RIGA TECHNICAL UNIVERSITY

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DECISION-MAKING IN TRANSITION TO SUSTAINABLE ENERGY

Summary of the Doctoral Thesis

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DECLARATION OF ACADEMIC INTEGRITY

I hereby declare that the Doctoral Thesis submitted for the review to Riga Technical University for the promotion to the scientific degree of Doctor of Science is my own. I confirm that this Doctoral Thesis has not been submitted to any other university for the promotion to a scientific degree.

Reinis Āboltiņš (signature)

Date

The Doctoral Thesis has been written in English. It consists of an introduction, 4 chapters (including conclusions); the total number of pages is 142. The Bibliography contains 194 titles.

Content

Introduction

The 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. Barriers and policies are analysed in the Thesis, which hamper or facilitate transition to sustainable energy, with the goal to supplement the existing knowledge base and collection of policy planning and implementation approaches with an algorithm that illustrates the logic and role of decision-making throughout the full lifecycle of energy and climate policy.

In the light of climate change and factors contributing to climate change it is essential what can be done to prevent or minimise anthropogenic 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 need to invest systematic knowledge into energy transition is highlighted by factors external to planning energy policy under standard circumstances, but which have become the single most important factor affecting the way policy makers are looking at the energy transition, and that factor is a deliberate war instigated by the Russian Federation, which is the single biggest supplier of fossil energy resources to the European Union. In the light of the challenges posed by the recovery of economy after the hight of the COVID-19 pandemic this aggression intuitively seemed to strengthen the opinions in favour of withdrawing the ambitions for the transition to sustainable energy. In practice, however, the new and unexpected situation has achieved the opposite and has significantly facilitated the understanding of energy consumers about the relevance of the transition to sustainable energy as swiftly as possible to decrease Europe's dependency on imported fossil energy resources.

The European Green Deal entails goals and actions that put climate goals on top of all priorities (European Commission 2019) 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 (European Commission 2021), 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.

Also, 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. By the beginning of the 2022 the factor of current issues has seen its relevance for energy transition grown significantly.

Quite clearly transition to sustainable energy is a complex matter involving multiple elements: stakeholders, processes, and policies, and it is influenced by climate and environmental, technological, economic, and social aspects, each one separately and in different combinations. Progress towards the goal of sustainable energy depends on policies defined by policymakers and adopted by decision makers. Many decision-making techniques, methods and approaches have been developed over time to serve as an aid to analysing past experience, current situation, modelling future developments under different scenarios, defining policy mix and reaching the defined policy goals.

The author of the Thesis, based on studies of existing pool of information and knowledge, as well as several case studies, has come to conclusion that lack of policy analysis and *ad hoc* decisions about energy and climate policy cannot and will not ensure transition to sustainable energy at all or at the pace required by what is known about factors triggering anthropogenic 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, a plethora of stakeholders across many sectors of economy 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 often perceived as too complicated. Subsequently, 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.

The Thesis offers a ten-step decision-making process organised in four clusters that are all essential to arriving to, adopting, and implementing policies that are based on analysis and evidence. The author believes that this process has ability to be applied in real-life decision-making about energy and climate policies.

Topicality of the issue

Decision-making has a critically important role in ensuring sustainable energy system. Therefore, the main attention in the Thesis is focused on the analysis of barriers to sustainable energy and policies best suited for overcoming the barriers.

Decision-making is affected by many factors and involved stakeholders who under conditions of scarce resources both cooperate and compete. Application of complex decision-making methods is perceived as too burdensome and decision makers give in to pressure and make conclusions based on irrational rather than rational methods. However, decision can also be made *ad hoc* under duress, which implies extreme rationality. Like, for example, getting rid of dependency of fossil fuel supplies from the Russian Federation can be done in record-short period of time in the light of Russia's ability to manipulate European decision-making owing to Europe's reliance on Russia's natural gas and crude oil supplies.

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 extraction or harvesting of resources, 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 variety of methods of analysis 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, energy being just one. 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 decision-making throughout 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 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. To 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) to review methods for making decisions about the best suited policy portfolio for developing and maintaining a sustainable energy system;
    b) to 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) to assess the relevance of policies in the interest of reaching climate goals.
2. To analyse policy lifecycle to establish which elements are essential for decision-making and policy making leading to sustainable energy.
3. To analyse the impact of the sequence of steps required for qualitative decision-making on policy choice and policy lifecycle.
4. To 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 that 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 (regression analysis, analytical hierarchy process, TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), "hugs, carrots and sticks" approach, climate policy integration) 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 following elements:

1) description of tasks;
2) description of outcomes;
3) description of quantitative and qualitative methods;
4) risks associated with failure to implement a decision-making step.

These four elements are fundamentally relevant for 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

Sound policymaking for the energy sector is about dismantling existing barriers and not creating new barriers on the way towards sustainable energy. It is inherently related to decision-making about policies to be adopted. 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 proposed 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 often volatile 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.

Transition to sustainable energy and climate system

This section of the Summary 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 an adopted policy or policies have 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 fundamental 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, but also 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, as well as economic and social aspects, or a combination of aspects.

Figure 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, implications 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.

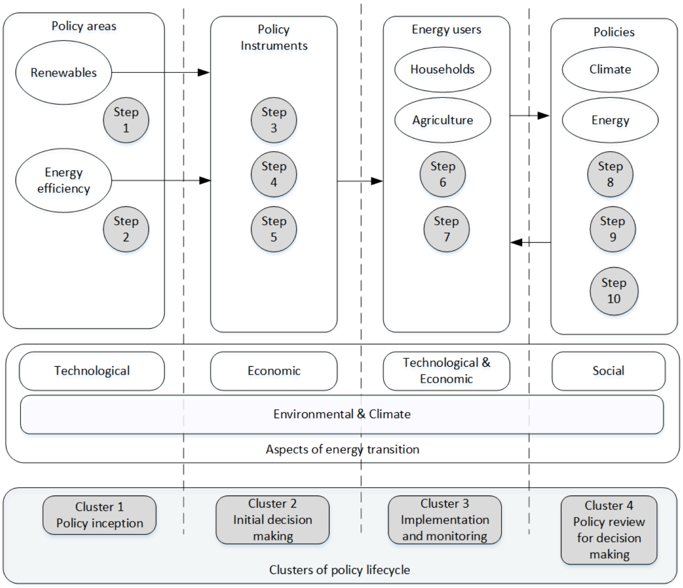

Fig. 1. Elements, processes, and aspects of transition to sustainable energy (illustration made by the author).

The 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.

Sociotechnical transition and other key concepts

For decision-making to meet the necessary quality it is essential to understand the overall context of changes required to 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 sociotechnical regime. For example, as adoption of "new" energy technologies and energy management solutions achieve broader diffusion, the pressure on the traditional energy sector grows and sociotechnical transition takes place (Rosenbloom and Meadowcroft, 2014; Child and Breyer, 2017).

Sociotechnical transition is not a static variable or a fixed situation: there is certain level of dynamism, and a transition can be categorised according to the scale of changes. The scale of the sociotechnical transition depends on multiple factors, and it serves as a basis for the typology of sociotechnical transition. One can distinguish between interim, deliberate and transformative transition largely depending on the temporary or permanent nature of changes (Edomah, Bazilian, and Sovacool, 2020). 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) (Timilsina, 2020; Hdidouan and Staffell, 2017; Bosch, Staffell, and Hawkes, 2019) 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 almost stagnation to fundamental. On the other hand, sociotechnical transition can provide an insight into what must 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 supportive 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 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 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 policy lifecycle to ensure transformative changes in the existing sociotechnical system. Interaction of the many elements is illustrated in Fig. 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.

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 creating barriers on the way to sustainable energy.

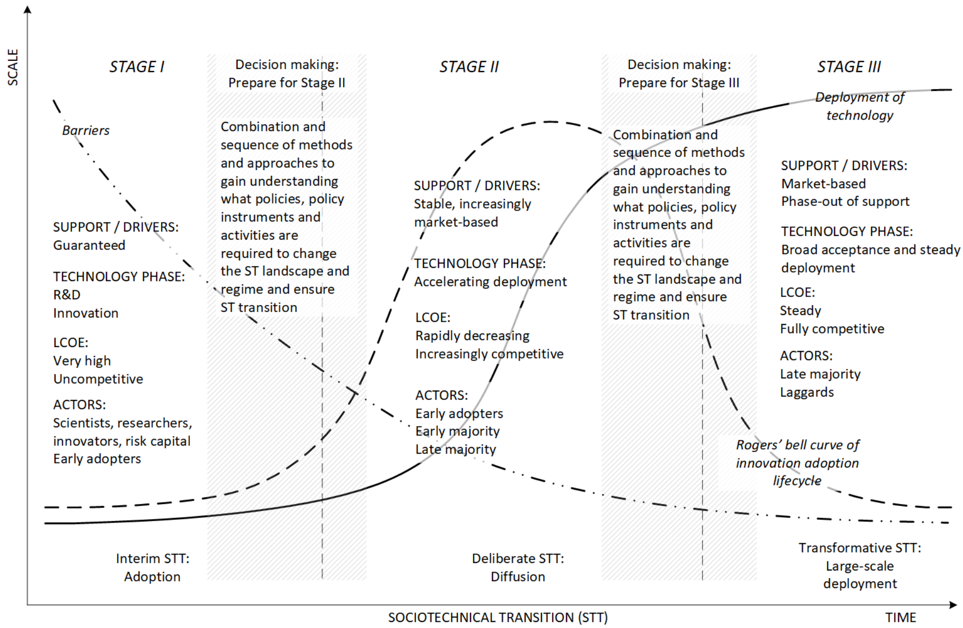

Fig. 2. Policy lifecycle: sociotechnical transition, learning curve, adoption of innovation, and RES support logic (developed by the author).

Although all actors belong to a category of adopters, dominant actors are usually the trendsetters either through being decision makers 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 the section "The role of energy user" and illustrated in Fig. 3 "Ways and means of influencing energy user's behaviour": 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 required 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 and 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 (as illustrated in Fig. 2). The need to analyse situation, make decisions and adopt policies that would lead to indicators 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).

From the perspective of achieving transformative changes, 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*) (Katre and Tozzi, 2019; Aboltins et al., 2020)? 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?

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.

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.

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. Put simply, energy users' behaviour can trigger, enhance, or hinder climate change (UNFCCC 1992). This section briefly explores 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.

The role of energy user

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 must 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 a 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.

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 of an individual vis-à-vis climate and environment: 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 of changing user's behaviour is illustrated in Fig. 3.

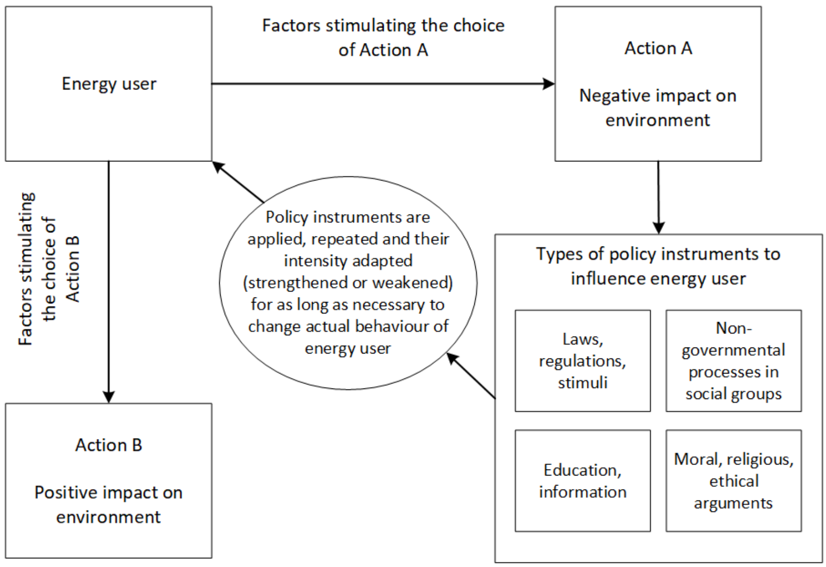

Fig. 3. Ways and means of influencing energy user's behaviour (illustration made by the author).

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 can be saved 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). The more barriers of exogenous character (Aboltins and

Blumberga, 2019), the less 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 (Paetz, Dütschke, and Fichtner, 2012; Liddell, 2015; Aboltins and Blumberga, 2018). Similarly, present bias can also prevent individuals from investing in energy efficiency as future gains are regarded as too irrelevant and too distant in comparison with the required immediate investment (Werthschulte and Löschel, 2021; Fuerst and Singh, 2018).

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, and this is directly related to decision-making about policies. Gardner and Stern 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)), 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; Rutherford and Coutard, 2014; Liebe and Dobers, 2019). Studies on behaviour and attitude towards environment and climate 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, which are conditioned also by policies resulting from decision-making.

When a persistent barrier to action 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 and retaining the new situation (Schot, Kanger, and Verbong, 2016), and thus ensuring the transition has permanent effect and qualifies as transformative (Kanger, Sovacool, and Noorkõiv, 2020).

Applying a variety of techniques of analysis and approaches plays 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.

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, 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 (Johnstone et al., 2020 a). 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.

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

Different actors involved in socio-technical transition possess different power to influence processes. At the same time, any disruptive processes lead to changes in the balance of power among the same actors. 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, 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).

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 transparency that consumers benefit from 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 as new conditions require new solutions and stakeholders need to adapt (Kivimaa and Kern, 2016) both their business structure and behaviour.

Yaqoot and others 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.

Cost of electricity and energy portfolio

Choice of energy production technology has always been inherently subject to considerations about the levelized cost of electricity (LCOE): producing energy for the least cost 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 twelve years, since circa 2009, the LCOE figures of climate-friendly electricity production technologies have significantly decreased (Lazard, 2022), causing chain reaction resulting in high intensity of deployment of such technologies as onshore and offshore wind as well as 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 (Kost et al., 2018).

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. Wind energy is considered one of the most perspective technologies for increasing the share of renewable energy in electricity production. 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, 2022), 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).

It should be noted that low electricity prices hamper deployment of wind energy while high electricity prices function as a positive stimulus as market price of electricity can cover the costs of deployment of wind energy infrastructure. Thus, while wind energy will help to achieve climate goals and will contribute to sociotechnical transition when deployed both onshore and offshore, climate goals can be achieved with least 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 if the costs are high and have negative economic and social repercussions. However, only a proper analysis of each particular initiative can provide an evidence-based answer to the question about the viability of that initiative.

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 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 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.

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).

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 policy instruments, and 3) ones associated with simultaneous implementation of energy efficiency policy instruments. These factors are often omitted in decision-making due to time constraints for decision-making or the terminal character of funding programmes for energy efficiency.

Eight groups of policy instruments can be identified (Cialani and Perman, 2014; International Energy Agency, 2017), which 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: 1) regulatory environment, 2) commercialisation and capacity building, 3) facilitation, information, and market transformation, 4) financial instruments, 5) technical support, 6) cooperation instruments, 7) voluntary agreements, and 8) obligation schemes. 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.

Methods and results

Transition to sustainable energy system is to a large extent a 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).

Current section briefly reflects on the methods and results of analysis done by applying one of the methods/approaches of analysis. The focus is on what conclusions can be drawn for the purpose of making decision-making and choice of policies with achieving sustainable energy system as the main goal.

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. Chapter 2 of the Thesis reviews methods used to assess policies related to renewable energy and energy efficiency through an overview of methods and approaches (see Fig. 4). 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.

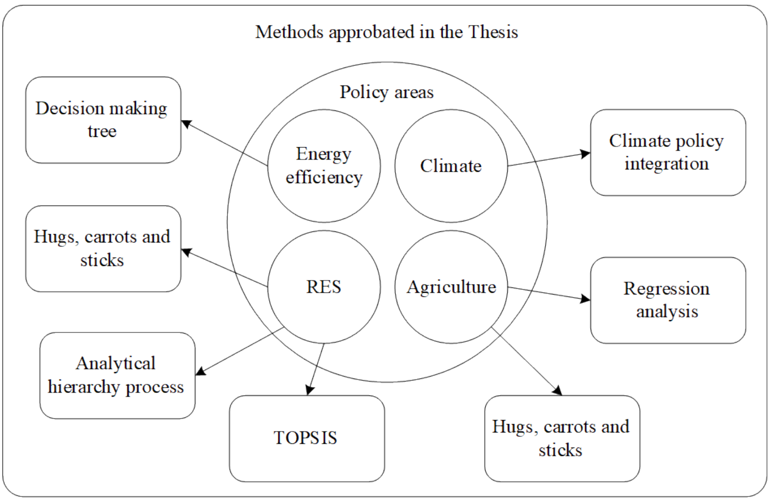

Fig. 4. Methods approbated in the Thesis (illustration created by the author).

Analysis is required to eradicate errors associated with the choice of policies and policy instruments, as it can help avoiding loss of time or extra costs associated with dealing with the consequences of choosing and implementing policy or policies that are not optimal for achieving the defined climate and energy goals.

Methods of analysis that are used to illustrate the role of policy analysis at various stages in the policy lifecycle are reviewed in Section 2.2 of the Thesis. Several methods are applied through case studies. Mathematical models such as linear regression and Technique for Order of Preference by Similarity to Ideal Solution (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 nine-step 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* suggests, 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 as it provides the basic layout for steps of policy analysis. It is also similar to decision-making steps throughout the policy lifecycle.

It should be noted that assessment of policies can also be done with other methods than the ones reviewed in the Thesis. Methods of analysis 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, which require application of various methods of analysis establishing the current status and identifying what has to be changed to ensure successful energy transition being just two.

Integration of decision-making steps and methods

This section of the Summary of the Thesis elaborates on the role and function of methods in decision-making. The Thesis attempts 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 for achieving the desired optimal result – transition to sustainable energy and climate neutrality.

To illustrate the sequence and logic of action for energy transition, Fig. 5 identifies ten steps of policy lifecycle highlighting the role of decision-making in adopting policies aimed at ensuring successful energy transition.

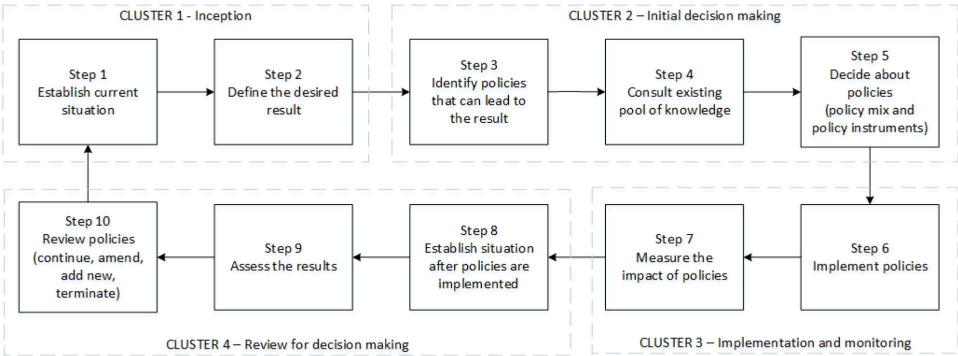

Fig. 5. Ten steps of decision-making during policy lifecycle (illustration created by the author).

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 required. 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 the 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 applied 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. With no point of reference policy or policies can suffer from being implemented perpetually even if there is no sufficient progress, resulting in loosing valuable time and resources and potentially making situation worse. 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.

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.

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.

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 is 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 that do not produce the required results.

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 the 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 in 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 a 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.

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, tasks and opportunities. State institutions ensure that 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, heavily based on analytics (methods of analysis) and should be viewed in the context of policy implementation.

Policies adopted in Step 6 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 6 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 6 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 6 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 the agency responsible for overall climate policy goals is introducing tighter rules on emission reduction, the 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.

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

The 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 an 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.

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.

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.

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 goals 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.

A checklist of questions to be answered in each decision-making step throughout policy lifecycle are summarised in Table 1 of the Summary.

Table 1

Check-list Questions to be Answered During Policy Lifecycle

Clusters and steps of decision-making	**Questions to be answered**
Cluster 1 – Policy Inception	
Step 1 – Establishing current situation	- 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	- 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	
Step 3 – Identifying policies that can lead to the defined result	- 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	- 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	- 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	
Step 6 – Implementing adopted policies	- 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	- 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	
Step 8 – Establishing situation after policies are implemented	- 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	- 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	- 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?

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. Similarly, unexpected, or extraordinary events or conditions (for example, natural disasters, war) have the potential to make policy makers adopt decisions, which would have otherwise not been adopted or would have been adopted in a long and complicated process. This is true about making decisions about the energy sector. 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 are at the centre of the Thesis. Sections of the Thesis are 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 must 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 of the Thesis.

This Thesis 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 as tested and proven.

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