Part B Project Description

Project title: Energy and climate modelling towards net zero emissions

1. Scientific Excellence

1.1. Contribution of the project to achieving the overarching goal, the goal of the programme, and to the implementation of the chosen thematic task
The goals and thematic tasks of the project as well the use of the TIMES group model are predefined in this project. Although TIMES model applies two different, and complementary, approaches to modelling energy: a technical engineering approach and an economic approach and combining it with EnergyPlan model, can improve the modelling of the energy system flexibility, several important aspects, especially behaviour aspects cannot be taken into account. To compensate these shortcomings, this project proposal has proposed innovative approach combining TIMES & EnergyPlan modelling system with the alternative approach – a National System Dynamics (SD) model – analysing complex socio-technical transition to zero greenhouse gas (GHG) energy system. The predefined goal of the project is to develop the analytical knowledge base necessary for establishing and implementing strategic goals of Latvian energy policy, monitoring its progress, prepare necessary policy proposals, as well as develop necessary analytical tools and models for this purpose. The predefined thematic tasks of the project are: 1) to establish and maintain the long term Latvian energy modelling system with the actualisation of its parameters, taking into account development requirements of the National Energy and Climate plan 2030; 2) to ensure elaboration of Latvian national energy system long term development scenarios, their annual updates, taking into account development requirements of the National Energy and Climate plan 2030; 3) to prepare proposals for long term energy policy goals, targets and actions to implement established goals, taking into account development requirements of the National Energy and Climate plan 2030; 4) to establish impact assessment of state energy policy goals, targets and implementation measures, taking into account the budgetary impact, impact on different sectors of economy, environmental impact, impact on reaching established climate targets and vice versa, taking into account development requirements of the National Energy and Climate plan 2030; 5) to ensure proper monitoring system of the policy implementation measures taking into account corresponding EU legal acts, identifying the necessary monitoring data and indicators, carrying out necessary data analysis and interpretations, as well as to establish the necessary analytical methodology and tools. To implement the predefined goal and tasks, this project proposal has proposed to elaborate comprehensive multi model system for energy climate modelling taking into account all aspects of future energy system transformations, especially the future energy system with large share of variable renewables. Pathways and scenarios for Latvia to achieve 2030 EU climate and energy targets as well as nationally established targets (including greenhouse gas (GHG) reductions, energy efficiency, renewable energy in final consumption, circular economy etc.) will be analysed taking into account more comprehensive tasks for fully decarbonizing energy system by 2050. The project will analyse the financial impact of the proposed scenarios which will include different financial instruments (carbon taxes, investment subsidies, etc.), impact on economic growth, sectoral impacts, as well as social impacts (including impact on inequity).

1.2. The goal of the project, hypotheses, objectives and the state of the art in the field of science
The goal of the project: The goal of the project and its objectives are to implement the predefined goal and tasks as well as wider approach proposed by this project (see section 1.1) introducing most up-to-date system of modelling instruments and tools, taking into account not only techno-economic approach, emphasizing detailed technological and economic variables, and system interactions, also over decades, in a formalised quantitative framework, but also socio-technical aspects (institutions, actors, values, technology innovation, etc.) and their interaction over longer time periods (decades) at multiple levels and scales[1] **Project hypotheses:** Future energy system will undergo substantial transition taking into account two driving forces – the comprehensive climate goals and technological changes (high share of flexible renewables, integration of electricity, district heating and transport energy systems, peer – to peer (P2P) energy trading, big

[1] S. Bolwig, G. Bazbauers, A. Klitkou, P. D. Lund, A. Blumberga, and D. Blumberga, "Review of modelling energy transitions pathways with application to energy system flexibility," pp. 1–23.

data and blockchain systems establishing smart energy systems). A quantitative model for sustainable energy transition analysis has to encounter the main reinforcing and balancing effects, which are created by the system's structure itself, and dynamics of shifting of dominance between these effects over time. Taking into account the future vision as well as predefined tasks of the project innovative approach combining TIMES & EnergyPlan modelling system with the alternative approach – a National System Dynamics (SD) model was proposed.

Project objectives

- conduct analysis for data availability and develop new methodology for data management, prepare data base for modelling purposes;
- develop scenarios for energy climate system socio-technical transition;
- develop the modelling systems and data sets, conduct modelling of socio-technical transition;
- compare and analyse the results of two modelling systems;
- assess economic, social and environmental impact of low carbon socio-technical transition;
- prepare policy proposals for the long term development of Latvian national energy system and climate policy.

The state of the art in the field of science

The IPCC Special Report, on the possibility of not exceeding a global temperature increase of 1,5°C[2], suggests that, if we continue on with our current trends, global warming is very likely to reach 1,5°C during the period between 2030 and 2025. In the 1,5°C scenario, the CO_2 emissions in 2030 need to be reduced by 45%, comparing to the 2010 levels (40-60% in some scenarios), whilst reaching net zero emissions around 2050 (2045-2055 in some scenarios) additionally with negative emissions (processes and measures that in future reduce the amount greenhouse gases in the atmosphere). Future energy and climate goals should address these challenges and as well as the analytical tools and modelling system.

Quantitative modelling of energy transition pathways (or energy-economic systems) traditionally draws on the techno-economic perspective, which focuses on "energy systems defined by energy flows, conversion processes, and consumption coordinated through the energy markets" and relies on theories from earth sciences, engineering and economics. The quantitative systems modelling approach in this theoretical perspective has limitations when considering the behaviour of the actors, the role of inertia and innovation and also explaining the spatial dimension of energy transitions. There are identified five analytical challenges to study sustainability transitions: (1) transformation processes forego at different socio-spatial scales and over extended periods of time and a comprehensive understanding of transition pathways requires a thorough understanding of the past, the present, and the future, but here the different approaches have different assumptions for studying these; (2) innovation dynamics is very complex and difficult to predict, but policy support has to comprehend the timing and possible changes of policy interventions and to take into account innovation dynamics; (3) sustainability transitions have to overcome inertia and path dependence, but these are captured differently by different approaches; (4) normative goals of sustainability transitions have to balance with other objectives, like economic competitiveness, human health, and security, (5) a variety of perspectives on governing transitions calls for more integrated perspectives[3].

Linear programming and optimisation approach. The comprehensive review of the available modelling tools has shown that only a few current modelling tools take into account the uncertainty of variable renewable energy sources (VRES) generation. Most tools are deterministic and VRES generation is based on historical meteorological data[4]. The TIMES model extends the MARKAL system in several directions (according to the model developers home page TIMES is strongly preferred over MARKAL): it is scalable from local to global, and it allows for vintage of technologies, flexible time slices (daily load curves), variable forecast horizons, and the distinction between service life and economic life of technologies. Although the MARKAL/TIMES models show a good level of detail and contain many features of the energy-economic system, they mostly lack an explicit treatment of the energy networks and decentralized generation sources, endogenous microeconomic behaviour, feedbacks of the energy system to the macro economy, and detailed system security assessments[5].

[2] IPCC, "IPCC special report on the impacts of global warming of 1.5 °C.," 2017.
[3] A. Cherp, V. Vinichenko, J. Jewell, E. Brutschin, and B. Sovacool, "Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework," Energy Res. Soc. Sci., vol. 37, no. January 2017, pp. 175–190, 2018.
[4] H. K. Ringkjøb, P. M. Haugan, and I. M. Solbrekke, "A review of modelling tools for energy and electricity systems with large shares of variable renewables," Renew. Sustain. Energy Rev., vol. 96, no. April 2017, pp. 440–459, 2018.
[5] P. Crespo del Granado, R. H. van Nieuwkoop, E. G. Kardakos, and C. Schaffner, "Modelling the energy transition: A nexus of energy system and economic models," Energy Strateg. Rev., vol. 20, pp. 229–235, 2018.

These shortcomings can be partially addressed by using TIMES model together with EnergyPlan model[6] .This approach will be used also in the current project, taking into account the experience with EnergyPlan model in Latvia[7]. However, such extension might still fall short on analysing the power systems operations, a strength of optimal power flow (OPF) models. OPF models analyses the power balance in the electricity grid at each node considering voltage and line limits. Grid topology and physical components are represented in high detail[5]. The European Union (EU) 2030 Framework for climate and energy, sets an economy-wide target of at least a 40% domestic reduction of GHG emissions compared to 1990 emissions to be achieved by 2030, and foresees a land use, land use change and forestry LULUCF contribution to achieving the target. The EU Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU lays down the accounting rules applicable to GHG emissions and removals from the LULUCF sector, building on the existing rules. It also requires Member States to ensure that the overall LULUCF sector does not generate net emissions. Therefore the proposed energy climate modelling should be supplanted with the LULUCF sector analysis.[8]

System Dynamic (SD) approach. Socio economic transition process can be characterized by nonlinear shifts from one pathway to another. These shifts depend mostly on endogenous factors rather than external impacts. Therefore, when making a quantitative model for sustainable energy transition analysis, one needs a tool that allows encountering main reinforcing and balancing effects, which are created by the system's structure itself, and dynamics of shifting of dominance between these effects over time. The limitation of most so-called traditional modelling tools lies in the inability to capture these complex dynamics, which result from the internal structure of the system under analysis. Furthermore, as shown in this section, the modelling approach must enable quantitative description of transition not only in the technology domain, but also in the institutional, market, and social domains. Therefore, SD is as an approach, which may help filling this gap[1]. It may be even more important with more flexibility of the future energy systems, not only in the electricity generation, but also district heating systems[9], and growing importance of the demand side management.

System dynamics models have been successfully used for energy system modelling for decades and a good overview is provided in[10]. The main advantage of system dynamics over traditional modelling approaches using econometric and linear programming methods is its ability to capture the complex and dynamic nature of energy systems. Namely, with system dynamics models we are able to consider:

1) Information feedback loops affecting demand and investment decisions, regulations and policy implications, environmental awareness of society;

2)Material (e.g. power generation capacity construction) and information (e.g. price signals, level of knowledge about new technologies) delays;

3) Co-development (co-flows) and mutual interaction of material (e.g. capacities of various technologies) and non-material (e.g. level of expertise, technology-readiness levels) stocks;

4) Non-linear causal relations governed by reinforcing and balancing forces (e.g. diffusion of new technologies and limits to growth) which are characteristic for technology disruptions in socio-technical systems.

Energy modelling currently tries to combine strengths of so-called top-down models (input-output models, econometric models, computable general equilibrium models and system dynamics), which provide endogenous assessment of economic and societal effects, with bottom-up models (partial equilibrium models, optimization models, simulation models, multi-agent models), which are able to provide higher technological detail[11]. Both modelling approaches are combined in so-called hybrid energy system models by either soft linking, i.e. manual transfer of data, parameters and coefficients, or hard linking by using automatic routines[13]. Thus, combining system dynamics with technologically detailed optimization models could be a prospective direction for modelling of socio-technical energy transitions and this approach will be further elaborated in the current project.

[6] A. Pina, C. A. Silva, and P. Ferrão, "High-resolution modeling framework for planning electricity systems with high penetration of renewables," Appl. Energy, vol. 112, pp. 215–223, 2013.
[7] J. Porubova and G. Bazbauers, "Analysis of Long-Term Plan for Energy Supply System for Latvia that is 100% Based on the Use of Local Energy Resources," Environ. Clim. Technol., vol. 4, no. 1, pp. 82–90, 2010.
[8] K. Paquel et al., "Analysis of LULUCF actions in EU Member States as reported under Art . 10 of the LULUCF Decision," no. November, 2017.
[9] D. Møller Sneum, E. Sandberg, H. Koduvere, O. J. Olsen, and D. Blumberga, "Policy incentives for flexible district heating in the Baltic countries," Util. Policy, vol. 51, no. February, pp. 61–72, 2018.
[10] H. Qudrat-Ullah, "Modelling and Simulation in Service of Energy Policy," Energy Procedia, vol. 75, pp. 2819–2825, 2015.
[11] A. Herbst, F. Toro, F. Reitze, and E. Jochem, "Introduction to Energy Systems Modelling," Swiss J. Econ. Stat., vol. 148, no. 2, pp. 111–135, 2012.

National SD model, including aspects shown in Fig 3. will be established, such approach has been already used[12], however, taking into account all tasks of the project, Latvian National SD model will be more comprehensive, however many elements of the model are already in place[13], [14],[15].
The structure and algorithm of the proposed modelling system is included in fig.1. Taking into account the proposed new and innovative approach the project and new data will develop new knowledge regarding the whole policy cycle, including agenda setting (analysys), formulation (impact assessement), adoption (support and advise to relevant institutions), implementation (verification, monitoring and methodological guidance), evaluation (proposals to improve efficency and effectiveness), support and meintanace (crisis response, feedback and updates).

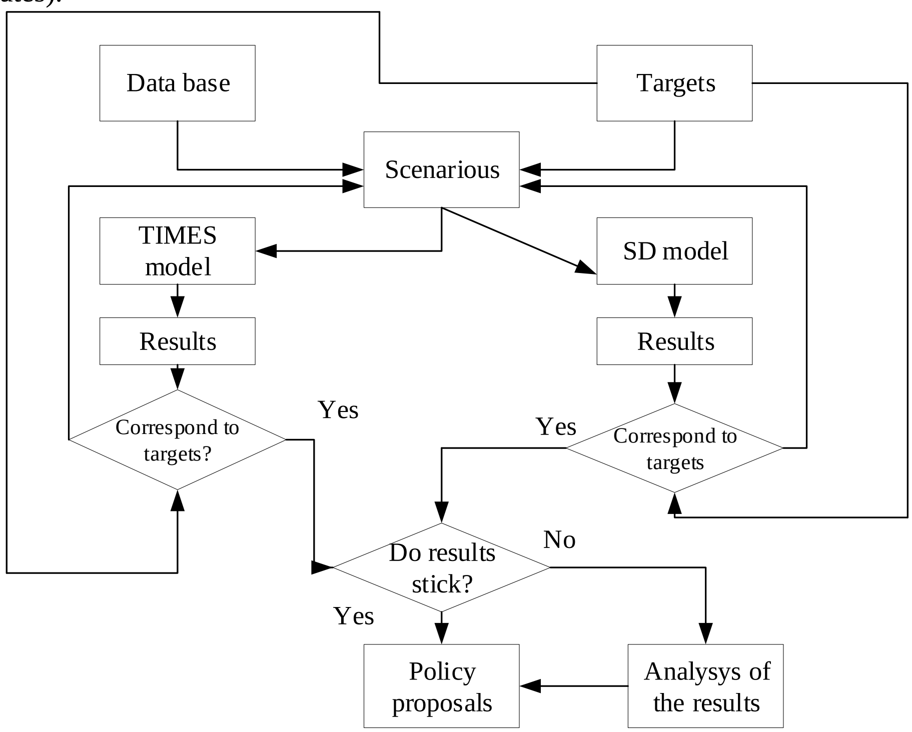

Fig.1. Algorithm of the proposed Latvian modelling system. Taking into account the significance and impact of the socioeconomic transition no only on energy system, but on all aspects of society development, it is proposed to establish two different modelling approaches – one based on linear programming and optimisation models (TIMES model, including supporting models)), other on SD model.

1.3. Contribution of cooperation partners in achieving the goal of the project and mutual complementarity, if applicable

The economic impact on other economic sectors will be carried out by the cooperation partner Latvian University (LU, Faculty of Business, Management and Economics) – leading scientist professor Gundars Berzins Two approaches will be evaluated, taking into account data availability, for the economic impact analysis on economic sectors 1) Computed general equilibrium (CGE) model and Social Accounting matrix (SAM); 2) Input – output matrix. The project team will include Liga Leitane with previous experience on assessing state support instruments in energy sector, as well as Rita Freimane specialising in R&D expenditures and the economic growth. The proposed approach will help to assess impact on different sectors of economy, potential co-benefits of the socio- technical transition of energy system, taking into account the output of the energy – climate models and the data bases developed in the project. The LU team will especially focus on the influence of socio –technical transition on competitiveness of other sectors.

[12] A. M. Bassi, "Moving towards integrated policy formulation and evaluation: The green economy model," Environ. Clim. Technol., vol. 16, no. 1, pp. 5–19, 2015.
[13] D. Blumberga, A. Blumberga, A. Barisa, M. Rosa, and D. Lauka, "Modelling the Latvian power market to evaluate its environmental long-term performance," Appl. Energy, vol. 162, pp. 1593–1600, 2016.
[14] J. Ziemele, E. Cilinskis, and D. Blumberga, "Pathway and restriction in district heating systems development towards 4th generation district heating," Energy, vol. 152, 2018.
[15] A. Blumberga, G. Bazbauers, P. I. Davidsen, D. Blumberga, A. Gravelsins, and T. Prodanuks, "System dynamics model of a biotechonomy," J. Clean. Prod., vol. 172, 2018.

Impact assessment of the LULUCF sector in relation to climate energy targets, will be carried out by other cooperation partner Latvian University of Life Sciences and Technologies (LULST) – professor Dagnis Dubrovskis, leading researcher in this project, and Salvis Dagis (Forest faculty) forestry sector, professor Ritvars Sudars and professor Ainis Lagzdins (Faculty of Environment and Civil engineering) The project team will focus on exploiting mitigation potential from LULUCF in a targeted and cost effective way: agriculture and forestry policies, as well as wider environment, climate, energy and biodiversity policies, contribute to increasing GHG sinks and reducing GHG emissions from land use sectors in a complex range of ways, taking into account requirements and indicators from the corresponding EU legal acts. Impacts on other policies, especially bioenergy (availability of resources) will be analysed. Forestry sector will be analysed using IT tool developed in LULST -the support system of planning and decision making for the sustainable forest management (MAPLAS). Main MAPLAS tasks are: support decisions for planning of forest management, provide fast and accurate calculations, help to choose targets, help to determine the optimal target path. The main objectives of the software are: forest inventory data processing, forest management planning; forest accounting; forest evaluation; forest management control and risk assessment.

2. Impact

2.1. The scientific results of the project, technological insights and the dissemination plan

Information transfer and knowledge dissemination are an important part of the project. Through scientific publications the sustainability of the results obtained will be achieved also beyond project finalization. Thanks to the approach of result dissemination (i.e. scientific publications, popular scientific publications, press releases, updates in RTU IESE homepage and social profiles, publicity activities) of the results, potentially all target groups (i.e. scientists, new researchers, society, students and government) of the project will be informed about presented innovative approaches and policy proposals.

Scientific results and technological know-how will be organized in the following way:

2.1.1. scientific publications (*SCOPUS, WoSCC* and/or *ERIH+*) 4;

2.1.2.establishment of long term Latvian energy modelling system with the actualisation of its parameters, taking into account development requirements of the National Energy and Climate plan 2030 including 2 modelling frameworks 1) linear programing and optimisation models (including TIMES, EnergyPlan,); 2) national SD model 3) tools for economic analysis CGE&SAM and/or I-O matrix;

2.1.3. international scientific conferences to participate in or organize 2, 3 local conferences will be organised;

2.1.4. policy proposal documents: proposals for long term energy and climate policy goals and actions to implement established goals, taking into account development requirements of the National Energy and Climate plan 2030 evaluating the budgetary impact, impact on different sectors of economy, social (including impact on poverty rate and inequity), as well as environmental impact and impact on public health (in particular regarding air pollution) 3 (each project year);

2.1.5. PhD works and master works prepared according to project tasks and goals 1+2 (2^{nd} and 3^{rd} project year);

2.1.6. other project specific results – 1) elaboration of Latvian national energy system long term development scenarios, their annual updates, taking into account development requirements of the National Energy and Climate plan 2030; 2) monitoring system of the policy implementation measures taking into account Regulation of the European Parliament and of the Council on the Governance of the Energy Union (Energy Union Regulation) and other relevant EU legal acts, identifying the necessary monitoring data and indicators, carrying out necessary data analysis and interpretations, as well as to establish the necessary analytical methodology and tools.

2.2. Involvement in international cooperation networks and consortia (including calls in research and innovation framework programmes and other support programmes for innovations and technological initiatives)

Project staff will participate in international conferences and networks, actively organising knowledge dissemination. Knowledge and scientific contacts from ongoing projects and networks where project team is participating will be used for the benefit of the current project, including Flex4RES - Flexibility for Variable Renewable Energy Integration, Nordic Energy Research , LowTEMP - Low temperature district heating for the Baltic sea region , “Accelerate SUNShINE” - continuation of project “SUNShINE” or further development, to re-establish in municipalities of Latvia both public and residential buildings, to mobilize all interested parties, to carry out feasibility study, to provide financial management instruments and to solve legal and regulatory issues, using long term energy efficiency agreement and reaching 50 – 60% of savings in renovated buildings, etc.

Taking into account the necessity of more detailed elaboration of climate and energy policy proposals after 2030, it is planned to prepare a project proposal for the EU Research and Innovation programme EU Horizon 2020, in 1) topic LC-CLA-02-2019: "Negative emissions and land-use based mitigation assessment", because negative emissions are needed to maintain 1.5 ºC goal; 2) in topic LC-CLA-06-2019: "Inter-relations between climate change, biodiversity and ecosystem services", taking into account that some of the proposed policy measures (for example regarding increasing use of bioenergy) may conflict with biodiversity goals and these aspects need further investigation.

2.3. The socio-economic impact of the results
Project results, publications, policy documents, scenarios as well as data bases and modelling tools (except commercial tool TIMES model) as much as possible will be available for public (as much as possible using Open Access and Open Data principles) also after finishing the project. The modelling system will be available for further use and development after the end of the project. The modelling system will be available not only to model and evaluate impacts of scenarios proposed by the project team, according to the project proposal, but also other scenarios proposed by other actors.

2.4. Measures for informing society about the importance of research and the specific topic throughout the duration of project implementation and after the conclusion of the project
Informing society will be important part of the project. Therefore, it is planned to use different forms of videos, popular science articles (at least 3 during the project). Information will be available in Riga Technical University (RTU) Institute for Energy Systems and the Environment (IESE) home page as well as especially for the project purpose created YouTube channel and Facebook page (which may include information from other relevant projects). The prepared channels and pages will be available after the end of the project. Public discussions and seminars are also planned, as well as it is planned to adapt in Latvia innovative modelling methodology – modelling with stakeholders, so improving the quality of the models.

2.5. Contribution to capacity building of university students
The project will create increased knowledge capacity for the students involved in the project. It is planned to involve 1 PhD students (regarding modelling and impact assessment issues) to involve and train 2 master students and 3 bachelor student to develop their scientific work connected with the project.

2.6. Contribution to improving the study environment and a plan for training specialists in the respective field for needs of the national economy
Project results will be integrated in existing RTU, LULST and LU study plans, including existing course on SD modelling so contributing for training specialists for the needs of national economy. New study course Energy and environment modelling will be introduced in RTU IESE.

2.7. Contribution to the capacity building of the project's scientific team, including training teams of individual scientists in the thematic area of the project, as well as building team's competitiveness internationally
The project will create a socio-economic impact and increased knowledge capacity for the scientists involved in the project, including new knowledge and skills in environment and climate modelling, implementing a long term institutional sustainability. Furthermore, qualification and practical experience of the employees will be improved. The project will improve cooperation between the involved institutions RTU, LU, LULST promoting and strengthening further interdisciplinary research and strengthening the competiveness internationally.

3. Implementation

3.1. Project applicant and scientific team
RTU IESE is holding a leading position in Latvia environmental engineering, renewable energy, climate change technologies and energy efficiency. Special attention of the RTU IESE is devoted to climate change policy, GHG reduction technologies and sustainable energy development. Scientists and researchers at the RTU IESE are experienced in analysing the energy systems with systems dynamics modelling, EnergyPlan model, life cycle assessments, life cycle cost and social assessments, artificial networks, MCA, indicator based approaches and others. Additional attention during the last years is paid to analysis of innovative energy technologies adoption and diffusion. Project leader is professor Andra Blumberga with expertise in modelling systems, SD,

energy efficiency and other issues. Leading researchers will be professor Dagnija Blumberga with expertise in energy modelling, including Baltic Energy Technologies Scenarios 2018 (BENTE) project bioeconomy, interdisciplinary research, preparing policy and legislative proposals; professor Gatis Bažbauers with expertise in energy policy (including EnergyPlan programme) SD, energy efficiency and bioeconomy and professor Andra Blumberga. The project team has long experience for preparing policy proposals for national government and local governments, (documents available in Latvian) regarding evaluation 2030 EU climate goals, project in cooperation with the Ministry of Environment and regional government, includes SD modelling renewable energy efficiency 4th generation district heating (ongoing) and other areas. Combination of the expertise of the RTU researchers with the contribution of the cooperation partners (described in section 1.3) will ensure multidisciplinary team covering all areas of the necessary expertise.

3.2. Work plan

Work plan of the project:

WP1 Project management

WP2 Data analysis:

- analysis of the Latvian Energy and Climate plan requirements, EU Regulation of the European Parliament and of the Council on the Governance of the Energy Union (Energy Union Regulation) requirements, identification of all necessary elements and outcomes of proposed modelling work;
- analysis of the existing situation and projections, taking into account the latest available data: macroeconomics (including GDP, demographics, regional mobility), structural changes, global trends (including forecasts of the prices of energy resources and energy technologies), GHG emissions and removals (EU ETS, non ETS, LULUCF), carbon intensity, non-CO_2 emissions, energy supply, energy demand (electricity and heat), transformation sector, renewable energy, energy consumption, energy efficiency and energy savings, energy security, interconnections, energy markets, R&D, land use, forestry and biomass for energy (including forest based biomass, agricultural biomass and organic waste biomass) and other relevant aspects, taking into account methodological requirements of the EU Energy Union regulation (Annex I- Annex X according to draft regulation 30. 11.2016 COM (2016) 759 final;
- analysis of the existing budgetary framework, availability of investments (analysing energy related investments to GDP), R&D aspects, existing situation and projections in different sectors of economy (including transport sector development, industry, housing), existing situation regarding social aspects (including impact on poverty rate and inequity), existing situation and projections of environmental sectors related with energy and climate issues such as circular economy and waste management, air pollution and its impact on public health, biodiversity aspects;
- conduct surveys and analyse the data for further modelling purposes derived from the surveys on society's values and opinions, the readiness to adapt a more sustainable lifestyle, participate in energy efficiency projects, change transportation habits, reduce individual GHG emissions, participate in energy demand side management, readiness to pay for environmental improvements etc.;
- conduct analysis for data availability and develop new methodology for data management.
- prepare necessary input data for the modelling systems, taking into account all necessary outcomes;
- annually update all necessary data and information.

WP3 Development of scenarios:

- analyse all relevant binding and nonbinding targets (international, EU, national), including GHG reductions, renewable energy, energy efficiency, circular economy, air pollution reduction, etc.; indirect goals, that influence energy and climate modelling (demographics, inequity etc.);
- analyse the available economic instruments, EU ETS system developments, CO_2 and other relevant taxes, investment support, renewable electricity support schemes, such as green procurement, feed-in- premium tariffs, etc.; promotion of energy service companies (ESCO) and their role on improving energy efficiency;
- analyse the possible influence of legal changes, such as changing decision making requirements for starting multi flat buildings energy efficiency projects;
- study how the perception of climate risk, changes of values and individual actions are influenced by various factors and their influence on energy climate sociotechnical transition;
- evaluate the potential co-benefits of energy climate sociotechnical transition, including regional development, improved air quality and green jobs. Include these aspects in the models;

- develop draft scenarios and organise consultations with relevant state institutions, local governments, social partners, scientific community, students, general public;
- use the scenarios for the modelling purpose;
- annually update of the scenarios.

WP4 Development of modelling system and data sets.

- improve the TIMES and EnergyPlan models regarding all necessary and relevant information according to WP2 and WP3;
- developing necessary data sets for forestry and other LULUCF emissions;
- development of Latvian CGE model and preparing the necessary input data in the form of social accounting matrix (SAM) and/or input-output matrix;
- validate and interlink the developed modelling tools;
- develop national SD model for energy and climate socio-technical transition, including aspects of behaviour change;
- adapt the method – modelling with stakeholders for the national SD model;
- elaborate proposals for combining system dynamics with technologically detailed optimization models for modelling of socio-technical transitions;
- development of data base including its e-management system on energy efficiency savings and its monitoring;

WP5 Approbation of the modelling system:

- carry out the modelling of scenarios, analyse and compare the results of two different modelling approaches;
- improve the modelling system, taking into account initial modelling results, as well as make annual improvements, taking into account knew knowledge;
- evaluate if the targets are reached, if not, reassess the scenarios, if necessary;

WP6 Development of policy proposals and legislative proposals;

- elaboration of policy proposals for the long term development of Latvian national energy system and climate policy, including impact assessment on energy system, economy and society, as well as their annual updates, taking into account requirements of the National Energy and Climate plan 2030 and requirements of all dimensions of the Energy Union Regulation;
- monitoring system of the policy implementation measures taking into account the requirements of the National Energy and Climate plan 2030, the Energy Union Regulation and other relevant EU legal acts, identifying the necessary monitoring data and indicators, carrying out necessary data analysis and interpretations, as well as to establish the necessary analytical methodology and tools;
- assessing the impact of the energy and CO2 taxes on energy consumption and development of methodology determining energy savings;
- develop legislative proposals facilitating the implantation of energy and climate and other national goals;
- prepare proposals for the necessary statistical data improvements for improvement of policy analysis and EU reporting;
- organise consultations with relevant state institutions, local governments, scientific community, social partners, students, general public on developed draft policy documents and legislative proposals;
- prepare 2 HORISON projects (see section 2.2.) as well as national level project proposal for the analysis implementation of circular economy and waste management goals and impact on climate energy goals.

WP7 Distribution of information and knowledge:

- organise public consultations and modelling with stakeholders according to WP3, WP4, WP6.
- include all new knowledge in study plans. Develop a new study course Energy and environment modelling;
- prepare at least 3 popular science articles on future energy systems and climate risks;
- organise at least 3 public lectures or seminars for schoolchildren, facilitating their attitude change towards less consumption and energy efficiency in everyday life.

3.3. Project management and risk plan
Project management will guarantee a fluent communication between all involved employees, to ensure timely delivery of milestones and scientific results (including the correspondence to the timeline of the development of the National Energy and Climate plan and the timetable of the relevant EU legislation, regarding development, consultations and monitoring of the energy policy) to discuss different project implementation issues, justified use of budget thus taking care of the overall project progress. Major project meetings will be held each 3 months of the project (total 12). Risks will be monitored according to the risk assessment. Project Quality Plan will ensure supervision of project implementation and credibility validation of achieved results. Scientific management plan will ensure timely delivery of scientific publications and participation in conferences. Once a year international steering committee meeting, with top foreign experts (including Tomi J. Lindroos VTT Technical Research Centre of Finland, Espoo, professor Pål Davidsen – University of Bergen) in the area will be organises (possibly in the form of video conference) to exchange knowledge.

Risk assessment					
No.	Risk	Risk description	Assessment		Risk prevention/reduction measures
			Probability	Impact	
1.	Organizational management	The possibility of uncoordinated actions between the RTU management – the structural unit that is the project implementer and other project participants. This could result in a project execution that lacks the level of quality.	Medium	Low	An RTU Project management procedure that states a single, transparent concept of the project, application preparation process, project implementation and monitoring processes at the RTU, as well as a definition of duties for the RTU management and project participants in order to sustain this procedure. Because the possible risks are already identified during the preparation of the procedure, the risk is completely dissolved at this stage. The management team oversees if there are any changes in the binding normative documents during the project implementation period. The cooperation partners – LU, and LULST has had extensive experience in similar tasks and this type of collaboration has been successful and effective. If necessary, the project implementer makes the necessary changes, coordinating them with the project financier.
2.	Leaders qualification and experience	The possibility of the project manager not being insufficiently competent or experienced to oversee the project, execute the given tasks, and reach the main goal of the project.	Medium	Low	The qualifications and the previous experience of the project manager has already been considered. Not only both of these factors meet, but also exceed the requirements of this position. Therefore, we can classify this risk as insignificant and unlikely. If for any reason the existing project manager cannot continue overseeing this position, a new suitable candidate is selected from the already existing scientific team of this project. Considering the needs of this project, regarding human resources and their qualifications, more than 10 RTU IESE scientific employees hold a doctorate degree and have previous experience in realizing projects and scientific researches, with regular inclusion in internationally cited scientific journals.
3.	Capacity of human resources	The possibility of insufficient qualification, experience and knowledge of the personnel involved in the implementation of the project, in order to carry out the appointed tasks and reach the main goal with a certain level of quality.	Medium	Low	The project manager can successfully evaluate the abilities and responsibilities of the team, efficiently organise their operations and assign the appropriate competences, in result excluding this risk of acquiring an excessive or insufficient number of human resources. If any changes occur, the project manager instantly reacts and redirects the team in the necessary direction, managing the amount personnel capacity if necessary. The project applicant (RTU IESE) has a team of more than 50 people, most of which hold at least a Master's degree. All scientific staff regularly participate in international scientific projects, participate in scientific conferences and publish their research. Consequently, RTU IESE would not have problems to attract other competent specialists from the staff to the project. The same goes with the cooperation partners – LU and LULST.

4.	Task definition and execution	The possibility of inaccurately defined or interpreted/executed project tasks, which would result in the risk of not reaching the aim of the project.	Medium	Low	Within the framework of each project activity, a plan of objectives, tasks and results has been developed, which will be regularly updated at project meetings, and which will clearly define the tasks for the scientific team involved in the project. If, during the project implementation, it is realized that one of the tasks has been defined inaccurately, in order to reach the aim of the project, changes will be made and coordinated with the project financer.
5.	Lack of financial resources	The possibility that the project applicant will not have the necessary pre-financing for the project implementation or that the project budget has been incorrectly drafted, as a result of which there is insufficient funding for the implementation of the planned activities.	Medium	Low	The risk of insufficient funding is reduced by a timely planning of the necessary funding from the applicant's budget. The financial plan is based upon the scale of necessary activities, considering previous project experiences in planning the budget flow. The project costs are planned in accordance with the necessary requirements, and the hourly rates are specified by the project applicant and based on past experiences in realizing similar activities. The salaries were determined in proportion with the amount and specificity of work and the average RTU employee salary. If the necessary costs become higher than expected, they will be amended within the framework of the project's budget. This will be coordinated with the project financer, and, if necessary, the additional costs will be covered from the project applicant's budget.
6.	Accounting records and progress reports	The possibility of project's accounting statements not being applied to the correct project, or that unrelated expenses are applied to this project. Also, the possibility of not following the task and review material deadlines defined by the project financer.	Low	High	Because a constant accounting control is provided, the RTU Project management system excludes the possibility of this risk. Any payments made within the project's framework automatically are registered in the payment/transaction section of the Project management system. This way there is control over task execution, deadlines, procurement system and the transparency of transactions, while also significantly facilitating the progress report system.
7.	Double funding	The possibility of the expenses for the same tasks are allocated to several different project and are repaid multiple times.	High	Low	RTU Project Management System ensures the elimination of overtime work and overtime working hours. During the project implementation, on all of the document originals and other project paperwork a unified project implementation number. On any documents that concern the implementation and results, a reference to the project is used, to dismiss the risk of double financing.
8.	Achievement of performance indicators	The possibility that all necessary tasks are not performed with quality during the project development process, and the achieved qualitative and quantitative results are not sufficient enough.	High	Low	Achievement of the projects goal will be ensured by the project managers' experience in project execution and the internal audit tools (monthly meetings, which cover the progress of the project). The personnel involved is highly qualified and can carry out the planned activities. They have extensive experience in project implementation and management, which will ensure a quality management and achievement of planned results within the scheduled time limits. The project is based upon assumptions about the competence and experience of the project management and employees, in implementing similar projects and activities.