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# **Recycled material application for encapsulated phase change material thermodynamic property improvement in active solar systems**

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This paper presents theoretical and experimental research on thermodynamics of the encapsulated phase change materials (PCM). Experiments will be carried out with recycled graphite from local industrial enterprises to explore the possibilities of industrial symbiosis.

Phase change materials are often used for solar energy accumulation. PCM has large latent heat capacity, which is why they are suitable for energy storing. Solar radiation is cyclic and variable during daytime, so it is important for storage material to have quick response time in case of temperature changes. In solar thermal systems which use water as a heat transfer fluid, it is possible to accumulate heat relatively fast, but specific heat capacity of water is comparatively smaller than potentially possible accumulated energy. Traditional solar thermal systems use water as a heat transfer fluid since it has relatively high specific heat capacity and thermal conductivity, however energy is stored only as a sensible heat. PCM allow to store energy also in latent form. To improve energy accumulation systems, encapsulated PCM spheres are placed in water tank. Since solar radiation is not constant, PCM needs high thermal conductivity to accumulate energy in short period of time. It is possible to improve thermal conductivity by adding to PCM additional materials which have higher heat conductivity. Agyenim et al. (2010) in his publication experimented with metal rings, carbon brushes, graphite flakes to improve heat conductivity of encapsulated PCM. The possibility of using recycled materials for thermal energy accumulation was researched by Reyes et al. (2014) where PCM was filled in soft drink cans made of aluminum. Additionally aluminum strips were placed inside the cans. It was found that the use of aluminum cans and strips doubled total thermal conductivity compared to pure PCM.

The aim of this research is to analyze the possibilities to use recycled materials with encapsulated PCM in solar thermal systems, improve heat conductivity of PCM by using recycled materials and to develop system dynamics model for theoretical research of encapsulated PCM.

## **Kopsavilkums**

Darba mērķis teorētiski un eksperimentāli pētīt iespējas uzlabot iekapsulēto fāžu pārejas materiālu (FPM) siltumvadītspēju izmantojot reciklētus materiālus no vietējiem rūpniecības uzņēmumiem, kuriem ražošanas procesā grafiīts un metāla sakausējumi paliek kā atkritumi.

Darbā tiek veikta vispārēja literatūras analīze par saules siltuma akumulācijas sistēmām un to nozīmīgo lomu mūsdienu pasaulē, kura pāriet uz atjaunojamiem energoresursiem. Tiek analizēta informācija par fāžu pārejas materiāliem, to problēmām, kā arī tiek aplūkotas līdz šim pētītās proporcijas FPM maisījumiem ar tūrām vielām siltumvadītspējas uzlabošanai. Tika izstrādāts arī sistēmdinamikas modelis programmā Powersim Studio 10 ar mērķi teorētiski simulēt iekapsulētā FPM enerģijas akumulāciju un pētīt sfēras parametru ietekmi uz akumulētās enerģijas daudzumu. Darba eksperimentālajā daļā tiek veikti pētījumi ar fāžu pārejas materiālu iekapsulēšanu, reciklēto materiālu apstrādi priekš pievienošanas FPM, un tiek meklēti labākie risinājumi optimālai enerģijas akumulācijai izmantojot FPM ar reciklēto materiālu piemaisījumiem. Darba nobeigumā tiek veikti secinājumi par reciklēto materiālu ietekmi uz FPM siltuma vadītspējas uzlabošanas iespējām, pozitīvajiem aspektiem un trūkumiem, kurus būtu jānovērš, kā arī sniegti priekšlikumi turpmākai iekapsulēto FPM izpētei un uzlabošanai priekš aktīvajām saules siltuma akumulācijas sistēmām.

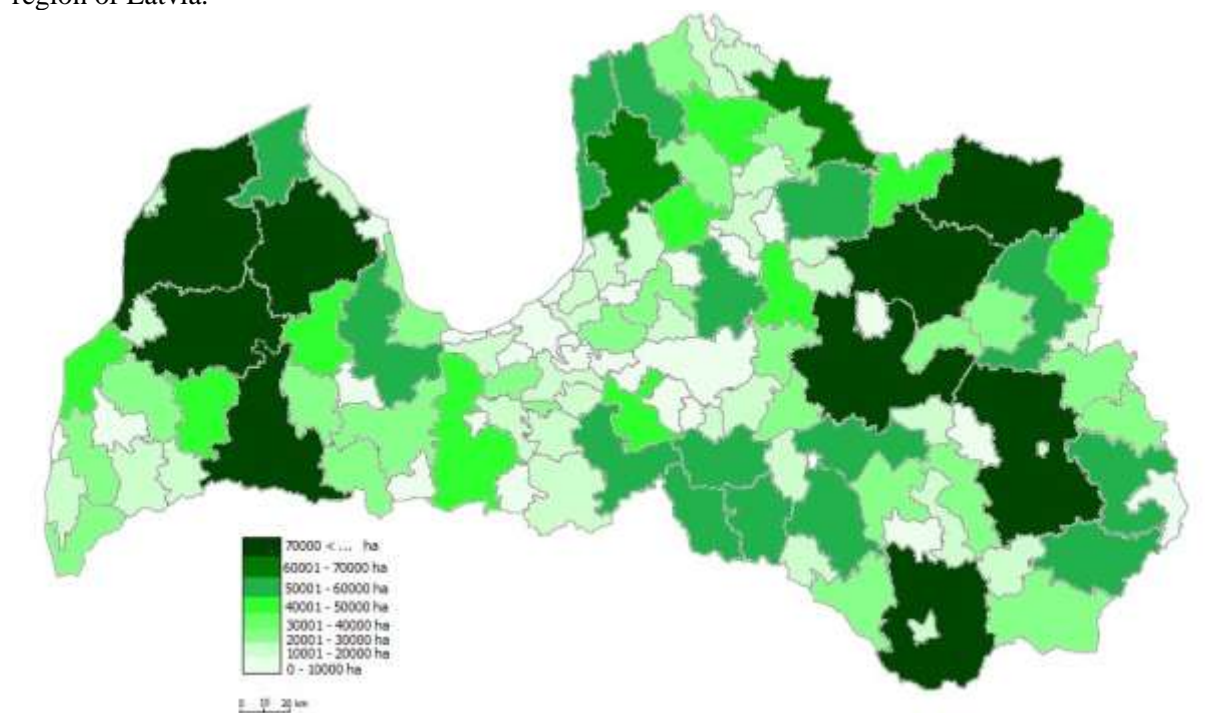
## Wood resources mobilization opportunities in Latvia

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Dr.Habil.Sc.ing. Dagnija Blumberga, M.Sc. Indra Muižniece

This paper presents an evaluation of wood resources in Latvia. Data about the development of forest industry since year 1990 till 2014 were collected and analyzed. All data were collected from National forest Services database. Collected data were sorted and summarized in form of cartographic materials, where you can see current situation of wood resources and forest areas from different viewpoints.

Wood area occupies above 53 % of Latvian territory. Over the years area of wood has increased. Latvia is one of the greenest countries in European Union, but Latvia does not use this resource sustainably. Usually we are exporting timber and after that importing high quality material, which could be produced here in Latvia. This is true not only with timber, but also with other resources from forest, for example berries, mushrooms, Christmas trees and other that can be used in various ways. Data analysis will allow to determinate how these resources could be most efficiently used in each region of Latvia.



*Forest areas in regions of Latvia in 2014*

Cartographic materials show how many and what kind of timber resources are in each region of Latvia. For example, in a picture above you can see forest areas and regions of Latvia, in 2014. By analyzing these data, each material gives opportunity to see what kind of resource, type of timber is better use in each region and what mobilization opportunity is best for it. For example, if in region are a lot of conifers, it could be used in resin extraction or needle extract acquisition.

### **Kopsavilkums**

Darbs veikts ar mērķi izvērtēt meža resursu mobilizācijas iespējas Latvijā. Apkopoti un analizēti Valsts meža dienesta statistikas dati laika periodā no 1990. līdz 2014. gadam. Šie dati tika attēloti kartogrāfiskā veidā, lai vizualizētu meža resursu pašreizējo situāciju Latvijas novados. Veikta pašreizējā meža resursu izmantošanas analīze un izstrādāti ieteikumi ilgtspējīgai meža resursu izmantošanai nākotnē. Darbā veikta literatūras analīze, kurā atspoguļota citu valstu pieredze meža resursu izmantošanā.

## Thermal superinsulation in buildings

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This work shows thermal conventional, new and super insulation materials physical and chemical parameters, economical gain and affect to nature and health. Main aim is to understand main issues in superinsulation materials, which have made them been unpopular and why they have taken so tiny part of global insulation materials market.

There are scientists who say that conventional insulation materials have reached their maximum by price and technical parameters and that is main reason why scientists desperately are researching and testing superinsulation materials to make them more effective and these materials will be more available to consumers. Main technical parameter for insulation materials is thermal conduction coefficient ( $W/(m \cdot K)$ ), for conventional materials it is 0.03–0.05 ( $W/(m \cdot K)$ ), while superinsulation materials reach 0.012–0.02 ( $W/(m \cdot K)$ ). But if we are taking a look to global market, it is clear that conventional insulation materials are dominating.

Main issue nowadays for superinsulation materials is high price, what makes it unavailable for most part of consumers. Also it requires special learning to set it up, while conventional insulation materials doesn't require such a big skills to set them up.

### **Kopsavilkums**

Darba mērķis ir izvērtēt augstas klases siltumizolācijas materiālu pielietojumu ēkās, vadoties pēc tehnisko parametru, ekonomiskajiem, ietekmes uz vidi un veselību aspektiem, salīdzinot tos ar tradicionālajiem un jaunajiem siltumizolācijas materiāliem.

Darbā tiek veikta literatūras analīze par tradicionālajiem siltumizolācijas materiāliem, to tehnisko parametru, ekonomisko, vides un ietekmes uz veselību novērtējums. Jauno siltumizolācijas materiālu izejvielu raksturojums, kā arī novērtēti tehniskie parametri un materiāla lietojuma attīstības tendences un nākotnes perspektīvas. Šajā daļā arī tiek iepazīti augstas klases siltumizolācijas materiāli, to tehniskie parametri, ekonomiskie aspekti un ietekme uz vidi un veselību. Otrajā daļā tiek izvērtēti augstas klases siltumizolācijas materiāli attiecībā pret tradicionālajiem un jaunajiem siltumizolācijas materiāliem. Tiek aplūkots potenciālā pielietojuma novērtējums un izdarīti secinājumi par šiem materiāliem.

## **Energy management system implementation in Latvian municipalities: from theory to practice**

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In master thesis „Energy management system implementation in Latvian municipalities: from theory to practice” is analysed opportunities and procedures how the energy management system can be implemented in the municipalities. Goal of this work is to develop guidelines for energy management system implementation in municipalities. The work is based both on theoretical sources of information, both on practical research. Were considered most relevant data of municipalities. In work are used qualitative research methods, including literature analysis and data evaluation. Objectives of this work are literature analysis, assessment of the current situation, development of guidelines for implementing energy management system in municipalities and to transfer experience from the municipalities where energy management system is being implemented to other municipalities. This topic is actual at the moment as the goal of Latvia is to increase the renewable energy share of gross final energy consumption to 40 % in year 2020, to reach 0.668 Mtoe of energy savings in year 2020 compared to forecasts of year 2007 and limit the country’s total GHG emissions in year 2020 so that they do not exceed 12.19 Mtoe.

### **Kopsavilkums**

Maģistra darbā „Energopārvaldības sistēmas ieviešana pašvaldībā: no teorijas līdz praksei” ir aplūkotas iespējas un kārtība, kā pašvaldībā var tikt ieviesta energopārvaldības sistēma. Darba mērķis ir izstrādāt vadlīnijas energopārvaldības sistēmas ieviešanai pašvaldībā. Darbs ir balstīts gan uz teorētiskiem informācijas avotiem, gan uz praktiskiem pētījumiem. Tika ņemti vērā aktuālākie pašvaldību dati. Darbā tiek izmantotas kvalitatīvās pētījumu metodes, kas iekļauj literatūras analīzi un datu novērtēšanu. Darba uzdevumi ir literatūras analīze, esošās situācijas novērtējums, vadlīniju izstrāde energopārvaldības sistēmas ieviešanai pašvaldībā un pieredzes pārņemšana no pašvaldībām, kurās energopārvaldības sistēma tiek ieviesta, uz citām pašvaldībām. Šis temats ir aktuāls šobrīd, jo Latvijas mērķis ir palielināt no atjaunojamajiem energoresursiem saražotās enerģijas īpatsvaru kopējā bruto enerģijas galapatēriņā līdz 40% 2020. gadā, sasniegt 0,668 Mtoe enerģijas ietaupījumu mērķi 2020. gadā, salīdzinot ar 2007. gada prognozēm, un ierobežot valsts kopējās SEG emisijas, lai 2020. gadā tās nepārsniegtu 12,19 Mtoe.

## Cost-benefit analysis of integrated approach of waste and energy management

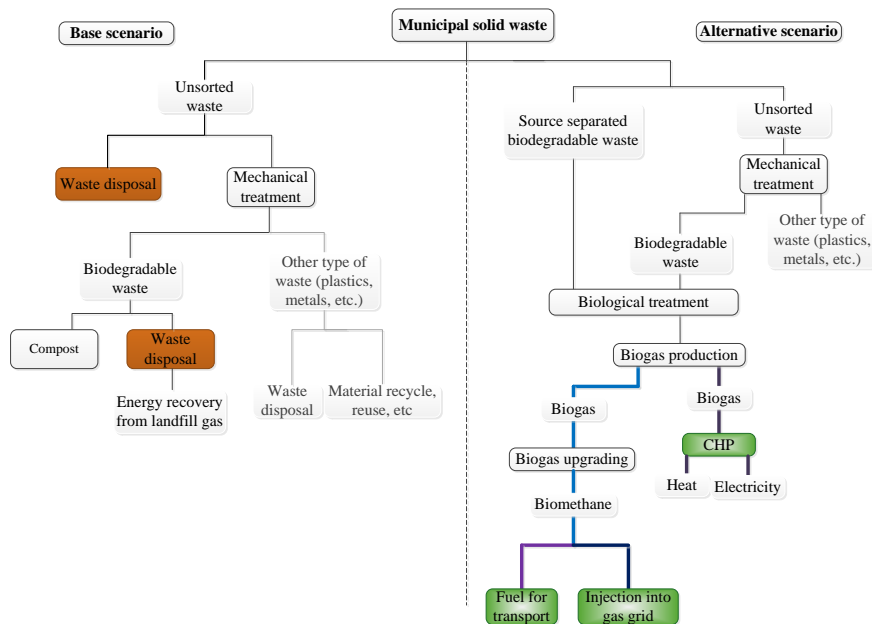
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The current needs of sustainable urban development give an effort to focus on environmental issues during the decision making. In urban areas major environmental concerns are usually related to air quality problems caused by transport activity. Another topical question is problems arising from inefficient waste management, i.e. the increasing amounts of waste.

The aim of the paper is to provide a methodology for an integrated approach to waste and transport management in urban areas. The methodology is based on the application of cost-benefit analysis and evaluates the waste-to-biomethane process route. The study covers the whole waste-to-energy system including waste management, energy production and energy end-consumption alternatives. Cost-benefit analysis was chosen for this analysis as a powerful tool that is used to guide decisions about the prioritization of different investment options. This approach allows including not only the investment costs and the economic value of the outcomes but provides wide range of environmental aspects that have economic valuation.

The cost-benefit analysis of the integrated waste-to-biomethane concept is demonstrated on a case study of Valmiera city in Latvia. Three alternative scenarios of waste-to-energy are discussed: biogas usage as a fuel for cogeneration plant; biomethane usage as a transport fuel in public transport; biomethane injection into the natural gas grid. The results show that introduction of waste-to-biomethane concept is not only beneficial from the environmental side, but also provides economic feasibility.



*Base scenario and alternative scenario with three outcomes*

### Kopsavilkums

Darba mērķis ir izstrādāt metodoloģiju integrētai atkritumu un transporta apsaimniekošanas sistēmai pilsētu teritorijās.

Darbā ir veikta literatūras analīze par pilsētvides enerģijas sistēmām, galveno uzsvāru liekot uz atkritumu un transporta sektora apsaimniekošanu, izvērtējot iespējas izveidot integrētu biodegradablu atkritumu un transporta sektoru apsaimniekošanas sistēmu. Darba praktiskajā daļā ir veikta izmaksu-ieguvumu analīzes metodoloģijas izstrāde, kas pielāgota atkritumi-biomētāns koncepta izvērtēšanai pašvaldībās. Izmaksu-ieguvumu analīzes metodoloģija ir aprobēta uz Valmieras pašvaldības piemēra. Rezultāti uzrāda, ka, ieviešot atkritumi-biomētāns sistēmu, tiek sasniegti ne tikai vides, bet arī ekonomiskie ieguvumi.



## Energy management in wood pellet's production

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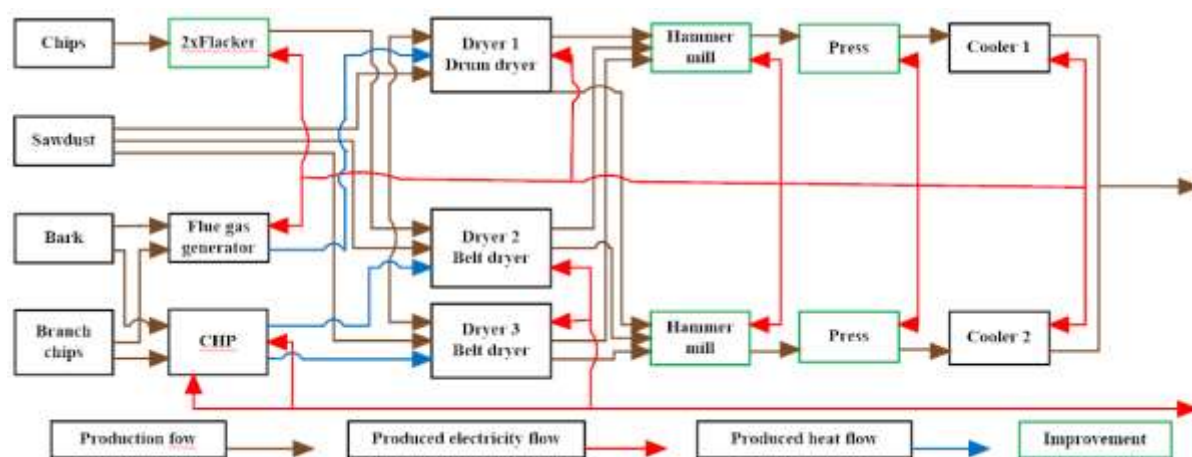
*Dr.Habil.Sc.Ing. Dagnija Blumberga, Mg.Sc. Haralds Vīgants, Dr. Raimondas Grubliauskas*

The production of energy from renewable energy resources plays an important role in the promotion of energy efficiency and thus also in the implementation of the European Parliament and Council Directive 2012/27/ to reach the EU energy efficiency target and increase energy efficiency by 20 % by 2020.

The topic of the research was chosen because the pellet production plants have the potential for growth and there is the demand for the product on the market. The aim of the study is the development of energy management model for production company. Hypothesis: introduction of energy management system in a production company improves its energy efficiency.

The actual production data was used in the methodology of the thesis. The data represents the indicators of a specific production plant and it was used to determine the overall production efficiency. Data about the amount of consumed electricity in comparison to the volume of production was used to determine the efficiency of the production plant and possibilities of optimization.

Potential improvements to the existing system to increase the effectiveness of the pellet plant are displayed in the figure below.



### *Improvements to the existing system to increase the effectiveness of the pellet plant (Vīgants et al.)*

The final management model will be integrate two basic management models - environmental management model and mathematical energy management model. The developed model provides information and helps to evaluate the operation of pellets production unit and the possibilities of improvement. Management model with the respective indicators of the wood pellets production unit have been integrated in this model. The introduction and evaluation of such model in a production unit allows to better determine the optimization of production stages and energy consumption. The possibilities of improvement have been tested in the pellets production plant and the correlation between produced energy flow and the volume of production has been established in case the system facilitates the optimization.

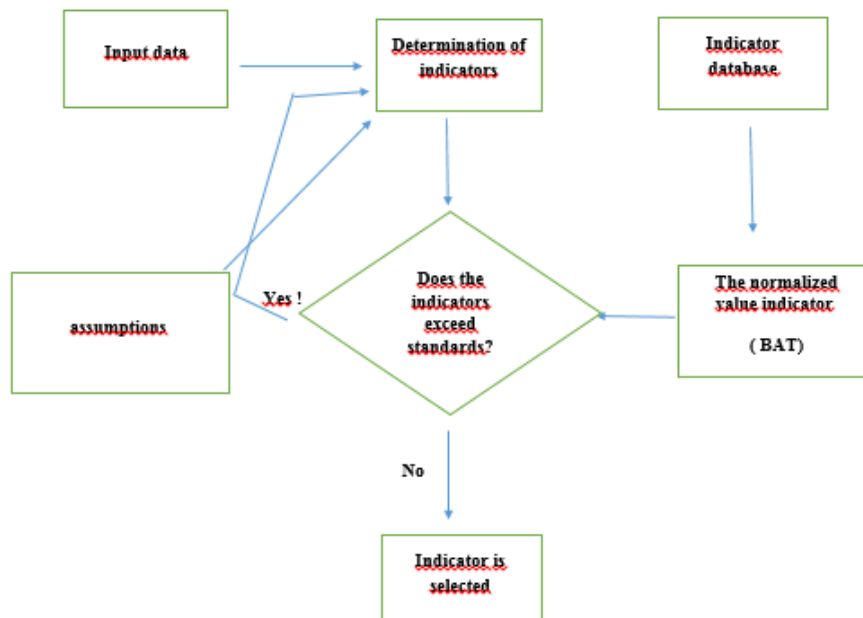
### **Kopsavilkums**

Darba mērķis ir izveidot energopārvaldības modeli granulu ražotnei, lai paaugstinātu šīs rūpniecības nozares efektivitāti. Zinātniskajā izpētē tiek veikta literatūras analīze un apskatīti dažādi jau esoši pārvaldības modeļi. Darba praktiskā daļa sastāv no konkrētām rūpniecības uzņēmumam pielāgota energopārvaldības modeļa izveidošanas. Zinātniskās izpētes praktiskajā daļā – izveidotajā modelī, tiek iekļauta sadaļa ar konkrētu parametru un sistēmas optimizācijas nozīmi efektivitātes uzlabošanai.

## Environmental indicators of charcoal production impact on air quality assessment

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In recent years, more and more in Latvia is intended for charcoal production development. In Latvia the good and scientifically based charcoal production technology are suspended for the moment, because the establishment and operation are based on the Environmental Impact Assessment which include the public consultation process, where the factory's fate depends on the incompetent people who are living nearby. The production of charcoal, directly or indirectly, may create a significant impact on the environment. To objectively evaluate new or existing charcoal production factories that are intended for the reconstruction and their possible impact and relevance to the air quality and the impact of the people's health that are living nearby the factories, it is necessary to draw up a single environmental indicator system. The developed environmental indicator system will be applicable and practical to a specific sector and at the same time will save resources: the time, the finances of the EIA process, providing concrete, verifiable, measurable, comparable and scientifically proven and reliable results of the actual operation's possible impact on the environment, namely, the impact of the air quality.



### *The methodology algorithm*

The methodology algorithm is designed to assess the potential environmental indicators to comply with laws and regulations set the indicator parameters. Indicators are defined from existing companies engaged in the production of charcoal.

### **Kopsavilkums**

Darba mērķis: Izstrādāt vides indikatoru sistēmu kokogļu ražotnes ietekmes uz gaisa kvalitāti novērtējumam. Darbā tiek veikta literatūras analīze par mūsdienu kokogļu ražošanas tehnoloģijām, par labākajiem pieejamajiem paņēmieniem kokogļu ražošanā, par Eiropas Savienības normatīvajiem aktiem, starptautiskajām konvencijām, LR likumdošanu, kas attiecināma uz kokogļu ražošanas iekārtām un tehnoloģijām, kā arī vides likumdošanas prasības attiecībā uz gaisa kvalitāti.

Darba praktiskajā daļā tiek izstrādāts metodikas algoritms, lai novērtētu iespējamo vides indikatoru atbilstību normatīvajos aktos noteiktajiem vides indikatora parametriem (lielumiem). Tiek veikta metodikas testēšana un vides indikatoru sistēmas izveide. Darba nobeigumā tiek veikti secinājumi par izveidoto vides indikatoru sistēmu un tā pielietošanas iespējām kokogļu ražošanas projekta – ietekmes uz vidi novērtējuma procedūrā.

## Predictive control of a building heating system

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Building sector is responsible for 40 % of the total energy consumed by the European Union. EU has set the goal to reach 20 % reduction in energy consumption and 20 % energy efficiency till year 2020. Because of increasing interest in this topic it is requisite to find ways how to reduce energy consumption in buildings.

When used in heating and cooling systems model predictive control can be beneficial comparing with current control strategies. Most important quality of predictive control is a model of building. Using model which includes thermal capacity of the building it is possible to decrease energy consumption of heating or cooling system. Predictive control also uses weather forecasts that optimize resources to prepare for changes in temperature. By using price of energy costs can be reduced.

There is a little information about application of model predictive control in Latvia and there is no information about using this kind of control in practice. Because of this it is necessary to do calculations and see if model predictive control can provide savings from economic and environmental point of view. Another reason for this calculation is to show the amount of these savings.

Paper will provide model predictive control for apartment building which is located in Latvia. Building uses heat pump as heat source for space heating and two thermal accumulation tanks for balancing heat generation and building heat demand. Input values consist of weather forecasts and price of electricity. Model predictive control will help to optimize apartment buildings heat supply.

First model predictive control calculates necessary heating energy to compensate heat losses from building. After that control evaluates if in next hours temperature will decrease and cost for electricity will increase. Depending on temperature and electricity price control selects heating source and calculates power for heat pump and necessary temperature for storage tank.

### **Kopsavilkums**

Darba mērķis ir izvērtēt pareģojošās siltumapgādes vadības ieviešanu Latvijā. Darba gaitā iegūts, vai šādas vadības uzstādīšana Latvijā ir lietderīga, un kādi ir ieguvumi lietojot šādu vadību gan no ekonomiskā, gan no vides viedokļa.

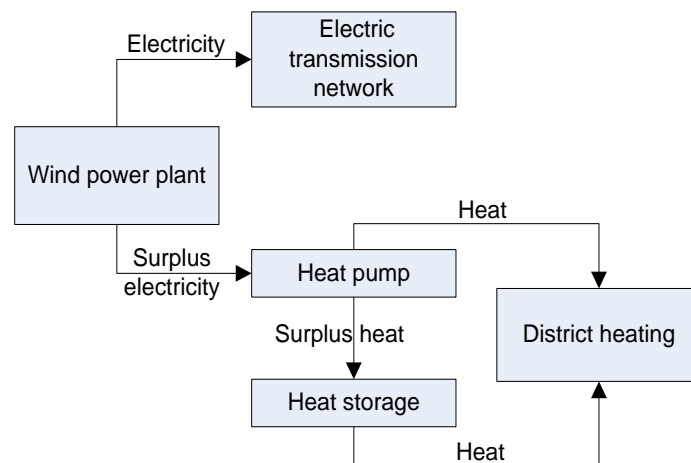
Darba rezultātā būs radīts pareģojošās ēkas siltumapgādes modelis. Ēka kā siltuma avotu izmanto siltuma sūkni un divas akumulācijas tvertnes, lai sabalansētu saražoto siltumu ar ēkai nepieciešamo siltuma daudzumu. Ar modeļa palīdzību noteiks, vai radītā pareģojošā vadība sniegs ieguvumu, kā arī cik liels būs pareģojošās vadības ieguvums no ekonomiskā un vides viedokļa.

Darbā radītā modeļa ievaddati ir ārgaisa temperatūras prognozes un elektrības cenas prognozes. Izmantojot ārgaisa temperatūru un ēkas konstrukciju, logu un durvju parametrus, aprēķināts, cik lieli ir ēkas siltuma zudumi, kuri jāsedz apkures sistēmai. Pēc tam pareģojošā vadība nosaka, vai tuvākajās stundās ārgaisa temperatūra kritīsies un vai elektrības cena paaugstināsies. Atkarībā no ārgaisa temperatūras prognozēm un elektrības cenas pareģojošā vadība izvēlas siltuma avotu siltumapgādes sistēmai. Bez tā vadība aprēķina siltuma sūkņa jaudu un nepieciešamo temperatūru akumulācijas tvertnē.

# Integration of District Heating Systems and Wind Power plants - Technical, Economic and Environmental Aspects

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Due to the intermittent character of wind power, substitution of the dispatchable conventional power sources with the wind power plants is challenging and several wind integration options have been studied. This paper focuses on using the surplus electricity generated by wind turbines for heat production by the heat pumps combined with the heat storage in the district heating systems.



*Scheme of using the surplus wind-produced electricity in the district heating system*

The main aim of this study is to determine the optimal capacity of heat pumps and heat storage facilities for the certain capacities of the wind power plants installed within the power supply system. The optimal capacities are sought on the bases of technical, environmental and economic criteria. The method used is modeling of Latvia's energy system by using energy system analysis tool EnergyPLAN. Life cycle inventory databases were used for determination of life cycle energy and material consumption.

The results showed that there is a certain optimal capacity of heat pump and heat storage facilities for the certain capacities of the wind power plants within the power supply system for each of the criteria- technical, environmental and economic.

## **Kopsavilkums**

Darba mērķis ir noteikt optimālu siltuma sūkņu un siltuma akumulatoru ietilpību dažādām prognozētām uzstādītajām vēja elektrostaciju jaudām, ņemot vērā tehniskos, vides un ekonomiskos kritērijus.

Darbā ir analizēts elektroapgādes un centralizētas siltumapgādes sistēmas integrēšanas modelis un izstrādātas vides, tehnisko un ekonomisko kritēriju optimizācijas funkcijas. Darba praktiskajā daļā ir modelēta Latvijas energosistēma EnergyPLAN vidē ar mērķi likt lietā izstrādātās vides, tehnisko un ekonomisko kritēriju optimizācijas funkcijas, lai noteiktu optimālu siltuma sūkņu un siltuma akumulatoru ietilpību dažādām prognozētām vēja jaudām, ņemot vērā tehniskos, vides un ekonomiskos kritērijus. Darba nobeigumā analizēti iegūtie rezultāti un dotas rekomendācijas vēja enerģijas integrēšanas efektivitātes uzlabošanai.

## Development of energy management systems in supermarkets

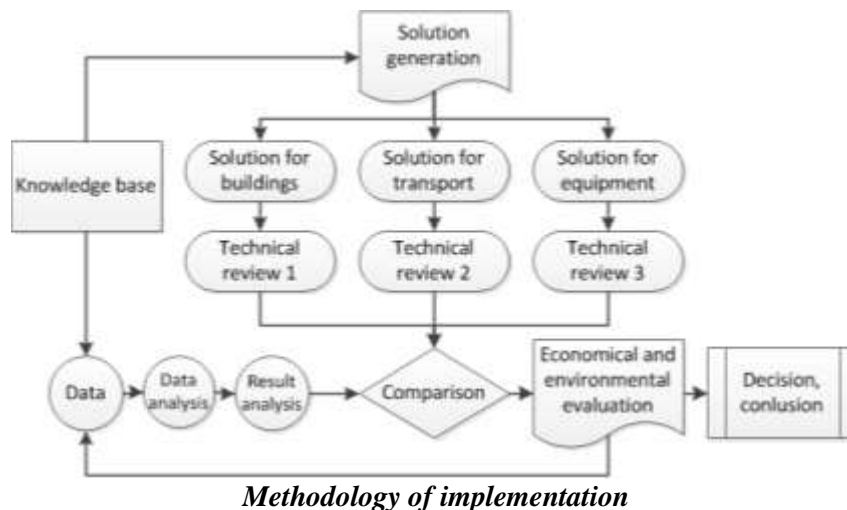
*Roberts Skudrītis, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master*

*Dr.Habil.Sc.ing. Dagnija Blumberga, Mg.Sc.ing. Lelde Timma*

Rapidly rising energy costs and global commitments to reduce greenhouse gas (GHG) emissions are forcing organizations to establish effective energy management as a priority in all areas of the company. The energy management projects are to be implemented to any organization, regardless of its size or scope. As a special argument for energy management solutions is that non-controlled or poorly organized management is inefficient.

The aim of implementation Energy Management Systems in supermarkets is to reduce energy consumption by at least 10% and to become more environmentally friendly, also it will improve its competitiveness in emerging market conditions as research is based on actual local supermarket chain. Practical work will affect local supermarket store chain consisting of 204 stores with different categories and will provide environmental as well as technical and financial benefits.

In this work it will be discussed energy management problems found in food trade supermarket chain. Reviewed problems and raised solutions in building management systems, use of transport, as well as facilities management - including not only sales equipment and office equipment, but also information systems management. All generated and proposed solutions are based on available funds, using a minimum of investment. Suggestions are based more on improvements to the existing system rather than a complete replacement of current solution. A large part of the proposed solutions are related to employee education and behavioral change. It is better to make a global picture of situation rather than jump into one individual problem. Lack of supermarket performance monitoring can lead up to unnecessary costs and energy usage kept on unnecessary level. All components found in supermarkets can be described as one complete system and individual equipment or element can't be considered as less necessary than other node. Also developed and implemented energy management system can help to detect equipment failure earlier.



Energy management systems implementation methodology is based on decision making in three defined problem fields using provided knowledge basis and data analysis.

### Kopsavilkums

Darba mērķis ir izveidot energopārvaldības sistēmu lielveikaliem, lai uzlabotu to energoefektivitāti un konkurētspēju. Veikta literatūras avotu analīze par dažādiem esošiem risinājumiem ēku vadības sistēmās, transporta pārvaldībā un dažādu iekārtu risinājumos. Izmantojot sagatavoto zināšanu bāzi, tiek piedāvāti risinājumi esošās situācijas uzlabošanai. Praktiskajā daļā tiek apskatītas pārtikas tirdzniecības lielveikalu ķēdes enerģijas patēriņa pārvaldības problēmas. Rasti risinājumi ēku pārvaldībā, transporta pielietojumā, kā arī iekārtu pārvaldībā - iekļaujot ne tikai tirdzniecības iekārtas un biroja tehniku, bet arī informācijas sistēmu risinājuma pilnīgu nomaiņu, enerģijas patēriņa samazinājuma sasniegšanai.

## **Evaluation of energy consumption: from municipal buildings to power supply companies**

*Agnese Skujevska, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master*

*Dr.Sc.ing. Marika Rošā, Dr.Sc.ing. Agris Kamenders, Dr. Mantas Pranskevičius*

The European Union has set important targets until 2020 to achieve in the field of energy production and consumption. These objectives are known as the "20-20-20" targets and one of the objectives is to raise energy efficiency by 20 % compared to 2005. Article 14.1 of the Directive 2012/27/EU on energy efficiency determine that Member States have to carry out a comprehensive assessment of the potential for efficient district heating and cooling. The aim of the study is to develop a methodology for the identification of heat energy consumers in municipalities and with the use of indicators analyze the potential of existing district heating system.

Being aware of the amount and location of final heat energy consumers, it is possible to:

- effectively plan the energy efficiency measures in both the private and municipal level, because it is possible to assess in which areas energy efficiency measures will make a major resource savings,
- determine in which areas renewable energy can be integrated as the heat source,
- reduce the consumption of fuel wasted in the energy supply companies,
- identify district heating "hot spots" and develop an appropriate action plan (the expansion of district heating or conversely - decentralization).

The research is based on guidelines for comprehensive assessment of national heating and cooling potential developed by European Commission. Comprehensive assessment mainly consists of 3 parts: data gathering, data processing and heat mapping, evaluation and cost-benefit analysis. The research object is Salaspils municipality. The planning tool will allow heat producers to plan their further action. In the meantime it will permit municipality to plan development and prepare territorial plan. Additionally government will be able to work out national development plans in connection with efficient heat energy production and transmission.

### **Kopsavilkums**

Darba mērķis ir izstrādāt metodiku, kā apzināt siltumenerģijas patērētājus pašvaldību teritorijās un ar indikatoru palīdzību analizēt centralizētās siltumapgādes sistēmas izmantošanas potenciālu.

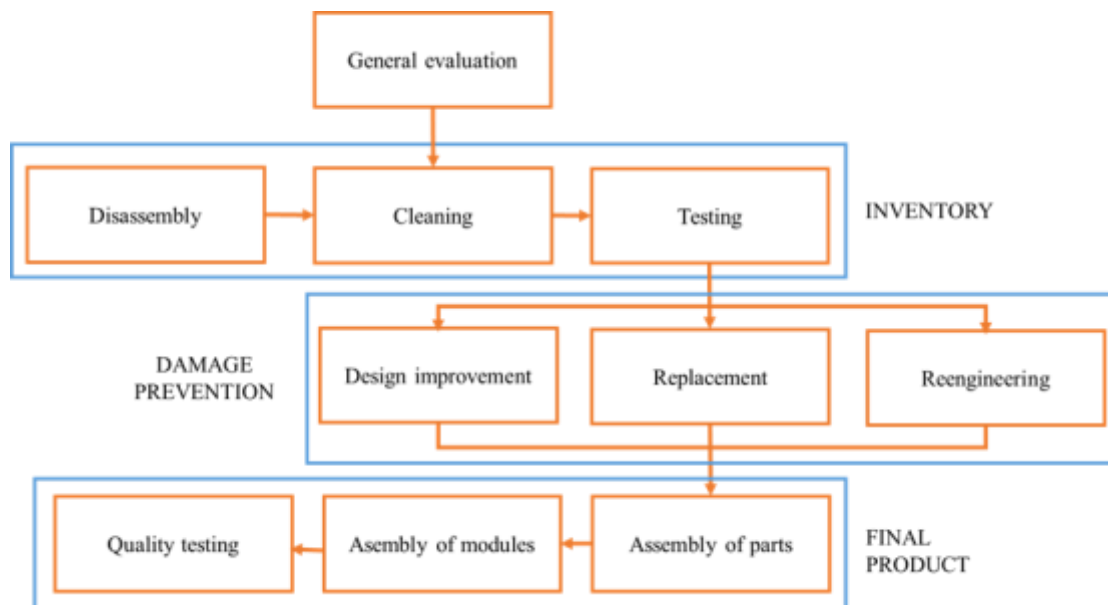
Darbā tiek veikta literatūras analīze par centralizētās siltumapgādes sistēmas stāvokli Eiropas Savienībā un Latvijā, attiecīgo likumdošanas aktu izpēte, kā arī Eiropas Savienības dalībvalstu izveidoto siltumenerģijas pieprasījuma karšu un centralizētās siltumapgādes sistēmas potenciāla izvērtējumu izpēte. Darbā ietvertas vadlīnijas Eiropas Komisijas izstrādātajai metodikai visaptverošam siltumapgādes potenciāla novērtējumam un tās piemērošanas iespējas Latvijas apstākļiem un pieejamajiem datiem. Darba praktiskajā daļā metodika tiek pielietota centralizētās siltumapgādes potenciāla izvērtējumam Salaspils novadā. Tiek izstrādāta siltumenerģijas pieprasījuma karte, ar kuras palīdzību iespējams noteikt potenciālos centralizētās siltumapgādes attīstības reģionus. Darba nobeigumā tiek veikti secinājumi un sniegti priekšlikumi siltumapgādes potenciāla novērtējumam Latvijas teritorijā, kā arī secināts, vai ir iespējams panākt efektīvāku resursu izmantošanu siltumenerģijas pieprasījuma segšanai.

## A decision support tool for the implementation of remanufacturing process in an enterprise

Lāsma Slotiņa, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master  
Dr.Sc.ing. Elīna Dāce

Several global challenges exist that force manufacturing organizations to reduce the environmental impact of their products. Nowadays, the most common practices of products' end-of-life stage are landfilling and recycling. However, there are several other practices for products' end-of-life management that support reduction of the environmental impact.

One such option is remanufacturing. It is a product recovery option that gives an opportunity to produce new products by using the products that have already reached their end-of-life stage. In the process, all modules and components are disassembled, and the used parts – recovered.



*Simplified remanufacturing process flow in general*

The process helps saving up to 60 % of energy and 70 % of raw materials, thus reducing the environmental impact considerably. Still, many barriers exist that prevent manufacturing enterprises from implementing the remanufacturing process. This paper presents a case study of one producing company in Latvia and market analysis of the product manufactured in this company. To assist the enterprises a decision support tool based on system dynamics modelling has been developed. The paper presents the tool, and shows how the decision of implementing the remanufacturing process in an enterprise changes its performance with respect to environmental and economic aspects in the selected company.

### Kopsavilkums

Darba mērķis ir izstrādāt sistēmdinamikas modeli – lēmumu pieņemšanas rīku, ar kura palīdzību iespējams noteikt atkārtotas ražošanas sistēmas dinamisko attīstību. Ar modeļa palīdzību ražošanas uzņēmumiem iespējams noteikt, vai atkārtota ražošanas ieviešana uzņēmumā ir pamatota.

Darbā tiek veikta literatūras analīze par produktu aprites cikla beigu veidiem, atkārtotas ražošanas un atgriezeniskās loģistikas koncepcijām, par tās ietekmējošiem parametriem un likumdošanas aktiem. Darba praktiskajā daļā tiek veikta viena ražošanas uzņēmuma apsekošana un analīze, atkārtotas ražošanas lēmuma pieņemšanas rīka izstrāde un tā aprobēšana, balstoties uz apsekotā ražošanas uzņēmuma datiem. Darba nobeigumā tiek veikti secinājumi par atkārtotas ražošanas ieviešanas galvenajiem ieguvumiem, trūkumiem un ietekmējošajiem parametriem.

## **Research of methanation process: Upgrading the biogas and syngas composition in the methanation process integrated with irregular renewable sources**

*Inese Tiļļa, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master  
Dr.Sc.ing. Elīna Dāce, Dr. Vaida Šerevičienė*

With the rapid population growth there is an ascendant trend of global energy consumption. On a global scale most of the energy supply now is generated by fossil fuels with all the subsequent consequences including depletion of non-renewable energy resources (e.g. oil, coal and natural gas), greenhouse gas emissions and climate change. With respect to the increasing global demand for cheap, reliable and environmentally safe energy there is a need for innovative technologies and increase in renewable energy share.

Biomass is a unique renewable resource with a wide range of uses and a huge potential. However its relevance for food industry poses an ethical dilemma. Therefore, finding the possible solutions for more efficient biomass use is increasingly important. A research of methanation process has been made in the study to identify the parameters and conditions responsible for the highest quality of outgoing gases from biomass gasification and digestion processes. A methanation is a reaction where carbon oxides present in the gases react with hydrogen to produce methane. To increase the methane yield an external addition of hydrogen is needed. The necessary electrical energy for the electrolysis process is where irregular renewable sources are integrated in the system. Another advantage to the biomass-to-methane system is the possibility to introduce the produced gas into the existing natural gas grid.

The hypothesis of the study is that the composition of output gas can be enhanced by optimizing the reaction parameters such as pressure, temperature, reactant ratios, gas composition, flow rate, mass etc. A scientific literature review is done in the study to identify the variables and make assumptions. Considering methanation's condition-dependent nature, simulation of methanation processes under different parameters is constructed. Various alternative scenarios are simulated by mathematical modelling to obtain the highest efficiency of the system. A review of scientific literature and simulation results approve the hypothesis.

### **Kopsavilkums**

Darba mērķis ir noteikt parametrus un modelēt apstākļus, pie kuriem iespējams iegūt kvalitatīvāko gāzi, kuras tālākā izmantošana būtu ar augstu izmantošanas potenciālu un iespējami samazinātām izplūstošajām emisijām.

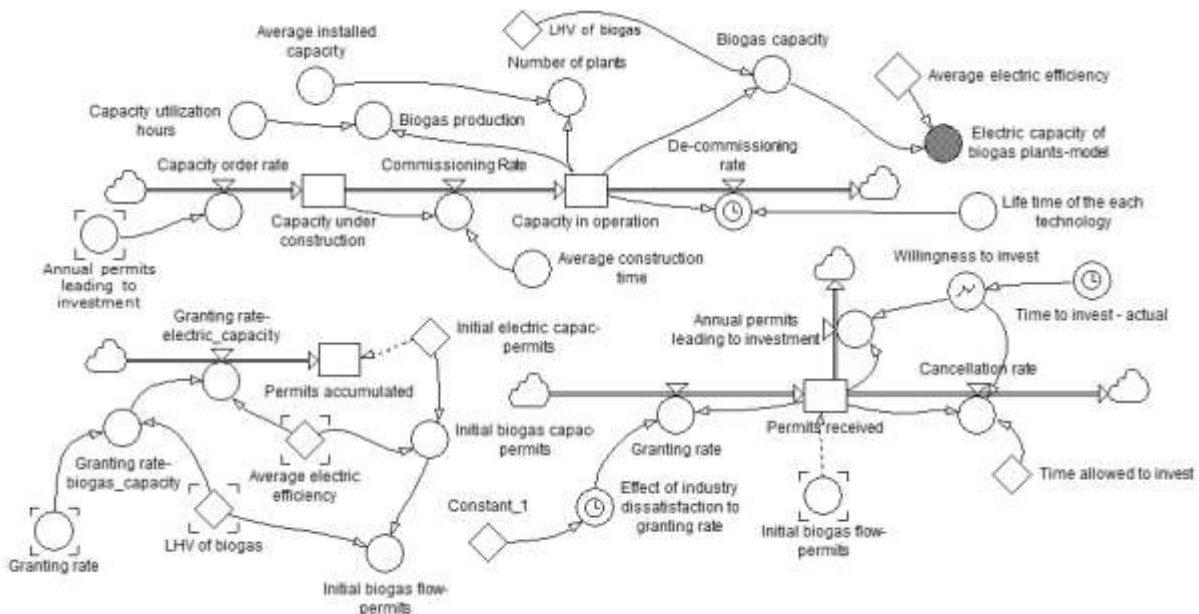
Darbā tiek veikta zinātniskās literatūras analīze par metanācijas procesa norisi un reakciju ietekmējošajiem parametriem. Darba praktiskajā daļā tiek veikta metanācijas procesa kinētikas modelēšana un analizēti iespējamie procesa norises scenāriji. Otrajā daļā tiek noteikts iegūtās gāzes sastāvs un kvalitāte, kas atkarīgi no ievadītajiem parametriem un izvēlētajiem scenārijiem. Darba nobeigumā tiek izdarīti secinājumi par iegūtajiem rezultātiem un sniegti priekšlikumi sekmīgai turpmāko laboratorijas eksperimentu veikšanai.



## System dynamics model for biomethane supply system supporting policy design

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Dr.Sc.ing. Gatis Bažbauers

Research has shown that in the future biomethane could become a good substitute for natural gas. Existing experience with renewable energy support policies proves that it is hard to establish a stable support system in the long term, which is a necessity for the sector to be invested in. There is a lack of research done related to biomethane support policy. Therefore, the aim of this study was to create the system dynamics model which can be used to design support policy for biomethane supply



system.

### *The structure of system dynamics model which represents the current support of biogas cogeneration plants in Latvia*

Energy supply systems usually are dynamic and complex. System dynamics methodology is used to deal with such problems. Analysis of the structure of such systems forms a deeper understanding of the behavioural causes and allows averting the problematic behaviour of the system. The model consists of stocks and flows that represent the policy for granting permits for mandatory purchase of the electricity produced by the biogas cogeneration plants in Latvia. The model is extended to include physical biogas and biomethane production assets. The main outcome of the study is the model for design of biomethane support policy. The model is validated using the data about increase of the electrical capacity of the biogas cogeneration plants and the accumulated permits. The results show the parameters which have an impact on stability of support policy system.

### **Kopsavilkums**

Darba mērķis ir izveidot biometāna atbalsta politikas izstrādei nepieciešamā sistēmdinamikas modeļa pamata struktūru, kas ietver būtiskākos krājumus un plūsmas. Sagaidāmais rezultāts ir sistēmdinamikas modelis, kura struktūra atbilst pastāvošajai atjaunojamo energoresursu atbalsta sistēmas dinamiskajai problēmai un ļauj pārbaudīt iespējamās politikas risinājumus, lai problēmu novērstu.

## **The probability examination of Mould fungi growth on historic brick building with internal insulation**

*Sabīne Elvīra Rožicka, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Sc.ing. Andra Blumberga*

Mold growth and development in climate of Latvia is relatively optimal, because the weather conditions forces to improve the thermal properties by insulating building walls. For energy efficiency improvement in historic brick buildings are used insulation from the inside. In Latvia most commonly is used mineral wool and foam plastic. Insulating buildings are altered previous air exchange system and by improperly installing, new air exchange may not be as good as it should. In addition, the insulation reduces heat loss, which increases the temperature of the indoor and because of that, air is able to accommodate more water weight. Breathing, food preparation, bathing and doing other activities indoor, we raise the indoor relative humidity. If the room is ventilated rarely, then increases the risk of mold growth and as a result deteriorating human health.

The study is based on investigation of wall which is insulated from inside. The measurements are -moisture, temperature and mold growth analysis in order to predict what is going on in the construction of the wall at the time when the relative humidity of human activity increases till to the size of the risk when mold growth is possible.

In order to assess the situation in the construction of the wall, the wall is modeled and tested in an experimental stand. Wall is consisting of a brick layer which is 510 mm thick, which is insulated with 100 mm thick insulation - stone wool or foam plastic with and without the vapor barrier, what is covered with gypsum board. In the experiment, each sample is tested 3 times in order to obtain reliable results. The stand will be exposed to outdoor air temperature and humidity on the one side (brick) and the other in optimum room temperature what will be 22 °C and relative humidity – 70 %. Experiment will last for 28 days, during which 7, 14, 21 and 28 days will be tested the amount of mold on gypsum, and every 20 minutes the temperature between the layers and the relative humidity between mineral wool and brick.

The hypothesis that, in such conditions, the mold should appear on construction is studied by the literature and developed in a model from program Delphin. The results show that on the wall with foam plastic with and without vapor barrier or mineral wool- with vapor barrier, are optimal conditions for mold growth on gypsum board, but on mineral wool, with vapor barrier, the risk is much lower or even non-existent.

### **Kopsavilkums**

Mūsdienās arvien lielāka problēma ir pelējums dzīvojamās zonās. Tas ir ne tikai laikapstākļu dēļ, bet arī ēku konstrukciju un dzīvošanas paražu dēļ. Pelējuma parādīšanās ir raksturīga arī tad, ja sienu konstrukcijai tiek pievienota iekštelpu izolācija. Tas izmaina iekštelpu klimatu - paaugstina temperatūru un nekvalitatīva darba rezultātā pasliktina ventilāciju.

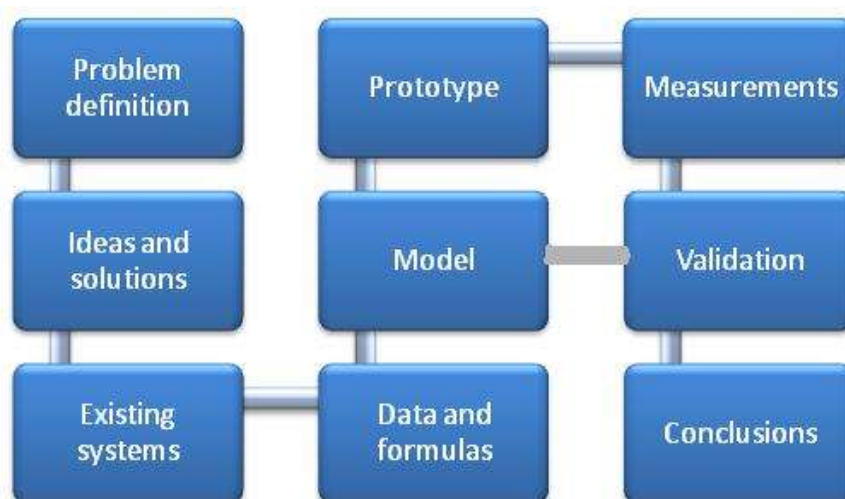
Lai redzētu, kā tas patiešām notiek, tiek veidots eksperimentāls stends ar 510 mm platu ķieģeļu sienu un 100mm izolācijas kārtu ar un bez tvaika barjeras, kas tiek noslēgta ar reģipškartona loksni. Konstrukcija tiek likta ārā apstākļos no ķieģeļu sienas puses un iekštelpu klimatā (temperatūra 22 °C un relatīvais gaisa mitrums – 70 %) no iekšpuses, kur stāv izolācijas slānis. Eksperiments ilgs 28 dienas, kad ik pēc 7 dienām tiks pārbaudīts reģipsis, un ik pa 20 minūtēm tiks iegūti temperatūras dati no katra sienas slāņa un relatīvais mitrums slānī starp ķieģeļi un minerālvati ar tvaika barjeru.

## Hydraulic and optical system development in building facade

*Edvards Sprūdžs, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Sc.ing. Andra Blumberga*

This paper presents potential use of Fresnel lense and phase change material (PCM) usage in passive solar system which could be integrated in the building facade. This kind of system would be passive and should reduce energy consumption (kWh) for building's heating and cooling. System should be appropriate for low and zero energy buildings. Considering the progress in solar technologies in recent years, construction of such types of buildings has become a rational and effective solution for energy saving, wherewith, to limit the climate change. The aim of paper is to evaluate the potential of current system by developing and analyzing system's model and protoype.

First step of paper is to define a problem, that is „reducing the energy consumption (kWh) for building's heating and cooling in hot and cold seasons by integrating current passive system in the building's facade”. Further, based on system's main components, such as Fresnel lense and PCM, the possible problem's solutions are defined. Within the literature review's framework, the existing systems, technical data about potential materials and mathematical formulas for calculations are reviewed. System's simulation model and prototype will be introduced in the paper's practical part. For validation of model, measurements with prototype will be done. After validation, there will be conclusions about comparison of theoretical and experimental results.



*The scheme of research*

### **Kopsavilkums**

Darba mērķis ir apzināt līdzīgas, jau esošas sistēmas un izvērtēt dotās sistēmas potenciālu, izveidojot un analizējot simulācijas modeli.

Darbā tiek veikta literatūras analīze par biomimikrijas risinājumiem, lēcām, aerogēlu, termotropiem materiāliem un līdzīgām pasīvām sistēmām. Darba praktiskajā daļā tiek izveidots sistēmas teorētiskais simulācijas modelis un eksperimentālais prototips. Darba nobeigumā tiek veikta teorētisko un eksperimentālo rezultātu salīdzināšana un izdarīti secinājumi.

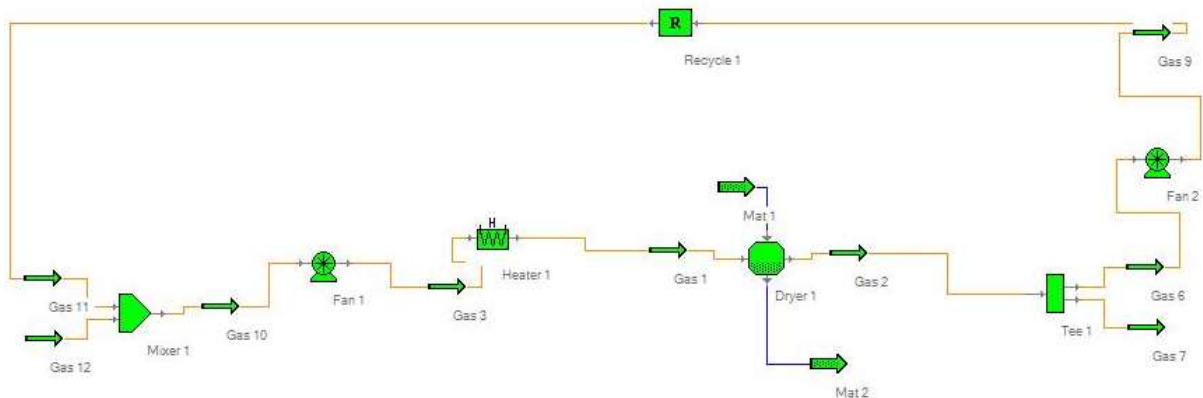
## Modelling of Biomass Drying with and without Recirculation of Drying Agent

Armands Cinis, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master  
Dr.Habil.Sc.ing. Ivars Veidenbergs

Drying implies removing moisture from materials down to specific moisture content, at the same time ensuring product quality. Drying is one of the most energy intensive unit operations in industry, from different countries it is 10–25 % from industrial energy consumption in industrial processes that is used in drying processes.

For wood drying it is necessary to dry it because after drying the wood increase its calorific value and it is stronger and more resistant from bacteria and fungi. For charcoal making the inlet wood is necessary to dry about 25 % moisture content for optimal operations in charcoal making.

Aim of the thesis: model adaptation for different input parameters. Hypothesis of the work: wood drying with drying medium recirculation do not increase amount of energy consumption for drying processes. For calculations of the heat and mass processes and necessary energy for heater and fans will use the drying software Simprosys.



*Drying process flow sheet with recirculation*

Changes in the recirculation ratio will change the energy consumption for drying processes. To reach the aim will need to find optimal air recirculation ratio for less energy consumption and costs.

### Kopsavilkums

Darba mērķis ir modelī adaptēt un izrēķināt žāvētāja parametrus ar viszemāko enerģijas gala patēriņu. Darbā tiek veikta literatūras analīze par pieejamajiem biomasas žāvēšanas veidiem, žāvējamā materiāla un žāvēšanas aģenta raksturojošajiem parametriem un izmantojamām modelēšanas programmām. Otrajā daļā tiek aprakstīta metodoloģija, veidots programmā modelis un vadīti dažādi ieejošie parametri un analizēti izejošie parametri atkarībā no recirkulācijas pakāpes.

## Assessment of indoor air climate in renovated buildings of Liepāja municipality

Toms Mols, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master

Dr.Sc.ing. Andra Blumberga, Mg.Sc. Līva Asere

This paper gives an input about the main characteristics of indoor air, explains the different components (relative humidity, CO<sub>2</sub> level, temperature and air velocity) which combined form indoor air climate and emphasizes the effect on the people that are performing mental tasks, students or social workers for instance. The aim of the project is to assess the indoor air quality in buildings that have undergone the process of renovation and to suggest improvements if necessary.

The paper studies current requirements for indoor air quality and thermal comfort that are currently valid. To emphasise the importance of the project experience from numerous similar experiments and case studies is collected and it indicates a correlation between air quality conditions and performance of the people that are subject to the indoor environment.

The assessment was held in Liepāja municipality's renovated buildings. Measurements of CO<sub>2</sub> levels, relative air humidity, air temperature, velocity and atmospheric pressure were taken in 9 buildings, 2 different rooms where it was possible.



*CO<sub>2</sub> measurements in Ezerkrastu primary school building*

The measurements in many of the buildings clearly indicate that during the school or office hours the recommended CO<sub>2</sub> levels are greatly exceeded. Mostly the cause of this lack of fresh air and acceptable environment is caused by ill strategy of energy consumption management. The economy from such management is significant on paper, but in reality there are case studies that prove that pupils and office workers might perform even by 30 % worse in such conditions than in satisfactory conditions when CO<sub>2</sub> level is below 1000 ppm.

### Kopsavilkums

Darba mērķis ir novērtēt Liepājas pašvaldības renovēto ēku iekštelpu mikroklimata kvalitāti un tā saistību ar cilvēku pašsajūtu, šajās telpās strādājot garīgu darbu.

Darbā veikta literatūras un normatīvo aktu analīze, kas atspoguļo esošās gaisa kvalitātes prasības sabiedriskā sektora ēkās, kā arī apskatīta jau veikto pētījumu pieredze par iekštelpu mikroklimata ietekmi uz cilvēku produktivitāti. Praktiskajā daļā veikti iekštelpu mikroklimata mērījumi deviņās Liepājas pašvaldības ēkās, kurās ir veikta renovācija, ierīkota mehāniskā ventilācija. Tiek vērtēts esošais, mērītais iekštelpu mikroklimats un tā saistība ar cilvēku subjektīvo vērtējumu – pašsajūtu atrodoties attiecīgajās telpās.

## **Anaerobic digestion of local macroalgal biomass. Laboratory development and evaluation of biomethane potential**

*Intars Aleksandrovs, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master  
Dr.Sc.ing. Francesco Romagnoli, M.Sc. Laura Pastare*

Latest research shows that human activities have led to a dramatic increase of nutrient content in the Baltic Sea in last 100 years with a constant increase of the eutrophication level. This environmental problem is involving 9 countries that have coastlines into the Baltic Sea. The increase of the algae blooming and thus the increase of the growing algae biomass due to a too an high eutrophication represents a problem potentially solvable in case of using this excess of algal biomass as alternative biomass type for energy purposes (i.e. biogas production).

The aim of this study is to evaluate the biomethane potential of marine macroalgae collected from Baltic Sea coastline in Latvia and to potentially evaluate the implementation of a large scale production facility. The study is mainly focused on multiples batch tests in order to evaluate the biomethane potential depending on different algae treatment methods and ratio among inocula (namely waste water treatment plant sludge) and algae biomass. Specifically for this case study the selected type of algae specie is *Fucus vesiculosus* directly collected from the Latvian coastline.

The experiments are conducted in a new lab stand developed at the Institute of Energy System and Environment at RTU; the experiments are conducted at mesophilic temperature, a condition constant to all batches. The cumulated amount of biomethane produced in every batch would be measured daily in order to evaluate the most efficient algae treatment methods and conditions from those selected within the experimental planning.

According to data available in literature *Fucus vesiculosus* presents a high solid content that could be an inhibiting condition for the biomethane production processes. To evaluate the total and volatile solid contents of the collected algae biomass the TS/VS evaluation experiments according to METHOD 1684 (U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division) have been conducted. The main outcome of experiments show an average volatile solid content around 17.8 %. In order to evaluate the biomethane production potential of the selected algae further experiments will be conducted in order to understand the carbon and nitrogen ratio and composition in chemical structure of algae other crucial aspects affecting the biomethane potential.

### **Kopsavilkums**

Pēdējos 100 gadu laikā ievērojami audzis barības vielu daudzums Baltijas jūrā. Ar slāpekli un fosforu pārbagātais ūdens un lēnais ūdens apmaiņas cikls veicinājis eitrofikācijas seku izplatīšanos. Dažādu sugu aļģu izplatība sasniegusi tādus apmērus, ka tiek apsvērtas to izmantošanas iespējas kā izejvielai alternatīvo energoresursu ražošanai.

Pētījums balstās uz Baltijas jūras piekrastē savākto makroaļģu laboratorisko analīzi. Tiek pieņemts, ka makroaļģēm, salīdzinot ar citām aļģēm, ir augsts sausnas saturs, kas paaugstina to potenciālo izmantošanas iespēju, kā izejvielu biogāzes ražošanā. Sākotnēji ticis veikts eksperiments ar mērķi noteikt kopējās un gaistošās sausnas saturu aļģēs. Rezultāti rāda, ka gaistošās sausnas saturs ir 17,8%. Lai noteiktu Baltijas krastā savākto aļģu biogāzes ražošanas potenciālu, nepieciešams turpināt laboratoriskos pētījumus ar mērķi noteikt paraugu ķīmisko sastāvu un tā ietekmi uz biogāzes ražošanu.

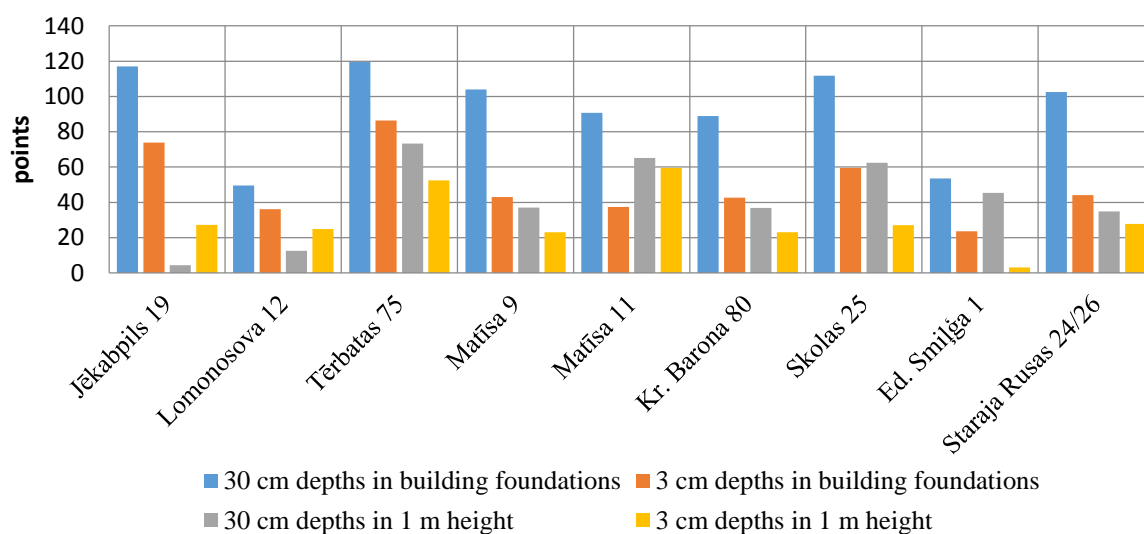
## The humidity of the exterior walls of historic brick buildings

Linda Grava, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor

Dr.Sc.ing. Andra Blumberga, Mg.Sc. Edīte Kamendere

One of the most pressing issues today is the energy efficiency in buildings, which means the energy used in the buildings should be used efficiently, thus reducing resource consumption and production of energy. The study investigated buildings that were built in the period from 1894 to 1917, the building facade of yellow or red bricks. The first step in order to make energy efficiency measures of the buildings is to clarify the technical condition of the said buildings, as well as how the surrounding environment influences the structure. The study looked at an option, where the wall is insulated from the inside, in which case the outer wall is put under much worse conditions, therefore the initial condition of the walls has to be evaluated. The research then carried out literature analysis on factors causing moisture and consequences of the potential reduction.

The goal is to determine the moisture condition of the exterior wall of 9 brick buildings in Riga. The research used non-destructive method used by the measuring tools – Trotec 650 and Trotec 600 dielectric moisture measurement indicators through which moisture can be found quickly without disrupting the structure and damages. Especially suitable for a provisional determination of the location of moisture. Moisture measurements were carried out at the foundation and 1 m height and 4 cm depth and 30 cm depth. Measurements were made on 8.02.2015., when the outdoor air temperature was around 0 °C, relative humidity of around 80 %. The hypothesis that the higher moisture is at the foundation of the building was confirmed, because there is no water collection system in the buildings and there is lack of waterproofing of the foundation.



### Results of examination of the construction of the moisture with Trotec 600 and Trotec 650

According to the obtained results have shown that the design depth of 30 cm is wet 7 of 9 cases (over 80 sections, which means that the test site is wet), which can be explained by the fact that the ones that have the largest points, the lack of waterproofing, rain water collection systems are in very poor condition or missing. As well as can be observed that the humidity remains the height of 1 m 30 cm, as happens moisture movement through pores.

### Kopsavilkums

Darba mērķis ir novērtēt 9 Rīgas vēsturisko ēku ārējo mitrumu un noteikt to tehnisko stāvokli. Darbā literatūras apskats ir par vēsturisko ķieģeļu fizikālajām īpašībām, mitruma cēloņiem un samazināšanas iespējām. Praktiskajā daļā ir veikta (būvētas no 1894. gada līdz 1917. gadam) ēku apsekošana. Veikti mitruma mērījumi pie pamatiem un 1 m augstumā, gan 30 cm dziļumā, gan 3 cm dziļumā, veikta rezultātu analīze.

## Heat pump hybrid systems. A study on potential increase in renewable fraction

*Elīza Ķeirāne, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor*

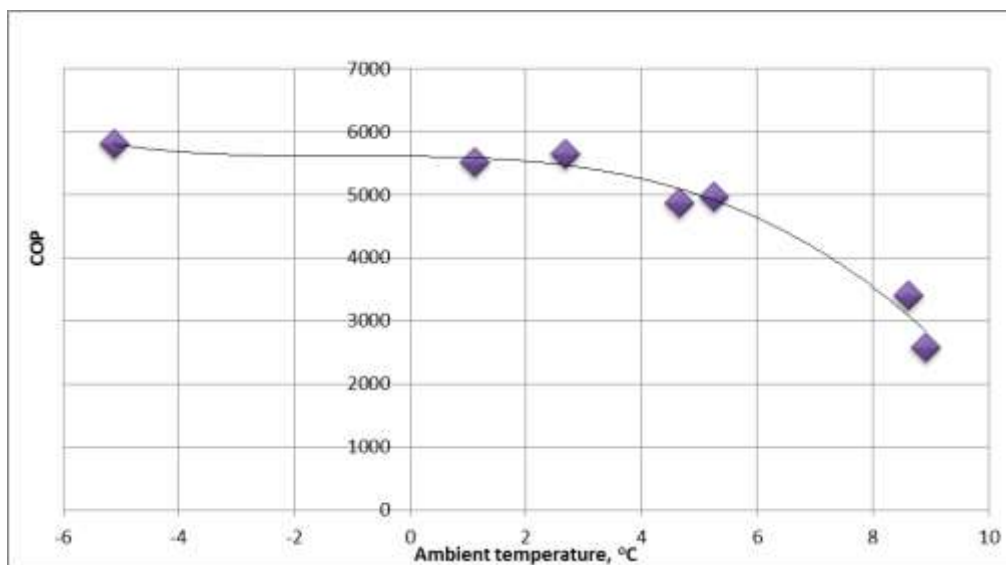
*Dr.Sc.ing. Claudio Rochas, Mg.Sc. Jānis Ikaunieks*

The aim of this paper is to analyse the possible additional heating sources in a residential building where two heat pumps have been installed, mainly focusing on increasing the use of environment friendly energy sources.

The basic principle of a heat pump is to transfer heat from one environment (the source) to another (the house). Heat pumps can be used for both domestic hot water and space heating. The heat can be taken from either water, air or ground, for example, lakes, rivers, wastewater, groundwater, ground, ambient air, air from ventilation systems, etc. The efficiency of a heat pump is measured in how many kWh of heat can be derived, by providing 1 kWh of electricity, it is called the coefficient of performance (COP).

As it is not profitable to install a heat pump that can produce the maximum heat the household can reach in the coldest days of the year, there are many possibilities to install additional heating systems, for example, solar collectors, furnaces, and others. If the heat pump can produce 50 % of the maximum heat, it can cover from 80 % to 90 % of the total heat demand of the year.

In this paper there will be a case study. The reference building is a 42 apartment house in 4 floors, with the total living area of 2656 m<sup>2</sup>. The installed heat pumps are used only for space heating, and the aim is to improve their COP.



*COP of the heat pumps regarding ambient temperature*

The reference building has been monitored since the heat pumps were installed and the conclusions of the most suitable alternative will be based on the research of the collected data.

### **Kopsavilkums.**

Darba mērķis ir analizēt un aprakstīt iespējamās papildu siltumenerģijas iegūšanas veidus daudzdzīvokļu ēkā, kurā uzstādīti siltumsūkņi. Galvenokārt koncentrējoties uz dabai draudzīgiem pasākumiem. Darba sākumā ir veikts literatūras apskats un aprakstīts siltumsūkņu darbības pamatprincips, kā arī to veidi un siltuma iegūšanas avoti. Ir izvērtēta kopējā situācija Latvijā un Eiropā, un apskatīti iespējamie hibridsistēmu veidi un to piemērotība mūsu klimatiskajiem apstākļiem. Darba galvenajā daļā tiek veikta ēkas modelēšana programmā TRNSYS. Pēc modelēšanas iegūtajiem rezultātiem tiek veikts salīdzinājums ar ēkas faktiskajiem datiem un piemeklēti piemērotākie alternatīvie enerģijas avoti. Darba noslēgumā ir tiek izdarīti secinājumi par to, kurš no papildu siltumenerģijas avotiem ir piemērotākais un būtiski uzlabo siltumsūkņu transformācijas koeficientu (COP).



## Modeling of phase change materials to increase building's thermal properties

*Liene Kancāne, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master*

*Dr.Sc.ing. Andra Blumberga, Mg.Arch. Ruta Vanaga*

All new buildings must be nearly zero-energy buildings (nZEB) by 2020, and all new buildings occupied and owned by public authorities must be nZEB after 2018. These targets are set in the European Member States according to EU directive on the Energy Performance of Buildings. Huge challenge is to achieve these goals in northern countries where traditional energy saving measures – insulation, window performance, heat recovery ventilation systems - balance on border of cost optimality. Climate adaptive building shell (CABS) constructions can be energy efficient alternative to common solutions.

The aim of the work is to assess the possible phase change material (PCM) use in solar thermal façade system with climate adaptive properties. The solution proposed would increase thermal inertia of building envelope and take part in indoor microclimate regulation processes. Different types of PCMs and heat transfer enhancers were studied. Mathematical model and a real dimension prototype was made and studied under real climatic loads.

The paper reviews a modulation of different PCMs used for solar energy storage in the prototype of solar thermal façade system. Three types of PCM are used in prototype – paraffin, salt hydrate and fatty acid. These materials were selected based on their thermal properties, compatibility with other building materials, thermal stability and availability in the market. The energy demand for heating the building can be reduced by the amount of accumulated solar energy in phase change materials thus cutting the CO<sub>2</sub> emissions from combustion processes. The task set is to store in PCM container and added accumulation tank the energy from the sun radiation on prototype surface intensifying solar heat gains during both in winter and in summer.

The effect of façade system with incorporated PCM layer on annual energy demand and PCM thermal properties are investigated. A simulation of prototype using *Delphin* software was carried out. The idea of solar thermal façade system prototype is based on biomimicry's principles imitating the processes found in nature to solve problems of humans.

The proposed solar thermal façade system can serve as a part of on-site energy production in nZEB buildings and reduce required energy demand during building lifetime.

### Kopsavilkums

Pēc 2020. gada visām jaunajām ēkām jābūt gandrīz nulles enerģijas ēkām un visām jaunajām ēkām, kurās atrodas vai ir īpašnieces valsts iestādes jābūt gandrīz nulles enerģijas ēkām pēc 2018. gada, nosaka Eiropas Parlamenta un Padomes direktīva par ēku energoefektivitāti. Tādēļ darba mērķis ir novērtēt iespēju lietot fāžu pārejas materiālus (FPM) kā vienu no sastāvdaļām klimata jutīgā fasāžu sistēmā, palielinot ēkas termisko inerci un panākot sienas konstrukcijas iesaisti iekštelpu mikroklimata nodrošināšanā. Plānots FPM uzglabāt no fasāžu sistēmas ārējās virsmas savākto saules enerģiju, ko izmantot kā atbalstu ēkas apkures sistēmai, tādējādi samazinot ēkas dzīves cikla laikā pievadāmo enerģiju no ārējiem resursiem.

Tika veikta literatūras analīze par FPM, kuri var tikt pielietoti prototipā, un izvēlēti balstoties uz to termiskajām īpašībām, saderību ar citiem būvmateriāliem, termisko stabilitāti un pieejamību tirgū. Tika apskatīti arī siltuma pārnese paātrinātāji. Klimata jutīgās fasāžu sistēmas prototips tiek modelēts vadoties pēc biomimikrijas principiem, kas imitē procesus dabā, risinot cilvēku radītās problēmas. Darba praktiskajā daļā tiek veidota eksperimenta plānošana matemātiskajam datormodelim un prototipam, kurš tiks novērots pie reālām klimatiskajām slodzēm. Simulācijas modelis tiks izstrādāts programmā *Delphin*. Darba nobeigumā tiks izstrādāts abu modelēšanas veidu salīdzinājums un veiktas korekcijas, ja tādas būs nepieciešamas, lai optimizētu sistēmu, kā arī tiks izstrādāti secinājumi un rekomendācijas nākotnes studijām.

## **Allocation of historical buildings in typology groups according to building construction solutions**

*Egita Pavlova, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master  
Dr.Sc.ing. Andra Blumberga, Mg.Sc. Kristaps Kašs*

Historic buildings are considered to be significant energy consumers, which account for considerable amounts of Green House Gas emissions, therefore it is important to find ways of reducing historic building energy consumption and their environmental impact. However, there are a number of limitations that need to be taken into account considering possible measures for historic building energy efficiency improvements. According to legislative acts it is not allowed to change buildings original design from the outside façade, therefore there are a number of limitations and problems associated with historic building retrofit.

The impact of climate change and urban pollution increases the negative impact on the historic building envelope. Therefore it is necessary to find solutions for energy consumption reduction of historic buildings, which can ensure the compliance with EUs high energy standards and at the same time providing reduced impact on the environment and ensuring historical buildings adaptation to climate change.

Therefore, the scope of this research is to establish historical building typology system according to main building construction materials and their physical parameters, to study possible energy efficiency improvement measures tailored to specific historic building typology group. According to this system, it will be possible to evaluate potential renovation steps.

To reach results it is necessary to perform an inventory of historic buildings and divide historic buildings in different groups. It is possible to divide buildings in different groups by building construction time (century), because each period has different building technologies and construction principles. It is needed to identify each century common buildings and distinguish different types to determine their physical characteristics - thermal transmission, moisture diffusion and other common parameters.

Based on the achieved results it could be possible to determinate which historical buildings are suitable for energy efficiency improvements and which are not. This system helps to achieve targets that are set by legislative acts – to reduce building energy consumption and negative environmental effects that have been caused by the unreasoned and wasteful resource use.

The results will provide evidence on the allocation of historic buildings and structures based on which it will be possible to determine the boundary conditions for building envelope insulation from the inside, for the potential risks and determine which buildings are suitable for retrofit from the inside and which are not possible to adapt to modern technological development. System will allow to evaluate what kind of measures can be done and what are not recommended for historical buildings due to building typology system.

### **Kopsavilkums**

Balstoties uz ES enerģijas efektivitātes plāniem un izvirzītajiem mērķiem, nepieciešams samazināt radīto SEG emisiju un patērētās enerģijas apjomu. Būtisku ieguvumu var sasniegt uzlabojot vēsturisko ēku energoefektivitāti, taču to vēsturiskā mantojuma statusa dēļ, nākas saskarties ar daudziem ierobežojumiem un problēmām.

Vēsturisko ēku tipoloģijas izveides mērķis ir radīt lietotājam ērtu ēkas novērtēšanas sistēmu, kas balstoties uz radīto vēsturisko ēku tipoloģiju, ļaus secināt un novērtēt iespējamās energoefektivitātes pasākumus, tuvinot ēkas funkcionalitāti un kvalitāti mūsdienu tehnoloģiju prasībām.

## **A comparative Life cycle assessment of refurbished multi-family building versus not-refurbished multi-family building**

*Dainis Selickis, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master*

*Dr.Sc.ing. Francesco Ramagnoli, Dr.Sc.ing. Claudio Rochas*

In order to meet targets of energy efficiency and to comply with regulations commitment of reduction harmful carbon dioxide gases by 20 % from building heating, more than 500 building renovations have been implemented in Latvia during previous five years. As buildings globally are consuming up to 40 % of energy and are responsible for half of the world's greenhouse gas emissions, measure of every environmental impact involved in building processes from cradle to grave is important. Research of building industry impact using Life cycle analysis has increased in recent years, including building processes and materials used.

The aim of this study is to investigate ten renovated 103<sup>rd</sup> series multi-family buildings in Latvia, using the opportunities offered by LCA and to identify the average building example which is defined by amounts of materials and energy used in refurbishing by m<sup>2</sup> of heated area.

Information obtained about refurbishing process and building materials is analyzed using LCA methodology, additionally using Simpro program. Impact of used materials for refurbishing and energy spend during operation is calculated for expected service life of 30 years after refurbishing.

The findings allows to determine environmental benefit of multi-family building refurbishment and define amounts of saved energy and greenhouse emissions. Data analysis allows to make average building example, that is defined with materials and energy used that can further be applicable in building refurbishment project analysis. Finally acquired information can be used in promotion of LCA of building refurbishment labeling.

### **Kopsavilkums**

Lai sasniegtu energoefektivitātes mērķus un ievērotu apņemšanos par kaitīgās oglekļa dioksīda gāzes samazināšanu par 20 % no ēkas apkures, Latvijā ir realizēti vairāk nekā 500 ēku renovācijas projekti iepriekšējos piecos gados. Tā kā ēkas pasaulē patērē līdz pat 40 % visas enerģijas un ir atbildīgas par pusi no pasaules siltumnīcefekta gāzu emisijām, katra būvniecības procesa ietekme ir svarīga ciklā no šūpuļa līdz kapam. Dzīves cikla analīzes izmantošana būvindustrijas analīzē ir pieaugusi pēdējos gados, tostarp celtniecības procesiem un materiāliem.

Šī pētījuma mērķis ir izpētīt desmit renovētas 103. sērijas daudzdzīvokļu ēkas Latvijā, izmantojot LCA, noteikt vidējo ēkas renovācijas piemēru, kurš definē izmantot materiālu un enerģijas daudzumu pēc m<sup>2</sup> apsildāmās platības.

Iegūtā informācija par mājas renovācijas procesiem un izmantotajiem materiāliem tiek analizēta, izmantojot LCA metodoloģiju, papildus veicot simulācijas ar Simpro programmu. Renovācijā izmantotie materiāli un enerģijas ietekme tiek aprēķināta nākošajiem 30 ekspluatācijas gadiem pēc renovācijas.

Iegūtā informācija ļauj noteikt daudzdzīvokļu ēkas renovācijas ietekmi uz vidi un noteikt ietaupītās enerģijas daudzumu un siltumnīcefekta gāzu emisijas. Datu analīze ļauj izveidot vidējās ēkas piemērs, kas tiek definēts ar izmantotajiem materiāliem un patērēto enerģiju. Radītais mājas renovācijas piemērs var tikt izmantots turpmāko projektu analīzē un LCA marķējuma attīstīšanā ēku atjaunošanas sfērā.

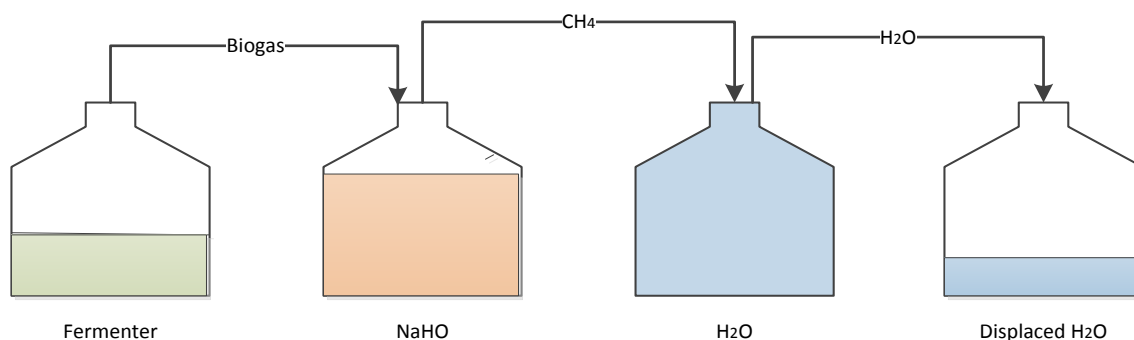
## Bio-methanation with additional hydrogen supply. Batch test experiment

*Dzintra Slišāne, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master*

*Dr.Habil.Sc.ing. Dagnija Blumberga, Dr.Sc.ing. Sylvestre Njakou Djomo*

National energy action plan sets a target of 40% RES share by 2020. EU progress report shows that Latvian progress trend towards the targets up to year 2012 is not sufficient for reaching the target. Something has to change. There are several studies considering possible policy instruments, however, in the opinion of authors development of technologies will open more possibilities and together with policy instruments allow us to eventually reach the target. This study focuses on improvement of biogas production process. Currently, majority of produced biogas consists of up to 50% of carbon dioxide (CO<sub>2</sub>), which is usually removed from gas before its transportation and use. During biological methanation process methanogens, microorganisms from Archaeobacteria domain, utilizes hydrogen (H<sub>2</sub>) and (CO<sub>2</sub>) and as a by-product of their metabolism produces CH<sub>4</sub>. This reaction takes place in bioreactors. Hypothesis of this thesis is that additional injection of H<sub>2</sub> may facilitate described process, therefore reducing the amount of CO<sub>2</sub> and increasing methane concentration.

Batch tests were selected as the optimal method for experimental testing of hypotheses. Tests were performed according to methodology described by B. Drosig et.al. in “The Biogas Handbook: Science, Production and Applications”. Six batches with feedstock sample (macro algae) and inoculums (ratio 3:1) were prepared, each batch is then connected to vessel filled with alkaline solution (3 mol/l NaOH). Alkaline solution reacts with CO<sub>2</sub> in biogas removing it from gas. The gas then flows into the water displacement bottle that is the third vessel in the array (See Fig.). Water is pushed out of the bottle and collected in another vessel, then measured. Volume of displaced water is equal to the volume of produced gas. Obtained results then can be recalculated to correspond to Standard conditions.



### *Experimental array for biological Methane Potential (BMP) test*

Hydrogen is added to 3 of the batches with feedstock and inoculums, while 3 others are left without any additions as a reference samples. Determination of hydrogen input is crucial part in the experiment. According to literature biological limit of hydrogen in feed is 4 m<sup>3</sup>H<sub>2</sub>/m<sup>3</sup>CO<sub>2</sub>. Mass transfer limit is 5% molar mass of hydrogen in total gaseous part of bioreactor. This means that maximum 0.05 m<sup>3</sup> of H<sub>2</sub> can be added for each m<sup>3</sup> of predictable biogas production in a time period. For 30 ml of biogas, this is predictable biogas yield per day at the beginning of the experiment; 1.2 ml of H<sub>2</sub> should be added daily.

### **Kopsavilkums**

Veicot papildus H<sub>2</sub> pievadīšanu bioreaktorā iespējams paaugstināt metāna saturu iegūtājā biogāzē. Hipotēze balstītās uz metanogēno baktēriju vielmaiņas īpatnībām – šīs baktērijas uzņem CO<sub>2</sub> un H<sub>2</sub> un vielmaiņas gala rezultātā rada CH<sub>4</sub> un ūdeni. Pārāk liela H<sub>2</sub> koncentrācija traucē baktēriju darbībai. Bioloģiskā ūdeņraža pievades robeža nosaka, ka H<sub>2</sub> attiecība pret CO<sub>2</sub> nedrīkst pārsniegt 4:1, masas pārvades robeža – 5% no saražotās biogāzes. Hipotēzes testēšanai tika izvēlēta „batch test” eksperimenta metode, kuras ietvaros izveidots eksperimenta stends.

## Assessment of thermo-physical properties of natural materials

Anna Vaivare, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master

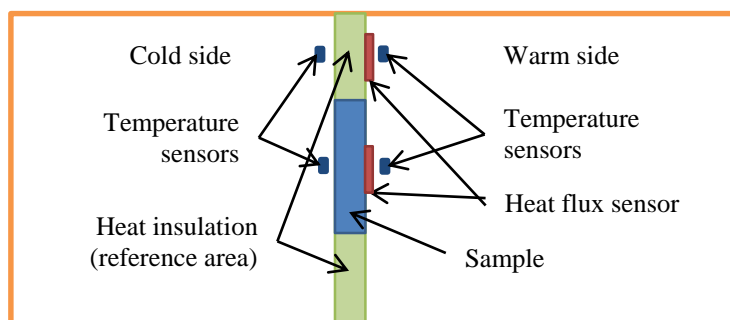
Dr.Habil.Sc.ing. Dagnija Blumberga, M.Sc. Indra Muizniece

This paper presents an evaluation of natural material thermo-physical properties – thermal conductivity coefficient. The aim of this research is to find materials of natural origin that are residues from different sectors of the economy that can be rationally used as thermal insulation material. This idea is inspired by biomimicry, because in nature aerial part of the plant serves as natural heat insulation layer, bioeconomy and enegefficiency. As the energy consumption needs to be decreased in building sector, amount of used thermal insulation materials will increase. It is important to offer alternative for mineral and synthetic material insolation to provide necessity amount of insolation.

In this paper discuss some of the natural material remain – fern, Canadian goldenrod (*Solidago Canadensis L.*) and leaves – usage as thermal insulation material. These materials are chosen because in nature leaves serve as insulation layer; Canadian goldenrod is invasive plant and they amount is significant but they are not rationally used; and fern both historically and in nowadays are used to insulate bee hives. To find the thermo-physical properties of natural materials, experiment planning was carried out. For this research are selected two-level factorial design – low level and high level of each factor. Influencing factors for thermal conductivity are particles size, and density. According to the experimental plan of each material was made and tested 12 samples. Each sample were taken heat flow measurement, moisture content, calculated thermal conductivity coefficient, density and gradation.

In this research thermal conductivity gained using heat flow meter measurement method what is described in ISO 9869-1:2014 “Thermal insulation – Building elements – In-situ measurement of thermal resistance and thermal transmittance – Part 1: Heat flow meter method”. For measurements is used experimental stand (see Fig.) that contains insulation sheet that separate cold side to warm side and where tested samples are put in. Heat flux sensors and temperature sensors are placed in two places – in front of sample and insulation sheet that serve as reference area for verify experiment results.

Analysis of the results of the experiment carried out using *Statgraphics*, and it is determined if the factors have an impact on the material thermal conductivity coefficient. The results are compared with other natural, synthetic and mineral insulation material thermo-physical properties and assessed the likelihood of studied materials usage as raw material in the production of thermal insulation material.



*Experimental stand to determinate thermal conductivity*

### Kopsavilkums

Darba mērķis ir atrast dabiskas izcelsmes materiālus, kas ir atlikumi no dažādām tautsaimniecības nozarēm, un izvērtēt vai tie varētu tikt racionāli izmantoti kā izejvielas siltumizolācijas materiālu ražošanai. Darbā tiek veikta literatūras analīze par pētītajiem un tirgū pieejamajiem siltumizolācijas materiāliem, kas izgatavoti no dabas materiāliem. Tie salīdzinātai ar sintētiskajiem un minerālu siltumizolācijas materiāliem. Praktiskā daļa ietver dabas materiālu – lapu, zeltslotiņas un paparžu – siltumfizikālo īpašību noteikšana. Materiāliem tiek noteikts siltumvadītspējas koeficients pēc ISO 9869-1:2014 standarta un citi to ietekmējošie parametri – blīvums, daļiņu izmērs un mitruma saturs. Darba nobeigumā tiek izstrādāti secinājumi par iespējām izmantot dabas materiālus kā izejvielu siltumizolācijas materiālu ražošanai.

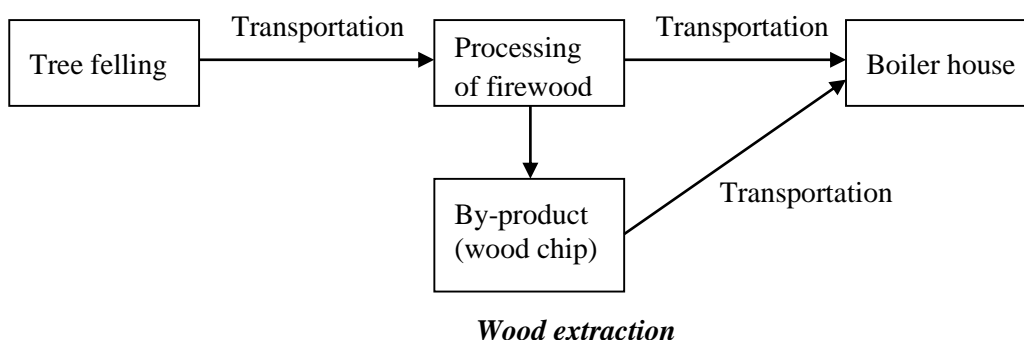
## Analysis of the alternatives of the sustainable biomass use in the region of Ventspils

Alise Ķierpe, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Sc.ing Marika Roša

This paper presents the use of biomass as fuel for sustainable exploitation of resources in a particular territory. Work deals with preparation for biomass fuels, starting with growing in the forest and up to its delivery of the boiler house; it can be seen in the figure below.

The objective of the work is to find out whether Ventspils municipality with their local forests and companies that works in the field of forestry may supply their own 12 civil parishes and one city. Views are only those buildings that are heated with municipal funds. In this work is cleared up if forests areas be enough to ensure buildings with biomass in the long term, does it pays off and what are possible solutions to the planned method.

In order to obtain the necessary materials were interviewed the parish boards leaders about the boiler house power, consumption and wood / wood chip purchases. The obtained data being further analysed and the best solutions for Ventspils municipality will be found.



### Kopsavilkums

Darba mērķis ir izpētīt Ventspils novada kurināmā iegūšanas procesu, un rast labāko risinājumu, lai šo procesu varētu izdarīt novada teritorijas robežās.

Darbā tiek veikta literatūras analīze par mežiem Latvijā, biomasas cikla apskats un analīze Ventspils novadā un resursu izmantošanu kā kurināmais. Darba praktiskajā daļā tiek veikta iegūto datu analīze par Ventspils novadu. Par esošo enerģētikas struktūru, enerģijas piegādes un patēriņa analīze. Biomasas iepirkšanas dati tiek salīdzināti ar tuvāko novadu datiem un analizēti gan ekonomiski gan ekoloģiski. Darba nobeigumā tiek veikti secinājumi par iespējām ieviest vietējo kurināmā ieguves ciklu. Par nepieciešamajām darbībām, lai sasniegtu mērķi un turpinātu to ilgākā laika periodā.

## Heat pump hybrid systems. A study on potential increase in renewable fraction

*Elīza Keirāne, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor*

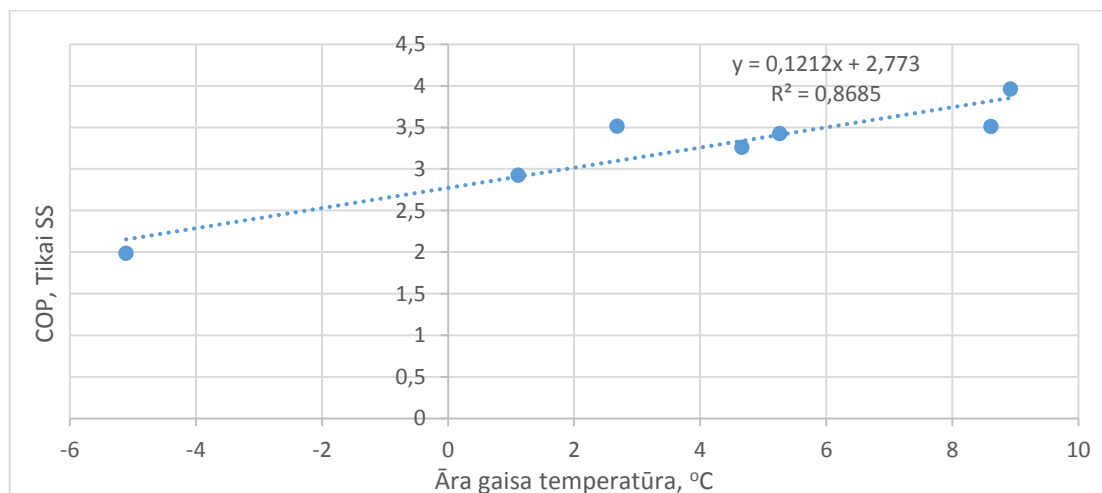
*Dr.Sc.ing. Claudio Rochas, Mg.Sc. Jānis Ikaunieks*

The aim of this paper is to analyze the possible additional heating sources in a residential building where two heat pumps have been installed, mainly focusing on increasing the use of environment friendly energy sources.

The basic principle of a heat pump is to transfer heat from one environment (the source) to another (the house). Heat pumps can be used for both domestic hot water and space heating. The heat can be taken from either water, air or ground, for example, lakes, rivers, wastewater, groundwater, ground, ambient air, air from ventilation systems, etc. The efficiency of a heat pump is measured in how many kWh of heat can be derived, by providing 1 kWh of electricity, it is called the coefficient of performance (COP).

As it is not profitable to install a heat pump that can produce the maximum heat the household can reach in the coldest days of the year, there are many possibilities to install additional heating systems, for example, solar collectors, furnaces, and others. If the heat pump can cover 50 % of the maximum heat load, it can produce from 80 % to 90 % of the building annual heat demand.

In this paper there will be a case study. The reference building is a 42 apartment house with 4 floors and total living area of 2656 m<sup>2</sup>. The installed heat pumps are used only for space heating. The aim of this study is to improve their COP and increase the renewable energy fraction in end use.



### *COP of the heat pumps regarding ambient temperature*

The reference building has been monitored since the heat pumps were installed and the conclusions of the most suitable alternative will be based on the research of the collected data.

### **Kopsavilkums**

Darba mērķis ir analizēt un aprakstīt iespējamās papildu siltumenerģijas iegūšanas veidus daudzdzīvokļu ēkā, kurā uzstādīti siltumsūkņi. Galvenokārt koncentrējoties uz labai draudzīgiem pasākumiem.

Darba sākumā ir veikts literatūras apskats un aprakstīts siltumsūkņu darbības pamatprincips, kā arī to veidi un siltuma iegūšanas avoti. Ir izvērtēta kopējā situācija Latvijā un Eiropā, un apskatīti iespējamie hibrīdsistēmu veidi un to piemērotība mūsu klimatiskajiem apstākļiem. Darba galvenajā daļā tiek veikta ēkas modelēšana programmā TRNSYS. Pēc modelēšanas iegūtajiem rezultātiem tiek veikts salīdzinājums ar ēkas faktiskajiem datiem un piemērotākie alternatīvie enerģijas avoti. Darba noslēgumā ir tiek izdarīti secinājumi par to, kurš no papildu siltumenerģijas avotiem ir piemērotākais un būtiski uzlabo siltumsūkņu transformācijas koeficientu (COP).

## **Research of bioeconomy, trends and development opportunities in Latvia**

*Maira Melvere, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Habil.Sc.ing. Dagnija Blumberga*

This paper presents an evaluation of bioeconomy in the Latvian agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnology and energy industries sectors. Searching for innovation, technology, solutions to change and supplement the present economic situation in Latvia including non-waste cycle when non-bio-resource sectors are replaced with bio-resource.

The biggest source of GHG in Latvia is the agricultural sector, so research has focused on the rural development, which is based on the provisions of a bioeconomy. The example is Ventspils region Puzes parish. Since 1995 there has been observed regression, which continues today. The situation is similar in many Latvian municipalities. Bioeconomy is viewed as a way to develop this parish. Must restore the old factories, improved agriculture, use of waste products as raw material and to promote the industry, with the potential in this parish. The author of work tries to search for the most effective scenario and summarize added value as an economical factor.

Need to create products that obtain the maximum added value, starting with the acquisition of raw materials and ending with the full treatment. Puzes parish is viewed as a "green district" where existing resources are used as innovative things that create new jobs, profits, form a common development and make creative thinking people.

The aim is to offer the most efficient and greener biological resources technology deployment scenarios. Is looking for a compromise between low investment, high efficiency and minimal environmental impact.

### **Kopsavilkums**

Izpētes mērķis ir saprast kopējās tendences bioekonomikas sektoros Latvijā, un veikt analīzi par Puzes pagasta iespējamo attīstības scenāriju, ieviešot uz bioekonomikas principiem balstītu saimniekošanu. Aprēķināt produktu pievienoto vērtību un ietekmes uz vidi izmaiņas.

Izvirzītā hipotēze: Puzes pagasta attīstība ir iespējama ieviešot noslēgta cikla saimniecību, kas balstīta uz bioekonomikas principiem. Puzes pagasts – piemērs Latvijas pagastu attīstībai un vieta „zaļiem uzņēmējiem”, eko – tūrismam un veselīgam dzīvesveidam.

Darbā tiek veikta literatūras un statistikas datu analīze par bioekonomikas sektoru tendencēm, esošo situāciju un iespējamām inovācijām jeb attīstības scenārijiem. Praktiskā daļa balstās uz reālu Ventspils novada Puzes pagasta piemēru. Pagastā kopš 1995. gada ir novērojama regresija, kas turpinās arī šobrīd. Līdzīga situācija ir daudzos Latvijas pagastos. Balstoties uz iegūtajiem datiem, tiek veikta analīze un piedāvāti attīstības scenāriji. Tiek meklēts kompromiss starp mazām investīcijām, augstu efektivitāti un minimālu ietekmi uz vidi.



## **The evaluation of electromobility in Latvian municipalities after the realisation of the KPFI competition**

*Agate Ķīsele, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Sc.ing. Marika Rošā, Mg.Sc. Aiga Barisa*

At the moment the transport sector is not a sustainable industry. It is a significant and still growing source of greenhouse gases. If nothing is done- it is estimated that CO<sub>2</sub> emissions by 2050 will reach a level three times higher than it was in 1990. Mobility reforms are important because transport sector is a worldwide industry that affects people's quality of life, the internal and external markets, as well as to create freedom of movement for the public. The transport sector is an important part of the economy and generates around 5% of GDP worldwide.

The study has been carried out with the aim to analyse electro mobility in Latvian municipalities, to assess current situation and possible solution for the future to optimize transport sector in Latvia. Electro mobility development has an important role in the reduction of emissions at national and European level, but at the same time the guidelines for electro mobility in Latvia is bound to expire by 2016. The study is important because it can help to define the main threats to the development of electro mobility in Latvia and allows to develop recommendations for the promotion of electro mobility in Latvia.

In this paper was used objective survey method. The questionnaire consists of three groups of questions, which includes technical information, vehicle habits and motivation, as well as future plans review. The survey was sent to all municipalities and associated companies that took part in Climate Change Financial Instrument (KPFI) project competition "Reducing greenhouse gas emissions in the transport sector - support for electric vehicles and charging infrastructure for implementing" co-financing for electro mobility support in regions. The obtained results of the survey were used in a system dynamics model to determine the impact of various factors on the development of electro mobility at national level.

The work suggests that there are many obstacles to the development of electro mobility. One being the lack of charging stations. It makes the drivers pay more attention to the mileage and the selected route, as the electro mobile per one charge is able to drive an average of 100km and if the machine is charging at the slow charging point, it can take up to 8 hours. High price of the electro mobile also can be a major factor although the maintenance costs are much lower it is still not sufficient enough for people to choose an electrical car over conventional vehicle. These are some of the main obstacles currently present in Latvia and if government manages to tackle some of the problems raised in this text, there is a high chance that trend of electro mobile use will steadily increase over time.

These are the main obstacles to electro mobility and developed work can be concluded that if just these points will be given more attention, and more and more consumers will choose in favour of electric vehicles, as already interest is observed.

### **Kopsavilkums**

Darba mērķis ir analizēt elektromobilitātes situāciju Latvijas pašvaldībā, lai atrastu piemērotākos risinājumus turpmākai elektromobilitātes attīstībai.

Darbā tiek veikta literatūras analīze par elektromobilitāti dažādos līmeņos. Tiek apskatīta elektromobilitāte starptautiska līmenī, kur tiek vērtēts politiskais ietvars un tehnoloģiskais progress, nacionālā līmenī, kur tiek analizēts politiskais ietvars, kā arī citu valsts pieredze, attīstot elektromobilitāti nacionālā līmenī. Literatūras apskats tiek veikts arī pašvaldību un sabiedrības līmenī, kur tiek vērtēta pašvaldību loma elektromobilitātes veicināšanā. Praktiskajā daļā tika izmantota aptaujas metode, lai analizētu līdzšinejo progresu pašvaldībās, kā arī, lai vērtētu attīstības šķēršļus un iespējas. Otrajā daļā tika veidots sistēmdinamikas modelis, izmantojot iegūtos aptaujas datus, lai vērtētu elektromobilitātes attīstības iespējas, balstoties uz pašvaldību nostāju. Darba nobeigumā tika veikti secinājumi par esošo situāciju Latvijā, kā arī izvirzīti priekšlikumi progresīvākai elektromobilitātes attīstībai.

## Assessment of macro-algae harvesting methods and preparation of macro-algae for anaerobic digestion

Asnate Skrebele, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Sc.ing. Francesco Romagnoli

Algae biomass as an alternative substrate for biogas production is not a new idea, but it has little discussed, because the production of energy in this way was costly and inefficient. In recent years this idea has returned because using algae as biomass would solve the problem of agriculture land usage for energy crops (crops used for fuel and not food).

Purpose of this paper is to make literature review about different macroalgae cultivation and harvesting methods and assessment of them. For example possibilities of growing and collecting algae off-shore or marine environment.

Using different pre-treatment methods it is possible to increase volume of biogas created. In table it is possible to see summary of different method (mechanical and/or thermal) impact on methane production.

**Algae pre-treatment impact on production of methane**

Algae	Batch t, °C	Pre-treatment	Improvement, %
Ulva lactuca	55	Unwashed, macerated	+56
	55	Washed, macerated	+17
	55	Washed, 130 °C/20 min	+7
	55	Washed, 110 °C/20 min	-10
	37	Unwashed, chopped	-7
	55	Dried, ground	+1

Not all of the methods are positive or give as much of improvement as others that is the reason why is so important to compare them. Evaluation of the best used method differs from one macroalgae species to other.

### Kopsavilkums

Darba mērķis ir veikt izpēti par dažādām makroaļģu audzēšanas metožu novērtējumu un to sagatavošanas metožu ietekme uz saražotās biogāzes daudzumu.

Darbā tiek veikta literatūras analīze par dažādām makroaļģu audzēšanas un ievākšanas metodēm. Tiek apskatīti dažādi makroaļģu apstrādes procesi pirms anaerobas fermentācijas – mehāniskā apstrāde (ar mehāniskām darbībām ietekmēt aļģu struktūru, piemēram, smalcināšana, samīcīšana, mazgāšana), termiskā apstrāde (paraugi tiek žāvēti dažādās temperatūrās). Darba eksperimentālajā daļā tiek apskatītas dažādi, apstrādātu aļģu ietekme uz biometāna produkciju.

## **Cost benefit analysis of biomass drying process**

*Ieva Kārklīņa, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor*

*Dr.Habil.Sc.ing. Dagnija Blumberga*

Nowadays biomass resources have an important role in energy sector, because they are renewable and environmentally friendly compared to the fossil fuels. However high moisture content is one of the main problems associated with biomass usage. To reduce moisture content in biomass several drying technologies can be applied. It is important to evaluate drying process from various points of view, to estimate the environmental costs.

Aim of the work is to look at widely used technological solutions for biomass drying and learn about main parameters which affect biomass drying process. It is necessary to choose indicators for the biomass drying process analysis based on the available literature. Emissions of greenhouse gases, energy balance or minimization of costs are some of indicators that can be used for cost benefit analysis. Cost benefit analysis is one of the various tools for sustainability assessment, which compares all the costs with expected benefits.

As the moisture content of biomass reduces, specific heat increases – it means that you need less resource to get the same amount of energy. Drying of biomass also reduces the costs of transportation and storage. Rotary, conveyor and pneumatic are the most commonly used dryers for biomass. As a drying agent hot air, flue gases or superheated steam can be used. To improve systems efficiency, it is possible to use waste heat from industrial processes. Air velocity, temperature, humidity and biomass layer density are some of the parameters affecting drying process. The Renewable Energy Directive “requires the EU to fulfill at least 20% of its total energy needs with renewables by 2020”. Wider and more effective use of biomass can help to achieve not only this goal, but also reduce greenhouse gas emissions by limit that is stated in Kyoto protocol’s second period.

### **Kopsavilkums**

Darba mērķis ir veikt biomasas žāvēšanas procesa vides izmaksu analīzi, iepriekš iepazīstoties ar žāvēšanas tehnoloģiskajiem risinājumiem un metodiku ieguvumu – zaudējumu bilances noteikšanai. Svarīgi izvērtēt, cik liels ir vides ieguvums sistēmai, kas lieto sausu/žāvētu biomasu, pret ieguldītajiem līdzekļiem un patērēto enerģiju salīdzinājumā ar sistēmu, kas žāvēšanu neīsteno.

Darbā tiek veikts literatūras apskats par visbiežāk sastopamajām biomasas žāvēšanas iekārtām un ieguvumu – zaudējumu metodikas pielietojumu žāvēšanas procesa izvērtēšanai. Ņemot vērā literatūras apskatu, darba praktiskajā daļā tiek izveidota žāvēšanas procesa metodika un algoritms, kam pamatā ir iepriekš izvēlēti indikatori. Darba noslēgumā tiek veikta iegūto rezultātu analīze koksnes žāvēšanas procesam.

## **Quality and composition refused derived fuel produced in Latvia**

*Ernests Pilsums, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Sc.ing. Elīna Dāce*

Refused derived fuel is fuel which is made of sorted and unsorted municipal solid waste, industrial waste, commercial waste, etc. In producing process it's necessary to take out all incombustible materials like glass or metals.

The aim of the study is to determine the composition and quality of refuse derived fuel (RDF) produced in Latvia to assess the potential possibilities for improvement of the quality by conducting literature analysis and samples' tests.

In the study, literary analysis is conducted on RDF quality requirements, production capacities in Latvia and Europe, design of production process' alternatives, and the importance of raw materials. Also, laws and regulations on RDF incineration and emissions generated are considered. In the practical part, RDF samples produced in Latvia were taken to determine their moisture and ash content, chemical composition (C, H, N, O, S), calorific value and particle size distribution. Finally, the tested parameters were used to assess the quality of the fuel.

### **Kopsavilkums**

Darba mērķis ir noteikt Latvijā ražota no atkritumiem iegūta kurināmā sastāva un kvalitātes uzlabošanas iespējas, veicot literatūras analīzi un analizējot Latvijā ražota NAIK paraugus.

Darbā tika veikta literatūras analīze par NAIK kvalitāti un prasībām, ražošanas jaudām Latvijā, ražošanas iekārtu veidiem un secību, kā arī izejvielu nozīmīgumu un normatīvo aktu analīzi, kuri ietekmē NAIK sadedzināšanas rezultātā saražotās emisijas. Praktiskajā daļā tiek veikta Latvijā ražotā NAIK paraugu paņemšana un analizēšana atbilstoši noteiktajiem standartiem. Tiek noteikts mitruma, pelnu, mikroelementu sastāvs, un daļiņu izmērs. No tā attiecīgi tiks novērtēta kurināmā kvalitāte.

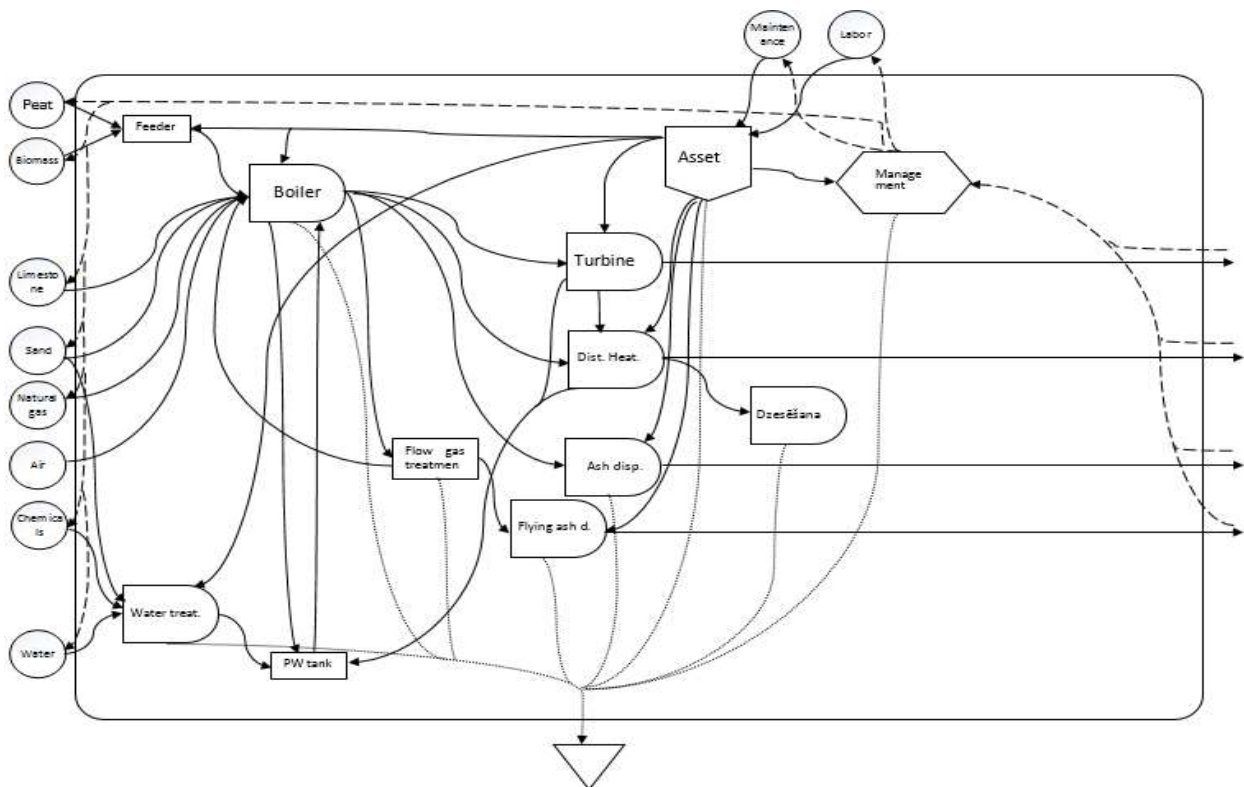
## Emergy Analysis in Biomass Cogeneration

*Toms Prodanuks, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 3rd year Bachelor  
Dr.Habil.Sc.ing. Ivars Veidenbergs*

This paper presents an emergy analysis in biomass cogeneration. Emergy analysis have been made for power plant which is located in Latvia. The aim of emergy analysis is to evaluate the amount of solar emergy used in energy production.

Emergy is the availability of energy (exergy) that is consumed in direct and indirect transformations needed to make a product or service. The unit of emergy is solar emjoule (seJ). To calculate emergy, transformity is used to express energy unit in to solar emjoules. To express other units into emergy, specific emergy, emergy per unit money, emergy per unit labour is used also. Empower is defined as flow of emergy.

A part of emergy analysis is the system diagram. The system diagram helps to show main inputs, outputs, components and flows between them. The system diagram of cogeneration plant is shown in figure.



*System diagram of cogeneration power plant*

Several inputs as renewable, non-renewable, labor and economical have been taken in account in emergy analysis. System diagram shows main flows between inputs and components of the system. All inputs and outputs are converted in emjoules. Finally, emergy indicators such as renewable fraction, emergy yield ratio, emergy sustainability index, etc. are calculated.

### **Kopsavilkums**

Darba mērķis ir veikt emerģijas analīzi koģenerācijas stacijai. Emerģija ir definēta, kā pieejamā enerģija (ekserģija), kas vajadzīga tiešā vai netiešā veidā, lai radītu produktu vai pakalpojumu. Emerģijas analīze tiek veikta, lai noteiktu sistēmas ilgtspēju.

Darbā tika veikts literatūras apskats par emerģijas analīzi, apskatīts koģenerācijas stacijas darbības princips, izveidota sistēmas diagramma, aprēķināta stacijas patērētā emerģija un emerģijas indikatori.

## **The development of the reconstructed grain dryers calculation methodology**

*Mārtiņš Kandis, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master  
Dr.Sc.ing. Mārtiņš Gedrovičs*

Latvia agriculture one of the main industries are grain production. In recent years, the harvested grain is growing and with it appear greater need for grain processing after harvesting. One of the ways to save long as possible whole grains and avoid damage is to remove moisture from the grain. Grain moisture is removed by drying method of a grain dryer. Thus, the increase in the extent of harvested grain drying energy consumption also increases.

Master thesis are under consideration for pit grain dryers, which is one of the most popular types of grain dryers Latvia. Work will be discussed opportunities for grain drying process to save heat, which is used for removing moisture from agricultural grain, corn and peas. The main tasks of the master's work is raised: Get the raw data from an existing and functioning grain dryers, grain dryers to evaluate the selected drying system in terms of efficiency, to model more efficient drying system, including the outgoing hot air heat recovery by means of recycling and the use of a heat pump, as well as to understand the size of the heat loss from unheated grain dryers. Finally evaluate the possibility of obtaining the necessary drying energy production with renewable energy sources.

Master at work will need to deal with several problems which can significantly affect grain drying efficiency. For example, one of the problems is the recirculation of air links with the cooling temperature and moisture content of the removal of the size, that is, because warmer air back into place on the grain in the dryer in less moisture is removed from the grain and conversely, thus the need to find the mid-point favorable. Therefore, the next question banged by the heat pump's capacity to handle damp air.

Results of the work will now work out the grain dryer and heat recirculation pump selection. The methodology will easily be defined in a recirculation or heat pump is necessary to the grain dryer, grain dryer having regard to the size and productivity. It is expected that it will be possible to save from 30 to 40 percent of the initial energy consumption. It is expected that work will be of considerable practical importance

### **Kopsavilkums**

Graudkopībai Latvijas lauksaimniecībā ir ievērojama loma. Lai nodrošinātu iegūtās ražas saglabāšanu, liela nozīme ir kvalitatīvai graudu žāvēšanai. Darbā aplūkotas šahtas graudu kaltes darbības uzlabošanas iespējas. Darbā tiek izvērtēta esošas graudu kaltes žāvēšanas sistēma no efektivitātes viedokļa, tiek modelēta efektīvāka žāvēšanas sistēma, iekļaujot aizejošā karstā gaisa siltuma atgūšanu, izmantojot gaisa recirkulāciju. Aplūkota siltuma sūkņa pielietošanas iespējas. Izvērtētas iespējas žāvēšanai nepieciešamās enerģijas iegūšanai no atjaunojamajiem energoresursiem – salmiem, kas rodas graudu ievākšanas rezultātā, un koksnes kurināmā. Darba rezultātā izstrādāta metodika graudu kaltes aprēķinam, izmantojot recirkulāciju un siltuma sūkni. Sagaidāms, ka ieviestie pasākumi ļaus ietaupīt līdz 30 procentiem enerģijas, salīdzinot ar esošo situāciju, līdz ar to iegūtajiem rezultātiem ir nozīmīga praktiska nozīme.

## Mathematical model of biomass pyrolysis process

Jānis Kļaviņš, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master

Dr.Habil.Sc.ing., Ivars Veidenbergs, Dr.Habil.Sc.ing. Dagnija Blumberga

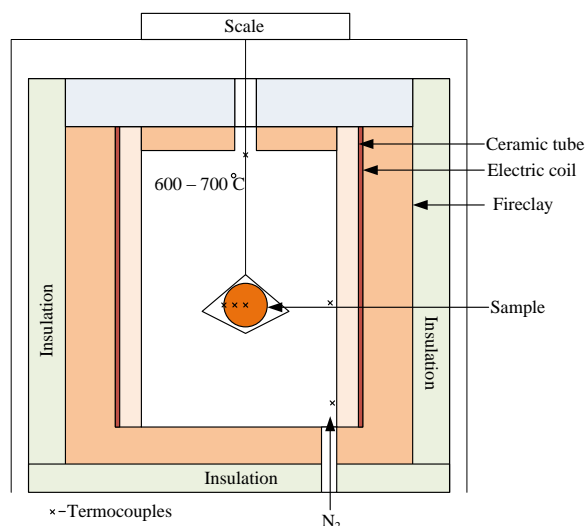
There is a high demand of charcoal and it has no rapid fluctuations because of the many options of usage. In addition, the pyrolysis can be done with any biological material, even waste. Therefore, the pyrolysis of biomass is a good idea for energy and fuel manufacturing in Latvia. The master's thesis are focused on the operational parameters and problems of charcoal production in Latvia with "Lambiotte" retort that is mounted in Livani city.

The aim of the master's thesis is to research pyrolysis process by combining the results of operational charcoal manufacturing plant, verified theoretical mathematical model and laboratory experiment in order to make pyrolysis process variable analysis and process optimization possibility analysis.

To investigate the production process the data and samples was collected form the operational charcoal manufacturing site for further investigation and data analysis. Received temperature data was analyzed with statistical methods to gain a correct view of average operational temperature regimes and detect values outside the confidence interval. Samples of biomass and charcoal from the operational retort was taken to analyze the physical and chemical properties. These parameters will help to determine the efficiency and productivity of the pyrolysis process and to control the data validity. For now – the gained data from Latvia are corresponding to overall known values of charcoal in the world.

For the modelling of pyrolysis process a freely available mathematical model "Gpyro" will be used to compare the output with the analyzed data. This model will give data about the process parameters like reaction time and rate, which cannot be detected in the large retort.

To verify and validate the received data from retort and model, additionally experiment will be carried out to gain data about the pyrolysis and compare with the data from the retort and the model. The experimental apparatus is shown in the figure below.



*Experimental apparatus for pyrolysis process*

### Kopsavilkums

Darba mērķis ir izpētīt pirolīzes procesus retortē, salīdzinot iegūstamos datus no kokogļu ražotnes, matemātiskā modeļa un pirolīzes eksperimenta.

Darbā tiek veikta literatūras analīze par pirolīzes fizikālajiem un ķīmiskajiem procesiem, tehnoloģijām un procesa matemātiskajiem modeļiem un procesa ietekmi uz vidi. Darba praktiskajā daļā tiek apkopoti un analizēti dati un paraugi no kokogļu ražotnes, izmantoti šie dati matemātiskā modelī un analizēti iegūtie dati, kā arī veikts pirolīzes eksperiments. Darba nobeigumā tiks salīdzināti visi iegūtie dati lai atrastu galvenos procesus ietekmējošos parametrus un to savstarpējās korelācijas.

## **Tar treatment by biofilters in gasification process**

*Karolīna Mickeviča, RTU Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, 2nd year Master*

*Dr.Sc.ing. Aivars Žandeckis*

Gasification is one of the most cost-effective methods nowadays used for the production of the high-quality synthetic gas, energy, fuel, chemicals and fertilizers from the low value raw materials. Tar formation in the synthetic gas composition interfere gasification process to become one of the cleanest and cheapest technologies. Filtering the steam of produced gas is the first step of tar separation and one of the most important activities for the safe engine processes. In this study downdraft gasifier is selected and such porous bio-filters as activated charcoal, straw, wood chips, paper and cardboard wastes are used as a solution to provide the qualitative reactions and separate synthetic gas contaminants. Wood pellets, wood chips and straw are selected as raw materials, basing on its physical, chemical and morphological properties, economical aspects and prognosticated tar amount formation. Tar Protocol Analysis or the condensation method- provides tar separation and synthetic gas purification by using 3-6 Impirger bottles filled with organic solvent (acetone). The method of solid phase adsorbtion using the Impirger bottles filled with Silica Gel is used to ensure validation of data. Gas volume meter used to collect data about the volume of purified gas. Gas Chromatography and gravimetric methods are used to analyse synthetic gas end composition. The results of usage of different porous biofilters are presented and discussed.

### **Kopsavilkums**

Darba mērķis ir izpētīt dažādu bioloģisko materiālu izmantošanas iespējas kā biofiltru pildījumu singāzes attīrīšanai no darvas.

Darbā tiek aprakstīts biomasas gazifikācijas process, pielietojums, iespējamie kurināmā veidi. Tiek salīdzināti gazifikatoru tipu konstruktīvie risinājumi, priekšrocības un trūkumi. Tiek veikta literatūras analīze par darvas rāšanās iemesliem un cēloņiem, ietekmi uz iekārtām un procesiem, ka arī par darvas koncentrācijas samazināšanas paņēmieniem un attīrīšanas tehnoloģiju. Darba praktiskajā daļā tiek veiktu eksperimenti ar dažādu biofiltru pielietošanu singāzes attīrīšanai no darvas. Darba nobeigumā tiek apkopoti dažādu porainu biofiltru pielietošanas iegūtie rezultāti un veikti secinājumi.



## **Measurement and verification of energy savings measure under performance contracting**

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As the main part of Latvian multi-family dwellings is built in Soviet Union the building sector consumes averagely 40% of total energy consumption due to the bad quality thermal properties. Energy efficiency in building sector has become as important problem all around the world and in Latvia due to the increase in world energy price. The European Union as well has set a target in environmental, energy and social sector.

In this research I will compile other country experience in measurements and verification phase and will develop guideline for Latvian building sector as a potential solution to raise society trust and clearly show the real results as energy savings of renovation project. As right now energy measurement and verification part is disorganized and in most of the cases verification part is done by the same construction company without third party involvement, which may evaluate results and increase transparency.

In research part I will develop a building physical model for multi-family buildings. With the help of model user will have possibility to predict energy saving results within a margin of accuracy. The model will be validated with 5 deeply renovated multi-family building projects.

Hypothesis: Measurement and verification procedure in Latvian multi-family buildings are not well harmonized with the stockholders as ESCO, municipalities, residents, house maintenance companies. With unclear accuracy and unpredictable costs allocation.

### **Kopsavilkums**

Darba mērķis ir izpētīt citu valstu pieredzi un praksi energoefektivitātes ietaupījumu mērīšanā un to verifikācijā, lai spētu nodrošināt pietiekamu augstu precizitāti ar pēc iespējas zemākām izmaksām.

Darbā tiek veikta literatūras analīze par Latvijas daudzdzīvokļu māju sektoru, lai atspoguļotu reālo situāciju un nepieciešamību steidzami attīstīt energoefektivitātes paaugstināšanas pasākumus. Ņemot vērā citu valstu pieredzi radīt vadlīnijas, kuras varētu ieviest Latvijas tirgū. Darba izpētes daļā tiek izstrādāts aprēķinu platforma, ar kuras palīdzību pie konkrēta līmeņa precizitātes varēs prognozēt ēkas energoefektivitātes ietaupījuma potenciālu. Aprēķinu modelis tiks validēts ar pieciem reāli realizētiem energoefektivitātes paaugstināšanas projektiem Latvijā. Darba nobeigumā tiek veikti secinājumi par enerģijas ietaupījumu mērījumiem un verifikāciju Latvijā, kā arī izvērtēta modeļa pievienotā vērtība ēku renovācijas projektiem.