D5.9: Playbook of regulatory recommendations for enabling new energy systems

+CityxChange | Work Package 5, Task 5.4

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List of Acronyms

AMS	Advanced Metering System
CSO	Community Grid System Operator
DNO	Distribution Network Operator
DSO	Distribution System Operator
EC	Energy Community
EPC	Energy Performance contracts
EV	Electrical Vehicle
LEM	Local Energy Market
PEB	Positive energy block
PED	Positive energy district
PV	Photovoltaic
P2P	Peer to peer
RME	Reguleringsmyndigheten for Energi, The Norwegian Energy Regulatory Authority
TSO	Transmission System Operator
V2G	Vehicle to Grid
+CxC	Positive City Exchange (+CityxChange)

Executive Summary

In the +CityxChange project we have designed, described and demonstrated local markets in principle based on a wide range of lessons learned from the existing European power market, and documented in several +CityxChange deliverables. An important area is mapping of the existing regulatory framework and how this is influencing the power market roles both in a global and local market set-up (Bertelsen, Livik and Myrstad 2019). This report discusses in detail how regulatory issues premise the development of a PEB/PED (Positive Energy Block/District) focused on the Trondheim, Norway case, but with application on the EU level. The dispensation applications for the local demonstrations, which ask for permissions to demonstrate local energy markets in a way that strengthens the incentives to develop and operate PEB/PED, are the outcome of the discussion with the national regulator for Norway. The dialogue and applications are done with a post-energy transition understanding as guidelines. An energy *system approach and understanding* was addressed in the dialogue. This was a prerequisite to understand the determining factor a renewed regulatory framework represents in the green transition.

To fully cover all local energy system issues and market actions, a methodology was chosen that decomposed the energy system operation in a list of simplified actions. The issues and actions were then analysed and recommendations were given for changes of the regulatory framework.

Key issues discussed in detail are the fast growth of installed distributed renewable energy resources, energy/capacity storage, and customers' flexibilities. In addition it is analysed how the existing power market construction with roles and actions could – and should – be transformed to markets tailored to serve all local renewables and flexibilities. Regulatory barriers that may stop and slow down the energy transition are identified. As a result, the +CityxChange project in Trondheim has applied to the regulator for dispensations from existing Norwegian rules regarding market operation and settlement/accounting.

The process to overcome regulation obstacles is managed stepwise and ends with the realisation of the PEB/PED. The process has been supported by a joint understanding of what will be the situation in a post-energy transition phase (ref. figure 0.1). Using this strategic approach, regulatory barriers have been defined both for the demonstrations and more generally for local energy systems. The barriers are identified as critical both when it comes to investments in renewables and flexibility and to how their value shall be justified in operational phases in a PED/PEB, including local market set-up.

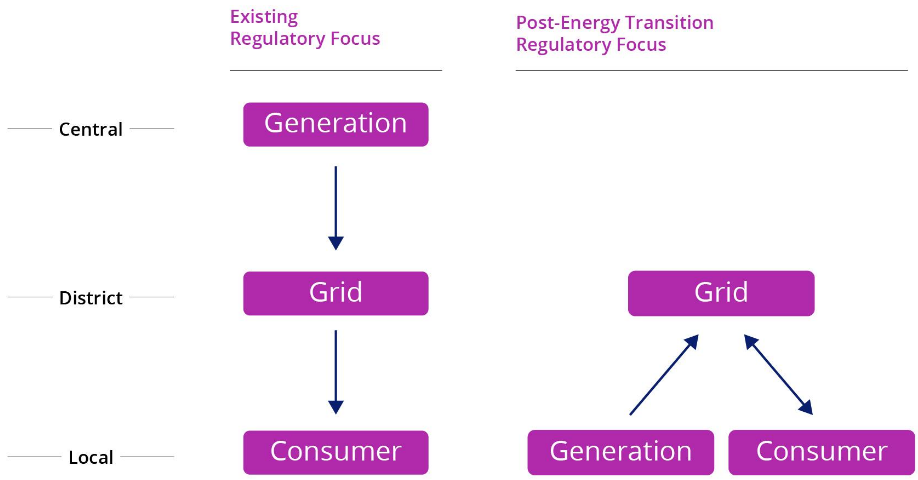


Figure 0.1 Post-energy transition regulatory focus compared with regulatory focus in the existing central dominated energy system.

The dialogue with the regulator was especially valuable during the application phase, defining how the demonstration should be able to execute. The decided demonstrations introduce operation of local energy systems, including local markets and support, and accelerate processes to establish positive energy blocks (PEB), districts (PED) and positive energy cities.

The following list shows recommendations of what must be renewed within the responsibility of actual regulatory framework:

- In local energy systems, the grid operator must be given the possibility to establish tariffs and agreements based on local conditions (load, generation, grid).
- PEB/PED as an energy system must be allowed to operate on local conditions.
- Local energy resources must have the right to operate within a framework supporting the energy transition.
- Regulation must change in a way that makes DSO a green transition catalyst.
- Regulation must open up for licenses in favor of local market operation.
- Market settlement/invoicing must be possible to execute for third parties.
- New entrants and new business models are positioned to feed the green transition.
- Energy Communities - and PEB/PED - must be given permission for expansions and innovation without extensive approval processes.
- Sector coupling of electricity and heat, with an energy system approach, must be addressed for the actual regulatory bodies.

The pending energy challenge in Europe emphasizes the need to accomplish functioning local energy markets.

1 Introduction

Task T5.4, Enabling Regulatory Mechanisms, has been an important part in the process of setting up the +CityxChange demonstrations in Trondheim. This report is the project deliverable "D5.9: Playbook of regulatory recommendations for enabling new energy systems" and documents methods, analyses and results focusing on regulatory issues in the process towards PEB/PED. The deliverable is structured to address definitions, descriptions and details for how new energy systems should be established and operated in a post-energy transition phase. The deliverable has the form of a playbook - and to some extent a document that at a rather basic level explains roles and actions in new energy systems - in a local market landscape.

A critical factor of success for all well functioning markets - including the energy market - is that they follow a regulatory framework that promotes innovation, intended incentives and scope of market operation and participation. The European Green Deal[1] and the energy transition are significant forces that will entice reorganisation and change, and well functioning markets are a prerequisite.

Within the European power sector, with its centralised system, it is experienced that the power market during the past decades has functioned well at both the wholesale and retail level. Customers have the possibility to choose suppliers and the producers have a marketplace to place their bids. The grid operators act as natural monopolies ensuring that the electricity is delivered at sufficient quality. Electricity is a critical societal good that must be regulated when it comes to production, market, transport, and customer rights and obligations. This is managed within complex regulatory frameworks within member states supported and coordinated by the EU.

The basic regulatory framework was introduced when the power industry was unbundled and the wholesale market was established. Next step was the introduction of the retail market which gave customers (previously named consumers) the right to choose among suppliers. The suppliers act as links between the wholesales market and the end customer. Regulation was developed for the purpose of serving a centric oriented power system - without significant connection of distributed energy resources/renewables.

In the process of developing future-proof energy systems in line with the ambitions of the energy transition, it is important to identify and use lessons learned from the existing European power market. To move from a centralised to a decentralised power system operation approach is impossible without understanding and using new technology, fully digitalised processes and the maybe most crucial task: A flexible and updated regulatory framework.

The +CityxChange project includes demonstrations of how local energy market set-ups may help to realise PEB/PED. In Trondheim the demonstrations were executed in the Brattøra and Sluppen city areas. These are areas involved in the project as PEBs within defined

[1] European Green Deal: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

system borders, with defined buildings, and local energy resources inclusive flexibility and eMobility.

The set-up and realisation of the demonstrations includes tasks that need dispensations from the existing energy regulatory framework in Norway to be executed. In the preparation of the task it was clarified that dispensations from the existing regulatory framework were required for the demonstrations. The complete value chain of energy supply from power generation to the consumer including transport, system operation, and trade is in detail operating in line with a regulatory framework at national levels. In addition, it is at EU level several ongoing projects and initiatives addressing regulation of the energy industry in the perspective of the green energy transition.

In the +CityxChange project the scope is to demonstrate local energy systems as a part of the process regarding development and operation of positive energy blocks (PEB) and districts (PED). The situation is that in most European states, the energy regulatory framework challenges the processes towards an operative PEB/PED. This process is critical to properly address and come up with joint understandings and dispensations, making it possible to execute planned demonstrations of local energy systems and markets that provide PEB/PED incentives. Figure 1.1 describes the actual steps that involve the regulatory bodies in this process.

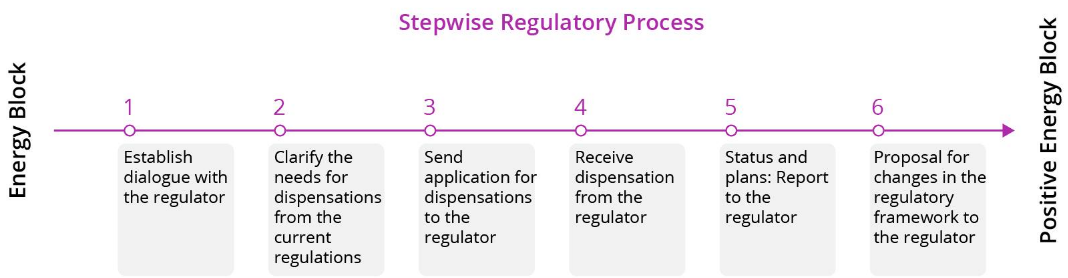


Figure 1.1 Process map of six identified regulatory key-stones to focus on in the process of establishing a PEB (Bertelsen et al. 2019).

The process is identified as 6 different steps that includes close dialogue between +CityxChange and the national regulator. Dialogue with the regulator clarified the need for dispensations and actual applications prepared. It is important to underline that the involved regulations were identified and discussed with the regulator in the perspective of a post-energy transition phase, with an increased share of connected local energy resources including Energy Communities and operative local energy markets.

This report focuses on the steps 1, 2 and 3 and how regulation works and why dispensations are required to execute the demonstrations. Steps 4, 5 and 6 are solely dependent on dispensations asked for, and since the project still awaits approval, these steps are not addressed.

1.1 Prerequisites and connection to other tasks within +CityxChange

The energy performance contract (EPC) part of the work was originally (as per Grant Agreement) part of Task 5.4, due to the expected importance of national regulations for realising EPCs in Trondheim. However, the EPC development and implementation work in Trondheim is mainly a business matter with developing local commercial preconditions to stimulate rollout of EPCs. The EPC work in Trondheim thus belongs more naturally to the scope of Task 5.11 - Sustainable Investment - and will be addressed in D5.16, "+Trondheim sustainable investment and business concepts and models".

Task 5.11 analyses and accentuates improvements of existing business models, where effects of frame condition changes, including regulatory mechanisms, will be taken into account. The analysis and deliverable from the work with T5.11 (D5.16) will include scenarios on how and to what extent legislative and regulatory changes from T5.4 may improve business models on a longer timescale. D5.16 "Sustainable investment and business concepts and models", is scheduled for deliverable after the D5.9 report.

This deliverable is based on the overall guidebook on regulatory mechanisms (Bertelsen et al. 2019). It describes the special regulatory district guidelines and framework for innovative planning, policy, and procurement within the city including energy, planning, conservation, fire safety and building regulations. In the prevailing report (D5.9) the focus is mainly on energy, since we discovered through the implementation of the PEB that this was the most challenging part of the regulatory issue. Planning, conservation, fire safety and building regulations proved to be of no importance in the T5.4 work. However, these topics are highly important in the work on setting up and implementing the PEBs at Brattøra and Sluppen. The process of solving these issues will be described as a part of the implementation of PEB in Task 5.6, Trondheim PEB Demonstration, and included in D5.11 (Trondheim DPEB Demonstration).

The work in T5.4 is influenced by how to innovate in the financial sector (FinTec) further described in D2.1 "Enabling Regulatory Mechanism to Trial Innovation in Cities" (Bertelsen et al. 2019). FinTec recognised that the most crucial obstacle obtaining innovation were regulations. They used regulatory sandboxes to simulate and test prototypes and pilots, and acclaimed the noticeable boost in FinTec to regulatory work done in collaboration with regulators.

1.2 Projects relevant for +CityxChange demonstration

How to update and improve regulations and regulatory frameworks for current centralised energy systems is addressed and discussed in numerous EU initiatives and projects by The Council of European Energy Regulators (CEER), European Network of Transmission System Operators for Electricity (ENTSO-E) and others. There are also important activities ongoing at national level in all EU states - and within the power industry. These activities have for years been partly driven by digitalisation, implementation of smart meters, connection of distributed renewables - and not to forget the challenges with grid planning and operation. A main reason for national discussions and revisions is that many projects ask for dispensations from existing regulations for the purpose of innovation and demonstrations related to energy transition projects.

To be able to fully demonstrate and make innovations in line with energy transition it is widely used regulatory sandboxes, special permissions and living labs. These provide the regulatory authorities opportunities to learn from the dispensations, the requests, as well as the actual deployments, in order to prepare for future updates of the regulatory framework. The Clean energy for all Europeans Package (CEP)[2] is a pan-European initiative to update regulations, offering specific concepts such as Energy Communities. The Fit for 55 initiative[3] is further trying to push member states and associated countries in the right direction.

Because the implementation of distributed renewables and energy resources reached a general level that made it a concern and opportunity for the energy system not before 2018, all lessons learned referred to in this report are from later projects.

The +CityxChange project demonstrates the local energy markets for energy communities, when moving from centralised to decentralised power production, storage and use of flexibility. The local marketplace as defined in the project includes trade of local power including flexibility. The marketplace is described and defined in the deliverable "D2.7: Local PEB trading market demonstration tool" (Livik, Danielsen and Nati 2021).

As a result of discussions within the +CityxChange projects and experiences from project partners and cities, the following list of topics linked to existing regulatory frameworks - and which will be addressed in this report - came up:

- Revenue incentives for the natural monopolies within a local energy system.
- Structure of tariffs for local transport of electricity.
- Metering and data management for local energy assets operating in a local market.
- Coordination between TSO and DSO in systems with significant distributed energy resources and local markets.
- Trade of local generated power and flexibility - standardisation of products and contracts.
- Operation of the local electricity system - quality of supply and system services.
- Design of the local market for the purpose of trade of flexibility.
- Feed in tariffs and rights to connect renewables.

[2]Clean energy for Europe: https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en
[3]Fit for 55: https://www.consilium.europa.eu/en/policies/eu-plan-for-a-green-transition/

- Local storage - how to maximize value.
- Investments, funding and incentives for renovation and energy efficiency at building level.
- Aggregators entering flexibility markets - integrating with local markets.

A post-energy transition phase will include local energy systems characterised by renewables, storage, flexibilities, and local system operation and trade. In order to reach a state with a regulatory framework able to serve this reality, renewed regulations will be a result of discussions of most of these listed issues.

2 +CityxChange challenges established framework and practices

2.1 Regulations forming the approach in Trondheim case

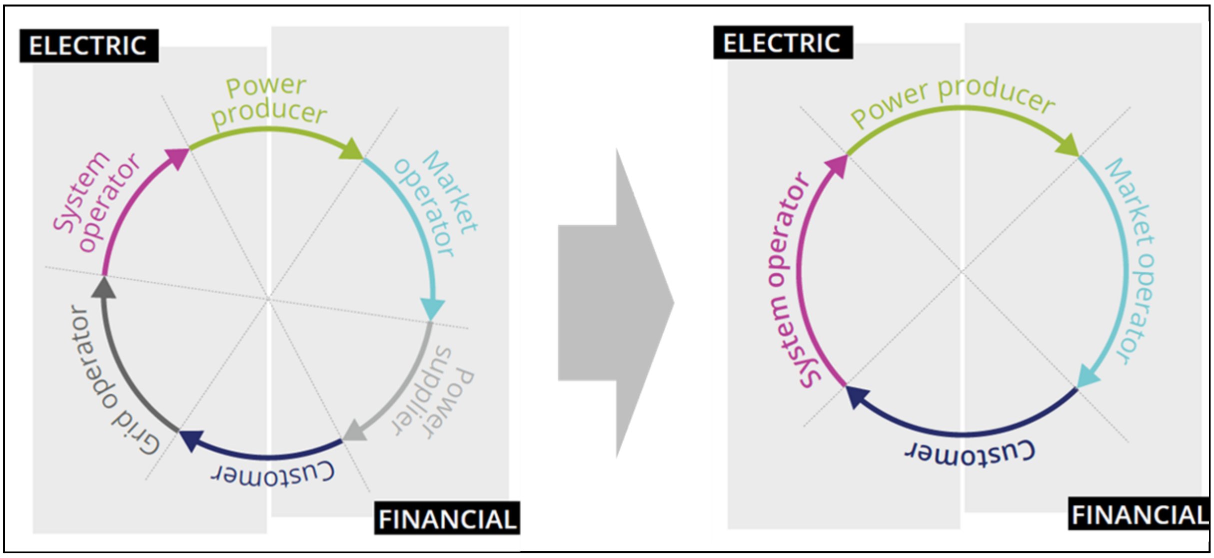
To set the stage, and to remove any doubt: if regulatory obstacles are removed, the PEB is ready for an operative phase that includes efficient usage of all local energy resources available, including a local energy market. A well functioning local energy system with local markets, significant use of renewables and consumers flexibility will, if correctly regulated and automated, make the operative phase of the PEB efficient with prerequisites for further expansions to scale to a PED or even a positive energy city.

Recognising that the regulations determine whether or not being able to demonstrate a PEB, the main priority in this deliverable became regulatory dispensations. The focus on dispensations, rather than sandboxes, was a result of the dialogue with the Norwegian Energy Regulatory Authority, *Reguleringsmyndigheten for Energi* (RME). Working with dispensations further led the project to recognise the need to address the issue to national authorities, with the purpose of achieving flexible and more future-proof regulatory changes. The project became aware that other cities also faced challenges with existing regulatory frameworks. For that reason the project connected with EUs smart cities marketplace to share and learn from other lighthouse city projects. These three processes thus became the primary topics in the Trondheim demonstration case: dispensations, national initiative, and the EU Smart Cities Marketplace.

2.2 Responsibilities and roles - local energy market

The local energy market with its roles and products is explained in the D2.1 deliverable report (Bertelsen et al. 2019) . The report explains with examples in what ways a local market serving a positive energy block (PEB) requires a strict, understandable and flexible regulatory framework which is suitable for an automated operation. To achieve this it is discussed which regulatory adjustments that are required - and how such adjustments and more basic changes will promote PEB processes and indirectly play a key role in the energy transition with decentralised rather than centralised energy systems.

As discussed in the D2.1 deliverable (Bertelsen et al. 2019) it is a basic prerequisite in setting up a well functional local energy market to clarify responsibilities and roles. Figure 2.1 presents how the local market roles correspond with organization of the existing global market. Since we are addressing market set-up from power production to customers consumption for electricity, it is underlined how both the electric and additional financial processes are covered. The global market, with its roles, is well functioning in Europe of today, while the local market represents a simplified version to be demonstrated as a part of the PEB operation phase in the +CityxChange project. The conclusion of these clarifications is that a local energy market includes four - not six - distinct roles to be able to operate as planned (ibid).



Global market roles **Local market roles**

Figure 2.1 Market roles change in the development of a local energy market and system. (Bertelsen et al. 2019).

The local market organised in four different and precisely defined roles is the basis for evaluation of the regulatory framework and its barriers. The grid company's role is in this local market approach included in the tasks operated by the local system operator. In the demonstration in Trondheim it is discussed how barriers could be removed. Based on the main findings, the need for dispensation(s) to execute the +CityxChange demonstrations of the process towards PEB establishment and operation are defined.

2.3 Regulations challenged by Trondheim demonstration

The existing power market is regulated by a detailed framework based on how the existing centralised market is operating. The fast development of distributed and local energy resources and Energy Communities (EC), are challenging to implement within the existing regulatory frameworks. Two main observations from ongoing work both within EU and national levels, are discussions and decisions in order to establish the details for the DSO (Distributed System Operator) role in the new energy landscape. The Council of European Energy Regulators (CEER) has several working groups comprising public deliverables and papers which discuss how different tasks will and should support the energy transition. The "CEER Paper on Electricity Distribution Tariff Supporting the Energy Transition" (2020) discuss the DSOs' use of tariffs and their incentives. A main observation is that the results are based on a discussion of existing framework and responsibilities; not a discussion from a post-energy transition approach. This makes it difficult to fully use their recommendations in our work to define a regulatory framework suitable and with expected incentives for promoting a green transition, including the process towards PEB/PED operation. They primarily discuss how the present and actual regulatory framework should be updated and changed to be able to serve a further development of the global market.

Figure 2.2 shows how focus on energy systems in a post-energy transition phase are changed from being central centric to more local centric. This change towards local energy systems will cause a need for renewing the energy regulatory framework. The local energy system is dominated by distributed renewable energy resources, available flexibility, active consumers supported by digitalised solutions and automatically operated local marketplaces for power (energy, capacity, system services).

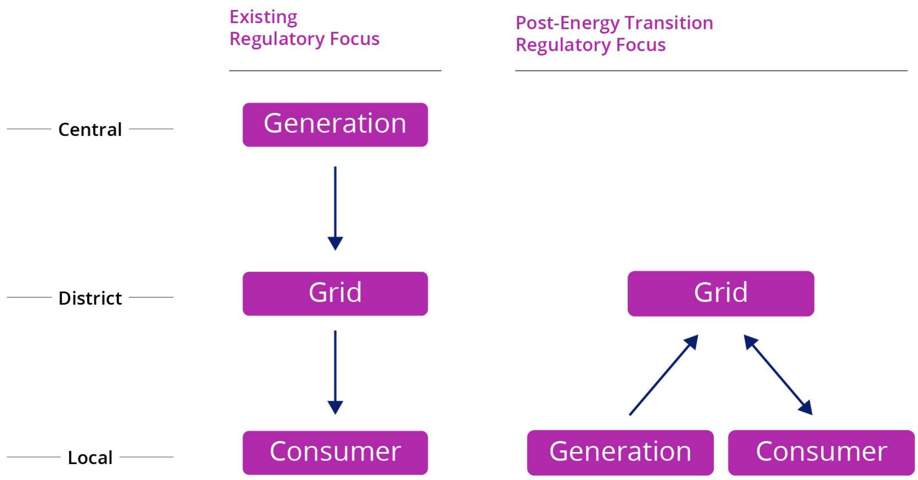


Figure 2.2 Post-energy transition regulatory focus compared with regulatory focus in the existing central dominated energy system.

2.4 Driving forces pushing regulatory changes

Thomas Kuhn introduced the term paradigm shift, explaining that it arises when the dominant paradigm is incompatible with change, and is replaced by a new paradigm that enables the change. The push for regulatory changes are caused by several factors. Examples of this are the digitalisation and smart meter rollouts, connection of distributed energy resources, new grid constraints, EV chargers and consumers with an increasing focus on sustainable energy behaviour. The fast growing implementation of local generation/energy resources, local resources' ability to behave more flexibly when it comes to use of capacity and energy, and consumers taking actions to achieve these benefits, are operationally consequences that typically challenge the regulatory framework. The technology contributing to this shift of paradigm is developing fast. Important examples are the results of digitalisation which makes it possible to manage local energy resources as automated systems, including consumption, production and storage - and use this in a more efficient system operation.

Within EU programs and initiatives such as BRIDGE[4], several activities concerning regulatory framework issues and challenges in the energy transition are addressed. The Clean Energy Package presents legal frameworks also for Energy Communities which are important to connect to the PEB/PED processes. Energy transition and green transition related projects are ongoing throughout Europe, and they include numerous pilot and demonstration

[4] BRIDGE: https://www.h2020-bridge.eu/

projects. Several of these projects challenge the current centralised energy system regulations, and as a consequence involved parties are dependent on legal sandboxes and dispensations from existing regulations. The +CityxChange project demonstration is only one example.

2.5 +CityxChange demonstration scope

The +CityxChange demonstration includes local energy systems, markets and grid. The local market design and PEB processes defined and implemented are used as the basis for how the regulatory framework should be outlined to enable the demonstrations. The scope of the framework is to efficiently serve implementation of local energy resources and their operation, and strengthen incentives for the green transition and smart cities. In this report, we have mapped and described how ECs, PEBs and PEDs can mutually support each other in a decentralised energy system, thus contributing to the energy transition. Figure 2.3 presents how a positive energy district (PED) may include several positive energy blocks (PEB) and an energy community (EC).

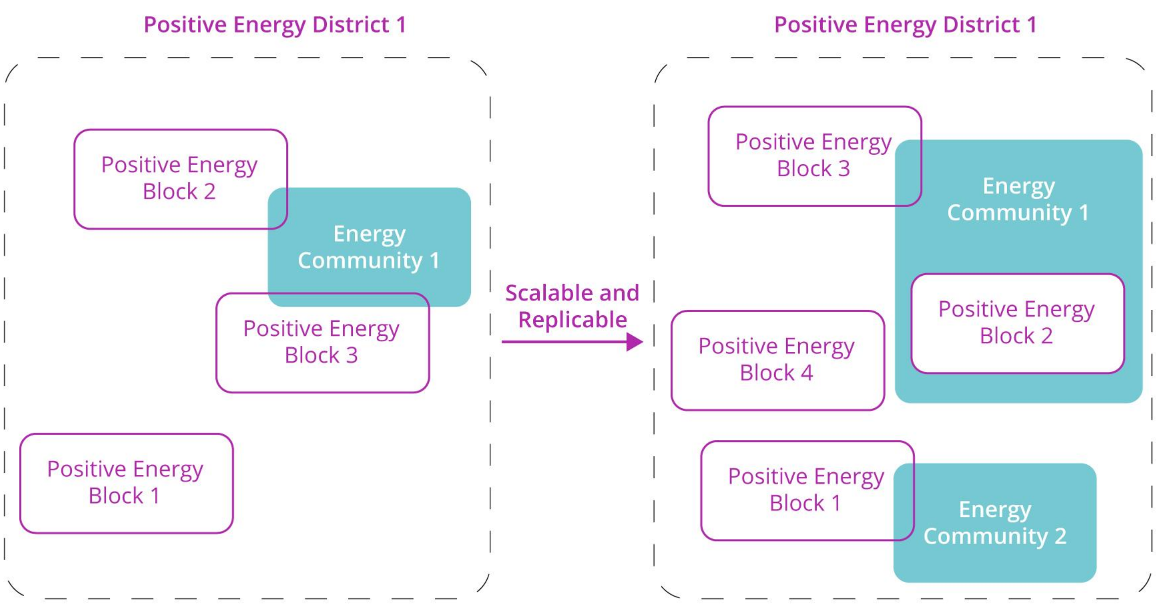


Figure 2.3 An overview with examples of relations between positive energy district (PED), positive energy block (PEB) and energy community (EC) within a process of scaling and replication in the same positive energy district.

The possible contribution from PEBs, PEDs and ECs towards the energy transition is explained in the following chapters. Examples of local initiatives are discussed, and regulatory changes that are required to support this transition are identified.

2.6 Known drivers in EU addressing energy communities

The EU JRC Science for Policy report "Energy communities: an overview of energy and social innovation" (Caramizaru and Uihlein 2020) shows that among 24 case studies there is a wide diversity of interests and motivations to engage in energy communities. Figure 2.4 presents a ranked list of drivers motivating participation in these case studies. The report concludes that the reason for the differences lies in the scope, geography, activity and characteristics of each energy initiative and its members. The drivers range from environmental consciousness and a desire to produce green electricity to stimulate increased ownership of local energy infrastructure.

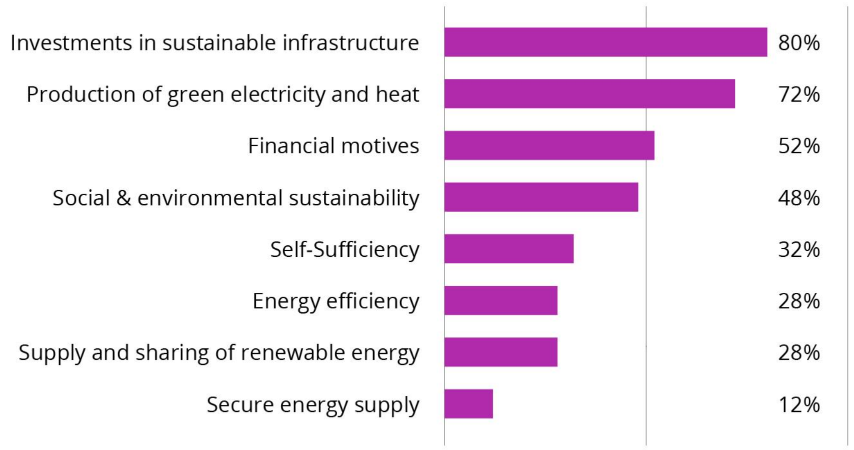


Figure 2.4 Drivers that motivate to participate in energy communities (EC) - results from 24 case studies (Caramizaru and Uihlein 2020).

The report with the case studies summarises that the top three most common drivers for ECs are the motivation to invest in community energy infrastructure (80%), renewable production of electricity (72%), and financial motives and monetary benefits (52%). The process of recommending a regulatory framework for a post-energy transition situation must keep these findings in mind, also within the scope of realising a PEB/PED.

3 Renewed regulations – a prerequisite for local energy transitions

Regulation of energy systems is indeed a complex responsibility. It covers roles, tasks, monopolies and markets and is expected to enable a smooth energy transition. The prevailing work and report focus on studying how the +CityxChange demonstrations are facing these expectations. To clearly understand the whole picture, a mapping is performed, and actual regulations are linked to this map as discussed in this chapter.

3.1 Regulation of an energy system - high level multitasking

With reference to how the existing power market in Europe is functioning for all customers and involved actors, it is an established understanding that the regulation of the involved market roles (ref. figure 2.1) has been rather successful. To fully understand the complexity of what energy regulators must address, figure 3.1 shows a high level map of relations with regulation of the energy industry. A regulatory body (regulator) has a wide range of detailed regulations available in order to manage and follow up on roles, actors and parties in the market. At the highest level regulation is split and addresses a) the competitive part of the market and b) the grid part, which is typically a monopoly.

Next level could be to regulate how the market should be accessed and operated.
For the monopoly the next level could be to regulate operation of the electricity system including transport. An even more detailed regulation will be about metering equipment and procedures. Metering is an example of activity that involves both grid usage, supply, and taxes with the consequences that the regulator must coordinate several incentives from many stakeholders. In figure 3.1 the regulatory hierarchy for some of the most basic roles and actions in the power market is presented. Metering is at the lowest level, but involves both grid and market activities.

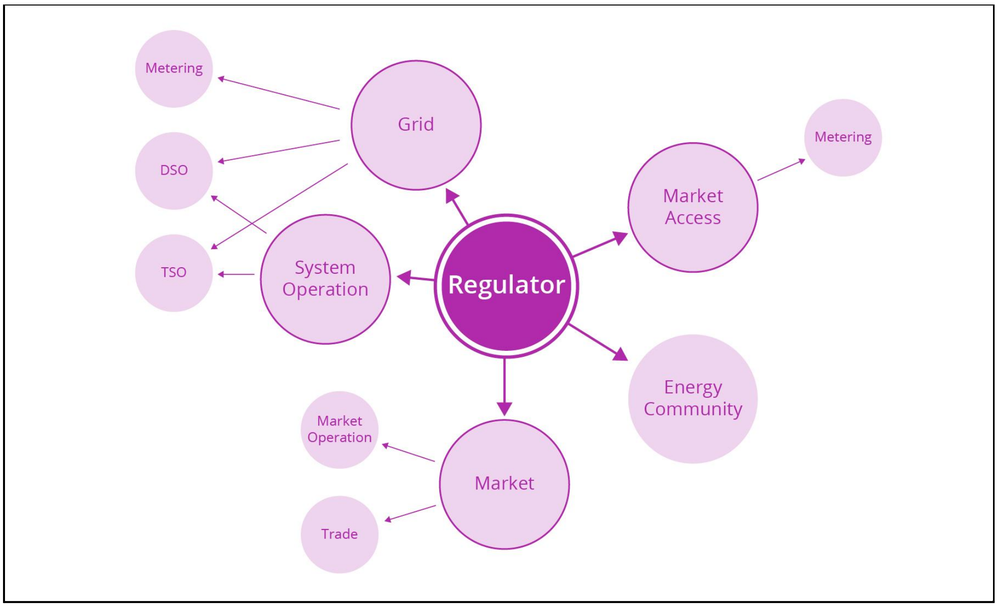


Figure 3.1 Example of regulatory hierarchy for some of the basic roles and actions in the existing power market.

This is in principle implemented in all EU member states and gives trust to the existing power market. In Norway the overall regulation is managed by a single "national regulatory body for energy" (RME), while in other countries mandates are distributed among several regulatory bodies. However the common side is that the regulator either reports to the Government or is a Governmental department itself.

The regulator regulates both the monopoly parts of the power industry (i.e. the grid companies) and the market activities (i.e. supplier and market operation). With reference to figure 3.1 the monopoly part is typically the grid operation and the system operation, usually executed by the distribution system operator (DSO) and transmission system operator (TSO). The market part includes market operation and the trade processes. An important ongoing process in EU member states and associated countries is digitalisation exemplified with the rollout of smart meters. This development addresses new regulatory challenges regarding metering including ownership and usage of smart meter data.

Moving towards a post-energy transition phase will call for updated regulations. However, energy transition will set a new scene with more local energy systems, increased share of local energy resources, more active customers, different energy communities (EC), and a more digitalised society in general. The regulatory outcome of this transition is still not fully understood and known.

3.2 Energy communities – a small scale energy system

In the +CityxChange we focus on the creation and operation of PEBs/PEDs. This is a process dominated by consumers and local power generation. In parallel - outside the project - the development of energy communities (EC) is ongoing, which are created with the local initiatives and energy activities at the core (energy sharing, prosumers, electromobility etc.). The similarities makes it important to include EC in the discussions regarding incentives and details for a post-energy transition efficient regulatory framework.

The European Energy Union has characterised energy communities (EC) as follows[5]:

- Organises collective and citizen driven energy actions that will help pave the way for a clean energy transition, while moving citizens to the fore.
- Contributes to increase public acceptance of renewable energy projects and makes it easier to attract private investments in the clean energy transition.
- Has the potential to provide direct benefits to citizens by advancing energy efficiency and lowering their electricity bills.
- By supporting citizen participation, ECs can moreover help in providing flexibility to the electricity system through demand-response and storage.

A report by CE Delft estimated that over 264 million or half of European Union citizens could be producing their own energy by 2050 (Kampman, Blommerde, and Afma, 2016). About 37% of the energy produced by energy citizens could come from energy community projects. Together with small businesses, households and public entities, these groups could own as much as 45% of Europe's renewable generation by 2050 (Connolly, Hendricks, Walsh and Vansintjan 2016). The role of energy communities is defined in two separate laws of the Clean Energy Package and the Renewable Energy Directive (EU) 2018/2001[6], and sets the framework for 'renewable energy communities' covering renewable energy. The revised Internal Electricity Market Directive (EU) 2019/944[7] introduces new roles and responsibilities for 'citizen energy communities' in the energy system covering all types of electricity.

The energy system approach includes that the energy community initiatives are put into the framework of the actual roles in the local power market. An EC could be implemented in a local energy market. If it fits for a local energy market, the market will contribute to add value to local resources including the contribution from prosumers. An example is battery storages managed by the EC that could be given an added value as a system reserve/service for the local system operator, and additionally act as a storage for surplus generated power sold locally when it is a local defisit of power. These examples are simple, but clearly linked to the regulatory framework that will allow and provide incentives for actions like this.

Table 3.1 presents a list of energy resources based on the +CityxChange demonstration project setup. The list is then mapped with respect to how such resources may play a role in an EC. Secondly the list is mapped related to which role the energy resource will exhibit in a local power market. This overview is then used for the purpose of understanding how different regulations will influence both EC and local markets as demonstrated in +CityxChange.

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[5] Energy communities: https://ec.europa.eu/energy/topics/markets-and-consumers/energy-communities_en
[6] Renewable Energy Directive (EU) 2018/2001: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=fr
[7] Internal Electricity Market Directive (EU) 2019/944: https://eur-lex.europa.eu/eli/dir/2019/944/oj

Table 3.1 Respective roles of energy resources in EC and in local energy markets.

Energy resource	Role in EC	Role in local energy market
PV and wind	Supplier	Producer (sell)
Battery - charging	Consumer	Customer (buy)
Battery - discharging	Supplier	Producer (sell)
Flexibility	Supplier (demand response)	Producer (sell)
Consumption	Consumer	Customer (buy)
Distribution	Distributor	System Operator (DSO/CSO)
Market operation	Sharing	Market Operator

The energy resources in table 3.1 include all actual participants/contributors in local energy systems. It classifies the participants in roles. The next step is to describe how the regulatory framework influences the processes in setting up and operating ECs and local energy markets.

In a post-energy transition state, it is supposed that local energy resources will form the backbone and foundation of the energy system. If these resources are not allowed to operate within market rules efficiently concerning cost and purpose, incentives for investments and expansions of renewables will be reduced.

3.3 Required leeway for local energy resources

Based on the +CityxChange project a list is produced displaying required opportunities for the local energy resources to ensure efficient investments, planning and operation. The main findings are presented in table 3.2. These findings are influenced by the ongoing discussions with the Norwegian Energy Regulatory Authority (RME) and their addressing of unpermitted actions within the existing framework.

Table 3.2 Overview of needed leeways and defined roles of energy resources in EC and local energy markets in a post-energy transition situation.

Energy resource	Crucial leeways	Local energy market role
PV and wind	**Rights to:** • install • own • lease • connect behind and/or in front of the meter • install smart meters on the actual resource • sell production locally without any fee/extra costs	**Producer** (sell)

	• access/sell to local marketplace • produce independent of forecast	
Battery - charge (consume)	**Rights to:** • install • own • lease • connect behind and/or in front of the meter • install your own smart meter on the actual resource • buy supply from the local marketplace • buy P2P from a local producer	**Customer** (buy)
Battery - discharge (produce)	**Rights to:** • install • own • lease • connect behind and/or in front of the meter install your own smart meter on the actual resource • sell production locally without any fee/extra costs • access/sell to local marketplace • produce independent of forecast	**Producer** (sell)
Flexibility	**Rights to:** • have access and sell downregulated demand [kW] to the local marketplace	**Producer** (sell)
Consumer	**Rights to:** • buy locally and globally • sell flexibility	**Customer** (buy)
Market operation	**Access to:** • receive and coordinate asks/bids • settle and verify trades • manage metered data for invoicing purposes	**Market Operator**

In the global power market, as regulated in Europe of 2021, transport and system operation are the distribution system operators' responsibility, and regulated as monopolies. The supply part is regulated as markets closely linked to the centralised grid system. The list of needed leeways in table 3.2 is partly linked to the monopoly and partly to the market part of the regulatory framework. With reference to the gap analyses among project partners countries presented in the D2.1 deliverable report, this is valid for most European countries (Bertelsen et al. 2019).

3.4 Roles and framework in local energy systems

In a local energy market the number of major roles will be reduced from six in the existing global market to four roles. Each market role has responsibilities and activities which are regulated to serve the existing global market. However, moving into a post-energy transition situation with local markets with only four actual roles, the regulatory framework must be updated. Table 3.3 lists local market roles and current regulatory framework (Bertelsen et al. 2019).

To be adequate in the post-energy transition phase, the listed involved framework must be updated to ensure efficient usage of local energy systems and resources - and secondly provide incentives for PEBs/PEDs and ECs. The regulations are presented at a general level, not including member state details.

Table 3.3 Overview of involved regulatory framework for actual roles in local energy systems and markets.

Market role	Activity	Regulatory framework
Producer	Produce and sell	Concession for production, feed in tariffs, P2P agreements.
Customer	Consume and buy	Consumers rights.
System Operator	Operates electricity system and secure quality of supply	DSO regulations including grid connections, income regulation, grid security and operation.
Market Operator	Operates local marketplace and ensures that local supply and consumption is cleared and settled correctly.	Market operation regulatory framework + permission to operate as counterpart with local bids/asks.

The local market includes four of the global power market roles with corresponding regulations as presented in the D2.1 deliverable (Bertelsen et al. 2019), and the listed regulations are basically required for the local energy market with market based "energy sharing" and electricity system operation services.

3.5 Regulation frameworks - key findings from pilot projects

The EU Bridge initiative[8] lists several ongoing projects that include regulatory framework activities and how to update them to be ready for the energy transition. The projects address this from the existing global energy markets point of view and not with a post-energy transition energy system approach. The demonstrations are typically addressing traditional smart grids or focusing on specific technologies such as batteries, load control centers etc. However, a main finding from all Bridge projects investigated is that the regulatory frameworks need to be updated continuously to be able to serve green energy transition actions. An important distinction in this context is that the described project demonstrations within BRIDGE are mainly to obtain regulatory permission to address and demonstrate energy innovations - not to investigate how regulations should be made for the energy transition. Examples of BRIDGE projects are Flexi Grid[9] and Parity[10]. Following the further work and activities in the BRIDGE regulation working group[11] will be of

[8] Bridge Horizon2020 https://www.h2020-bridge.eu/
[9] www.flexigrid-h2020.eu
[10] www.parity-h2020.eu
[11] BRIDGE working group: https://www.h2020-bridge.eu/

importance and useful, given its efforts on topics related to energy market design including coordinated flexibility markets for system services.

Some major findings from demonstrations documented in the BRIDGE initiative are:

- At national levels the regulatory framework challenges almost all local energy system pilots - including energy communities.
- Different flexibility markets are designed and demonstrated in many pilot projects.
- Thanks to regulatory sandboxes and project dispensations it is possible to explore new market designs, roles and products - and set up time limited demonstrations.
- Existing regulatory frameworks are experienced to be barriers in demonstrations and upscaling of innovative technologies and new business models.
- Local energy system stakeholders are waiting for a regulatory framework with a post-energy transition focus.
- Design of flexibility markets are work in progress with only experimental demonstrations going on at present.

The global market and its roles has been regulated and operative in most EU member states for decades. A summary of some main regulatory dependent experiences addressed (projects, the press, events) could be summarised as follows:

- The traditional energy industry and their federations participate in many processes concerning renewing and updating regulations - however local energy system regulatory changes will not be the outcome from their ongoing processes.
- The regulatory frameworks are expected to become even more complex to understand and overcome when incremental add-ons are implemented to serve green transition political decisions.
- DSOs do not have incentives to use flexibility as an alternative option to grid investments ond operation.
- The regulatory framework is experienced to serve the wholesale market well.
- Use of cost based distribution tariffs for local transport of generated power is not discussed and demonstrated.

A reason why regulatory frameworks are perceived to be complicated and not turned into enablers of energy transition, could be its lack of flexibility in a situation with fast evolution of energy systems and their technology. It is observed that designs of local energy markets - including energy communities - are unclear and dependent on ongoing processes like interactions between TSO/DSO, smart meter rollouts, digitalisation and redefinitions of market responsibilities. The consequence is that regulatory framework discussions are characterised by unclear scopes.

It is within this rather complex landscape that +CityxChange project developed a local energy market (LEM) design to be demonstrated in Trondheim. The market set-up has well defined roles, exhibits extensive digitalisation, and an automated market and system operation. Such a scheme and set of solutions will - as far as we are concerned - be possible to replicate and scale, and may prove to create market opportunities for different types of innovators and private companies.

4 Regulatory options in local energy systems

Before defining the need and details of the regulatory framework for a post-energy transition local energy system, it is important to have clear definitions of roles and their tasks. The next step is to clarify the need for regulation. This approach makes it possible to discuss and propose a post-energy transition regulatory framework. With the demonstrations in Trondheim as the case a simplified model is made on how regulation in a defined energy system with a local market for renewables and flexibility could be implemented.

In all markets a seller and a buyer is required, in addition to a common market place. The trade may happen either through a neutral market operator or as a P2P trade. A local power market also requires a system operator to secure the quality of supply. Electricity is generated and consumed in the same moment - independent of regulatory framework, location, borders, and price. A rather populistic frame, but nevertheless something that must be kept in mind when a post-energy transition local power system is designed and operated. If the regulatory framework is not sufficiently tuned to serve this system approach, consequences could be reduced investments in renewable resources, inefficient operation of local power markets - and low general interest to encourage energy efficiency measures and use of flexible energy resources.

In the post transition phase it will be common with local energy markets and energy communities. The design of a regulatory framework is discussed with this predicted situation as a prerequisite. By focusing on the predicted new roles and activities in the energy system it is discussed how the regulatory framework should be designed or renewed. Not the opposite way: How local energy systems should be developed and implemented to comply with existing regulation and structure for operation. This chapter discusses each task's need for required options to operate including incentives to invest in local energy resources and systems.

4.1 Invest, generate, and sell

The resources that generate electricity are typically photovoltaic, wind, discharge of batteries, and consumers flexibility as disconnected consumption. All these resources are categorised as assets with the ability to sell generated electricity in a global market, a local market, or P2P. Figure 4.1 describes three basic steps that must be managed within a regulatory framework. These are incentives and permissions to invest, generate, and sell power from local assets.

Figure 4.1 Basic steps in the chain from investment in energy resources to selling electricity.

The share of distributed energy resources all over Europe increases fastly. The investments are mainly coming from new players - private and commercial - outside the traditional electricity industry. Consequences are that the traditional power system planning and operation procedures including generators and grid companies to some extent are disrupted. Drivers are supposed to be a mix of environmental and commercial interests and goals. From the green transition perspective this is positive, and is given political support - at national and EU levels.

When the investments are realised in energy generating assets, it is expected that generated renewable power products are possible to sell in local marketplaces as described in deliverable 2.5 (Skoglund, Main, Eljueidi and Nati 2020).
To fuel investments and operation of local renewables a need for regulatory frameworks that both support investment arguments and enable the green transition in terms of local energy systems is crucial.

Important for investor:
- Stability - low risk for regulatory changes that will reduce the value of confirmed investment business-case.
- Economic viability on investments.
- Flexibility - free to change technology and scale up generation capacity.

When the investment is executed, the investor is ready to start the power production. The production must be with accepted quality, and if the power is not self consumed it is measured with certified meters and sold through a marketplace.

Important for power producer to be:
- Allowed to produce in line with their forecasts/plans.
- Allowed to sell all produced power locally or to the global power market.
- Allowed to negotiate price in a P2P trade scheme.
- Allowed to provide bids in local and global power market(s).
- Allowed to buy power to eliminate their own imbalances.

In order to “solve” the highlighted issues there is a need for regulation that has an overall goal of enabling acceptable business cases for investments in local renewable energy resources. Today's situation is that investment conditions, within this scope, are not future-proof.

4.2 Connect to local grid

All energy resources are connected to a grid which transports the generated power to the consumer. The grid is either internal and owned by the producer, or it is owned and operated by a DSO, the community, or third parties. The process from investment in energy resources including the required grid connection agreement is shown in figure 4.2. For the investments it is crucial that the assets that generate power have permission to connect to the local grid. The grid connection must be reasonable when it comes to connection fee and price structure for the feed-in tariffs. The grid must ensure the capacity to receive all power generated - independent of time. When the investment is realised and the grid connection agreements are signed, the basic legal aspects before starting the generation are onboard.

Figure 4.2 Required decisions before a local asset generates power.

When the generation starts, the process of investments and grid connection agreements are closed and accepted. From the generator's perspective it is crucial that the connection to the local grid ensures the following rights:

- To be allowed to feed in all generated power - independent of time.
- Connection fee similar to consumers or lower/cost based.
- Market based feed-in price.

With these three main requirements confirmed, the generation process can start. To achieve a suitable grid connection, the project developers need and ask for regulatory requirements possible to comply with. Typically for larger generation assets grid codes exist, while for smaller distributed renewables it is not sure whether such grid codes are feasible for well functioning local energy systems and communities.

4.3 Transport of local generated power

The transport of the electricity power from generating assets to the consumers is executed within a grid operated as a natural monopoly. The grid assets are operated as strictly regulated monopoly transport companies - typically named utilities. Main responsibilities are to secure safe and reliable supply from generator to consumer. Building and operating the infrastructure are key tasks. Figure 4.3 shows the interactions between generation, transport, and consumption assets within the local energy market.

Figure 4.3 The transport of power from generator to consumer is a natural monopoly with the need of precise and future-proof regulation.

The transport of local generated power is characterised in a way that it could significantly influence the local load flows. This must be understood and accepted by the local grid operator and taken into account when grid expansions and operation is planned. From the grid operators perspective it is important to be able to offer a transport service level for local generated power as follows:

- Available grid capacity for feed in of local generation.
- A regulatory framework that accepts connections of PV, wind, batteries and other types of local generation.
- A regulatory framework that accepts connections of all kinds of consumers.

For the local grid company with the responsibility to transport power it is only the three listed bullets that are crucial to ensure that locally generated power has electrical connection to local consumers.

4.4 Operate local grid system

Locally generated power will in given situations influence the operation of the grid system. To ensure reliable supply from generators to consumers - as shown in figure 4.4 - an operation of the grid system with regards to quality of supply is required. In connection points with no available grid capacity due to high consumption, investment in grid expansion is required. The overall consequence is an improved grid operation situation, maintaining the quality of supply. In connection points with low utilisation of available capacity, feed-in of local generation adds more available capacity and gives a situation with a too low utilisation of the grid capacity, resulting in a possible reduced income from grid transport. These two extreme and opposite situations will influence reliability and need for system operation services. Renewables are in its nature more unpredictable in its generation output than the load. The consequence is access to local system operation services possible to activate on short term notices. This may cause situations of system operation challenges that must be managed for the local grid.

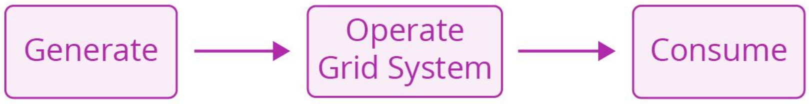

Figure 4.4 System operation with local generated power.

The operation of local grid systems with a significant share of local energy resources and flexibility includes managing several system services. Activation of local system services requires access to local resources. These are energy resources that enable the system responsible to secure reliability and quality of supply. The system reserves may either be supplied from the responsible local operator's own resources or purchased from local resources operated by third parties. This purchase may either be P2P contracts or from the local market operators' product portfolio. For the local system operator the following options for activation of system services must be available:

- To purchase P2P actual local system service from local consumer or producer - local storage included.
- To purchase from local marketplace products to be used for system operation.
- To invest in and use their own energy resources tailored for their own system operation.
- To purchase system services from third parties outside the local grid area.

The local system operation responsibility is a monopoly and the regulation must be closely linked to standards for security and quality of supply.

4.5 Establish and operate local market platform

In the process of designing a local market it is crucial to ensure that all local energy resources are equally managed as assets with market access. The marketplace must be operated by a neutral operator with the permission to clear and settle all buy and sell bids and resulting trades. In the local market as described in deliverable D2.5 (Skoglund et al. 2020) all processes are digitised and the market is operated automatically. Figure 4.5 presents the simple principle of how the market access realises bids of sell and buy to settled trade thanks to an efficient and neutral market operation.

Figure 4.5 Local market trade with open market access and operation.

All identified and defined energy assets require access to the local energy market. The market access is performed digitally due to the fact that all assets have a meter that communicates remotely with the marketplace. The meter could either be a DSO certified smart meter or measurement equipment accepted for the local energy market trade and invoicing. The metered data is represented as verified time series for the sales and buy process managed by the market operator. In order to operate the local market the following requirements must be fulfilled:

- All assets have certified meters that measure consumption and/or generation with time resolution that corresponds with traded products.
- All assets have a market access agreement with the market operator.
- The market operator has a license to operate the local market.
- The market operator has a concession to operate as the assets counterpart in the trade process.
- Market operators have the responsibility to manage and store all time series used in market operation and trade.

The local energy market has one market operator. It is a prerequisite that the market is operated with transparency and trust.

4.6 Buy locally generated electricity

The buyer of locally generated electricity products could either access the local market operators' traded products or make P2P contracts. An example of P2P is when the buyer is a system operator asking for capacity for system services that includes special conditions such as reservation and activation pricing and options. Figure 4.6 presents a sketch of the two principles of buying local generated electricity.

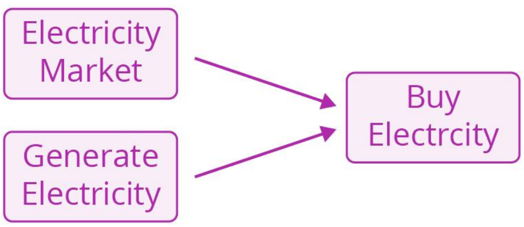

Figure 4.6 Buying electricity from local resources.

In the process of buying locally generated electricity the local buyer has two options; either send a request/bid to the local market operator or buy directly from a local generating asset in a P2P scheme. For the buyer it is required that the following actions and responsibilities are within the legal framework:

- Market access contract with local market operator.
- Trade and settlement contract with market operator.

- Bilateral trade contract with generating assets.

The procedures for buying are fully digitalised and comparable with wholesale procedures.

4.7 Sell demand response to local market

Flexibility of the energy consumption requires the consumer to change load patterns as a result of price variations or contracts. The structures of the price variations that activate demand responses as change in demand for load or change in load patterns will influence how consumers respond. Figure 4.7 shows that the price change signal may come either from a buy signal in the electricity market place or from a single buyer based on a P2P contract. It is important to understand that charging a battery is defined as a consumption.

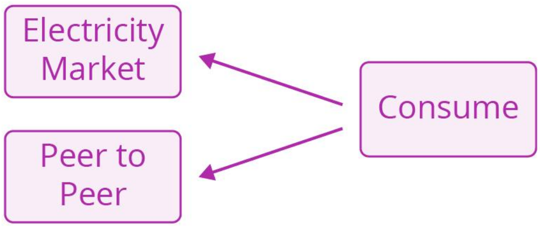

Figure 4.7 Demand response flexibility traded either in the open local market or as a peer to peer (P2P) contract.

Demand response is defined as flexibility offered from consumers - not local generation. The response is typically activated as a result of a price signal either as a part of a P2P contract for system services or an accepted bid in the local electricity market. To be able to settle the demand response flexibility exactly, it requires proven methods and equipment for measuring the traded demand response. With consumers demand flexibility traded on the local market it is crucial that the following prerequisites are followed:

- Consumers have smart meters with suitable granularity in operation.
- Flexible loads behind the smart meter are measured and dispatch routines implemented and accepted by counterparts.
- Disconnected demand (load) is measured and total energy response measured and properly calculated.

Estimates of demand response are replaced with more precise calculations based on metered load with time resolution of one hour or less. Use of load curves and end-user profiles must be replaced with metered time series of total consumption and consumption of actual flexible loads before and after the dispatches. This will be managed by a smart meter.

4.8 Settle and invoice local trade contracts

A critical part of operating the local energy market is the procedures for settlement and invoicing. Procedures similar to what are used in the wholesale market are used for the settlement process, while the billing procedure is used with the same principles as in the retail market.

A critical prerequisite for using the wholesale settlement procedure is that all assets have digital market access and that the bids and asks are represented in time series. The time series includes metered data of assets' contribution to the local market when it comes to generation, consumption and time. This is data delivered from smart meters and/or other for the actual local market certificated measurement equipment.

The invoicing completes the market operation action. In the local market it is the market operator that is the counterpart for all local trade and sends the bill to the buyer and credits the seller. This is executed as a result of exact calculation of traded volume and price. Figure 4.8 presents the process of actions from receiving bids/asks, the settlement process for confirmed trades, and then the invoicing process. The process is within the responsibility of the local market operator.

Figure 4.8 Received bids/asks are settled and confirmed trades are invoiced.

The market operator has the responsibility to make the following crucial actions regarding settlement and invoicing:

- Receive digital time series with asks and bids from all local market players/assets.
- Calculate local price based on all received bids and asks.
- Store all received time series used in trade contracts.
- Communicate digitally with buyers and sellers.
- Calculate cost based on time series for price and volume for accepted trades.
- Send invoices to buyers.
- Credit sellers.
- Permission to trade on behalf of buyers and sellers.

The local market platform developed as a part of the D2.5 deliverable (Skoglund et al. 2020) and documented in the report "Development of a platform for local trade of energy and flexibility" demonstrates market access and settlement procedures.

4.9 Sector coupling - heat and power

Sector coupling refers to interconnecting the supply chain of electricity with the supply chain of heating and cooling. The interconnections can be at different levels of the supply chains and have a wide range of possibilities to be realised. Figure 4.9 presents some possible interconnections and their motivations in a dual local energy supply chain. An example with two sectors is used here. Sector A is a supplier of heating and cooling with water and/or air as energy sources. Sector B has wind and/or sun as energy resources for supply of electricity for different end uses.

The technical coupling between Sector A and Sector B is realised through the following interconnections:

- Heat pump in Sector A is powered from Sector B.
- Surplus heat from Sector A is used as input to the heat pump with output energy to Sector B.
- Surplus heat from Sector B is used as input to the heat pump in Sector A.

In addition to the described technical connections it is possible to expand with more opportunities such as thermal storage, batteries, and integration with surrounding energy systems. However the example addresses the basic principles of technical sector coupling as demonstrated in the +CityxChange project.

To realize the full potential of sector coupling it is important that value creation in one sector, as a consequence of measures in another sector, can be shared. For instance if heat from sector A replaces power demand in sector B, this could reduce the total energy supply cost - and reduce total environmental impact.

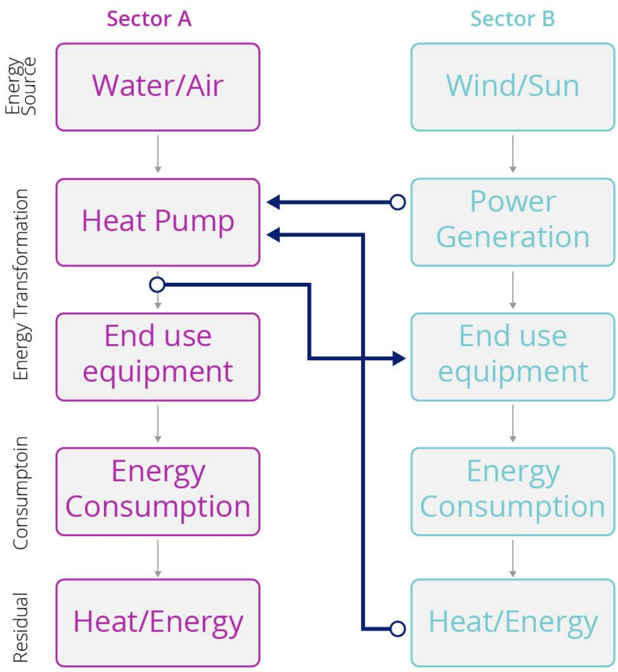

Figure 4.9 Technical local sector coupling between Sector A - heating/cooling and Sector B - electricity.

Figure 4.9 shows how the heat pump may get its electricity supply from the locally generated renewable power. The heat pump is also receiving surplus heat from local electricity consumption. This heat is then included in the total heat pump energy output. Energy output from the heat pump is exported to end use equipment for consumption either in Sector A (i.e. direct space heating) or in Sector B (i.e. water heaters).

In most energy systems there are different regulatory frameworks for supply of heat/cooling and electricity. This is experienced as obstacles regarding setting up a coupling with one energy system approach. The most simple example is that electricity supply is market oriented with clearly defined roles while the heating/cooling system is a more cost based utility model in addition to a price cap with reference to the electricity grid + supply cost. In addition there are different metering and invoicing procedures in the sectors. These differences have most probably resulted in lack of possible innovation in the sector coupling area.

There are dual heating systems including heat pumps in the +CityxChange demonstration areas, and sector coupling as described in figure 4.9 are investigated and will be instrumented for technical sector coupling. This will be included and become an integral part of the +CityxChange Local Energy and Flexibility Market solution (T5.10).

5 Dispensations - from dialogue to permission

For the purpose of realising the demonstrations within the +CityxChange project in Trondheim it was required to start a constructive dialogue with the Norwegian Energy Regulatory Authority (RME) for the set-up and define the need for required dispensations. RME went for a process where the involved parties applied for dispensations in the areas where demonstrations are contradicting the actual regulatory framework. The process towards the specification of required dispensations involved the local market operator, the local grid company with some DSO responsibilities. The city of Trondheim was also involved in this process. The process also included collaboration with other Norwegian innovation projects addressing EC issues and energy sharing.

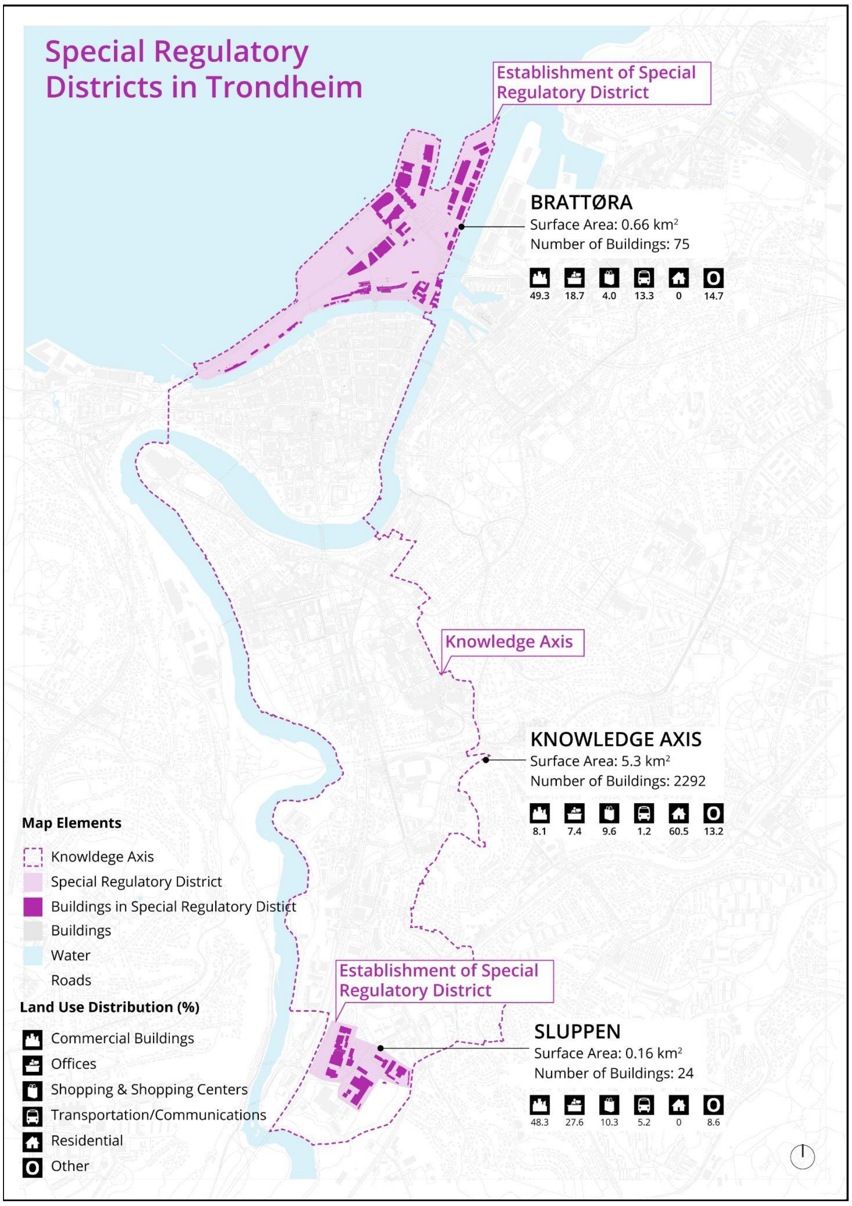

Figure 5.1 The establishment of the special regulatory district within the city.

Figure 5.1 presents the established regulatory district in Trondheim. Brattøra and Sluppen were selected as demonstration areas within the city. The areas were treated equally with similar required dispensations. The areas are quite small and contain corporate office buildings with different types of businesses.

5.1 The stepwise regulatory process

This is the first time a local market set-up with flexibility and local energy resources will be demonstrated on a larger scale in Norway, so the process was new for all involved parties. Figure 5.2 presents all experienced steps towards operation of a PEB including a local market. This is a process map of six identified regulatory key-stones to focus on in the process of establishing a PEB. For the purpose of getting the required +CityxChange dispensations, step 1, 2, 3 and 4 was developed.

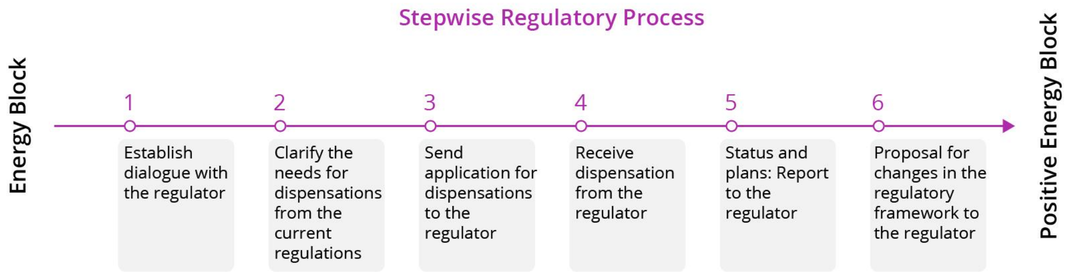

Figure 5.2 Stepwise regulatory process towards establishing a positive energy block (Bertelsen et al. 2019).

The steps represent learning processes, clarifications, and re-definitions on how the demonstrations should be orchestrated and executed. A main observation is that market operator Trønderenergi was given the responsibility to manage metered data for accounting purposes while the DSO's responsibility was accordingly reduced.

A main lesson learned from the process to get dispensations is that it must be easier to test and demonstrate innovative solutions that favor the energy transition. Sandboxes rather than dispensitions, as the regulators instruments, should be preferred.

5.2 Dialogue with the regulator

Large scale piloting and demonstrations within the domains of energy transition are in its nature a challenge for the energy regulatory framework - internationally. This is mainly because such demonstrations apply new technologies and digitalisation for demonstrations regulated by authorities established for traditional energy systems, roles and activities. In the +CityxChange project this is fully experienced by Lighthouse cities and Follower cities.

In general, regulators, with their mandates and mission, keep a role as a manager of existing frameworks which are not created for the shifts that the demonstrations' future needs represent. To fully realise the demonstrations and innovations, the +CityxChange partners informed the regulator about project scope and demonstrations already in the application phase. This dialogue was important and gave the regulator an early overview of the project content and scope.

An important part of the dialogue was the detailed evaluation of what project tasks would operate outside the existing regulatory framework. The outcome of the evaluation undoubtedly required dispensations, and at an early stage the regulator concluded that dispensations were preferred rather than a regulatory sandbox. The project partners then started the process of applying for specific dispensations linked to the actual task that were planned for demonstration.

5.3 Clarification of need for dispensations

Demonstrations in +CityxChange need dispensations from national regulations and legislation to demonstrate activities related to grid monopoly, market operation and accounting. The local energy market plays an important role in the project set-up for the demonstrations. This implies involvement from all four defined local market roles: power producer, local system operator, local market operator and customer/consumer.

Firstly it was clarified how the local system and market operator should cover required tasks. Figure 5.3 presents the main set-up for the local market with market access for all local energy assets, including consumers and their defined flexibilities (Livik et al. 2021).

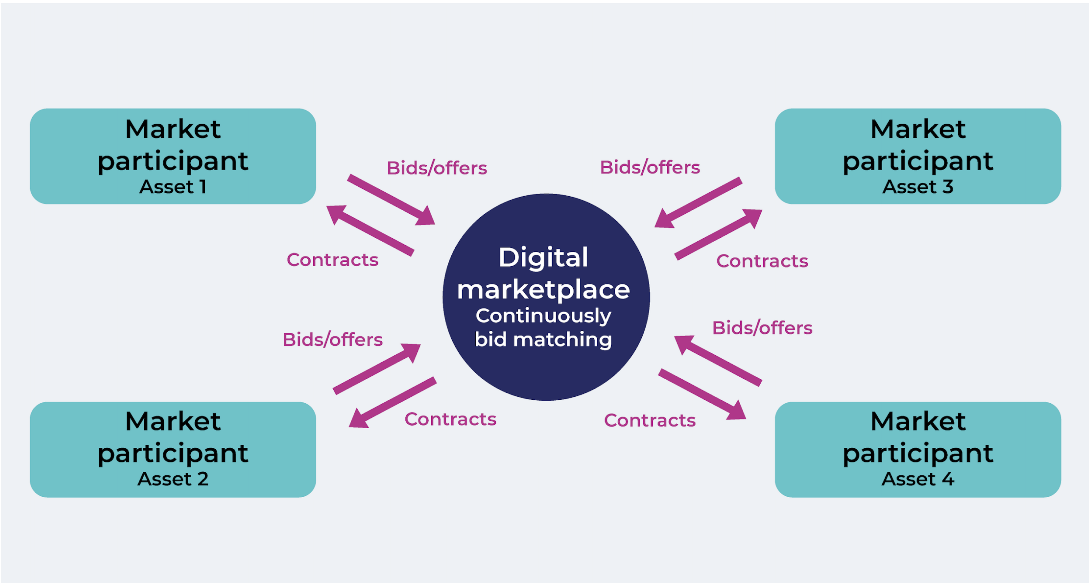

Figure 5.3 Main set-up for the local market demonstration in Trondheim (Livik et al.2021).

The market operator is responsible for operating the digital marketplace, receiving bids/offers, calculating the price and making the settlement. For this purpose dispensations are required regarding metering at asset level and in addition to existing meters for consumption.

A main principle for the local market set-up is that all customers shall have the possibility to buy from the local market in addition to the global market (whole-sale). This prerequisite represents a transition in market operation and constitutes a significant innovation in the project. Figure 5.4 presents how the metering principles can be demonstrated with a digital link between metered data with supply from both local and global markets using PV and V2G as examples.

Figure 5.4 Principle for metering of a customer partly supplied from local and global markets (Livik et al 2021).

Correct metering procedures of a customer with supply from local and global suppliers is easily managed by using smart meters. However, it presumes an innovative set-up that needs a dispensation for use of meter data aggregation and split for the invoice from local and global market.

The conclusion was that the project had to apply for the following two dispensations:

1. To operate the local market including settlement of bids and asks.
2. To use metered data from certified smart meters to perform invoicing for supply from both local and global supply.

It was an elongated process to decide who could and who should be the sender and thus stand behind the application. The process ended up with Trønderenergi being responsible for de facto finalising and submitting the applications. They are the market operator and responsible party for local market accounting and invoicing. This was possible because Trønderenergi possessed a dual role, with meter data responsibilities as meter data administrator, in addition to being the market operator.

A basic message in both applications is that granted permissions, as asked for, will ensure realisation of the innovation as described in +CityxChange Grant Agreement - with the purpose of piloting solutions that stimulate the implementation and operation of local renewables and consumers flexibility within positive energy blocks (PEB).

An important lesson learned and outcome from this process, is that - with some minor adjustments in responsibilities and routines regarding metering and meter data management - it was possible to avoid that the local grid company needed to apply for any dispensations. This is in line with the hypothesis that it is possible to establish and operate a local market with only four roles as described in figure 2.1.

In Norway smart meters are rolled out to all customers, which is important for the metering tasks. EL-Hub[12], a strictly regulated national data hub, is responsible for collecting all smart meter data from grid companies with the purpose of making the data available for suppliers for billing purposes - and other services.

It is important to notice that system operators do not need dispensations to purchase system services locally. This service is permitted to purchase either as a P2P product or through a local market place organised by a licensed market operator.

5.4 Dispensation application - layout and content

The regulator requested the following elements to be included in the dispensation application:

Project overview

- Description of main goal and project deliverables.
- Details about project innovations.
- Describe if the project plans to build and/or operate electricity installations.
- Expected project outcomes and results.
- Technical readiness of the project.
- Partners and their roles - including how they are regulated.

The need for dispensations

- From which framework is dispensation needed.
- Explain why the project cannot be executed within the existing framework.
- Timeframe for needed dispensation.

Project execution and costs

- Investments in equipment - address who is paying for what.
- Cost sharing among partners with focus on cost paid by monopoly/grid operator.

Other elements that could influence the application

The innovative content in the project deserves and needs a detailed and precise description. The main reason for this is that if dispensations already are given to similar innovations, the applications will be rejected. Dispensations are generally given for a period of 1-3 years, with 5 years as maximum.

5.5 Trondheim case – a post transition demonstration

The energy transition will entice and drive groundbreaking changes through innovations and disruption. This puts a notable pressure on existing regulations and how they are practiced. It is not a static or linear process with easily forecasted outcomes easily

[12] El hub 2021: www.elhub.no

domesticated and adjusted to Norwegian conditions. It is a dynamic process that will not necessarily consider our legislation, nor adapt to it. The Trondheim demonstration case experiences have so far been in line with these hypotheses.

Working with local PEB demonstrations revealed the controversy derived from the work. Namely, testing the possibility of moving from the existing centralised energy system, with its regulation scheme, to a local energy system using a post-transition approach. This defies the regulations "as is''. It invokes politics with the capability to change the existing regulation framework. To achieve this, a collaborative national initiative targeting decision makers, is commenced. The initiative addresses the need for rethinking regulations, and highlights the following tasks:

- Several barriers are directly related to the regulations that are given by national authorities with judicial management by proxy.
- National focus and involvement in solving regulation barriers will appease the controversy experienced between parties involved in this demonstration.
- To achieve a solution, supporting the green transition through energy transition, solving regulatory barriers is of national concern, and responsibility.
- The impact field of the innovations from the PEB demonstration are national at the least, and to ensure that the innovations become known, adapted and set in use, it requires new regulations.

Meetings, seminars and workshops have been an important part of the work. The contribution and dialogue with and between project partners and others involved in the work has been invaluable. It led to a shared understanding and need for a national initiative to elevate, and hopefully solve, the issues in regard. The initiative has, as of today, the following two merged branches:

- A joint local and regional policy proposal. The input from project partners and experience from the project forms the basis for the proposal. In short the proposal informs local and regional politicians about implications with existing regulations, and why there is a need for a national initiative signed and supported by the politicians. It further asks for permission to move forward and reach out to other cities to mobilise for a new national regulation scheme.
- A private-public-political signed endorsement to inform national authorities, explaining the legal and practical issues and consequences with today's regulations. The initiative also presents arguments to foster a regulation in pace with the technological and societal development that has taken place since the legislation and regulations were made.

The outcome of the initiatives led to extended focus and continuous work on changing the regulations, as a spin-off from the +CityxChange project.

6 Some regulatory weaknesses and barriers

The energy industry in Europe is considered to be stable and rather institutionalized surrounded by legislations and regulations. These arrangements have been beneficial for the society as a whole, and have previously not truly been challenged to a large extent.

It is a general understanding that changes can be prompt through external, internal and beneficial enabling triggers or disruptive incidents. How to adapt and change in response as internal and external conditions evolve is not an exact knowledge. Such change challenges the perceived perception of roles, responsibilities and presumed consequences. Change is not necessarily a wanted process for all parties involved, challenging their status quo.

Within the energy sector the possible outcome or direction can challenge existing business models, market positions, investment plans and can be considered unwanted due to uncertainty or a loss of a well regulated monopoly position and stable market roles. To others it is a much welcomed development that creates new business opportunities, new markets, spin-offs and new research and development niches. As mentioned in section 2.4 we consider a paradigm shift in the energy sector is imminent.

6.1 Identified regulatory weaknesses

In the ongoing energy transition it is experienced that many regulatory issues are discussed and concluded to be unsuitable for the post transition period. In the +CityxChange project and the connected EU Smart Cities Marketplace Initiative on Regulatory Framework, a list of regulatory weaknesses are identified. These weaknesses have been put forward as part of a new Smart Cities Marketplace Initiative on Regulatory Frameworks (Myrstad, Livik and Wyckmans 2020) within the Integrated Planning, Policy and Regulation Action Cluster. These overall weaknesses, in an European perspective, are listed in table 6.1. They represent the shared need for regulatory updates and changes in Europe. If regulatory frameworks accommodate these changes, it will provide a powerful incentive to create and operate positive energy districts. Some of the weaknesses are not valid for all member states.

Table 6.1 List of some observed and experienced weaknesses in the regulatory framework typically followed by member states (Myrstad et al. 2020).

No	Identified weaknesses - European perspective
1	Mandates and responsibilities within the energy community are not with clear definitions of roles and responsibilities to accomplish climate neutral and smart cities in the near future.
2	Energy system operators are not allowed to buy system services to avoid grid disturbances to a locally set price.This will reduce the quality of supply locally.
3	The grid tariff and price structure are not set in terms of local grid costs.The price is set higher than actual costs.
4	Producers are not allowed to sell locally without a supply license. Supply licence complicates local energy production and trading.
5	Metering requirements are not in line with local market preferences when it comes to system operation and billing of supply, including the grid fee.
6	Consumers are not free to sell flexibility and buy supply locally.
7	Tax regulations are not used to strengthen incentives to implement and operate local, sustainable energy systems.
8	It is not allowed to operate a local energy system independently of the responsibility of the local distribution system operator (DSO) – or in cooperation with the DSO.
9	There is a lack of funding instruments to support local energy system start-ups.
10	It is not established invoicing and metering procedures that allow consumers to be part of both the local and global power market.
11	Absence of licenses that invite and give commercial actors incentives to new entrants to operate local energy market roles.

6.2 Experiences on Regulation – Trondheim case

With the purpose of addressing different regulatory barriers in disfavour of the energy transition it is, in detail, mapped the overall experience of the Trondheim case demonstrations. It is shown the co-dependency and degree of negative cascade effect within a possible energy community when trying to get dispensations from national legislations in order to adapt to the rapid development in the energy sector. As previously mentioned this calls for national leadership and authority to facilitate reinvention of the energy system and market legislations. A green sustainable energy sector needs regulations that redeem it to a post-energy transition stage.

It is, without a doubt, experienced in Trondheim that enabling local, green energy trade will be an unlikely task without considering a reinvention of the energy regulations. The complexity within the legislation and regulation framework and resilience to plasticity has been challenging. When the energy regulations and legislation are experienced more as gatekeeping tools not habituating necessary agility to enable innovation and market developments, it is time to address regulations and legislation as a relikt from another epoch.

Figure 6.1 is a copy of figure 3.1 with added bold lines that underline the regulated activities that are experienced to be involved in the Trondheim demonstration case. The process included being innovative and working meticulously to navigate around regulatory hindrances. Although the project established a good dialog with regulators from an early stage of the project, the regulators' role and mandate is managing and preserving existing laws and directives. Dispensations are then by nature a contradictory operation and not easily granted.

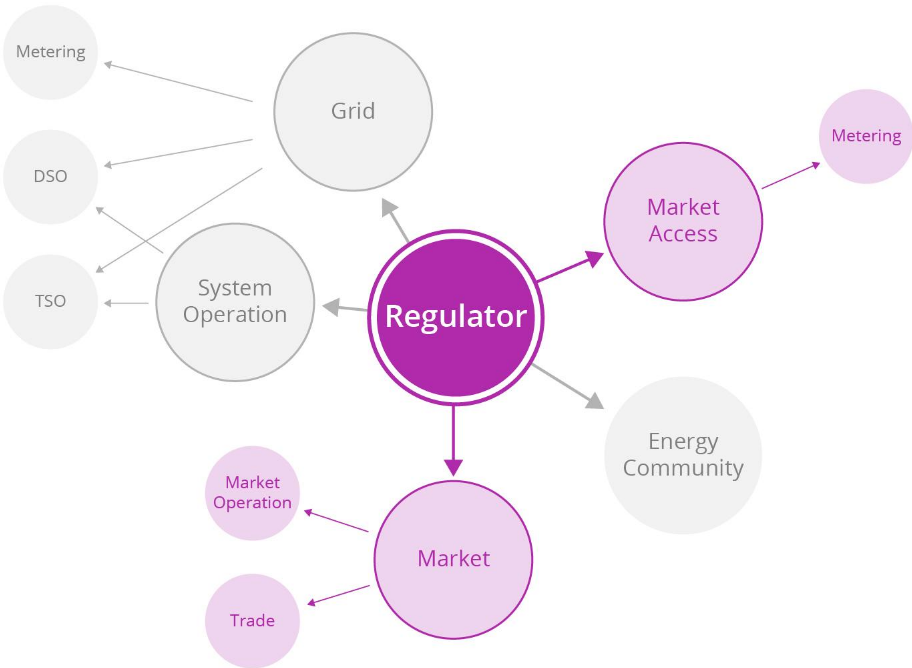

Figure 6.1 The involved regulatory framework connections (in bold pink) for the Trondheim case demonstrations.

An important finding is that if the market operator is given permission to manage market access, settlement and metering for the local market resources, it is not necessary to involve the DSO to ask for any dispensations regarding metering of global and local shared market production and consumption. This is because all local market assets are metered individually in addition to, in some situations, also included in the main meter for grid tariff and wholesale market purposes.

6.3 Barriers that influence the demonstration in Trondheim

The experienced barriers are extracted from major parties in the development of demonstration areas in Trondheim. They represent investments, city planning, construction, energy supply, energy trade, eMobility and realisation of flexibility.

Out of the six experienced regulatory key-stones presented in figure 5.1, attention focus has been on number three and four in the Trondheim case. These two areas proved to be the most challenging and controversial due to the groundbreaking work needed done and conflict of interest. They are both focusing on how to get dispensations for demonstrations rather than how to move for an operative PEB. The barriers are especially faced by the involved parties in dialogues with the local grid operator. In addition discussions were caused by unclear responsibilities when dispatch of flexible resources are detailed and set in operative plans. In the investment phases it has been difficult to estimate the value of the resources because the energy system freedom to maximise value is unclear for the entities involved.

During the process of understanding how to cope with regulations that are not future-proof, there were many lessons learned. Norway is a frontrunner when it comes to eMobility with 64% of all new cars sold in August 2021 being electric, and electric personnel car share constituted 10% in 2020. Vehicle to grid (V2G) chargers are installed in the demonstration area and electrical buses with fast chargers are parts of the demonstration. Sadly it is experienced that from the regulatory framework perspective, this is looked upon as upcoming problems rather than local energy resources. This reality perception is a hinder for new technology, new business models and new entrants in the space of commercial opportunities linked to the green transition.

The lessons learned are extracted in table 6.2 and presented as a list of regulatory barriers with negative influences to actions crucial to take and manage, in the attempt to realise a green transition characterised more or less like the Trondheim demonstration cases.

Table 6.2 List of experienced regulatory barriers that will influence realisation of local energy resources and their contribution in the green transition.

Required actions	Experienced regulatory barriers in Trondheim case
Invest in local renewables	• Not adjusted to local production and local use of renewables - increased risk. • Regulation does not include an energy system approach. • Regulation not in favor of renewables. • Lack of knowledge of the energy transition complexity and related opportunities - increased risk. • Upper limits for buildings' own generation.
Connect renewables to grid	• Generation capacity limits calls for a production licence. • Extra grid connection costs for renewables. • Metering procedures must be in line with existing regulation
Distribute power locally	• Lack of tariffs for battery use - risk of double invoicing (charge/discharge fees). • DSO/local grid owner is not obliged to allow local P2P or naboursharing between production and consumption units/bodies/meters.

	• Existing security and control routines block the possibility to connect neighbouring buildings with electrical cable.
Ensure quality of supply	• DSO has no incentives to ask for suitable and cheap system services locally. • Local resources cause disturbances because system operation is regulated to serve a centralised power system - not the local system. • DSO has no incentives to invest in and operate local system resources. • Mismatch between social and business economic incentives • DSO income regulation is not in favour of local system operation.
Operate local market-place	• No existing regulation for how to operate local market-places with local energy resources and digitised metering. • Local market operators' licence is not made for settlement and invoicing.
Buy and consume locally	• Non existing P2P regulation. • P2P responsibilities/risks not clarified. • Lack of "green" incentives • Not allowed to use DSO owned local cable/grid from generation to consumption connection points. • Not allowed to transport electricity from one building to another as part of local trade. • Lack of knowledge of that exchange of power between buildings/consumers/producers is a guarantee for improved efficiency, higher value of local resources and for the best of environmental reasons.
Produce and sell locally	• Lack of "green" incentives. • Grid obstacles due to existing regulation. • Grid tariffs do not reflect costs. • Local production is sold at a fixed reduced price while consumption must be purchased at a higher price.
Invoice local trade	• Non existing regulations for metering and invoicing in favour of local trade (generation and consumption). • The responsible metering operator does not update routines to be able to manage local market needs for data exchange and validation routines.

6.4 Experienced consequences of regulatory barriers

There are other barriers and consequences, not just regulatory, experienced during this project. The barriers and consequences have been identified and categorized in table 6.3. The table gives a substantial overview, partly as a playbook, but also as documentation of an innovation process including politics, public sector, private sector and citizens. The barriers are sought to be clustered, explained and set in context with direct and indirect consequences. When reading table 6.3 the clustered barriers have a following row with explaining examples that will apply to one or more of the listed barrieres. Same follows for the row of consequences. This has to do with barriers being interconnected or correlated, with cumulative effects on consequences.

Table 6.3 Overview of consequences of experienced barriers in the Trondheim case.

Experienced barriers and consequences in Trondheim case		
Key words: predictability, longevity, trade, framework, cultural, communication, knowledge transfer		
Legal barriers	**Explaining examples**	**Consequences**
Electrical trade is prohibited within a local market. Even illegal between neighboring buildings with one owner. Local produced power is obliged to travel through the DSOs grid. Production > 100kW, at any time, demands a supply licence. Supply licences are tailored for a central energy system solely. Shared area metering system is not allowed. Buildings have no right to sell their locally produced power to their tenants even if they have their own meter installed. Legislations and regulations from different public divisions, concerning buildings, technical installations and energy, are opposing one another.	Feed >100 kW triggers the entire production to be sold to the DSO for a fixed low price, and own consumption must be bought back at a 100% price rate. The DSO can set the trading price, without negotiation, since the surplus yield must use their grid regardless of distance. A building with several meters installed is considered consisting of multiple subunits. Only the subunit behind the PV-system meter can use the energy produced, the rest must be fed to the grid. New buildings >500 m^2 within Trondheim concession area of district heating, must connect to the central heating system. Connection fee must be paid, regardless of intended use or not. Exemption from connection fees is possible if more sustainable energy solutions can be argued. However PV and heat pumps will trigger construction grants by the DSO if the infrastructure must be adjusted.	Local green energy cannot be used by neighbours/within the block. A community cannot buy PV-installment and share the production between them. Surplus energy can not be used in a local flexibility market. Export/trade of excess PV-energy is not lucrative for the local producer. Public Ev-buses cannot be charged with local green energy even within their driving route. Building owners with large PV-systems buy extra equipment to stall production, and produce less than capacity. Even if the area has capacity for a larger feed. Building owners don't invest, or only in small, PV-systems. El-tax reduction is limited because the buyer and seller are the same.
Investment and incentive barriers	**Explaining examples**	**Consequences**
The grid tariff and price structure is not set in terms of local grid costs. Unsupportive national funding and finance instruments.	Grid tariffs in a local energy system are set higher than factual costs. Prices are unreasonable for surplus local energy production.	Investments are considered high risk within today's regulation system. Building owners do not invest in PV.

Communication barriers	Explaining examples	Consequences
Complex thematic. Many parties involved. Fragmented responsibility. Perception of roles and responsibilities.	Difficult to communicate the challenges in a general term to layman and decision makers. The legislation is so complex that experts must interpret and operationalize it. The parties handling the regulations are not experienced as impellers. The DSO is more a DNO, so the overall need and want to catalyze these processes are moderate.	The severity of the issues are lost in translation, and solutions delayed or missed. Difficult for new actors to enter the business. Suppression of innovation.
Sector coupling	**Explaining examples**	**Consequences**
Different regulations for thermal and electric energy. Energy, based on different energy sources, are not combined in alignment.	When combining different energy sources in regard to season, time, pricing, peak loads, consumption and storage, there is money, energy and CO_2 emissions to save. Building owners convert electrical energy to heat, since they can trade heat.	Loss of economic and energetic profitable return and use. Hindrance enabling an optimized PEB. Unnecessary climate impact persists.
Lack of	**Explaining examples**	**Consequences**
Plasticity within legislation. Flexibility within the regulatory framework. Willingness/ability to adapt to a changing energy system. Political framework stimulating the green transition. EPC-contracts	Dispensations do not come easily, and the applicant is responsible to come up with a solution within existing legislation. This is a time-consuming search for loopholes in the regulation framework. Energy smart renovation of old buildings is expensive, and there is little to gain from investing in optimal green buildings. There is a need for an unambiguous settlement within local energy markets, with defined and clarified responsibilities and rights for all parties involved.	Loss of motivation and momentum. Challenges the collaborative work between project partners. Failure to complete the demonstration. Failure to speed up towards the green transition within the energy sector. Loss of opportunities economically, environmentally and innovatively.
Cultural differences	**Explaining examples**	**Consequences**
Different entries and motivations.	Difficult to get key actors engaged.	Conflicts, time consuming deliberations and unnecessary delays.

Monopoly situation. Conflict of interests.	Grid operators have a natural monopoly on the infrastructure leading to the electricity meter. This key position and the dependency on their benevolence to get dispensations is problematic.	Possible demonstration failure. Belated energy transition.
Loss of opportunities/consequences		
Key words: societal differences, environment, climate, socio-economic, efficiency, optimizing		
Socio-economic	**Explaining example**	**Consequences**
Unnecessary investment costs in the grid. Cost efficiency	Utilising and amplifying locally produced electricity will reduce the need and costs for upgrades of the local grid infrastructure significantly. The reduction in grid investments is estimated to be 20 M€ in the Brattøra demonstration area alone.	The incentive or need for building owners to invest in PV, to help solve local energy capacity challenges, is absent if infrastructure for increased central electricity is put in place. Elevated grid tariffs, paid by the public, to cover the infrastructure investment.
Loss of:	**Explaining example**	**Consequences**
Effective energy utilization. Energy flexibility in an area. Possibility to reduce grid load Innovation, spin-offs, new services Value creation, jobs Business models prepared for energy transition R&D position Market Momentum Green remodeling Synergy with e-mobility Robust energy system	Functioning energy trading system will attain a better energy utilization and reduce grid load. It can also reduce energy losses along the grid. Increased local energy consumption and peak hours will cost consumers through the pricing system of the DSO. Digitalization and active use of AMS (advanced metering system) and Elhub is not favored within today's energy regulation system. The market solution in Trondheim PEB is able to document green, local energy production and consumption. This has value for green remodeling. It is also an important part in helping companies and investors navigate to a low-carbon, resilient and resource-efficient economy.	Energy consumption will cost more than needed, it will use more energy than needed, and the area's energy stand by capacity will be at an unnecessary heightened level. EV will not be able to contribute to peak shaving. Building sector as a whole, will continue to be labeled high energy consumers and high CO_2 providers. Companies and corporations cannot access or label their business green in regards to energy consumption.

Failing to:	Explaining example	Consequences
Lowering CO_2 emissions through renewable green energy production and local consumption Achieve climate-neutral Europe by 2050. Fully conduct and develop future energy smart areas, both for housing, business and industries. Incentivise optimized green renovation.	Building unnecessary infrastructure and using more energy, less efficiently than possible, will have a negative environmental impact. Renovating existing buildings, with optimized energy systems and el-production when possible, will be more expensive than to outlast their lifetime and rebuild on the property.	The energy sector will not be a significant contributor in speeding up towards the green transition. Increased or continuously high CO_2 emissions from the building industry.
Ripple effects:	**Explaining example**	**Consequences**
Limit energy intensive industries. Limit the establishment of energy intensive industries. Fortify already existing competitive advantages within an area or country with favourable energy conditions. Reinforce social differences. Belated realisation of the EU taxonomy for sustainable activities through the energy sector[13].	Energy demanding industries will face problems in regard to their energy source when EUs taxonomy for sustainable activities is put into use. Energy prices will rise with increased demand and may cause social differences. Increased energy costs will inhibit or lower revenue in other industries.	Energy demanding industries will favour establishment and business in countries with affordable green renewable energy or flag out the business. The entry cost and attraction level for other, unfavourable locations will be comprehensive. Industries will experience demanding required adjustments with few beneficial solutions.

6.5 Paradox at system level

Cities consume two thirds of the global energy demand, and emit 70% of the global CO_2 emissions[14]. As cities grow, energy demand increases and emission reduction will be particularly important. Multiple states have ratified the Paris agreement on climate goals that obligate them to take sustainable actions and reduce their emissions. Norway's Parliament has set even more ambitious targets and provides financial support for emissions reductions projects in all sectors of the economy. Partners in this project have been benefactors of several supported projects in addition to the +CityxChange project.

[13] EU Taxonomy for sustainable activities: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en
[14] C40 2021: https://www.c40.org/why_cities

At the same time, laws, legislations and regulations are contradicting wanted development and both prevent and delay the potential in the energy sector moving forward. Clean energy lies to a large extent in decentralised and distributed renewable energy solutions. Laws and regulations however, are customised solely to large-scale centralized energy systems. Some key actors directly involved in this case are more or less public owned bodies, that one should expect to have a perspective on the greater good, expediting needed innovations, emphasizing new business opportunities and models, rather than fearing loss of monopoly. CEER (2018) advocates in their conclusion paper that the DSOs should have a wider vision of the value chain, with social net benefits as the main criteria, rather than solely the DSOs own grid, but without precluding competition. This is unfortunately not the case in Trondheim.

The development of the energy industry towards a post-energy transition reality will include many other industries. Among these are finance institutions that don't have the right instruments to catalyze investments, reduce risk nor stimulate or incentivize a paradigm shift. National funding and finance instruments are in a transition phase with new programs that will support an accelerating technology development within the energy sector.

The EU Taxonomy for Sustainable Activities, which was established to help companies and investors navigate the transition to a low-carbon, resilient and resource-efficient economy by defining which economic activities are environmentally sustainable, is yet to roll out. In absence and in anticipation of a possible EU green support factor, the general impression is that an overall pending approach is taking place. When knowing there will be a time lag in implementing EU-regulations, the question is: Do we have the luxury to sit and wait, or should we take an active approach with the tools we have at disposal?

A lot of time and money are invested in R&D, testing, piloting and trying out innovations in sandboxes, but solutions and results tend to fail at an easy implementation and use of results at a scaled level. The distance between those wanting and financing testing, those who conduct it and the decision making authorities seem to reinforce the paradox. With the 2030-targets approaching fast, the time for "demonstrations" alone is passé. It is time for a regulatory framework that allows commercially viable and effective technology zero-emissions solutions to be put in use at scale. CEER opt the regulators to follow up on the developments in the energy sector with a stable, transparent predictable regulatory framework. They are also asked by CEER to have a whole system approach, focusing on the societal net benefit, and again to encourage DSOs to consider the consequences of their decisions on other actors in the value chain.

Innovation and development processes are not straightforward, and when planning demonstrations it was not thought that getting dispensations should become so difficult. The dispensation must have specific partners involved in the project applying, which should be manageable in theory. It is then a paradox when the motivation for writing the application is absent, and the demonstration was solely dependent on the goodwill of a reluctant DSO. The vulnerability in application rule, set up by the regulatory body, has caused delays, frustrations and even threatened the whole implementation of the demonstration. Only because the market operator was considered to be a grid operator by

Elhub, and the DSO could be extracted from the equation, the dispensations were possible to send.

6.6 Regulation “as is” will cause loss of opportunities

The reason and need for an energy transition is well founded and argued for by the EU and national governments. However the regulatory implications and consequences for the different stakeholders are complex, not fully evaluated or understood. It is easy to assume that for some there will be unbiased positive outcomes, whereas for others there will be both negative and positive consequences, and for some uncertainty might dominate their postulations. It will depend on how well one adapts, local and national conditions, but also the ability to see and seize the opportunity within a new order.

The consequences of not taking part in the energy transition can be as blunt as loss of opportunities; financially both for the present opportunity but also future innovations, spin-offs, market positions and relevance. Ending up with a “Kodak moment” covers the worst case scenario standing by hoping the future will be exactly as the present, and utterly missing the fast moving train passing by. Assuming the energy transition is likely to happen, regardless of the barriers and obstacles encountered in this case, disruptive business models and new players on the field may be the outcome. That can cement the loss of opportunity permanently or result in a belated ability to take part in the new value creation.

From a socio-economic, societal and environmental point of view the consequences of a future-proof and flexible regulatory framework are potentially formidable. There are infrastructure investments, CO_2 emissions, grid and electricity expenses that can be largely reduced and kept down. If we add the loss of value creation, new jobs, international market position with R&D and technology innovations, it adds up.

From a security and quality of supply perspective, there is also a potential loss of resilience. PEBs can contribute to secure power supply. Assets, like batteries, can contribute in case of a crisis. Privately owned PV-systems, with their own local grids connected to the main grid, can be a valuable backup if the main grid fails to provide enough energy. They can self provide if intended or unintended incidents happen. Like extreme climate events, terrorism and cyber attacs towards critical infrastructure.

The growing demand for energy, especially electricity, within the society and other industries will be affected. When it comes to our responsibility as a catalyst and possible energy game changer, embodying the green transition, the loss is noticeable if the regulatory framework is not changed towards future needs.

6.7 Citizen expectations to the green transition

Citizens want to be a part of the green transition, to have their contribution count. The consumer, as a citizen, is expecting that their sustainable decisions and investments will not meet regulatory barriers implemented and legislated to serve the past. There is a need for future-proof and predictable incentives that secure investments and use of local, green renewable energy.

Conscious consumers and early adapters expect sensible access to local renewable resources. Same as for smart neighbourhoods, they will take it for granted that they can share local energy production and provide others with surplus yield, regardless of production volume. Knowing that the technology is there, for citizens private or in businesses, creating a seamless user interface customized for consumers, producers and prosumers, the stage is set for flexible consumption and energy produced and consumed locally. Examples of existing prerequisites ready to support the transition are:

- Vehicle-to-grid charges already exist, and EV owners will soon expect to contribute to a flexible energy market.
- A local market platform, that makes it possible to trade PV, wind, flexibility and battery storage locally, that also facilitates for the grid operator to purchase local system reserves, is in the pipeline.
- Norway is a highly digitalized country, with climate and sustainability consciousness asserted.
- High expectations and willingness to adapt to new, green solutions, benefitting the globe.

Worth paying attention to in this context, is software able to calculate the best design for a local energy system. This is work in progress that will help to avoid stressing the distribution grid. Grid calculations, including load-flow analyses based on local topology, are crucial for planning and operating a local grid which feeds in from local generation and realised flexibility. By using such calculations, it is possible to find out if e-mobility will stress the local grid knowing that cars, chargers, and carpools can stress the system.

D5.16 ”Sustainable investment and business concepts and models” will include scenarios on how and to what extent legislative and regulatory changes from T5.4 may improve business models on a longer timescale. Expedient regulations are a measure and action that will enable and boost innovative sustainable public and private investments for citizens, building owners and other stakeholders within the Trondheim demonstration projects.

7 Recommendations

7.1 Start with the general

There is not an easy or predefined road to innovations and demonstrations on a system changing level. The involvement of partners and allies with different ambitions and reasons to participate can be rewarding and demanding, but never straightforward or foreseen. Experiences from the work have ended up in a list of regulatory related recommendations as listed in table 7.1. Each one, singled out, is of minor importance, but seen together they can be read as a set of practical advice and recommendations in a playbook.

Table 7.1 Overview of general recommendations in the process of setting up and demonstrating local energy markets - focusing the involvement with the regulator.

Method	Recommendations
Dialogue	All parties involved must be heard, seen and taken into consideration.
Transparency	Documents, plans, meetings etc. must be available for parties involved. Honesty and realistic expectations of why and what the partners want from the participation is important.
Negotiations	Necessary to involve other stakeholders or affiliated parties when negotiating. Use different people within the organisation, to meet peer to peer and to avoid wear on people involved.
Multiangle approach	The work is not linear, and different areas and topics must be attended simultaneously to reinforce one another, save time and to find solutions.
Knowledge based decisions	Knowledge developed within the project from other partners, from the R&D sector, other initiatives and other demonstrations are helpful guidelines.
Focus on the bigger picture	Having a conscious reference to a believed post-energy transition phase is important.
Problem solving mindset	It is important to have a constant reminder that problems and hiccups are a natural part of demonstrations and innovations.
Teamwork	Interdisciplinary innovations need a diverse team able to see the task from several angles, and to contribute with valuable insight.
Addressing challenges as they occur	There is no set path in this line of work, the path is made by walking. Challenges will arise, and must be seen as a part of the innovation journey.

It is experienced that if you do not have an energy system approach it is difficult to understand how local energy resources will be beneficial in a post-energy transition phase. A prerequisite for successful implementation of a local energy market demonstration is to involve the regulator in this process. A joint understanding will ease the work with applications for dispensations - and secondly will help to transfer knowledge to the regulator and other involved parties.

7.2 Clarifications and suggested solutions

The following list describes a summary of recommended changes and clarifications based on +CityxChange experiences with regulatory frameworks:

- In local energy systems, the grid operator must be given the freedom to establish tariffs and agreements based on local conditions (load, generation, grid).
- PEB/PED as an energy system must be allowed to operate based on local conditions.
- Existing and planned local energy resources have the right to operate within a framework supporting the energy transition rather than existing DSO concerns.
- The regulation must give DSO some incentives to act as a green transition catalyst rather than a premise.
- Regulation must open up for licenses in favor of local market operation with fully automated solutions.
- Market settlement/invoicing must be possible to execute for third parties.
- New entrants within the local energy market helping to feed the green transition must be favored in the regulatory framework.
- Energy Communities - and PEB/PED - must be given permission to expansions and innovation without extensive processes for approval.
- Metering must be allowed to execute by licenced meters - even outside DSO/metering companies responsibility.

The green transition is an ongoing global process with energy as one of several tasks. It is expected that innovations, disruptions, new technologies, digitalisation and human concerns about climate change will influence policy makers and secondly regulatory frameworks significantly. This deliverable with its basic descriptions of how energy systems should evolve and support PEB processes addresses basic actions in a post-energy transition phase. The suggested re-established regulatory framework with some selected actions experienced from the demonstration cases in Trondheim are general and member state independent. In Annex it is presented a document sent to Norwegian politicians at national level on behalf of power industry, customers federations and commercial players that want to be innovative and make innovative steps supporting the green transition. It extracts main issues which are discussed, experienced and presented in this deliverable - and ends up with a list of proposals for how updated regulations may stimulate PEB, PED and energy communities towards an energy transition.

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Annex

As a part of the deliverable it has been an ongoing process with an inquiry to national politicians regarding the need for a renewed energy regulatory framework. It is sent to the minister of state for petroleum and energy, the national parliament committee on energy and the environment, and to a government appointed board committee (*Strømnettutvalget* [15]). The inquiry is submitted on behalf of the city[16] and county[17] councils, research and development sector and business organisations. In addition, several national organisations have supported the inquiry. The inquiry is a result of the experiences and findings from D5.9 deliverable: "Playbook of regulatory recommendations for enabling new energy systems deliverable". It is formed in a general matter, adaptable to other countries and is written as follows:

Changes in energy regulatory framework is required

The purpose of this inquiry is to address needs for changes to and adaptations of the framework that regulates implementations and usage of local renewable energy resources, including trade of flexibility among consumers. We want to contribute with proposals for how a flexible future-proof regulation will provide incentives for electrification and decarbonization in line with climate goals. The target group for this inquiry is governments and politicians at the national level.

As a result of the ongoing energy transitions in EU member states, it is obvious that this will stimulate the development and implementation of new technologies, new players, new energy systems and an overall change from centralized to more local focused energy systems. This synergy between energy transition and value creation is extremely important and will lead to new commercial opportunities for member states. In addition it will stimulate increased use of renewables and development of energy communities. However, in order to contribute to this development, there is a significant need for a future-proof and flexible regulatory framework in the energy sector.

The national energy act[18] regulates the traditional generation, transport and the customer side of electricity. This framework, with its regulations and precepts, have an urgent need to be revised with the purpose to favor the transition towards an electric, low-emission society. Experiences from ongoing pilot- and R&D projects, with development of new technologies and large scale demonstrations, documents that regulatory changes are required. If such changes are legislated, our opinion is that the probability to reach climate goals and value creation, such as new jobs, will increase significantly.

[15] Strømnettutvalget: https://stromnettutvalget.no/
[16] City Council, political decision 28.09.21 (PS 0313/21): https://innsyn.trondheim.kommune.no/motekalender/motedag/50010318
[17] County Council, political decision 05.10.21 (PS 208/21): https://opengov.360online.com/Meetings/TRONDELAG/Meetings/Details/1213090?agendaItemId=210828
[18] The National Energy Act: https://lovdata.no/dokument/NL/lov/1990-06-29-50

Within the new energy system in a post transition phase, the power generation from renewables will be dominating on a local scale and close to the consumer. This will cause changed use of the power grid, and the local supply of energy will more commonly be managed by smart cities and energy communities (EC). A critical factor of success in this realization is a regulatory framework providing future oriented and predictable incentives. The key must be that the regulations give the grid a role as a catalyst and enabler for the shift. If the grid companies operate within a regulatory framework with this focus, it will as an example be normalized to apply and utilise flexibility with the purpose to reduce grid operation cost. Secondly it will strengthen incentives to electrification and implementation of local energy resources.

In the development of cities – and city districts – it is all over Europe an emphasis on applying future-proof and innovative energy supply solutions. Through close cooperation between buildings and local energy resources (including batteries) this local system will remedy peak demand periods and contribute with feed in of local renewable power.

Cooperation in innovation projects between the public sector, private businesses and universities is given high priority in the EU. This represents a strong driving force for the transition phase. Changes of the regulatory framework must keep this in mind to ensure that such triangular cooperation may deliver the required technologies, knowledge and implementation of the transitions. Secondly, implementations will result in successful commercialization and new jobs.

Coordinated use of batteries, thermal storages, and smart planning of power generation will help to reduce grid constraints and investments. However to realise the benefits of this flexibility and sector coupling, it is required a suitable regulatory framework and a market design that supports local flexibility. Given these prerequisites and incentives, cities and energy communities will develop in line with the transition goals.

A global observation is that electrification, digitalization and growth of locally connected energy resources develop fast. Innovation is in focus and new commercial entrants and new business models are registered daily. Such a positive industrial development is experienced to face regulatory frameworks as barriers for commercialisation, implementation and scaling. It is obvious that with a more flexible regulatory framework, the development of efficient and future oriented local energy systems will evolve faster. The result will be cheaper energy and an increased share of renewables. However, the time window for member states to achieve positions as global leaders in energy transition generated technologies, solutions and knowledge is limited. This reality underlines the need for fast and constructive renewing of the regulatory framework which today is experienced as barriers.

Existing regulations and rules makes it difficult to carry out demonstration and pilot projects within the flexibility area, local power generation, and storage. Such projects must apply for dispensations – processes which are experienced as demanding and time-consuming. This is critical for our state in its plan to increase the participation in EU programs which support innovation projects in the energy transition. This is an additional and important argument to why the regulatory framework must be updated and made more flexible.

The energy transition is observed in many areas to challenge existing rules and practices. This situation creates demanding processes for all involved parties (public, universities, businesses) and it is essential that clear and future-proof political guiding is established. Summarised, the political guiding must deliver a future-proof and agile regulation that favors:

- Incentives and framework that motivates to invest in local renewables and flexibility.
- Cities and communities with strong incentives to realise the transition.
- Coordinated and energy transition perspective in the administration of national laws such as: Energy act, planning and building law, grid regulation, sector coupling, and electricity security.
- Local power generation with efficient sharing principles within the community, neighborhood, or local market.
- Cost based use of local grid with energy transition friendly tax regimes.

The reality of 2021 is that the public sector, universities and businesses involved in the energy transition, state that they are prohibited to choose preferred solutions and technologies due to legal issues at governmental level. At the same time it is a significant mobilization within the EU to include a wide range of realized and planned stimuli including updated regulations. For us as a nation it is extremely important that we renew our energy regulatory framework in line with the EU – and not end up with delays that reduce our innovative power and prohibit an efficient energy transition in our country.

The demand for new, smart and local renewable energy is obvious and deserves that all possible opportunities for innovation, demonstrations, implementations and operations are supported. More precisely, it is our recommendation that the regulatory framework facilitates the following:

1. Distribution and community grid operators given the authority to establish solutions and tax regimes based on local conditions.

2. All local energy resources are easily and efficiently connected with conditions that favor the green transition.

3. Energy blocks, districts and Energy Communities with incentives for efficient and reasonable energy exchange and energy sharing – including the development of solutions making it efficient to realise flexibility.

4. Energy blocks, districts and Energy Communities are allowed to optimize their internal interactions with common batteries or capacity reducing actions to reduce cost inclusive taxes.

5. Incentives to develop and set up local marketplaces and development of new energy services/products and support for sector coupling (electricity, heat, cooling).

6. Experiencing the regulatory framework as predictable and agile.

An updated regulatory framework, in line with the recommendations discussed and proposed in this inquiry, will accelerate the green energy transition and will increase our possibilities of having success. The results will also become more positive for our businesses, and will add value to our society as a whole.

The intention with this inquiry is, through its proposals, to contribute to the shift and additionally to address what is required of efforts – including having a future-proof local grid with a significant share of its load coming from local renewable resources.