of service while implementing these innovations.

Data privacy was considered a major concern for all the respondents.

5.1.4 Summary

Table 2 summarizes the potential stakeholders engagement barriers that have been identified at the light of the information gathered during the survey.

Table 2– Summary of the impact of Stakeholders engagement aspects

Stakeholder engagement aspects	Impact	Short explanations
Target Group Perception	Medium	The respondents are v-ery well informed about the functioning and the potentials of Virtual Power Plants. However, the characteristics and the potential of the other solutions are not very well known. Some utilities have already established cooperation with third parties to implement VPP on real networks, but similar cooperation schemes have not been implemented for the other solutions. Finally, methodologies for performing cost benefit analysis of these solutions shall be developed. The main barriers perceived by the respondents are technical feasibility and regulation.
Customer engagement	Medium/low	According to the respondents, there is still a limited trust by end users regarding the innovative solutions tested in the demo. To overcome this barrier, pilot projects involving real customers must be realized. Several pilot projects are funded by the Canadian Government to test these innovations with real customers
Impacts on corporate strategies and adaptation	High	A lot of internal approvals withing the corporate structure is needed to ensure to maintain the same level of quality of service while implementing these innovations.

		Data privacy was considered a major concern for all the respondents

5.2 Technological aspects

5.2.1 Integration with external systems

According to the respondents, the main tools adopted to create an interface between the energy grids and other users are SCADA, EMS and ADMS. Interfaces can allow a smooth integration of innovative components needed to implement the Platone solutions: e.g.: forecasting tools, state estimations, baseline calculation tools, etc. Devices are installed on premises and can share data using cloud systems.

5.2.2 Standardised Data Models and Communication protocols

The respondents stated that they adopt standardized data models and communication protocols like Distributed Network Protocol and Inter-Control Center Communications Protocol. However not all the standards adopted are non-proprietary and therefore this could represent a barrier in case the utility shall integrate new components developed by another vendor.

5.2.3 Security and data privacy

Data privacy and security is considered as a major concern for the utilities that are addressing these problems using private networks or VPN (Virtual Privat Network).

5.2.4 Summary

Table 3 summarizes the potential technological barriers that have been identified at the light of the information gathered during the survey.

Table 3– Summary of the impact of technological aspects

Stakeholder engagement aspects	Impact	Short explanations
Integration with external systems	low	Utilities implement system interfaces between the energy grids and the other stakeholders that allow a smooth integration of innovative components needed to implement the Platone solutions. These devices are installed on premises and can share data using cloud systems
Standardised Data Models and Communication protocols	low	Utilities adopt standardized data models and communication protocols like DNP and ICCP. However not all the standards adopted are non-proprietary
Security and data privacy	low	Data privacy and security is considered as a major concern for the utilities that are addressing these problems using private networks or VPN

5.3 Regulatory aspects

In Canada, significant variations in the regulatory framework can be observed across different Regions and Territories. Various Provincial regulators are in operation across the country, each responsible for overseeing local energy generation, intra-provincial transmission, distribution, retail pricing, and wholesale activities. The degree of unbundling and functional separation similarly varies from one province to another. For instance, Alberta and Ontario enforce relatively stringent requirements, particularly regarding the separation of generation and transmission functions. In contrast, provinces where Crown corporations hold significant influence tend to have fewer regulatory demands. The prevalence of provincial ownership of Canadian electricity assets has constrained the involvement of the federal government. Federal regulation of inter-provincial electricity transmission and electricity exports is relatively minimal. Typically, provincial electricity regulators adopt a public utility approach when dealing with the non-competitive aspects of their markets. This involves mandating "certificates of public convenience and necessity" or similar authorizations for facility expansions. They also exercise control over the terms and conditions of service through tariff submissions and rate evaluations, ensuring a balance between the regulated utility and its customers. In provinces with competitive market sectors, entities such as Alberta's Market Surveillance Administrator might function as competition overseers.

5.3.1 DER participation in network services and relationship with DSO

Canada's legal framework for renewable energy storage exhibits provincial variations, with several jurisdictions currently crafting tailored energy storage frameworks. Notably, the Alberta Electric System Operator has outlined an Energy Storage Roadmap to integrate storage into its regulatory structure, grid, and market systems. Ontario leads in addressing energy storage, mandating an electricity storage license, while adhering to general laws and regulations, including Market Rules set by the Independent Electricity System Operator. These Rules establish a competitive, reliable electricity market. Financial incentives exist on federal and provincial levels. The Smart Renewables and Electrification Pathways Program provides $922 million (Canadian Dollars) over four years for energy and grid modernization, while the Smart Grid Program supports grid and storage upgrades for renewable integration. Provinces like Ontario and Yukon offer their funding programs. The Canada Infrastructure Bank has invested up to $170 million in Ontario's Oneida Energy Storage project, expected to be Canada's largest [15]. Provinces differ in how energy utilities exercise powers over DER owners. Crown corporations in vertically integrated systems, such as BC Hydro, possess expropriation authority. In Alberta, transmission utilities wield regulatory power within assigned zones, while the unregulated generation sector follows relevant statutory and legislative prerequisites without specific service rights.

5.3.2 Business model for purchase and sale of energy by DER

Electricity trading, including Distributed Energy Resources (DER), varies across Canadian provinces due to differing regulations. Proposed amendments to the Clean Energy Act in British Columbia would enable BC Hydro to buy electricity beyond provincial boundaries. Alberta employs private contracts for electricity trade within a competitive market supervised by the Alberta Electric System Operator (AESO). Power purchase agreements (PPAs) support small-scale independent power producers (IPPs) in selling electricity, with about 20% of Saskatchewan's power generated via IPPs and PPAs with SaskPower. BC Hydro suspended its "Standing Offer Program," previously streamlining IPPs' electricity sales. Ontario and Québec facilitate inter-provincial electricity trade through agreements known as the Electricity Trade Agreement [16].

Local authorities can acquire non-statutory services through local markets. For example:

- Provinces manage system balancing strategies, such as maintaining excess generating capacity or engaging in electricity trading with neighbouring utilities. BC Hydro collaborates with Alberta and US balancing authorities. Demand-side management and BC Hydro's role as the Reliability Coordinator also contribute to grid stability, as the electricity industry requires long-term strategies. Energy storage and Smart Grid technologies are emerging solutions [16].
- Electricity capacity markets compensate plants for future power supply or generation investments. Alberta's "energy-only" market determines wholesale prices based on supply and demand. The government considered introducing a capacity market by 2021 but later opted against it. Ontario's Independent Electricity System Operator is developing an incremental capacity auction proposal, though it hasn't been adopted by the government. The aim of capacity markets is to support cleaner electricity generation and stabilize prices, particularly during peak demand.

Effects of DER on planning, operation, network losses, reliability of supply and incremental costs

Canada still operates the conventional remuneration schemes in which CAPEX get an extra remuneration. TOTEX approach is not yet considered.

Distribution charges and conditions associated with electricity distribution are completely dominated by provincial (and to a large degree, sub-provincial) entities that preclude generalisations in a Canada-wide context. However, in virtually all cases distribution charges are assessed on a cost-of-service basis, even in provinces with de-regulated market structures [16].

5.3.3 Active demand response and smart metering

The implementation of smart meters across various Canadian provinces exhibits diversity and is primarily at the discretion of local utilities. While not obligatory in Alberta, DSOs have taken the initiative to introduce smart meters due to market dynamics, with the deployment process commencing during the COVID era. To execute widespread smart meter deployment, utilities must substantiate to regulators the societal benefits, conducting a comprehensive cost-benefit analysis. Consumer-level electricity rates are overseen by provincial regulators, typically adhering to a cost-of-service approach. Alberta and Ontario are exceptions, offering end-use customers the option of longer-term fixed price agreements with non-utility suppliers.

5.3.4 Local energy communities and microgrids

The legal framework of LECs and microgrid is not defined at national level, however several pilot projects were launched in order to gather the relevant data that are necessary to elaborate a national regulatory framework (see Figure 3)

RECIPIENT (PROVINCE/ TERRITORY)	PROJECT TITLE	ENERGY MARKET AND RATE INNOVATION	SOLAR	WIND	ADVANCED INVERTER FUNCTIONS	STORAGE	LOAD MANAGEMENT	EV INTEGRATION	ARTIFICIAL INTELLIGENCE	PROJECT TYPE	SYSTEM CATEGORY
Bracebridge Generation (ON)	Smart, Proactive, Enabled, Energy Distribution; Intelligent, Efficiently, Responsive (SPEEDIER) Project		•			•	•	•		Hybrid	DERMS
London Hydro (ON)	West 5 Smart Grid Project		•			•	•	•		Hybrid	DERMS
Alectra Utilities (ON)	Power.House Hybrid: Minimizing GHGs and Maximizing Grid Benefits		•			•	•	•	•	Demonstration	DERMS
Alectra Utilities (ON)	GridExchange	•					•		•	Demonstration	DERMS
Independent Electricity System Operator (IESO) (ON)	York Region Non-Wires Alternatives Demonstration Project	•	•			•	•			Demonstration	New markets & rate options (NRO)
Lakefront Utilities (ON)	Digital Utility Platform						•	•		Deployment	Grid monitoring and automation
Hydro-Québec (QC)	Smart Grid Deployment of Off-Grid Networks					•	•			Deployment	Microgrid off-grid, grid monitoring, automation and storage off-grid
Hydro-Québec (QC)	Lac-Megantic Microgrid		•			•	•	•	•	Hybrid	Microgrid-connected
Saint John Energy (NB)	Integrated Dispatchable Resource Network for Local Electric Distribution Utility		•			•	•	•	•	Hybrid	DERMS
New Brunswick Power (NB)	Collaborative Grid Innovation for Atlantic Smart Energy Communities	•	•			•	•			Hybrid	DERMS
Nova Scotia Power (NS)	Collaborative Grid Innovation for Atlantic Smart Energy Communities	•	•			•	•			Hybrid	DERMS
PEI Energy Corporation (PEI)	Slemon Park Microgrid Project		•			•	•		•	Deployment	Microgrid, DERMS

Figure 3 – Overview of the pilot projects implemented in Canada (source: [17])

5.3.5 DSO incentives for innovation

On top of the pilot projects described in Figure 3, the government plays a crucial role in providing financial support for microgrids in northern and remote areas. The federal administration committed to phase out diesel fuel by 2030 and has allocated increased funding to facilitate smaller-scale opportunities. Several funds have programmes were launched to support these goals and to support the DSOs in achieving this transition [18], as illustrated in Figure 4

Federal Initiative	Allocation (Year)
Smart Renewable and Electrification pathways (SREPS)	$964 Million (2021 - 2025)
Smart grid program	$100 Million (2019 - 2022)
Northern REACHE Program	$64.2 Million (2016 - 2019)
Arctic Energy Fund	$400 Million (2018 - 2028)

Figure 4 - Summary of federal and territorial initiatives, expressed in Canadian dollars (source: [18])

5.3.6 Summary

Table 4 summarizes the potential regulatory barriers that have been identified at the light of the information gathered during the survey.

Table 4 – Summary of the impact of regulatory aspects

Regulatory aspect	Impact	Short explanations
DER participation in network services and relationship with DSO	medium	Regulatory frameworks exist in Canada to allow to integrate storage units and DER in the operation of the network and to allow DER and Storage operators to sell some services to the different energy markets. However, the regulatory frameworks change among different regions and territories. These significant differences represent a potential barrier for potential investors that shall consider the different regulations and remuneration schemes when preparing a business model to operate DER and storage units at national level
Business model for purchase and sale of energy by DER	high	The trading of electricity (including DER) in Canada varies depending on the province and the governing regulations. Moreover, DER owners are allowed to trade their productions on wholesale markets only in certain provinces and territories
DG network access: connection charges and use-of-system charges	High	Distribution charges and conditions associated with electricity distribution are completely dominated by provincial (and to a large degree, sub-provincial) entities that preclude generalisations in a Canada-wide context. However, in virtually all cases distribution charges are assessed on a cost-of-service basis, even in provinces with de-regulated market structures. No special treatment is granted to DG owners to incentivize the connection of new DG units
Effects of DER on planning, operation, network losses, reliability of supply and incremental costs	High	Canada still operates the conventional remuneration schemes in which CAPEX get an extra remuneration. TOTEX approach is not yet considered. This regulatory scheme represents a significant penalty for the operators that want to invest in digital solutions that typically are associated to digitalization investments and to the investments needed to implement the Platone solutions. To overcome this barrier, Canadian regulators shall experiment the TOTEX approaches
Active demand response and smart metering	Medium	The deployment of smart meters (AMI) in Canada varies among the different provinces but it is mostly based on a voluntary decision of the local utility. At consumer level, electricity prices are regulated by provincial regulators and vary significantly among the different Canadian Provinces, generally on a cost-of-service basis. Only a few

		provinces such as Alberta and Ontario offer end-use customers the choice of longer-term fixed price arrangements with non-utility suppliers. These significant differences represent a potential barrier for investors that want to deploy the Platone solution at a large scale due to the differences in regulatory and remuneration schemes. However, several pilot projects have been financed at national level in order to gather information that could be used to develop business models
DSO incentives for innovation	Low	Several pilot projects have been financed at national level to gather information that could be used to develop business model. These pilot projects can support new investors and regulators to find enough data to develop innovative regulatory schemes and to guide future decision investments.

6 Main findings obtained from the literature review

The results reported in chapter 5 are complemented with additional results obtained from the analysis of the relevant literature and further documentations suggested by the experts. These results tackle the context boundary conditions describing the general characteristics of the Canadian energy system (reported in sub chapter 6.1) and stakeholder conditions (sub chapter 6.2)

6.1 Context boundary conditions

Globally, Canada represents world's sixth largest electricity producer (2% of world production in 2018) and it is the world's third largest energy exporter (8% of world export in 2018). All Canadian electricity trade is with the US (2019) Canada is the world's third largest producer of hydroelectricity (2020). The Canadian energy industry generated 641.1 TWh of electricity in 2018. 14.8% of Canada's electricity is produced from nuclear generation (2018) and 7.4% of Canada's electricity is produced from coal (2018) while 59.6% of Canada's electricity is produced from hydropower (2018) [19]. The Canadian transmission system is operated by 14 Transmission Facility Owners (TFO) that serve a specific province of the Country.

The responsibility to control generation and transmission of power is assigned to provincial governments. The policies, the market and the industrial structure of the Canadian power system changes according to the regulation adopted in each province. In some provinces the unbundling process started several years ago while in other provinces the energy sector is still vertically integrated Figure 5. These significant differences in the market and industrial structure in each region have an impact on the replicability potential of the Platone solutions in Canada.

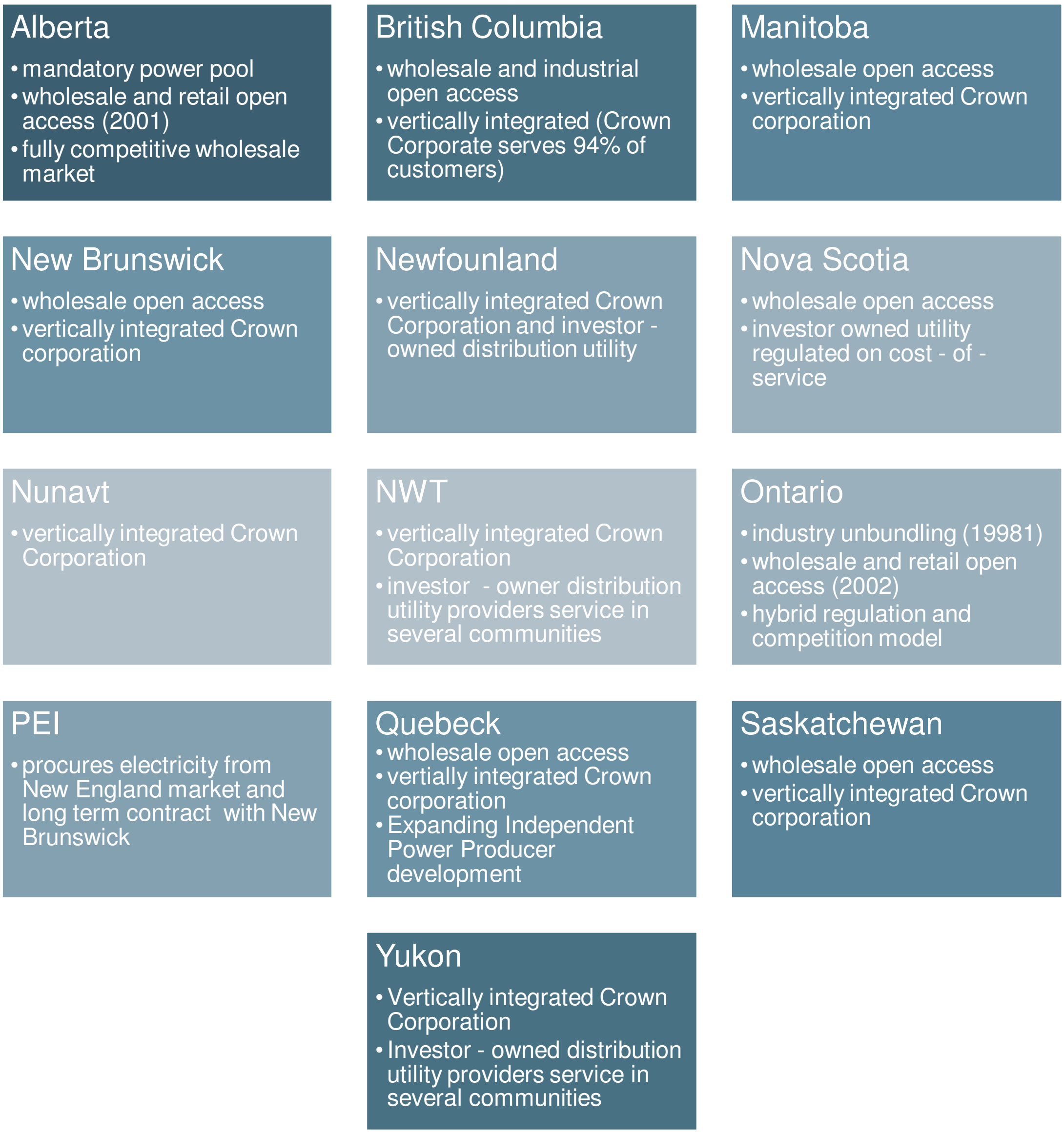

Figure 5 – Characteristics of the different Canadian energy markets (source: [19])

In those provinces characterized by an unbundled energy sector, TFO and Distribution Facility Owners (DFO) are regulated as monopolies that control a specific control area. In these situations, the cooperation between TFOs and DFOs is allowed only for specific tasks (e.g.: congestion mitigation of transmission and distribution lines; management of transmission-distribution interface; voltage support).

Figure 6 illustrates the location and the typology of the Renewable Energy Sources (RES) installed in Canada. As stated in previous paragraph, the majority of the RES installed capacity is represented by hydro power plants, however, especially in the latest year, the penetration of wind farms and Photovoltaic (PV) plants had significantly increased as illustrated in Figure 7

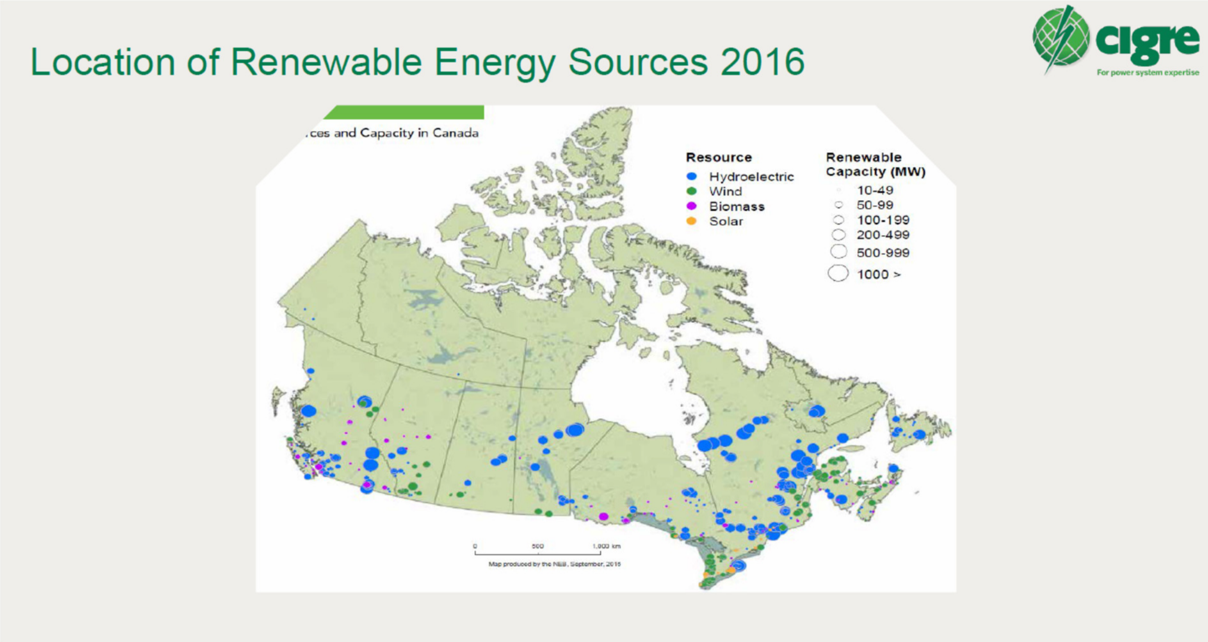

Figure 6 – Location and typology of Renewable energy sources in Canada (source: [19])

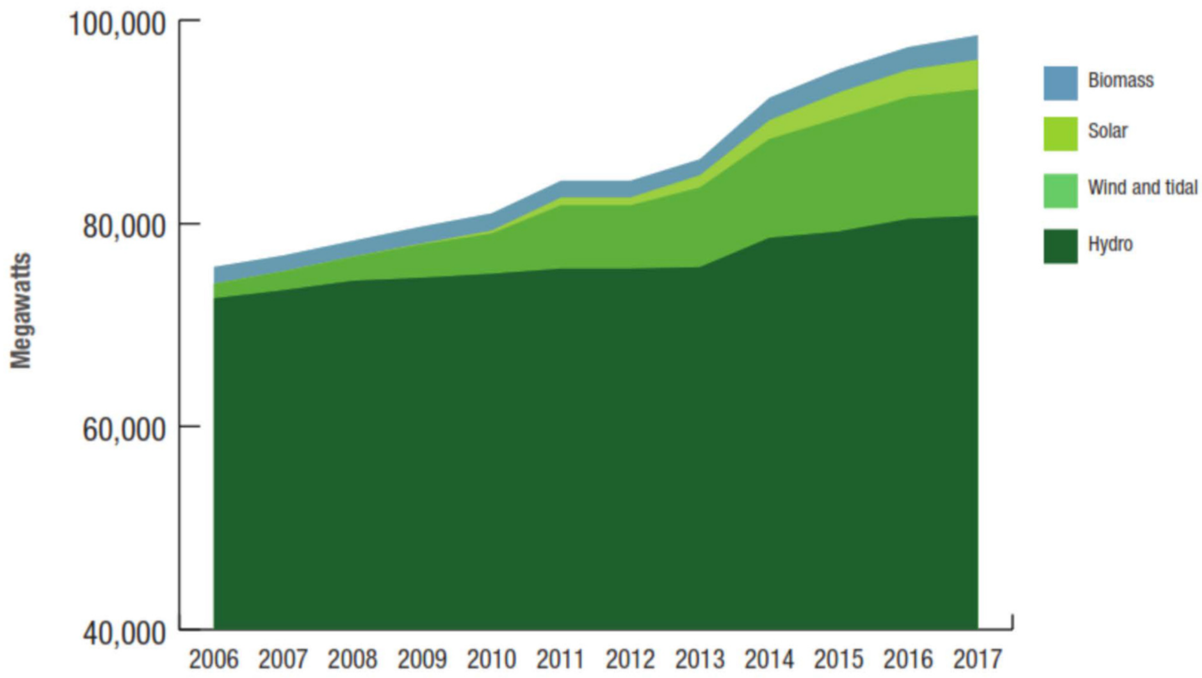

Figure 7 – RES installed capacity and yearly production in Canada (source: [19])

As illustrated in Figure 8, the installed capacity of PV power plants has increased by 151% since 2013 while the production of PV panels tripled with respect to the 2013 data. Typically, PV panels represent distributed generation units that are connected to MV and LV grids. In order to safely connect these units to the existing grids, significant modifications on the conventional approaches adopted by the utilities to plan and operate the grids are needed (e.g.: avoid the intervention of protections, prevent the reverse power flows from distribution to transmission grids etc.).

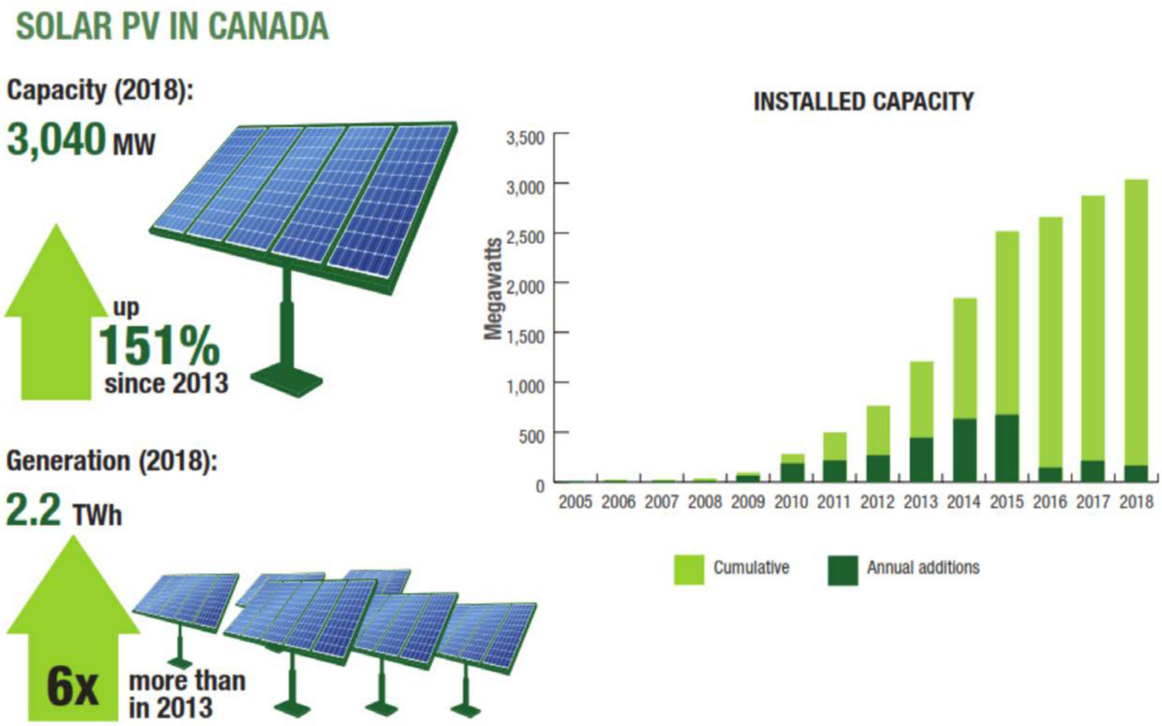

Figure 8 – Installed PV capacity in Canada (source: [19])

However, these distributed resources can also contribute to solve local network problems (congestions, peak load reductions, voltage problems) and can thus support the DFO to safely operate the grids. In the long terms, the provision of flexibility services can also support the DFO in the grid planning activities and the flexibility services enabled by these sources will allow the DFO to avoid or postpone conventional grid investments like the replacement of existing transformers or the construction of new lines. This contribution has already been acknowledged and supported by national energy strategies and by Directives issued by the European Union [20], [10]. These benefits can help the DFO to reduce the costs related to the grid maintenance and development and therefore, it can lead to a significant reduction of the grid components of the electricity bill. In fact, in Canada, different energy prices can be noted among the different market zones of the Canadian energy grids, as illustrated in Figure 9

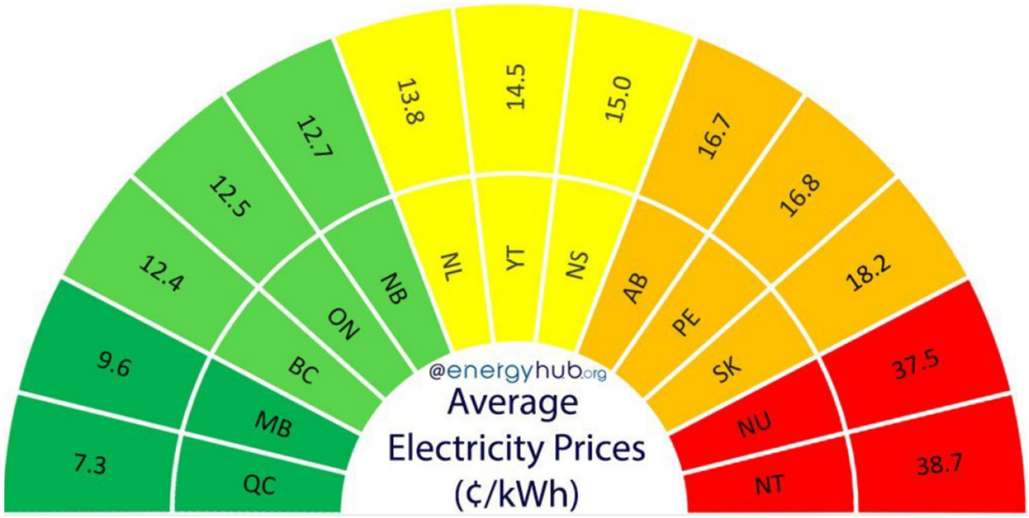

Figure 9 - Different energy prices can be noted among the different market zones of the Canadian energy grids (source: [19])

To enable the DER to provide these services, the DFO shall develop, test and integrate into existing energy system digital platforms that can monitor in real time the status of network components, the potential grid problems that might arise and the contribution of flexible generators and loads. In fact, flexibility is a key resource in a scenario in which the grid is more and more changing from being a load-driven system to a generation-driven system, given the limited control capability on energy infeed from renewable energy generation plant. This process implies also that the changes are not only related to the operational aspects but also to the market element. Digitalization and interoperability are key enablers of this process, opening the way to smart and efficient management of data sources in a secure way and making the separation between market and operation less meaningful. The consortium of Platone project had developed and tested a blockchain platform aimed at enabling this transition. This platform enables the following advantages: enabling new mechanisms for customers engagements and empowerment of local energy communities; transparent unmodifiable data management and sharing is preserved and guarantee; multi-party data sharing can be seamlessly extended to data collected in the field for operational purposes and not only for market reasons.

6.2 Stakeholders engagement

As stated in sub chapter 2.4, the stakeholders analysed in the survey are regulatory Authorities, Ministries, grid regulators and energy agencies.; Grid operators (DFO and DSO), energy producers and distributed energy resources owners; end Customers: Industrial customers, retailers, households and finally manufacturers and providers.

6.2.1 Regulatory Authorities: Ministries, Grid regulator, energy agencies

The Canada Energy Regulator (CER) [21] is the agency of the Government of Canada under its Natural Resources Canada portfolio, which licenses, supervises, regulates, and enforces all applicable Canadian laws as regards to interprovincial and international oil, gas, and electric utilities. CER, among its duty, prepared in 2023 the report "Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050 (EF2023)" [22]. It is the latest long-term energy outlook from the CER. The Canada's Energy Future series explores how possible energy futures might unfold for Canadians over the long term. EF2023 focuses on the challenge of achieving net-zero greenhouse gas (GHG) emissions by 2050. It contains three scenarios: Global Net-zero, Canada Net-zero, and Current Measures, described in Figure 10

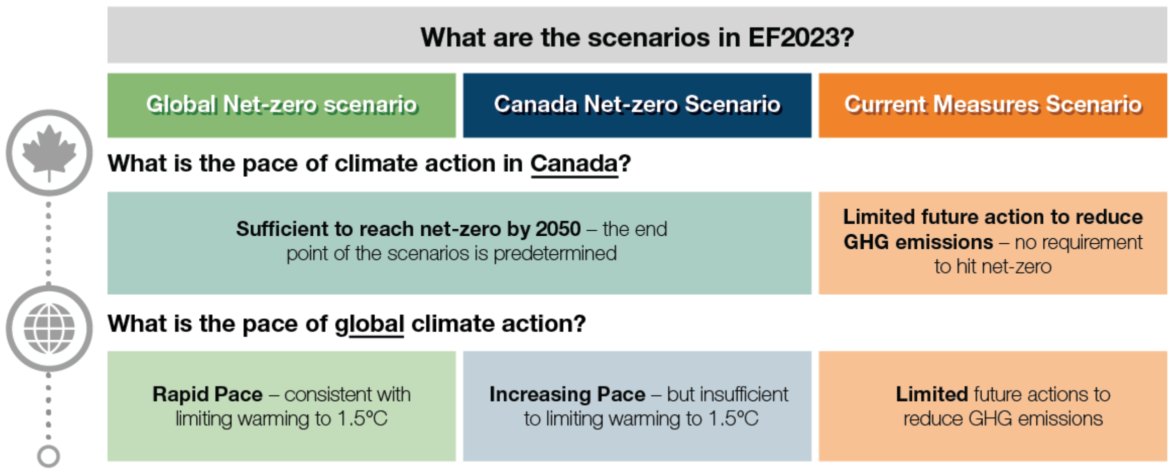

Figure 10 - Illustration of the scenarios in EF2023 (source: [23])

The main conclusions of this study include the following statements:

"In the net-zero scenarios, the types of energy Canadians use change dramatically, including using a lot more electricity. In both net-zero scenarios, electricity use increased more than double from 2021 to 2050, becoming the dominant energy source in the energy system. With greater use of low and non-emitting energy sources, fossil fuel use drops by 65% from 2021 to 2050 in the Global Net-zero Scenario, and by 56% in the Canada Net-zero Scenario. Fossil fuels still play an important part in the energy

system, with much of the fossil fuel in 2050 used at industrial facilities outfitted with carbon capture technology. Electricity will also be used for heating and cooling services in Canada.

The electricity system, which decarbonizes by 2035 and achieves net-negative emissions, thereafter, is the backbone of our net-zero scenarios. In both net-zero scenarios, the electricity sector transforms to accommodate increasing electricity use while also rapidly decarbonizing electricity production. By 2050 in both net-zero scenarios, more than 99% of electricity is from non- or low-emission technologies, connected to all levels of electricity grids. Solar generation increases steadily in both net-zero scenarios, making up 5% of total generation by 2050 [21]".

The results of these scenarios prove that, in order to achieve the decarbonization targets set in the net zero scenarios, a significant role must be played by innovative resources, that are distribute all over the Canadian grids and connected to different voltage levels. To accommodate these innovative technologies, significant changes in the current approaches that are adopted to plan and operate the grids must be adopted. The CER did not refer in their studies to the transformations that shall be implemented by the network operators to enable this transition. These plans are published by the local network operators.

6.2.2 Grid operators DSO or DFO

The Canadian electricity distribution grids are operated by several independent DSOs or DFOs as illustrated in Figure 11 Utilities represent the main respondents of the survey; therefore, they represent the companies that are addressed in the sub-chapters 5.1.1 and 5.1.3.

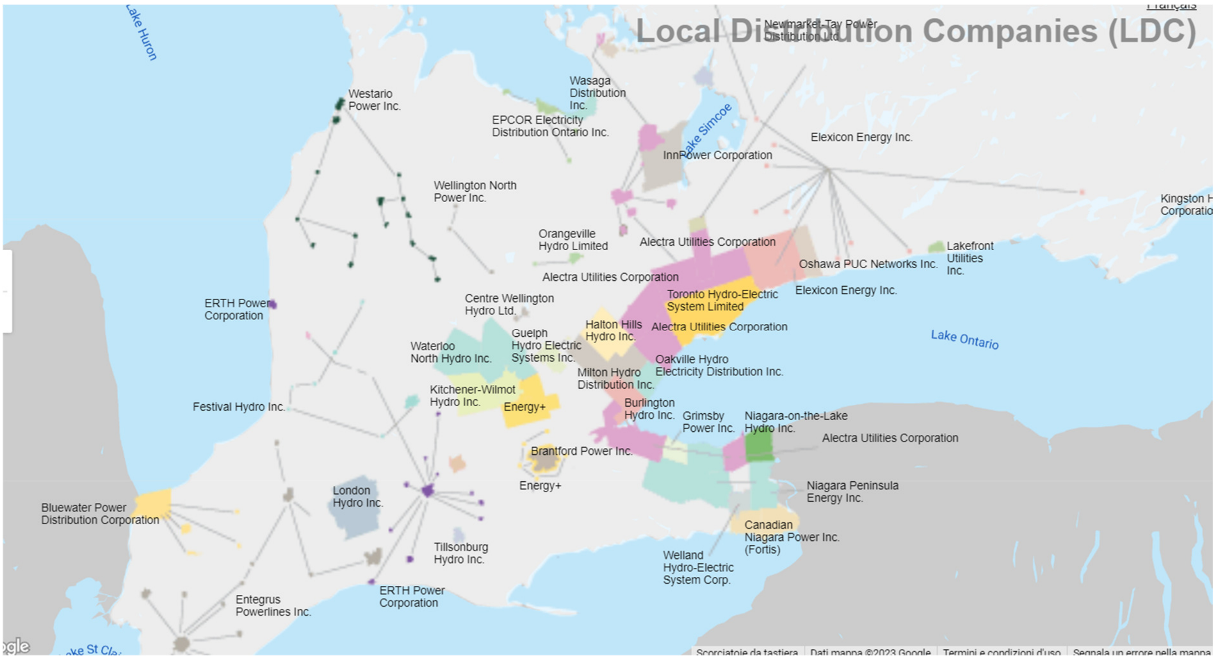

Figure 11 – Map of Canadian distribution company (source: [24])

EPCOR Utilities Inc. is a utility company based in Edmonton, Alberta. EPCOR manages water, wastewater, natural gas, and electricity distribution systems in the Canadian provinces of Alberta, British Columbia, and Ontario, and the American states of Arizona, New Mexico, and Texas. EPCOR is a municipally owned corporation with the City of Edmonton as sole shareholder. EPCOR performed, in cooperation with the University of Alberta a study that assessed the potential risks for the distribution networks caused by the massive PV penetration expected in the scenarios prepared by the Canadian regulator [25]. The study allowed to reach the following conclusions:

- The main impacts of DER in the distribution grid are in terms of voltage quality (over- and under-voltage) and infrastructure capacity (power lines and transformers overloading). Effects on protection, fault levels, and fusing were investigated, but yielded no significant effects, and are therefore omitted from this paper for brevity.

- EPCOR's grid is well-positioned for PV uptake, if customers stick to 'appropriately' sized arrays (and exceptions can be easily identified based on topology).
- The near-term and most significant challenge is in-house EV charging. Even for relatively small penetration levels, due to the peak load overlapping, they represent potentially significant loading impact to local infrastructure (especially if clustered in certain areas).
- Although customer equipped with an electric storage face similar issues like PV when discharging and like EV when charging, they have much more flexibility in terms of control and can be treated as a longer-term challenge.
- There is a need for further analysis and pilot projects in order to assess non-wire alternative measures (which make use of advanced control schemes, power electronics, communication, and control) and/or regulatory changes (e.g.: dynamic pricing, increase allowance for capacity, demand-response, EV charging limiting / control) [25].

6.2.3 Energy producers: Distributed Energy Resources

The penetration of DER in the power system involves new challenges to the system operation and planning to ensure supply reliability and economic efficiency. The correct connection of DER and their participation in network services may contribute to achieve these goals but an appropriate regulatory framework should be in place, so DER perceive the right incentives.

6.2.4 End customers: Industrial customers, retailers, households

Consumers are the end users of the power system but historically they have been considered only as passive actors. However, within the smart grid paradigm they are expected to play an active role, although this change highly depends on their degree of awareness with all the new opportunities that are starting to arise, like participating on Demand Side Management programs or adopting dynamic pricing or self-consumption initiatives. As seen in Figure 5, significant differences in the unbundling process exist among the different Canadian Regions, therefore a significant effort might be requested in order to harmonize the regulatory and market frameworks.

6.2.5 Manufacturers and providers

Equipment manufacturers and ICT service providers are also key actors to make smart grids happen. The large-scale deployment of smart grids requires the integration of several new devices and makes use of secure and reliable communications infrastructures. Notwithstanding, the use of standard, open and interoperable technologies is critical to ensure the proper functioning and efficiency of smart grid implementation Use cases addressed by Platone demos to be replicated in Canada.

7 Conclusions

The goal of D7.5 was to perform a qualitative analysis of the replicability potential of the Platone solutions in the Canadian energy system. This exercise was executed considering the boundary conditions and recommendations suggested by past projects that carried out a similar exercise.

The characteristics of the boundary conditions were found in the overview of the relevant scientific literature and are complemented by the survey prepared by Platone and distributed among relevant Canadian stakeholders.

Following the analysis of the barriers to Platone functionalities, rules and methods for scaling-up and replication have been established. These guidelines were formulated based on the relative impact of the implementation barriers associated with each functionality. The qualitative comparison chart in the following section presents the summarized impact of the implementation barriers for each solution as shown in the chapters before.

Table 5 – Relative impact of the implementation barriers of the Platone Solutions

Solution	Technology	Context	Regulatory	Stakeholders

Local Energy Communities	Low	Low	Medium	Medium
Virtual Power Plant (VPP) as a support for DSO	Low	Low	Medium	Medium
Flexibility Based Reinforcement Planning	Low	Low	High	High
Flexibility provision by distributed resources	Low	Low	High	High

7.1 Common barriers and enabling factors

From the analysis of the data gathered, a set of barriers that are common to all 4 solutions can be identified:

Regarding the stakeholder engagement aspects, the main barriers are represented by the lack of methodologies for performing cost benefit analysis of the innovative solutions in Canada, consequently it is also difficult to identify the optimal mechanism to remunerate the parties that would like to implement the Platone solutions to provide flexibility services of mentioned solutions to the network operators. Moreover, to implement these changes in the daily operation of utilities of the 4 solutions, big changes are required. According to the respondents, a lot of internal approvals within the corporate structure is needed to ensure to maintain the same level of quality of service while implementing these innovations. Regarding technological aspects, the main barriers are represented by Data privacy, security concerns and by the lack of non- proprietary standards.

On the contrary, the common enabling factors and barriers found in the literature overview (this was not analysed in the survey) that might impact on the need to invest in the solutions tested in Platone are:

- The commitment of the Canadian Government to achieve the policy target stated in the "Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050 (EF2023)" [22]. EF2023 focuses on the challenge of achieving net-zero greenhouse gas emissions by 2050. This aspect, that has been highlighted in the description of the "context" aspects, demonstrates that the solutions implemented in Platone can provide a significant contribution to the achievement of the Canadian energy policy goals. According to the conclusions of the EF2023 study, the Canadian regulator states that "We project that many provinces utilize this flexibility in both the Global Net-zero Scenario and Uncoordinated Charging Case to offset peak periods of demand. Without this demand flexibility, the difference in peak demand in the two scenarios would have been higher, requiring more investment in new generation in the Uncoordinated Charging Case". This statement proves that all the solutions that can support the penetration of demand flexibility are key enablers of the Canadian energy policy.
- The challenges that the local utilities must solve to accommodate the huge increase of distributed energy resources, while keeping the costs for upgrading and operating the grid within reasonable limits.
- The significant differences among energy prices that exist in the different Canadian regions might motivate the customers that live in areas characterized by high electricity prices to invest in solutions that promote local productions, self-consumption and might help the DSOs to operate the distribution grids.
- The characteristics of the Canadian context are favourable for the deployment of the 4 solutions; in fact, the Canadian energy strategy and the future scenarios foresee a huge increase of distributed generation in next decades. However, as demonstrated also in several studies [25] and [21], it will not be possible to accommodate such a huge increase of DG with conventional grid investments. Grid reinforcement investments must be therefore complemented with

innovative solutions that exploit the contributions of flexibility services provided by DGs and flexible loads, like the 4 Platone solutions.

7.2 Local energy communities

The survey results confirm the absence of significant technological barriers for the extensive implementation of this solution. In fact, all required components can be seamlessly integrated into systems and installed on end users' premises. Furthermore, utilities have already established communication systems facilitating interaction among DG, loads, and DSO control centers. The primary technical obstacle tied to this solution pertains to Advanced Metering Infrastructure (AMI) deployment. The path to widespread AMI implementation closely aligns with utility investment plans, potentially leading to delays in specific Canadian regions.

In terms of the regulatory framework, substantial disparities among Canadian regions pose significant barriers. These discrepancies span regulations regarding DER participation in network services and business models for energy trading involving DER-produced energy. These discrepancies potentially hinder potential investors who must account for varying regulations and remuneration structures while devising business models for operating DERs and storage units adaptable to diverse regulatory frameworks within Canada. Conversely, notable variations in energy prices across Canadian regions can potentially motivate customers in areas with high energy prices to invest in self-consumption solutions like local energy communities and Virtual Power Plants. Additionally, the presence of diverse pilot projects experimenting with Virtual Power Plants and local energy communities across Canadian regions serves as an enabling factor. These initiatives provide valuable insights for conducting cost-benefit analyses, creating business models, devising suitable remuneration schemes, and more. Concerning stakeholder involvement, significant operational changes must be introduced within the corporation to facilitate the deployment of local energy communities by local utilities.

7.3 Virtual Power Plant (VPP) as a support for DSO

Some Canadian utility companies have already implemented communication systems that enable data exchanges with distributed devices. One significant technical challenge for this solution lies in the deployment of AMI. The successful large-scale deployment of AMI is closely tied to the utilities' investment plans, and the differences among Canadian regions may lead to delays in certain areas. As for the regulatory framework, substantial variations exist among the different Canadian regions regarding the regulation of DER participation in network services and the business models for buying and selling energy produced by DER. These differences could pose potential barriers for investors who need to consider various regulations and remuneration schemes while developing a business model for operating DER and storage units at the national level. However, the considerable differences in energy prices among Canadian regions may serve as a motivating factor for customers residing in areas with high energy costs to invest in self-consumption solutions such as Virtual Power Plants. Furthermore, the presence of diverse pilot projects experimenting with Virtual Power Plants and local energy communities in different Canadian regions provides valuable data for conducting cost-benefit analyses, developing business models, and designing appropriate remuneration schemes.

7.4 Flexibility based reinforcement planning

The main enabling factor that can promote the deployment of this solution in Canada is represented by the need to accommodate a large penetration of distributed renewable while keeping the costs for reinforcing the grid low and to enable the distributed resource to manage the electricity system.

However, the main barriers that might hamper this solution are represented by the lack of familiarity among the utilities about this solution. Moreover, the Canadian regulator still implements the conventional remuneration schemes in which CAPEX get an extra remuneration. TOTEX approach is not yet considered. To promote investments that improve the observability of the grid, innovative regulatory approaches that establish an equal remuneration for CAPEX and OPEX shall be implanted, for example the mechanism implemented by the Italian Regulatory Agency [26].

7.5 Flexibility provision by distributed resources

The main barriers that might hamper this solution are represented by the lack of familiarity among the utilities about it. The main regulatory barriers associated to this solution are:

- Electricity distribution charges and conditions are primarily controlled by provincial (and to a large extent, sub-provincial) entities, making it difficult to generalize in a Canada-wide context. Nevertheless, across most cases, distribution charges[1] are determined based on a cost-of-service approach, even in provinces with deregulated market structures.
- Regarding DER participation in network services and its relationship with DSO (Distribution System Operator), regulatory frameworks are in place in Canada to facilitate the integration of storage units and DER into the network's operation, allowing operators to sell certain services to different energy markets. However, these regulatory frameworks vary among different regions and territories, posing a potential barrier for investors who need to consider diverse regulations and remuneration schemes when developing a business model for operating DER and storage units at the national level.
- Regarding the business model for the purchase and sale of energy by DER, the trading of electricity, including DER, differs depending on the province and the governing regulations. Moreover, in certain provinces and territories, DER owners are permitted to trade their energy productions on wholesale markets only.
- Concerning DG network access, including connection charges and use-of-system charges, the control of distribution charges and associated conditions lies predominantly with provincial (and to a large extent, sub-provincial) entities, making it challenging to make blanket statements that apply nationwide. However, in almost all cases, distribution charges are calculated based on a cost-of-service basis, even in provinces with deregulated market structures. No special incentives are provided to DG owners to encourage the connection of new DG units.

7.6 Final remarks

In this sub-chapter, common barriers and enabling factors for the analysed solutions have been identified based on the survey materials collected. Across all solutions, stakeholder acceptance is pivotal in determining the success of innovative solutions. Barriers encompass the absence of adapted cost-benefit analysis methodologies within the Canadian context, hindering optimal remuneration mechanisms for parties aiming to implement Platone solutions for providing flexibility services to network operators. Furthermore, substantial corporate structural changes are required for implementation, while upholding service quality. Shared technological barriers include data privacy and security concerns, along with a lack of non-proprietary standards. Overcoming these hurdles is essential for successful deployment. Enabling factors that can encourage investment in Platone-tested solutions encompass the Canadian Government's commitment to achieving net-zero greenhouse gas emissions by 2050, challenges faced by local utilities with growing distributed energy resources and grid cost management, and considerable energy price discrepancies among Canadian regions. These factors may drive investments in self-consumption solutions like Local Energy Communities and Virtual Power Plants. Each solution has its specific barriers and enablers. For example, Local Energy Communities face minimal technological hurdles but encounter regulatory and stakeholder involvement challenges. Virtual Power Plants' deployment tackles technical obstacles tied to Advanced Metering Infrastructure, in addition to varying regulatory barriers. Flexibility Based Reinforcement Planning demands addressing utility unfamiliarity and innovative regulatory approaches for fair remuneration. Lastly, flexibility provision through distributed resources encounters obstacles concerning utility awareness and complex regulatory landscapes linked to distribution charges and network access. To ensure the triumphant implementation of these solutions in Canada, it's imperative to address identified barriers through comprehensive cost-benefit analysis methodologies, fortified data privacy measures, standardized practices, and regulatory alignment. Enhanced awareness and comprehension among stakeholders, coupled with supportive government policies, will be vital for their broad acceptance and integration within the Canadian energy framework.

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[1] Distribution charges cover the cost of moving electric energy from the transformers through local, lower-voltage lines that carry electricity to the customer’s meters.

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11 List of Abbreviations

Abbreviation	Term
AESO	Alberta Electric System Operator
AMI	Advanced Metering Infrastructure
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
DEMI	Development of a Distributed Energy Management Initiative
DER	Distributed Energy Resources
DFO	Related Term
DG	Distributed Generators
DMS	Demand Management System
DSO	Distribution System Operator
EC	European Commission
EDTI	EPCOR Distribution and transmission, Inc
IESO	Independent Electricity System Operator
IPP	independent power producers
NRA	National Regulatory Agency
OPEX	Operative Expenditure
PCF	Pan-Canadian Framework
PMU	Phasor Measurement Units
PV	Photovoltaic
RES	Renewable Energy Sources
SCADA	Supervisory control and data acquisition
TFO	Transmission Facility Owners
TOTEX	Total Expenditure
TSO	Transmission System Operator
V2G	Vehicle-to-Grid
VPN	Virtual Privat Network
VPP	Virtual Power Plant