Preliminary toolkit for goals and KPIs

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PI-SEC

Planning Instruments for Smart Energy Communities

Forord og sammendrag

PI-SEC er et norsk forskningsprosjekt som påløper i tidsrommet april 2016 til mars 2019. Prosjektet er finansiert av Norges forskningsråd. PI-SEC står for "Planning Instruments for Smart Energy Communities", og prosjektet har som mål å utvikle effektive planleggingsinstrumenter for integrering av energispørsmål på områdenivå. Prosjektet vil øke kunnskapen rundt hvilke parametere som er viktige for byer med fokus på smart og bærekraftig energi, samt hvordan disse kan kobles med planlegging, drift og monitorering av nye og eksisterende områder. Forskningspartnerne er NTNU og SINTEF Byggforsk, i samarbeid med Bergen og Oslo kommune og partnerne Standard Norge, FutureBuilt og Norwegian Green Building Council. Bydelene Ådland i Bergen og Furuset i Oslo er pilotområder i prosjektet.

Prosjektet er delt inn i to arbeidspakker (WP), hvor WP1 tar utgangspunkt i utviklingsprosjekter (*bottom-up*), mens WP2 tar utgangspunkt i kommuneplanlegging (*top-down*). Det er videre 4 aktiviteter i hver av arbeidspakkene (tasks).

Denne rapporten avslutter Task 1.2. Rapporten redegjør for et sett verktøy som skal testes ut i Task 1.3. Dette arbeidet har hatt fokus på en indikatorbasert verktøykasse som kan dekke behov påvist i Task 1.1 og Task 2.1. Målet er at verktøykassen vil være nyttig for områder med fokus på energieffektiv og smart byutvikling, gjennom at disse, på en enklere måte, kan velge samt følge opp gode mål og nøkkelindikatorer.

Basert på relevante indikatorer (KPIer) samlet fra litteraturen ble en sluttliste på over 21 hovedindikatorer generert gjennom en strukturert utvelgelsesprosess. Indikatorer er fordelt på underkategorier og sektorer.

Målene som er definert av de involverte byene og pilotområdene har blitt samlet og strukturert. Målene er kategorisert i fem hovedkategorier:
1. CO_2 reduksjon
2. Økt bruk av fornybar energi
3. Økt energieffektivitet
4. Økt bruk av lokale energikilder
5. Grønn mobilitet

Rapporten redegjør for metodikk for valg og utvikling av egnede mål og indikatorer og hvordan disse verktøyene kan tilpasses pilotområdene Furuset og Zero Village Bergen. Metodikken baserer seg på Multi Attributt Beslutningstaking (MADM), for å gjøre objektive valg basert på all tilgjengelig informasjon. Gjennom den utviklede prosessen er det utarbeidet en foreløpig verktøykasse med 21 hovedindikatorer delt i underkategorier og sektorer.

For å forenkle bruken av indikatorene og knytte dem til måloppnåelse, er det foreslått et indikatorbasert planleggingsverktøy for områder. Verktøyets hovedformål er å knytte spesifikke tiltak til grad av måloppnåelse via beregning av tiltakenes påvirkning på valgte indikatorer.

Rapporten går også i gjennom andre verktøy som kan være relevante for bærekraftig byutvikling i pilotområdene i kapittel, samt redegjør for det juridiske rammeverket som ligger til grunn for ulike måledata.

En rapport tilknyttet Task 2.2 er utviklet av NTNU parallelt med denne rapporten. I task 2.2 så presenteres et planleggingshjul. Hjulet illustrerer mulige verktøy som kan bidra til at energiplanlegging integreres i kommunal planlegging. I tillegg til planleggingshjulet så presenteres en rekke planleggingsverktøy brukt i internasjonale Smart City eksempler. Disse verktøyene kan bistå planleggingsprosessen, og vil bli testet i task 2.3, sammen med anbefalingene fra denne rapporten.

Takk

Gjennom arbeidet med denne rapporten har vi fått hjelp av mange gode partnere og støttespillere. Tusen takk for nyttige innspill og kommentarer:

Helene Egeland (Klimaetaten, Oslo Kommune)
Mathias Carl Mangor Bjornes (Plan- og bygningsetaten, Oslo Kommune)
Elisabeth Sørheim (Klimaseksjonen, Bergen Kommune)
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Miimu Airaksinen (VTT)
Guro Grøtterud (NVE)
Jens Gran (Standard Norge)
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Gerhard Stryi-Hipp (Fraunhofer ISE)

Summary

"Planning Instruments for Smart Energy Communities" (PI-SEC) is a Norwegian research project lasting from April 2016 to March 2019. The project is funded by the Research Council of Norway. The project aims to develop effective planning tools for the integration of energy issues at the property level. The project will increase knowledge about parameters important for cities with a focus on smart and sustainable energy, as well as how these can be connected with the planning, operation and monitoring of new and existing areas. Research partners are NTNU and SINTEF in collaboration with Bergen and Oslo and reference partners Standard Norway, FutureBuilt and Norwegian Green Building Council. The districts Ådland in Bergen and Furuset in Oslo are case studies in the project.

The project is divided into two work packages (WPs), where WP1 has a bottom-up approach from building project development, while WP2 has a top-down approach from municipal planning. There are four tasks in each work package.

This report shows the results of Task 1.2. The report outlines a set of tools to be tested in Task 1.3. The work has been focused on an indicator-based toolkit that can meet needs detected in Task 1.1 and Task 2.1. The goal is that the tools will be useful for areas focusing on energy efficient and smart urban development and that it will be easier to choose and follow up goals and key indicators.

Based on relevant key performance indicators (KPIs) collected from literature, a final list of 21 main indicators was generated through a structured selection process. The indicators are divided into subcategories and sectors.

The goals defined by the case projects and the pilot cities relevant for SECs have been collected and structured. The goals have been categorized into five main categories:

1. CO_2-reduction
2. Increased use of renewable energy
3. Increased energy efficiency
4. Increased use of local energy sources
5. Green mobility

This report outlines the methodology for selecting and developing suitable targets and indicators and how these tools can be adapted to the Furuset and Zero Village Bergen pilot areas. The methodology is based on Multi Attribute Decision Making (MADM), to enable objective decisions based on all available information. Through the developed selection process, it is formulated a preliminary toolkit of 21 Key Performance Indicators (KPIs) divided into subcategories and sectors.

To simplify the application of the indicators and connect them to goal achievement, an indicator based planning tool for neighbourhoods is proposed. The main goal for the tool is to tie specific measures to the degree of goal achievement through calculation of the influence the measure has on the indicators.

The report also presents other tools that may be relevant for sustainable urban development and legal frameworks related to the monitoring of KPIs.

A report discussing the results of Task 2.1 is written by NTNU in parallel with this report. In task 2.2, a planning wheel is presented, which lays forward possible tools that can guide the integration of energy planning into municipal planning practices based on the two cases. The wheel is presented alongside a number of planning tools from international smart city cases, which can support the planning process and will be tested in task 2.3 together with the testing of the recommendations of report 1.2.

Acknowledgement

Thank you to the national and international experts giving valuable input and comments to this report:

Helene Egeland (Klimaetaten, Oslo Kommune)
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Gerhard Stryi-Hipp (Fraunhofer ISE)

English - Norwegian dictionary

In the report, the following translations are used [1]:

English	*Norwegian*
Building applications	Byggesak
Central government land-use plan	Statlig arealplan
Cities of the Future	Fremtidens byer
County master plan	Fylkesplan
District	Fylkeskommune
Energy frame requirements	Energirammekrav
Key Performance Indicator (KPI)	Nøkkelindikator
Municipal master plan	Kommuneplan
Municipal coordinator	Kommunal saksbehandler
Plan for land use	Arealplan
Planning and Building Act	Plan og bygningsloven
Prosumers	Plusskunder
Regional master plan	Regional plan
Regulations on technical requirements for building works	TEK / Byggteknisk forskrift
Smart Energy Communities (SEC)	Energismarte områder
Urban Environment Agreement	Bymiljøavtale
Waterborne heating / cooling	Vannbåren varme/kjøling
White paper on energy policy towards 2030	Energimeldingen
Zoning plan	Reguleringsplan

[1] A general English-Norwegian termlist for the Planning and Building Act is available on https://www.regjeringen.no/no/tema/plan-bygg-og-eiendom/plan--og-bygningsloven/plan/veiledning-om-planlegging/Bokmal-nynorsk-ordliste/ordliste-norsk-engelsk--plan--og-bygning/id462717/

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1. Introduction

Introduksjon – En kort oppsummering av kapittelet

PI-SEC er et norsk forskningsprosjekt som varer fra april 2016 til mars 2019. Prosjektet er delt inn i to arbeidspakker (WP), hvor WP1 tar utgangspunkt i utviklingsprosjekter (*bottom-up*), mens WP2 tar utgangspunkt i kommuneplanlegging (*top-down*).

Denne rapporten oppsummerer prosessen bak utvelgelsen av et generelt sett med indikatorer for energieffektiv og smart byutvikling. De valgte indikatorene presenteres i et eget kapittel. Indikatorene linkes også til hver av PI SEC sine pilotområder. Et eget planleggingsverktøy, "PI SEC Indicator Tool", presenteres og andre verktøy som er mulig å bruke for bærekraftig byutvikling blir også presentert.

1.1. About the research project PI-SEC

PI-SEC is a Norwegian research project, lasting from April 2016 to March 2019. The project is funded by the Research Council of Norway.

PI-SEC will deliver efficient planning instruments for integrated energy design at the neighbourhood scale, qualified for Norwegian planning context in cooperation with public stakeholders. The project will provide increased knowledge about what parameters are essential for moving towards smart and sustainable energy use in Norwegian cities and how these can be linked to the planning, operation and monitoring of new or existing neighbourhoods.

The research partners are the Norwegian University of Science and Technology (NTNU) (Project manager and WP2 leader) and SINTEF (WP1 leader), in close cooperation with the municipalities Bergen and Oslo as well as the partners Standard Norge, FutureBuilt and the Norwegian Green Building Council. The project has a European reference group of central institutes and municipality representatives from the European Innovation Platform on Smart Cities and Communities as well as the EERA Joint Programme Smart Cities. Moreover, the project partners participate in IEA ECB Annex 63[2], including also non-European partners such as China, Japan, Australia and South-Korea.

The main target groups of the project are urban decision makers, municipal planning departments and other stakeholders that are developing targets, criteria, roadmaps and tools for sustainable energy use in Norwegian communities.

PI-SEC addresses the thematic priority area *Smart Cities and Communities* and the challenge of developing effective planning instruments to improve the energy performance of built environments, and monitor corresponding progress made over time.

The originality of the project lies in the coupling of planning instruments on *different scales* (i.e. building, neighbourhood and city) applying a *multi-disciplinary* approach including *case studies*. The project applies a multidisciplinary approach by analysing ambitious case study projects both from a bottom-up viewpoint (developers and designers) and a top down viewpoint (municipalities). To avoid sub-optimization and ensure that overall goals are met, the planning instruments will be interrelated in a way that makes it possible to transfer and aggregate information from building level, to neighbourhood, city, regional and national levels, and vice versa (see Figure 1.1).

[2] International Energy Agency, Energy in Building and Community Systems, Annex 63: "Implementation of Energy Strategies in Communities", project period 2013-2017, Objective to develop recommendations for effective translation of a city's energy and GHG reduction goals to the community scale, develop policy instruments, and models for cooperation and business.

The knowledge developed in PI-SEC will be a catalyst for achieving long-term political goals for reductions in energy use and greenhouse gas emissions (GHG emissions), use of local renewable energy sources, and security of supply. Having specific, agreed upon goals and key performance indicators (KPIs) is important for development of new smart energy services and products by and for the construction industry, as well as for shaping policy and legislation for sustainable development of built environments. This knowledge will also be a basis for standardization, certification and regulations.

Country level ↓↑	Energy use per capita, Energy use per unit of GDP, Reserves-to-production ratio, Non-carbon energy share in energy and electricity, Net energy import dependency, Percentage of income spent on energy, Storage capacity, Security of supply, etc.
City level ↓↑	Total residential electrical energy use per capita, Energy consumption of public buildings, Percentage from renewables of total energy use, Impact on the electricity network, Air pollution, Charging networks, Intelligent transport systems, Average commuting times, Value of fuel savings, etc.
Neighbourhood level ↓↑	Reductions in CO_2-emissions, Life Cycle Costs, Air pollution, Import and export of energy, kWh/m^2 per hours of occupancy, CO_2/travel km, Distance to public transport nodes, Frequency of public transport, Cycling networks, Integration of RES, Intelligent transport facilities, etc.
Building level	Energy demand in kWh/m^2 floor area, Delivered and primary energy in kWh/m^2 floor area, Power demand, CO_2-emissions from materials, construction and operation, Life cycle energy costs, Load match/grid interaction indicators, User interaction, etc.

Figure 1.1 Examples of key performance indicators (KPIs) used at different levels
Note 1: District level and regional/international levels are not included in the figure, for simplicity reasons.
Note 2: The figure only presents examples of typical indicators used at different levels, collected from different sources[3], and is not meant to be a complete list of indicators.

Task 1.2, summarised in this report, includes selection and specification of goals and KPIs to make the basis for the testing in case studies related to Task 1.3. The case studies are presented in the table below.

Project name and location	**Energy/ environmental goals**	**Type and size of development**	**Time frame**	**Special issues**
Ådland, Bergen	Zero GHG emissions for area, www.zeb.no	600 dwellings and a community centre. Planned for new buildings/infrastructure	2015-2020	Local renewable energy and electro- mobility

[3] Sources: www.concerto.eu; www.civitas.eu; www.rfsc.eu; www.cityprotocol.org; www.breeam.org; www.usgbc.org www.pub.iaea.org/MTCD/publications/PDF/Pub1222_web.pdf; www.covenantofmayors.eu; www.morgenstadt.de; www.siemens.com/entry/cc/en/greencityindex.htm; ec.europa.eu/regional_policy/en/policy/themes/urban-development

Furuset, Oslo	Climate neutral district centre, www.futurebuilt.no	Existing suburb from 1970's with 9500 inhabitants	2010-2020	Energy strategy plan and GHG accounting analysis

1.2. Report context and content

This report is primarily based on the closing reports from task 1.1 in addition to closing report from task 2.1 (Figure 1.2) and meetings with area stakeholders. Task 1.1 is an analysis of goals and indicators in design projects and relevant international projects, in total about 200 indicators. A primary objective of task 1.2 (this report) is to refine this list to a manageable list of useful KPIs (key performance indicators), all especially valuable for measuring progress towards defined goals for the pilot areas. Chapter 4 describes this process and the final collection of KPIs.

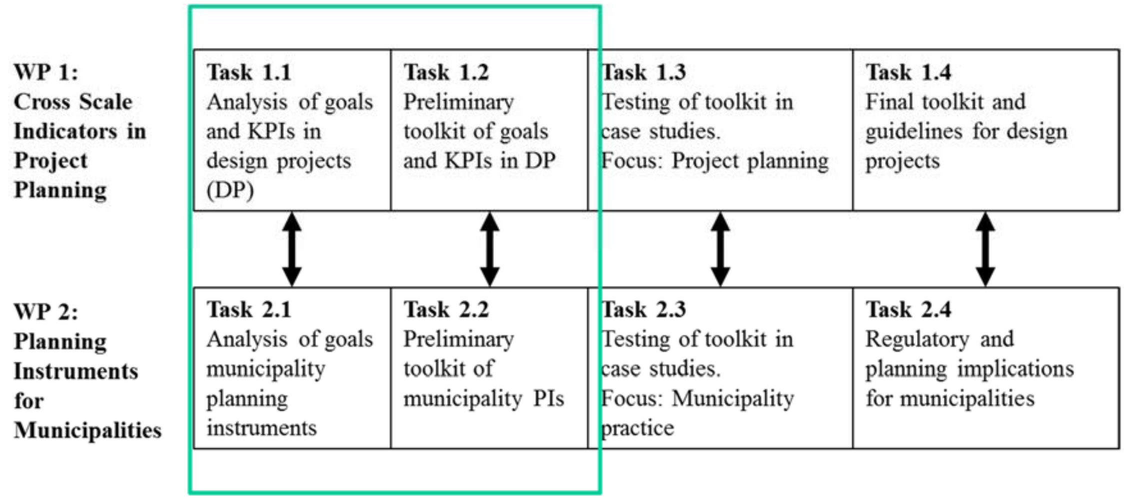


Figure 1.2: Preliminary toolkits in Task 1.2 and Task 2.2 must be interrelated and connect all levels.

One special challenge was revealed in the process and meetings; On one hand, area planners and municipal decision makers set ambitious energy or emission goals for the area, while on the other hand, land and estate developers use their right to construct buildings complying with the minimum building code and keeping energy ambitions at a low level. This challenge is illustrated in Figure 1.3.

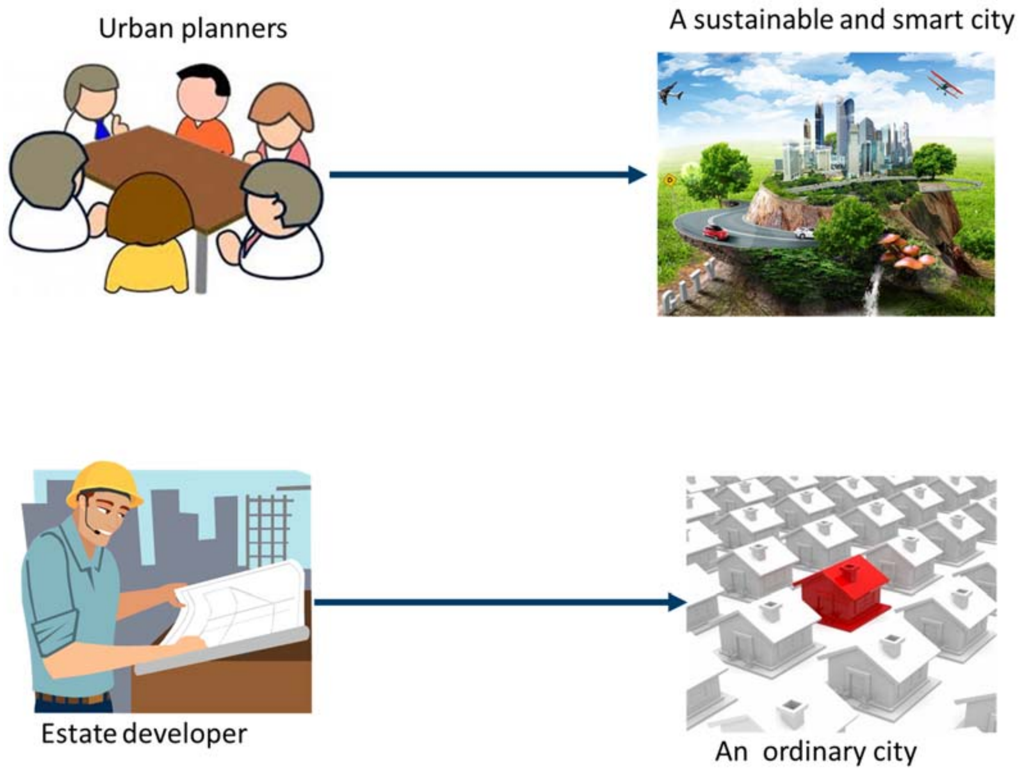


Figure 1.3: Urban planners tend to set a very ambitious goal for the area without reflecting that private estate developers can use theirs right to construct building complying with the minimum building code. The consequence is weak links and vast deviation between theoretical and practical area development. Illustrations: Microsoft clip gallery.

Based on this, it is suggested a PI SEC Indicator Tool defining specific consequences an areas ambition has before the area are constructed or renovated. This indicator tool and its relation to WP2, is described in chapter 5. The tool links the area goals to all up-coming building measures (Figure 1.4).

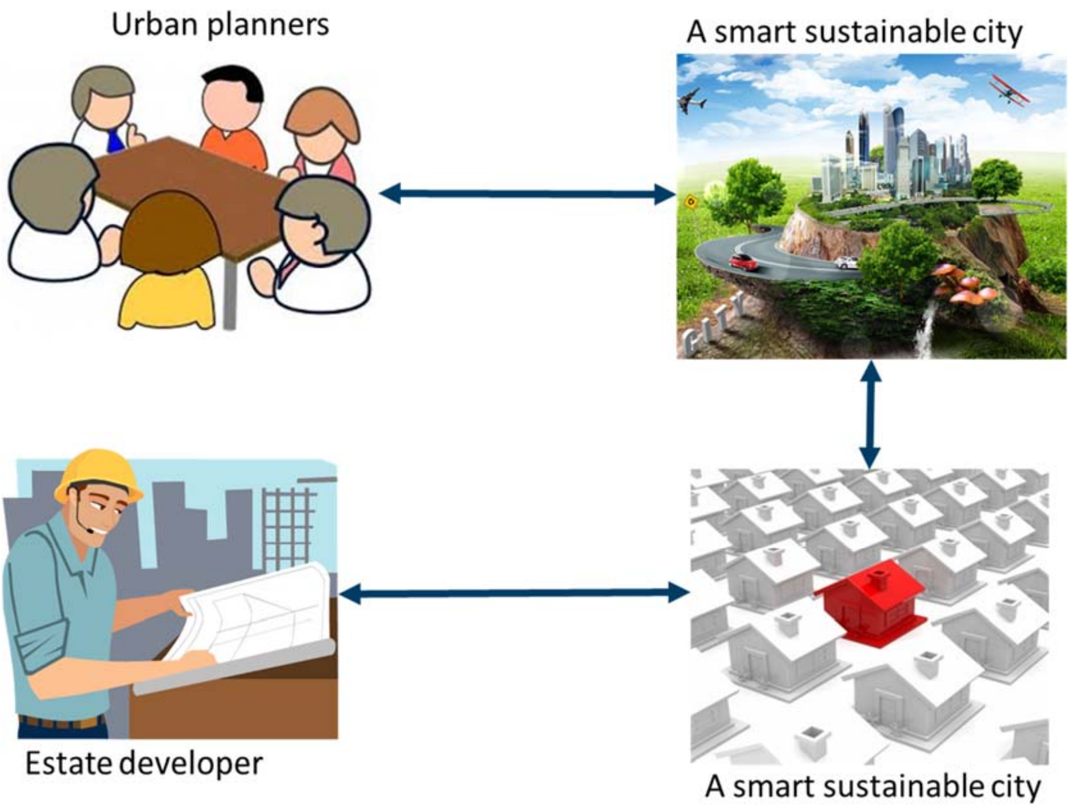


Figure 1.4: An indicator tool defining the specific consequences an ambitious area goal has on building level before the building is constructed, can help the urban planners to set realistic goals, close the gap between theoretical and practical area development, enable increased consciousness and improved utilisation of subsidies, incitements and law enforcement. Illustrations: Microsoft clip gallery.

Work Package 1 has a "bottom-up" approach focusing on the goals and indicators used in the planning and design of buildings and neighbourhood development projects. Work Package 2 has a "top-down" approach focusing on how the municipalities should design their planning instruments to facilitate the move towards smart energy communities.

Together, they aim to design tools for planning new or renewed neighbourhoods based on preliminary toolkits from task 1.2 and 2.2. However, the toolkits will overlap. Figure 1.5 shows the different target groups and identified tools visualized in a bottom-up interpretation. The KPIs and the indicator tool are the main tools identified in task 1.2, described in chapter 4 and 5.

Some tools are relevant for different target groups. One example is the district dashboard that shows daily development compared with baseline and target. This is suggested as a tool for urban planners which is defined as the top level target group, see chapter 5.3 for explanation. This same screen can be the "visual area screen" to inform and motivate inhabitants.

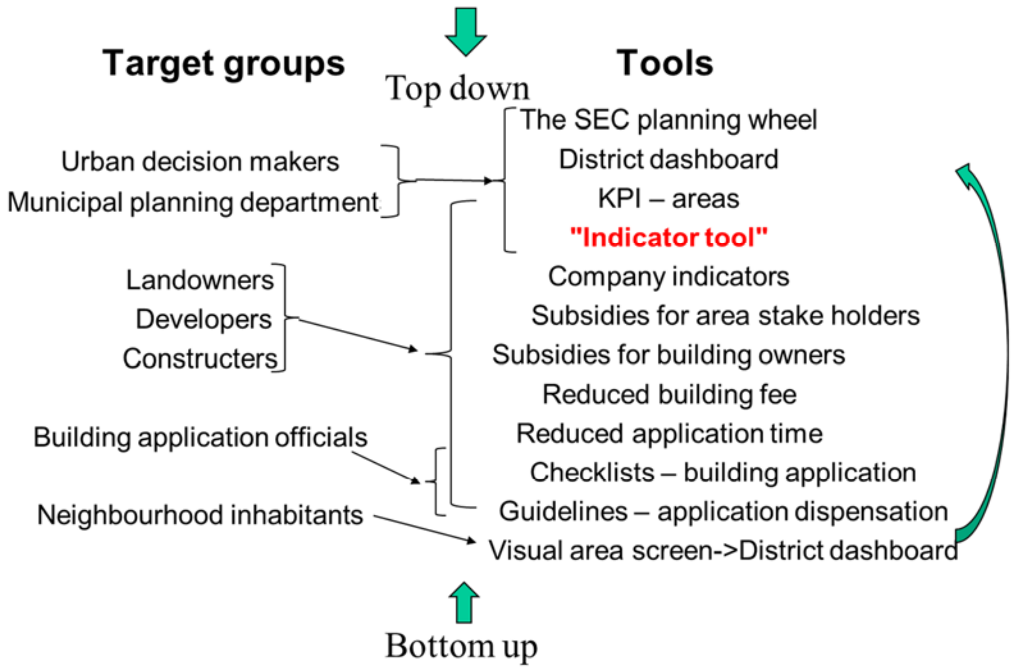


Figure 1.5: Target groups and identified tools that are relevant for target group visualized in a top-down/bottom-up interpretation

1.3. Input from stakeholder meetings

During task 1.2, the project group has received valuable input from Bergen and Oslo municipality as well as other stakeholders. There has been meetings and dialog with e.g. the Agency for Climate in Oslo and Bergen (Klimaetaten/ klimaseksjonen), the Agency for Planning and Building Services in Oslo, Futurebuilt[4], and the energy companies Hafslund and BKK. There are also dialog with building owners, and further input from public and private building owners will be important during the upcoming testing in task 1.3, such as ByBo, OBOS, Selvaag Eiendom, Omsorgsbygg, Undervisningsbygg, etc.

1.4. Interplay with BREEAM Communities

As mentioned in chapter 2.5 in the report connected to PI SEC Task 1.1 (Sørnes et al., 2016), the approach of BREEAM Communities towards energy efficiency is connected to the establishment of an

[4] About Futurebuilt: http://www.futurebuilt.no/English

energy strategy which gives credit according to the level of reduction in CO_2 emissions (RE 01 Energy Strategy presented in BREEAM Communities manual (BRE, 2012)). The larger reductions accomplished, the more credits will be given. The wish of involved partners in PI SEC is that the developments accomplished in PI SEC can be of value for more holistic rating systems like BREEAM Communities. The PI SEC indicator tool presented in this report strive to be a tool which can be used when the energy strategy in a project shall be set also when it shall be used for purpose of getting credits in a BREEAM project.

According to the BREEAM Communities manual, the energy strategy shall be done by an "energy specialist" and include the following (BRE, 2012):

1. A prediction of the baseline energy demand and associated emissions for a Building Regulations Part L compliant development calculated using approved Building Regulations compliant energy modelling software and other modelling to cover site-wide consumption. This should include:
   - a breakdown of the site wide heating, cooling and electricity demand
   - emissions for both regulated and unregulated energy use
   - emissions associated with street lighting and other electrically powered street furniture
2. Recommendations for reducing energy use and associated emissions beyond baseline levels through implementation of energy efficient measures including:
   - site layout
   - use of topography
   - shading
   - solar orientation
   - use of daylighting
   - wind management
   - use of natural ventilation.
3. Opportunities to further reduce emissions through the use of decentralised energy including:
   - connection to existing or future heat distribution networks
   - installation of site wide communal heating and cooling networks
   - utilisation of combined heat and power (CHP) systems, including any opportunities to extend beyond the site boundary
4. Opportunities to further reduce emissions through the installation of local (on-site or near-site) low or zero carbon (LZC) energy sources including details of the following:
   - energy generated from LZC energy source
   - payback
   - land use
   - local planning criteria
   - noise
   - feasibility of exporting heat/electricity from the system
   - life cycle cost/lifecycle impact of the potential specification in terms of carbon emissions
   - all technologies appropriate to the site and energy demand of the development
   - how any proposed LZC sources will be integrated with and complement any proposed decentralised energy networks
   - reasons for excluding other technologies
5. Summary of the carbon dioxide savings resulting from energy efficient design measures, the use of decentralised energy and the installation of LZC energy sources.

Its only approved energy software which can used for the calculations and the PI SEC tool therefore needs to be approved by NGBC, the national institution connected to BRE.

2. Legal framework for Smart Energy Communities in Norway

> **Lovens rammeverk for energismarte områder – En kort oppsummering av kapittelet**
>
> Kapittel 2 er en gjennomgang av lovverk i Norge relevant for energismarte områder. Informasjonen er fordelt på temaene energieffektive bygg; miljøvennlig produksjon og leveranse av varme og strøm; samt smarthet, fleksibilitet og synlighet i nabolagssystemer. For hvert av temaene er det vurdert hvordan lovverket legger til rette for energismarte områder.

Adequate legislation sets the supportive framework for sustainable development of communities. Legal frameworks as basis for effective and efficient spatial and energy planning are necessary (IEA EBC Annex 63, 2017 (to be published)). Energy planning is a relatively new discipline and is subject to rapid changes.

The legal framework can give both possibilities and obstacles for a Smart Energy Community. This chapter describe relevant legal framework for Smart Energy Communities divided on:

1. Energy efficient buildings
2. Environmentally friendly production and distribution of heat and electricity
3. Smartness, flexibility and visibility in district management systems

For each topic, it is discussed how the legal framework can be used by a municipality, to achieve ambitious goals in a Smart Energy Community.

In general, it can be noted that the Planning and Building Act (*Plan- og bygningsloven*) is the central legal framework for areas and buildings in Norway. The Act contains rules on technical requirements for construction works, local plans, and building permits. The Regulation on technical requirements for building works (TEK 10) was given pursuant to the Planning and Building Act section 29-7.

Beside the legal framework, also a number of other incentives are relevant when developing Smart Energy Communities – not described in this Chapter. More information about such incentives can be found in other reports, such as the PI SEC report from task 1.1 (Sørnes et al., 2016) and (Knudsen and Dalen, 2014).

In addition, most municipalities have declarations or guidelines which affects the available options for buildings and Smart Energy Communities. This can for example be opportunities or restrictions given in municipal council declarations (*byrådserklæringer*), in city ecological programs (*Byøkologisk program*) and in requirements for concept selection studies (*Konseptvalgutredning, KVU*). Also these types of guidelines are important when realizing Smart Energy Communities, providing either possibilities or barriers.

2.1. Energy efficient buildings

New buildings: Minimum requirement

The National building code (TEK) regulates technical requirements for new buildings. TEK ensures that projects complies with the technical standards for health, safety, the environment and energy. Within energy, TEK includes requirements on energy efficiency and heating solutions. The total net energy needs of buildings shall not exceed defined maximum energy budgets and there are minimum requirements for U-values and leakage figures.

A municipality cannot legally demand more ambitious requirements for buildings in an area, such as a requirement to follow the standards for low energy and passive house buildings. Such requests have to be based on voluntarily agreements with private investors. However, if the land is owned by the municipality, there are additional possibilities to demand more energy efficient buildings. The municipal can then set their own requirements for the use of the land.

The **Municipal master plan** is described in the Planning and Building Act (*Plan- og bygningsloven*) § 11. The master plan (according to § 11-9) can define building boundaries, which is relevant in terms of placement of buildings and thus possible utilization of solar energy. The Municipal master plan can also describe environmental qualities for an area, which for example can include issues such as air quality and noise. Also, the master plan can include conditions to be clarified and highlighted in further regulatory work. This can include provisions on environmental monitoring as well as other issues such as material choices.

Order requirements (*rekkefølgebestemmelser*) can be determined by a municipality in the Zoning plan (*reguleringsplan*). Order requirements are described in the Planning and Building Act (*Plan- og bygningsloven*) § 12-7, and are requirements related to a particular order in which projects are to be implemented pursuant to the plan. Development of an area cannot take place until technical installations and public services are adequately established. For example, to develop a new building, the municipality can require that infrastructure needs to be in place beforehand. Order requirements can therefore contribute to achieve Smart Energy Communities. Order requirements need to be considered in connection with the implementation plan, with a realistic plan for financing, dialog with land owners, etc., to avoid delays in the implementation.

The Zoning plan can also include requirements for **further investigations** prior to implementation of the plan, as well as **surveys** aimed at monitoring and clarifying impacts on the environment, health, safety, accessibility and other social interests. Such investigations and surveys can increase the knowledge and focus on issues relevant for a Smart Energy Community. For example, it can be a requirement to investigate the total energy use in an area, or to investigate local sources of excess heat.

Energy performance certificates (EPC) are mandatory for all new buildings that are to be sold or rented out. EPC summarizes the energy status in a building describing energy sources (colours red to green) and the energy efficiency level of buildings (marks A-F).

Existing buildings

In general, **the National building code (TEK)** also regulates work on existing buildings. However, according to § 31-2 in the Planning and Building Act (*Plan- og bygningsloven*), the municipality can give permission for renovation of existing buildings to a lower standard than TEK when "it is not possible to adapt the building to technical requirements without disproportionate costs, if the modification is necessary to ensure suitable use". As an alternative, the municipality can also give dispensation, according to § 19-2 in the Planning and Building Act (*Plan- og bygningsloven*). The municipality can set conditions for the dispensation.

In the PI SEC case study municipalities Oslo and Bergen, there are no standard guidelines on how disproportionate costs should be calculated. The applicants therefore use different methods, and the municipal coordinators have limited possibilities to ask additional questions. Almås et al. (2015) describes further details regarding existing building and § 31-2.

The Zoning plan can also provide measures and requirements to existing activities to prevent or limit pollution (according to § 12-7-3).

Discussion: Legislation for energy efficient buildings in a Smart Energy Community

A municipality has limited opportunity to demand environmentally friendly solutions from private building owners.

It could improve the state of new buildings if a municipality were allowed to demand more ambitious requirements for buildings in a SEC-area, such as a requirement to follow the standards for low energy and passive house buildings.

For existing buildings, the number of buildings being upgraded to the National building code could be increased. Standard guidelines or checklists could be developed, requesting the applicants to use a standard method calculating the investment and operational costs for upgrading existing buildings (life cycle costs).

To request further investigations and surveys for an area can increase the knowledge and focus on issues relevant for a Smart Energy Community. A list with possible topics to invest could be developed, to assist the planners to choose knowledge areas which can trigger new measures.

Today, the involvement of private building owners is mainly based on voluntarily agreements with the investors. If the municipality could offer attractive benefits, this could contribute to achieve ambitious SEC-goals. If an ambitious building project for example has the possibility to utilize 1 to 2% more of the land for buildings, this would have a great economic impact for the investor. However, such benefits can cause negative consequences for the neighbourhood, such as less green areas, sun light or space for bike parking, which also need to be taken into consideration by the municipality.

2.2. Environmentally friendly production and distribution of heat and electricity

The PI SEC definition of Smart Energy Communities (SEC) in Chapter **Error! Reference source not found.** states that *the Smart Energy Community aims to become highly energy efficient and increasingly powered by renewable and local energy sources and lowered dependency on fossil fuels*. Further goals are connected to the utilization of surplus energy-sources in a community, as well as less use of electricity for heating purposes in buildings. This Chapter therefore describes Norwegian legislation related to production and distribution of heat in a community (district heating) as well as production and distribution of electricity.

Production and distribution of district heating

The Energy Act (*Energiloven*) § 5, regulates the **licence to construct and operate district heating networks**. Such licences are given by the national energy directorate NVE, while the municipals can participate in the public hearing. If a Smart Energy Community wants an innovative district heating solution, it is up to NVE to add such requirements to the licence. The district heating company is not obliged to connect certain buildings to the district heating system. However, the licenced company is obliged to provide district heating to its connected customers.

Only district heating systems above 10 MW need a licence, according to the Energy Regulation Chapter 5 (*Energilovforskriften*). However, the owner of smaller systems can also apply for licence. A licence is needed before a municipality can impose on buildings an obligation to connect to a district heating system, as described below.

District heating concessionaires can be obligated to connect to other district heating grids, if the grids are compatible (The Energy Act (*Energiloven*) § 5-3).

Municipalities may impose on buildings an **obligation to connect to a district heating system** within a defined concession area, according to the Planning and Building Act (*Plan- og bygningsloven*) § 11-9, 12-7 and § 27-5. Historically, this obligation, along with market conditions and other policy measures, has supported significant growth in district heating. After the new TEK10-revision in 2016/2017, a building with obligation to connect to a district heating system is no longer obliged to actually use district heating in the building. The municipalities also have the opportunity to exempt from mandatory connection to the district heating system, if other energy solutions are more environmentally friendly (§ 27-5).

According to TEK10 (§ 14-4), buildings larger than 1 000 m^2 should have **flexible heating solutions**, where it is a real possibility to change the heating source for at least 60% of the heating need. The heating need includes domestic hot water, room heating and ventilation heating. Use of district heating is one of the possible heating solutions, which can fulfil the requirement.

The Energy Act (*Energiloven*) also provides a framework for **heat-prosumers** in a SEC. § 5-6 describe that the concessionaire has a duty to negotiate with a third party which wants to deliver heat to the district heating system. If the parties do not agree, the concessionaire needs to justify its refusal. Disputes may be brought before the Ministry of energy.

Production and distribution of electricity

The Energy Act (*Energiloven*) § 3 and 4 regulate the licence to construct and operate electrical energy distribution. Also such licences are given by the national energy directorate NVE, while the municipals can participate in the public hearing. A licenced company is obliged to provide electricity to its connected customers.

There are some exceptions to the need for licence, as described in § 4-2 in the Energy Regulation Chapter 5 (*Energilovforskriften*), such as farms and neighbourhoods (*grendeverk*) that do not have high voltage systems.

For local electricity production, such as from solar cells, there is a simplified **prosumer arrangement** for end users with consumption and production behind connection point, where input power at the connection point at no time exceeds 100 kW. A prosumer cannot have licensable construction behind the connection points or turnover that requires trading license. It is therefore not allowed for a prosumer to distribute electricity to its neighbours, if the prosumer does not have a license or an exception for the need of such licence. For apartment buildings, NVE is in the process of finding a solution for this in the so-called Elhub arrangement, so an apartment building with several connection points can have a joint electricity production system. Elhub is described in Chapter 2.3.

The grid operator may claim a connection fee for connecting consumers and producers to the grid, and the claimed cost is a result of the actual cost for the grid operator. Production and consumption of electrical energy is object to both a fixed (power tariff) and variable (energy tariff) tariff (NVE, 2017).

Discussion: Production and distribution of heat and electricity

It is possible for a municipality to facilitate for district heating in a SEC. However, to implement new and innovative solutions, the municipality is dependent on the willingness of the energy company and the licence conditions set by NVE.

It is possible within the legal framework above to request that local sources of excess heat are investigated. It is also possible to make a prosumer agreement for heating, where buildings can sell/deliver excess heat to the district heating network. However, such agreements are new to Norway and are dependent on the interest of the energy company, as well as the technical possibilities at the site. In Sweden, prosumer agreements for heating exist, for example Fortum's "Öppen Fjärrvärme" in Stockholm (Öppen Fjärrvärme, 2017). Also in Norway it is possible for innovative energy companies to develop new business areas within district heating.

For electricity production and distribution, the prosumer arrangement provides options. However, the current framework has limitations when it comes to larger systems and trading possibilities, as described above. At the same time, the licence system for trading electricity is developed for (larger) energy companies, and does not seem suitable for energy production in a single community, e.g. from solar energy. Also within electricity trade, innovative energy companies can develop new business areas.

Ideally, smart grids will result in more precise dimensioning of needed amounts of electricity, by improved metering and local management, thereby improving the overall energy efficiency in society at large (Knudsen and Dalen, 2014). If a Smart Energy Community is energy flexible, combining energy consumption, production and storage in a district management systems, this has a value also for the grid company (European Commission, 2013). As in several other EU countries, the introduction of new market mechanisms for flexibility are investigated in Norway (NVE, 2015). This may provide basis for dialog between the community, the energy company and NVE, discussing new solutions and framework conditions for energy flexible areas. In the future, building owners and neighbourhoods may be able to play a more active role in the energy system – together with the grid company.

2.3. Smartness, flexibility and visualization in district management systems

The PI-SEC definition of SEC (Chapter **Error! Reference source not found.**) states that *the governance is smart in the way that it is knowledge-driven by innovative approaches for strategic planning. The application of open information flow, large degree of communication between different stakeholders and smart technology are central means to meet these objectives*.

This Chapter describes Norwegian legislation related to such aspects, divided on new technology (AMI and Elhub) and access to information.

New technology

Advanced metering infrastructure (AMI) will be installed at all electricity customers by January 2019, making it easier for both the consumer and energy supplier to consider measures for better distribution and use of energy. There are requirements to the AMI meters, e.g. that they can provide detailed real time information to equipment from third parties through an AMI-HAN Interface (AMI regulation (Forskrift om kraftomsetning og nettjenester), § 4-2). Such third parties can e.g. be developers of energy management systems or visualization apps. The end-user shall have a local access to the metering values and a cost-free access to information of energy use on the internet (ibid, § 4-6). Every 24 hour, hourly metering data is provided to Elhub. **Elhub** is the central datahub for metered data and market processes in the electricity market (elhub.no).

Access to information

Access to information forms the basis for developing solutions for smartness, flexibility and visualization in district management systems. According to regulation No. 1158 on **energy studies** (*Forskrift om energiutredninger*), energy companies shall upon request from municipalities provide (not sensitive) information about the energy supply relevant for municipal climate and energy planning.

Customers have ownership of their **AMI-data**, due to privacy issues. However, on an aggregated level, such data can probably become available for a municipality.

More information on data access is available in a Data Access Guidebook for Sustainable Energy Action Plans, developed by the EU-project DATA4ACTION (2016).

Discussion: Smartness, flexibility and visualization in district management systems

With AMI, Elhub and other new technologies, detailed and real-time information can become available for stakeholders in a Smart Energy Communities (e.g. electricity customers, municipalities and third parties). This will make it possible to develop solutions for smartness, flexibility and visualization in district management systems. Dialog and agreements between the municipality and the energy company are needed for the municipality to get access to information for a SEC.

3. Methodology for selection and structuring of goals and KPIs

Metodikk for utvelgelse og strukturering av mål og KPIer – En kort oppsummering av kapittelet

Kapittel 3 er en gjennomgang av hvilken metode som er brukt ved utvelgelsen av indikatorer. Metoden som ble brukt heter Multiple Attribute Decision Making (MADM) og er beskrevet i (Yoon and Hwang, 1995). Metoden er en måte å velge indikatorer basert på flere ulike kriterier/attributter som er satt. MADM prosessen kan deles inn i tre steg: 1. Generering av attributter og definering av data, 2. Rangering av attributter og 3. Bruke MADM metoden for utvelgelse. Utvelgelsen av indikatorer i PI-SEC fulgte MADM metoden i stor grad. Et eget PI-SEC prosessflytdiagram for hvordan prosessen ble utført kan studeres i kap.3.3.

3.1. Introduction: The goals and indicator selection process

PI-SEC Task 1.1 collected and structured goals and indicators from development projects, both internationally and from the case studies. This resulted in a comprehensive list of about 200 indicators. The indicators have different qualities and it is difficult to choose the optimal set of KPIs because each area to measure needs to be treated in its own way. A process that utilises selection methodologies is therefore important to make sure that the best set of goals and indicators are chosen.

3.2. Decision making methods

The KPI selection process in PI-SEC is based on multiple attribute decision making (MADM) methods described in (Yoon and Hwang, 1995). MADM problems are diverse, but share some common attributes (Yoon and Hwang, 1995):

- *Alternatives*: Each problem consists of a finite number of alternatives that are screened, prioritized, selected and/or ranked.
- *Multiple attributes*: Each alternative is characterised by a set of attributes. The decision maker (DM) must generate the relevant attributes.
- Incommensurable Units: Each attribute has different units of measure (if any).
- *Attribute Weight*: Almost all MADM methods require information regarding the relative importance of each attribute.
- *Decision Matrix*: A MADM problem can be concisely expressed in a matrix format, where columns indicate attributes and rows list competing alternatives.

The MADM process can be split into three steps:

1. *Generating attributes and defining the data*: To establish a foundation for the decision making, the relevant attributes need to be identified. The term "attributes" can be referred to as "goals" or "criteria". The set of attributes should represent all the important parameters relevant for the decision. Preferably, the attributes should be broken down to "sub-attributes" until they reach a measurable level. For most MADM methods, it is also necessary to rank or weigh the attributes, as they seldom are considered equally important.
2. *Attribute rating*: All the alternatives must be rated against all attributes. For quantitative attributes, this could be a relatively simple process. For qualitative attributes, this is more complex and requires a more subjective assessment. Many MADM methods require quantitative data for the attribute evaluation, and the qualitative evaluation then has to be quantified.
3. *Applying the MADM methods*: The MADM methods are classified based on the available information. Figure 3.1 shows a classification developed by (Yoon and Hwang, 1995). In some MADM problems, it is reasonable to apply more than one method, e.g. apply one method to

eliminate the alternatives with unacceptable performance at important attributes, and then rank the rest using a secondary method.

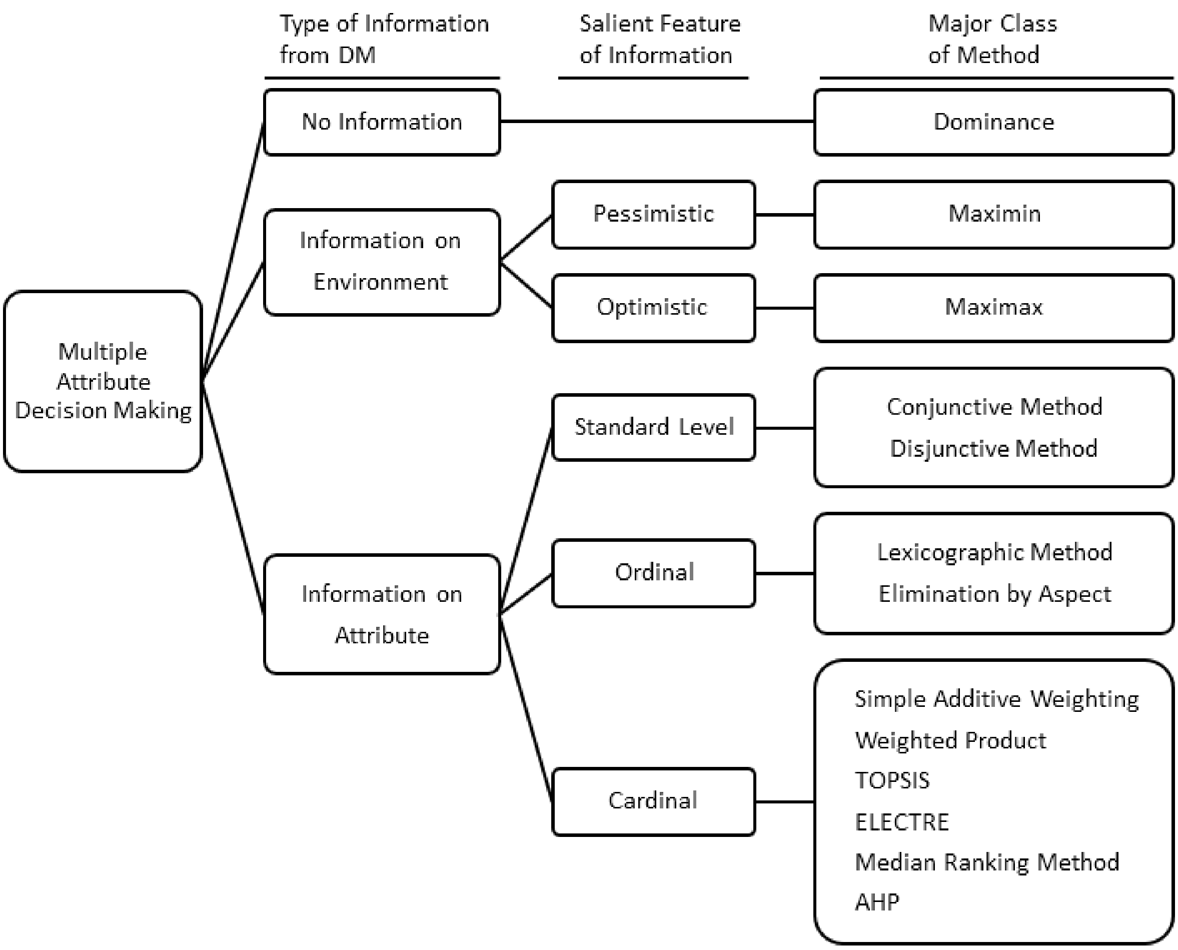


Figure 3.1: Classification of MADM methods. Source: Yoon and Hwang (1995)

3.3. Application of the MADM methods to the PI-SEC KPI selection process

Throughout the work in Task 1.2, a process for selecting goals and KPIs has been developed and applied by the research group. Figure 3.2 shows the main steps in the developed selection and structuring process in Task 2.1. Each step in the process shown in the figure consists of some sort of decision making, or preparation for it, and the steps in the MADM methods described above can be recognized in this process.

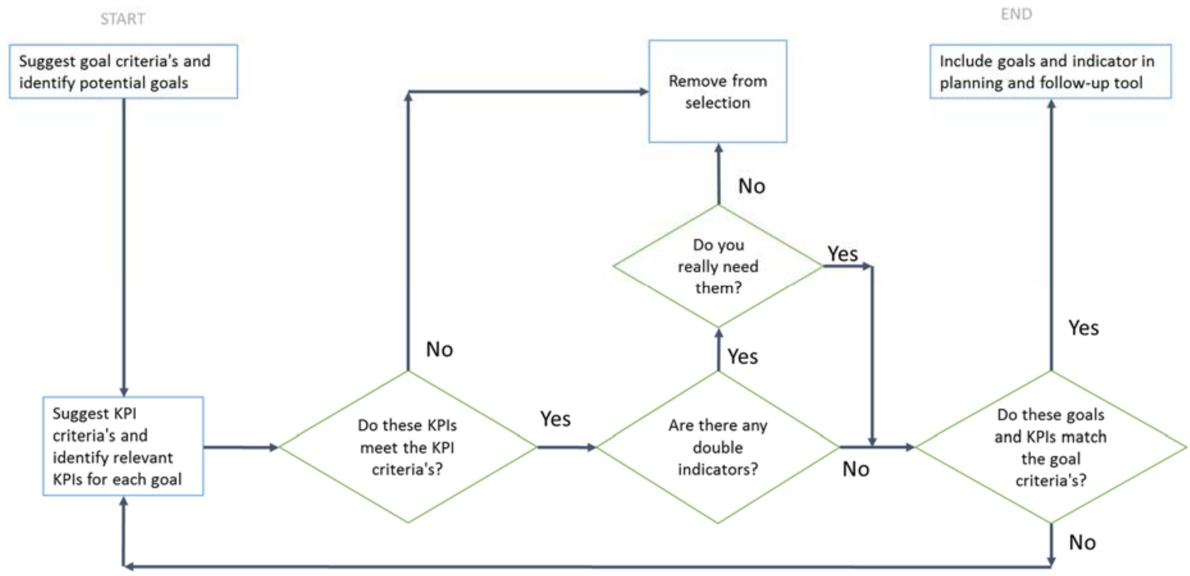


Figure 3.2: Process for goals and indicator selection

The PI-SEC KPI selection process is shown in Figure 3.2.

The attributes ("criteria") are generated and rated for each alternative (KPI) in the second step of the process ("Suggest KPI criteria's and identify relevant KPIs for each goal"). Several relevant attributes for indicators were listed in the Task 1.1 report, based on choices made in the ongoing European project CITYkeys. These attributes in addition to other relevant attributes (e.g. cross scale applicability) are used in the evaluation. All the indicators are rated against the chosen attributes.

In the third step of the KPI selection process: "Do these KPIs meet the KPI criteria?" the suggested KPI are evaluated with the "conjunctive" MADM method. The "conjunctive" method is a satisficing method to discard alternatives that does not satisfy a minimum rating in all or selected attributes (Yoon and Hwang, 1995). If an alternative has a lower score than the minimum cut-off value for any of the attributes, it will not be considered further.

In the step ("Do you really need them?"), redundant indicators are identified. If not all are necessary, some should be discarded. This elimination process can be performed with a lexicographic sequential elimination method described by Yoon and Hwang (1995). With this method, all attributes are ranked according to selection importance. The ranking of the attributes must be defined by the decision maker. The duplicate KPIs are then evaluated against the most important attribute. If two or more alternatives are equally good, they are evaluated against the second most important attribute, and so on. It is possible to introduce a margin in the evaluation, so that alternatives are only discarded if they are significantly "worse" than the rest. This is called the Lexicographic Semiorder method. This method reduces the importance of the attribute ranking.

After the elimination process, it has to be evaluated if the KPI selection set is complete (i.e. that all the defined goals can be measured through the indicator set). If not, new indicators have to be suggested and evaluated again.

4. Development of goals and KPIs toolkit

Valg av mål og indikatorer – En kort oppsummering av kapittelet

I dette kapittelet introduseres definisjon, mål og valgte indikatorer. En definisjon på hva en Smart Energy Community (SEC) er laget med hjelp fra involverte partnere i den internasjonale arbeidsgruppen EBC Annex 63 (*Implementation of Energy Strategies in Communities*).

Målene til hvert pilotområde er gjennomgått for å finne felles mål som kan være gjeldende for PI SEC. Disse er videre nyttet som utgangspunkt i PI SEC Indicator Tool (PI SEC sitt indikator verktøy).

Prosessen rundt hvordan indikatorene har blitt valgt og strukturert på grunnlag av valgte kriterier/attributter er også presentert. De ulike attributtene som ble brukt i utvelgelsesprosessen er: Relevanse, Tilgjengelighet, Målbarhet, Pålitelighet, Gjenkjennelighet, Skalerbarhet, Anvendbarhet (for ulike faser).

4.1. Introduction

There is currently no clear definition of a Smart Energy Community (SEC). A working definition was developed in PI-SEC, which will further be refined during the empirical work. The definition is made by the involved partners in PI SEC together with partners in EBC Annex 63.

A Smart Energy Community is an area of buildings; infrastructure and citizens sharing planned societal services[5], where environmental targets are reached through the integration of energy aspects into planning and implementation. The Smart Energy Community aims to become highly energy efficient and increasingly powered by renewable and local energy sources and lowered dependency on fossil fuels. Its spatial planning and localization considers reduction of carbon emissions also through its relationship with the larger region, both through the design of energy systems and by including sustainable mobility aspects of the larger region; it further encourages sustainable behaviour through its overall design from building and citizen scale to community scale. The application of open information flow, large degree of communication between different stakeholders and smart technology are central means to meet these objectives.

The "smartness" is related to efforts done on behalf of the environment with smart use of resources, but also with a focus on smart instruments in the sense of larger use of ICT to be able to measure the selected indicators.

[5] *By societal services is here meant 'samfunnstjenester' as in the Norwegian Planning and Building Act 12.7 : such as energy delivery, transportation and road net, health and social services, kindergardens, play areas and schools*

4.2. Definition of goals

The main PI-SEC goal is to ensure that communities use the energy in the most smart and efficient way which is described through the definition of what a Smart Energy Community (SEC) is supposed to be.

Goals set by the two case studies, Oslo and Bergen, and for the two communities Furuset (Oslo) and Zero Village Bergen (Bergen), are gathered from relevant city and area plans (Table 4.1) and summarised in Table 4.3. The case studies and their goals are further described in the PI-SEC report for Task 1.1. Table 4.2 shows the overall goals that can be linked to the specific goals (Table 4.3). The overall goals are common for all areas/cities and these are chosen to be the goals implemented in the PI SEC tools.

Table 4.1 City and area plans

City/Area	Reference
Oslo	Klimabudsjett Oslo kommune (www.oslo.kommune.no)
Furuset	Handlingsprogram Furuset (www.arkitektur.no/furuset)
Bergen	Grønn Strategi Bergen (www.bergen.kommune.no)
ZVB	ZVBs nettside (www.zerovillage.no)

Table 4.2 Summary of goals for the cities and case studies

Nr	Goal
1	CO_2-reduction
2	Increased use of renewable energy
3	Increased energy efficiency
4	Increased use of local energy sources
5	Green mobility (reduced CO2 emissions and better air quality)

Table 4.3 Summary of specific goals for the cities and case studies

Goal	Specific neighbourhood targets	Reference
No 1	Minimum 50 % reduced greenhouse gas emissions	Ref. Action plan Furuset
No 1	Phase out all oil boilers used for heating in buildings	Ref. Climate budget Oslo municipality
No 1	Reduce the use of fossil gas by 30 %	Ref. Green strategy Bergen
No 1	Fossil-free district heating	Ref. Climate budget Oslo municipality
No 1	CO2-capturing at waste plants	Ref. Climate budget Oslo municipality
No 1	Increased utilisation of landfill gas	Ref. Climate budget Oslo municipality

No 1	Max. 1.5 ton of CO2 emission per person/year	Ref. Green strategy Bergen
No 1	All buildings and neighbourhoods in Bergen should be climate neutral by 2050	Ref. Green strategy Bergen
No 1	Neighbourhoods as a whole shall satisfy ZEB-O	Ref ZVB homepage
No 1	Every building shall satisfy ZEB-O÷EQ as a minimum	Ref ZVB homepage
No 1	After 2 years measures shall be taken to satisfy ZEB-OM	Ref ZVB homepage
No 1	After 4 years measures shall be taken to satisfy ZEB-COM	Ref ZVB homepage
No 1	Low-emission materials shall be used	Ref ZVB homepage
No 1	Fossil-free building sites	Ref. Climate budget Oslo municipality
No 2	Renewable energy sources for 40 % of the total energy consumption	Ref. Action plan Furuset
No 2	Install 200W solar cells per citizen by 2030	Ref. Green strategy Bergen
No 2	70 % of all buildings should produce energy	Ref. Green strategy Bergen
No 2	Establish joint energy systems based on renewable energy sources	Ref. Action plan Furuset
No 3	Utilise surplus heat – Exchange of cooling and heating requirements	Ref. Action plan Furuset
No 4	High energy standard in all new buildings	Ref. Action plan Furuset
No 4	Reduce demand for energy in buildings by 1.5 TWh	Ref. Oslo municipality Climate and energy strategy
No 4	By 2020/2030 40/80 % reduction in energy consumption for public outdoor lightening	Ref. Green strategy Bergen
No 4	30 % reduction in energy consumption per citizen within 2030	Ref. Green strategy Bergen
No 4	Energy efficiency measures will be implemented in existing buildings.	Ref. Action plan Furuset
No 5	Fossil free busses	Ref. Climate budget Oslo municipality
No 5	Fossil free ferries	Ref. Climate budget Oslo municipality
No 5	Zero-emission taxis	Ref. Climate budget Oslo municipality
No 5	Reduced emissions from private cars	Ref. Climate budget Oslo municipality
No 5	Widespread infrastructure for renewable fuels (el, hydrogen, bio)	Ref. Green strategy Bergen
No 5	Reduced private car traffic	Ref. Climate budget Oslo municipality og Green strategy Bergen
No 5	On-shore power supply for all ships within 2020	Ref. Green strategy Bergen
No 5	New cars' sales a 100% zero-emissions from 2025 onwards	Ref. Green strategy Bergen
No 5	By 2020 double the number of passengers per car during rush-hour	Ref. Green strategy Bergen
No 5	Within 2025 reduce the number of cars per household to 1	Ref. Green strategy Bergen
No 5	Establish low emissions areas	Ref. Green strategy Bergen
No 5	Establish zero-emissions areas	Ref. Green strategy Bergen

No 5	Reduced emissions from goods transport	Ref. Climate budget Oslo municipality
No 5	Light goods transport with fossil free vehicles by 2025	Ref. Green strategy Bergen
No 5	Reduced emissions from freights transport	Ref. Climate budget Oslo municipality
No 5	Increase share of freights transport by ship or rail	Ref. Green strategy Bergen
No 5	Reduced emissions from construction machinery	Ref. Climate budget Oslo municipality
No 5	In 2019, 10% of all trips shall be made by bicycle	Ref. Green strategy Bergen

4.3. Selection and structuring of KPIs

In the task 1.1 report (Sørnes et al., 2016), a comprehensive list of reviewed KPIs was presented. In task 1.2 this list has been used as a basis for further evaluation and screening of KPIs according to the methodology described in section 2.

Dividing KPIs into sectors and subcategories

Most KPIs can be broken down into sectors and subcategories. In the selection and structuring process, the KPIs have been evaluated at an elevated level, and then broken down into relevant sub-categories.

Dividing KPIs into sectors and subcategories is useful and necessary for analysing data and targeting measures. In many cases, the data from measurements and gathering are already divided in subcategories and minimal extra work is necessary in the analysing process.

The breakdown of the KPIs should as far as possible be aligned with established internal and external reporting channels (e.g. Greenhouse Gas Protocol, SSB (Statistics Norway) etc.) and practical availability from measurements. Table 4.7 shows how the selected KPIs are divided into sectors and sub-categories.

Indicator units

The choice of units for indicators are important, as they can have a large influence on the interpretation of the development and the choice of measures. An example of this is greenhouse gas emissions. Often, a municipality has a goal to reduce the total emissions from a neighbourhood. In principal, if one looks at the neighbourhood isolated and only evaluate the total emissions, the most effective measure would be to reduce the activity in the neighbourhood. This is however seldom the desirable solution. Other possible units are emissions per inhabitant or per m^2 of building area, but also these may have other non-desirable effects. In Table 4.4 some possible units with pros and cons are listed.

Table 4.4: Examples of choice of indicator units.

KPI	Unit	Pros	Cons
GHG emissions	Tonnes CO_2 eqv.	• Gives the total emissions directly. • Suited for comparison of scenarios within a neighbourhood	• Does not take local factors such as activity or population into account • Difficult to compare different areas directly
	Tonnes CO_2 eqv./ inhabitants	• Suited for large areas with typical distribution of industry, residential and commercial buildings (districts, countries)	• Not representative for areas with predominance of industry or offices • Comparison of small areas are difficult
	Tonnes CO_2 eqv./ m^2 BRA	• Suited when divided into sectors or building categories.	• Difficult to compare areas with different share of building categories • Preference for larger building (m^2/person)

In the KPI selection and structuring process described in this report, it has been decided that the choice of units is not concluded. The units for comparison will be evaluated during the test phase in task 1.3. The indicator planning tool, described in section 5.2, is designed with the possibility to choose units.

Initial screening

An iterative initial screening of the KPIs from the literature study in Task 1.1 has been performed, to discard KPIs that are obviously not relevant for the PI-SEC project. These are indicators that are too detailed or are related to measures or components that are not relevant. Examples are: number of energy efficient lifts, number of energy efficient laboratories, gas flow rate, etc. This was done to ease the further evaluation process and keep focus on the relevant subjects.

Generating the attributes for the KPIs

The goals and KPIs of the different case studies/districts will be different, however the main attributes/criteria for which the KPIs are evaluated should be the same. The rating of the attributes can be different from case to case.

In the Task 1.1 report, eight important attributes for KPIs were listed from the CITYkeys project (CITYkeys, 2016). Five of these attributes are related to the specific indicator, while the other three are related to the selection of indicators. In addition to the CITYkeys attributes, the attributes "scalability" and "phase applicability" are included. Table 4.5 lists the chosen attributes for the PI-SEC project. These attributes are slightly different from the criteria mentioned in the PI-SEC project description, but in total, they represent the same properties.

Table 4.5: KPI attributes in PI-SEC (CITYkeys, 2016, Sørnes et al., 2016)

Attributes	Description	Likert scale
Relevance	Each indicator should have a significant importance for the evaluation process. That means that the indicators should have a strong link to one or more of the selected goals or targets. Further the indicators should be selected and defined in such a way that the implementation of the smart city measures will provide a clear signal in the change of the indicator value.	1: None 2: Low 3: Medium 4: High 5: Very High
Availability	Data for the indicators should be available. It is desirable that the inventory for gathering the data for the indicators should be limited in time and effort. Indicators that require, for instance, interviews with users or dwellers may not be suited as the large amounts of data needed are too expensive to gather.	1: Impossible 2: Difficult 3: Acceptable 4: Easy 5: Very easy
Measurability	The identified indicators should be capable of being measured, preferably as objectively as possible.	1: Impossible 2: Difficult 3: Acceptable 4: Easy 5: Very easy
Reliability	The definitions of the indicators should be clear and not open to different interpretations. This holds for the definition itself and for the calculation methods behind the indicator.	1: None 2: Low 3: Medium 4: High 5: Very High
Familiarity	The indicators should be easy to understand by the users. The definition should have a meaning in the context of policy goals.	1: None 2: Low 3: Medium 4: High 5: Very High
Scalability	Indicators should be applicable cross scales: building, neighbourhood, city, district and country.	1: One scale only 2: 2 scales 3: 3 scales 4: 4 scales 5: All scales
Phase applicability	Indicators should be applicable in several phases of a project: planning, regulation, design, construction, operation, end of life. Many indicators are not directly measurable in the different phases, but can be simulated/predicted based on scenarios.	1: One phase only 2: 2 phases 3: 3 phases 4: 4 phases 5: All phases

Quantification of attribute rating

All of the attributes discussed above are qualitative. To enable and simplify comparison of the KPIs in relation to the attributes, the attributes have been quantified through a Likert scale (Likert, 1932). For all KPIs, attributes are rated with a value between 1 and 5. Table 4.5 shows the applied Likert scales for the attributes.

Attribute ranking

As described in section 2, the attributes must be ranked to enable the use of most MADM methods. Table 4.6 shows the attribute ranking proposed by the research group, as well as some comments to how the attributes functioned during the selection process in 1.2.

Table 4.6: Proposed attribute ranking

Ranking	Attributes	Comment
1	Relevance	Relevance in defined as the most important attribute in the selection process. If an indicator is not relevant for the project goals, it is not necessary to include.
2	Availability	Availability is important to reduce the workload in data gathering and processing. However, it must be evaluated in relation to other attributes. One can accept lower availability for a highly relevant indicator, compared to a less relevant indicator.
3	Measurability	Measurability is an important attribute, as it is necessary for evaluating the KPIs. However, it is also an attribute that is in continuous evolvement (instrumentation, AMI). One should therefore be careful to discard indicators based on todays situation.
4	Reliability	Reliability is challenging to rate, as the indicators have different target groups with different background and foundation for understanding the indicator. To increase the level of reliability it is important to carefully define the scope and objective for each indicator and how it is to be measured.
5	Scalability	Cross-scale applicability is defined as an important attribute in the PI-SEC project
6	Familiarity	Familiarity is an important attribute in dissemination of the results, but it is challenging to rate, as the indicators have different target groups with different background and foundation for understanding the indicator
7	Phase applicability	The PI-SEC project focuses on planning instrument, and the indicators should therefore be applicable in the planning phase. To be able to follow up the influence of the planning on the actual development, it is important that indicators also are applicable in the planning phase.

Attribute rating and structuring

The WP1 research group has through a process of individual work and meetings rated all indicators for each attribute.

As relevance has been ranked as the most important attribute by the research group, this was used in the KPI screening process with the conjunctive method. All indicators with relevance rated lower than 3.0 have been removed from the selection. Similarly the indicators scoring higher than 4.0 have been directly chosen to be included in the test period.

The rest of the indicators were discussed and sorted based on their rating in the other attributes. From this, a set of indicators was chosen for further evaluation.

When testing the indicator set in Task 1.3, the attribute rating from Task 1.2 will be revaluated based on more insight from the case studies. This especially applies to the attributes measurability and availability. These attributes are dependent on the case study and available technology (e.g.

implementation of advanced meters, AMI), and for the current rating, estimations on how data will be gathered must be made.

Evaluation of KPI set against non-redundancy and independence

The KPI set was evaluated against non-redundancy and independence. Indicators within a project should not measure the same aspect of a subtheme, and small changes in the measurements of an indicator should not impact preferences assigned to other indicators in the evaluation (CITYkeys, 2016).

A typical example of this is: energy consumption, energy savings and reduction in energy use. These three indicators measure the same, energy savings and reduction denominate just the change in the total consumption. There are similar constellations within other subjects. As a general principle, the research group has decided that the "total indicator" will be selected, as the other will be interpretations of the result.

Evaluation of KPI set against completeness

After the preliminary selection and discarding of double indicators, the KPI set was compared to the collection of goals and targets from the case studies and municipalities.

Some specific targets where considered not to be satisfactorily covered by the indicator set. For these targets, several possible new KPIs were identified. These new indicators then went through the same MADM selection process as the other KPIs. Based on this, one new indicator for each target was selected.

During Task 1.3, the selected indicator set will be further tested on the case studies. During the test period, the completeness of the indicator set will be evaluated, and indicators will be added or removed based on the findings. This work will be performed by the WP1 research group, in close collaboration with the case study partners.

Preliminary selection divided in goals

Table 4.7 lists the selected indicators and their relation the overall goals. Specifications on how each of the indicators shall be measured will be set in the next phase (task 1.3) when each indicator will be tested.

Table 4.7: Selected KPIs

KPI	Goals	Sub-categories		Sectors	Unit
CO_2 emissions	CO_2-reduction	Stationary Energy	Electricity Biofuel Fossil fuel District heating	Public buildings Residential buildings Private buildings Infrastructure	Tonnes CO_2 eqv./yr
		Mobility		Private cars Taxi Public transport Goods transport Freight transportation Construction machines	
		Materials		Public buildings Residential buildings Private buildings	
Energy Use	Increased energy efficiency	Electric	Buildings	Public buildings Residential buildings Private buildings	MWh/yr
			Infrastructure	Outdoor lighting Transport Other	
		Thermal	Solar Biofuel Oil Gas District heating	Public buildings Residential buildings Private buildings Infrastructure	

KPI	Goals	Sub-categories	Sectors	Unit
% of different kinds of RES in district heating	Increased use of renewable energy	Electricity Heat pump Solar Biofuel Waste		%
% of buildings with Energy Certificate at each of the grades	Increased energy efficiency	Certificate A Certificate B Certificate C Certificate D Certificate E Certificate F Certificate G Not registered	Public buildings Residential buildings Private buildings	%
Use of energy related incentive (related to both single and multiple buildings)	Increased energy efficiency	Futurebuilt Enova Bream Communities Local	Public buildings Residential buildings Private buildings	#
% of buildings with a benchmark and with measure of energy performance	Increased energy efficiency		Public buildings Residential buildings Private buildings	%
# fossil free construction sites (machines and transportation)	Total CO2 emissions Increased use of renewable energy	Construction Machines Energy production	Public buildings Residential buildings Private buildings	#

KPI	Goals	Sub-categories		Sectors	Unit
Modal Split	Green mobility	Fossil free Cars Fossil fuel Cars Fossil free Public transport Fossil fuel Public transport Lorries Bicycle Foot			%
# filling stations with RES fuel	Green mobility	Electric Hydrogen Biofuel			#
% fossil free cars of new cars registered	Green mobility	Electric Hydrogen			%
% of berths with power connection	Green mobility				%
Installed capacity of RES	Increased use of local energy sources Increased use of renewable energy	Electric Thermal	Solar Geothermal Hydro Power Wind Power CHP Waste CHP Biomass		kW
Generated energy by RES	Increased use of local energy sources Increased use of renewable energy	Electric Thermal	Solar Geothermal Hydro Power Wind Power CHP Waste CHP Biomass		MWh
Buildings with installed RES	Increased use of local energy sources	Electric Thermal	Solar Geothermal Hydro Power Wind Power		%

KPI	Goals	Sub-categories		Sectors	Unit
	Increased use of renewable energy		CHP		
Use of secondary heat	Increased use of local energy sources				MWh
Buildings connected to district related thermal energy source	Increased use of local energy sources Increased use of renewable energy				%
Identification of available resources of renewable energy	Increased use of local energy sources Increased use of renewable energy		PV, Solar Thermal, Biomass, Geothermal, Hydro Power (Waste heat, energy from waste)		MWh
Number of registered oil tanks	Increased use of renewable energy Total CO2 emissions				#
Peak Load Consumption	Increased use of local energy sources	Electric Thermal			kW
Peak Load Production	Increased use of local energy sources	Electric Thermal			kW
Energy Storage	Increased use of local energy sources Increased use of renewable energy	Electric Thermal			MWh

5. Application of the goals and KPIs

Bruk av mål og KPIer i case studiene – En kort oppsummering av kapittelet

Kapittel 5 beskriver verktøyet "PI SEC Indicator Tool". Dette er et Excel-basert verktøy som skal gjøre det enklere å velge ut indikatorer for et spesifikt område basert på valgte mål. I tillegg gjennomgås det som er kommet frem av innspill etter møter med diverse aktører i byggebransjen, samt andre type verktøy som nyttes av de ulike aktørene i bransjen. I siste del av kapittelet (5.4) relateres arbeidet som gjøres i WP1 på indikatorutvelgelse og verktøyutvikling til arbeidet som gjøres i WP2. I WP2 har det blitt utført en gjennomgang av ulike type tilgjengelige verktøy i Norge og internasjonalt som har resultert i en verktøykasse som kan nyttes inn i planlegging og oppfølging av SEC områder.

5.1. Introduction

The goals and KPIs form a toolkit for planning and monitoring smart energy communities on its own. However, to simplify and improve the output of their utilization, supporting tools are necessary. Such a tool should help in analysing the goals and indicators, and relate them together.

The main tool proposed in task 1.2 is a tool for planning and follow-up of neighbourhood projects, based on calculation for selected indicators. The tool is meant to enable efficient use of resources and targeted measures on the pathway to smart energy communities. The tool is further described in section 5.2.

5.2. The indicator tool

To enable use of the KPIs and goals developed through the process described in section 2 and 4, in the planning of smart energy communities, an indicator tool for neighborhoods is proposed.

The main goal for this tool is to evaluate how different measures and projects within a neighborhood influence chosen indicators and the possibility to reach specified goals. In this way the tool links the goals and indicators to specific decisions and measures. The tool can then be used to define the most efficient measures, so that resources and initiatives are used in the most efficient way.

Basic features

The indicator tool was initially inspired by the FutureBuilt rules for calculation of greenhouse gas emissions from neighborhoods described in Selvig et al. (2014). The main principle described here is calculation of a "current situation", a "baseline scenario" and one or more "development scenarios".

The tool is meant as a supplement to the greenhouse gas emission calculation rules and klimagassregnskap.no, by calculating additional KPIs, such as: energy consumption in different sectors (residential buildings, public buildings, transport etc.) and sources (electric, thermal); energy efficiency indicators, and energy generation. It can be used to generate input to calculations, and it will need input from calculations in e.g. klimagassregnskap.no.

The tool should be useable for different users and levels of available information. It will include a database of normative numbers and proposed efficiencies, that can be overwritten if more detailed information is available.

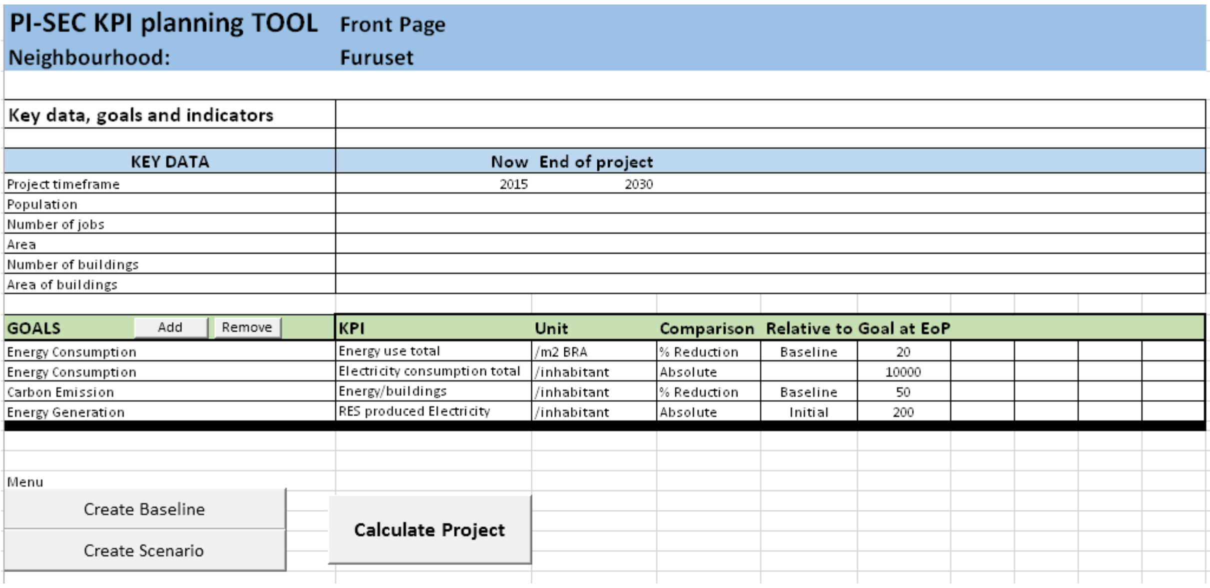
The first version of the tool is based on a Microsoft Excel Workbook. At a later stage, it can be developed to a different format, such a web based tool.

Below the steps for utilizing the tool for a neighborhood are briefly described.

Step 1 – Defining the project

Firstly, the framework of the SEC project should be defined. This includes parameters such as start and end year for the project, location and area.

In addition, a set of goals and related KPIs should be selected by the planners. Goals and KPIs must be selected from predefined drop-down lists, based on the goals and KPIs selected in the PI-SEC project, but specific target values must be set by the project/neighborhood. The predefined list of goals and KPIs are based on the selection process described in section 4.



PI-SEC KPI planning TOOL — Front Page

Neighbourhood: Furuset

Key data, goals and indicators

KEY DATA	Now	End of project
Project timeframe	2015	2030
Population		
Number of jobs		
Area		
Number of buildings		
Area of buildings		

GOALS (Add / Remove)	KPI	Unit	Comparison	Relative to	Goal at EoP
Energy Consumption	Energy use total	/m2 BRA	% Reduction	Baseline	20
Energy Consumption	Electricity consumption total	/inhabitant	Absolute		10000
Carbon Emission	Energy/buildings	/inhabitant	% Reduction	Baseline	50
Energy Generation	RES produced Electricity	/inhabitant	Absolute	Initial	200

Menu

Create Baseline

Create Scenario

Calculate Project

Step 2 – Building a neighborhood, the current situation

The current status must be described by the planner. The neighborhood description is divided into the following categories: buildings, infrastructure, local energy plants, district heating and transport. For new development areas, no input is necessary.

For **buildings**, the existing buildings must be defined related to size, residents/employees, energy consumption, energy carriers and energy production. Energy related data can be difficult to obtain for existing buildings, and therefore normative numbers based on building category and regulations on technical requirements for building works valid at the year of construction may be used. Buildings can be described individually, or as a group of buildings with the same properties.

PI-SEC KPI planning TOOL	Initial Situation	2015				
Neighbourhood	Furuset					
Buildings (Add, Upgrade, Demolish)						
General description						
Building	Category	Year of construction	Area [m2]	Ownership	residents/ employees [#]	Res above 13y/ Other Users [#]
Furuset senter: kjøpesenter, bibliotek, svømmehall	Cultural building	1960	3500	Private	5	100
Furuset senter: kjøpesenter, bibliotek, svømmehall	Comercial building	1960	6500	Private	60	200
Furuset senter: kjøpesenter, bibliotek, svømmehall	Office building		9600	Private		
Furustien barnehage. Parkering	Kindergarten		400	Public		
Papyrusbygget: lager og kontorer. (Huser bla Dekkm	Office building		4000	Private		
Papyrusbygget: lager og kontorer. (Huser bla Dekkm	Comercial building		600	Private		
Papyrusbygget: lager og kontorer. (Huser bla Dekkm	Industry/Workshop		12400	Private		
Furuset forum: Ishall, håndballhall, noen kontorer	Sports Facility		16500	Public		
Scala barnehage, friområde	Kindergarten		600	Public		
Bakers bakeri (produksjon), Fürst laboratorium	Office building		3600	Private		
Bakers bakeri (produksjon), Fürst laboratorium	Industry/Workshop		3600	Private		
Suveren rørmøbelfabrikk	Industry/Workshop		4800	Private		
Øvre Furuset borettslag, byggeår 1980, planlegger c	Residential apartment building		22700	Private	505	
Nordre Gran borettslag, byggeår 1978, opprusting ut	Residential apartment building		32300	Private	719	
Granstangen borettslag, byggeår 1979, opprusting f	Residential apartment building		17400	Private	387	
Granstangen borettslag, byggeår 1979, opprusting f	Residential apartment building		22000	Private	489	
Gransletta borettslag, byggeår 1978, opprusting ute	Residential apartment building		9100	Private	202	
Gransletta borettslag, byggeår 1978, opprusting ute	Residential apartment building		9900	Private	220	
Gransletta borettslag, byggeår 1978, opprusting ute	Office building		6000	Private		
Gransletta borettslag, byggeår 1978, opprusting ute	Comercial building		2000	Private		
Kurland borettslag, byggeår 1978, fasader pusset op	Residential apartment building		34500	Private	768	
Ulsholt borettslag, byggeår 1978, fasader pusset op	Residential apartment building		22900	Private	509	
Lager	Industry/Workshop		26500	Private		
Furuset sykehjem	Nursing home		9300	Public		
Ny Gran ungdomsskole (bygges nå, FutureBuilt-pros	Kindergarten		4100	Public		
Ahmadiyya-moskeen	Cultural building		4000	Private		
Furuset skole	School		10000	Public		
Gran skole	School		8000	Public		
Kurland barnehage	Kindergarten		500	Public		
Del av Furuset senter	Office building		11500	Private		
Del av Furuset senter	Sports Facility		3000	Private		
Moske, næringsbebyggelse	Cultural building		1000	Private		

Figure 5.1: Example of input for buildings in neighbourhood. Details on energy consumption, sources and distribution is not shown

For **infrastructure**, the main focus in the tool is on energy consuming infrastructure, such as street lighting and snow melting systems. Some input data, such as estimated yearly energy consumption, must be added.

Infrastructure						
General description			Energy performance			
Outdoor lighting	**Year of installation**	**# units**	**Energy performance Category**	**Energy consumption [kWh/unit]**		
Lighting	1980	1000	Low efficiency	550		
Snow Melt Systems	**Year of installation**	**Size [m2]**	**Energy performance Category**	**Energy consumption [kW/m2]**	**Energy source**	**Efficiency/COP [-]**
Snow Melt	1980	500	Low efficiency	350	Electric heater	0,9

Figure 5.2: Example of input on infrastructure

For **local energy plants**, data on central units for energy production that are located inside the neighborhood/area are added. This option is meant for production units that are connected to the district grid (thermal or electric). This could be units such as biofuel Combined Heat and Power systems, solar thermal or Photovoltaic (PV) parks. Produced electricity will be calculated with CO_2 emissions equal to the difference between the CO_2 emissions related to the production and the CO_2 emissions for electricity from the grid. This means that production with renewable sources such as PV, will result in a reduction in total CO_2 emissions. Produced heat that replace the use of district heating for the buildings connected to district heating, will change the CO_2 factor accordingly.

Local energy plant									
Energy Source				Heating to District Heating system		Cooling to District Cooling system		Electricity to grid	
Type	Energy Source	CO2 Emission [g/kWh]	Efficiceny [%]	Capacity [kW]	Production [kWh]	Capacity [kW]	Production [kWh]	Capacity [kW]	Production [kWh]
CHP	Pellets	19	85 %	400	2500000			200	1250000
Solar PV	Sun	0	100 %					500	500000

Figure 5.3: Example of input on local energy plants

For **district heating**, the yearly average distribution between the energy sources used in the heat production must be defined. In this phase, the use of district heating will be calculated from the building and infrastructure data.

District Heating				
Energy Source				Distribution
Heat Source	Coverage [%]	CO2 Emission [g/kWh]	Production efficiency [%]	Distribution losses
Electricity	28,2 %	123	0,95	10 %
Heat Pump	7,9 %	123	3,125	
Solar Collector		0	1	
Waste Heat		0	0,9	
Waste Incineration	57,6 %	11	0,9	
Wood Chips		18	0,9	
Pellets	1,7 %	19	0,9	
Bio-oil	3,6 %	10	0,9	
Bio-gas		10	0,9	
Fossile Oil	0,2 %	268	0,9	
LPG	0,8 %	235	0,9	

Figure 5.4: Example of input on district heating system

For **transport**, calculations will be based on the same approach as for klimagassregnskap.no, with input on the use of each building category and estimations on modal splits and generated transport from the buildings. It might be that the user must supply data from the project into klimagassregnskap.no to generate input to the tool. The transport module is not yet developed.

Step 3 – Creating a baseline scenario

When the current situation has been described, a baseline scenario can be created. The baseline scenario should be based on the current situation, but planned renovations and new buildings should be included. Renovations and new buildings must be defined with an energy consumption according to prevailing regulations on technical requirements for building works.

The transport data must be updated based on the change in activity due to changes in the building stock (population, number of jobs etc.), but other factors, such as modal split and travel data should be kept constant.

Step 4 – Creating development scenarios

For the development scenarios, the new buildings and renovation projects should be described with the planned energy performance levels. In addition, other factors such as installation of renewable energy systems (solar collectors, PV) on the buildings must be described.

Planned installations of local energy plants must be described.

Data on the district heating system should be altered if there are plans for improving the energy efficiency or changing the share of different energy sources.

Transport input data can be altered based on development of transport hubs or other relevant measures.

Several scenarios can be generated to investigate the effect of different measures and ambition levels.

Step 5 – Calculation and analyzing data

When the current situation, baseline scenario and development scenarios are defined, the system can be calculated and the results will be shown in a set of charts, based on the chosen indicators. The results will give important insight in what measures and ambition levels that are necessary to reach the project targets.

After the evaluation, modification to scenarios can be made, or new scenarios can be defined before the system is recalculated.

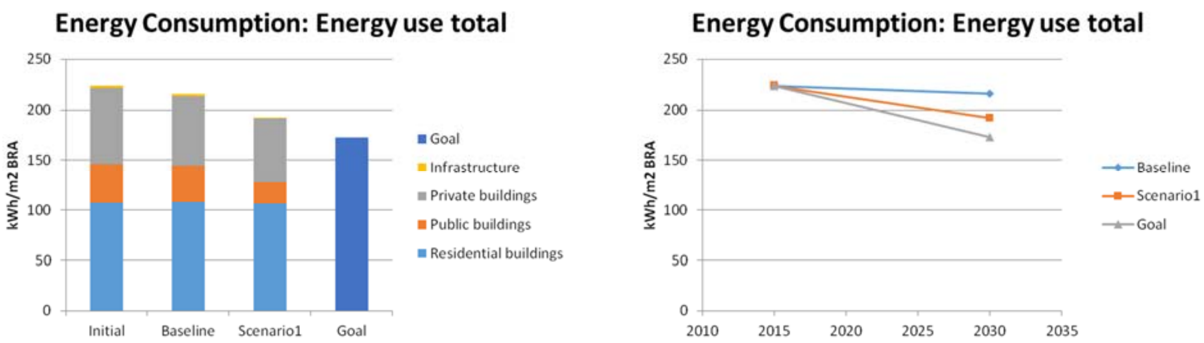


Figure 5.5: Example of charts for analysing results from calculation

Step 6 – follow-up

To enable follow-up of the project compared to the planned scenarios, a follow-up system will be developed. This will allow for updated versions of the "current situation" during the project lifetime. The input can be a combination for more detailed information from simulations and from measurements/monitoring.

Current status and further development

An alpha version of the tool has been developed in task 1.2, to test some of the basic features. Stationary energy consumption and production have been the main focus. The transport module has not yet been developed. In task 1.3 the tool will be further developed and tested on the case studies.

By implementation of a cost factor in renovation projects and new developments, it can be possible to extract cost/benefit indicators. Cost has not been a focus in the preliminary indicator set, but from the testing in task 1.3, one might find feasible ways to implement it into the tool.

Another feature that has not yet been developed, but could be interesting, is the opportunity to categorize the evaluation with respect to different building owners. It would then be possible to show what individual building owners have planned, and the effect on the KPIs.

The tool will be presented for the reference group at a suitable opportunity. Based on feedback from the presentations, the tool will be further developed and tested on the case studies, within the task 1.3 research group. When a preliminary version is ready and tested, the tool will distributed to the project reference group connected to the case studies, for testing and feedback from the developers. Further details of the testing are described in Chapter 7.

5.3. Other tools

Introduction

Figure 1.5 show the different target groups and identified tools that are relevant for target group visualized in a top-down interpretation. Primary objective of task 1.2 (this report) is KPIs for areas (chapter 4) and Indicator tool employed for areas (chapter 5). The rest of the tools are listed below.

District dashboard and visual area screen

Targeted use of smart measurements and data processing enables "automatic" production of KPIs for monitoring and reporting purposes. A district dashboard could display this information by means of a multiple choice of screens. The dashboard will be set up to present selected indicators which of especially interest like energy consumption and production and carbon emissions will be analysed and presented by dynamic curves, updating with suitable intervals. Other secondary indicators will be linked to the dashboard giving information on a more detailed level.

The purpose of the dashboard is four-fold:

1) help urban developers to monitor progress toward the goals and make best real-time choices
2) motivate the community inhabitants to become and act more energy- and environmentally conscious by showing the effect of their actions together with valuable information like real time energy forecast / consumption / generation graphs, public transport information, weather, air quality, noise levels, etc.
3) informing an inspiring other urban decision makers, neighbourhoods and general people
4) enabling comparison of neighbourhoods identifying best-practice and trigger competition between neigborhoods, cities and countries

A visual areal screen is planned at Trygve Lies Plass in Furuset. This could show the same screens as the district dashboard or a variant if more appropriate.

It is a possibility to make the data accessible via the internet, on computers, tablets and smartphones if serviceable.

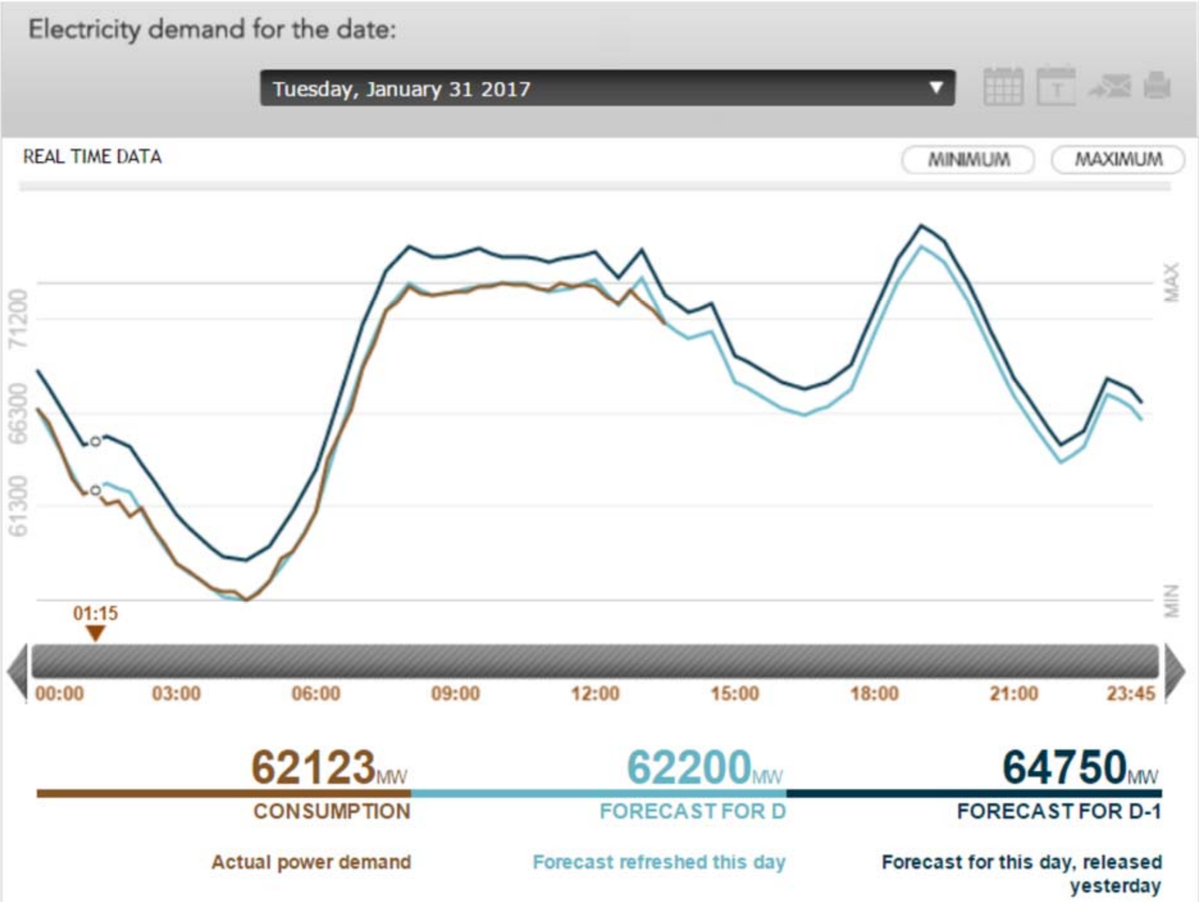


Figure 5.6: Example of a dashboard presenting energy consumption measures. Source: http://www.rte-france.com/

Company indicators

It is believed that companies find green branding attractive because of increased company value, employee motivation or other positive mechanisms for their core business. The KPIs can easily relate to such company indicators and substantiate green values and green branding. One example for a real estate company is carbon emission from the portfolio of buildings. Use of company indicators will be analysed in task 1.3.

Grants/Subsidies for building owners and developers

Targeted use of grants/subsidies could obviously trigger energy ambitious construction or retrofitting. There are several "funding sources" with Enova as the most important. The indicator tool might help targeting use of subsidies to reach an area ambition. This will be analysed in task 1.3.

Other incentives (reduced application fee, reduced application time)

At Furuset, building that comply with specific "FutureBuilt rules" have reduced application fee or reduced application time. However, these advantages are relatively small and has probably minor impact. If the municipality could offer attractive benefits, this could contribute to achieve ambitious SEC-goals. If an ambitious building project for example have the possibility to utilize 1 to 2% more of the land for buildings, this would have a great economic impact for the investor. However, such benefits can cause negative consequences for the neighbourhood, such as less green areas, sun light or space for bike parking, which also need to be taken into consideration by the municipality.

Checklists and guidelines

Building application officials have stated a need for checklist and guidelines for dispensation application to deviate from building code requirements for existing buildings. §31-2 in the Norwegian building law (Plan og bygningsloven) gives opportunity to deviate from the minimum requirements in case of disproportionate costs. However, this is not defined and estate developers make the documentation based on their own interpretation of what should be included in the documentation of disproportionate costs. For instance, inclusion of investment costs only. The building application officials has a limited opportunity to ask for more documentation even though a fair analyse of most energy measures require a balance between increased investment costs and reduced operating costs. Hence, there is a need for more specific guidelines for LCC-based (Life Cycle Cost) documentation and standardised calculation framework (choice of calculation interest, lifespan, energy costs etc), together with a checklist enabling a quick quality assurance of the documentation.

5.4. The toolkit in relation to the WP2 planning instruments

The goals and indicators of WP1 are developed through a bottom-up approach and emphasize KPIs that are useful for target setting and monitoring in smart energy communities. In the parallel task 2.2 performed by NTNU, a planning wheel is presented which lays forward possible tools that can guide the integration of energy planning into municipal planning practices based on the two cases.

The planning wheel is developed based on interviews and design thinking workshops with the involved stakeholders of each case. It suggests a process which sees stakeholder agreement of the SEC design as of high importance to the entire planning process and exemplifies this through a planning wheel consisting of 5 steps: (1) a SEC agreement including builder(s), utility company(ies) and municipality, (2) a core of community fund created by the stakeholders within the SEC agreement, which ensures the construction of agreed societal services and infrastructure, (3) an incentive pool which directs the stakeholders to easier processing etc., followed by a (4) strict policy on parties outside the SEC agreement, and finally (5) a flagship status and evaluation process driven by the municipality.

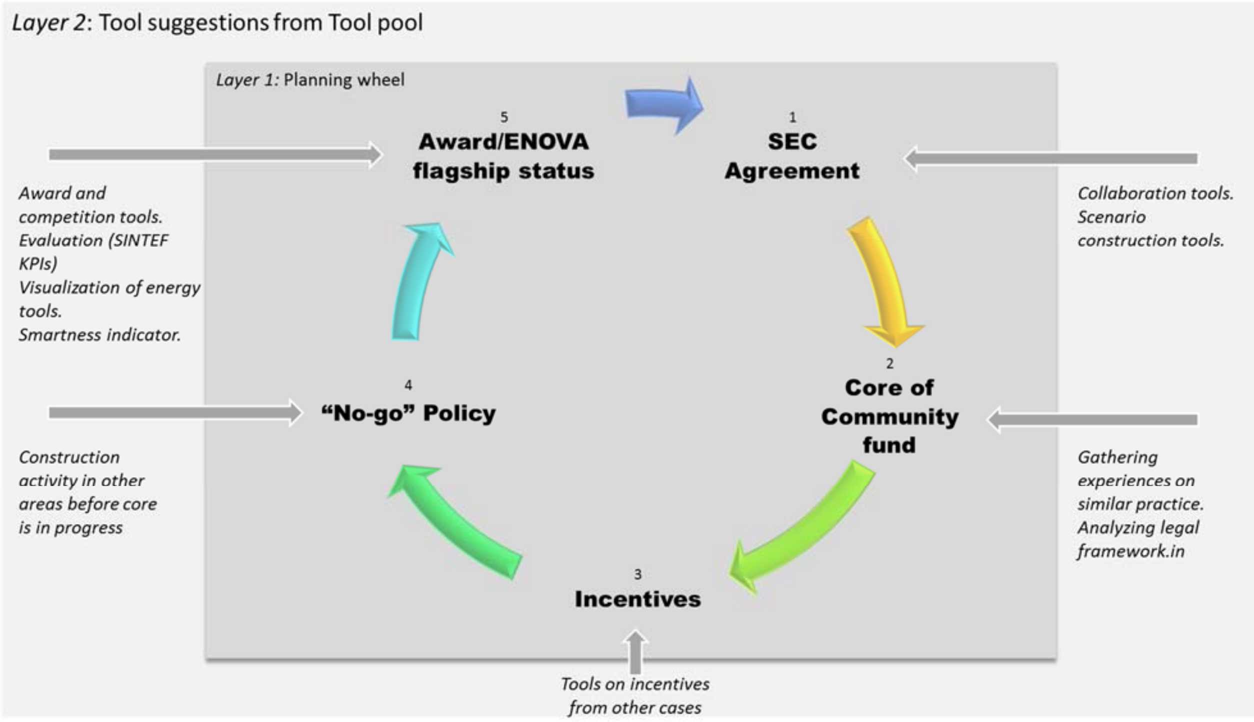


Figure 5.6: Planning wheel illustrating how to read the toolbox

The process is presented as a circular and iterative process in order to illustrate that experience gathering and knowledge driven policies for the improvement of SEC thinking is made possible. The wheel is presented alongside a number of planning tools from international smart city cases which can support the planning process and will be tested in task 2.3 together with the testing of the recommendations of report 1.2.

Figure 5.7 illustrates the connection between the indicator based planning and follow-up tools developed in WP1 and the planning wheel developed in WP2. To improve the understanding of the interactions, the WP2 planning wheel has been folded out to a straight line planning process. Generally the goal and indicator toolkit developed in WP1 can be seen as a set of utility tools to aid the planning process described in WP2.

The first stage of the planning wheel is the development of a SEC agreement. The WP1 indicator tool will be an integral part of this stage, by enabling definition of realistic, but ambitious, goals both on neighbourhood and individual building owner level. The use of indicator analysis on development scenarios can result in a property plan, as a part of the SEC agreement.

The third stage of the planning wheel is access to incentives. The scenarios from the indicator tool and the resulting property plan will act as decision basis for choosing the incentives that best support the SEC development. Incentives can be tailored based on the goal achievement of the individual builder.

The fifth stage in the planning wheel is the evaluation of the SEC planning and implementation process. Through monitoring of KPIs, the indicator toolkit will aid the evaluation both by comparing the planned scenarios with the real development of the indicators, and by enabling comparison between different SECs. Degree of goal achievement for individual building owners and properties can be directly compared with the property plans in the SEC agreement, and influence the disbursement of incentives. The results can as an example be visualised through a local screen or a city dashboard.

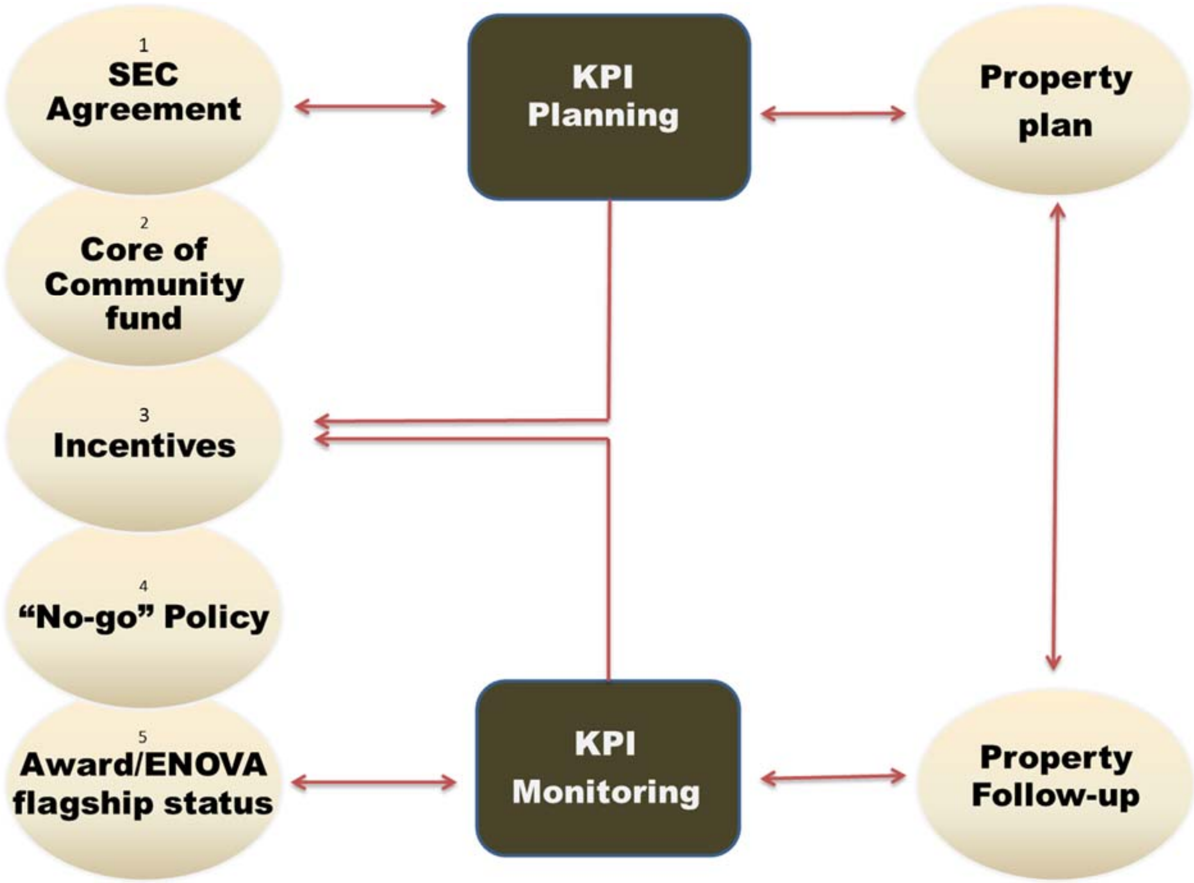


Figure 5.7: The connection between the WP1 and WP2 tools.

6. KPIs and goals in the case studies

KPIer og mål i pilotområdene – En kort oppsummering av kapittelet

Kapittel 6 beskriver hvordan indikatorene kan benyttes mot PI SEC sine pilot områder Furuset (Oslo) og ZVB (Bergen). Noe er allerede gjort i byene når det gjelder valg av indikatorer og oppfølging av disse, men det meste blir fulgt opp på en ny måte gjennom PI SEC Indicator Tool. Neste fase av prosjektet vil handle mye om uttesting opp mot pilotområdene og involverte parter i disse.

In the following sections, the case studies are given a brief introduction. The report from Task 1.1 gives more details on the background. Some details on new development since the last report are included.

6.1. Case Study Zero Village Bergen (Ådland)

Zero Village Bergen (ZVB) is a large development project with several types of multifamily residential buildings consisting of 2-4 floors, all together approximately 800 units. The development site is located at Ådland, about 15 km south-east of Bergen, near the airport (Flesland).

Figure 6.1 Illustration of what Ådland will look like. Illustration: Snøhetta

The project is currently in the planning phase and is being developed by the company ByBo AS in close cooperation with the Norwegian research centre on Zero Emission Buildings (www.zeb.no) with partners NTNU, SINTEF, Snøhetta and Multiconsult.

The overall energy ambition of the development is that the greenhouse gas emissions related to the operation of the buildings should be zero on an annual basis. The embodied emissions from construction materials should be accounted for. For some of the dwellings the ambition is to also to include emissions from construction materials in the zero emission balance. More about ZEB definition and ambitions can be read in PI-SEC Report 1.1.

Previous work has included a preliminary design and analysis of energy concepts for the buildings, as described in Risholt et al. (2014) and Sartori et.al (2015 and 2017). As described in the report related to task 1.1;

The building envelopes and HVAC equipment are to be constructed according to the Norwegian passive house standard NS 3700 (2013). Two alternative energy supply systems were explored in the concept design phase: 1) A combination of a central ground source heat pump system and building integrated solar thermal collectors and photovoltaics, and 2) A combination of a centrally located biogas cogeneration machine combined with building integrated photovoltaic systems. See Risholt et al. (2014) for a further description.

In order to get a more detailed overview of the amount of PV electricity that may be generated, consumed, or exchanged between the buildings and the grid, a more comprehensive analysis needed to be carried out. This was done by (Sartori et al., 2015). The load profiles of the commercial buildings in the neighbourhood have been included in the analysis, in order to consider the export of PV electricity to these buildings

Based on new discussions with the project partners, three possible solutions where investigated for the heating system of Zero Village Bergen (Igor Sartori et al., 2017) (this was done after the report related to Task 1.1 was finished):

1. District Heating (DH)
2. Biomass fired Combined Heat and Power (Bio CHP)
3. Ground Source Heat Pump (GSHP)

When comparing the three systems against one another two sets of key performance indicators are considered: ZEB target and system cost. Furthermore, technical system performance indicators are also calculated but not used to compare the systems because either they do not have an implicit good-or-bad value (e.g. thermal capacity) or such value is already embedded in the other indicators (Igor Sartori et al., 2017).

The results show that, with the conversion factors used in this study, only the Bio CHP system meets the ZEB balance target, actually achieving a slightly negative balance.

Furthermore, the results show that while the DH system has the highest operational cost (and minimum investment cost) and the Bio CHP system has the highest investment cost (and intermediate operational cost), the two end up having approximately the same global cost. The GSHP system has the lowest operational cost (and intermediate investment cost) and ends up with the lowest global cost; significantly lower than the two other systems.

The choice of energy system is not obvious. The developer and the team needs to consider the options and see what will be most suitable for the project. It is not yet decided when the project will be built and finished.

Target groups/stakeholders

In the ZVB project there are only one developer: ByBo. This makes the project less complex and more controllable. ByBo wants to be in front of the development and construction of houses of the future with regard to energy and environmentally friendly buildings, which is also why they wants to build ZVB as one of the first ZEB/ZEN neighbourhoods in Norway.

PI-SEC indicator tool

At ZVB, many detailed simulation studies have already been performed. The results from these studies serve as important input to the PI-SEC indicator tool, instead of estimation from normative data. Even though many of the indicators are evaluated through other more detailed work, the use of the PI-SEC indicator tool can be useful to get a simplified overview of the overall performance of the neighbourhood. In the next year, further work will be done related to the planning of the energy system, mobility and building envelope, and it will be interesting to see if the PI SEC indicator tool can be useful into these processes.

6.2. Case Study Furuset

Furuset in the area Groruddalen is an Oslo suburb from the 1970s (Oslo kommune PBE 2014). The development at Furuset was carried out according to municipal planning and included a nursing home, schools, nursery schools, a shopping mall (Furuset senter), commercial buildings, public transport (T-bane, a subway) and walk- and driveways in the whole area. The co-operative building society OBOS was responsible for building approx. 2800 apartments. Following the main development, several minor additional developments have been carried out, such as Furuset Forum in 1998, the extension of Furuset senter in 2001, the Ahmadiyya mosque in 2011 and the building of storage and production facilities along the motorway E6.

Furuset is served by subway, local busses, express and regional busses. A widespread network of foot- and cycle paths exists. The area is cut through by the motorway E6 with high traffic volume.

Per 1.1.2011 about 9500 people lived in the Furuset district as a whole. The population of Furuset comes from about 140 different nations. Within the boundary for the local development plan, there where per 2014 about 3800 residents and about 1500 jobs.

The planning and buildings authority started work on the development plan on Furuset in 2009. In December 2014 a proposal for a climate efficient urban development on Furuset was submitted for political decision (Oslo kommune PBE 2014).

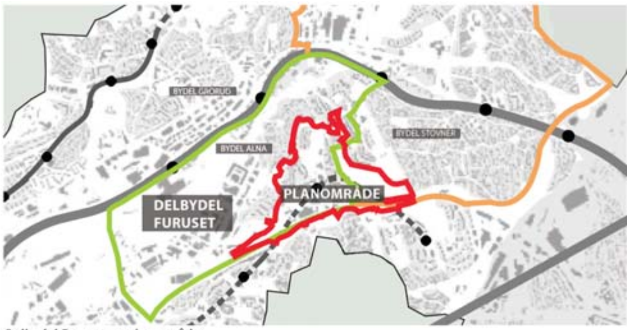


Figure 6.2 Map of Furuset

The proposed plan prepares for a development of new buildings with a gross area of approx. 390 0000 m^2 such as housing, commercial buildings and social infrastructure within the planning area. This could result in building around 1700 apartments. If a lid is built over the motorway E6, the number of new built apartments can increase to around 2300.

Table 6.1 shows todays' situation at Furuset and two possible scenarios for development. Scenario 1 includes a lid over E6, scenario 2 is the planning proposal without a lid.

Table 6.1 Facts about the buildings in Furuset (Oslo kommune PBE, 2014).

	Todays' situation (2014)	Planning proposal incl. lid over E6	Planning proposal without lid
Gross area in total	323 000 m^2	571 000 m^2	571 000 m^2
Housing, gross area	142 000 m^2	373 000 m^2	300 000 m^2
Number of dwellings	1 400	3 700	3 000
Gross area schools, nursery schools, sports facilities, cultural facilities, senior citizens' community centre	68 000 m^2	88 000 m^2	85 000 m^2
Gross area shopping mall	6 500 m^2	15 000 m^2	15 000 m^2
Gross area commercial / service area on ground floor (S1-S10)		15 000 m^2	15 000 m^2
Gross area office / commercial / storage	75 000 m^2	54 000 m^2	130 000 m^2
Number of floors (min-max)	2-9 floors	2-9 floors	2-9 floors

The ambition of Oslo is to reduce greenhouse gas emissions by 50 % by 2020 and by 95 % by 2030, compared with the level of 1990 (Byrådet Oslo kommune, 2016).

Furuset is Oslo's designated priority project within the FutureBuilt-programme. The objective of FutureBuilt is to develop climate efficient urban areas and reduce greenhouse gas emissions. The ambition of Oslo municipality is to facilitate a reduction of CO_2 emissions in the area by 50 %. This is more ambitions than the Oslo goals, because the emissions are calculated differently. E.g., in the FutureBuilt calculations electricity is given an emission factor (according to the ZEB definition (Fufa et al., 2016)), while for the Oslo targets, the emissions from electricity is set to zero. In order to achieve this goal, a sharp reduction in emissions associated with cooling and heating, both in new and existing buildings, is a presumption. One of the main initiatives is to establish a local energy grid at Furuset (Oslo kommune PBE, 2014).

One of the main focus areas at Furuset, is the development of a micro energy system. A micro-energy system consists of a local energy grid (both thermal and electrical) that supplies energy to users in the neighbourhood, but also can accept energy from the users (Etterstøl, 2015).

Hafslund Varme (from August 2017 Fortum Varme Oslo) has concession for district heating at Furuset (NVE, 2016a), but are obliged to prepare the system for integration with local secondary heat sources (NVE, 2016b). Currently, Hafslund is looking into developing a local low temperature district heating network, with seasonal storage of surplus heat from the waste incineration plant at Klemetstrud.

Hafslund Nett is currently installing advanced meters (AMI) in the Furuset Area. This will be finished within the end of 2017, and can be a useful tool for gathering data for KPIs.

More information about the ambitions in Oslo and Furuset is available in PI SEC Report 1.1.

Target groups/stakeholders

One of the main challenges with Furuset, is the number of stakeholders involved. The largest landowner in the Furuset area is Oslo municipality. The centre of the area is dominated by a few large private landowners whereas the properties in the rest of the area is mostly owned by nine different housing cooperatives. In addition, there are privately owned individual houses (Oslo kommune PBE 2014).

Proposed use of toolkit

Oslo municipality is the main driver for the SEC goals, and it will be challenging to get the private stakeholders to implement the measures necessary to reach the goal. The main objective for the toolkit will therefore be to find necessary measures, and aid closer collaboration between the municipality and private stakeholders.

The proposed PI-SEC indicator tool could be an important instrument at Furuset. Mainly for the municipality to evaluate what is necessary measures from the private stakeholders, and how far they can reach by only taking action on their own property. The tool can then be used to create specific targeted incentives for the private stakeholders.

7. Discussion and further work

Diskusjon og veien videre – En kort oppsummering av kapittelet

Kapittel 7 diskuterer prosessen som har vært ved valg av mål, indikatorer og verktøy-struktur. Så langt er det kun et foreløpig resultat som presenteres og flere ting kan endre seg i de neste fasene av prosjektet hvor indikatorer og verktøy skal testes. Noen usikre momenter:

- Fremtidens teknikk og juridiske lover, spesielt med tanke på muligheten for å måle de ulike parameterne.
- Interessen og treffsikkerheten hos brukergruppene, kommunale og spesielt private.

Metoden som ble brukt, MADM, fungerte til en viss grad. Siden det var første gang denne metoden ble nyttet av de involverte i forskningsgruppen ble ikke metoden alltid fulgt, men det var en god metode som grunnlag for en utvelgelsesprosess og gav gode diskusjoner som førte frem til et ferdig indikatorsett for videre arbeid.
Videre så beskrives planene videre for prosjektet PI SEC Task 1.3, hvor verktøy skal testes ut i Oslo (Furuset) og Bergen (Ådland).

This report presents a preliminary toolkit for goals and key performance indicators in Smart Energy Communities developed in close relation to stakeholders. We will now enter a test period where goals, indicators and tools will be calibrated by testing against the two pilot areas, Furuset and ZVB.

Future possibilities are uncertain

A challenge in the process of choosing the preliminary indicator set is that the future is uncertain in terms of technical and legal possibilities, especially when it comes to monitoring and instrumentation. For example, something that are under discussion in Norway today is the degree of measurements of real time energy consumption in each building or area, based on AMI or other smart instrumentation. The developments within "smart" ICT is moving fast and the potential is huge. The questions are often on a legal level, more than what is technical feasible.

The indicator set is chosen based on technical and legal possibilities in Norway today or in near future.

Stakeholders feeling of ownership

Until now, the work has been developed based on literature studies and dialogues with different kinds of stakeholders. A risk we are facing is that the stakeholders have not been included *enough* in the developing face – that we are not meeting the needs of the user group, especially the developers. In the next phase, the user groups will be involved to a much larger degree, to be able to test the indicator sets and tools. This will give valuable input for developing the PI-SEC tool further.

Evaluation of the MADM methodology

The MADM methodology was tested on selection of KPIs. Overall, the methodology was found useful for structuring the decision-making process.

The process with rating all indicators against the attributes is quite time consuming. The fact that all attributes were qualitative in their nature, and therefore had to be quantified, means that there is a lot of subjective evaluation involved. Due to this, it was found that the methodology was not suited for direct selection based on rating, but rather useful as a basis for discussion. The process of selecting attributes and rating the indicators improves the foundation for the decision-making, and ensures that indicators are evaluated more structurally.

Further Work

Task 1.3 encompasses analyses of data from the case studies to validate, optimize, or discard the KPIs chosen in Task 1.2. The preliminary set of indicators will be tested in the selected neighbourhood development projects (case studies). This will be done through the following steps, some of them in cooperation with task 2.3 (testing of municipality toolkit):

1. Updated information on the case studies: The first step in task 1.3 will be to gather the necessary *updated information for the cases*. This means data on the existing and planned building stock and infrastructure as input to the indicator tool. For ZVB, a lot of information already exists in the studies that has been performed in the ZEB project and currently is performed in ZEN. For Furuset, a more comprehensive data gathering is necessary, especially for the existing building stock. The work has been initiated by the "Micro energy system"-project lead by the Municipality of Oslo and Rambøll.

2. Document analysis: The case studies will first be *analysed "as planned"*, i.e. an analysis of the actual performance indicators, goals, and criteria that have been applied by the planners involved. This will be done through *document analysis* of the chosen case studies. The questions to be addressed are (the last two questions will also be addressed in the group interviews/ interviews described in point 4-5):

    - What criteria for energy performance have been used, and what was the result in choice of concepts, technical solutions, energy performance and GHG emissions?
    - How do the criteria used relate to higher and lower level criteria (building, city, regional levels) and how can they be measured and aggregated to higher level criteria?
    - How do the criteria contribute to fulfilling the overall goals of smart sustainable cities?
    - Were the criteria easy to understand, measure and communicate?
    - How much time has been spent on analysing the criteria, and what tools have been used?

3. Researchers testing the toolkitson the case studies: After the initial analysis of the case studies "as planned", the *preliminary tool-kits with KPIs developed in Task 1.2 and 2.2 will be tested* on the same case study projects with different energy scenarios. The results of the two sets of analysis ("as planned" vs "alternative energy scenarios with preliminary tool-kits") will be compared, discussed and analysed in cross-disciplinary workshops with respect to how the targets and tool-kits can be applied in practice (data quality, uncertainty, resource use, etc.). This first testing will mainly be done by the researchers who developed the KPIs, and the results will be presented in a workshop for further development.

4. Presentation of test results and group interviews[6]: The workshop will start out with presentations of toolkits from wp 1.3. (and scenarios) and 2.3, and there will be a focus group interview about

[6] Focus group interviews: This is a type of group interview is characterized by group conversations on selected topics, emphasizing underlying norms, attitudes and values. The participants should all be interested and familiar with the topic, and the interview should be carried out in an informal and open way. Ref: Parker, A. & Tritter, J. (2006). Focus group method and metholology: current practice and recent debate. *International Journal of Research and Method in Education, 29*(1), 23–37

the toolkits. The participants will be both municipal employees and developers. The discussion will be recorded and transcribed, and the findings will be grouped and analysed. The main questions to be addressed during data collection in point 4-5 are:

- Where to set the geographic system boundaries for export/import of energy
- How much of the life cycle of the project may be included, secondary effects
- What are the appropriate measurement units with respect to time
- How many indicators should be included
- How to aggregate the indicators: transparency, double counting, synergies, rebounds, etc.
- How to deal with data quality and monitoring procedures, including future scenarios for AMI legislation and the development of Internet of Things

In addition, we want the participants to compare the old and new indicators and toolkits in the group interview, and discuss and differences and possible outcomes.

The group interview may be divided in 5 topics after the 5 categories with KPIs/ indicators from report 1.2:

Nr	Goal
1	CO_2-reduction
2	Increased use of renewable energy
3	Increased energy efficiency
4	Increased use of local energy sources
5	Green mobility (reduced CO2 emissions and better air quality)

If necessary, the topics will be divided between two workshops with groups interviews.

5. User test of KPIs and toolkits: Further, the toolkits will be tested by the municipal employees and the estate developers, and the researchers will be involved through *action research*, helping and guiding the testing Is in the different planning groups for the case studies. The case studies will be analysed using both quantitative and qualitative methods; MCA, computer simulations, interviews, and interdisciplinary analyses in workshops. Different technological scenarios will be analysed against the KPIs and energy-related targets using computer simulation tools to model energy performance, GHG emissions and the exchange of energy between buildings and the grid or storage, as well as the dynamic interactions between stationary energy use and transport. The proposed PI-SEC indicator tool will be the main tool used for analysing the cases. The more detailed technological scenario investigations will serve as input to the indicator tool, to increase the accuracy in evaluation. This will also improve the underlying reference base of normative values and typical efficiencies. During the test period, need for improvement and further development will be evaluated and prioritised. The most relevant developments will be implemented through the test phase and used in the evaluation of the KPIs.

The toolkits will also be discussed in meetings with the international reference group during 2017, and these inputs will be analysed together with data from users and experts.

6. Analysing data and further development of KPIs and toolkits: Redesign of the KPI toolkit will be done on the basis of the qualitative and quantitative data from the evaluation process described in point 2-5. The user participation in the process contributes to co-designing of the toolkits, and the process therefore secures that the tools and KPIs will be in accordance with the user needs.

7. The co-designing process and the final toolkit will be described in reports and scientific papers.

	Task 1.3 in cooperation with task 2.3 Duration 5 quartiles Start date to be decided				
1. Updating the information on the case studies					
2. Document analysis of the case studies "as planned"					
3. Researchers testing the new KPIs on the case studies					
4. Workshops presenting toolkits, focus group interviews.					
5. Test period of tool-kits, action research					
6. Analysing data from group interviews, action research, and input from international and national partners, further development of toolkit/ KPIs					
7. Report					M3
Scientific papers					SP1 and 2

Milestones: M3: Common report task 1.3 and 2.3.

SP1 and 2: Scientific paper 1 and 2 on the use of the tool-kits.

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