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Reinis Āboltiņš

DECISION-MAKING IN TRANSITION TO SUSTAINABLE ENERGY

Doctoral Thesis

RTU Press
Riga 2023

RIGA TECHNICAL UNIVERSITY

Faculty of Electrical and Environmental Engineering

Institute of Energy Systems and Environment

Reinis Āboltiņš

Doctoral Student of the Study Programme “Environmental Science”

DECISION-MAKING IN TRANSITION TO SUSTAINABLE ENERGY

Doctoral Thesis

Scientific supervisor
Professor, Dr. habil. sc. ing.
DAGNIJA BLUMBERGA

RTU Press
Riga 2023

Anotācija

Promocijas darbu “Lēmumu pieņemšana ceļā uz ilgtspējīgu enerģētiku” Rīgas Tehniskās Universitātes Vides aizsardzības un siltuma sistēmu institūtā izstrādājis Reinis Āboltiņš.

Darba mērķis ir izveidot lēmumu pieņemšanas algoritmu, kas ņem vērā esošās zināšanas par šķēršļiem un politikām, kas kavē vai veicina ilgtspējīgas enerģijas attīstību, koncentrējoties uz lēmumu pieņemšanas posmu un soļu identificēšanu un analīzi pilnā politikas dzīves ciklā, kā arī noteikt piemērotas analīzes metodes katrā lēmumu pieņemšanas posmā un solī, lai atbalstītu lēmumu pieņemšanu par enerģētikas un klimata politiku, un integrēt šīs metodes lēmumu pieņemšanas procesā, lai nodrošinātu tādu politikas dzīves ciklu, kas noved pie ilgtspējīgas enerģētikas sistēmas.

Promocijas darba uzdevumi ir:

1) Analizēt esošo zināšanu un prasmju kopumu par lēmumu pieņemšanas līdzekļiem un lēmumu pieņemšanas ietekmi uz enerģētikas pārejas politiku izvēli.
    a. Pārskatīt metodes lēmumu pieņemšanai par vispiemērotāko politikas portfeli ilgtspējīgas enerģijas sistēmas attīstībai un uzturēšanai;
    b. Pārskatīt analīzes metožu izmantošanu vairākās politikas jomās (atjaunojamā enerģija, enerģijas lietotāju uzvedība, lauksaimniecība, klimats, energoefektivitāte), lai ilustrētu metožu lomu lēmumu pieņemšanā par politikām;
    c. Novērtēt politikas virzienu atbilstību klimata mērķu sasniegšanai.
2) Analizēt politiku dzīves ciklu, lai noteiktu, kuri elementi ir būtiski lēmumu pieņemšanai un politikas veidošanai, kas noved pie ilgtspējīgas enerģijas;
3) Analizēt kvalitatīvai lēmumu pieņemšanai nepieciešamo darbību secības ietekmi uz politikas izvēli un politikas dzīves ciklu;
4) Formulēt ieteikumus lēmumu pieņemšanas algoritmam politikas dzīves ciklā, kas ietver:
    a. Lēmumu pieņemšanas posmu identificēšana un aprakstīšana politikas dzīves cikla ietvaros;
    b. Katram lēmuma pieņemšanas posmam būtisku lēmumu pieņemšanas elementu identificēšana un aprakstīšana.

Promocijas darbam ir ievads, četras nodaļas (ieskaitot secinājumus), un literatūras saraksts.

Ievadā iezīmēta temata aktualitāte, izpētes mērķi un uzdevumi, formulēta hipotēze, zinātniska inovācija un darba praktiskā pielietojamība. Tāpat ievadā īsumā skaidrots promocijas darba analīzes un secinājumu plašāks konteksts.

1. nodaļā (Literatūras analīze) skaidroti galvenie jēdzieni un aplūkoti ar promocijas darba tematiku saistītie zinātniskās domas avoti. Tiek aplūkoti tādi jēdzieni kā enerģijas pāreja, sociotehniskā pāreja, tehnoloģiju apguves līkne, inovāciju ieviešana, AER atbalsta loģika, šķēršļi atjaunīgās enerģijas tehnoloģiju ieviešanai un energoefektivitātes pasākumu īstenošanai, enerģijas lietotāju uzvedība, politikas veidošana un lēmumu pieņemšana, politiku kombinācijas,

politiku ieviešana un pārskatīšana. Tāpat skaidroti enerģijas pārejas elementi, procesi un aspekti.

2. nodaļā (Metodoloģija) aplūkoti politikas dzīvescikla četri posmi: 1) politikas uzsākšana, 2) lēmumu par politikām pieņemšana, 3) politiku ieviešana, un 4) politiku pārskatīšana.

Katrs politikas dzīvescikla posms ietver divus vai vairāk soļus, kas veido katram posmam atbilstīgas soļu kopas. Lēmumu pieņemšanas soļi katrā kopā atbilst konkrētā politikas dzīvescikla posma vajadzībām. Nodaļā analizēti četri ikvienam lēmumu pieņemšanas solim būtiski elementi: 1) uzdevums, 2) metodes, 3) vēlamais iznākums, un 4) ar soļa izlaišanu saistīti riski. Īpaša uzmanība pievērsta analīzes metožu lomai un pielietošanai lēmumu pieņemšanā dažādos politikas dzīvescikla posmos.

2 nodaļā iztirzāti lēmumu pieņemšanas posmi un soļi. Pirmkārt, tiek skaidrota politikas dzīvescikla loģika. Otrkārt, skaidrotas lēmumu pieņemšanas kopas un soļi, aplūkojot uzdevumus, analīzes metodes, vēlamo iznākumu un riskus. Treškārt, skaidrots analīzes metožu pielietošanas visā politikas dzīvesciklā nozīmīgums, aplūkojot katru identificēto metodi un galveno uzmanību pievēršot katras metodes pievienotajai vērtību lēmumu pieņemšanā.

Politikas dzīvesciklā katrā lēmumu pieņemšanas solī kvalitatīvas informācijas iegūšanai piemērotākās metodes tiek pielietotas atkārtoti. Tādēļ vispārējam lēmu pieņemšanas ikvienā solī pielietojamajam metožu aprakstam seko katras metodes detalizētāka novērtēšana.

Analīzes metožu pārskatīšana sākas ar lineāras regresijas metodi, turpinās ar multikritēriju analīzes metodēm (analītiskas hierarhijas process (AHP) un TOPSIS), apskāvienu, burkāna un pātagas metodi, lēmumu pieņemšanas koka metodi. Nodaļas noslēgumā tiek aplūkota klimata politikas integrācijas metode, kas ir īpaši piemērota enerģijas un klimata politiku savstarpējas mijiedarbības pētīšanai un klimata politikas mērķu prioritātes līmeņa noteikšanai, salīdzinājumā ar citām politikām.

3. nodaļā aplūkotas lēmumu pieņemšanas analīzes metodes un pieejas, kas ir būtiskas tādas enerģijas un klimata politikas izvēlei, kurā sociotehniskā pāreja rezultējas ar klimatneitralitāti. Aplūkoti gadījumizpētes piemēri, galveno uzmanību pievēršot analīzes metožu pielietošanai lēmumu pieņemšanā visos politikas dzīvescikla posmos.

Ar mērķi uzsvērt lēmumu pieņemšanas nozīmīgumu visā politikas dzīvesciklā 3. nodaļas 3.6. apakšnodaļa veltīta dažādu analīzes metožu un pieeju iekļaušanai algoritmā, kas nodrošina kvalitatīvu politikas analīzi, lēmumu pieņemšanu un politikas veidošanu.

Visbeidzot, 4. nodaļā kopsavilktas promocijas darba izstrādē gūtās svarīgākās atziņas, galveno uzmanību pievēršot izveidotā metožu pielietojuma algoritma izmantošanai ilgtspējīgas enerģētikas politikas veidošanā.

Annotation

Doctoral Thesis "Decision-making in transition to sustainable energy" has been elaborated by the author Reinis Āboltiņš at the Institute of Energy Systems and Environment of the Riga Technical University.

The goal of the Thesis is to create an algorithm of decision-making, which takes into account existing knowledge about barriers and policies that hamper or facilitate development of sustainable energy by focusing on identifying and analysing stages and steps of decision-making throughout policy lifecycle, as well as identifying suitable methods of analysis at each stage and step of making decisions to support decision-making about energy and climate policy, and integrating those in the decision-making process with the purpose of ensuring a policy lifecycle leading to sustainable energy system.

The tasks of the Thesis are:

1) Analyse existing pool of knowledge and know-how about decision-making aids and the impact of decision-making on the choice of policies for energy transition.
    a. Review methods for making decisions about the best suited policy portfolio for developing and maintaining a sustainable energy system;
    b. Review the use of methods of analysis in several policy areas (renewable energy, energy user's behaviour, agriculture, climate, energy efficiency) to illustrate the critical role of methods in decision-making about policies;
    c. Assess the relevance of policies in the interest of reaching climate goals.
2) Analyse policy lifecycle to establish, which elements are essential for decision-making and policy making leading to sustainable energy;
3) Analyse the impact of the sequence of steps required for qualitative decision-making on policy choice and policy lifecycle;
4) Formulate recommendations for an algorithm of decision-making in a policy lifecycle encompassing:
    a. Identification and description of steps of decision-making within a policy lifecycle;
    b. Identification and description of elements of decision-making relevant for each step of decision-making.

The Thesis includes and introduction, three chapters, conclusions, and a list of bibliography.

Introduction outlines the topicality of the subject, goals and research tasks, the hypothesis, scientific innovation and applicability of the Thesis. It also briefly explains the context in which the analysis and conclusions of the Thesis are applied.

Chapter 1 (Literature analysis) provides an overview of key notions and concepts and sources of scientific thought on the topic of the Thesis. This covers concepts such as energy transition, sociotechnical transition, technology learning curve, adoption of innovation, RES support logic, barriers to the adoption of renewables and energy efficiency action, energy users' behaviour,

policy and decision making, policy mix, policy implementation and policy review. It also explains elements, processes and aspects of energy transition.

Chapter 2 (Methodology) looks at four stages of a policy lifecycle: 1) policy inception, 2) decision making about policies, 3) policy implementation, and 4) policy review.

Each stage of a policy lifecycle encompasses two or more steps forming clusters of steps corresponding each stage. Decision making steps in each cluster reflect the needs and actions relevant for the particular stage in a policy lifecycle. Further, four elements key to every step are analysed: 1) task, 2) methods, 3) expected outcome and 4) risks associated with skipping the step. Particular focus is placed on the role and use of methods of analysis facilitating decision making throughout different stages of a policy lifecycle.

Chapter 2 follows the stages and steps of decision making. First, the overall logic of a policy lifecycle is explained. Second, decision making steps and clusters of decision-making steps are explained. This is done by exploring tasks, methods of analysis, expected outcomes and risks. Third, the relevance of application of methods of analysis throughout a policy lifecycle is explained in Chapter 3 (Results) by exploring the role of each method reviewed, with a focus on the value added by the use of a method to support decision making.

Use of methods of analysis suggested as adequate for the purpose of producing information necessary for qualitative decision making during each step of decision making is repeated several times throughout a policy lifecycle. Therefore, a detailed review of each method follows the overall explanation about the place and role of a method in each decision-making step.

Overview of the methods of analysis begins with linear regression and progresses with multi-criteria decision analysis methods (Analytical Hierarchy Process and TOPSIS), *Hugs, Carrots and Sticks* approach, as well as decision tree method, to finalise this chapter with an insight into the Climate Policy Integration approach to analysing interactions of energy and climate policy and evaluating the level of priority of climate policy goals over other policy goals.

Chapter 3 (Results) reviews methods and approaches to analysing policymaking relevant to energy and climate policies that lead to climate neutrality through sociotechnical transition with examples represented by case studies, which focus on highlighting the relevance of applying methods of analysis in decision making throughout the policy lifecycle.

To support the thread of relevance of decision making throughout policy lifecycle Section 3.6. of Chapter 3 focuses on integrating methods and approaches for analysis into an algorithm for policy analysis, decision-making and policymaking.

Finally, Chapter 4 (Conclusions) summarises key findings of the Thesis, focusing on the practical applicability of the generated algorithm in policymaking.

Pateicības

Vai uzklausīt aicinājumu studēt doktorantūrā, kad aiz muguras jau darba un pieredzes gadi, kas saistīti ar nozares analīzi, un šķiet, ka jau zini ja ne visu, tad ļoti daudz? Šādiem aicinājumiem ir jāatsaucas. Jo aicinājumam, kas sākotnēji šķita kā joks, pamatā bija zināšana un saprašana par to, kā nozare darbojas. Tādēļ esmu pateicīgs Dagnijai Blumbergai – viņa pēc kāda pasākuma, kurā biju viens no runātājiem, smaidot teica: “Nāc studēt doktorantūrā, lai Tu beidzot pa īstam saprastu, kas ir tas, par ko Tu runā!” Izstudēju, sapratu, kļuvu gudrāks, un ar katrām jaunām zināšanām saprotu, ka ir vēl tik daudz, ko izzināt un saprast.

Paldies akadēmiski pieredzējušākajām VASSI kolēģēm un kolēģiem, kuri laipni dalījās ar pieredzi un padomu, kamēr studēju un strādāju RTU. Paldies Andrai Blumbergai par atspirdzinošo norādi “Redzu, ka Tu nezini, kas ir zinātne!” pēc pirmajiem soļiem akadēmiskajā pētniecībā, kas fundamentāli mainīja manu pieeju tekstu lasīšanai un radīšanai. Kad jāizprot un jāatrisina kāda problēma, vienmēr vispirms skatos publikācijās indeksētos avotos. Paldies Kārlim Valteram un Dzintaram Jaunzemam, kuri neliedza padomu akadēmiskajā komunikācijā, lai izdotos četru gadu darbu saprotami izstāstīt 20 minūtēs. Jā, tas ir iespējams! Visbeidzot, paldies Līgai Sniegai, kura mani pacietīgi un profesionāli vadīja cauri doktorantūras administratīvajiem brikšņiem, kad šķita, ka neglābjami apmaldīšos formālajās prasībās un procesos.

Paldies ģimenei, kura dažkārt bija spiesta pacietīgi vērot manas radošās mokas cīņā pašam ar sevi un jautājumu “Kādēļ man šis nepieciešams?” Bija brīži, kad bērni mani redzēja mazāk, nekā būtu bijis taisnīgi, tādēļ ceru, ka mans padoms un pieredze viņiem kādreiz noderēs.

Pro scientia et patria!

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Introduction

In the light of climate change and factors contributing to climate change it is essential what can be done to prevent or minimise anthropogenous causes of climate change. Energy and climate goals of the European Union set out in several strategic documents adopted over the last decade outline a clear trend towards sustainable energy, which honours climate goals and is aimed at planning, implementing and sustaining a fundamental shift in energy technologies and the way we use resources and energy. Concepts like energy security and secure supply of energy have contributed significantly to ensuring that energy transition and energy efficiency remain high on the agenda of policymakers and decision makers in the EU. The European Green Deal entails goals and actions that put climate goals on top of all priorities (European Commission 2019b) and does it in an institutionalised way, thus setting a new standard of integrating climate goals into a broad spectrum of policies covering every sector of economic activity. The new EU Climate Law makes climate policy goals legally binding to the EU Member States, which brings in a new and more concrete perspective also on decision making about past, present and future policies that serve the purpose of achieving climate policy goals.

Change of attitude and behaviour of energy users as well as technological changes are essential to achieve climate goals. Change of behaviour takes place under certain conditions: usually it is a set of measures or policies or policy instruments that are applied to certain situations with the aim to alter behaviour of users of resources and introduce new technologies. Technological changes take place if the conditions are right: policy framework and regulatory environment does not create barriers to the deployment of innovative and climate-friendly technologies and processes and creates incentives for energy producers and users alike to choose renewable energy technologies as opposed to making choices in favour of fossil energy technologies. Transition to sustainable energy depends heavily on policies and policies depend on decision making about what is best for climate policy. Decisions are influenced by many factors – current issues, forecasts and projections of future development, availability of resources (time, human, financial, material), availability of information and analysis.

Quite clearly transition to sustainable energy is a complex matter involving multitude of elements: stakeholders, processes, policies and it is influenced by climate and environmental, technological, economic, and social aspects. Progress towards the goal of sustainable energy depends on policies defined by policymakers and decision makers. Many decision making techniques, methods and approaches have been developed over time to serve as an aid to analysing current situation, modelling future developments under different scenarios, defining policy mix and reaching the defined policy goals. The author of this Thesis, based on studies of existing pool of information and knowledge, has come to conclusion that *ad hoc* decisions about energy and climate policy cannot ensure transition to sustainable energy at all or at the pace required by what is known about factors triggering anthropogenous impact on climate change (United Nations 2015).

Often energy transition and change of behaviour is related to overcoming or taking down existing barriers to the deployment of innovative and more efficient technology, and motivating energy users to act in a certain way to decrease consumption of resources, make resource and energy consumption more effective or make choices in favour of sustainable technological and behavioural solutions. Energy transition is also about not creating new barriers to the adoption of renewable energy-friendly and more energy efficient way of life of private individuals and society in general. This is where the ability to analyse the situation, distinguish between future development scenarios and pursue evidence-based policymaking becomes essential. The abundance of approaches to analysing policy influences decision making, and a systematic approach to decision making is perceived as too complicated. Intuitive decision making models or *ad hoc* policy choices are made, creating risks that the desired policy goals will be achieved partially, will be achieved with extra cost, or will not be achieved at all.

This Thesis elaborates on elements essential for decision-making processes that can ensure transition to sustainable energy, covering steps and methods of decision making that can be consolidated in an algorithm of actions leading to sound decision making about energy and climate policy instruments that ensure energy transition and lead to sustainable energy with minimal risks of failing.

Topicality of the issue

Decision making has a critically important role in ensuring that policies are adopted and implemented that favour sustainability of energy. Share of renewable energy in gross final energy consumption varies significantly as do levels of energy efficiency in different sectors, be it industry, commerce, government, and public sector in general, or households. Sustainable energy is based on the use of zero and low emission resources and technologies in full energy lifecycle – from the need to produce energy, to energy consumption, to repeated use of resources. Therefore, significant attention of past research focuses on analysis of policy instruments most suitable for preventing and overcoming barriers to sustainable energy. Existing sources of information and knowledge, through statistics as well as qualitative studies, regularly contribute to the learning curve about the impact of policies and policy instruments on the actual dynamics of indicators defined with the purpose of measuring progress towards policy goals.

There is a lot of research about what results can be expected when implementing certain policy instruments and combinations of policy instruments (policy mix), and which policies are mutually strengthening or weaking when included in a policy mix. There is also an abundance of research about different decision making aids aimed at providing methods of analysing past and existing policies and forecasting potential results of future policies. There is a variety of methods ranging from simple to complex and choosing a single method may be confusing: applying [only] one approach to analysis and decision making may seem too simple or too complicated, and, in general, insufficient for decision making for a broad spectrum of policy issues across a variety of sectors of economy. Decision making in real life involves a multitude of actors and stakeholders with synergetic as well as competing interests usually stemming from limited availability of financing for the implementation of policies. Such situation may make application of complex methods of analysis and decision making seem too complicated and drive decision makers to conclusions based on intuitive rather than rational approach to decision making.

Thus, the challenge for researchers is to propose decision makers methodology of decision making and policymaking, which would not be too complex while also not being too simplistic and would take into consideration the many elements of transition to sustainable energy, and which would ensure that results of analysis and application of decision making methods contribute to the progress towards reaching the defined climate policy goals. The Author of the Thesis attempts to contribute to the existing knowledge basis by elaborating on the elements and aspects of policymaking and stages and steps of policy lifecycle to facilitate decision making aimed at developing sustainable energy system.

Goal and tasks of the Thesis

The goal of the Thesis is to create an algorithm of decision making, which takes into account existing knowledge pool about barriers and policies that hamper or facilitate development of sustainable energy by focusing on identifying and analysing stages and steps of decision making throughout policy lifecycle, as well as identifying suitable methods of analysis to support decision making about energy and climate policy and integrating those in the decision making process with the purpose of ensuring a policy lifecycle leading to sustainable energy system.

The tasks of the Thesis are:

5) Analyse existing pool of knowledge and know-how about decision making aids and the impact of decision making on the choice of policies for energy transition.
    a. Review methods for making decisions about the best suited policy portfolio for developing and maintaining a sustainable energy system;
    b. Review the use of methods of analysis in several policy areas (renewable energy, energy user's behaviour, agriculture, climate, energy efficiency) to illustrate the critical role of methods in decision making about policies;
    c. Assess the relevance of policies for the interests of reaching climate goals.
6) Analyse policy lifecycle to establish, which elements are essential for decision making and policy making leading to sustainable energy;
7) Analyse the impact of the sequence of steps required for qualitative decision making on policy choice and lifecycle;
8) Formulate recommendations for an algorithm of decision making in a policy lifecycle encompassing:
    a. Identification and description of steps of decision making within a policy lifecycle;
    b. Identification and description of elements of decision making relevant for each step of decision making.

Hypothesis

The hypothesis of the Thesis is that adopting and implementing a standardised process of policy analysis and decision making through a correct sequence of decision making steps supported by suitable decision making methods in a policy lifecycle ensures reaching climate and energy policy goals in an optimal way.

One of the main issues with policymaking is that it usually involves many interests of many stakeholders. Some of the interests can be exercised in a cooperative manner, but some are mutually competitive, which leads to competition of interests for limited resources. Under such circumstances, policymaking may get confined by partisan interests and there is a risk that decisions are made based on these partisan interests and result in leveraged agreement between the involved stakeholders instead of decisions being based on evidence and sufficient analysis of what needs to be done to reach the defined goals.

Energy and climate policy is an especially sensitive area of policymaking as it often touches interests of well-established industries and stakeholders from across a variety of sectors of economy, such as fossil energy production and imports, large-scale agricultural production, fossil fuel transport sector, energy intensive industries, to name but a few. Thus, to ensure sustainable energy and climate interests are represented and factored into sectoral policies, decision making must be exercised according to a set algorithm, which prioritises sustainable energy and climate issues over other policy issues through all steps of decision making during policy lifecycle.

Scientific innovation of the Thesis

Most of existing research focuses attention on individual methods of policy analysis with the aim to emphasise the qualities of a specific method of analysis or with the aim to elaborate on steps of decision making, seldom trying to integrate a combination of methods of analysis with steps of decision making throughout the policy lifecycle and according to the logic and needs of often complex transition to sustainable energy.

This Thesis attempts to generate an algorithm for decision making encompassing sequential steps of policy analysis and assessment of potential impact of policies throughout the decision making process and a full policy lifecycle. Several approbated methods are integrated into the algorithm, which facilitates analysis of past, current and future policies to ensure progress towards achieving sustainability goals in the energy sector. Decision making steps are organised in clusters according to the logic of policy lifecycle and encompass description of tasks, outcomes, quantitative and qualitative methods and risks, ensuring the required policy assessment and evaluation, and can produce conclusions valid for making decisions about the choice and application of energy and climate policies.

Practical applicability and value

Following the correct sequence of steps of decision making within a policy lifecycle ensures that past mistakes do not get repeated and optimal policies for sustainable energy are chosen, implemented, and followed up until the desired policy goals are achieved. The decision making algorithm can be replicated and performance of policies can be repeatedly assessed and compared to measure progress towards the defined policy goals.

The integration of methods of analysis with decision making steps over policy lifecycle in the context of transition to sustainable energy has the potential to serve as an algorithm of reference or a checklist during actual decision making in real policymaking circumstances where multiple stakeholders interact under a variety of circumstances. The algorithm does not ignore the role of potential partisan political influences of many stakeholders. It rather provides a common point of reference for all stakeholders about what is relevant in the process of making decisions about energy and climate policy.

Approbation of the Thesis

Participation in conferences:

1. CONECT 2019, *Choosing energy efficiency policy instruments*, poster session presentation;
2. CONECT 2020, *What type of instrument – hugs, carrots or sticks?*, poster session presentation;
3. CONECT 2021, *Identifying Key Challenges of the National Energy and Climate Plan Through Climate Policy Integration approach*, poster session presentation.

Publications in monographies:

1. Reinis Āboltiņš, Laine Lupkina, Dagnija Blumberga, *Enerģētiskās drošības reģionālais un globālais raksturs*, in monography "Klimata inženierija un politika", published in 2020 (Āboltiņš, R., Bariss, U., Blumberga, A., Blumberga, D., Cilinskis, E., Feofilovs, M., Grāvelsiņš, A., Kuzņecova, T., Lupkina, L., Muižniece, I., Rochas, C., Romagnoli, F. Klimata inženierija un politika. Rīga: RTU Izdevniecība, 2020. 204 lpp. ISBN 978-9934-22-102-6); 14 pages.

Publications in journals:

1. Reinis Aboltins, Dzintars Jaunzems, Jelena Pubule, Dagnija Blumberga, *Are Hugs, Carrots and Sticks Essential for Energy Policy: A Study of Latvia's National Energy and Climate Plan*, Environmental and Climate Technologies, 2020, Volume 24, Issue 2, 1 September 2020, Pages 309-324; listed on Scopus; 16 pages.
2. Reinis Aboltins, Dagnija Blumberga, *Key Factors for Successful Implementation of Energy Efficiency Policy Instruments: a Theoretical Study and the Case of Latvia*,

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3. Reinis Aboltins, Dagnija Blumberga, *In search for market-based energy efficiency investment in households:* Energy Procedia, Volume 147, 2018, Pages 1-6; listed on Scopus; 6 pages.
4. Reinis Aboltins, Dzintars Jaunzems, *Identifying Key Challenges of the National Energy and Climate Plan Through Climate Policy Integration Approach*, Environment and Climate Technologies, Volume & Issue: Volume 25 (2021) - Issue 1 (January 2021); 17 pages.

Structure of the Thesis

Structure of the Thesis is based on analysis of decision making steps at consecutive stages throughout a policy lifecycle.

Following the Introduction, which lays out the overall idea of the Thesis, Chapter 1 (Literature analysis) of this Thesis provides an overview of key notions and concepts and sources of scientific thought on the topic of the Thesis. This covers concepts such as energy transition, sociotechnical transition, technology learning curve, adoption of innovation, RES support logic, barriers to the adoption of renewables and energy efficiency action, energy users' behaviour, policy and decision making, policy mix, policy implementation and policy review. It also explains elements, processes and aspects of energy transition.

Chapter 2 (Methodology) looks at four stages of a policy lifecycle: 1) policy inception, 2) decision making about policies, 3) policy implementation, and 4) policy review.

Each stage of a policy lifecycle encompasses two or more steps forming clusters of steps corresponding each stage. Decision making steps in each cluster reflect the needs and actions relevant for the particular stage in a policy lifecycle. Further, four elements key to every step are analysed: 1) task, 2) methods, 3) expected outcome and 4) risks associated with skipping the step. Particular focus is placed on the role and use of methods of analysis facilitating decision making throughout different stages of a policy lifecycle.

Chapter 2 (Methodology) of the Thesis follows the stages and steps of decision making. First, the overall logic of a policy lifecycle is explained. Second, decision making steps and clusters of decision making steps are explained. This is done by exploring tasks, methods of analysis, expected outcomes and risks. Third, the relevance of application of methods of analysis throughout a policy lifecycle is explained in Chapter 3 (Results) by exploring the role of each method reviewed, with a focus on the value added by the use of a method to support decision making.

Use of methods of analysis suggested as adequate for the purpose of producing information necessary for qualitative decision making during each step of decision making is repeated several times throughout a policy lifecycle. Therefore, a detailed review of each method follows the overall explanation about the place and role of a method in each decision making step.

Overview of the methods of analysis begins with linear regression and progresses with multi-criteria decision analysis methods (Analytical Hierarchy Process and TOPSIS), *Hugs, Carrots and Sticks* approach, as well as decision tree method, to finalise this chapter with an insight into the Climate Policy Integration approach to analysing interactions of energy and climate policy and evaluating the level of priority of climate policy goals over other policy goals.

Thus, the structure of the work can be summarised in a following way:

1) Cluster 1: Policy Inception:
    - Step 1: Establishing current situation;
    - Step 2: Defining desired result;
2) Cluster 2: Initial Decision making:
    - Step 3: Identifying policies that can lead to the defined result;
    - Step 4: Consulting existing pool of knowledge and information on best policies to reach the desired result;
    - Step 5: Deciding about policies;
3) Cluster 3: Policy Implementation and Monitoring:
    - Step 6: Implementing policies;
    - Step 7: Measuring the impact of policies on initial situation and progress towards the defined desired result;
4) Cluster 4: Policy Review for Decision Making:
    - Step 8: Establishing situation after policies are implemented;
    - Step 9: Assessing the results (deployment of RES and increase in energy efficiency);
    - Step 10: Continuing, amending, adding new, terminating existing policies.

Chapter 3 (Results) reviews methods and approaches to analysing policymaking relevant to energy and climate policies that lead to climate neutrality through sociotechnical transition with examples represented by case studies, which focus on highlighting the relevance of applying methods of analysis in decision making throughout the policy lifecycle.

To support the thread of relevance of decision making throughout policy lifecycle Section 3.6. of Chapter 3 focuses on integrating methods and approaches for analysis into an algorithm for policy analysis, decision-making and policymaking.

Finally, Chapter 4 (Conclusions) summarises key findings of the Thesis, focusing on the practical applicability of the generated algorithm in policymaking.

Sociotechnical transition to sustainable energy and climate system

This section explains the context and environment in which policies go through a full lifecycle, starting with understanding that *business as usual* energy model is not sustainable and ending with a situation where a policy has contributed to the transition to sustainable energy in a meaningful way and can be terminated. This section elaborates on the logic of sociotechnical transition, describing elements, factors, processes and interactions, to provide a broader picture and highlight areas where decision-making and choice of policies plays crucial role for transition to a more sustainable energy system to take place.

Sociotechnical refers to the interrelatedness of social and technical aspects of functioning of the society. Sociotechnical changes, including transition from one distinct situation to another distinct situation, in the context of climate and energy refer to behavioural and technological aspects of accepting climate goals as priority goals in all sectors of economy and making renewable energy a primary choice.

The current climate situation is demanding of policy makers: energy and climate policy goals require significant changes in the ways energy resources are obtained and delivered, energy is produced and consumed. Energy and climate policy is thus at the core of a broader set of changes that constitute sociotechnical transition from carbon intensive to carbon neutral economy. Adapting user behaviour and deploying renewable energy requires making decisions about putting in place the right mix of policies and policy instruments. Making policy choices requires ability to make decisions, and decision-making requires information and knowledge. Evidence-based policymaking requires analysis of information and, therefore, knowledge about methods of analysis of information. Information and evidence-based policymaking is even more important when achieving radical changes (in other words – a sociotechnical transition) is at stake.

Integration of climate policy goals and actions in sectoral policies is essential for achieving the overall climate goals. However, world is not ideal and competition among policy sectors and areas persists primarily because of limited financial resources, overall structure of economy, dominant contribution of certain sectors of economy to the national GDP, employment structure, and other factors. Making decisions about energy and climate policies under constraint leads to a situation when decisions are often generated *ad hoc*, based on insufficient evidence and analysis, skipping relevant steps in the process of decision making. This happens due to several issues: time constraint, lack of or insufficient information, lack of or insufficient analysis, lack of policy priorities, political context (e.g. how the government functions politically), as well as economic and social aspects, or a combination of aspects.

Fig.1 illustrates elements, processes and aspects, which form the basis of the overall context of sociotechnical transition and serves as a basic structure where decision making plays its role throughout policy lifecycle. Variables involved in the scheme are attributed to three groups: elements, processes and aspects. Elements include renewable energy sources, energy efficiency, policy instruments, energy users and policies. Processes include policy areas, implication for policymaking, energy users' behaviour, policies affecting energy users and producers, mutual feedback loop (between energy users / producers and policymaking), and aspects influencing the elements. Aspects include climate and environment, economic, technological, and social aspects, which play a second most important role in each stage of transition after environmental and climate aspects. Environmental and climate aspects are horizontal aspects that affect all elements and all processes while building combinations with economic, technological, and social aspects.

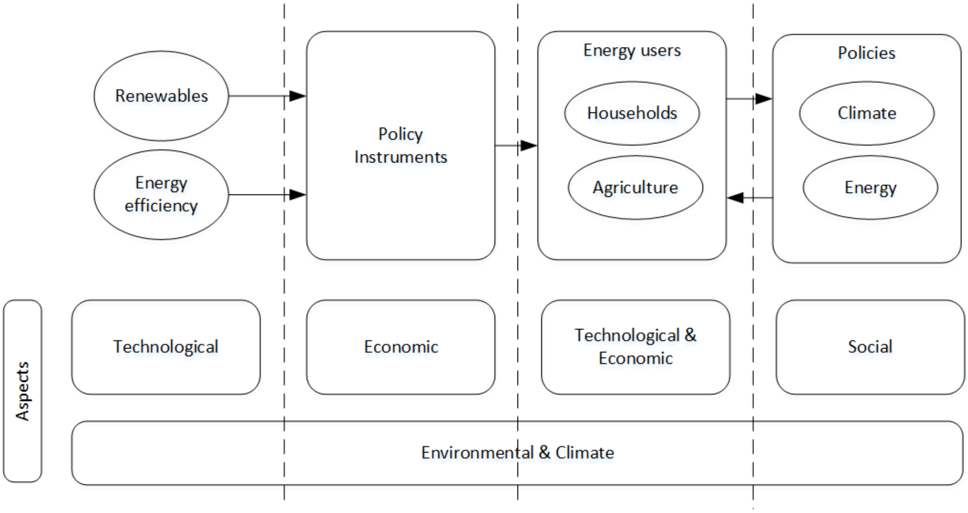

Fig. 1. Elements, processes, and aspects of transition to sustainable energy.
(Author's own illustration.)

Achieving climate goals is closely related to the way society functions, including the use of technology for a broad variety of tasks. Certain aspects of life that constitute the "regime" of the sociotechnical system have significant impact on climate and environment. At times, this impact is so significant that changes in the sociotechnical system are required to sustain environment and avoid deterioration of climate conditions. Greenhouse gas (GHG) emissions are admittedly the cause of climate change and climate crisis. Energy, transport, and agriculture sectors are the biggest contributors to GHG emissions. Thus, the way society produces, delivers, and consumes energy and [agricultural] goods, has a direct impact on factors that influence climate situation. Attitudes and actual behaviour of individuals and groups of individuals, also commercial enterprises and state institutions including the choice and use of technology, can either prevent or mitigate, or, to the contrary, contribute to and facilitate climate change.

This Thesis provides an insight into obstacles to and opportunities of experiencing a successful transition to sustainable energy. It elaborates in detail on the steps and stages of policy lifecycle highlighting the most critical moments in decision making and making policy choices, implementing policies and using monitoring and a comprehensive policy review to ensure that factors hindering transition to sustainable energy are prevented or minimised and factors facilitating such transition are amplified.

1. Literature review

1.1.Sociotechnical transition and other key concepts

Sociotechnical transition: context, logic, and role

For decision making to meet the necessary quality it is essential to understand the overall context of changes required reach the set climate policy goals. Prevention and mitigation of climate change require change of the mainstream technology and behaviour or ways technology is used. In other words – change of "regime" of sociotechnical system or sociotechnical transition is needed to reach climate goals. Processes, trends and changes in society influence the regime of the sociotechnical system. Processes, trends and changes in society, in turn, are influenced by "landscape" – factors such as climate change, energy prices, prices of energy resources, public awareness of environmental, climate and energy issues (Geels et al. 2017). Such multi-level perspective (MLP) approach further implies that "niche developments" representing products, solutions and processes outside the mainstream that consumers adhere to are needed. This [gradual] "switching over" to new behaviour and new technological solutions creates trends in the landscape, which then put pressure on the existing socio-technical regime. For example, as adoption of "new" energy technologies and energy management solutions achieves broader diffusion the pressure on the traditional energy sector grows and sociotechnical transition takes place (Child and Breyer 2017; Rosenbloom and Meadowcroft 2014).

Sociotechnical transition (changes in sociotechnical regime) is not a static variable, a fixed situation: there is certain level of dynamism, and a transition can be categorised according to the scale of changes. Further, the scale of the sociotechnical transition depends on multiple factors, and it serves as a basis for the typology of sociotechnical transition. Edomah et al. distinguish between interim, deliberate and transformative transition (Edomah, Bazilian, and Sovacool 2020) largely depending on the temporary or permanent nature of changes [x]. Such typology is in essence related to the scale of change in behaviour and rate of adoption of innovations or [new] technological solutions (Rogers 1962, 1995). This approach has rather close similarity with the way deployment of technologies is associated with levelized cost of electricity (LCOE) (Bosch, Staffell, and Hawkes 2019; Hdidouan and Staffell 2017; Timilsina 2020) and learning curve of power generation technologies (Azevedo et al. 2013; Wiesenthal et al. 2012).

On one hand, sociotechnical transition is descriptive of changes that take place in society regardless of who, why and how takes decisions pertaining to policies, regulation, norms, behaviour, choices, changes ranging from stagnation to fundamental. On the other hand, sociotechnical transition can provide an insight into what has to be done to initiate and facilitate changes that are targeted and necessary. From this perspective the ultimate goal of sociotechnical transition is to achieve transformative changes that are intentional and associated with benefits to the involved actors (Edomah, Bazilian, and Sovacool 2020), stemming from supporting regulatory environment aimed at not only achieving transformative changes, but also at retaining the changes achieved through complex interaction leading to invention and reproduction of new rules. Acceptance and retention of new rules and / or institutions is essential to qualify the changes in the sociotechnical regime and landscape as a trend or mainstream (Geels 2002; Geels et al. 2016).

The author of this thesis builds on existing body of knowledge and overlays existing approaches to explaining the stages of sociotechnical transition, technology learning curves, adoption of innovation, the logic behind support to energy technologies, the role of levelized cost of electricity, actors involved in transition processes, and how policies, policy instruments and activities come into play over the policy lifecycle to ensure transformative changes in the existing sociotechnical system. Interaction of the many elements is illustrated in Fig.1.2.

Sociotechnical transition represents a set of complex interactions. Decision-making and policymaking are essential elements of sociotechnical transition as they can be both part of barriers and part of solution and driver of transition. It is important to be able to identify policy intervention points and scenarios or pathways (Kanger, Sovacool, and Noorkõiv 2020) for development as once pursued, certain scenarios or pathways may be difficult to transform as they may lack elasticity and require time to adjust.

Transition pathways may also be reflective of the prevailing overall attitude of decision-makers and policymakers towards changes triggered by both endogenous and exogenous factors. Depending on the landscape and combination of factors the type of pathway can be of "substitution, transformation, reconfiguration or de-alignment and re-alignment". This is consistent with the assumption that there is a permanent dynamic interaction between actors and stakeholders that involves "agency, conflict and struggle" and is associated with aspirations and goals of actors that have various weight and influence (Geels et al. 2016), some being dominant and others non-dominant.

Function of actors stems from being in a dominant or non-dominant role, thus being involved in reproduction and change of rules and institutions (in case of dominant actors) [..] or, in case of non-dominant actors, adhere or not adhere to existing or new rules and institutions, recognize or not recognize institutions relevant for the processes to take place. To achieve energy and climate goals decision making and choices of both dominant and non-dominant actors is relevant as any actor, be it dominant or non-dominant, can play a role of a neutral participant, active facilitator or burdensome denier.

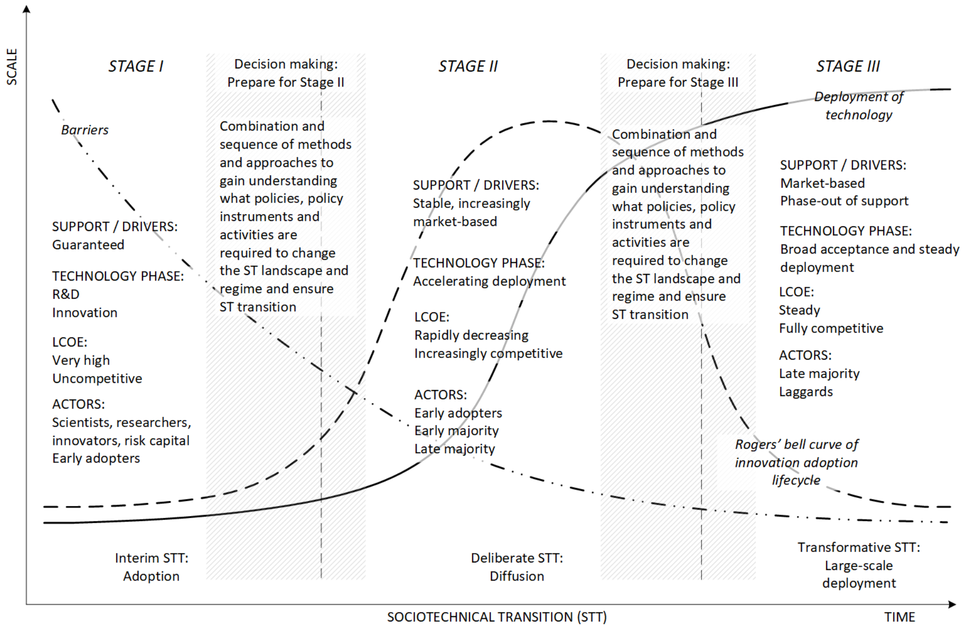

Fig. 1.2. Policy lifecycle: sociotechnical transition, learning curve, adoption of innovation, and RES support logic. (Author's own illustration)

Although all actors belong to a category of adopters (of behaviour and innovation that leads to sociotechnical transition), dominant actors are usually the trendsetters either through being decision makers (and therefore dominant actors) or opinion leaders and early adopters that possess the ability to trigger changes that facilitate sociotechnical transition typical to transition from an interim to a deliberate type of transition essential for stimulating change during the early stages of diffusion of innovative technology (Rogers 1962, 1995).

Non-dominant actors usually become the primary targets of adopted policies. In fact, policies are often adopted to influence behaviour and technology (innovation) choices of non-dominant actors, which is consistent with Gardner and Stern's and Ophuls' approach to influencing energy user's behaviour explained in Section 1.2. (The role of energy user) and illustrated in Fig. 1.4: policy instruments are applied for as long as necessary to amend energy user's behaviour to align it with action that contributes with positive impact on climate and environment. Non-dominant actors usually tend to be at the receiving end of coercive measures (policies designated as *sticks*) as because of the individual and collective social roles influencing innovation-decision (Rogers 1995) it is not enough to apply only *hugs and carrots* as *sticks* are also needed to help adopt decisions contributing to diffusion of innovation (which includes both technological advancement as well as behavioural changes).

Also, the dynamism of interaction can have persistent or transformative nature, the former describing processes and interactions that are characteristic to maintaining status quo or leading to changes in a sociotechnical regime that have little or no impact on transition, and the latter describing processes / interactions that lead to changes in a sociotechnical regime that are characteristic to a next stage of sociotechnical transition or to a transition or intermediary stage between Stages I, II or III (see Fig. 1.2). The need to analyse situation, make decisions and adopt policies that would lead to criteria characteristic to the next stage of transition is probably the only way to formally identify this intermediary stage.

It should also be taken into account that processes of innovation, development and deployment of technology take place permanently and there is no clear-cut border between stages of transition. Cyclical factors, such as energy production support framework, or support to specific types of technology, contribute to technology deployment and change of behaviour early in a given stage, but are typical to transition from Stage I to Stage II or change from interim to deliberate to transformative transition and is consistent with innovation adoption lifecycle and the dynamic of progress from research and development activities to full market saturation (Rogers 1995).

The significance and the role of applying an algorithm of decision making – choosing optimal research methods, coming to understanding of what policies would work best – which would ensure that optimal (rather than suboptimal) result is achieved is illustrated in Fig. 1.3, which further details the interactions first highlighted in Fig.1 (Elements, processes, and aspects of sociotechnical transition) and Fig. 1.2 (Sociotechnical transition, learning curve, adoption of innovation, and RES support logic).

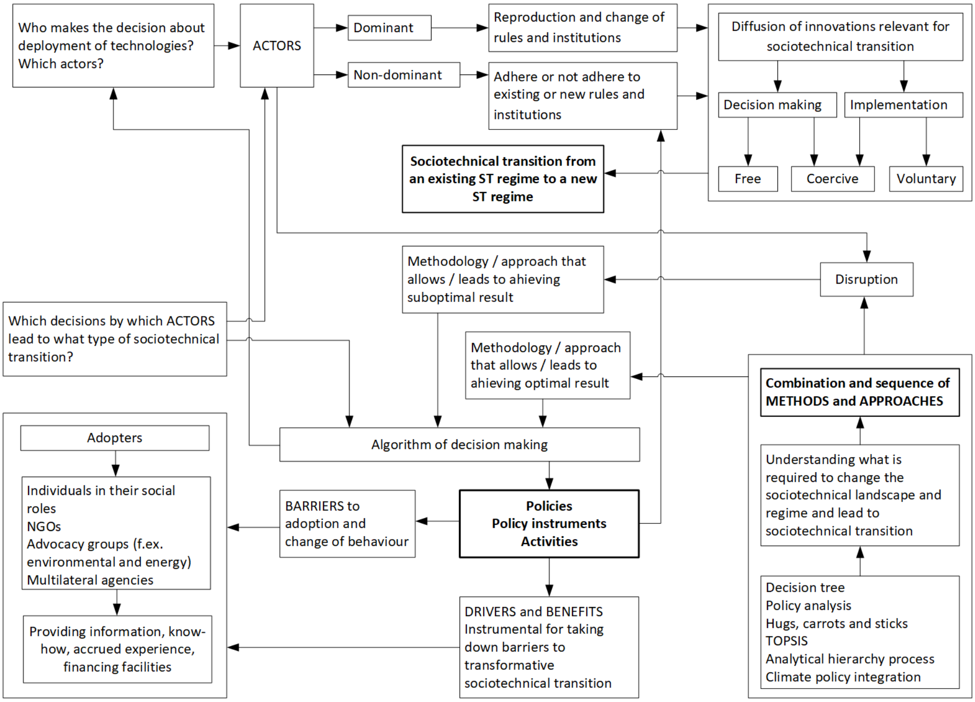

Fig. 1.3. Interaction of elements and processes that lead to sociotechnical transition. (Author's own illustration)

The essence of sociotechnical transition can probably be expressed as getting from an existing sociotechnical regime (X_1) to a new sociotechnical regime (X_2) through using policy mix (Y). From this perspective it is relevant what type of policies are adopted and in what manner they are implemented. There are several relevant questions pertaining to the choice of policies and policy mix. What type of policy – hugs, carrots, or sticks – dominates and why? Is there a good balance between the three types of policies? Are there enough sticks to ensure adoption of new patterns of climate-friendly behaviour? Can hugs and carrots alone pull off the desired change or is it enough to have coercive measures (sticks) (Aboltins et al. 2020; Katre and Tozzi 2019)? What is the role of different actors in decision making? How does the “supply side” and the “receiving side” of decision-making function, and what factors influence what interactions?

When it comes to climate and energy, sociotechnical transition is about long-term changes in the way society in general and individuals produce and use energy resources and energy. Ideally, sociotechnical transition is expressed through fundamental and long-lasting changes in favour of climate neutrality. However, energy transition can take various forms depending on the actions of actors involved in a transition, actual action can depend on beliefs, knowledge and willingness to act, internal and external barriers and complexity of formal processes relevant to ensuring changes. Parameters of these variables may mean that energy transition is interim, deliberate or transformative (Edomah, Bazilian, and Sovacool 2020). Policy or, in other words, environment in which transition takes place is also an element of the bigger picture of sociotechnical transition.

1.2.Barriers, policies and policy instruments

Sustainable energy means sustainable production and consumption of energy. A significant part of research and argumentation in this Thesis focuses on decision making and policymaking related to renewable energy and energy efficiency. In the bigger scheme of why and how energy is produced and consumed, energy user plays a crucial role. Energy user is one of the key elements in the equation leading to sociotechnical transition to climate neutrality or energy transition, if put in simpler words.

Ideological justification of sociotechnical transition is found in the concept that the way individuals and society as a whole use natural resources in general and more specifically energy, influences natural processes and triggers new processes. The new processes result in imbalances in the natural lifecycle of resources and components that ensure sustainable existence of ecosystems. Extraction and use of fossil fuels for the production of energy, chemical components and as transport fuel impacts atmospheric and terrestrial processes, which increase the proportion of carbon dioxide and lead to the rise of temperature of the atmosphere and of the water in the global ocean. Put simply, energy users’ behaviour can trigger, enhance, or hinder climate change (United Nations 1992b). This section briefly reviews the existing body of knowledge about the role of energy user, barriers to broader deployment of renewable energy technologies and implementation of energy efficiency measures as well as policies to tackle the above-mentioned issues.

Current global and regional climate strategies like the Paris Agreement (an international treaty) and the European Green Deal (a regional strategy) represent a translation of the essence of the knowledge and information accumulated about environment, climate, natural and anthropogenous changes in the Earth's climate. The two aforementioned documents are supported by a variety of targeted sectoral strategies, policy documents and treaties (f.ex., *Bioeconomy strategy*, *Climate Law*, *Biogas Strategy*, *Methane* Strategy). All these sources aim at stopping, preventing, reversing or mitigating the causes and effects of climate change. Transition from the use of fossil to the use renewable energy resources and technologies, as well as making effort to limit or optimise energy consumption, is key to tackling climate change and its effects.

There is a wealth of literature on what are the main causes of failure of policies introduced by policymakers with the goal of improving use of renewables in energy production and optimising energy consumption. Use of natural resources, including energy resources, to make the best out of the whole lifecycle of these resources, which would correspond the principles of bioeconomy and circular economy, has also been studied a lot. This section provides an overview of literature on the role of energy user, policies and barriers to effective implementation of policies aimed at achieving sustainable energy system that respects climate goals and functions according to the principles of circular economy and bioeconomy.

1.2.1. The role of energy user

Renewables and energy efficiency is an inalienable part of sociotechnical transition. As illustrated in Fig.1, sociotechnical transition is the very framework for the change of processes, values, behaviour, and technologies, in which certain role has been prescribed to renewables and energy efficiency, and decision making and policy instruments. Rather than being only a part of the scheme in Fig.1, sociotechnical transition itself encompasses all elements and processes represented in Fig.1.

Sociotechnical transition to climate neutrality is directly related to the use of energy and energy user, as energy does not use itself – it is produced and used by somebody, something and for certain reason. Thus, energy user is at the centre of past, current, and future changes related to climate. To achieve changes in behaviour, energy user has to be somehow influenced. Influence on energy user can be characterised as individual activity or a cluster of activities that can change energy user's energy consumption pattern. For example, decreasing energy consumption and becoming more energy efficient, or choosing renewable energy over fossil fuels. It must be noted that there is difference between an individual as energy user and society as a collective energy user. An individual adopts new technologies and patterns of behaviour while for the changes affecting majority of society on mass scale a set of factors that essentially characterise sociotechnical transition needs to be in place (Aboltins and Blumberga 2019). Energy users' behaviour has perhaps been underestimated in decision making related to changing the energy system in favour of renewable and more sustainable energy resources and technologies as well as in favour of energy efficiency (in a very broad understanding).

In essence, all major changes in the energy system centre around energy users' behaviour. Gardner and Stern, who represent a solid body of analysis and knowledge in their own right, in their analysis of human attitude and behavioural change refer to the studies by William Ophuls concluding that one of the bigger problems has always been possibility to coordinate behaviour of individuals for a common good (i.e., environment and climate) and that socially responsible behaviour of individuals can be stimulated by very few simple methods. These methods have been identified over the course of time: impact on energy user is facilitated by factors like information, education, research, innovation, deterrence, mandatory mechanisms, and introduction of inconveniences (Gardner and Stern 2002). Four kinds of solutions can be identified that allow stimulating socially responsible behaviour [vis-à-vis climate and environment] of an individual: 1) use of laws and regulations; 2) education programmes aimed at changing attitude and promoting socially responsible behaviour by providing information; 3) employing non-governmental processes to facilitate socially responsible behaviour (acknowledged to work well within communities and smaller social groups); and 4) use of arguments of moral, religious and ethical nature to achieve individual's socially desirable behaviour (Ophuls 1973). A synthesis of Gardner and Stern's and Ophuls' approach to influencing energy user with the goal to change behaviour is illustrated in Fig. 1.4.

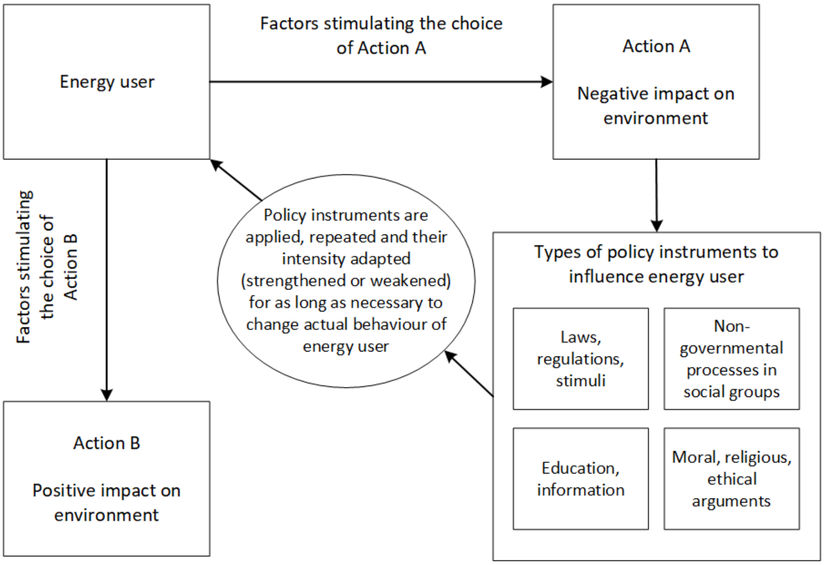

Fig. 1.4. Ways and means of influencing energy user's behaviour.
(Author's own illustration.)

Individuals cannot always act in a way, which reflects their attitude and values. For example, let us assume that someone wants to decrease expenses for the energy used, but this individual lacks information and knowledge about how much energy he or she may save by insulating the building or installing heaters or electrical appliances with higher energy efficiency. This individual may lack financial resources or motivation and willingness to replace an existing well-functioning heating system for the sake of environmental and climate goals, and use the resources for other useful and current purposes. It may also be that the person does not trust builders, or the premises are rented and the individual has no right to make decisions about any significant changes in the relevant infrastructure of the premises, be it a house or an apartment (Abreu, Oliveira, and Lopes 2017). In other words, the more barriers of exogenous character (Aboltins and Blumberga 2019), the less impact on actual action there is going to be despite individual's strong beliefs in and overly positive attitude towards energy saving.

Studies on technology acceptance also speak of multiple factors influencing individual's decision to act or not to act. Just as perceived cost of advanced technology that can potentially save money on top of certain elements of convenience influences behavioural intention, the perceived cost factor can influence energy user's actual behaviour regarding choice in favour of renewable energy or energy efficiency (Aboltins and Blumberga 2018; Liddell 2015; Paetz, Dütschke, and Fichtner 2012). Similarly, present bias can also prevent individuals from investing in energy efficiency (Fuerst and Singh 2018; Werthschulte and Löschel 2021).

Gardner and Stern also note that positive attitude towards energy efficiency may result in action that is easy to implement and does not necessarily require big investment (perceived ease of use in technology acceptance studies (Masukujjaman et al. 2021; Shuhaiber and Mashal 2019), like lowering the maximum temperature of a thermoregulator of a heating device. However, the more complex actions are required and the bigger the potential investment, the weaker the correlation between attitude and action (Gardner and Stern 2002; Liebe and Dobers 2019; Rutherford and Coutard 2014). In this context one could point towards analysis by Rosenow, which points to findings that in the United Kingdom the change of behaviour related to energy efficiency measures could ensure about 6% better energy efficiency in households by 2035 compared with 2015 (Rosenow, Kern, and Rogge 2018). In other words, change of behaviour has significant potential in improving energy efficiency in household sector. Therefore, one of the central questions is how to achieve, enforce or stimulate behavioural changes of an energy user.

Studies on behaviour and attitude towards environment (and indeed climate, which is a broader notion and encompasses environment) indicate that although *the right attitude* stimulates action aimed at solving environmental issues, attitude serves only as an indicator that action is just going to follow, and it is going to happen only under certain circumstances. Technology acceptance studies show that factors such as perceived ease of use, perceived costs and perceived usefulness influence attitude towards accepting something new – be it technology or practice, and especially if it requires change of behaviour (Hubert et al. 2018; Nikghadam Hojjati and Khodakarami 2016; Shuhaiber and Mashal 2019). This is typical to fragile or interim sociotechnical transitions as the sociotechnical system or regime lacks elements that would *cement* results of *ad hoc* policies (Geels et al. 2016) and spontaneous and short-lived user behaviour in favour of the achieving climate and environmental goals.

When a persistent barrier is taken down, the chance that attitude will be followed by action is bigger. This is characteristic of situations, where there is an external barrier to action that is often related to availability of financial resources (Aboltins et al. 2020). Better though, if sociotechnical changes evolve into a deliberate type of transition with a good balance of drivers (e.g., positive emotions and rational benefits) for behavioural and technological change stemming from attitudes and actions that are persistent despite regulatory shortcomings (Edomah, Bazilian, and Sovacool 2020). Ideally, the level of climate and environmental awareness is high and forms strong synergies with supportive regulatory measures and initiatives benefiting energy users' proactive engagement in instigating and implementing changes (Schot, Kanger, and Verbong 2016), and thus ensuring the transition has permanent effect and qualifies as transformative (Kanger, Sovacool, and Noorkõiv 2020).

In this context applying a variety of techniques of analysis and approaches play essential role in providing decision-makers and policymakers with information, knowledge, forecasts, recommendations about optimal solutions to barriers to climate-friendly sociotechnical transitions as well as risks that have the potential to disrupt implementation of policies aimed at facilitating sociotechnical transition. A ten-step algorithm of decision making is introduced in this Thesis, where several methods of analysis are presented. The author argues that the decision making steps and the methods used (and reviewed through case studies) are essential for the purpose of sound policymaking when it comes to broader use of renewables, enacting energy efficiency policy and reducing negative impacts on environment and climate in agriculture (European Commission 2020).

1.2.2. Renewable energy

Deployment of renewable energy happens in a complex set of variables some of which facilitate deployment and others hinder. Also, while the term "deployment" seems to be more related to technical and technological aspects of introducing renewable energy technologies (Langer et al. 2018), some researchers have been referring to "disruption" as a more appropriate notion to characterise the complexity of change in the energy sector as technological innovation introduces radical changes in the energy system and the way society uses energy (Clayton M. Christensen 2005; Johnstone et al. 2017, 2020a). Johnstone and Kivimaa note that "disruption" is an important conceptual tool for analysing the ways in which socio-technical systems are changing in specific contexts (Johnstone and Kivimaa 2018a). Although there has been a debate about using the notion to describe the changes in the energy system, it is still worth mentioning it as it has gained attention as a good way to explain interactions between actors involved in the change of energy system.

Socio-technical transition is usually associated with technological advancement, a fundamental change of what can be done with innovative technologies. However, Johnstone and others argue that processes of socio-technical transition encompass a much broader spectrum of issues and also cover such dimensions of socio-technical transition as market structures, composition of actors and networks, division of ownership between actors, dominant forms of business models and market structures to name but a few. Thus, when looking at what is disrupted, why, and how, it is suggested that system change analysis covers the dimensions of transition that reach beyond merely technological change (Johnstone et al. 2017).

The complexity of precise predictions and evaluation of disruption stems from insufficient empirical clarity about when disruption is of technological character and when it is associated with changes in business model (Markides 2006). A debate on the character of the concept of disruption has been ongoing since mid-2000s (C.M. Christensen, Raynor, and McDonald 2015; Clayton M. Christensen 2005) associating the lack of empirical clarity about what "disruption" actually means with the expansion of the notion into other areas of social activity, like welfare and healthcare (C.M. Christensen et al. 2006). Johnstone and Kivimaa who have addressed the issue on numerous occasions (Johnstone et al. 2017, 2020b; Johnstone and Kivimaa 2018b, 2018a), have hailed the discussion on the theory of disruption, which has experienced new insights from this very expansion of disruption into new areas including but not limited to education, environmental sustainability, energy, mobility, welfare and regulation (Johnstone and Kivimaa 2018b).

When analysing aspects of energy system change, authors distinguish between seven groups of factors related to the deployment of renewable energy: 1) technology, 2) grid, 3) actors and networks, 4) market structures, 5) business models, 6) ownership, and 7) regulation (Johnstone and Kivimaa 2018a), which is at least partially a consequence of technological advancement and disruptive innovation.

Different actors involved in socio-technical transition possess different power to influence processes. At the same time, any disruptive processes lead to changes in, sociologically speaking, the balance of power among the same actors. For example, changes transforming energy market leading to decreasing relevance of energy incumbents (usually – energy utilities) as well as dominant networks of actors and their functions. Disruption may relate to changes in business models, market structures and institutions. Technology advancement and regulatory changes influence how centralised energy producers or service providers operate: large dominant players (like incumbent energy enterprises referred to above) may need to adjust to new market conditions through, first, unbundling an integrated monopoly and, second, bundling their main services with new auxiliary services that are in demand on the market as energy consumers are granted bigger (and actual) freedom to choose their service provider (Dijk, Wells, and Kemp 2016). It is important to note that fundamental changes, such as energy market liberalisation and unbundling of monopolies, can happen only if monopoly-based energy systems have been properly analysed and policymakers have admitted that decision making is required to change the situation.

For example, energy incumbents may need to introduce new aspects to their business model by starting to offer solar photovoltaic technologies to their clients as new competitors are luring the clients away from the incumbents who need to adapt to the new market conditions. EU natural gas and electricity sector ownership unbundling is an example of how massive the regulatory disruption can be in terms of the broad scale of influences from targeted changes in favour of consumer-benefitting transparency and ownership structure of stakeholders in the energy sector. Abolition of subsidy schemes for energy producers, that use older energy technologies incurs disruption in terms of market environment (Fuenfschilling and Truffer

2014) as well as technological change: new conditions require new solutions and stakeholders need to adapt (Kivimaa and Kern 2016) both their business structure and behaviour.

Johnstone and others speak of four dimensions of disruption in socio-economic transitions – technology, ownership and actors, markets and business models, and regulation (Johnstone et al. 2020a). Yaqoot and others have carried out a study of literature on barriers to the dissemination of decentralised (distributed) energy production and they identify five groups of barriers: technical, economic, institutional, socio-cultural and environmental barriers (Yaqoot, Diwan, and Kandpal 2016). The case study on the factors influencing adoption of various energy technologies by households in this Thesis follows a similar logic by referring to five criteria (five groups of criteria) – economic, technical, environmental, political, and social.

When it comes to deployment of energy technologies by households, choosing from among alternatives is influenced by both internal and external factors. Therefore, decision making throughout the policy lifecycle is essential to nudge households towards making their choices in favour of renewable energy solutions. Labanca and Bertoldi speak of the relevance of policy makers being able to propose policy instruments that help bridging the so-called intention-action gap. A positive attitude towards environment through the use of renewable energy does not necessarily translate into an active choice (Labanca and Bertoldi 2018a). Ingold and others have similar observations pointing out the relevance of balance in what investment is expected of households and what is on the incentive side of energy transition (Ingold, Stadelmann-Steffen, and Kammermann 2019a).

1.2.3. Energy portfolio

The realm of energy is, in broad terms, about producing, supplying and using energy resources or energy. Primary energy resources are about choosing certain types of energy resources "to get electricity or heating or cooling". Choice of resources is closely related to what is that one wants "to get out of energy resources" and the most effective way to do it or choice of energy production technology. Choice of energy production technology has always been inherently subject to considerations about the levelized cost of energy / electricity (LCOE): producing energy for the least costs has been the driving force behind development of energy markets. Although climate awareness is increasingly growing in significance when it comes to technology choices, the simple question "How much does it cost?" functions as a reality check. Thus, there are both behavioural and technical aspects that influence interaction between elements of sociotechnical transition. Ability to understand interactions between these aspects and elements is essential for decision making when it comes to defining policies aimed at ensuring that future energy portfolio is more sustainable than at present.

An encouraging factor is that over the last ten years, since circa 2009, the LCOE figures of climate-friendly electricity production technologies has significantly decreased (Lazard 2018), causing chain reaction resulting in high intensity of deployment of such technologies as onshore and offshore wind and solar PV systems (International Energy Agency 2020). This has happened due to growing cumulative capacity of deployed renewable energy technologies, accrued information, aggregated knowledge and experience, technological innovation as well as slowly but steadily increasing social acceptance of renewable energy technologies (Bauwens and Devine-Wright 2018; Liebe and Dobers 2019).

When looking at energy portfolios from a future perspective, renewable energy technologies are viewed as the main and often even as the only solution to generating energy, be it electricity, or heat, or cooling. Wind energy is considered one of the most perspective technologies for increasing the share of renewable energy in electricity production. Furthermore, it is viewed as an important technology for synergies creating clusters of renewable energy technologies, such as combinations of wind power and hydrogen production. When modelling the transition of energy system to using climate-neutral and low-carbon technologies, different development scenarios (International Energy Agency 2020) reduction of costs associated with deploying wind energy technologies and the ability of these technologies to compete with the so called conventional energy technologies, including those already built and operational (Lazard 2018), are emphasised. Because of these factors and also owing to the RES support policies, use of wind energy technologies has experienced rapid growth in all energy markets, including Europe (BP 2020).

In the context of sociotechnical transition, it does have significance what are the costs of transition to carbon neutral energy production and consumption. Desired results can be achieved in an optimal way, but they can also be achieved paying a hefty price. It has not been seldom that social acceptance of renewable energy depends on the perceived expensiveness of RES rather than on ideological considerations. The fact that RES support schemes have been in place to achieve progress in RES deployment over the last 10-15 years in most countries in Europe and elsewhere in the World has contributed to such views.

It is argued that wind energy has become one of the cheapest and most competitive RES technologies, but there is still significant difference in the cost of electricity produced in wind farms onshore and offshore. While setting up wind energy infrastructure on land along with solar PV technologies without state support (e.g. subsidies, compensation of capital expenses, feed-in tariff, feed-in premium, other), it is able to compete with such widespread technologies as combined cycle gas turbines, installing offshore wind energy technologies cannot compete in all energy markets on free market grounds. Costs of offshore wind energy can be as much as two times higher than the costs of onshore wind energy (International Renewable Energy Agency 2020b, 2020a; Lazard 2018). Thus, while wind energy, both onshore and offshore, will help to achieve climate goals and will definitely contribute to sociotechnical transition, climate goals can be achieved with less cost: offshore wind can be more productive, but costs more. If wind energy infrastructure on land can be considered an optimal solution, then wind infrastructure off the shore is a suboptimal solution.

1.2.4. Energy efficiency

Decision making about policies for energy efficiency should in theory not be any harder than making decisions about other directions of energy policy. However, energy efficiency policies have often failed to achieve the desired results. There may be many reasons why policies fail. Ideally, preference should be given to policy instruments that are adapted to the local market conditions, as such *localised* policy instruments will have higher possibility to tackle existing barriers and to strengthen market forces, which contribute to reaching the result defined at early stages of decision making and policymaking (Rosenow, Kern, and Rogge 2018). Therefore, in this context it is essential to be able to identify and assess factors and elements facilitating or restraining the effectiveness of interaction of energy efficiency policy instruments. Such factors and elements can be grouped in three big categories; 1) ones associated with how a policy instrument is managed, 2) ones related to the scope and time designated to the implementation of particular policy instruments, and 3) ones associated with simultaneous implementation of energy efficiency policy instruments.

Some policy instruments have a rather broad spectrum of application and can contribute to a sizable growth of deployment of energy technologies. For example, obligation schemes, such as mandatory purchase of electricity produced from renewables, represent a widespread policy instrument. They are considered to be a comfortable solution to tackling energy efficiency issues. Nevertheless, obligation schemes also have their limitations and risks. The capacity of energy and utility companies depends on market conditions, their place on the market, and other factors, as they vary in terms of size and field of work. It is no secret either that obligation schemes have opposition (Moser 2017; Rosenow et al. 2017; Rosenow and Bayer 2017; UPRC 2016).

The debate about interest of companies from the industrial sector to invest in energy efficiency is often narrowed down to keeping a balance between requirements and incentives and combining bottom-up and top-down approaches (Gardner and Stern 2002). Such a setting of energy efficiency policies, which facilitate reaching energy efficiency goals in a cost-effective way (Rosenberg et al. 2012) with a following debate on the role, which financial stimuli play (Schlomann, Rohde, and Becker 2012) in energy efficiency investment activity (Barbara Schlomann, Matthias Reuter, Sohaib Tariq 2015) contributes to the overall energy efficiency. To summarize this debate – direct financial stimuli tend to increase activity in a short-term perspective while decreasing activity related to investing in energy efficiency in the longer term (Bordigoni et al. 2016).

Conditions of the local market should be analysed prior to making a decision about implementing an obligation scheme for utilities as they can have their upsides and downsides, although obligation schemes for utility companies are considered a relatively easy way to contribute to end user energy efficiency (Bertoldi et al. 2010). Upsides include, but are not necessarily limited to such conditions as: 1) existing cooperation with end users of energy, which represent often a sizable go-to market, existing billing systems and data about energy consumption, 2) availability of own financing, given the company has sound financial management, 3) recognisability to consumers – given the reputation of the company is good), 4) already existing portfolio of services and network of delivery of services, subject to restrictions of geographical licensing, 5) forecasting clients' energy consumption and demand compensation as a responsibility. There are also downsides – potentially low level of coincidence of commercial interests of companies and interests of society – potentially little interest to increase own costs and the cost of services or products or to decrease sales of products and services. International Energy Agency, which has contributed to the public pool of knowledge through a freely available analysis about energy efficiency policy instruments, with decision-makers as primary target audience, underlines that tailor-made analysis is necessary for each particular situation, but elements and factors that are in common allow making broadly applicable conclusions and producing suggestions about applicability of specific policy instruments (International Energy Agency 2017).

Seven groups of policy instruments are identified by (Cialani and Perman 2014): they range from providing education and information about the significance of energy efficiency to a variety of target groups to specific legally and financially binding solutions amounting to compulsory energy efficiency measures (see Table 1.1.).

Table 1.1.

Energy efficiency policy instruments. (Adapted from Cialani and Perman (Cialani and Perman 2014), and IEA (International Energy Agency 2017))

Category	Examples of instruments
Regulatory environment	Targets of energy consumption reduction Energy efficiency investment obligation schemes for private enterprises Building codes Minimal energy consumption standards Monitoring of energy consumption and compulsory energy audits
Commercialisation and capacity building	Establishment of energy service companies (ESCO) Development of energy efficiency sector
Facilitation, information, and market transformation	Labelling (certification) of energy consumption of buildings, vehicles, and devices Public information campaigns Incorporation of energy efficiency topics into school curricula Dissemination of knowledge and education programmes Labelling of electric devices Informative bills and smart metering of energy consumption
Financial instruments	Subsidies for energy efficiency Mandatory procurement for energy saving Fiscal instruments (tax reductions, tax rebates) Grants for investment in energy efficiency Loans (subsidised or on beneficial terms and conditions) Direct purchasing / procurement of energy efficient goods and services Penalties for non-compliance with obligations or standards Circular funds for investment in energy efficiency Differentiated tariffs to discourage higher consumption
Technical support	Energy audits Assistance and tools for project preparation Development and demonstration of practical application of energy efficiency technologies
Cooperation instruments	Purchase of goods and services through wholesale Energy efficiency in public procurement, procurement of energy efficient technologies Buy-back of used goods and recycling schemes
Voluntary agreements	Voluntary agreements about reduction of energy consumption and/or investment in energy efficiency
Obligation schemes	Supplier / distributor obligation schemes Energy consumption reduction certificates (white certificates) Investment of income from selling CO_2 quotas in energy efficiency

There is a solid research basis that contributes to understanding of how to approach decision making and policymaking about energy efficiency, and how to turn energy users' attitudes positive towards energy efficiency in general and how to turn positive attitude into change of behaviour and actual action or, in other words, how to bridge the intention – action gap (Gardner and Stern 2002). In the case study on energy efficiency policy instruments a nine-step policy analysis approach (Hogwood and Gunn 1984) has been used in combination with decision tree method to find out whether correct sequence of decision making is essential for the success of energy efficiency policy. The case study on energy efficiency refers to sixteen modules of analysis to describe the causal relationships and mutual influences of different factors when making decisions about policy instruments aimed at improving energy efficiency through higher activity of various stakeholders and involvement of the relevant target groups.

Energy efficiency is an essential element of sociotechnical transition. One of the best ways to cut GHG emissions is to consume less energy as there is no need to produce [more] energy in a situation of decreasing or steady demand. Economic development and growing GDP might imply growing energy consumption, especially, if energy consumption per capita has been or still is low compared with developed economies, which have already achieved high welfare level and high living standards, where energy use per capita is also high (higher than in less economically developed countries).

Distinguishing between economic and normative stimuli and communication to enhance energy efficiency is another approach how to categorise energy efficiency policy instruments. Much of focus centres around a more detailed list of policy instruments, such as taxes associated with GHG emissions and energy consumption, investment by state authorities, technology standards, subsidies, deposit or compensation systems, tradable and non-tradable allowances, prohibition of use of certain products, voluntary agreements, and, last but not least – support to research and development (Blok et al. 2004). Other authors distinguish between seven groups of policy instruments ranging from education of a variety of target groups about the importance of energy efficiency to very targeted financially and legally binding solutions (Cialani and Perman 2014). This aggregated knowledge about what works and what does not work when it comes to choosing correct energy efficiency policies, is essential for decision making on future policies leading to energy efficiency targets.

1.2.5. Hugs, carrots and sticks

The *hugs, carrots and sticks* (HCS) approach is used rather widely to analyse, define and apply different policy instruments related to use of voluntary or coercive measures with the aim of bringing about changes in models of economic behaviour of individuals (Katre and Tozzi 2019). Behavioural change is achieved by us the HCS approach to induce learning experience (Marmefelt 2009). Coercion (Beilock 2000), persuasion (Kesting 2010), motivating measures (Rintamäki, Rikkonen, and Tapio 2016) as well as opportunity to avoid loss (Mahmoodi et al. 2018) have to be applied in just the right balance to achieve individual’s rational behaviour (Van Den Bergh, Ferrer-I-Carbonell, and Munda 2000).

Resting the success in achieving the needed result on only one policy instrument or using too general policy instruments, when it is essential to apply targeted measures, appears to be an incorrect approach to improving energy efficiency (EC DG Energy 2017; Gardner and Stern 2002). Literature on the effectiveness of energy efficiency policy instruments shows that policymakers and those representing executive branch should focus much more on applying multiple policy instruments simultaneously to maximise the required amplifying effect as individual policy instruments (often applied according to *ad hoc* principles) cannot deliver the expected result (Edmondson, Kern, and Rogge 2018; Rogge, Kern, and Howlett 2018; Rosenow, Kern, and Rogge 2018).

A variety of approaches to categorising barriers to energy efficiency and policy instruments to eliminate these barriers are used by researchers. Putting both barriers and policy instruments in certain categories should not be regarded as a limitation. Various categories can be introduced, but the real-world situations require that such policy instruments are identified and implemented, which are able to deal with the barriers best and regardless of categories. Categorising barriers and policy instruments just systematises available knowledge and can make the task of choosing the optimal policy measure less complex. Thus, in the context of *hugs, carrots and sticks*, categorising barriers and policy instruments can play crucial role of helping to identify the policy mix that serves the purpose of eliminating barriers to energy efficiency best, and it is useful to know some of the most frequently used approaches to systematising barriers as well as policy instruments (Bertoldi and Boza-Kiss 2017; International Energy Agency 2010; Johansson and Thollander 2018; Labanca and Bertoldi 2018a). Description of the methodology of analysis of energy efficiency policy is elaborated in detail in Chapter 2 of the Thesis.

1.2.6. Decision tree

As noted also above, literature analysis about energy efficiency policy instruments indicate that trying to reach the required result by applying one separate policy instrument is one of the most common shortcomings of policymaking and implementation (Gardner and Stern 2002), (EC DG Energy 2017) as is a too simplistic approach to picking policy measures (Cunningham et al. 2013) when being as specific as possible is essential to achieve the desired results effectively (Patrick Plötz and Tobias Fleiter 2012). Existing research points towards another important message to policymakers and the executive branch responsible for the implementation of policies, laws, and regulations – it is relevant, if and how and what policy instruments are being implemented at the same time to achieve the necessary synergies (Wiese, Larsen, and Pade 2017).

Literature study about factors that have key role in effective energy efficiency policy reveals that there are three such factors. Firstly, it is simultaneous implementation of multiple policy instruments. Secondly, it is the correct sequence of implementation of policy instruments if more than just one policy instrument is available and applied. Thirdly, it is coordination of policies and policy instruments when more than one policy instrument is implemented (Kern, Kivimaa, and Martiskainen 2017; Per Ivar Helgesen and Marit Sandbakk 2012; Rogge and Reichardt 2016). Relevance of these factors is elaborated in greater detail further in the Thesis through describing and explaining the function of each of the modules.

From the perspective of decision making it should be noted again that having only one policy instrument to improve energy efficiency will most likely be insufficient to achieve the desired results (Barbara Schlomann, Clemens Rohde, Wolfgang Eichhammer, Veit Bürger n.d.). Applying just one policy instrument at a time is likely to result in failure to achieve the results (Wiese, Larsen, and Pade 2017). Simultaneous implementation of several policy instruments can significantly increase the possibility of getting to the expected outcome in terms of improved energy efficiency (Robert Tromop, Viktor Badarek, Oleg Dzioubinski, Scott Foster, Stefanie Held 2015). It can also significantly influence a more widespread adoption of innovative technologies (Abeelen and Both 2012) and solutions that work in favour of climate change mitigation (Veugelers 2012) and efficient use of resources (Wilts and O'Brien 2019). Further, such an approach has the potential to contribute to social aspects through helping households with low income to participate in energy efficiency activities (Schleich 2019). It has also been argued, however, that certain combinations of simultaneously enacted policies can have weakening rather than strengthening influence (Wiese, Larsen, and Pade 2017).

Literature analysis shows that *carrot-type* activities aimed at triggering particular socially accepted or unaccepted behaviour or moral motivation might not be able to contribute enough to achieve the expected result (Nyborg 2003). *Stick-type* policy measures might be required to achieve a successful change of behaviour related to climate and environment such as, for example, waste disposal and circulation and waste management. Research indicates that there are certain types of measures, which are effective in achieving improved sorting of waste, recycling and collection results. Such measures include, but are not necessarily limited to weight-based waste tariff (Andersson and Stage 2018; Bel 2016), assigning specific monetary charges to desirable and undesirable environmental effects (Arvidsson and Stage 2012), reducing the number of waste collection times per month to increase pressure on households to recycle (Abbott, Nandeibam, and O'Shea 2011), introducing unit-based tariffs for waste along with accessibility of sorting and recycling infrastructure (Hage et al. 2018), introducing any kind of payment for waste disposal that motivates households to reduce their future bills for waste through sorting and recycling (Czajkowski, Hanley, and Nyborg 2017). The polluter pays principle can also achieve a lot: extended producer responsibility schemes facilitate implementation of "polluter pays" principle and consumers engage in sorting and recycling once producers of goods have to internalise costs associated with waste management (Leclerc and Badami 2020). At the same time, waste management based on frequency and volume has been found to be less effective than management of waste based on units and weight of waste (Dijkgraaf 2004).

Throughout the policy lifecycle decision making should be based on knowledge and evidence about the effectiveness of policy instruments and their ability to deal with barriers. A variety of existing barriers requires a variety of policy instruments to be chosen and applied. Once there are multiple policy instruments involved, several things follow: 1) there is need to coordinate the implementation of multiple policies, 2) decision makers have to be able to identify policies that fit together in a mix (Rosenow, Kern, and Rogge 2017), and 3) decision makers need to understand what is the correct sequence of implementation of policies (Wiese, Larsen, and Pade 2017). Research shows that rational (as opposed to irrational) decision-making (Johansson and Thollander 2018) about combining policies is unlikely to take place in real-life situations (Cunningham et al. 2013). As a consequence, a random combination of policy instruments emerges through political processes and political decisions instead of getting to the result through an elaborate decision making process based on information, knowledge and evidence. However, awareness of this shortcoming can also be exploited in favour of creating a good and suitable policy mix (International Energy Agency 2010, 2017, 2018).

Analysis of potential impacts of policies and policy instruments must take place at the policy review stage in the policy lifecycle. Rosenow concludes that policy instruments of low complexity appear to be dominant, however emphasising that policy instruments characterised by low cost and low complexity are still important for successful implementation of more complex and protrusive policy instruments, related to measures such as deep renovation of multiapartment buildings, which is an issue for urban centres with older houses (Rosenow, Kern, and Rogge 2017).

Costs associated with energy efficiency influence the way decision makers think about policy instruments and overall approach to energy efficiency policy. In decision making, the choosing policy often narrows down to two scenarios – supporting investment in renovation of buildings with little focus on energy efficiency and afterwards spending too much energy and money, or investing reasonable and sufficient money to renovate buildings properly and according to energy efficiency standards and requirements and saving energy and money afterwards owing to higher energy efficiency rating of the renovated building stock (Pikas et al. 2015).

1.2.7. Climate policy integration

Environmental or climate policy integration represents an institutionalised recognition of sustainable and green thinking and practice, even if the driving force behind EPI / CPI is the need to achieve a situation when sectoral policies are developed in line with sustainability principles.

Climate policy integration (CPI) is defined as integration of activities aimed at mitigating climate change as well as adaptation activities in all policy making levels and stages in other policy sectors supplemented by inclusion of impact assessment of climate change mitigation and adaptation policies in the overall policy assessment, and commitment to reduce and prevent contradictions between climate policy and goals and policies and goals of other policy sectors. Stemming from this definition climate policy goals are ascribed higher priority in sectors that are not directly related to environmental policies. CPI should be reflected in overall strategic policy objectives as well as specific sectoral strategic and policy planning documents as well as among the defined policy outcomes (Mickwitz, Per; Aix, Francisco; Beck, Silke; Carss 2009).

Three variables are identified to explain the level of climate policy integration in other policies: 1) is there any functional interaction (conflict or synergy) between climate and other policy goals, 2) is there political commitment to prioritise climate goals over goals of other policies, and 3) does the institutional setup of policymaking reflect the priority of climate goals.

Sectoral policies are usually defined in strategic development and policy planning documents, which is the first step towards recognising the importance of climate goals or, vice versa – lack of climate policy aspects in policy documents is indicative of potential problems to achieve climate goals. Analysis of sectoral policies (be it *ex ante* assessment or periodic policy review) must assess whether a policy contains climate policy aspects – what policy goals are set, do they respect climate aspects, do specific policies and policy instruments foresee adherence to climate goals, and, if included, whether the principles of sound climate policy are actually implemented (Runhaar, Driessen, and Uittenbroek 2014).

Historically attempts to integrate environmental and climate issues into policies aimed at sustainable development can be referenced back to 1992 when the UN Committee on Environment and Development adopted Agenda 21 representing a plan of action to be taken globally, nationally and locally in every area in which there is a human impact on the environment (United Nations 1992a). The key idea of CPI is that policy planning should pursue the principle of climate policy integration (Adelle, Pallemaerts, and Chiavari 2009) instead of being viewed as detached from policies of the many sectors of the economy. Climate policy shall rather be looked at as a horizontal policy element represented in every sectoral policy (Andrew Jordan and Lenschow 2010a). However, the roots of climate policy integration come from the concept of sustainable development as it is this concept that requires and foresees putting environmental aspects of economic activity higher on the agenda of any sectoral policy (W. M. Lafferty and Hovden 2003).

Climate policy integration as an approach to policy planning has experienced strong interest and application. EU energy and climate policy is an example of this trend represented, for example, by Europe 2020 Strategy where climate change and energy is one of five main directions of action (European Commission 2010). Climate policy integration into other policy areas and synergy of policies with climate policy is critical for achieving optimal implementation and impact of policies on climate goals. Lack of synergy or competing interests prevent from achieving optimal implementation and impact (creating a situation of suboptimal solution), which has negative impact on reaching long-term and strategic goals of policies (Adelle, Pallemaerts, and Chiavari 2009).

Integration of climate issues in other sectors' policies relates to the output aspects of climate policy integration while the involvement of stakeholders from across the entire spectrum of sectors of the economy and recognition of interrelation of policies with climate policy goals pertains to the policy process aspects of CPI (Dupont, Claire; Oberthür 2012; Dupont 2011).

Jordan and Kivimaa argue that horizontal integration of climate policy works better than attempts to pursue the path of vertical control over the implementation of climate policy aspects in sectoral policies (Andrew Jordan and Lenschow 2010a; Kivimaa and Mickwitz 2009). Integration of climate policy in sectoral policies prevents climate and environmental issues from being neglected and sectoral policies potentially coming into conflict with climate policy goals.

Prior to Climate Policy Integration, Environmental Policy Integration (EPI) was the approach describing integration of environmental policy aspects into other policy areas. When debating indicators for measuring EPI Lafferty and Hovden distinguish between group of vertical and horizontal indicators, the former applying to how government sectors implemented EPI and the latter focusing on the ability of centrally administering integration of environmental policy aspects in sectoral policies and arguing that the vertical dimension of policy integration matters more and can achieve more as centralised attempts to dispatch environmental policy aspects across sectors might produce a broad spectrum of results depending on factors like the competence and place in the governance hierarchy of a particular administrative unit, or instruments chosen to implement environmental aspects of a policy (W. Lafferty, Hovden, and Lafferty 2010).

In the first decade of the 21st Century another trend took place where environmental policy integration was replaced, although temporarily, by the European Union's Sustainable Development Strategy. The development towards a new and more dynamic economy was used to argue that sustainable development and environmental policy can serve a greater good although sustainable development should be regarded as the umbrella policy. The Strategy did not refer to EPI *per se*, however, introduced a valuable approach of pushing for mainstreaming of principles of sustainable development be incorporated in all policies across the spectrum of economic activity (Mickwitz, Per; Aix, Francisco; Beck, Silke; Carss 2009).

When thinking about sustainability, decision making and policy definition and implementation, it is worth not forgetting the distinction between policy as an outcome and policy as a process (Nilsson and Persson 2003). Dupont elaborates on climate policy integration from the perspective of both policy process and policy output. Indicators associated with the policy process include internal and external stakeholders, which favour climate as a priority and recognise the presence of interaction between the objectives of sectoral policies and climate policy objectives. The success of climate policy integration in policy outcomes is measured by assessing the extent to which policy objectives of various sectors of economy conform with climate policy goals. Dupont operationalises the indicators according to a scale ranging from "very low" to "very high" level of integration of climate policy (Dupont 2015).

Presence of environmental policy goals in economic activity has often been influenced by challenging economic conditions. In the EU, the notion of prioritising the environment amidst many outstanding issues has been vague in the beginning and then gradually disappeared under increasing economic pressures during the global economic crisis of 2008 – 2009. However, situations vary, and EU member states have had varying success in integrating environmental policy in other sectoral policies. For example, Sweden is perceived as a country with progressive attitude towards nature as a value. Thus, climate policy integration in this Scandinavian welfare country has benefited from a long history of public support for strong environmental policy, therefore, it is easier to justify integration of principles of sustainable development into all levels of policy as a matter of an unalienable element in any policy.

Germany, which is often referred to as the engine of the European economy, sector-specific niches of high climate policy integration level have emerged either due to perceived problem pressure or due to the specifics of the local political system, which requires balancing different political interests often resulting in coalition governments and politics. Environmental policy in Germany has played an important role periodically projecting climate issues high on the policy agenda. While such periods may embed environmental measures or regulations in the practice of sector policies, the lack of an overall climate policy integration framework makes the emergence of such niches or sub-sectors vulnerable to downgrading or even reversal of policies, especially if representation of political parties in government coalitions shift away from forces that support environmental policy integration (Andrew Jordan and Lenschow 2010b).

Another aspect of successful CPI is agreement among stakeholders (policy makers, decision makers, experts) about defining climate and sustainability goals on par with the goals of sectoral policies, supported by a choice of policies (policy mix), which respects the set goals of sustainability. Precise definition of goals and adequate policy regime will ensure optimal integration of climate policy, while failure to do so will lead to suboptimal outcome (Rayner and Howlett 2017). In real world to a large extent the ability to come to agreement on climate goals across different sectors of economy rests on what is called political will, or even willingness to take some sort of leadership over climate issues, of stakeholders that are key to defining policies and policy goals (Candel and Biesbroek 2016; A. Jordan and Schout 2006). Governing processes in sectoral institutions may differ and this can have repercussions for attempting to integrate climate agenda in all relevant government institutions to equal extent (A. Jordan and Schout 2006). A centralised approach to coordinating climate policy integration across a spectrum of institutional structures might also require a special agency or task force to ensure that CPI actually takes place (Adger and Jordan 2009), as there may be risks that the only supporters of sustainable environmental and climate policy and practice are the institutions and agencies directly responsible for environmental and climate policies (Steurer 2008).

2. Methodology

This chapter describes the methodological approach of the thesis. The task of this chapter is to establish, what elements are essential for creating an algorithm of decision making that can ensure that no relevant energy and climate aspect is omitted in policymaking throughout a full policy lifecycle. First, elements of decision making steps are identified and described and, second, methods of analysing policies are identified and described with the purpose of explaining the role of each method in facilitating sound decision-making and policymaking.

Methodology of this thesis is built on the assumption that by subjecting policymaking relevant for sociotechnical transition to climate neutrality to following a certain algorithm of analysis and decision-making, a set of policies and policy instruments (policy mix) will be produced and implemented, which will ensure that climate goals will be achieved to their full extent across all relevant sectors of economy and renewables and energy efficiency in particular. In other words, following an algorithm comprising a set of elements, including methods of analysis and approaches, will result in optimal rather than suboptimal solutions for practical policymaking relevant to the sociotechnical transition and renewable energy and energy efficiency specifically, which would be representative of the climate and energy goals defined in the European Green Deal (European Commission 2019b).

In policy analysis, it is important to be aware that decisions are made, and policies are implemented in an inherently political context. In real world policymaking one can distinguish between two types of policy solutions – “ideal ideal” and “relative ideal” solution. “Ideal ideal” solution would mean making decisions with no constraint whatsoever and regardless of political context [.. re: John Rawls’ *veil of ignorance*]. “Relative ideal” solution means making decisions about policies under given circumstances that always have a set of constraints, which make policy analysis critically important as decisions about policies need to be justified, primarily but not exclusively because of the competition for limited financial resources (Hogwood and Gunn 1984). Problem situations may need solution and there may be different levels of urgency to make decision and take action, and urgency as a factor may present risks as well as opportunities [..].

2.1. Clusters, steps and elements of decision making

Energy and climate policy, which is at the centre of analysis of this Thesis, represents sectors where decisions have especially long-lasting consequences both on the supply and demand side. Introducing innovative technologies for energy production and consumption (energy efficiency) and achieving behavioural change of energy users requires massive long-term investment in hardware and software (research and development) as well as education and information. All steps identified further are essential to ensure the sociotechnical transition (transition to sustainable energy) can take place from interim to deliberate to transformative as explained in Fig. 1.2 in Chapter 1 of this Thesis.

Whenever a decision about policies is adopted, there are actions that have preceded the decision and actions that are going to follow the decision. If a decision is adopted, it means that there is a reason for making such decision: a need or an opportunity to make a decision has been identified by decision makers themselves or other stakeholders interested in a decision. Ideally, decision is based on previous research about the policy issue at stake (which is consistent with issue filtration and identification steps in policy analysis (Hogwood and Gunn 1984)) and it is either about introducing a new policy, or amending or terminating an existing policy. Thus, a decision about policy is inevitably associated with a certain place in the timeline of policy lifecycle if we image policy lifecycle as a linear sequence of events with a beginning and end.

A basic set of methods that would satisfy the needs of decision making for transition to sustainable energy is applied throughout the process of decision making, which, the author suggests, should consist of ten steps. The 10 steps are grouped in four clusters according to their function in a full policy lifecycle: 1) policy inception, 2) making of the initial decisions about policies, 3) implementation and monitoring of policies, and 4) review of policies for further decision making. The four stages represent altogether ten steps of decision making. Usually, multiple policies are implemented at the same time, especially when it comes to such complex issues as reaching climate and energy goals. It means that decision making processes about policies overlap, taking place at various stages in policy lifecycle. Therefore, it is essential to base decision making on proper analysis of past experience, current state of affairs and forecasting and modelling of future developments through using appropriate methods of analysis. Interactions of policies can produce different outcomes: simultaneous existence of multiple policies may result in synergies that are mutually strengthening but may as well result in mutually weaking interactions.

It was established that decision making should be evidence-based. To be able to take decisions that ensure best possible result, it is essential to be aware of four elements in each step of decision making:

1) Decision makers need to be able to define the task of the particular decision making step.
2) Decision makers need to be aware of methods of analysis available.
3) Decision makers need to be able to define expected outcomes of a policy chosen to reach the defined goal[s].
4) decision makers need to be aware of risks if a step (or rather – the step) is skipped in decision making.

Application of methods referred to in each one step of decision making throughout the policy lifecycle shall follow these steps:

5) establish current situation;
6) define desired result;
7) identify policies that can lead to the result;

8) consult existing pool of knowledge and information on best policies to reach the desired result;
9) decide about policies;
10) implement policies;
11) measure the impact of policies on initial situation and progress towards the defined desired result;
12) establish situation after policies are implemented;
13) assess the results (deployment of RES and increase in energy efficiency);
14) continue, amend, add new, terminate policies.

The algorithm of decision making illustrated in Fig. 2.1 resembles the decision tree approach discussed in Section 3.4. of this thesis built for the purpose of explaining the critical nature of correct decision making for successful energy efficiency policy, but it does not replicate it. Although decision making in the reviewed model can schematically be applied to any policy, adaptations would be required to apply a similar scheme to renewable energy diffusion policies or fossil fuel phase-out policies, or any other policy related to reaching energy and climate policy goals.

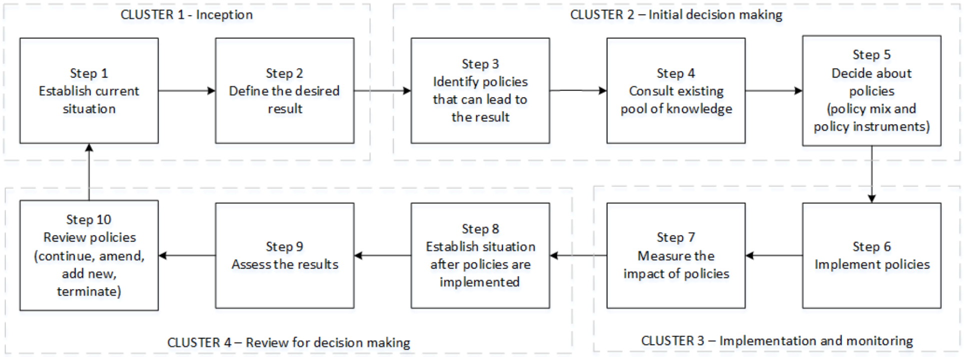

Fig. 2.1. Clusters and steps of decision making in a policy lifecycle.

The logic and role of each step (as presented in Fig. 2.1) and methods used is illustrated below explaining why four elements are important for each respective decision making step in the policy process – task of the respective step, methods to be used for analysis, expected outcome of a step, and risks of skipping a step. Particular attention must be paid to the risks of skipping a step as issues with policy planning and implementation are often related to faulty decision making. Being aware of risks associated with skipping a step in decision making algorithm is especially important when it comes to decision making about processes that require long time to take place and changes are often difficult to alter or reverse or are even irreversible. Description of methods typical to the four stages of decision making is provided in Section 2.2.

2.2. Methods of analysis and decision making aids

Section 2.2. of the Thesis reviews methods of analysis, which are used to illustrate the role of policy analysis at various stages in the policy lifecycle. Analysis is needed to eradicate errors associated with the choice of policies and policy instruments. Mathematical models such as linear regression and TOPSIS are useful to analyse relatively simple situations (correlations and causal relationship). *Hugs, carrots and sticks* approach is useful to draw conclusions about the balance of stimuli and coercive policies preventively indicating potential issues with the choice of policy instruments. Decision tree (combined with classic policy analysis) offers an algorithm for following up decision making and policy implementation with the correct steps to be taken and questions to be asked to succeed with reaching policy goals – deployment of RES and increase in energy efficiency. This method does not *per se* suggest, which policy is best for which result as other methods are better suited for this task. It represents a tool to ensure a systematic approach to organise a full lifecycle of the policy process. Climate policy integration approach asks the questions relevant for identifying if policies are in line with climate policy goals and to what extent suggested policies are synergetic or conflicting with climate policies and climate policy goals.

In the context of causalities relevant for successful energy transition (sociotechnical transition) to sustainable energy system from the research done it follows that the first layer of policy making must follow the step-by-step approach of decision tree / policy analysis as it provides the basic layout for steps of policy analysis. It is also similar to decision making steps throughout the policy lifecycle.

Assessment of policies, however, can be done with other methods than the reviewed ones. These come in during various stages and steps of policy making with the relevant stages and points of intervention identifiable in a decision tree / policy analysis matrix. There are several such stages that require application of various methods of analysis establishing the current status and identifying what has to be changed to ensure energy transition being just two.

A variety of decision-making aids can be used to facilitate decision-making: sociotechnical transition to climate neutrality is a complex set of issues having high probability that more than one method of analysing policy implications and more than one decision-making method may need to be applied to be able to draw valid conclusions to achieve the desired results based on a policy or a combination of policies. Further in the chapter, methods used to assess policies related to renewable energy and energy efficiency are reviewed through an overview of methods and approaches. Application of the methods and approaches is performed through case studies in Chapter 3, which demonstrate why a particular approach ought to be applied in a particular decision making step for the policies to succeed.

Transition to sustainable energy system is to a large extent as sociotechnical transition encompassing technological advancement, innovation, technology diffusion and changes in energy users' behaviour in terms of attitude towards the use of technologies, energy resources and energy and how this attitude translates into action. Sociotechnical transition involves interaction between a variety of elements through multiple processes and under the influence of multiple aspects. Elements have mutual interaction and influence, processes and feedback loops create new processes and new influences and patterns of mutual interaction (Edmondson, Kern, and Rogge 2018). These are described in the Introduction and Results sections (section 3.6. in particular) of this Thesis.

Fig. 2.2 illustrates the methods used to exploit decision-making in the relevant policy areas in Chapter 3 of this Thesis.

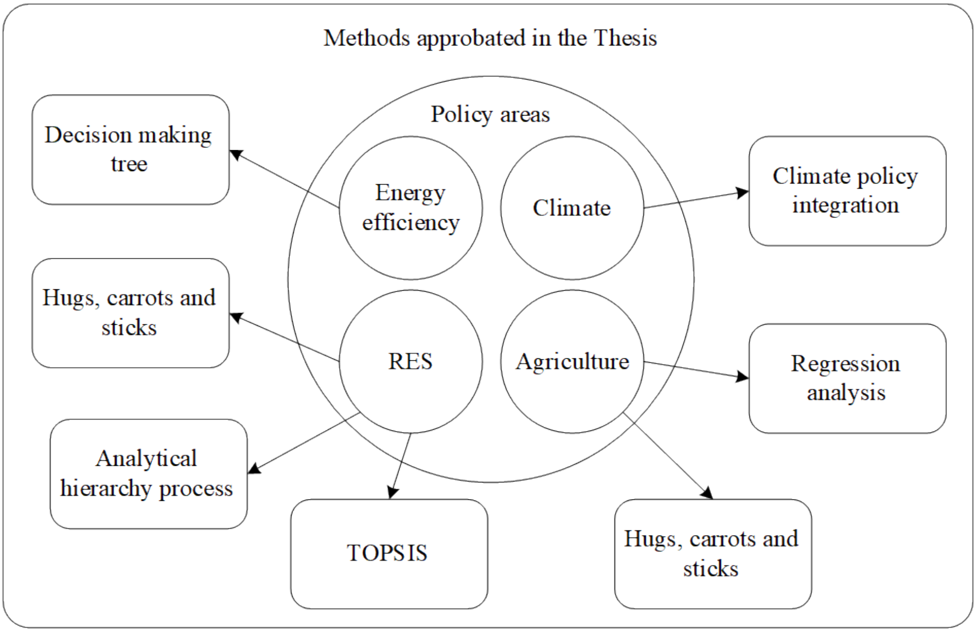

Fig. 2.2. Methods explored with a case study in select policy areas and sectors. Author's own illustration.

Energy efficiency policies are reviewed through applying a combination of decision tree and nine-step policy analysis approach. Renewable energy (RES) policies are reviewed through applying a combination of three methods: *hugs, carrots and sticks* approach, Analytical Hierarchy Process and TOPSIS. Climate aspects of agricultural policies are analysed by applying *hugs, carrots and sticks* approach as well as regression analysis. Finally, impact of policies on climate goals is assessed by applying Climate Policy Integration approach. The results are presented keeping in focus the climate and energy aspects, which are horizontal, but also viewing the impact of policies through the prism of technological, economic, and social aspects (explained in the Introduction, Fig. 1).

2.2.1. Regression analysis

Applying regression analysis is a comparatively simple method of getting answers to questions such as “is there any relationship between certain variables, which characterise either success or failure of policies” and “is a variable relevant for further policy analysis”. Formally, regression analysis is a set of statistical processes for estimating the relationships between a dependent variable (outcome) and one or more independent variables (predictors). Regression analysis is used to determine whether there is correlation between an independent and one or more dependent variables. Regression analysis studies relationships between two or more variables and is usually conducted 1) when there is a need to know whether any relationship between two or more variables actually exists; 2) when there is interest in understanding the nature of the relationship between two or more variables; and 3) when there is a need to predict a variable given the value of other variables.

The most common form of regression analysis is linear regression, which allows finding a line that fits the data best according to a specific mathematical criterion. For example, the method of ordinary least squares computes a unique line that minimizes the sum of squared differences between the true data and that line. For specific mathematical reasons, this allows to estimate the conditional expectation (or population average value) of the dependent variable when the independent variables take on a given set of values. Less commonly used forms of regression analysis use slightly different procedures to estimate alternative location parameters (e.g., quantile regression or Necessary Condition Analysis) or estimate the conditional expectation across a broader collection of non-linear models (for example, non-parametric regression).

In its simplest form regression analysis emulates correlation as the underlying mathematical models are almost identical. Regression analysis can, however, be used where there are many explanatory variables and where various data types are used together. The general regression model is represented in Fig. 2.3.

$$Y = a + bX$$

$$b = \frac{N\sum XY - (\sum X)(\sum Y)}{N\sum X^2 - (\sum X)^2} \qquad a = \frac{\sum Y - b\sum X}{N}$$

Fig. 2.3. Linear regression equation.

Linear regression analysis is handy to obtain quick results that serve as an indicator of whether there is a need to study variables in more detail to see what factors affect values of variables and how those factors can be influenced through adopting particular policies. In the context of clusters of decision making steps linear regression can be particularly useful during early stages of policy lifecycle, but it can also be useful for analysis in Cluster 3 of decision making steps for monitoring purposes during policy implementation. It will be valuable also during the final stage of policy lifecycle when assessment of the current state of affairs and in-depth analysis of policy results is carried out in decision making steps 8 (Establishing current situation) and 9 (Assessing results of policy implementation).

2.2.2. Application of Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to analyse energy alternatives for households

Two types of multicriteria decision analysis (MCDA) – Analytical Hierarchy Process (AHP) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) – is suggested as method of choice to be utilised in policy analysis in several of the ten decision making steps throughout the policy lifecycle. The main reason for that is that MCDA is convenient when there is a need to make choice about which policy has proven to be effective or can provide best results in a particular situation, as well as when there is a need of making choices from among a broad spectrum of energy policies (Greening and Bernow 2004).

Energy use by households is an important issue as there is huge potential for households being more environmentally and climate friendly when it comes to patterns of energy consumption and choice of energy technology among those households, which have the possibility to make decisions about technology for energy production. Therefore, energy technology choices by households have been one of the focuses of this Thesis. As for the analysis of energy technology alternatives for households, one of the most commonly used MCDA methods is TOPSIS (Ishizaka and Nemery 2013), which is applied in this case study in combination with another MCDA method – Analytical Hierarchy Process. MCDA analysis is also used in Chapter 3 to identify and test optimal choices for the use of agricultural residues. As methodology is the same, this case has not been elaborated on in this section on methodology.

Application of both methods – AHP and TOPSIS – is shortly explained in this section providing a perspective on the role of MCDA methods in decision making at various stages in the policy lifecycle.

2.2.2.1. Analytical hierarchy process

Analytical hierarchy process is usually used to achieve consistent results allowing to calculate the impact of different criteria on the calculation of the best choice (Waris et al. 2019). For the purpose of this study on energy technology alternatives for households AHP comparison matrix was created to calculate the weights for each of five key criteria to be used in TOPSIS calculation of ranking of alternatives. The normalised pairwise comparison matrix was created according to formula:

$$X_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}},$$

where

X_{ij} – normalised pairwise value;

C_{ij} – pairwise comparison value for each element;

$\sum C_{ij}$ – the sum of pairwise comparison column.

Priority vector for each criterion was calculated according to the following formula:

$$W_{ij} = \frac{\sum_{j=1}^{n} X_{ij}}{n},$$

where

$\sum_{j=1}^{n} X_{ij}$ – the sum of normalised pairwise column

n – number of criteria

In this case the AHP method is used to support the TOPSIS method to analyse the best energy technology alternatives for households through a case study elaborated on in more detail in Chapter 3 of this Thesis.

2.2.2.2. Technique for Order Preference by Similarity to Ideal Solution

To carry out TOPSIS analysis five criteria were selected as relevant to the choice of energy production solutions in households: economic, technical, environmental, political and social. Tsoutsos and others have utilised similar set of criteria apart from distinguishing between social and political criteria separately (Tsoutsos et al. 2009). Sub-criteria were identified for each of the criteria to facilitate the evaluation of the importance of each of the criteria by experts. In total, however, twenty sub-criteria were identified. The criteria and sub-criteria and the alternatives are outlined in Fig. 2.4.

Five alternative technology choices for households were analysed, including solar photovoltaic (PV), solar thermal, heat pump, biomass and fossil fuel technologies represented in one alternative. Fossil energy technologies as a group are included as those represent a sizeable share of choice among households in Latvia. There are several reasons why such choice thus far has been dominating. First, natural gas (pipeline) distribution system is well developed in many bigger cities and towns and represents a relatively simple way to provide individual space heating, which is either alternative of choice to district heating or simply a good alternative to hard fuels like coal or firewood or pellets or wood chips in those areas, where there is no district heating or natural gas. Second, natural gas technologies for individual space heating are widespread, well-known and assessed by users as mostly reliable. Third, natural gas lobby has invested time and resources to ensure that natural gas is positioned as easily accessible, reliable and cheap resource that everyone can afford to use while renewable renewables and RES technologies are unreliable, expensive, complex and inaccessible. Fourth, contradicting opinions and user experience with other [renewable energy] technologies.

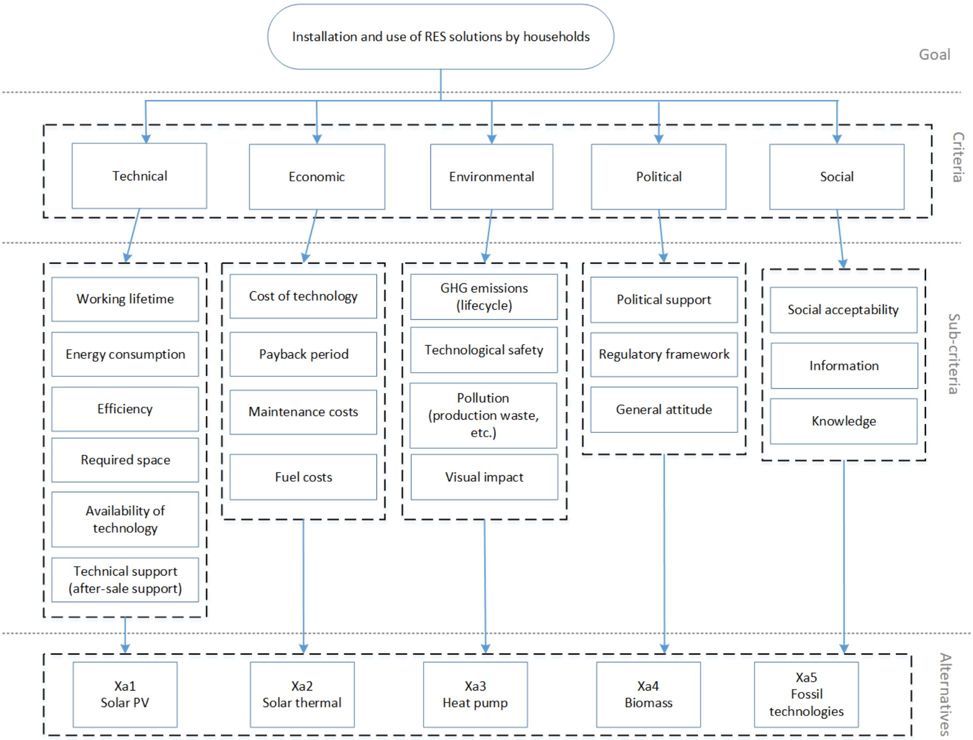

Fig. 2.4. Alternatives, criteria and sub-criteria used in the analysis. (Author's own illustration.)

Decision matrix was created by giving each attribute (criterion) a value as shown in Table 2.1 with example of renewable energy technology alternatives to carry out evaluation using TOPSIS method. Values represent the mean scores calculated from the expert judgement. Favourability of each criterion (factor) for each of the alternatives is evaluated considering the current situation. The principle of quantification of the qualitative evaluation is shown in Table 2.1. For example, if the Social criterion (criterion i_5) is assessed as less favourable for investing in solar PV (alternative x_{a1}), the value is expressed as 2, or if the Environmental criterion (criterion i_3) is rather unfavourable for fossil energy solutions (alternative x_{a5}), the value is expressed as 2 while the value for solar PV (alternative x_{a1}) is 5 as it is favourable for the alternative. This exercise was carried out for each of the criteria ($i_1 - i_5$) vis-à-vis each of the alternatives ($x_{a1} - x_{a5}$) by each of the involved experts and the average result was calculated for each of the combinations.

Table 2.1.

Decision matrix / Weighted Normalised Decision Matrix.

	Alternatives					
	Criteria (value between 1 and 5)	X_{a1} (Solar PV)	X_{a2} (Solar th)	X_{a3} (Heat pump)	X_{a4} (Biomass)	X_{a5} (Fossil)
i_1	Technical	4.17	4.17	3.89	3.67	4.06
i_2	Economic	3.92	4.08	3.92	3.33	3.67
i_3	Environmental	4.58	4.42	4.08	3.58	2.92
i_4	Political	3.56	3.78	3.89	4.00	4.11
i_5	Social	3.56	4.00	3.78	3.78	4.22

Quantification of qualitative evaluation was done according to value attributes in Table 2.2.

Table 2.2.

Quantification of qualitative evaluation

Value	**Favourability of the criterion**
1	Criterion is unfavourable
2	Criterion is rather unfavourable
3	Criterion is neutral
4	Criterion is rather favourable
5	Criterion is favourable

After a value was given to each attribute (criterion), they were normalised with distributive normalisation method according to formula:

$$r_{ai} = \frac{x_{ai}}{\sqrt{\sum_{a=1}^{n} x_{ai}^{2}}},$$

where

r_{ai} – normalised value

a – alternative

i – criterion

After a normalised decision matrix was created the values were recalculated with the determined weights according to formula:

$$v_{ai} = w_i * r_{ia},$$

where

v_{ai} – weighted value

w_i – weight

In the next step the ideal and anti-ideal solution was calculated. Each weighted value was compared with the maximal and minimal value of the corresponding criterion. The sum of squares of each alternative's difference from the maximal value was used to determine the total distance of an alternative to the ideal solution. The distance to the ideal solution was calculated according to the following formula:

$$d_a^+ = \sqrt{\sum_{j=1}^{n}(v_i^+ - v_{ai})^2},$$

where

d_a^+ - distance to the ideal solution

The distance to the anti-ideal solution was calculated according to the following formula:

$$d_a^- = \sqrt{\sum_{j=1}^{n}(v_i^- - v_{ai})^2},$$

where

d_a^- - distance to the anti-ideal solution

The final step was to calculate the relative closeness of each alternative to the ideal solution. This was done according to the following formula:

$$C_a = \frac{d_a^-}{d_a^+ + d_a^-},$$

where

C_a – relative closeness to the ideal solution

The result for each alternative ranges between 0 (zero) to 1. The best alternative is the one closest to value 1 (one). The results of application of this method – considerations about the best energy technology alternatives for households as well as optimal choices for utilising agricultural residue – is reflected in Chapter 3.2. of the Thesis.

2.2.3. Hugs, carrots and sticks

There are moments in the policy lifecycle when the decisions that are made are going to have a long-lasting and profound effect. Decision making based on a thorough assessment of past and existing policies is crucial. Poor balance or lack of balance of policies that stimulate or enforce change in the energy sector is a common issue in decision making as applying only coercive methods or only favours fails to deliver expected results. Therefore, finding the right balance between different types of policies is a challenging task for policymakers.

In this Thesis, *hugs, carrots and sticks* (HCS) approach is one of the methods suggested to facilitate decision making. It is mostly aimed at helping to get to the best decision about how to influence energy users to change their behaviour. It is used to identify types of policy measures (policy instruments) creating basis for further in-depth analysis of adequacy and balance of measures included in a policy mix. “Hugs, carrots and sticks” approach is used to identify, which policy instrument and action belongs to which group of policy instruments – the incentivising or the enforcing ones. The purpose of *hugs* is to achieve a consensus through convincing, educating and participation. *Carrots* reward and compensate for the desired action. *Sticks* allow achieving the desired effect (action) through applying compulsory methods, threats or punishment (Boulding 1990).

A *carrot* is any kind of positive stimulus and gain for energy user if energy is produced and used in an environmentally friendly way. A *stick* is a measure characterised by enforcement, creation of an obligation and inconvenience costs for energy user with the intent that from the point of view of energy production and consumption it pays to be environmentally friendly. A *hug* encompasses measures and activities like research, information, education, exchange of experience, visiting of pilot projects, advertising best practice, involvement in the discussion about social responsibility, assuring energy user about positive effects of acting in an environmentally conscious way as well as other activities facilitating change of social opinion.

Box 1: Criteria for identifying the type of policy.

A *hug*: information or education campaign, showing best practice, visits to demonstration projects, research or analysis to provide information for decision-making.

A *carrot*: favourable regulatory environment, financial instrument and co-financing for the purchase and installation of renewable energy technology (for example, PV panels or solar thermal collector, electricity net metering system).

A *stick*: cancellation of tax rebates for fossil fuels, higher real estate tax for those properties, where the owner chooses not to implement energy efficiency measures although it is technically possible to do it and financial support is available for this purpose.

Box 1 briefly describes examples of each type of action / policy instrument.

The right balance of *hugs, carrots and sticks* can have a significant impact on sociotechnical transition and the type of transition that can be or is achieved in a given landscape of a sociotechnical system and policies adopted to influence transition: different proportions of *hugs, carrots and sticks* will lead to different transition pathways like, for example, substitution or transformation pathway (Geels et al. 2016).

Application of the HCS approach is illustrated in Fig. 2.5. A select policy is compared with the criteria corresponding each of the three types of policies and, depending on the match, it is identified as being either *a hug, a carrot* or *a stick*. In real life it may turn out that a policy can be identified as belonging to more than just one type of policy.

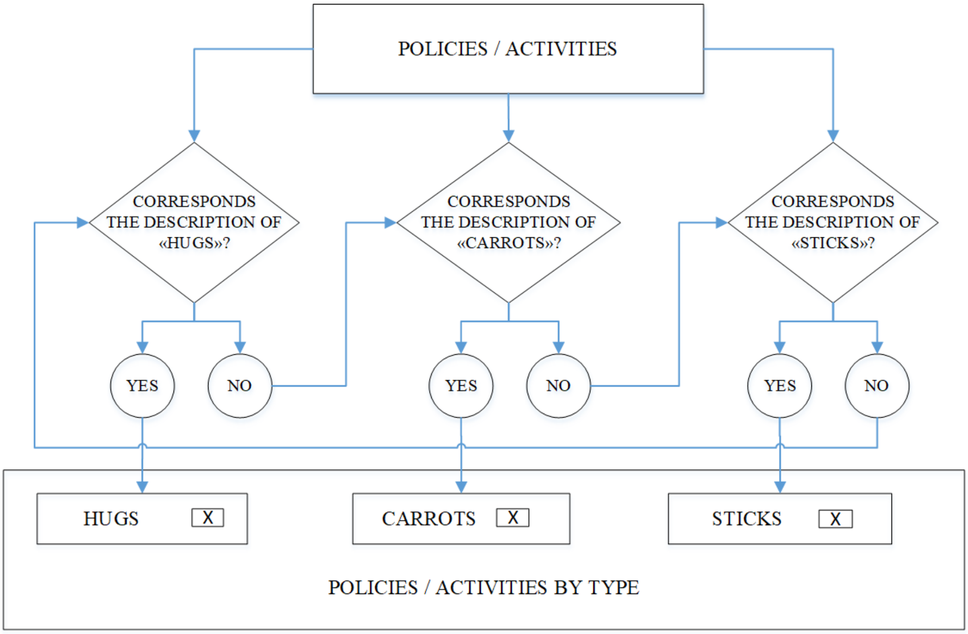

Fig. 2.5. Identification of the type of policy (activity) according to the *hugs, carrots and sticks* approach. (Author's own illustration.)

The results of this approach are discussed in detail in Chapter 3 by through a case study on Latvia's National Energy and Climate Plan where the method of *hugs, carrots and sticks* is used to categorise NECP2030 activities (policies and policy instruments) and through applying literature analysis on policy goals and most appropriate policy instruments conclusions are drawn whether the chosen activities are adequate to achieve NECP2030 goals.

In the case study of NECP2030 a carrot is any kind of positive stimulus and gain for energy user if energy is produced and used in an environmentally friendly way. A stick is a measure characterised by enforcement, creation of an obligation and inconvenience costs for energy user with the intent that from the point of view of energy production and consumption it pays to be environmentally friendly. A hug encompasses measures and activities like research, information, education, exchange of experience, visiting of pilot projects, advertising best practice, involvement in the discussion about social responsibility, assuring energy user about positive effects of acting in an environmentally conscious way as well as other activities facilitating change of social opinion.

Also, in the case study of NECP2030 when analysing the impact of activity directions and activities (policy measures) listed in Appendix 4 of NECP2030 on environment and energy user by applying the HCS approach, the "H, C and S" have been replaced by A, B and C respectively for the purpose of data collection and easier perception. Activities (policy measures) can be identified also as combined, for example, AB, AC, BC or ABC. The logic of identification of type of activity/policy measure is illustrated in Fig. 2.5. All policy instruments (activities) belonging to activity groups and activity clusters have been assessed according to the “hugs, carrots and sticks” approach.

Choosing a particular policy instrument or a set of instruments through a thorough decision making process can facilitate development of renewable energy technologies for electricity production and contribute to CO_2 reduction and mitigation (del Río and Cerdá 2017). Paying insufficient attention to detail, to the contrary, can hamper this process. For example, RES electricity quota system can be an effective way to promote production of renewable electricity (Bao et al. 2019) while creating a burden on other (non-RES) power producers. Similarly, renewable energy certificate system can be an effective way to promote RES albeit with potential negative social costs as support system needs to be financed through the end user (G. Wang et al. 2019). Similarly, renewable energy portfolio standards (Bento, Garg, and Kaffine 2018), feed-in tariffs and targeted tendering schemes can boost deployment of renewable energy technologies (Bolkesjø, Eltvig, and Nygaard 2014), but can deliver differing results depending on the design of the renewable energy policy instrument (Choi et al. 2018). Voluntary RES support mechanisms based on supply-side offers to consumers in the form of various electricity products appear to be inefficient (Herbes et al. 2020) requiring to have some sort of a more targeted approach depending on energy technology preferences (Barbose et al. 2015) for achieving a rapid and dynamic deployment of particular technologies (Chapman, McLellan, and Tezuka 2016) and availability of renewable electricity for all consumers.

Thus, the common knowledge is that less mature renewable energy technologies require stable support over longer period of time while those that have achieved certain market penetration can rely on less persistent and usually market-based support mechanisms such as green certificates or tradable permits (Polzin et al. 2015). Green certificates are considered to be a better choice from the perspective of authorities as they are more cost-effective than fixed price and more stable support schemes such as feed-in tariffs (Aune, Dalen, and Hagem 2012). Possibility to trade certificates is considered an important precondition for investment in RES electricity production (Bistline, Santen, and Young 2019) while the more complex the combinations of so called black (emissions), green (renewable electricity) and white (energy savings) certificate schemes, the higher the risk that the effects of simultaneous implementation of different certificate systems can undermine the effectiveness of green certificates in particular (Amundsen and Bye 2018).

2.2.4. Adaptation of nine-step policy analysis process and elements of decision tree approach

Classic policy analysis process has nine steps and the sequence of steps has logic behind it. The steps have to be implemented in a certain order to achieve correct results in terms of establishing what are the policy issues and producing and implementing a plan how to deal with those issues. The nine steps of policy analysis are:

1) Deciding to decide (issue search or agenda setting);
2) Deciding how to decide (issue filtration);

3) Issue definition;
4) Forecasting;
5) Setting objectives and priorities;
6) Options analysis;
7) Policy implementation, monitoring, and control;
8) Evaluation and review;
9) Policy maintenance, succession, or termination.

These steps are not definitive, but rather represent a framework for understanding what happens and what does not happen during the decision making process. However, the nine steps of policy analysis ensure that decision making and policymaking is evidence-based and follows logic that leads to the best result. This "nine step approach" represents a legitimate way to analyse policy issues and potential solutions in its own right, but it also contains reference on why and how a variety of specific methods of analysis can and ought to be applied during some of the steps or stages of policy analysis (Hogwood and Gunn 1984) and decision making throughout the policy lifecycle.

It stems from the elaboration on methodology in Chapter 2.1. that decisions ought to be made in a step-by-step manner, which means discussing and analysing issues in the correct order and without skipping steps. The case study where a combination of decision making tree and nine-step policy analysis is applied looks at the role of decision making in ensuring that effective energy efficiency measures are adopted and implemented. The first major step according to the method is identifying barriers to energy efficiency followed by analysis of causes of barriers to energy efficiency. This is followed by answering three questions: 1) is simultaneous implementation of multiple policy instruments required? 2) is coordination of policy instruments required? 3) is the sequence of implementation of policy instruments correct? Choice or change of policy instruments must follow only after answers to all three questions are produced. Failure to carry out analysis and provide answers will also lead to failures in policy implementation, which may result in, for example, cyclical factors like availability of funding for the renovation of buildings being available only periodically with intermissions thus disincentivising citizen's engagement in energy efficiency activities.

In a full policy lifecycle, last steps are related to policy review. Policy review should be regarded as mandatory to ensure that the policies chosen by decision-makers deliver towards achieving the required goal, whether expressed in quantitative or qualitative terms. Skipping this step will likely lead to either suboptimal results or, in a worst-case scenario, will lead to waste of time and resources in addition to achieving only suboptimal results (for example, quantity and quality of renovated buildings in case of renovation with the aim of increasing energy efficiency of buildings) or failure to achieve even minimum acceptable result. Thus, [a simplified] process of decision-making about energy efficiency policy mix can be expressed in six steps (Fig. 2.6).

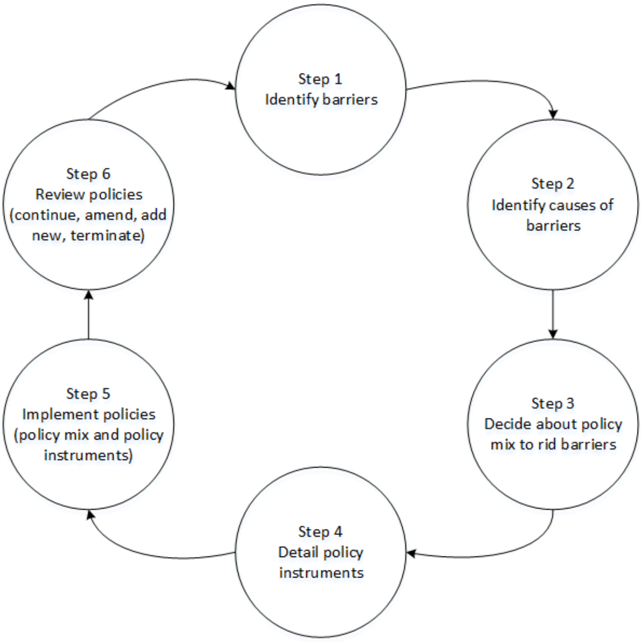

Fig. 2.6. Six steps of decision-making about energy efficiency policy mix.

Decision tree analysis is a tool to facilitate decision-making, which represents various alternative solutions to a given problem. Using squares, lines and circles is the usual way to visualise this method. The squares represent decisions, the circles represent uncertain outcomes, and the lines represent consequences of decisions. The representation of a decision tree is created in four steps:

1) Use the square to describe the decision that is required.
2) Draw lines from the square and formulate potential solutions for each of the lines.
3) Outcome of the potential solution sits at the end of the line. Use a circle to describe an uncertain or unclear decisions are described in a circle. If a solution leads to a new decision, this decision is represented as a new square.
4) Analysis of each square and circle is done before the final decision is applied.

This method was adapted to the needs of classic policy analysis approach described earlier in the section to analyse barriers and solutions to energy efficiency policy. The case study in Chapter 3 on energy efficiency uses a combination of classic decision tree and nine-step policy analysis.

Why choose this combination of methods? Energy efficiency is one of several essential elements ensuring transition to climate neutrality. The process of improving energy efficiency involves many aspects associated with technology and energy user’s behaviour. Decisions about policy instruments are inevitably associated with barriers to energy efficiency and measures to take barriers down. Facilitating behaviour oriented towards improving energy efficiency is especially complex when it comes to households and individual choices. There can be many internal and external barriers that can prevent positive attitude towards energy efficiency turn into action and result in improved energy efficiency. Therefore, a whole set of factors associated with environmental and climate, technological, economic and social aspects (see the general scheme of energy transition illustrated by Fig.1 in the Introduction) of the required change must be taken into consideration when deciding about policies and policy instruments supposed to facilitate energy efficiency.

When of the key problems with the barriers is that decision makers have to be able to convince target groups about investing in energy efficiency. Market conditions and market relations set the context for energy efficiency. Therefore, policymakers have to be able to formulate the value proposition of energy efficiency to the target groups with the ultimate goal of energising citizens for action (Blumberga, Zogla, and Laicane 2012), (Gardner and Stern 2002), which would increase the scale of collective energy efficiency activity (Pikas et al. 2015).

Decision tree as a method is used in combination with classic policy analysis approach also described earlier in Chapter 2 to analyse barriers and solutions to energy efficiency policy. The algorithm for decision making leading to effective energy efficiency policies is described in Chapter 2. There are several important aspects that deserve particular attention. These are: 1) simultaneous implementation of multiple policies, 2) coordination of multiple policy instruments, and 3) correct sequence of energy efficiency policies. These aspects are discussed further on in this section.

Decision makers should be aware the local market conditions when formulating and adopting policies (Cunningham et al. 2013) as such policies will serve best for overcoming current barriers and strengthening market forces, which facilitate achieving the required result (Rosenow, Kern, and Rogge 2017). In this context it is essential to identify and evaluate factors, which either hamper or foster the efficiency of mutual interaction of multiple energy efficiency policies. These factors can be categorised in three clusters:

1) factors related to the mechanism of management of a policy, 2) the scope of a policy and the time designated to the implementation of different energy efficiency policies, and 3) implementation of multiple policies simultaneously (Wiese, Larsen, and Pade 2017).

Sixteen modules are used in a case study on factors affecting implementation of energy efficiency policy instruments in the Thesis to illustrate the mutual interrelations and causalities of different actions and factors in reaching or, to the contrary – not reaching higher energy efficiency in through achieving higher participation rate and overall activity of the involved target groups.

The sixteen modules represented in the scheme include: 1) Analysis of the current energy efficiency situation in Latvia (Module A), 2) Energy efficiency policy in the EU (C), 3) Identification and classification of barriers (B), 4) Analysis of causes of barriers (D), 5) Energy efficiency policy instruments in literature (E), 6) Sequence of energy efficiency measures (J), 7) Choice and change of policy instruments (F), 8) Coordination of energy efficiency policies (I), 9) Simultaneous implementation of policy instruments (H), 10) Policy instruments and measures (G), 11) Policy review (K), 12) Assessment of the level of achievement (L), 13) Decision to terminate policy instrument (M), 14) Continuation of a policy instrument (N), 15) Modification of a policy instrument (O), and, finally, 16) Introduction of a new policy instrument (P).

Each module in the scheme can be associated with one of four clusters:

1) modules related to data input and output (A, C, E and F);
2) modules related to barrier identification and analysis of causalities (B, D);
3) modules related to aligning the three clusters of policy factors and policy instruments (H, I and J);
4) modules related to policy review (G, K, L, M, N, O and P).

Each of the modules is characterised to describe its role in this analysis. The decision making scheme about energy efficiency policies is illustrated in Fig. 2.7. This figure explains the stages and steps of decision making within a policy lifecycle in more detail than represented in Chapter 2 (see Fig. 2.1).

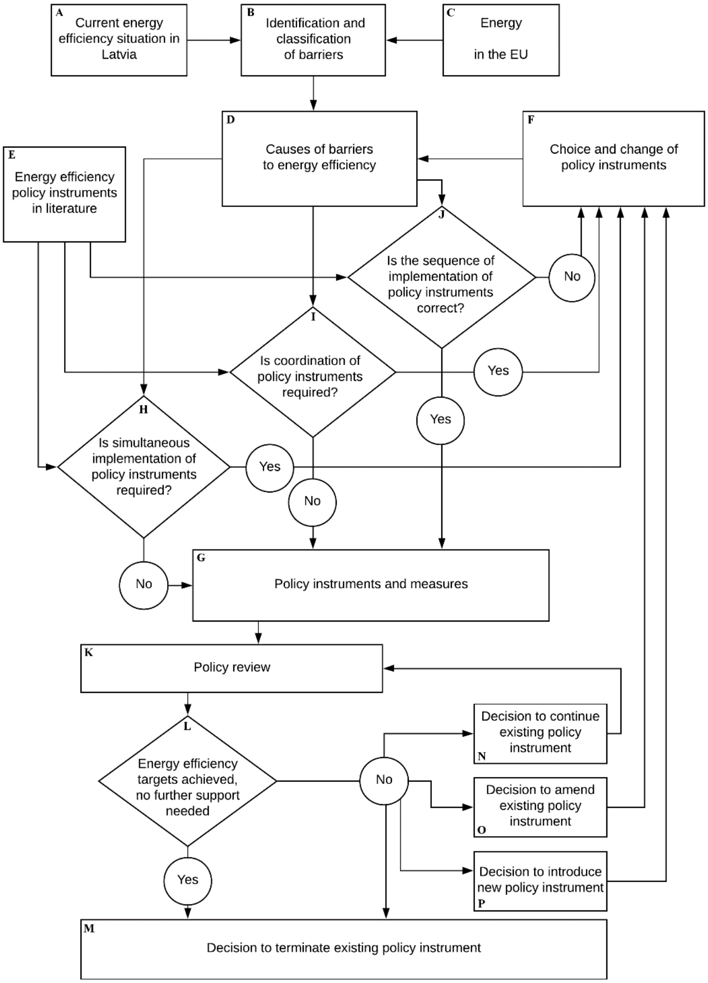

Fig. 2.7. Decision making scheme about energy efficiency policies in the context of barriers to energy efficiency.

2.2.4.1. Decision making about energy efficiency (Module A)

Looking at energy efficiency one can distinguish between macro and micro level. On the macro level, improving energy efficiency is essential for reaching the defined national target values of reduction of energy consumption. On the micro level, it is about improving energy efficiency in several areas on an individual (but not exclusively) scale. Overall or macro level goals may suffer in the event of inability to achieve micro level goals.

There is significant potential to improve energy efficiency in Latvia. Some of the key areas for improving energy efficiency are listed by the Government and include improving energy efficiency in public and commercial buildings, insulation of residential multi-apartment buildings, introduction of energy efficient lighting in municipal public space, developing energy efficient heat production (for district heating in particular), and increasing energy efficiency in transport sector (Cabinet of Ministers of the Republic of Latvia 2019).

Although energy efficiency level in industry, services, public buildings and households varies, improvements are required in every sector of economy. Scarce national funding is one of the key issues related to making decisions about investments in energy efficiency. A usually narrow spectrum of policy instruments associated with financial incentives adds to this issue. Also, authorities rely too much on the potential availability of the EU grants for energy efficiency and renovation, dedicating too little of own national funding for this purpose. Planning energy efficiency according to availability of the EU funds is indicated by experts as a problem amplifying the negative effects of the cyclical character of availability of such funds. The cyclic availability (and, in fact, also unavailability) of the EU funds contributes to high costs of renovation and energy efficiency because of sudden hikes in demand of materials, services and labour force. Thus, paradoxically, the availability of the EU funding for energy efficiency in the form of grants appears to also be a barrier in addition to being a factor facilitating investment in energy efficiency.

Individual houses and multi-apartment buildings cannot in their majority boast high energy efficiency. Energy efficiency in industry is just slightly better than in the household sector and needs to be improved, too. As many businesses, especially in service sector and retail, are not owners of the premises where they do business, they often have little ability to improve energy efficiency of the premises apart from using more energy efficient technologies, which are used to run business. Another factor decreasing interest of commercial enterprises (and utilities, too) to invest in energy efficiency, is the ability and possibility to include the costs associated with extra energy consumption in the price for the service or of the product, thus making other consumers pay for the wasted energy.

According to Eurostat data about apartments, Latvia ranks in the range of average energy efficiency in the EU with annual consumption of energy reaching 1.41 tons of oil equivalent (toe) per household. The EU average consumption is 1.39 toe. In the neighbouring countries of Lithuania and Estonia the figure stands at 1.13 and 1.48 toe respectively per household. These figures represent the respective average values in the region. As for efficiency of space heating, Latvia fits the picture with its 0.94 toe consumption along a diverse company of countries such as Estonia (0.95 toe), France (0.94), Italy (0.96 toe), Sweden (0.96 toe), and the United Kingdom (0.96) (European Environment Agency 2016; Eurostat 2021).

Latvian Ministry of Economics is responsible for energy efficiency policy. It views energy efficiency policies and policy measures in the context of the overall national energy efficiency targets emanating from the obligations of the EU Energy Efficiency Directive 2012/27/EU (EED), National Energy Efficiency Action Plan as well as National Energy and Climate Plan. Policy framework for 2030 and beyond was agreed to get updated by adopting and implementing the Clean Energy for all Europeans package in 2018, and the new amending Directive on Energy Efficiency (2018/2002).

At the time of the case study, there was no obligation for Latvia to submit its indicative national energy efficiency target. However, there are two mandatory components, which Latvia has to fulfil. Firstly, Latvia has to ensure new savings of 0.8 percent of the annual final energy consumption by calculating these savings as the average value over the period of three years prior to the 1st of January 2019. Secondly, Latvia has to achieve the annual renovation rate of 3 percent of the total space of buildings owned by the state (Cabinet of Ministers of the Republic of Latvia 2019). The main goal of these activities is to create a national energy efficiency system allowing to save energy in all relevant areas of the energy sector upstream and downstream – energy production, transmission and distribution, and also end use.

Several consultations with experts in 2019 allowed to identify and stratify over 50 different barriers to energy efficiency. One of the main conclusions of these consultations – assessment of existing policy instruments and policy outcomes has significant potential for improvement. Taking into consideration all stages and steps of decision making throughout the policy lifecycle is essential: monitoring of policy implementation and regular policy review has an important role, and a methodological approach to collecting, analysing, reporting and reviewing information on energy efficiency can significantly advance the information environment needed for a coherent energy policy planning, decision making and policy implementation.

2.2.4.2. Identification and Classification of Barriers (Module B)

Identification of barriers to successful implementation of energy efficiency policies belongs to early stages of the policy lifecycle. Decision making Steps 1, 3, 4 and 5 should include analysis, which reveals current situation: identifies existing barriers and puts the barriers into slots for later in-depth analysis of causes of barriers.

There are three bigger groups of causes of barriers to energy efficiency:

- firstly, information and knowledge,
- secondly, financing and
- thirdly, regulatory environment (laws, regulations, standards, too little regulation or too much regulation, voluntary or mandatory approach to energy efficiency obligations) (Gardner and Stern 2002; Miezis et al. 2016).

From the point of view of institutions and authorities, it should be clear that barriers are always a consequence of policies (Bukarica and Tomsic 2017) and decision making related to energy efficiency (Wiese, Larsen, and Pade 2017). Consequently, it is possible to remedy barriers by phasing out unsuccessful policies, amending existing policies or adding new ones. Responsibility to engage policy analysts and researchers to elaborate alternatives lies on authorities. It is up to decision makers to adopt and implement policies that are best suited for improving energy efficiency.

Barriers to energy efficiency in Latvia have been analysed using information and expertise from several events dedicated to this issue and involving experts on energy policy and energy efficiency, practitioners from municipalities, construction companies and utilities. A series of events[1] dedicated to the analysis of barriers helped identifying over fifty barriers. Two workshops had a broader approach to the topic, while one event was dedicated specifically to the financial aspects of energy efficiency. Participants of these events contributed information and expertise in raw form and afterwards categorised by the author of this Thesis as well as co-authors of research article (Aboltins and Blumberga 2019) using a mix of typologies. Results of analysis shows that barriers to energy efficiency represent a broad spectrum of issues – information, knowledge, market shortcomings, financing, technical issues, laws and regulations, and, of course, practice and implementation of energy efficiency measures (Gardner and Stern 2002).

Conclusions from the three events referred to above are similar and coincide with what sources of earlier analysis represent (see, for example, Fig. 1.4) (Bertoldi and Boza-Kiss 2017; International Energy Agency 2010; Johansson and Thollander 2018). These conclusions can be stratified according to the same principles as described above. It indicates that barriers and causes of barriers to energy efficiency have similarities from case to case. Conditions in the local markets may differ and may result in different environment for policy instruments to be implemented in, but similarities related to barriers to energy efficiency remain. Therefore, it is justified to claim that certain universal principles apply when it comes to classifying the barriers and policies and policy instruments as well as usability for the purposes of further analysis of causes and decision making in later stages and steps of the policy lifecycle. Local adaptability of these universal principles matters a lot, however.

2.2.4.3. Energy Efficiency Trends in the European Union (Module C)

Energy efficiency goals have been set by the EU in all sectors of economy to improve energy efficiency. The situation varies among the EU member states, but the overall trend is towards improving energy efficiency in all sectors, be it households, industry and commercial services. Policies implemented in the Member States have had certain level of success as overall energy consumption level for space heating has been slowly but steadily improving in the Union reaching as high as 89.78 and 75.52 percent of the 1990 level in 2005 and 2016 respectively (European Environment Agency 2016).

Countries, which are economically more advanced than the Baltic States, consume on average more energy than the latter group of countries, especially when it comes to energy consumption for lighting and electrical appliances (Eurostat 2019). However, this does not *per se* mean that there is a direct causal relationship between the GDP and energy consumption indicators. Decoupling of GDP and energy consumption can be explained by improved awareness about energy saving and gains as well as investment in energy efficiency measures. Latvia has done relatively little itself in terms of ensuring sufficient own investment in energy efficiency

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[1] 1) A workshop organised by the Riga Technical University (RTU), 2) an open workshop on energy efficiency by RTU with the participation of Pål Davidsen, system dynamics expert from the University of Bergen , and 3) annual Sustainable Energy Investment (SEI) Forum organised by the Ministry of Economics and the European Commission on financing energy efficiency.

measures and has largely relied on the financing instruments of the European Union. Such approach has facilitated the trend that GDP growth also means higher consumption of energy.

Energy consumption in buildings in commercial services sector reach approximately 46 percent. Final energy consumption in buildings in the EU in general constitute approximately 40 percent of final energy consumption (European Commission 2019a). This figure is decreasing steadily as energy performance of buildings is being improved (51 percent in 2005 against 63 percent in 1990). Energy consumed in information and communication technologies sector, as well as appliances and for lighting is the second biggest source of consumption with 39 percent share in 2016. Energy use for cooking and heating of water have a relatively limited role in the overall energy consumption as these activities represent six percent and five percent of this consumption respectively. One might think that cooling of buildings consumes a lot of energy, however, in the service sector, only five percent of energy is used for space cooling (three percent in 1990) (European Environment Agency 2016).

Studies of energy efficiency through analysis of National Energy Efficiency Action Plans in the EU indicate that fiscal measures, including taxes, also funds and other financial support, which corresponds the category of *carrot-type* measures, have been the most used measures, followed by introduction of policies related to regulatory environment, such as industry standards, laws, and government regulations (Economidou et al. 2018). The adoption of the EU Energy Efficiency Directive has facilitated adoption of policies by the Member States speeding up the generally slow rate of raising energy efficiency level in all sectors of economy.

2.2.4.4. Analysis of Causes of Barriers (Module D)

It is of utmost importance for future decision making about energy efficiency policies to understand what conditions or factors cause new barriers or cement the existing barriers. A brief look at the factors creating barriers explores the risks associated with failing energy efficiency policies and measures.

2.2.4.4.1. Information and knowledge

Key causes of the barriers attributed to knowledge are lack of information, lack of knowledge about energy efficiency in general, lack of knowledge about energy efficiency measures, lack of willingness to get information, lack of willingness to learn about energy efficiency, lack of willingness to use knowledge. A significant share of causes is related to behavioural issues like, for example, lack of motivation to use one's knowledge and information about energy efficiency to actually exercise action leading to improved energy efficiency. At the same time, although barriers associated with lack of or insufficient information and knowledge is regarded as one of the key problems in achieving mass scale of energy efficiency activity, it is argued that policy instruments to tackle these particular barriers have a low impact rate if exercised as stand-alone policy measures (Blumberga, Žogla, and Laicāne 2012; Gardner and Stern 2002). Therefore, policies related to dissemination of information and knowledge usually serve as auxiliary instruments and in combination with other policy instruments (Barbara Schlomann, Matthias Reuter, Sohaib Tariq 2015).

2.2.4.4.2. Availability of financing

When it comes to barriers pertaining to financing, one can distinguish between individual and collective levels of causes for barriers to occur. Typical causes on an individual level include lack of financial motivation to invest in energy efficiency, inability or lack of willingness to pay for energy efficiency measures (Gardner and Stern 2002), lack of trust and confidence in energy efficiency processes (Miezis et al. 2016), lack of financial instruments to support energy efficiency activities in households (Markandya, Labandeira, and Ramos 2015). On a collective level, there is lack of financial instruments that could trigger deployment of energy efficiency activities that would have mass character and would help to achieve not only individual but also country energy efficiency goals (Miezis et al. 2016).

Several experts during the two workshops and the conference referred to earlier in this section noted that periodical availability of grants for energy efficiency that do not have to be repaid are good but have one important side effect – target audiences for this measure get used to getting a grant covering all needed investment and do not show any activity when generous grant mechanisms are not available, thus transforming a seemingly well-intended policy instrument into a serious barrier discouraging investment in energy efficiency (Gardner and Stern 2002; Wiese, Larsen, and Pade 2017) when similar grants are not available, and slowing down the process of improving overall energy efficiency level.

Other kinds of financial instruments than grants are regarded as a better and more effective choice compared to grant schemes as they tend to attract private financial resources and the money returned provides funds for future investment (EC DG Energy 2017). There is also another issue related to financial incentives: authorities tend to choose to employ policy instruments that are characterised by relatively simple technological solutions and low costs (the phenomenon often described as "reaching for the low-hanging fruit"), thus contributing to further insufficiently complex and effective energy efficiency solutions (Rosenow, Kern, and Rogge 2017). Causes to such policy decisions might stem from lack of willingness to contribute to more fundamental improvements because of a number of factors and not least expectations to see and feel the result of investment timewise as close to the moment of investment as possible (Gardner and Stern 2002). Present bias may also contribute to this problem (Fuerst and Singh 2018; Werthschulte and Löschel 2021). An aspect in favour of a less expensive step-by-step approach to energy efficiency measures however is the possibility to engage the private sector with financing on a project basis (Robert Tromop, Viktor Badarek, Oleg Dzioubinski, Scott Foster, Stefanie Held 2015). At the same time, providing targeted support to technology advancement and thus promoting fundamental changes in energy efficiency deserves more attention despite being a relatively costly policy approach (Bariss et al. 2017).

2.2.4.4.3. Regulatory barriers

The main cause of regulatory type of barriers is embedded in faulty policy and decision-making about factors affecting energy efficiency. There can be many reasons behind poor decisions affecting energy efficiency, but one common reason is lack of analysis of barriers to energy efficiency, lack of modelling of scenarios followed by decision making, and implementation of policies that are not based on research, analysis and evidence. Lack of or insufficiently regular policy review can also contribute to faulty decision making leading to implementation of wrong policy that does not allow to achieve the desired policy goals at all or to the full expected extent. Subsequently, failure of one policy instrument to achieve the desired results on its own may lead to a faulty conclusion that a policy instrument is useless and does not function (Kern, Kivimaa, and Martiskainen 2017).

As noted earlier, barriers to energy efficiency are consequences of decisions, except for the barriers associated with consumer behaviour and willingness to pay or other personal [de]motivators that are not related to any other factor. Decisions about policy instruments targeted to improve energy efficiency are related to first-time choices as well as decisions to change policy instruments (Kern, Kivimaa, and Martiskainen 2017). If choices are based on limited or no analysis about the causes of barriers, there is risk that either erroneous decisions will be made or repeated feeding of the loop of wrong choices and decisions will take place (Hogwood and Gunn 1984). In the case of Latvia, more than 50 barriers to energy efficiency were identified by experts and this requires getting answers to the main questions – what are the causes of these barriers and have correct decisions been made when choosing and implementing policy instruments?

For the purpose of good decision making and knowing the causes of barriers, questions ought to be asked about the three key factors that influence success of a policy instrument for energy efficiency:

1) Is the sequence of policy instruments correct?
2) Is coordination of policy instruments required?
3) Is simultaneous implementation of several policy instruments required?

As illustrated in Fig. 2.6, answers to these questions (represented in Modules H, I and J) feed into the Module F of choice and change of policy instruments that feeds into Module D of causes of barriers to energy efficiency. Alternatively, Modules H, I and J feed into Module G of policy instruments and measures, which then requires regular periodic review (Module K) to assess whether the chosen policy instruments that are being implemented deliver outputs that will allow to achieve the desired result (improved energy efficiency). Such approach is consistent with the principles of sequential implementation of steps of decision making within the policy lifecycle as explained in Section 2.1. of the Thesis.

Problems occur and persist in a system that lacks modules representing key factors (H, I, J). Under such circumstances choices end up having policy instruments and measures (Module G), which are not best suited or are not suited for achieving desired energy efficiency at all. The situation may get worse if policy review (Module K) does not take place and decisions about causes of underperformance and choice and change of policy instruments are dealt with based on insufficient analysis (Hogwood and Gunn 1984) or intuition (intuitive rather than rational decision making) thus contributing to maintaining or strengthening existing or creating new barriers (Blok et al. 2004).

2.2.4.5. Implementation of Energy Efficiency Measures: Building on Existing Analysis (Module E)

The decision making scheme about energy efficiency barriers and policy instruments demonstrates the role of an external source of information and knowledge. Energy efficiency is not a new sphere of policy; it has been researched thoroughly including research on barriers and policies to overcome barriers (Bertoldi and Boza-Kiss 2017; Rogge and Reichardt 2016; Wilson, Pettifor, and Chryssochoidis 2018). Exploring existing body of knowledge is the least resource consuming approach to find out more about energy efficiency prior to making own decisions about policy instruments: empirical and theoretical studies are a valuable and necessary resource of information. The problem, however, is that oftentimes authorities responsible for policy planning tend to adopt decisions based on *ad hoc* principles (Rosenow et al. 2016) and intuitive decision making models.

In an ideal process, many elements, which are included in the model (see Fig. 2.7), have a specific role, and ignoring any one of these elements influences the rest of the system, creating risks just as explained in detail in Section 2.1. earlier in the Thesis. For example, the situation in Latvia shows that correlation exists between energy efficiency activity (and activity in construction sector in general) and the availability of EU funds as the portfolio of energy efficiency policy instruments is relatively scarce and based on availability of financial instruments, which fall in the category of so-called *carrot* type policy measures, which reward for action taken. Thus, contribution to supplement the EU funds for energy efficiency activities is only one and very typical policy instrument. Choice of other additional policy instruments is scarce and does not contribute to building synergies between a set of policy instruments thus not exploring the available types of policies and policy instruments to full extent or underutilising them. In fact, ng existing pool of knowledge and expertise is contrary to the principle of integrating climate policy in sectoral policies during the decision making process of defining sectoral policy strategies, planning and development documents.

2.2.4.6. Simultaneous Implementation of Policy Instruments (reference to Module H)

One separate policy instrument can be successful given a certain set of conditions is present. However, usually there is more than just one policy instrument involved in making energy efficiency a success. It means that simultaneous implementation of several policies is a standard situation.

Effects of simultaneous implementation of policy instruments or interactions have been reviewed (Cunningham et al. 2013) looking at how interactions are defined and what criteria result in mitigating or enforcing capacity (Wiese, Larsen, and Pade 2017). For example, financing for energy efficiency is essential, especially, when EU funds are available according to financing cycles. Lack of or insufficient own resources lead to a cyclic financing environment, which results in sharp drops in activity related to energy efficiency. Simultaneous implementation of alternative financing would complement the financial framework enforcing the effect of sufficient financial resources being available to target groups during the period when EU funds are not available.

Therefore, according to the decision making matrix (scheme), countries should plan their own budget for financing energy efficiency taking into consideration other financing sources to be able to counteract or balance the cyclic nature of external financing. In other words, counter-cyclic measures and policy instruments should be planned to keep energy efficiency activity stable if not linear throughout the period of time needed to achieve the desired energy efficiency results. It may be 10, 15 or 20 years, which means that planning of energy efficiency policy instruments should have a long-term approach, which also works well when decision making is done in line with climate policy integration principles.

2.2.4.7. Coordination of Energy Efficiency Policies (Module I)

Whenever more than just one policy instrument in support of energy efficiency is introduced at the same time, some sort of coordination is necessary to maximise gains from two or more instruments and avoid a potential situation when policy instruments are implemented disregarding effects like competition between the measures or mitigating effects as discussed above (Wiese, Larsen, and Pade 2017) as well as loss of synergy effect that a better coordination of multiple policy instruments could bring (Wilts and O'Brien 2019).

The importance of coordination of energy efficiency policy instruments cannot be underestimated as it intertwines with simultaneous implementation of more than one policy instrument as well as correct sequence of implementation of two or more policy instruments. Coordination is especially important in a situation where there are numerous barriers to energy efficiency representative of all types – lack of knowledge and information, insufficient or no financial support, lack of regulatory incentives, market failures, absence of market-based instruments (European Union 2018) or other. Numerous barriers require more than just one policy instrument to be overcome (Wiese, Larsen, and Pade 2017), (EC DG Energy 2017) thus creating a situation where policymakers during the decision making process have to choose from a variety of policy instruments (Bordigoni et al. 2016).

Most appropriate policy instruments to tackle specific barriers shall ideally be selected and implemented; a set of criteria (application of multicriteria analysis, like AHP and TOPSIS reviewed earlier in Chapter 2) can introduce consistency in choosing a policy instrument and justifying the choice especially if it is related to influences on state or municipal budget. When elaborating on interactions of different policy instruments, Wiese has analysed those using criteria like effectiveness, static or dynamic efficiency, institutional requirements and governmental concerns, coming to conclusion that policymakers shall assess the interactions between policy instruments looking beyond direct impacts of combinations of policy instruments, as certain aspects relate to social and welfare influences. It has also been argued that factors like scope of the policy instrument, timing of implementation and steering mechanism shall be used to analyse interactions between policy instruments and their mitigating or enforcing effects (Wiese, Larsen, and Pade 2017).

2.2.4.8. Sequence of Energy Efficiency Measures (Module J)

Correct sequence of implementation of energy efficiency policy instruments in Latvia has been one of the factors having negative influence on overall energy efficiency. In fact, it is difficult to talk about a correct sequence of implementation of policy instruments as any sequence has depended on availability of resources/funding. Also, measures have been focused mainly on insulation works while, for example, deep renovation is a rare occurrence. Once again, picking the low-hanging fruit approach has dominated. One can say that the simplest measures are implemented mainly because of financial aspects: insufficient overall financing, fear to invest, long payback period, expensive to borrow money, very few ESCOs, lack of understanding of how energy efficiency financing works, etc. Scarcity of instruments that rely on availability of financing excludes applying a sequence of measures.

The principle of a correct sequence could be applied if additional or more than just one policy instrument would be available to support energy efficiency measures and policy instruments would be part of a set where one instrument complements another and there is certain logic behind introducing policy instruments in a particular order (Wiese, Larsen, and Pade 2017).

Policy making involves various types of environments and elements that range from rational and quantifiable to irrational, based purely on political will of participants of decision-making process at various stages and because of a multitude of reasons. Decision makers ought to try to rank the barriers and policy instruments to overcome the barriers trying to figure out priorities ideally stemming from results of multicriteria analysis or modelling methods such as system dynamics (Module G) analysis that allows ranking issues as part of a complete set of policy analysis processes and factors.

To avoid mistakes and costly errors, policy analysis must be factored into decision making about energy efficiency policy instruments. Also, using a combination of quantitative and qualitative analysis will produce the best results covering the diversity of aspects to be considered when deciding about the most appropriate policy measures. For the purpose of quantification of results of analysis, it is recommended that econometric and system dynamics models are used to analyse impacts of policies on the possibility to achieve the desired results (Module K).

The ideal model would also exploit policy analysis, which focuses on determining the characteristics of issue to be analysed as well as the organisational and political setting of the issue (Hogwood and Gunn 1984). Ignoring the context of processes may lead to dismissing factors, which contribute to creating and maintaining barriers to the desired policy results. Energy efficiency policy is no exemption to this rule.

2.2.4.9. Choice and Change of Policy Instruments (Module F)

The choice of policy instruments shall be done firstly having carried out assessment of the situation in Latvia, experience in other countries and markets, being aware of the barriers to energy efficiency in Latvia, having modelled influences of various factors on achieving improvement in energy efficiency when it comes to scalable events/developments that already have or can potentially have significant impact on the overall energy efficiency performance of the country. The choice of new or change of existing policy instruments should take into account results of policy review aimed at establishing, which policies have succeeded in achieving better results and which have failed and need either to be terminated or amended (Bariss et al. 2017).

Furthermore, policy mix or interaction between various policy instruments must be assessed ex ante if a new policy is being considered or ex post if existing policy has come to an end (International Energy Agency 2017). Success in overcoming existing barriers to energy efficiency must be analysed from the perspective of the three key factors – simultaneous implementation, coordination and sequence of implementation of policy instruments.

Policy review cluster (Modules K to P in Fig.2.7) comes into play always when existing policy instruments need to be assessed the key point of reference being whether energy efficiency targets have been achieved and if further action is required to progress towards the desired results. Results of action taken within this cluster feeds input into the choice and change of policy instruments module (Module F) leading to new decisions that have to deal with causes of barriers. In theory, if steps in the scheme for adopting decisions on energy efficiency are not skipped, unsuccessful policy instruments will be terminated (Module M) or amended (Module O) and will not reach the beginning of a new cycle of implementation of policy instruments.

If the desired results for improving energy efficiency are not achieved by employing one or more policy instruments, this shall be revealed by policy review and through comparing situation with examples and studies in external sources of knowledge (Module E). Such a process should be sufficient for the purpose of effective policy making allowing at the same time to identify errors and solutions.

2.2.4.10. Policy Instruments and Measures (Module G)

Analysis of factors causing barriers shall be carried out (using multi-criteria analysis or system dynamic) to eliminate or minimise barriers, and the most appropriate policy instruments for overcoming barriers under the particular energy efficiency market conditions shall be identified and implemented. Although policy instruments usually have to be prepared and adapted to a specific situation, environment, circumstances, generic policy instruments or generic sets of policy instruments exist that can be applied in almost any situation (EC DG Energy 2017). The question is whether analysis has been done to establish, which policy instruments are going to be best suited to achieve the desired energy efficiency results. According to the logical scheme of decision-making once the process has reached the module of policy instruments and measures (Module G), it is up to regular policy review (Bariss et al. 2017) to monitor and assess success of policy instruments that are being implemented.

Typology of policy instruments has already been illustrated above when outlining the categories of barriers. Policy instruments that tackle barriers can also be categorised in other groups; those pertaining to the supply side and those pertaining to the demand side. Certain types of policy instruments can be attributed to both sides of the market, affecting both supply as well as demand side (Wilts and O'Brien 2019). One can also elaborate on types of policy instruments further as those can be categorised as mandatory, voluntary or mixed (Economidou et al. 2018), or as being price-based, quantity-based or having form of obligation schemes (Godinho et al. 2017).

Still, the potential of all policy instruments must be assessed prior to pinpointing to instruments or combination of instruments. According to the logical scheme of decision making this process has its place ideally at the beginning of policy-making process (Module F) or, once decisions have been made, during policy review (Module K). Regardless of what stage policy making is in, there are certain aspects to consider when deciding about policy instruments – relevance, impact of implementation, acceptance and consistent approach to implementation (Wiese, Larsen, and Pade 2017). These aspects encompass analysing a broad range of issues (EC DG Energy 2017) like barriers (Blok et al. 2004), mitigating and amplifying effects, availability of services, technologies (Cialani and Perman 2014) and financing (Johansson and Thollander 2018), consumer behaviour, information and awareness (Economidou et al. 2018) as well as compromises with other policy areas while competing for [often limited] resources (International Energy Agency 2010).

2.2.4.11. Policy Review and Deciding about Policy Instruments (Module K)

Regular policy review must be an essential element in the process of policy implementation. Policy review is part of policy analysis that allows assessing whether policy instruments that are being implemented are succeeding in achieving the desired result of the policy when policy was adopted, and allows making evidence-based decisions about terminating, continuing or amending existing policy instruments, or introducing new policy instruments instead of the terminated or in addition to existing ones (Klinckenberg and Sunikka 2006). Referring to classic policy analysis means that assessment of exiting policy or policies have to be carried out not only before and after the planned period of implementation of a particular policy, but also at a set moment or several moments during the implementation of a policy.

Authors of this article suggest that basic simplified approach to analysis of policy choices would involve at least measuring policy instrument's effectiveness (most positive impact with least cost) (International Energy Agency 2018) and required urgency of action the latter having direct relation to actual physical condition of infrastructure and the rate of deterioration of this infrastructure if left unattended in terms of improving energy efficiency. Analysis would be expected to have been done already during the inception phase of policy making to avoid extra costs associated with need for major corrective actions if the chosen policy fails to achieve the desired results (Bariss et al. 2017).

As few energy efficiency policy instruments have been employed in Latvia thus far it is particularly relevant to review the current approach to assess whether existing policy instruments have been satisfactory in achieving policy goals – an improved energy efficiency.

Low and slow uptake of energy efficiency measures in the housing sector indicates the lack of success of the chosen approach so far. It is preferable that sector by sector assessment is carried out and conclusions drawn considering the proportional share of each sector in achieving the overall energy efficiency goals. There would normally be more than just one policy instrument to review and review might also involve deciding about introducing instruments, which correct errors created by past or existing instruments (Blok et al. 2004).

Policy review would normally result in one of four ways (as identified above) for each implemented policy instrument. If energy efficiency targets have been achieved and it is deemed that no further energy efficiency-specific policy instrument is needed (Module L) then a decision can be made about termination of existing policy instrument (Module M). If energy efficiency targets have not been achieved yet, but analysis shows that a particular policy instrument is succeeding towards the set goal, decision can be made to continue pursuing existing policy instrument (Module N) for a set period of time when policy review shall be repeated again (Module K). If existing policy instrument indicates only partial success, then decision can be made about amending the existing policy (Module O) to make it more successful in terms of achieving the desired result. Last, but not least, if any of existing policy instruments have had to be terminated for the reason that it did not work properly or the contribution of existing policy instruments was not sufficient enough to achieve the desired results, it can be decided to introduce a new policy instrument as a replacement or in addition to the existing ones. A set of criteria can be used to assess whether a particular policy instrument has been or is still successful (for example, using a simple multi-criteria decision analysis, or system dynamic).

After this point the decision-making flow feeds back to choosing and changing of policy instruments (Module F), which was the beginning of the initial loop. Decision-makers would be expected to make choices again based on the policy review results and their knowledge and information about barriers to energy efficiency, their causes and assessment of the three key factors influencing the success of adopted policy instruments referred to above – simultaneous implementation, coordination and correct sequence of policy instruments.

The results of the case study are elaborated in detail in Chapter 3 providing explanation and conclusions about the gains from using this approach to achieve optimal results from adopted energy efficiency policies.

2.5. Climate policy integration

Climate policy integration as an approach of policy planning has experienced increased interest and application over the last decade. This is confirmed by the EU energy and climate policy and related strategic and sectoral policy documents and legal acts, e.g. Europe 2020 Strategy, where climate change and energy is one of the five key directions of action (European Commission 2010).

Climate policy integration method was chosen to analyse the influence of policies and policy instruments included in Latvia's National Energy and Climate Plan for year 2030 owing to its particular focus on climate policy. Based on such analysis, conclusions about the country's ability to reach the set climate goals were drawn in yet another case study represented in this Thesis.

The definition of climate policy integration explains CPI as "integration of activities that minimise climate change and allow adaptation to climate change on all policymaking levels and during every policymaking stage in other policy sectors, supplemented by including climate change mitigation and adaptation policy impact assessment in the overall policy assessment, and commitment to minimise contradictions between climate policy and goals and policies and goals of other sectors" (Mickwitz, Per; Aix, Francisco; Beck, Silke; Carss 2009). According to this definition, climate policy goals are given higher priority in policy sectors not associated with environment and climate, and integration of climate policy goals should be reflected in general as well as in sector-specific policy planning and strategy planning documents and defined policy outcomes or reduction of GHG emissions (Dupont, Claire; Oberthür 2012; Dupont 2011).

Policy assessment according to the Climate Policy Integration method allows getting answers to four key questions (Dupont, Claire; Oberthür 2012):

1) Do policy sectors have functional overlap and what kind of overlap – is there a direct or indirect overlap of sectoral policies and whether policies are in a mutual conflict or create synergy?
2) Does political commitment exist to define overall climate goals and within sector-specific policies?
3) Does political commitment exist to reflect climate policy integration in institutional and policy context?
4) Does CPI influence policy outcomes?

Development of different sectors of economy is determined by many policy areas and climate policy cannot be looked at as separated from these other policy areas. Climate policy aspects must be looked at in an integrated way as a horizontal element of policy that must be included in every policy of every sector of economy (Andrew Jordan and Lenschow 2010b) with the goal of averting potential risks associated with juxtapositioning and competing interests between climate and other policies and lack of integration of climate aspects into other policy areas. In other words, the principle of climate policy integration should be implemented going beyond simply defining climate policy as a priority (Adelle, Camilla; Pallemaerts, Marc; Chiavari 2009).

At the same time, overall goals of economy and development of society as well as specific sectoral policies should be analysed by assessing whether and to what extent climate aspects have been included in a policy. It is relevant to identify what goals have been set, do those goals include climate aspects, do directions for action and activities (policy instruments) oblige to obey climate goals, and whether climate aspects, if included in sectoral policies, are actually being observed and implemented (Runhaar, Driessen, and Uittenbroek 2014).

Climate policy integration into other policies as well as synergy of a variety of policies with climate policy is critically important to achieve optimal implementation and influence of involved sectoral policies. Lack of synergy or even competing interests do not allow optimal implementation and influence of climate policy creating so called *suboptimal solution* situation, which has negative impact on achieving long-term and strategic climate policy goals (Adelle, Camilla; Pallemaerts, Marc; Chiavari 2009).

The emphasis of the evaluation of the degree to which climate policy is integrated into other policies should be on answering the question "where should policy integration be found?". Political will or commitment to integrate climate policy in policies across the spectrum of sectors of economy needs to be exercised by including climate policy goals and priorities through various formal channels at various levels. For example, integration of climate policy goals must be reflected in long-term development strategies, such as *umbrella* policy programmes covering all sectors of economy as well as sectoral strategy documents, and at the level of specific policy instruments used to actually implement strategies and policies, for example, primary and secondary legislation, taxes, subsidy and other support schemes, informative and educational materials, etc. The idea of climate policy integration is about achieving actual changes that contribute to climate change mitigation that can be measured in terms of policy outputs and results (Mickwitz, Per; Aix, Francisco; Beck, Silke; Carss 2009).

It must be noted that from the assessment of separate NECP2030 policies it can be concluded that 1) micro-level assessment does not identify impacts and influences – the set policy instrument has no direct impact on climate policy and serves only as a precondition for the implementation of other policies; and 2) macro-level assessment, using such an approach allows comparing and assessing interaction of policies, but in that case, there is insufficient detail to assess potential policy impacts on micro-level.

The logical scheme according to which the impact of policy *X* on climate policy is assessed is represented in Table 2.3. Following six factors are used: 1) political commitment, 2) functional overlap, 3) policy instruments, 4) weight, 5) time perspective, and 6) cost of GHG reduction. The latter factor has been added to the original scheme with the purpose of assessing the impact on the prospects of achieving climate goals of such an important factor as levelized cost of energy (LCOE). The identified factors are analysed by using following four criteria: 1) is a factor neutral? 2) does policy *X* create synergy with climate goals? 3) are policy goals defined clearly in a policy? 4) does policy *X* conflict with climate policy?

Table 2.3.

Interaction of policy and policy instrument with climate policy. Assessment of interaction of climate policy with policy *X* is represented as follows: A1=0 or 1, where 0 means that the Factor does not correspond the Criterion and 1 means that the Factor corresponds the Criterion. Adaptation of the Table from (Kettner and Kletzan-Slamanig 2020).

Policy / Policy instrument				
Criterion **Factor**	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	[A1] Commitment to achieve climate goals is formulated as motivation (no other conflicting goals)	[A2] Commitment to achieve climate goals is formulated as the main motivation (no other conflicting goals)	[A3] Climate goal commitment exists along with conflicting goals of other policies	[A4] No specific climate goal commitment and existing commitments conflict with goals of other policies
Functional overlap (B)	No overlap between policy goals	Policy goals facilitate or strengthen climate policy	Policy goals are in partial synergy and partial conflict with climate policy	Policy goals obstruct or work against climate goals
Policy instruments (C)	Policy instruments do not influence GHG emissions	Policy instruments facilitate reduction of GHG emissions	Policy instruments facilitate both GHG increase and reduction	Policy instruments (potentially) increase GHG emissions
Weight (D)	No correlation between policy goals	Climate goals have higher priority as a matter of principle	Climate goals have higher priority under certain conditions	Other policies have priority over climate policy
Time perspective (E)	NA	Policy reflects long-term climate policy goals	Policy includes medium-term climate goals	Short-term policymaking
Cost of GHG reduction (F)	[F1] Policy financing is not related to financing for other solutions	[F2] Policy has positive interaction with other solutions	[F3] Policy both positively interacts and conflicts other solutions	[F4] Policy is in conflict with other solutions in other sectors

Elements of the climate policy interaction scheme overlap in certain aspects with the ideas formulated by Edomah and others that all sociotechnical transitions that need to bring about change can be attributed as belonging to one of three types of transition: interim, deliberate and transformative (Edomah, Bazilian, and Sovacool 2020). Timely and successful integration of CPI principle in sectoral policies can significantly contribute to how smoothly transition from one stage of sociotechnical transition to the next stage takes place. Generally, synergies between policies are more likely to happen when policymakers integrate climate policy aspects into sectoral policies from the very beginning and during early stages and decision making steps of policy lifecycle.

The climate policy integration approach is represented in Chapter 3 to analyse the inclusion of and the effect of climate policy/-ies in Latvia's NECP2030 through a case study on the group of horizontal policy measures in the NECP2030.

3. Results and discussion

Chapter 3 (Results) reviews methods and approaches to analysing policymaking relevant to energy and climate policies that lead to climate neutrality through sociotechnical transition with examples represented by case studies, which focus on highlighting the relevance of applying methods of analysis in decision making throughout the policy lifecycle.

Energy and climate policy outcomes depend on the quality of decision making throughout all of the policy lifecycle, be it policy inception, choosing policies, policy implementation and monitoring, or policy evaluation and review. Chapter 3 represents results of analysis of decision-making and policies on energy efficiency, renewable energy (RES), agriculture and climate goals. The approbation of methods and approaches to analysing energy and climate policy that have been described in Chapter 2 is carried out through several case studies related to renewable energy, climate and energy efficiency policy planning and implementation.

Renewable energy sources (RES) and energy efficiency are two elements (out of several) essential for the change towards carbon neutrality. Chapter 3 discusses the importance of analysis and methodological approach in decision making and policy making throughout policy lifecycle in achieving the desired goals through choice of policy instruments and measures. The following methods are approbated in Chapter 3 in the following order: linear regression, MCDA (AHP and TOPSIS), *hugs, carrots and sticks*, decision tree, and Climate Policy Integration.

3.1. Results of analysis of NECP2030 policy impact on agriculture sector (Regression analysis)

Agriculture is one of the key sectors in any economy, not least because it produces and supplies food that society consumes every day. Agriculture is also among sectors of economy significantly contributing to greenhouse gas (GHG) emissions. It does so through a variety of processes including but not limited to land and livestock management, manure management, crop farming. Agricultural activity involves use of technologies and processes, techniques of farmland treatment and use of fertilisers to make farmland more productive or prevent diseases in agricultural crops. Therefore, there are many ways in which agriculture impacts environment and climate.

Given the impacts of the agricultural sector on environment and climate it is essential to measure changes in the sector to be able to identify and prevent processes that have negative impact on environment and climate and also to measure progress towards minimising these impacts. This study focuses on the efficiency of investment and its friendliness towards environment – use of nitrogen fertilisers and whether and how use of fertilisers is related to investment in agricultural land and whether investment is related to wealth and ability to invest. Furthermore, the study attempts to identify potential weaknesses in agricultural policies leading to the ways investment in agricultural productivity is taking place and how that may be related to decision making in the policy lifecycle.

The framework for measuring progress in agriculture sector stems from the EC Communication about agri-environmental indicators and indicators reflecting the state of environment in the land use, land use change and forestry sector (European Commission 2000) and the EC Communication about the statistical information required to measure the integration of environmental factors into the Common Agricultural Policy (CAP) (European Commission 2006).

Among agri-environmental indicators, nitrogen has a special place. It is the most widely used fertiliser for increasing agricultural productivity. It also has substantially higher impact on environment than other types of greenhouse gas emissions: one kilogram of nitrogen oxide (N_2O) is equivalent to 298 kilograms of carbon dioxide (CO_2) (Latvijas Republikas Ministru kabinets 2018). Latvia's National Energy and Climate Plan 2030 (NECP2030) also notes that management of organic soils and use of nitrogen fertilisers are key sources of GHG emissions related to agricultural tillage (Latvijas Republikas Ministru kabinets 2020). Nitrogen contributes to eutrophication and worsening of water quality not only in direct proximity of utilised agricultural area (UAA), but also in inland lakes and rivers and other water bodies that get contaminated down the stream. In Latvia, nitrogen (fertiliser) contamination ends up in the Gulf of Riga, and the Baltic Sea through the many rivers and streams.

There are international efforts to tackle the impacts of agricultural sector on the water quality in the Baltic Sea. To decrease eutrophication processes in the Baltic Sea, The Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention) restricts activities that are related to the use of nitrogen compounds also in agricultural activities (HELCOM 1992, 2020). Latvia has ratified the Convention in 1994. As a result, concentration of nitrogen compounds in the Baltic Sea has been decreasing gradually since 1994 although remaining seasonally (in Summer) high in its Southern part, and risk of eutrophication remains (Gauss and Bartnicki 2018). The desired benchmark level was not reached in 2017 yet (see Fig. 3.1) with most of nitrogen contamination originating from agriculture sector (Umweltbundesamt 2020), hence so much attention to the use of nitrogen fertilisers and attempts of improving agricultural practice in the Baltic Sea region through change and application of policies and policy instruments.

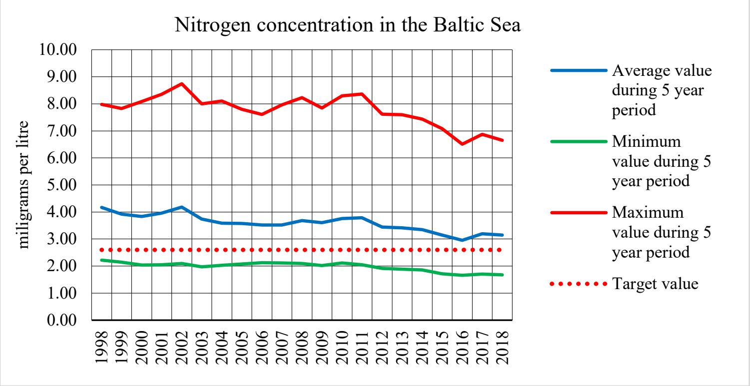

Fig. 3.1. Nitrogen concentration in the Baltic Sea in milligrams per litre (Umweltbundesamt data).

3.1.1. Gross nitrogen balance

Gross nitrogen balance (GNB) as an indicator reflects the potential excess nitrogen or its deficit in agricultural land. The balance is calculated between nitrogen, which is added to the agriculture system and nitrogen, which is taken out of the agriculture system. The calculation is done in kilograms of nitrogen per hectare of UAA annually. The input side of the GNB counts mineral fertiliser application and manure excretion as well as atmospheric deposition, biological fixation and biosolids (compost, sludge and sewage) input. The output side of the GNB represents the removal from grassland (grazing and mowing) and the net crop uptake (removal) from arable land. The GNB takes an “extended soil” surface (or “land” surface) as the system boundary, meaning that it also includes nitrogen losses from animal housing and manure management (e.g. storage) systems (European Environment Agency 2018).

When calculating changes in trends, indicators over a longer period should be taken into account to avoid having occasional extreme weather conditions influence the calculation for a particular year. This indicator ranks Latvia and other Baltic States at the bottom end of the graph of the EU countries meaning a comparatively good gross nitrogen balance (see Fig. 3.2) (European Environment Agency 2018). If normalised per 100 000 inhabitants this indicator places Latvia in the middle of the graph with medium-high results (see Fig. 3.3).

To illustrate the existing correlation between indicators or to demonstrate that there is no correlation between indicators, a group of countries were selected for the purpose of this study from among the EU Member States (plus the UK, which is not an EU member state any more) and included in the reference group for analysis, according to the following criteria: 1) high and low GDP per capita; 2) significant differences in the ratio of high, medium and low-intensity agriculture; 3) differing number of inhabitants; 4) differing volume of used nitrogen; 5) differing input in UAA. Thus, following 11 countries were selected according to the criteria: Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, The Netherlands, Sweden, the United Kingdom.

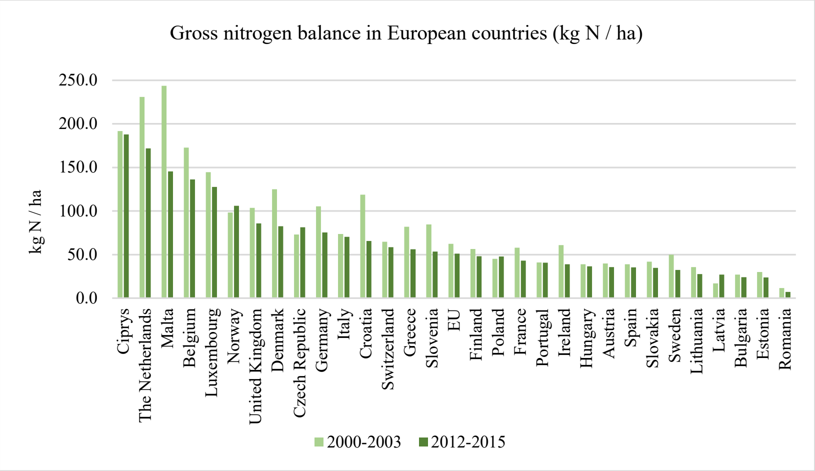

Fig. 3.2. Gross nitrogen balance in European countries in kilograms of nitrogen per hectare of UAA (European Environment Agency, Eurostat [aei_pr_gnb]).

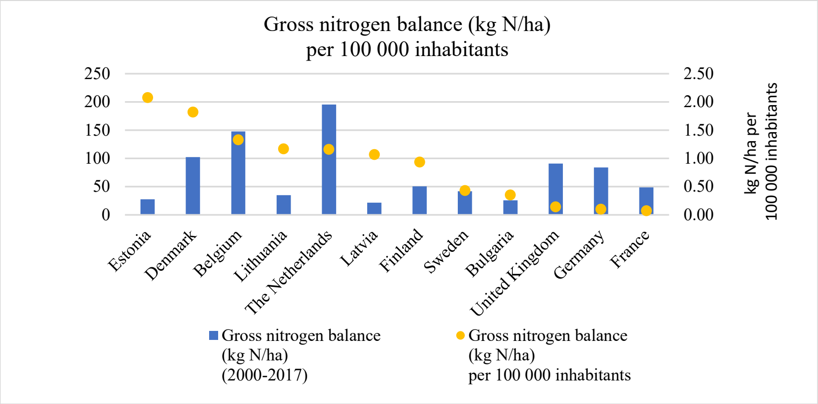

Fig. 3.3. Gross nitrogen balance in kilograms of nitrogen per hectare per 100 000 inhabitants.

EU countries have differing input (expressed in EUR) per hectare of UAA. Absolute figures expressed per 100 000 inhabitants allow drawing conclusion that indicators place countries in different order than if placed according to nominal data. Differences are significant: for example, in The Netherlands and in Belgium input indicators are high both in absolute figures and per 100 000 inhabitants, while input in the Baltic States per 100 000 inhabitants is proportionally higher although absolute figures are low (see Fig. 3.4). One could intuitively draw conclusion that there is correlation between this indicator and the level of welfare (GDP per capita), however regression analysis provided further on refutes such an assumption (see Fig. 3.8).

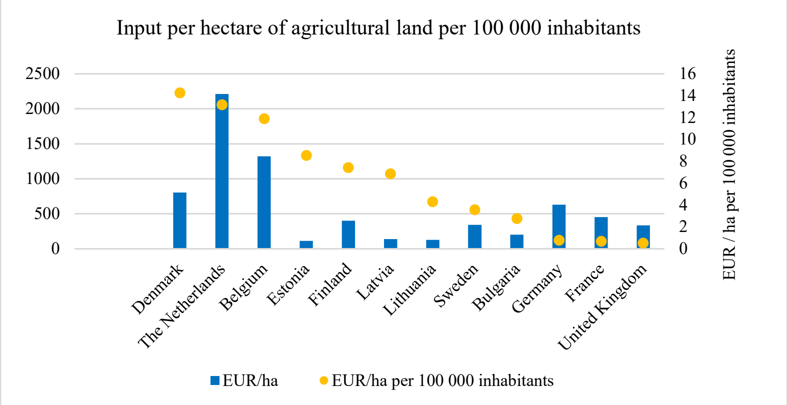

Fig. 3.4. Input per hectare of UAA per 100 000 inhabitants. Data source: Eurostat

In absolute figures the Baltic States are among EU countries that consume nitrogen fertiliser least. However, the correlation of input in euro per hectare of UAA and gross nitrogen balance Latvia’s indicators are on average worse than in countries with higher ratio of high-intensity agriculture (Table 3.1).

Table 3.1.

Gross nitrogen balance (kg/ha), input in UAA (EUR/ha) and the ratio between gross nitrogen balance and input (kg N/EUR).

	Gross nitrogen balance	Investment in utilised agricultural area	Ratio between gross nitrogen balance and investment in utilised agricultural area
	(kg N/ha)	(EUR/ha)	(kg N/EUR)
The Netherlands	195	2 213	0,0882
France	49	454	0,1073
Belgium	148	1 322	0,1117
Sweden	42	343	0,1213
Finland	51	403	0,1257
Denmark	103	803	0,1276
Germany	84	632	0,1328
Latvia	22	139	0,1563
Estonia	28	113	0,2434
United Kingdom	91	336	0,2700
Lithuania	35	128	0,2725

For the purpose of this study it is assumed that countries with GDP per capita below 18 000 EUR are low GDP countries and countries with GDP per capita over 27 000 EUR are high GDP countries (see Fig. 3.5). When comparing gross nitrogen balance by groups of countries ranked by GDP *per capita*, one can conclude that in the group of countries with high GDP *per capita* there is no pronounced correlation between GDP *per capita* and gross nitrogen balance. In countries with low GDP per capita gross nitrogen balance is similar – it is lower and similar in all four countries with low GDP (Bulgaria, Estonia, Latvia, Lithuania), which is illustrated in Fig. 3.6.

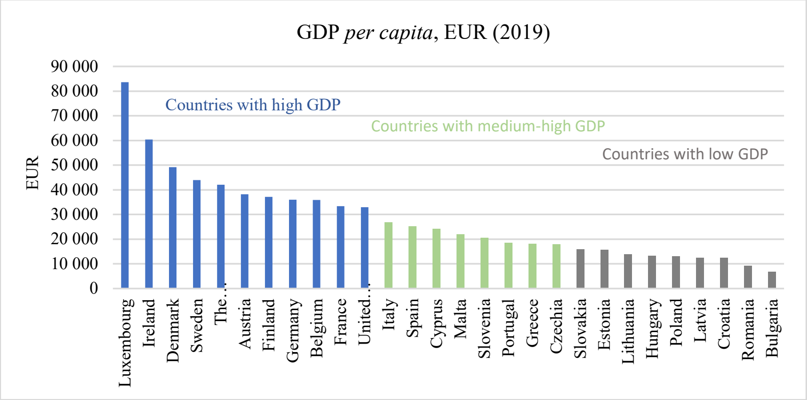

Fig. 3.5. GDP per capita of EU countries, EUR, 2019 (Eurostat).

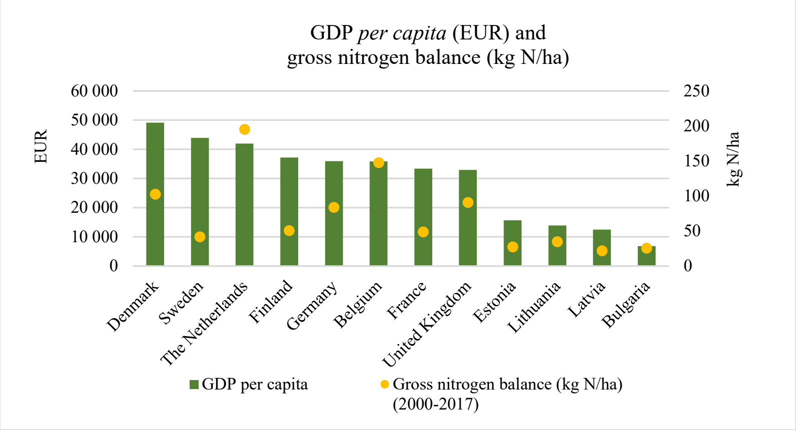

Fig. 3.6. Gross domestic product per capita and gross nitrogen balance (Eurostat, European Environment Agency).

3.1.2. Regression analysis

Regression analysis was used to establish whether there is any correlation, if at all, between GDP *per capita*, input in UAA and use of nitrogen. The result would serve as a marker for possible policymaking issues, showing whether despite relatively high use of fertilisers agricultural productivity is relatively low. First, regression analysis shows that among the countries in the reference group there is high correlation between input in UAA and nitrogen balance: the higher the input, the higher the intensity of agricultural production and the nominally worse nitrogen balance (Fig. 3.7).

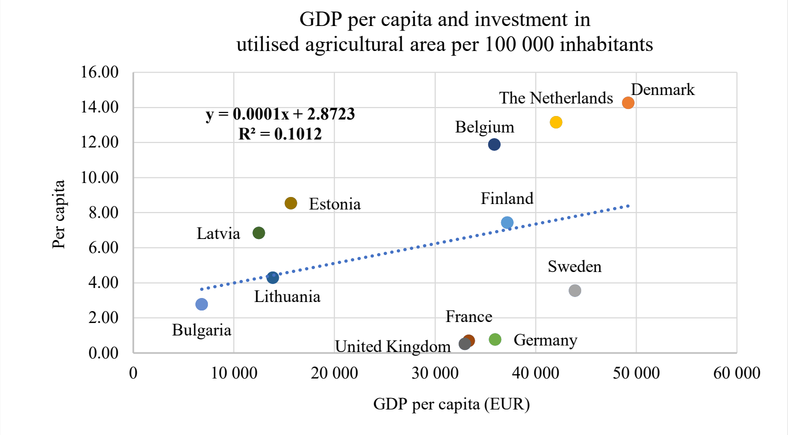

Fig. 3.7. Relation between input in UAA and gross nitrogen balance.

Second, high GDP *per capita* does not necessarily have direct correlation with input in used agricultural area (Fig. 3.8), which is substantiated by result normalised per 100 000 inhabitants.

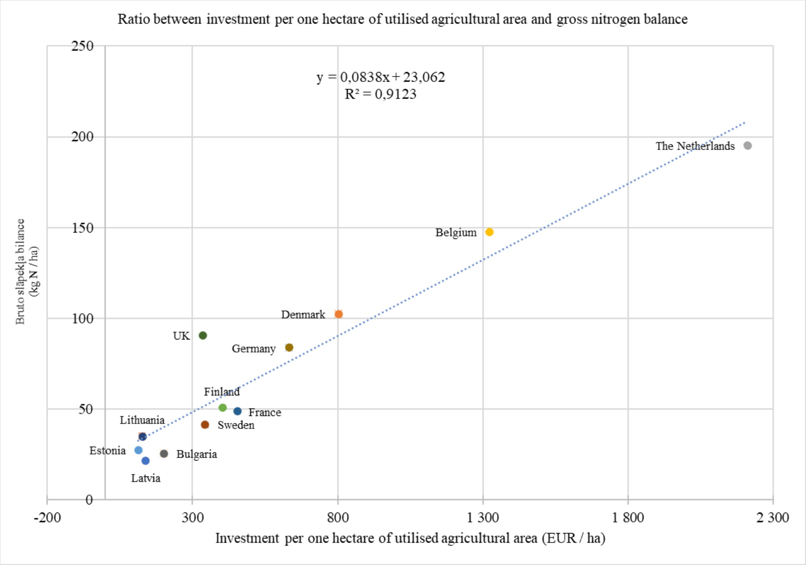

Fig. 3.8. Relation between GDP *per capita* and input in UAA.

Third, regression analysis shows weak correlation between GDP *per capita* and volume of nitrogen per one euro invested in UAA (Fig. 3.9). This may indicate that the efficiency of one euro invested in agricultural intensity is not necessarily related to the wealth of the country. This efficiency may rather be stemming from agricultural policies and practices. For example, the Netherlands, which ranks high in terms of GDP per capita and belongs to the cluster of countries with high intensity agriculture, apparently achieves agricultural results with lower nitrogen volume per one invested euro.

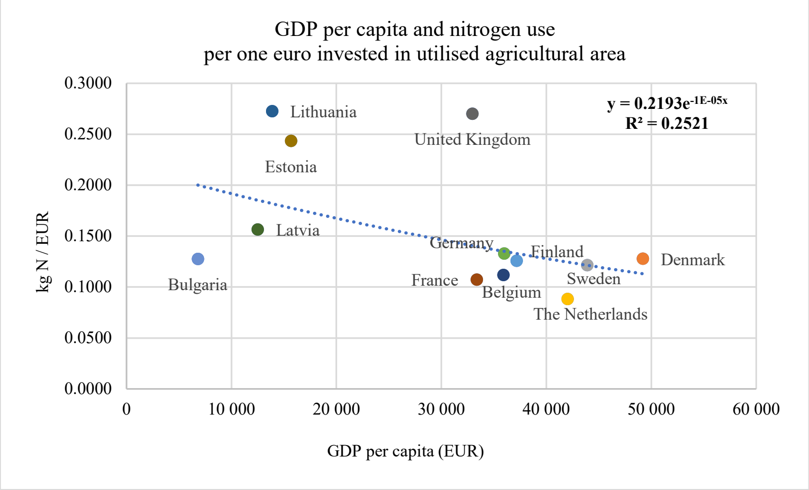

Fig. 3.9. GDP *per capita* and use of nitrogen per one euro invested in UAA.

Nitrogen is key indicator for making conclusions about relationship between farming intensity, agricultural productivity and environmental impact of agriculture. It can be concluded that use of nitrogen as an important fertiliser in Latvia does not provide the desired result. Latvia is among EU member states with the lowest ratio of high and medium intensity farming. Increasing agricultural productivity is associated with a more intense use of fertiliser and land tillage. Raising agricultural productivity by increasing use of fertilisers is a development trajectory associated with risks that have the potential to become an insurmountable obstacle in attempts to achieve NECP2030 agri-environmental goals. The efficiency of investment shall stem from adoption and application of policies aimed at increasing agricultural productivity through change in agricultural practices rather than based on the assumption that higher investment in fertilisers will result in higher efficiency per unit of used agricultural area.

As nitrogen is a critically important fertiliser element, which facilitates growth of the mass of agricultural crops, a more intense use of fertiliser will increase the presence of nitrogen compounds in the soil and in the atmosphere and leaching into water thus having negative impact on environment.

From such a point of view activities included in Latvia's NECP2030 activity direction RV 8 (Effective use of resources and reducing of GHG emissions in agriculture, see Table 3.2) are directed towards decreasing negative impact on environment of the agriculture sector.

Table 3.2.

Activities of NECP2030 activity direction RV 8.

RV 8. Effective use of resources and reducing of GHG emissions in agriculture
RV 8.1 Facilitate and support precise use of mineral fertiliser
RV 8.2 Facilitate fertilisation planning
RV 8.3 Facilitate and support direct incorporation of organic fertiliser into soil (liquid manure transportation via a hose system or a barrel and incorporation into soil through injectors)
RV 8.4 Biological dairy farming (emissions-reducing dairy farming)
RV 8.5 Facilitate planning of feed rations
RV 8.6 Facilitate feed quality improvement
RV 8.7 Reduction of indirect NO2 loss through improved maintenance of drainage systems in agricultural land
RV 8.8 Facilitate integration of legumes in crop rotation to facilitate nitrogen uptake
RV 8.9 Create a map of peat soils on agricultural land
RV 8.10 Support and facilitate broader use of undersowing in cereal sowings
RV 8.11 Support and facilitate use of green fallow prior to sowing winter crops
RV 8.12 Support development of innovative technologies and solutions to facilitate resource efficiency, GHG emission reduction and increase CO2 fixation in agriculture

However, the goals of increasing productivity and increasing income in the agriculture sector create risks that it may not be enough with the activities included in the NECP2030 for achieving the desired environmental and climate goals. Eight out of 12 activity groups can be identified as a *stick*, eight as a *carrot*, and four – as *hugs*. From this perspective balance has been maintained between positive stimuli and compulsory activities. These conclusions must be taken into account during decision making about the choice of policies and during the policy review phase of the current agricultural policies.

3.2. Choice of energy technology by households (Multicriteria decision analysis: Analytical Hierarchy Process and TOPSIS)

When it comes to choosing from a range of options, be it technology or policy, setting priorities is essential. Applying a combination of Analytical Hierarchy Process and TOPSIS can systematise the process of choosing allowing to justify choices based on rational arguments. Section 3.2 of the Thesis reviews two cases of how these MCDA methods can be used for analysis for decision making.

3.2.1. Case: energy technology choices by households

The need, the opportunity, and the awareness of being more environmentally friendly in energy production and consumption creates multiple challenges to the energy system. More active deployment of distributed power generation from renewable energy sources and using climate-neutral energy technologies requires from the energy system to be more flexible and more adaptive to variable power production sources than ever before. The growing number of actors involved in different processes, which make energy system function, sets the stage for a complex system of interactions between those actors. Households are increasingly becoming part of the producing side of the energy system and this trend will continue as electrification of the transport system as well as heating of homes (through heat pumps) will develop. It must also be noted that choice of energy production technology is more affected by the need to produce heat rather than willingness to produce electricity for own consumption. Consequently, the competition is determined by the type of energy that is primarily needed. This aspect must be kept in mind during decision making about the most suitable policies to ensure there is market for particular energy technologies.

Thus, looking forward to a sustainable future energy system is related to national scale energy production as well as choices made on micro level. Although micro-generation technologies are available on the market, few households make choices in favour of using renewable energy technologies for self-consumption and feeding excess power into the grid. As with energy efficiency, there is a broad spectrum of factors affecting deployment of renewable energy technologies in households: technical, economic, environmental, political, social. Decision makers have the responsibility and opportunity to adopt policies that help make the decision in favour of renewables instead of sticking to fossil energy solutions. Therefore, choices in decision making in the policy lifecycle are essential as they can have long-lasting effects, which are difficult and costly to correct.

The results of a study on energy technology choices in households in Latvia by applying a combination of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Analytical Hierarchy Process (AHP) methods indicate that renewable energy technologies represent the most suitable option. AHP method was used to produce criteria weights to be used in calculating ranking of alternatives in TOPSIS and TOPSIS method was used to produce the list of priority ranking.

Ranking of the criteria weights in the AHP analysis shows that the Economic criterion and the Environmental criterion scored significantly higher (32% and 27% respectively) than the Technical and the Political criterion (scoring 17% and 15% respectively). The weight of the Social criterion was assessed as having less than 10 per cent weight in the calculation (Fig. 3.10).

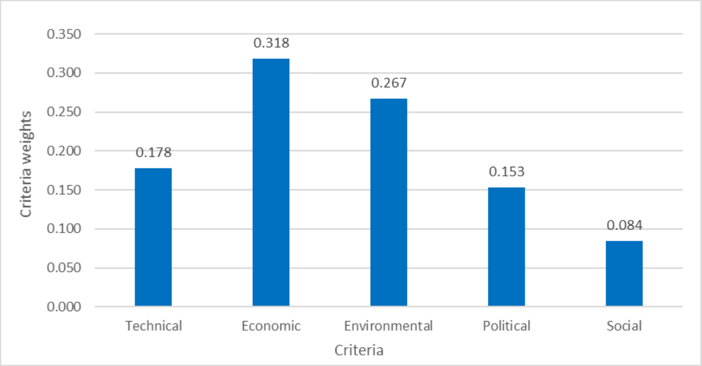

Fig. 3.10. Results of AHP analysis, weights for each of the five key evaluation criteria.

As for the TOPSIS results, analysis indicates that under current conditions Solar thermal (*X a2*) is the technology of choice, followed by Solar PV (*X a1*) and Heat pump (*X a3*) and leaving Biomass (*X a4*) and Fossil (*X a5*) alternatives significantly behind in terms of the score (Fig. 3.11). As explained further in the text (including sensitivity analysis) the top three alternatives have ranked significantly better than the rest as the Environmental criterion has played an important role in the assessment of future energy choices. Such result possibly indicates that decision makers and policymakers can be more affirmative of choosing policies that encourage a more targeted approach to RES technology deployment.

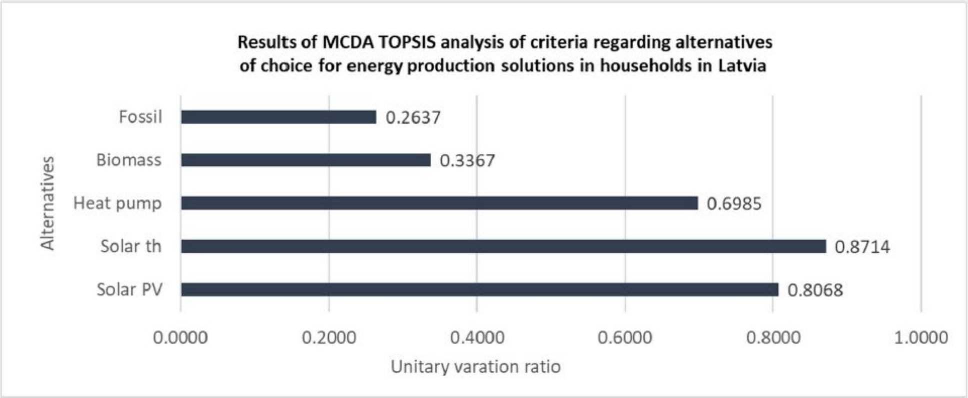

Fig. 3.11. TOPSIS results for the evaluation criteria.

Although analysis indicates the trend of choosing energy technologies that are not related to combustion, changes in factors (criteria) that determine results of the current analysis may have an impact on future choices. Results of the AHP analysis indicate that economic and environmental criteria have higher impact on potential choices with technical and political following and social criterion trailing. Economic criterion is important as it is indicative of energy users' ability or willingness to invest in sustainable energy solutions and potential issues with present bias (Fuerst and Singh 2018). It can be relatively easy measured, and conclusions can be made about it being a barrier or a facilitator to RES deployment depending on economic conditions of energy users and technology costs. Decision makers can utilise this knowledge when preparing decisions and formulating policies, be it during policy inception, policy adoption or policy review stage of the policy lifecycle.

Sensitivity analysis of all five criteria was done to identify whether changes in the weight of any of the criteria has effect on the result and if yes, then what the effect is. Analysis shows that changes in two out of five criteria have potentially significant impact.

Environmental criterion can have significant impact on choices regardless of other factors as it is related to users' attitude and behaviour regarding sustainable energy solutions. Chapter 1 (The role of energy user) elaborates on this topic in more detail, but, in essence, if energy user's positive attitude towards sustainable development translates into action, the weight of environmental criterion increases and probability of fossil technologies being technologies of choice significantly decreases. This is illustrated through sensitivity analysis (Fig. 3.12). This aspect can be factored into policy mix adding elements that strengthen willingness to act and decrease barriers to turning intention into action thus bridging the infamous "intention – action gap" (Masukujjaman et al. 2021).

The political criterion also has the potential to influence future technology choices of households. Regulatory framework (policy instruments) results from decision making and policymaking, which is inherently political. Policies that favour renewables or fossil energy sources are going to influence households' choices. For example, if there are no incentives (*hugs and carrots*) to facilitate microgeneration from RES or net metering while increasing excise tax on fossil gas, deployment of RES technologies will stagnate.

The Environmental criterion has significant impact on the results (Fig. 3.12). It indicates that with the incrementally increasing significance of the weight of the criterion the Fossil alternative (*X a5*) loses its position as a viable option of choice, while Solar PV alternative (*X a1*) has the biggest gains. The other three alternatives are affected only moderately.

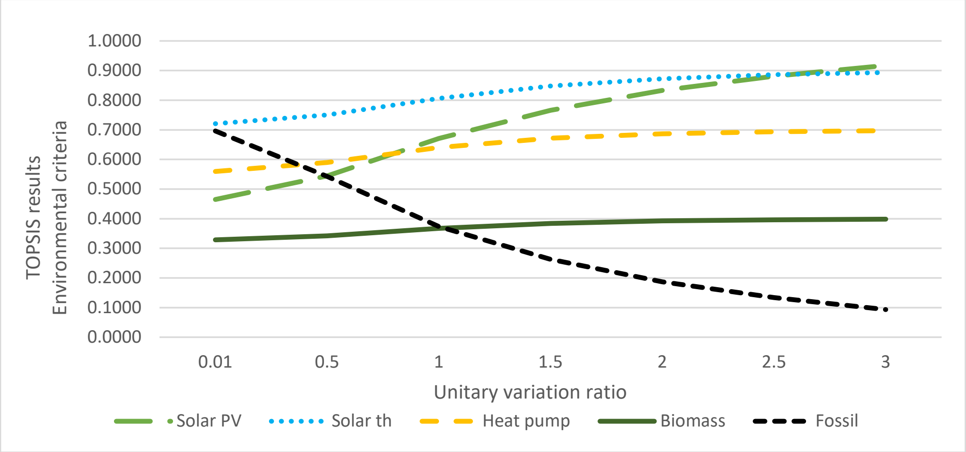

Fig. 3.12. Results of Sensitivity analysis for the Environmental criterion.

Sensitivity analysis of the Political criterion (Fig. 3.13) illustrates that a targeted policy affecting the regulatory and political environment can influence decision making about the choice of one or another alternative by households heavily in favour of the Fossil alternative (*X a5*) and discourage choosing RES alternatives (except for biomass, as it is used for space heating by using pellets and firewood). Sensitivity analysis of the Social criterion produced almost the same results as the Political criterion, thus supporting the argument that individual values and convictions of energy consumers as well as the existing policy context can have an important role in the overall success of deployment of RES in households (Dermont et al. 2017; Ingold, Stadelmann-Steffen, and Kammermann 2019b).

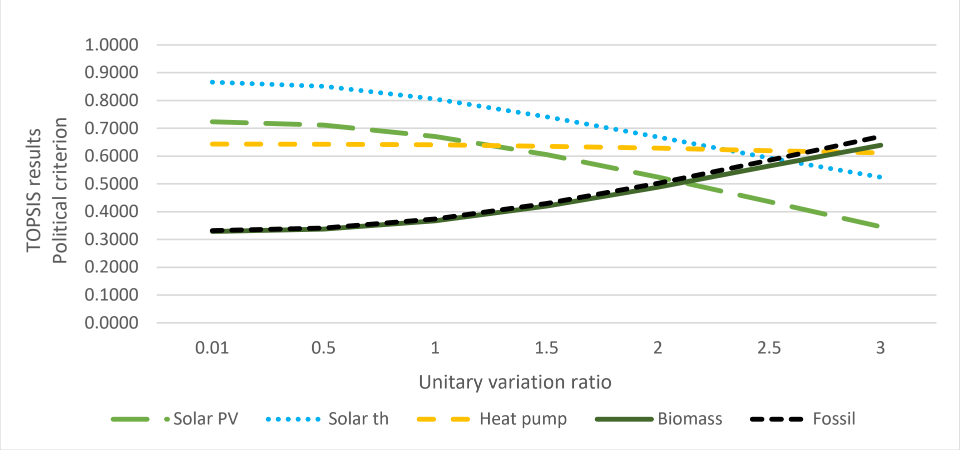

Fig. 3.13. Results of Sensitivity analysis for the Political criterion.

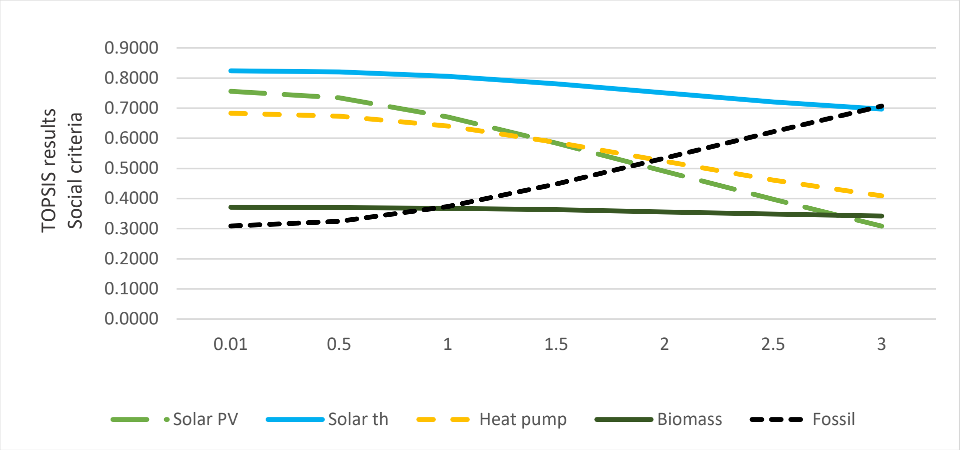

Fig.3.14. Results of Sensitivity analysis for the Social criterion.

Sensitivity analysis of the Technical criterion indicates no radical changes in potential choices if the weight of this criterion increases (Fig. 3.15). One possible explanation is that Economic criterion is more important due to its capacity to influence decisions owing to a set of costs associated with deploying particular technology, be it cost of technology, payback period, maintenance costs or fuel costs. Working lifetime, energy consumption, efficiency, required space, availability of technology, technical support (after-sales support), which would all have relevance, are still considered less relevant to make the final investment decision. Correlation between wealth and the importance of the same criteria in decision making would be an interesting aspect to research further. Economic aspects definitely are at play when a household has to decide about technology choices.

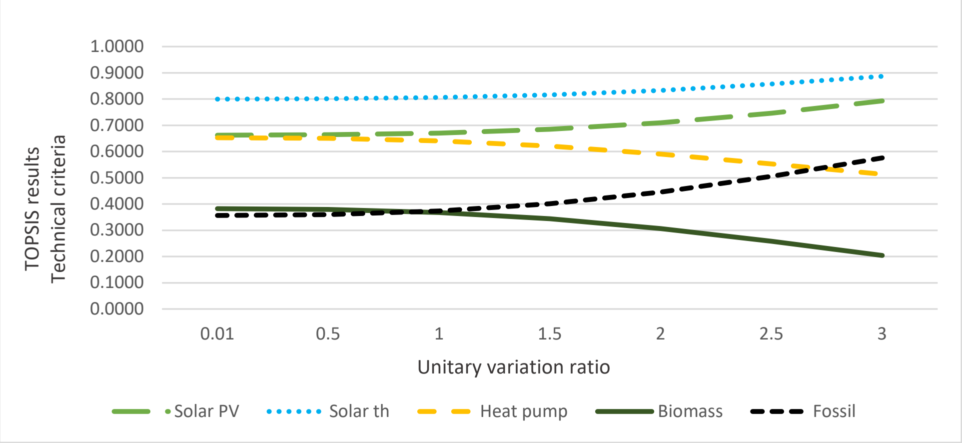

Fig. 3.15. Results of Sensitivity analysis for the Technical criterion.

Economic criterion, which rates highest among the five criteria, has only marginal impact on technology choices. No other alternative apart from biomass technologies shows significant variations, the potential explanation being that the costs associated with biomass technologies are generally regarded as more costly than other choices. This may indicate a need for policies targeting specific technologies if policymakers regard the need to facilitate biomass technology adoption by households as a welcome solution for space heating needs.

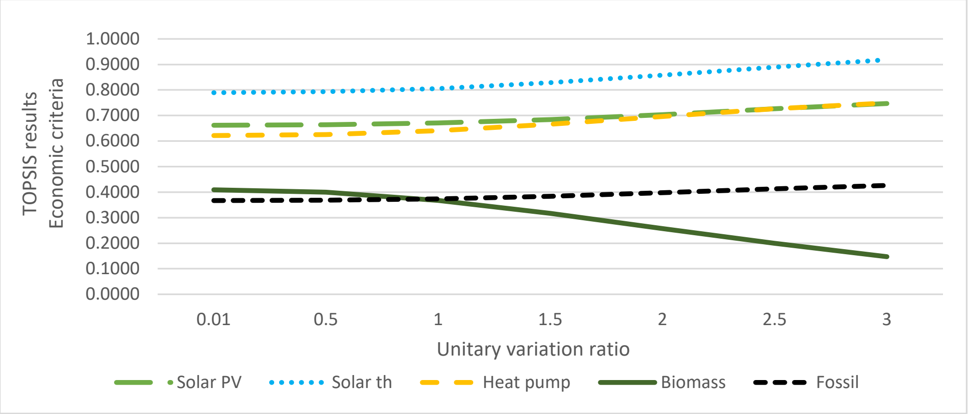

Fig. 3.16. Results of Sensitivity analysis for the Economic criterion.

Thus, this case illustrates the potential benefits from using the combination of AHP and TOPSIS methods for making seemingly simple choices of energy consumers, which, however, can be seriously affected by the choice of policies, which, depending on the alternative chosen, can hamper or facilitate deployment of renewable energy technologies in households.

3.2.2. Case: evaluation of opportunities for RES utilization in agriculture

Agriculture sector encompasses a broad spectrum of activities, including various ways of utilization of agricultural residues (AR). In the case study the options included 1) agricultural reuse of AR, 2) AR as a material for combustion, 3) AR as a building material, 4) AR as a modern biofuel, and 5) AR as a resource for biogas production.

Results of AHP and TOPSIS analysis show that the best possible utilization option of agricultural residues is biogas production, which has a relative closeness coefficient to the ideal solution of 0.66 (Fig. 3.17). The second-best option from the selected alternatives is use of AR as a building material, which has a relative closeness result of 0.63. Results for two other alternatives – the production of modern biofuel and agriculture reuse – show a similar score – 0.51 and 0.50 respectively. Results suggest that AR as a material for combustion is the least favourable utilization option for agricultural residues, which shows a relative closeness coefficient of 0.47.

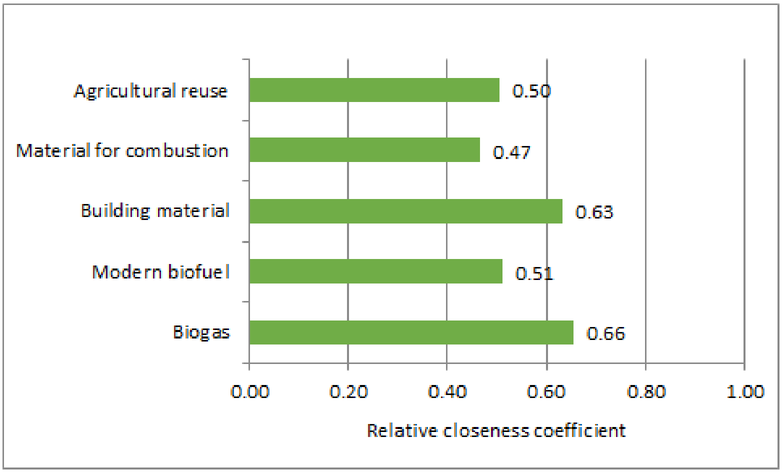

Fig. 3.17. Result with the realistic weights.

To test how the presence of political goals and consequential interventions in relation to RES would change the result, different scenarios were created by changing criteria weights. Equal-weights, economic, climate and political scenarios were selected for testing.

3.2.2.1. Equal-weights scenario

The equal-weights or base scenario was selected to test the ranking of utilization options in situation where all factors are equally important. Basically, this test represents the ranking made by attribute values only. In the base scenario the ranking of utilization options is somewhat similar to the ranking with the realistic weights, however in the base scenario the production of biogas switches places with the use of AR as a building material option (Fig.3.18). Building material option takes the top priority with the highest relative closeness score of 0.71, while biogas is left the second best. The ranking of all the other options matches the realistic scenario.

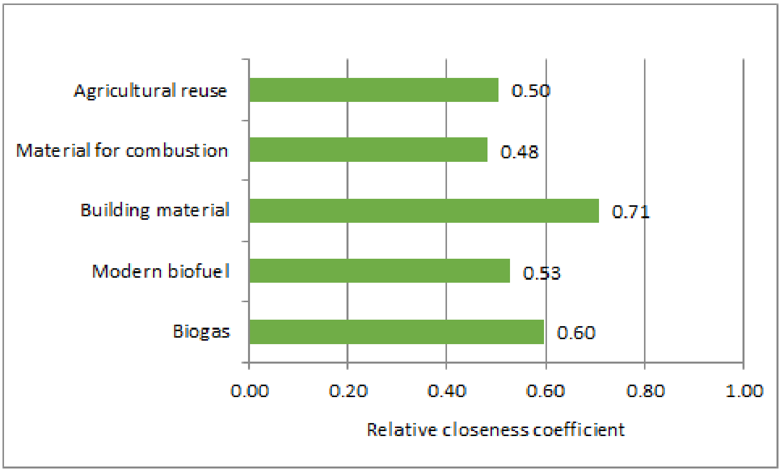

Fig. 3.18. Result of the base scenario with all weights being equal.

3.2.2.2. Economic scenario

Economic scenario was selected to test how the ranking would change if the importance of economic factor was even more pronounced. The weight of economic factor was increased to 50 percent and the weights of all the other factors were calculated proportionally to the realistic weights. Ranking in the economic scenario is somewhat similar to the ranking in the realistic scenario as well (Fig. 3.19). Nevertheless, the bottom priority (use of AR as a material for combustion) is expressly less favorable with the relative closeness score of 0.40, and the top priority (biogas option) is expressly more favorable with the score of 0.72. This represents the variety in values assigned to the utilization options in relation to the economic criterion.

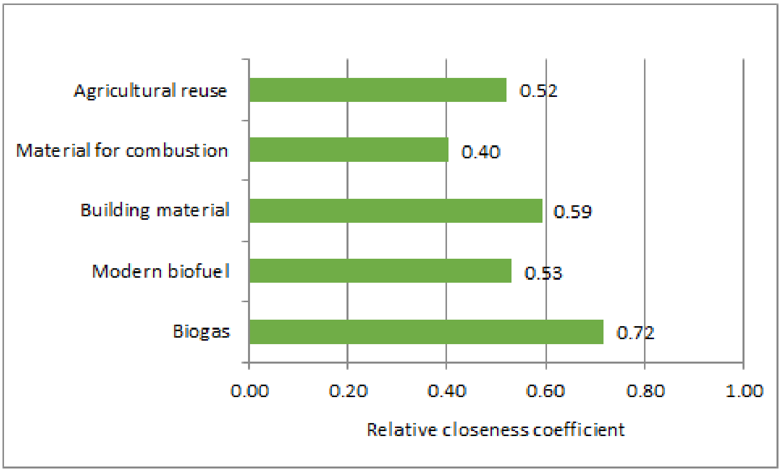

Fig. 3.19. Result of the economic scenario with the weight of the economic factor being 50 percent.

3.2.2.3. Climate scenario

Taking into account the possible increase of significance for the climate factor through growing political targets, the ranking of alternatives was tested with a 50 percent weight of the climate factor. Results of the climate test give a different result than the test with realistic weights (Fig. 3.20). When the weight of climate factor is increased to 50 percent, use of AR as a building material alternative is the most preferred utilization option with a relative closeness coefficient of 0.70. It is followed by us of AR for biogas, modern biofuel, and material for combustion and agricultural reuse.

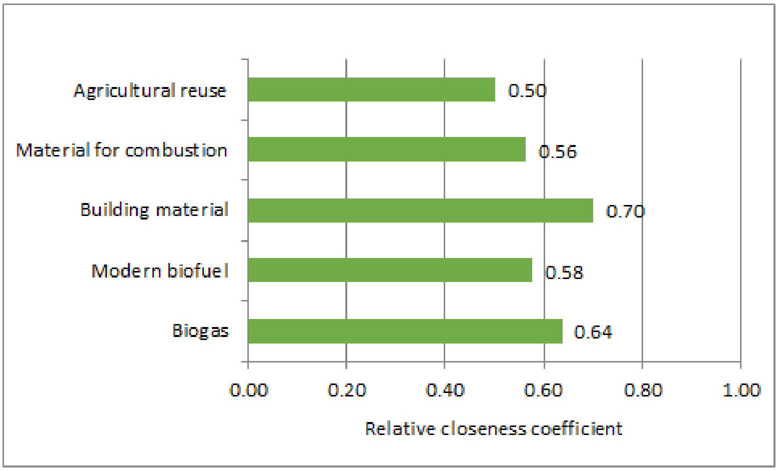

Fig. 3.20. Result of the climate scenario with the weight of climate factor being 50 percent.

3.2.2.4. Political scenario

This test allows to determine the influence of the existing policy and shows how the ranking of favorability for different ways of residue utilization would change if policy was equally favorable to all utilization options. Influence of the political factor was tested by giving the highest attribute value to all products (Table 3.3) and increasing the weight of the political factor to 50 percent. This test differs from the previous ones, as along with the changed criteria weight, attribute values were also changed. It is assumed that the values determined by the political factor can be affected more easily, while values of other factors are a combination of several aspects, which can be more difficult to influence.

Table 3.3.

Modification of attribute values for the political factor.

	Product	Biogas	Modern biofuel	Building material	Material for combustion	Agricultural reuse
	Criteria	x1	x2	x3	x4	x5
i_1	Technologic	5	3	5	5	5
i_2	Economic	5	3	3	1	3
i_3	Environmental	3	4	5	1	4
i_4	Climate	4	4	5	4	2
i_5	Social	4	5	5	4	5
i_6	**Political**	**5**	**5**	**5**	**5**	**5**

When the political factor is of the highest favorability for all utilization options and the weight of political factor is increased to 50 percent the potential success for the use of AR for biogas production alternative is even more expressed with the relative closeness coefficient of 0.75 (Fig. 3.21). As with the realistic values and weights, us of AR for production of building material is the second-best option. Meanwhile, the suitability of agricultural reuse and the production of modern biofuel rank equally and indicate a relative closeness score of 0.56. AR as a material for combustion alternative is even less desirable option than in the scenario with the realistic values and weights. The test shows that the political factor has no significant influence on the ranking of the selected options for residue utilization. Nevertheless, political factor is particularly significant, because it has the power to impact all the other factors.

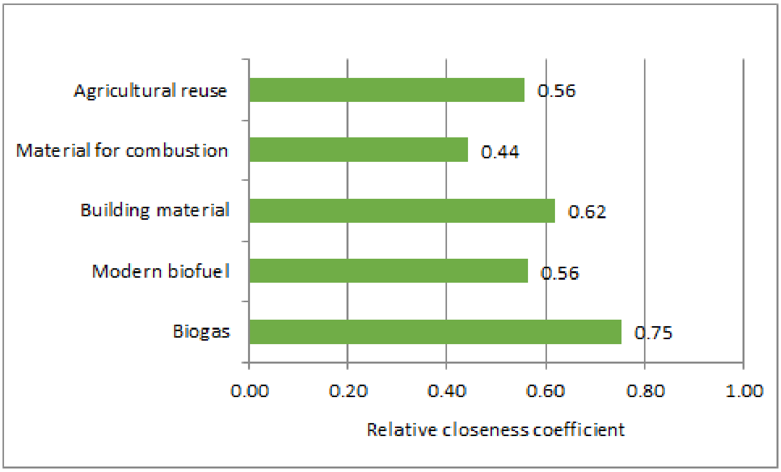

Fig. 3.21. Result of the political scenario with the weight of political factor being 50 percent and highest favorability value.

Use of AR for biogas production, according to the results of the test with the realistic weights, holds a high potential for agriculture residue utilization, and it can contribute significantly to the replacement of fossil fuels. Results for favorability for biogas production from all the tested scenarios are represented in Fig. 3.22.

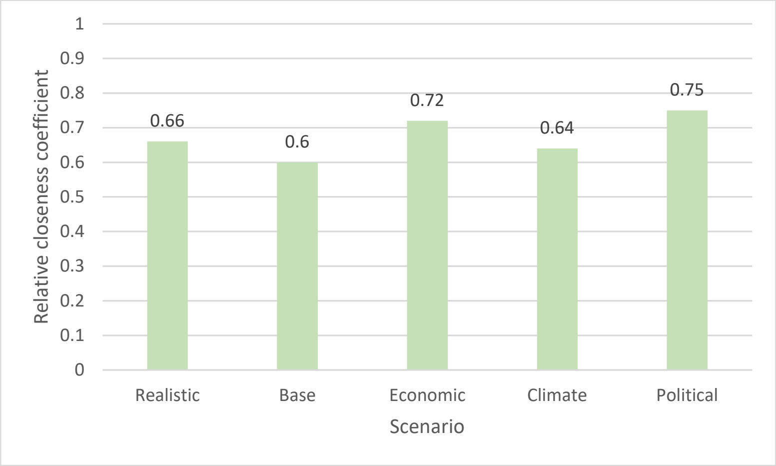

Fig. 3.22. Favorability for biogas production from agricultural residues according to different scenarios.

It can be seen that the highest potential for biogas production might be from implementing the political scenario and increasing the favorability and importance of the political factor by setting respective goals and implementing policy instruments. Economic scenario shows the second-best option for biogas production with a slightly lower score than in the political scenario. This shows that a targeted promotion of economic importance of this resource in the agriculture sector can facilitate biogas production.

3.3. Balance of policy measures in Latvia's National Energy and Climate Plan 2030 (*Hugs, carrots and sticks* approach)

Decision making may be based on complex calculations and in-depth analysis, but it may also be enough to identify the proportion of different types of policies in the policy portfolio to get sufficient understanding about potential issues with existing or suggested policies. *Carrots and sticks* is a colloquial phrase used to describe what type of policies or policy instruments are applied or need to be applied to reach the required result. However, as described in Section 2.2.3. of the Thesis, applying *hugs, carrots and sticks* approach can produce a sufficiently detailed picture of issues and ways to tackle those issues.

To assist decision making on future policies aimed at reaching the defined energy and climate goals, impact of the policies and policy instruments incorporated in the NECP2030 on energy user was forecasted and identified by applying *hugs, carrots and sticks* approach. After assessing and identifying activities and policy measures according to the *hugs*, *carrots* and *sticks* methodology (described in Section 2.2.3.), following results were obtained.

NECP2030 encompasses 255 activities in total. All activities are distributed among 12 activity groups and a separate set of horizontal activities. In three activity groups (designated with initials RV) – RV 8, RV 9 and RV 10 – activities cannot be identified as having significant impact on energy user or having impact on energy user at all. Regardless of that, the activities can and have been identified according to the *hugs, carrots and sticks* (HCS) approach. Activities in all other activity groups and those that have been identified as belonging to one or more categories / type (a *hug* designated as h-type, a *carrot* as C-type, and a *stick* as S-type) are considered as having impact on energy user.

Certain conclusions can be drawn from analysis of the NECP2030 activity types according to the methodology set out in Section 2.2.3. of Chapter 2 (Methodology) on how the activities by type correlate with Strategic Environmental Impact Assessment (SEIA) analysis about environmental impact of those same activities:

1) NEKP2030 is dominated by type A (*hugs*) and type B (*carrots*) activities;
2) The number and proportion of S-type or compulsory activities is significantly smaller than that of H-type and C-type activities;
3) H-type and C-type activities dominate in several activity groups (RV 3, RV 4, RV 6, RV 7, RV 9, RV 12), which causes doubt if this type of activities will be enough to achieve the required changes and the goals set for each respective activity group.

In general, the activities included in NECP2030 can be regarded as sufficient to achieve the goals of activity groups if implemented. However, a detailed look at the proportion of activities by type is necessary to see whether policies chosen to achieve renewable energy and climate goals are well balanced as these conclusions can be essential for decision making during policy definition and policy review stages, as well as when defining completely new policies during policy inception stage of the policy lifecycle.

NECP2030 has 101 activity cluster encompassing 255 activities and policy measures in total. Of the total number of activities 141 activity can be identified as *hugs*, 120 activities as *carrots* and 60 as *sticks*. One and the same activity can be identified as belonging to one separate category (H, C and S) or two categories (H and C, H and S, C and S) or even all three categories (H, C and S) at the same time, therefore the total number of activities by type (H, C and S) can appear higher than the total number of activities.

Activities by type vary within activity groups and among activity clusters of the NECP2030, however, H-type (*hugs*) dominates. The number of S-type (*sticks*) and C-type (*carrots*) activities is equal and their number is higher than that of H-type activities only in the activity group RV 8. The proportion of activities identified as hugs, carrots and sticks varies among NECP2030 activity groups as is illustrated in Fig. 3.23.

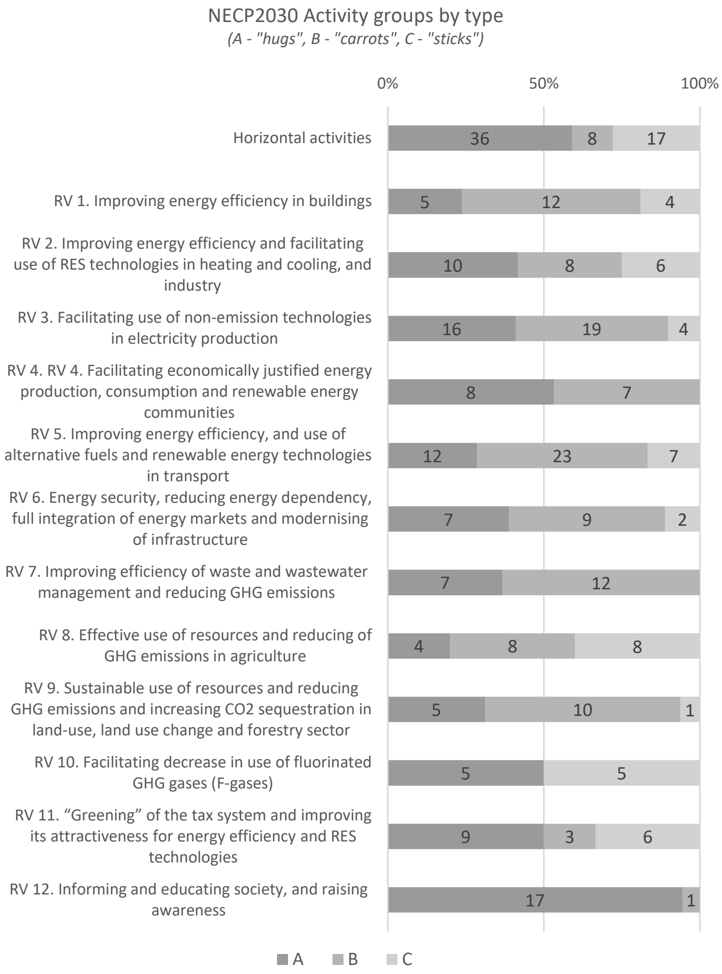

Fig. 3.23. Proportion of activities in NECP2030 Activity groups by type. (Author's own illustration.)

A more detailed overview of results of those NECP2030 activity groups is presented, where according to literature analysis on the relevant topic the dominant type of activity would likely be insufficient to achieve the desired result. Activity groups RV 3, 4, 5 and 7 are reviewed for this purpose in more depth identifying aspects that might turn out to be problematic on the course of achieving the goals of each of the aforementioned activity groups.

Facilitating use of non-emission technologies in electricity production (RV 3)

Activity group "Facilitating use of non-emission technologies in electricity production" has seven activity clusters encompassing 32 activities. 16 of those activities are identified as H-type), 19 as C-type) and four as S-type. According to Strategic Environmental Impact

Assessment (SEIA) of the NECP2030 two groups (1 and 3) out of seven have negative impact on environment, but five (2, 4 to 7) have no impact on environment. Of activities that according to SEIA do not have impact on environment 14 are H-type, nine are C-type and four are S-type activities (see Table 3.4 for illustration).

Table 3.4.

Distribution of activities by type in Activity clusters of Activity group 3 (RV 3).

	Activities (by type)					**Impact on environment according to SEIA**	
Activity groups	Number of Activity groups	Total number of activities	A (*hugs*)	B (*carrots*)	C (*sticks*)	Impact of Activity cluster Positive / Negative	Activity cluster has No impact
RV 3. Facilitating use of non-emission technologies in electricity production	7	31	16	19	4	1, 3	2, 4-7
RV 3.1 Implementing cross-border offshore wind farm projects (in cooperation with Lithuania / Estonia)		5	1	4	0	Negative	
RV 3.2 Reviewing existing conditions for limitations to deployment of RES technologies associated with territory, construction rules and use of land		7	3	4	4		No
RV 3.3 Elaborating conceptual solution for the development of wind farms on land (wind energy production)		6	1	6	0	Negative	
RV 3.4 Facilitating use of solar energy in electricity production		1	1	1	0		No
RV 3.5 Implementing the assessment needed for further development of RES electricity		5	5	0	0		No
RV 3.6 Facilitating trading of RES electricity		4	4	1	0		No
RV 3.7 Supporting development of innovative and energy efficient solutions to increase RES share in the energy system (electricity supply, heating, cooling)		3	1	3	0		No

Activity groups 1 (RV 3.1) and 3 (RV 3.3), according to the authors of SEIA, have negative impact on environment. These two activity clusters, which are related to the development of wind energy, according to SEIA, are the only two activity clusters with negative impact on environment in all of the NECP2030. The goal of activity cluster 3.6 is to facilitate RES energy trading and activities to achieve this goal are H-type and C-type activities while numerous sources suggest that mandatory trading of RES electricity would help to achieve the goal more effectively (Mac Domhnaill and Ryan 2020).

Facilitating economically justified own energy production, consumption and renewable energy communities (RV 4)

Activity group "Facilitating economically justified energy production, consumption and renewable energy communities" has 6 activity clusters encompassing 15 activities. Eight of those activities are identified as H-type and seven as C-type. No S-type activities have been identified. According to SEIA, two groups (1 and 4) out of six have positive impact on environment, but other have no impact on environment. As Table 3.5 illustrates, of activities that according to SEIA have positive impact on environment five are H-type, but no activities have been identified as C-type and S-type activities. Activity cluster RV 4.3 has both H-type and C-type activities. Of activities that according to SEIA have no impact on environment H-type (RV 4.2, 4.3, 4.5, 4.6) and C-type (RV 4.3) activities have been identified.

Table 3.5.

Distribution of activities by type in Activity clusters of Activity group 4 (RV 4).

	Activities (by type)					**Impact on environment according to SEIA**	
Activity groups	Number of Activity groups	Total number of activities	A (*hugs*)	B (*carrots*)	C (*sticks*)	Impact of Activity cluster Positive / Negative	Activity cluster has No impact
RV 4. Facilitating economically justified own energy production, consumption and renewable energy communities	6	15	8	7	0	1, 4	2, 3, 5, 6
RV 4.1 Elaborating legal framework for own energy production and consumption		4	0	4	0	Positive	
RV 4.2 Elaborating solutions to facilitate use of net electricity metering		4	4	0	0		No
RV 4.3 Facilitating development of energy communities and renewable energy communities		3	1	2	0		No
RV 4.4 Facilitating use of RES technologies in farms		1	0	1	0	Positive	
RV 4.5 Facilitating use of RES technologies in public sector		2	2	0	0		No
RV 4.6 Facilitating more effective tariff methodology for electricity transmission and distribution		1	1	0	0		No

In activity cluster 4.5, which has the goal of facilitating use of RES technologies in public sector, two activities can be identified as H-type. Although attempts to make almost-standalone renewable energy systems for buildings cost efficient and competitive, it still appears that grid connections are necessary and incentives are required to facilitate deployment of RES technologies as sources of energy in buildings (Xie et al. 2018) especially if complex solutions with energy storage systems (Marino et al. 2013) and renovation of historic buildings is involved (Galatioto et al. 2019).

Persisting policy and regulatory uncertainty acts as a barrier to the roll-out of RES systems for individual buildings (Cabeza, de Gracia, and Pisello 2018) despite particularly good potential of technologies such as, for example, solar thermal heating (Aivars et al. 2011). Energy user behaviour (Jimenez-Bescos and Oregi 2019) and physical limitations of available space for RES energy installation (Miezis et al. 2016) also play an important role in motivating RES integration as different patterns of use of energy can either hamper or foster use of RES energy.

At the same technological development in sectors such as transport amplify the motivation to integrate renewables into energy systems of buildings – possibility to charge electric vehicles using, for example, solar PV energy, can strongly support the cause of integration of RES (Alanne and Liimatainen 2019). Limited space and concentration of economic activity in densely populated cities with high density of commercial and public buildings is another factor driving research and investment in RES integration in buildings (Huang et al. 2019). Although support policies and incentivisation of integration of RES technologies in buildings dominate as key factors, existing research also suggests that it would be reasonable to introduce obligations and mandatory actions vis-à-vis public sector actors along with incentives. For example, a requirement to assess possibility to integrate RES technologies in case of renovation of a building, thus making the course towards the goal more efficient and purposeful (Fiaschi, Bandinelli, and Conti 2012). These conclusions are essential for decision making throughout the policy lifecycle as keeping the proportion of various types of policies (according to the H, C and S) can determine whether policies are going to be successful.

Improving energy efficiency, and use of alternative fuels and renewable energy technologies in transport (RV 5)

Activity group "Improving energy efficiency and use of alternative fuels and renewable energy technologies in transport" has 14 activity clusters encompassing 34 activities. 12 of those activities are identified as H-type, 13 as C-type and seven as S-type activities. According to SEIA, nine groups (1, 2, 3, 4, 5, 8, 12, 13, 14) out of 14 have positive impact on environment, but others have no impact on environment. Of activities that according to SEIA have positive impact on environment seven are H-type, 17 are C-type and six are S-type activities. Of activities with no impact on environment four are H-type, six are C-type and one is S-type activity.

Activities of cluster 5.8 are aimed at "facilitating use of railway as a backbone of a modern and environmentally friendly public transportation". According to SEIA this activity cluster has positive impact on environment. From the point of view impact on energy user activities of the cluster are H-type and C-type activities. Analysis of factors facilitating change of behaviour of energy users suggests that to achieve the desired goal (facilitate use of public transport) S-type (*sticks*) activities might be needed at least until energy users have adapted their behaviour to the new conditions – they are using public transport instead of private transport, thus contributing to a better and more efficient use of energy (Sussman, Tan, and Kormos 2020). While C-type (*carrots*) activities like providing information (Bamberg 2007), combining information with adapted or new services (Bamberg and Schmidt 2010) is an important factor that narrows the gap between willingness to shift to public transportation actual behaviour (S. Wang, Wang, and Yang 2020), choosing public transportation is a conscious decision affiliated with goal-directed behaviour (Carrus, Passafaro, and Bonnes 2008) that can be affected by interventions that produce change in attitudes (Bamberg and Schmidt 2010) as well as additionally motivating factors such as increasing traffic congestions (Ercan et al. 2017).

Improving efficiency of waste and wastewater management and reducing GHG emissions (RV 7)

Activity group "Improving efficiency of waste and wastewater management and reducing GHG emissions" has 4 activity clusters encompassing 12 activities. 7 of those activities are identified as H-type, 12 as C-type and none as S-type. According to SEIA two groups (1 and 3) have positive impact on environment and two have no impact on environment. Of activities that according to SEIA have positive impact on environment none are H-type or S-type, five are C-type activities. Of activities with no impact on environment one is H-type, and one is C-type activity while there are no S-type activities.

According to SEIA, activities in two activity clusters have positive impact on environment although no S-type activity has been identified to achieve the goals of the cluster. For example, activity cluster 7.1 (Reducing the volume of dumped waste, facilitating sorting, recycling and regeneration of different kinds of waste) has several only C-type (*carrots*) activities that, according to NECP2030, will allow to successfully reach the goal. Similar conclusions can be drawn about activity type in activity cluster 7.3 (Increase the number of households / houses connected to the centralised sewage system in certain agglomerations) where only C-type (*carrots*) activities can be identified currently. *Carrots* may be a welcome type of policy as positive incentives work well in taking down those barriers to activity that are related to availability of financing or lack of support from government and municipalities. However, a good balance between *carrots* and mandatory actions or *sticks* may be required to avoid leaving impression with the target groups that support to taking action is going to be available forever without any limitation of time and scope of support. Target groups must get a clear message that, if no action is taken in certain defined period of time when support is available, the costs of action will shift towards the target group.

3.4. Analysis of factors affecting successful energy efficiency policy (Decision tree)

Energy efficiency is one of the key directions of energy policy aimed at reaching climate goals and it requires long-term approach. However, solutions that are based on long-term policies have greater risk of not getting a proper policy making process than those solutions that can survive under short-term approach (Polzin et al. 2015; Rogge, Kern, and Howlett 2018; Royston, Selby, and Shove 2018; Yaqoot, Diwan, and Kandpal 2016). A proper policy analysis requires time and resources to be conducted, but actual conditions often require decision makers to act swiftly. For example, a need to make decision about allocation of funds that have become available (for example, because of manifestation of political will) or will not be available already soon can create pressure on decision makers. Processes associated with democratic governance, such as voting for priorities, or voting in general or municipal elections may also constitute a factor affecting the process of making decisions and choosing policies. Closeness of elections may also trigger awareness-raising events about how important energy efficiency is or can serve simply as a platform for promising redistribution of limited resources in favour of energy efficiency measures or to the contrary of interests of investing in energy efficiency.

The complexity of achieving higher energy efficiency stems from many aspects of policies that must be taken into account to overcome barriers. Energy efficiency has many aspects and one can distinguish between different categories like energy efficiency in households, in industry, in commercial service sector, and in transport, to name but a few. Whichever category it is, key reasons why energy efficiency is still high on decision makers' agenda is embedded in different types of barriers to energy efficiency, be it on decision making or implementation side.

A scheme of commonly accepted classification of barriers as well as policy instruments is represented in Fig. 3.24. Barriers are grouped in five larger clusters according to their character and issues they are related to. Barriers are associated with information and knowledge, financing, market conditions, technical factors, and with institutional structure and regulatory framework. Policy instruments are grouped in seven bigger clusters, which originate from the logic of application of policy instruments and the way they are associated with certain types of barriers to energy efficiency.

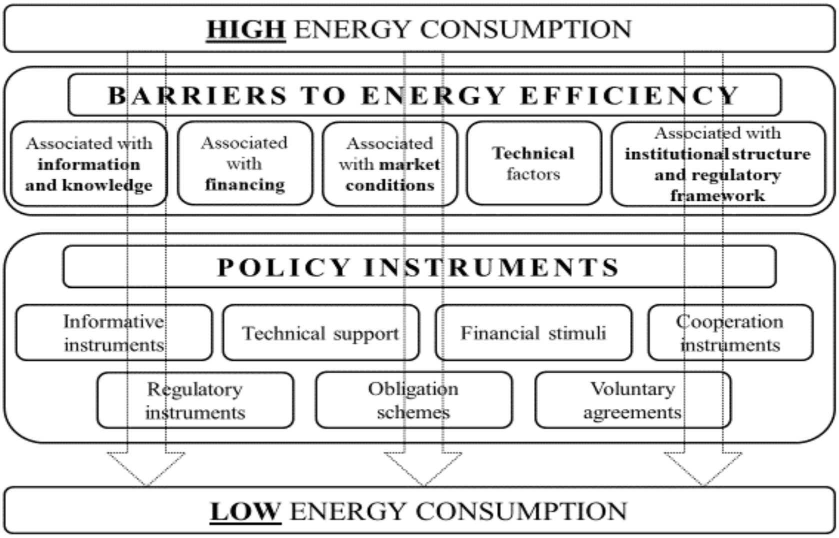

Fig. 3.24. Classification of barriers to energy efficiency and policy instruments to tackle the barriers. (Author's own illustration).

Case study on energy efficiency policy and implementation in Latvia led to a conclusion that lack of financing tools, lack of awareness, complex decision-making about renovation of residential buildings, low level of trust in ESCOs and financial institutions, inability to see long-term gains vis-à-vis investment (present bias) are among the more common barriers.

Another scheme (Fig. 3.25) shows groups of policy instruments depending on whether they belong on the supply or demand side of energy system. It may serve as a platform for building on the debate of creating policy mix for energy efficiency. In this scheme, policy instruments represent the same clusters as indicated in Fig. 3.24 but have been slotted according to their role from the perspective of being related either to supply or demand side. The grouping of clusters has illustrative nature as it visualises policy areas that are typically associated with measures on the supply and demand side. It also points to an area of policies where instruments overlap targeting both demand and supply side mostly through mixed and mandatory instruments.

Policy instruments that "belong" to each of the seven clusters might direct policy-makers' thinking towards introducing combinations of policy instruments (Barbara Schlomann, Clemens Rohde, Wolfgang Eichhammer, Veit Bürger n.d.), which, when implemented simultaneously or launched in the correct sequence, have the potential to create amplifying interaction or positive synergy to increasing energy efficiency activity (Labanca and Bertoldi 2018b). Still, risks of having mitigating (Cunningham et al. 2013) rather than amplifying effects (Wiese, Larsen, and Pade 2017) persist.

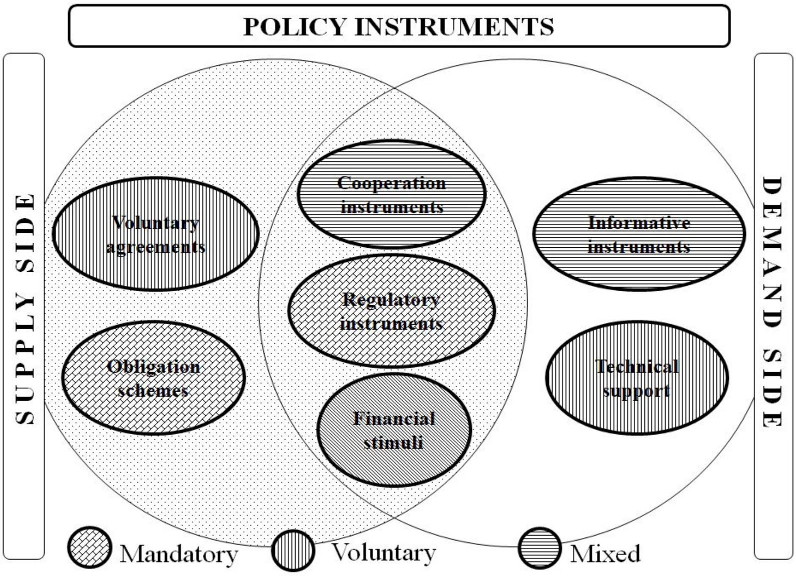

Fig. 3.25. Grouping of policy instruments depending on their relation to supply or demand side. (Author's own illustration.)

Conclusions

There are two main conclusions to this study on decision making about energy efficiency. First, three factors – 1) simultaneous implementation of several policy instruments, 2) coordination of several policy instruments and 3) correct sequence of implementation of policy instruments within a mix – are essential. Their role in decision making is underestimated, often leaving decisions to an *ad hoc* random opportunity. Second, adopting a decision about energy efficiency policy instruments is a complex problem where taking down multiple barriers is usually required. Furthermore, barriers are related to a variety of aspects associated with availability of financing, information, regulatory framework, market conditions, availability of labour force for renovation as well as willingness to pay for improved energy efficiency. In situations with multiple barriers, they ought to be taken down simultaneously. Getting rid of one barrier, like financing, will not be able to trigger renovation activity if other barriers remain. The task of getting rid of barriers is performed in Steps 3 through 5 (see Fig. 2.1 in Chapter 2) of decision making in the policy lifecycle, when initially deciding about policy mix and specific policy instruments.

Policy analysis relevant to energy efficiency can be done through a swift process, which takes into consideration limitations set by real-life situations. Conditions such as those related to any of the identified sets of instruments – financial, informative, regulatory, or other aspects affecting decision-making – can be factored into decision making algorithms when formulating policy instruments.

3.5. Results of NECP2030 policy impact assessment on climate policies

National energy and climate plans are a uniform way to keep track of policies aimed at reaching climate goals, through defining policies and creating clusters of activities that are supposed to ensure that policies progress towards the goals set in decision making Step 2. The biggest challenge for national governments is the complex rivalry between sectoral policies. Synergies between policies in different sectors to progress towards climate goals would be an ideal situation. However, analysis of policies by applying Climate Policy Integration (CPI) approach indicates that policies and activities lack synergy and at times even have conflicting interests.

Most significant challenges related to achieving climate policy goals are:

1) manage that the biggest potential impact from policy implementation can be achieved by using policy instruments where *hug*-type activities and policies dominate.

2) ensure that climate targets included in sectoral policies have priority over other goals.

3) the set climate goals in various strategic and policy planning documents are defined in a synergetic rather than mutually competitive way.

Analysis of the EU renewable energy and energy efficiency legislation demonstrates these two policy areas as an example how climate policy integration in the documents regulating energy industry facilitates progress towards achieving climate goals including reaching the targets for GHG emission reduction (Kettner and Kletzan-Slamanig 2020) (Kettner and Kletzan-Slamanig 2018). Results of analysis of policy measures included in the horizontal direction of activities (H) are presented further in this section.

Horizontal policies of Latvia's National Energy and Climate Plan 2030 were analysed in detail by applying Climate Policy Integration method with the aim of assessing to what extent they are in line with overall climate policy goals and whether they can facilitate achieving climate goals by implementing NECP2030 policy instruments. NECP2030 indicates that a separate group of horizontal policies (activities) has been created for the purpose of grouping together polices, whose activities / actions and influences reach beyond just one separate activity direction (and there are 12 such directions). Two conclusions can be drawn from applying such approach: 1) horizontal policies have the biggest potential to influence positively several policy directions in different sectors of economy simultaneously; and 2) the influence and reach of the group of horizontal policies would be stronger if policies would have been designated to this group in a targeted and deliberate way with the aim of achieving strongest potential positive impact on reaching climate goals.

When assessing policies by applying CPI method a reference has been made to the *hugs, carrots* and *sticks* approach as it makes assessment of interaction of NECPs policies with climate policy more effectively. Thus, it takes into consideration the type of policy instrument (*hug, carrot* or *stick*): for example, interaction of just one *stick*-type policy instrument can potentially have significantly more impact on achieving policy goals than several *hug* or *carrot*-type policy measures, and *vice versa*.

Altogether, 44 or almost one fifth out of 255 activities in the NECP2030 belong to the group of horizontal policies and policy instruments. Of those, 36 can be identified as *hugs*, eight as *carrots*, and 17 as *sticks* (see Table 3.6). This illustrates the proportion of so-called soft measures in the overall portfolio of policy measures. Information about the type of NECP2030 policy instrument allows a more precise assessment of interaction of NECP2030 policies with climate policies making it possible to determine whether there is going to be a synergy, or policies can be regarded as competing or even mutually exclusive.

Table 3.6.

Horizontal policies of the NECP2030 by type.

Activity direction	**Activities (by type)**				
	Activity groups	Total number of activities	A (hugs)	B (carrots)	C (sticks)
Horizontal activities	14	44	36	8	17
H1 Application of "energy efficiency first" principle		3	1	0	2
H2 Expanding EPS to significantly facilitate implementation of energy efficiency measures by big energy suppliers and energy consumers		2	2	0	2
H3 Strengthening of agreements about improving energy efficiency measures, use of RES and energy efficiency services with simultaneous support to contracting and implementation		3	3	1	2
H4 Improving the system of monitoring energy saving, and reporting about implemented activities		3	1	0	2
H5 Facilitating production and use of biogas and biomethane		3	0	0	3
H6 Ensuring full-fledged functioning of the system of certificates of origin		5	4	0	4
H7 Simplifying and speeding up the procedure (including permits) of introduction of RES technologies and ensuring public benefit from RES projects		5	5	0	0
H8 Facilitating acquisition of financing for stimulating use of RES and energy efficiency		8	8	6	0
H9 Evaluating possibility to introduce trading of energy savings		1	1	1	0
H10 Carrying out research about availability of RES for energy production (except for wind energy) in Latvia's territorial waters, including evaluation of possibility of building new infrastructure		3	3	0	0
H11 Expanding the work of Energy and climate council		2	2	0	0
H12 Introducing and applying social conditions aspect in energy and climate policy		2	2	0	2
H13 Elaborating solution for the number of parallel connections of energy supply systems		1	1	0	0
H14 Elaborating research programmes to stimulate research on reaching energy and climate goals		3	3	0	0

Further, analysis of all horizontal activity directions is provided with a concise assessment of key aspects of policies represented in each activity direction.

Table 3.7

H1 – Application of "energy efficiency first" principle

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	1	0
Functional overlap (B)	0	1	1	0
Policy instruments (C)	0	1	1	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	0	0

Energy efficiency policy and activities implemented under the policy facilitate reduction of GHG emissions – buildings consume less energy, less energy (primarily – heat) has to be supplied and produced, and less primary energy resources have to be consumed to produce energy. Energy efficiency is directed at implementing activities that produces immediate results but also fosters reaching medium and long-term GHG reduction targets. However, one must keep in mind that energy efficiency is part of energy policy, where tackling issues related to energy user's choices and behaviour is especially pronounced. Therefore, achieving synergies with other policies is essential and has repercussions for decision making especially during policy inception and policy definition stages of the policy lifecycle.

Table 3.8

H2 – Expanding EOS to significantly facilitate implementation of energy efficiency measures by big energy suppliers and energy consumers

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	1	0

Energy efficiency obligation schemes as a bundle of energy efficiency instruments provide direct and indirect contribution to GHG emission reduction depending on policy instrument. For example, broadening EOS to include activities, which "improves energy efficiency and gains energy savings in end users' buildings, devices and transport, and must implement certain activities to assist consumers that are under energy poverty risk", produces a direct contribution to GHG reduction. At the same time, payments to the energy efficiency fund by the responsible parties provide an indirect contribution to energy efficiency.

Table 3.9

H3 – Strengthening of agreements about improving energy efficiency measures, use of RES and energy efficiency services with simultaneous support to contracting and implementation

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	0	1	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	0	0

It can be forecasted that agreement about improving energy efficiency measures and other policy instruments included in the horizontal group of activities of the NECP2030 are going to work in synergy with other policy goals and will ensure progress towards achieving climate goals in medium and long-term. This approach corresponds the principle of simultaneous implementation of multiple policies with coordination of these policies from inception through to implementation and review stage of the policy lifecycle.

Table 3.10

H4 – Improving the system of monitoring energy saving, and reporting about implemented activities

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	1	0	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	1	0

Possibility to measure progress in achieving energy efficiency goals is critical for the ability to trace the dynamic of energy efficiency changes and assessment of effectiveness of policy instruments. Monitoring and reporting system makes it possible to estimate the required corrections in choosing and implementing policies in medium and long-term. This step is essential in the policy lifecycle as it provides important information, which further analysis of success of policies vis-à-vis the set goals is based on.

Table 3.11

H5 – Facilitating production and use of biogas and biomethane

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	1	1	1	0
Functional overlap (B)	0	1	1	0
Policy instruments (C)	0	1	1	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	1	1

Use of biomethane as an alternative fuel to natural gas facilitates progress towards reaching climate goals and reduces the need to import primary energy resources. At the same time production of biomethane can potentially have negative effect on reaching climate and environmental goals: for example, there is a risk of spreading agricultural monocultures. Creating infrastructure for the use of biomethane in transport or in stationary combustion devices has the potential to reduce the use of other types of fossil fuels in transport and energy production sectors that have more negative impact on environment.

Table 3.12

H6 – Ensuring full-fledged functioning of the system of certificates of origin

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	1	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	0	0
Cost of GHG reduction (F)	0	1	1	0

Although the system of certificates of origin (CoO) may not have a direct and immediate impact on GHG reduction, CoO as a long-term policy stimulates the role of energy origin in the energy system by using renewable energy in production and consumption of electricity and heat (from biogas) and also transport fuel (biogas / CNG). It also contributes to the competitiveness of local RES energy.

Table 3.13

H7 – Simplifying and speeding up the procedure (including permits) of introduction of RES technologies and ensuring public benefit from RES projects

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	1	0	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	0	0

A broader use of renewable energy technologies for energy production facilitates progress towards climate goals. Although activity direction H7 contains no mandatory policy activities and much of emphasis is put on *hugs* type of policy instruments policy goals related to making RES deployment easier do not conflict with climate goals and work in synergy with other policies, which stimulate progress towards achieving climate goals.

Table 3.14

H8 – Facilitating acquisition of financing for stimulating use of RES and energy efficiency

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	0	0

Creation of a fund for financing activities aimed at facilitation of use of renewables and improvement of energy efficiency implies increase of financing available for deploying renewables and improving energy efficiency. Although this activity (policy instrument) is not of mandatory character it is still a *carrot* type of policy instrument with tentatively indirect positive impact on GHG emission reduction through broader diffusion of renewables and implementation of energy efficiency measures.

Table 3.15

H9 – Evaluating possibility to introduce trading of energy savings

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	0	0
Functional overlap (B)	0	1	1	0
Policy instruments (C)	0	1	1	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	0	0

Possibility to introduce mutual trading with energy efficiency savings where one user of the system can transfer the excess of own achieved savings to another user of the system does two things simultaneously: it both facilitates GHG reduction and creates a risk that the possibility to acquire excess energy efficiency savings for the sake of improving ones balance is used to avoid setting GHG reduction targets or setting less ambitious targets than it would be possible to set and achieve. In relation to the clarity of interaction criterion in case of factors B and C the indicator has been marked with “1” based on a potential risk that H9 policy measures can potentially demotivate investment in energy efficiency.

Table 3.16

H10 – Carrying out research about availability of RES for energy production (except for wind energy) in Latvia's territorial waters, including evaluation of possibility of building new infrastructure

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	1	0	0	0
Functional overlap (B)	0	1	1	0
Policy instruments (C)	1	1	0	0
Weight (D)	0	1	0	0
Time perspective (E)	NA	1	0	0
Cost of GHG reduction (F)	1	0	0	0

Goals of this activity direction do not have an immediate and direct positive impact on achieving climate goals, however, in longer term, given the results of research showing that development of territorial and geothermal water for energy production is possible, impact on climate goals is forecast to be positive. Whether biogas as energy product is the best solution for achieving climate goals in longer term needs to be assessed separately. In short and medium-term there is potential to use biogas as a replacement to environmentally unfriendly fossil fuels (diesel, petrol) in transport sector. Indicator "1" has been marked for the factor and criterion C1 as H10 policy measures do not reduce CO_2 emissions directly but can have long-term indirect positive contribution to CO_2 reduction.

Table 3.17

H11 – Expanding the work of Energy and climate council

Criterion Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	1	1	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	1	0	1	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	NA	NA	NA	NA

Activity direction H11 does not have an immediate and direct positive impact on reaching climate targets, however, creating and strengthening the source of expertise – energy and climate analysis group – can have positive impact on policy monitoring and review thus contributing to decision making during the implementation stage of the policy lifecycle (Cluster 3 of decision making steps including Steps 6, 7 and 8). The fact that there is an intention to develop cross-sectoral sustainable mobility sub-council to the Energy and Climate Council with the aim to strengthen cooperation with NGOs with expertise in their respective sector is a positive factor contributing to achieving climate goals.

Table 3.18

H12 – Introducing and applying social conditions aspect in energy and climate policy

Criterion / Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	0	1	0
Functional overlap (B)	0	0	1	1
Policy instruments (C)	0	0	1	1
Weight (D)	0	0	1	1
Time perspective (E)	NA	0	1	1
Cost of GHG reduction (F)	1	0	0	1

Activity direction H12 defines the need to foresee a mechanism of compensation for situations if transition to cleaner and more sustainable energy production would create additional costs with energy poverty risks. Introduction of such policy measures potentially conflicts with climate policy goals by, for example, creating risk that in a situation when sustainable energy production contradicts the promise of cheap energy a political decision can be adopted to maintain low energy prices (through regulatory means and influenced by decision making that is political), thus disincentivising energy users' motivation to invest in energy efficiency and rid the use of those energy resources, which contradict the interests of achieving climate goals.

Table 3.19

H13 – Elaborating solution for the number of parallel connections of energy supply systems

Criterion / Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	0	0	0
Functional overlap (B)	0	0	1	0
Policy instruments (C)	0	0	1	0
Weight (D)	0	0	1	0
Time perspective (E)	NA	1	0	0
Cost of GHG reduction (F)	1	0	0	1

A research *per se* about optimisation of energy system through assessing possibility for the municipalities to determine and set conditions allowing to connect parallel energy supply systems to one object in one territory cannot create a direct and positive impact on reaching climate goals. In theory, however, there is potential that a regulatory framework, which supports energy system with parallel connection of multiple energy supply systems, can have a positive impact on the use of RES in energy supply. It must be noted that parallel systems may imply extra costs and thus be contrary to the principle of installing and utilising the capacity of a single energy supply system with optimal costs.

Table 3.20

H14 – Elaborating research programmes to stimulate research on reaching energy and climate goals

Criterion / Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflict with other policies 4
Political commitment (A)	0	1	0	0
Functional overlap (B)	0	1	0	0
Policy instruments (C)	0	1	0	0
Weight (D)	0	0	1	0
Time perspective (E)	NA	1	1	0
Cost of GHG reduction (F)	0	1	1	0

Research serves as basis for analytical information which helps decision makers to formulate and implement evidence-based decisions and policy making. Policy measures of the activity direction H14 are aimed at supplying decision makers with energy and climate policy analysis. This serves as a solid basis for adopting decisions about maintaining, reviewing, or terminating existing policies, or introducing new policies. Such an approach is synergetic with climate policy goals and is directed towards establishing and developing long-term sustainable policy and increases possibility that climate policy goals could be granted a higher priority in comparison with other policies.

Out of 14 horizontal policy areas (directions of activity) of the NECP2030 most can be identified as contributing to the progress towards climate goals. There are, however, several policies (for example, H1, H5, H9, H12, H13 and H14) that qualify as partially contributing. One – H12 (Introducing and applying social conditions aspect in energy and climate policy) and to a lesser extent also H5 (Facilitating production and use of biogas and biomethane) and H13 (Elaborating solution for the number of parallel connections of energy supply systems) qualify as ambiguous with risks of no sufficient contribution to reaching climate goals because of competing or conflicting interests between policies (see Table 3.19).

Table 3.21

Assessment of all horizontal activities of the NECP2030 according to Climate Policy Integration approach

All horizontal policies of NECP2030				
Criterion / Factor	Neutral interaction 1	Synergetic interaction 2	Clarity of interaction 3	Conflicting interests 4
Political commitment (A)	5	9	4	0
Functional overlap (B)	0	12	6	1
Policy instruments (C)	1	12	5	1
Weight (D)	1	9	4	1
Time perspective (E)	NA	13	11	1
Cost of GHG reduction (F)	3	10	6	3

Altogether there are seven markers indicating an issue under criterion 4 (Conflict with other policies) and 36 markers indicating an issue with criterion 3 (Clarity of interaction). Five out of seven conflicting situations occur in one single direction of activity H12 (Introducing and applying social conditions aspect in energy and climate policy) while H5 (Facilitating production and use of biogas and biomethane) and H13 (Elaborating solution for the number of parallel connections of energy supply systems) have one marker each. As for the Clarity of interaction criterion markers are scattered among all directions of activity with no single direction without at least one indication of potentially contradictive policy formulation.

The way the horizontal policies are formulated leads to conclusion that policies have been included in the group of horizontal policies according to the principle of surplus, perhaps because it has been difficult to include these policies and policy instruments in other activity directions of the NECP2030. Nevertheless, activities included in the group of horizontal activities are certainly relevant and deserve assessment.

Inclusion of policies and policy instruments in the group of horizontal policies would have stronger added value if they would be grouped with the aim of ensuring that different sectors of economy, when planning development, take into consideration climate aspects and avoid formulating their goals and policies in a way, which competes or even contradicts climate goals, and stating that horizontal policies have priority over policies of other policy directions in the NECP2030 and they serve as element uniting different policies.

Applying Climate Policy Integration approach to policy planning can save time and energy (also literally) allowing to avoid situations of confrontation between sectoral policies and climate policy goals. There is no universal consensus about whether CPI shall take place through vertical or horizontal approach: political systems vary and ability to exercise strong vertical control over climate policy planning and implementation may be strong in centralised political systems while strong awareness and presence of climate policy goals among policy actors across sectors may suggest applying horizontal CPI approach. In any of the two cases considering application of CPI principles during early stages of policy lifecycle can contribute significantly to the quality of decision making.

3.6. Integration of decision making steps and methods

This section of the Thesis elaborates on the role and function of methods in decision making in greater detail. It is based on the review of methods in Chapter 2 and analysis of results of the case studies and conclusions drawn in Sections 1 to 5 of Chapter 3 to establish a more detailed sequence and description of decision making steps and clusters as first referred to in Chapter 2 (Methodology).

Further elaboration will attempt to apply the current methodological framework to explain why building an algorithm of decision making, including choosing a set of methods of analysis leading to policy choices, and sticking to it, is essential to achieve the desired optimal result – transition to sustainable energy and climate neutrality.

Cluster 1 – Policy inception

Cluster 1 can be identified as representing the Inception phase in the policy process and it encompasses Step 1 and Step 2. For the purpose of establishing the current state of affairs Step 1 employs several methods: regression, *hugs, carrots and sticks* (HCS), and Climate Policy Integration (CPI). Step 2 (defining the desired result) does not involve methods as it represents policy goals derived from international treaties, laws, strategies, and policy documents.

Step 1 – Establishing current situation

The main task of Step 1 is to set the point of reference for future analysis of progress of policies towards the set climate and energy goals.

For the purpose of establishing the current state of affairs Step 1 can employ a spectrum of methods depending on whether a high-level assessment of the situation is sufficient, or a more detailed analysis is needed. Thus, methods can range between simple statistical analysis of data representing current state of affairs and more complex methods of multicriteria analysis or qualitative content analysis. Simple linear regression, *hugs, carrots and sticks* (HCS) approach, and Climate Policy Integration (CPI) approach are methods explored in this Thesis and would probably be sufficient to fulfil the task of Step 1 – establishing the point of departure, creating a point of reference that will allow measuring progress towards new set policy goals and allowing to draw conclusions during further steps about the need to modify policies.

The expected outcome of Step 1 should represent "a photography" of the current situation representing a full picture of "how things are". It can range from statistics of various levels of detail to expert assessment of achievements and major issues that require attention and introduction of new policies. The outcome should include figures reflecting current status of indicators, analysis of past and current policies / policy instruments.

There are certain risks if Step 1 is implemented partially or omitted. It follows from the task of decision making Step 1 that failure to establish current facts and gain a deeper insight through qualitative assessment will result in lack of point of reference for future policy outcomes and goals. Lack of "a picture" reflecting current state of affairs also poses serious risk to repeat previous policy mistakes when defining policies set to achieve the desired policy result in future.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Has it been defined, what is necessary to establish?
- Has a method been chosen to establish current situation?
- Is information that has been obtained and will be used to define the desired result verifiable and comparable?

Step 2 – Defining the desired policy result

Task of decision making Step 2 is simple and complex at the same time – set the desired future policy goals compared to current and past situation. Defining the desired policy result is essential for being able to decide about policies and policy instruments best suited for achieving progress towards the set goal[s]. It must be noted though that defining policy result in Step 2 does not necessarily disqualify decision makers and policymakers from adjusting the set goals during later stages and steps in the policy lifecycle. This is especially true when it comes to setting climate policy goals; as policies progress through implementation policymakers may decide to adjust previously defined goals to exercise more pressure or decrease pressure on stakeholders from sectors most influenced by climate policy goals. In such case decision makers will have to assess whether policies need to be adjusted to be able to meet the redefined climate goals.

Decision making Step 2 does not involve application of methods as it represents formulating policy goals derived from data collected in Step 1, international treaties, laws, strategies, and policy documents. However, when defining climate policy goals, which do not stem from international obligations, decision makers should keep climate policy goals as a priority to maintain or introduce sufficient ambition. In this respect, Climate policy Integration approach can serve as a set of guidelines for prioritising climate policy over other policies. Such an approach can also strengthen ability of decision makers to monitor policy implementation and assess progress towards reaching climate policy goals during later stages in the policy lifecycle.

Outcome of Step 2 should, as a rule, include a range of defined indicators, both quantitative and qualitative. Those can be figures indicating future values of indicators, outcomes of current and future policies and policy instruments to be implemented, sufficiently detailed description of expected state of affairs in sectoral policies after implementation of policies that are to be decided on in Step 5 of the decision making process.

Step 2 plays an essential role on the policy lifecycle as without defined policy goals there will be lack of point of reference for future policy outcomes and goals. Failure to define indicators and indicator values poses potential risk to the ability to define future policies [in Step 5] best suited for reaching the expected results. This can lead to choosing and implementing random policies and results different from the desired policy results.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Has the result been defined?
- Is the desired result defined so that it will be possible to compare it with previous and future results?

Cluster 2 – Initial Decision Making

Cluster 2 represents initial decision making about policies, including preparation for deciding about policies. Step 3 (Identification of policies leading to the desired result) employs literature analysis, HCS, CPI and a MCDA method of choice – TOPSIS. Step 4 (Consulting existing pool of knowledge) involves literature analysis and functions as a prerequisite for actions in Step 5 (Deciding about policies). Step 5 employs HCS, CPI and TOPSIS method to arrive to decisions about the most appropriate policy mix for renewable energy deployment and increase in energy efficiency.

Step 3 – Identifying policies that can lead to the defined result

Task of decision making Step 3 is to identify policies that may produce desired results as defined in Step 2. There is "general knowledge" that certain actions lead to results; for example, decreasing excise tax for gas [as energy carrier] that is used in transport may serve the purpose of users switching over from diesel engines to gas powered engines and may also facilitate development of production of biomethane. Similarly, introduction of support for renewable energy technologies is expected to increase the share of renewable energy in energy production.

Several methods can be applied to fulfil the task. Literature analysis (including legislative acts, policies implemented in other countries, policy overviews, any reliable sources about what policies can be or have been or are being used to reach any defined climate policy goals) as a method would probably suffice at this point as aggregating information about policies is the main task. Policy analysis methods such as, for example, *hugs, carrots and sticks*, Analytical Hierarchy Process and TOPSIS, which are reviewed in this Thesis in detail further in Chapter 2, are to be applied during Step 5 to establish policy ranking.

Step 3 should produce a catalogue of policies that decision makers and policymakers think can contribute to achieving the defined climate policy goals. The expected outcome should include current and future policies and policy instruments to be applied. However, vetting of policies and choosing the most appropriate solutions shall take place during Step 5 (Deciding about policies) after the catalogue of policies is reviewed in Step 4 by checking what the existing pool of knowledge, information and expertise says about the effectiveness of policies.

Policymakers tend to believe they intuitively know what policies will be best for achieving certain goals. Good intuition in policymaking is hailed as necessary to make decision making effective and with almost immediate tangible results. Intuitive decision making may fulfil its function at times of extreme crisis under conditions when there is no time for sufficient analysis of sources of a problem, channels feeding the problem, and future scenarios of development of a problem under a set of rapidly changing factors. Intuitive models of decision making are characteristic under pressures created by social conditions, lack of finances, priority of other outstanding issues, opposition from interest groups, limited time for making decisions, and other. However, such approach, which omits looking into what policies and solutions can be discussed lacks systematised approach and creates risks of not discussing relevant policy solutions. Skipping this step partially or completely poses potential risk to miss the path required to reach the desired policy results leading to *ad hoc* decisions on the go. Risks of choosing incorrect policies are even higher when there is need to reach multiple policy goals at the same time.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Have policies been identified to choose from for the purpose of creating a suitable policy mix for achieving the defined results?
- Have methods of analysis been identified and utilised to support a catalogue of policy long-list?

Step 4 – Consulting existing pool of knowledge and information on best policies to reach the desired result

The task of decision making Step 4 is analysis of existing sources of information and knowledge about policy instruments and their impact on energy and climate policy results after aggregation of information about available policies and policy instruments has taken place in Step 3. Learning from existing research and experience facilitates choice of best available policies and can signal about mistakes when choosing and implementing energy and climate policies.

The key method during Step 4 is analysis of research literature, existing sources of information, knowledge and analysis about implementation of policies, including case studies, impacts of the respective policies on the progress towards set climate and energy policy goals. Environmental, climate and energy policies cover a broad spectrum of detailed policy instruments including but not limited to various types of support to renewable energy technologies, measures facilitating energy efficiency, phasing out use of fossil energy resources, electrifying transport system and engaging energy users in energy production through renewable energy communities. Thus, there is a lot of research available on a variety of topics that can and must be used to draw conclusions about what has already been analysed and what conclusions have already been drawn about different policy measures.

Expected outcome of Step 4 should represent an overview of research and policy results allowing to narrow down the potential choice of policies from the initial policy catalogue aggregated in Step 3. This overview of what research and analysis says about policies and their impacts functions as a prerequisite for actions in Step 5 when decisions have to be made about policy mix best suited for reaching the climate policy goals defined in Step 2.

If, during policy lifecycle, this Step is skipped there is risk to repeat past mistakes that have already been studied. This increases the probability that incorrect policies and policy instruments will be chosen, and energy and climate goals will be reached partially or will not be reached at all. Impacts of skipping Step 4 have potential to impact the rest of policy lifecycle leading to policy failures and extra costs associated with the need to abandon implementation of certain policies than do not produce the required results.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Have relevant sources of knowledge about impacts of policies been consulted?

- Has availability of resources for policy implementation been established?

Step 5 – Deciding about policies

Task of decision making Step 5 is simple and complex at the same time – making decision about the policy mix and policy instruments that are assessed and estimated to have the most positive impact on achieving the desired result of energy and climate policy defined in Step 2. At this point in policy lifecycle analysis of the current state of affairs have been carried out, goals have been defined, possible policies identified and existing knowledge about policies has been consulted, concluding preparatory work for one last task before actual choice of policies (policy mix) is made. Step 5 includes analysis of past and current legislative framework to identify legislative changes required to enact policies defined in this step of decision making.

Step 5 is the moment in policy lifecycle, which sets in motion processes that have certain consequences in terms of investment of time, financial, human and technical resources. Once decision about policies is adopted a set of complex activities follows to proceed with policy implementation. It means that decisions must be well prepared and evidence-based. If actions in Steps 3 and 4 were about aggregating information and consulting existing expertise, then Step 5 introduces a selection of methods of policy analysis that allow making conclusions about reasons, why previous policies have not succeeded with contributing to the progress toward set climate goals (if such have been previously defined) and what policies are likely to deliver acceptable results. Methods such as *hugs, carrots and sticks* approach, Climate Policy Integration, and multicriteria decision aids like Analytical Hierarchy Process and TOPSIS can provide indications as to what are the causes for underachievement of policies as well as produce suggestions about remedies to existing problems. Section 2 of Chapter 2 reviews several methods that are applied as an example through case studies in Chapter 3, which illustrate the role of application of recognised methods of policy analysis in decision making.

The immediate outcome of Step 5 is list of policies and policy instruments, and information and expertise about simultaneous application of multiple policies (policy mix) or the correct sequence of policies to be implemented ("cascaded") as well as about the necessary coordination of policies. In practice, new legislative initiatives or amendments to existing legislative acts should follow the conclusions about the most suitable policy mix.

Skipping Step 5 will lead to *ad hoc* decision making and policy implementation with no coordination of policies leading to policy failure and failure to reach the desired energy and climate policy goals. Once again, choosing policies through relying on intuitive rather than rational decision making models will most likely be followed by policy mistakes and extra costs to reaching the defined goals.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Have policies been short-listed and criteria established to choose components of policy mix?

- Have costs of various policies been analysed on top of establishing the effectiveness of policies?

Cluster 3 – Policy implementation and monitoring

Cluster 3 represents steps related to policy implementation and monitoring. Step 6 (implementing policies) does not involve methods of analysis as it is about translating the set targets and policies into action leading to Step 8. Step 7 (measuring the impact of policies) involves monitoring essential indicators and key processes of policy implementation.

Step 6 – Implementing adopted policies

The task of Step 6 is implementing the policy mix and policy instruments defined in Step 5 of energy and climate policy. At this point in the policy lifecycle analysis necessary to make evidence-based choices of policies has been carried out and translated into legislation. It means that all involved stakeholders know their roles and functions, and tasks and opportunities. State institutions ensure legislation is implemented through *hugs, carrots and sticks*, while entrepreneurs translate the new situation into their business plans. Energy users start adjusting their behaviour by adapting energy use patterns, choice of more environmentally and climate friendly technologies.

Step 6 as such does not involve application of methods of analysis as it is about following the plan and guidelines of policy implementation established when policies were put in place. Several next steps are, however, extremely import, are heavily based on analytics (methods of analysis) and should be viewed in the context of policy implementation.

Policies adopted in step 5 may have short, medium, or long-term character and impact. Policies that can be implemented quickly have shorter policy lifecycle, and it may be easier to monitor the progress of such policies towards set goals. Longer term policies require regular monitoring. Also, different policies overlap, but seldom they overlap during the same stage of policy lifecycle. It means that monitoring and evaluation of implementation of one policy will inevitably coincide with making decisions about another policy at a different stage of policy lifecycle. Therefore, coordination of policies and prioritisation of environmental and climate policy goals over policy goals of other sectors plays an essential role in achieving progress towards climate goals.

The expected outcome of Step 5 is that policies and policy instruments are implemented and planned (or defined) results (including progress towards results) are achieved. The effectiveness of policy implementation is assessed during further steps.

Although policy lifecycle up to Step 5 is aimed at ensuring that decisions about best policies are adopted and policies are actually implemented, it may happen that policies are implemented partially or not implemented. This creates risks: if no policy is implemented then there is no progress towards the defined energy and climate policy goals. If a policy from a policy mix is not implemented there is a risk that the goals might not be achieved to full extent or as expected.

In real-life situations there may be various reasons why a policy is not implemented or is implemented partially. Normally it is government agencies, which are responsible for introducing new norms and ensuring these norms are translated into action by the subjects of the policy. Policy implementation may be hampered, for example, by lack of adequate financial resources stemming from planning mistakes during earlier decision making steps but Step 5 in particular. It may also indicate lack of coordination of policies between policymakers and / or government agencies or failure to prioritise climate policy goals vis-à-vis goals of sectoral policies ending in a situation when policies aimed at progressing toward and reaching climate policy goals have to compete for resources with policies aimed at improving situation in particular sectors. For example, while agency responsible for overall climate policy goals is introducing tighter rules on emission reduction, agency responsible for agriculture introduces reduced excise tax that favours more extensive use of fossil fuels in agriculture (by agricultural machinery) with a goal to strengthen the sector's productivity and international competitiveness. This simple example illustrates relevance of coordinating multiple policies not only within energy sector, but also between multiple policies among a spectrum of sectors, which play role in reaching climate goals.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Are policies of the policy mix adopted and actually implemented in correct order?
- Are policies of the policy mix adopted and implemented simultaneously?
- Does coordination between policies take place?

Step 7 – Measuring the impact of policies / Monitoring policy implementation

Task of Step 7 is measuring progress of the policy mix and policy instruments that are being implemented towards the set energy and climate policy goals. This step has important role in following that indicators of policies are in line with the forecast / expected trajectory of development set in Step 5 according to the policy goals defined in Step 2. Monitoring is essential for identifying possible deviations from the required trajectory through measuring of indicators and analysing development of policies.

Step 7 is where methods allowing to draw conclusions from a limited set of historical data can be applied. Regression, MCDA methods (AHP and TOPSIS) Climate Policy Integration, which are reviewed in this Thesis, can be applied, be it with or without simultaneous application of other methods considered suitable for monitoring purposes. The benefits of applying regression, AHP and TOPSIS, and Climate Policy Integration are discussed further in Section 2.2. and through practical examples in Chapter 3.

The expected outcome of decision making Step 7 is expressed in current status of indicators of policies and policy instruments defined in earlier stages of the policy lifecycle. Provided the policy targets have not been redefined, the outcome of Step 7 is information about the trends and potential issues. However, Step 7 is characterised by following the progress, not judging policy results. Depending on results of monitoring policies may later need to be adjusted once a thorough analysis of indicators and policy outcomes and results is done during Steps 8 and 9.

Although monitoring policy implementation may seem of lesser importance to policy implementation and further decision making than Step 8 (Establishing situation after policies are implemented) and Step 9 (Assessing policy results) lack of monitoring can result in missing a deviation or policy mistake at an early stage of policy implementation. Not noticing a mistake or deviant development soon enough can lead to extra costs in terms of lost time and also financial resources invested in activities not producing the desired results. Lack of monitoring may also result in a missed opportunity: monitoring has the potential to indicate that more resources are required to implement a well-defined policy leading to a situation when wrong reasons for policy failure are identified.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Is monitoring mechanism in place that allows evaluation of implemented policies?
- Do incremental results of the policies of the policy mix follow the intended trajectory?

Cluster 4 – Policy review

Cluster 4 of decision making steps represents the review phase of the policy lifecycle, including decision making about what to do with the existing policies. It includes three steps that are to certain extent similar to each other but differ in detail and function: Step 8 (establishing current situation after policies are implemented), Step 9 (assessing policy results) and Step 10 (reviewing policies).

Step 8 – Establishing situation after policies are implemented

The task of decision making Step 8 is establishing current situation through measuring policy indicators and analysing policy effects once policies are implemented to see if the defined policy goals have been achieved. Actions in this step follow policy implementation till timewise a moment is reached when there ought to be tangible results to the policy implemented. It must be noted though, that a policy can be defined as implemented according to qualitative assessment of, say, change of behaviour of energy users. Regardless of how it is defined there will be need to "take a picture" of current situation. Once the situation has been established, the ground will be prepared for a thorough analysis and interpretation of information in Step 9.

Data collection, statistical information, indicator matrix (checking values against the defined policy goals) along with qualitative methods of research (especially when it comes to obtaining views of energy users and experts) are sufficient to fulfil the task of comparing policy implementation results with the initial data (from Step 1 and Step 2) and measure the progress towards climate policy goals.

The expected outcome of activities in Step 8 is similar to the expected outcome of Step 1 as this outcome should represent "a photography" of the current situation representing a full picture of "how things are" after policies have been implemented. The outcome can range from statistics of various levels of detail to expert assessment of achievements and major remaining issues that require attention. The outcome should include figures reflecting current status of indicators identified during inception phase of policy lifecycle. Put it simply – the outcome would be a list of values of indicators of policies and policy instruments implemented with the aim to reach defined energy and climate policy goals.

Paying insufficient attention to this step or skipping it completely creates risk of not noticing issues with underperformance of policies and policy instruments. Underestimating the role of "taking a follow-up picture" will result in lack of information and evidence for further decision making. It will complicate decision making about the need to continue, amend or terminate existing, or add new policies in the context of the desired energy and climate policy goals. Step 8 is relevant for the rest of activities in Cluster 4 of policy lifecycle as more thorough assessment of policy impacts is carried out in Step 9.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Is monitoring mechanism used to deliver information about incremental results of policies?
- Is sufficient data available about all policies that are implemented?
- Do preliminary results of policies indicate deviation from the set trajectory?

Step 9 – Assessing policy results

The task of decision making Step 9 is carrying out an in-depth analysis of the situation after policy implementation by using indicator values collected in Step 8 and measuring policy indicators once policies are implemented to see if the defined energy and climate policy goals have been achieved and determine whether corrections are required.

The methods involved can range from statistical analysis to regression analysis, to multicriteria decision analysis (like AHP and TOPSIS), to *hugs, carrots and sticks* approach and Climate Policy Integration. All of the aforementioned methods should be able to clarify if [the implemented] policies have facilitated progress towards energy and climate goals. It should be noted that this list of methods of analysis is not exhaustive and is rather aimed at suggesting application of methods, which are not too complex, but are elaborate enough to deliver results that allow making decisions about successes and failures of policies. No modelling methods are reviewed in this Thesis and this is the limitation of this study. Modelling methods, such as Energy Plan, TIMES or System Dynamics can provide additional input for making complex decisions about future policy trends.

The expected outcome of Step 9 is in-depth analysis of impacts of policies and policy instruments implemented with the aim to reach energy and climate policy goals defined in Step

2. While the outcome of analysis in Step 8 answers the question “what is the situation now?”, analysis in Step 9 answers the question “why do we have situation that we have now?”. Step 9 is crucial for decision making in Step 10, which is the final step in the policy lifecycle, as decisions about what to do with current policies have to be made.

Skipping decision making Step 9 will lead to lack of analysis and evidence about the performance of implemented policies for further decision making about the need to continue, amend, add new or terminate existing policies. There is an aspect of climate policy in almost every other policy area where processes related to energy (production, accumulation, consumption) have some relevance. Step 9 resembles Step 5 as both represent a point in policy lifecycle when in-depth analysis is required to make decision about choosing policies for implementation (in case of Step 5) and choosing what to do with policies that are implemented.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Has in-depth analysis of policy impact taken place?
- If deviations from the required policy results are observed then what are the causes of the deviating results?

Step 10 – Reviewing policies

The task of Step 10 is to take decision whether policies must be continued, amended or terminated, or new policies introduced. Execution of this task must be based on the outcome of Step 8 and 9, that provide information and knowledge about actual results of policies and can be compared with the initially defined gals and forecasts made when defining policies and the policy mix in Step 5.

At this point in-depth analysis by applying methods of analysis has been done and conclusions need to be drawn. Thus, Step 10 does not pursue additional analysis, but relies on outcomes of analysis in Step 9. Making decisions based on results obtained through application of methods of analysis ensures that rational decision making models will be used. Skipping Step 9 or ignoring outcome of Step 9 will lead to reverting to irrational decision making models.

The expected outcome of Step 10 are decisions about what to do with policies or, in other words, answering the question “what next?“. Given a policy has been implemented and has achieved progress towards the set climate policy goals policymakers have to decide what shall be the next step in the lifecycle of a policy. There are four main alternatives to what can happen to a policy: 1) it can be continued; 2) it can be amended; 3) it can be terminated, and 4) a new policy can be introduced to “assist” existing policy. Thus, Step 10 is about one of the four choices depending on what results of analysis suggest.

If analysis indicates that the intended results have been achieved, then the policy can be terminated. If analysis says that overall course of development of the policy is acceptable, but the result has not been achieved yet, a decision may be about the continuation of the policy. Analysis may also show that a policy is not progressing towards the goals as expected due to a barrier which can be tackled with the help of additional new policy. In such case, a decision will follow in Step 10 about introducing a new policy to support and strengthen the effects of the primary policy. This way policy mix is expanded. Another approach to deal with barriers that hamper policy progress is amending exiting policies: depending on the scale of problem minor or major amendments may be necessary. Analysis may also show that a particular policy has failed to deliver the expected results and even the trend of development does not indicate that goals can be reached if the policy is continued. In such case the policy should be terminated, and decision makers should be looking into results of analysis for new solutions to the problem.

Without analysis and decision about “what next?“ there is a risk of failing to achieve the defined energy and climate policy goals as obsolete policies may be bringing results closer to failure than progress towards reaching the goals. Lack of information and evidence for further decision making and lack of decision about the need to continue, amend, add new or terminate existing policies in the context of the desired energy and climate policy goals deprives policy lifecycle of a proper ending phase through activities of Cluster 4 of decision making steps.

Questions to be asked and answered during this step of decision making include, but are not necessarily limited to the following:

- Is there sufficient knowledge to support decision making about policy termination, continuation or transformation?
- Can decision be reached without additional analysis about all policies that have been implemented or that are being implemented?

4. Conclusions

Decision making is key to any policymaking process, not least energy and climate policy. Setting ambitious policy targets requires complex planning and implementation of policies. The main challenge is dealing with pressures on decision making caused by limited resources, be it finances, time, material, or human resources. Another source of pressure is vested interests due to the political nature of policymaking, as crucial decisions are often associated with "political will" of those in a position to make decisions. Several conclusions about decision making on energy and climate policy are to be drawn from the study.

The purpose of decision making in any sector is to adopt policies that will improve the current situation. The purpose of decision making in the context of environmental and climate policy is to adopt policies, which, if implemented, will lead to a sustainable energy system. The first conclusion from the case studies is about the significance of sticking to a proper set of procedures throughout a complete policy lifecycle regardless of various pressures, be those endogenous or exogenous, on decision makers. In fact, it is exactly such approach, which serves two purposes:

1) observing procedures routinely functions as a "repellent" against attempts to "privatise" decision making in favour of a stakeholder or a narrow group of stakeholders, and

2) ensures that the quality of decision making leads to the best possible outcome and result in terms of policy issue identification, choice of policy instruments, policy implementation and policy review.

Thus, decision making is of essential importance for achieving sustainability goals.

Decision making related to energy efficiency, efficient and sustainable use of resources, and factors influencing renewable energy choices in the context of developing a sustainable energy system were at the centre of the Thesis. Sections of the Thesis dedicated to specific topic focused on specific policy issue characteristic to the particular sector, or processes around decision making in that particular sector. There are some conclusions to be drawn from this analysis.

Although that does not happen exclusively so, agriculture is among sectors contributing to greenhouse gas emissions most, but it also has a good potential to contribute to decreasing GHG emissions through change of agricultural planning and practice. It is often argued that Latvia, being among the three EU Member States with the lowest agricultural intensity, ought to implement policies and practice that increases agricultural productivity. However, increasing agricultural productivity is associated with increased use of mineral fertilisers. At the same time, one euro invested in a unit of used agricultural area (UAA) and gross nitrogen balance per one invested euro is less effective than in the EU Member States with high intensity agriculture. This may indicate that decisions about agricultural subsidies, for example, have been made with limited regard to the gains from such an investment.

It is true that there is high correlation between investment in used agricultural area and gross nitrogen balance, which may be related to the wealth of a country. A more thorough analysis can provide clues as to what policies have to be changed to make investment more effective while maintaining high environmental standards.

Relevance of correct steps and correct sequence of steps is highlighted through the case study on energy efficiency policy. The algorithm of decision making represented in the study can serve as a practical tool for policy makers. Practical application of knowledge of barriers, causes of barriers and policy instruments in relation to the involvement of multiple stakeholders of the energy efficiency realm, would improve the overall process of decision making in energy sector, thus contributing to achieving sustainability criteria in terms of policy making as well as achieving sustainability goals defined to be met in the energy sector.

A practical approach that can be applied by policymakers and decision makers to decision making should follow from this study summarised in these four stages of policy lifecycle: 1) Identification of policy area and policy issue; 2) Identification of an appropriate method of analysis and carrying out of analysis; 3) Deciding about the best combination of policies (policy mix) for achieving the optimal result, and 4) Implementing and reviewing policies according to the 10 step decision making approach as explained in Fig.2.1 in Chapter 2.

Overall conclusions

This Thesis / analysis reveals mutual interaction and causal relationship of policies, which consequently reveal that decision making and policymaking insufficiently uses existing knowledge base about policymaking and decision making, which would ensure transition to sustainable energy in an optimal way.

Policy analysis and the choice and application of methods of policy analysis optimal for each step of decision making throughout a complete policy lifecycle prevents or minimises risks of not achieving the set climate and energy goals (transition to sustainable energy).

It is important to apply similar approach to decision-making in other policymaking areas related to energy and climate policy, such as transport, agriculture and land use, land use change and forestry. A proper step-by-step approach ensures that no relevant stage is skipped moving towards a decision about the most appropriate policy mix and policy instruments to achieve optimal result.

Thus, the hypothesis formulated in the Introductory chapter of the Thesis – adopting and implementing a standardised process of policy analysis and decision making through a correct sequence of decision making steps supported by suitable decision making methods in a policy lifecycle ensures reaching climate and energy policy goals in an optimal way – can be regarded tested and proven.

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Abbreviations

AHP – Analytical Hierarchy Process
CAP – Common Agricultural Policy
CHP – combined heat and power
CNG – compressed natural gas
CO – Certificate of Origin
CPI – Climate Policy Integration
DG – Directorate General
EC – European Commission
EEA – European Economic Area
EGD – European Green Deal
EIA – Environmental Impact Assessment
EOS – energy efficiency obligation scheme
EPI – Environmental Policy Integration
ESCO – energy service company
EU – European Union
GDP – gross domestic product
GHG – greenhouse gases
GNB – gross nitrogen balance
HCS – *hugs, carrots and sticks*
IEA – International Energy Agency
IRENA – International Renewable Energy Association
JRC – Joint Research Centre
LCOE – levelized cost of electricity
MCDA – Multicriteria Decision Analysis
MLP – multi-level perspective
NECP – national energy and climate plan
OECD – Organisation for Economic Cooperation and Development
PV – photovoltaic
RES – renewable energy sources
SEA – Strategic Environmental Assessment
SEIA – Strategic Environmental Impact Assessment
TOPSIS – Technique for Order of Preference by Similarity to Ideal Solution
UAA – utilised agricultural area
UN – United Nations
UNFCCC – United Nations Framework Conventions for Climate Change

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Reinis Āboltiņš received a Bachelor's degree in Political Science in 1996 and a Master's degree in International Law in 1999. He had close connection with the energy sector since 2006 with special interest in analysis and research of energy market functioning, energy efficiency policy, renewable energy regulation, policy and decision-making in energy sector, and energy security.
R. Āboltiņš is an energy market analyst with the Public Utilities Commission with main responsibilities related to energy market monitoring and surveillance. R. Āboltiņš has prepared many analytical publications about national and EU energy policy, energy security, as well as interaction between energy, environment and climate issues in English and Latvian both in Latvia and abroad. R. Āboltiņš has been a member of the State President's Energy Security Commission and has acted as an invited expert at the Energy and Transport Working Groups of the Foreign Investors' Council in Latvia.