Residential Energy Efficiency Policy in Latvia: A System Dynamics Approach

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Abstract

To ensure implementation of requirements of EU Directive 2006/32/EC on energy end-use efficiency and energy services in Latvia First National Energy Efficiency Action Plan (EEAP) 2008 – 2010 is approved where the goal is established to reduce energy consumption by 3483 GWh by 2016. The greatest energy savings 77% or 2701 GWh are planned in the residential sector as it is the major energy end user in the country. The largest part of it is multifamily buildings with every flat owned by individual owner.
Although Latvia has huge building energy efficiency potential former policies are not noticeably facilitating its use – an increase of number of renovated buildings is insignificant – only 100 of more than 30 000 apartment buildings are completely renovated. It indicates that energy efficiency measures have to be reviewed in wider socioeconomic context considering that inhabitants' motivation is impacted not only by rational reasons but also by combination of complex socioeconomic factors.
In order to understand how building renovation process is affected by different energy efficiency policies a system dynamics model was developed. With the help of the developed model it was possible to determine whether the goals set in the First National Energy Efficiency Action Plan are achievable.

Keywords

End use energy efficiency, Residential buildings, Energy efficiency policy, Renovation of buildings, EU Directive 2006/32/EC, First National Energy Efficiency Action Plan

1. Introduction

World energy demand is continually increasing – overall consumption of primary energy has increased nearly three times in the past 44 years from 3813 M t_{oe} in 1965 to 11 164 M t_{oe} in 2009. It is predicted that this will increase by 49% by 2035 (DOE/EIA, 2010). Carbon dioxide emissions have increased substantially along with the growth in energy consumption, thus creating negative effect on climate change. The UN Framework Convention on Climate Change and the Convention's Kyoto Protocol on the reduction of greenhouse gas emissions was adopted to reduce the negative outcome of energy consumption and the effect on climate change. The EU and its member states ratified the Kyoto Protocol on May 31, 2002, and it came into effect on February 16, 2005. From 2008 to 2012, countries ratifying the Kyoto Protocol are required to jointly reduce greenhouse gas emissions by an average of 5.2% when compared to 1990. European Union countries must reduce these emissions by 8%.

The Council of Europe has agreed that developed countries should set an example by reducing greenhouse gas emissions by 15–30% by 2020. The European Parliament has suggested that CO_2 emissions in the EU should be reduced by 30% by 2020 and by 60–80% by 2050. In addition, the authors of the Fourth Report of the Intergovernmental Panel on Climate Change emphasize that a drastic reduction in GHG emissions must take place within 10–25 years to significantly slow down the increase in the world's average temperature.

A reduction in energy consumption and the introduction of energy efficiency measures is the most significant investment towards CO_2 emission reductions, with the European Union making this one of its main priorities. Directive 2002/91/EC on the energy performance of buildings was adopted to regulate building energy efficiency issues in the European Union. The main goal of the Directive is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. The second most important European Union directive is Directive 2006/32/EC on energy end-use efficiency and energy services, which states that each member state must reduce its end energy consumption by 9% by 2016, against the baseline year. This must be done in accordance with an action plan to be developed by each member state and must be coordinated with the European Commission. A variety of energy efficiency policy measures to help achieve this goal may be included in this plan.

In this paper we propose a system dynamics model representing building energy efficiency policy in Latvia in order to simulate and evaluate policy measures included in Latvia's First Energy Efficiency Action Plan and to evaluate the impact of the policy tools not included in Latvia's First Energy Efficiency Action Plan on the energy efficiency process.

2. Problem description and purpose of the study

A number of policy documents establish energy efficiency policy in Latvia. The Latvia's Guidelines for Energy Sector Development 2007–2016 prescribe that the average specific heat energy consumption in buildings must be reduced from 220–250 kWh/m^2 per year to 195 kWh/m^2 per year by 2016. Average specific heat energy consumption of 150 kWh/m^2 per year must also be reached by 2020.

Law on Energy Efficiency implies the requirements of Directive 2002/91/EC on the energy performance of buildings that was adopted to regulate building energy efficiency issues in the European Union. The main goal of the Directive is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

One of the most important planning documents for improving energy efficiency is the Latvia's First Energy Efficiency Action Plan 2008–2010, which was adopted to ensure the implementation of the European Union's Directive 2006/32/EC on energy end-use efficiency and energy services. The goal of the action plan is to reduce end use energy consumption by 3483 GWh by 2016, without taking into account climate corrections. The goal of Latvia's First Energy Efficiency Action Plan is shown by year, in Figure 1.

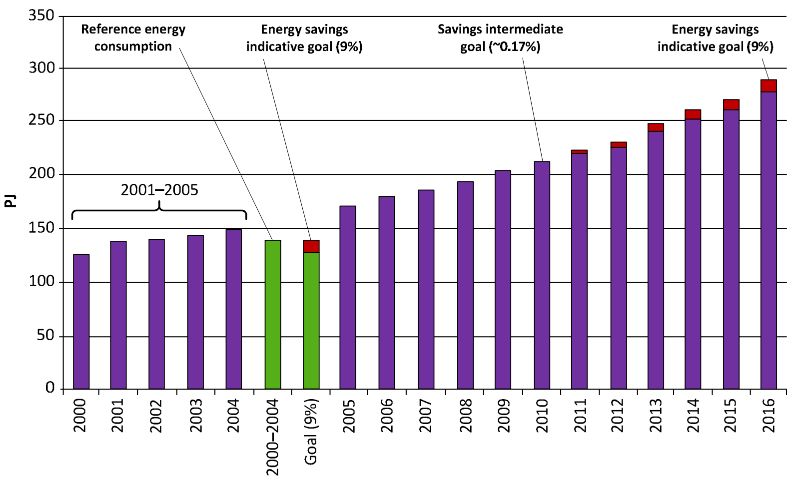

Figure 1. National energy end-use and planned cumulative energy savings

The greatest energy savings – 77% or 2701 GWh – are planned in the residential sector. This reduction in household energy use is based on the fact that the residential sector is currently the greatest end energy consumer in Latvia, consuming approximately 40% of overall energy end-use in the country. In 2009, total housing area in Latvia reached 61.1 million m^2 and the major part of it is comprised of multi-family buildings built during Soviet period (1945-1990).

Figure 2. Multi-apartment buildings built during the Soviet period consume the most heating energy in Latvia's residential sector

Table 1 shows planned energy efficiency policy measures in Latvia's residential sector, the results expected, and their planned implementation period. The total energy savings planned in the residential sector from 2008 to 2016 is 2701 GWh, whereas 52 GWh is planned for the intermediate period from 2008 to 2010.

Table 1: Energy efficiency measures in the residential sector

No.	Measures	Expected energy saving by 2016 (GWh)	Term
1.	Energy audits in buildings and building energy certification	*	2005–2016
2.	Subsidies for energy efficiency measures in multi-apartment buildings: 110 million EUR	1900	2007–2016
3.	Subsidies for energy efficiency measures in public buildings	570	2007–2016
4.	Information of energy consumers	*	2006–2016
5.	Development of secondary legislation in accordance with Directive 2002/91/EC	*	2008–2016
	Total	**2701***	

* – the expected energy savings from information dissemination activities and the development of legislation documents are stated for the sector as a whole. The savings are calculated based on the number of participants involved in the campaign and an evaluation of the influence of the measures undertaken in the sector compared to a base scenario where no measures are undertaken. To evaluate the influence of the measures, indicators from the sector are to be used.

Up till now only one combined action policy and media discourse analysis has been undertaken in Latvia, namely, the 'Latvian model and action plan for the use of renewable energy resources and improvement of energy efficiency' (VASSI, 2009). It was concluded that up till now policy on energy efficiency in the residential sector has, to a great degree, been based on the basic assumption that this policy goal was equally important to the community and that the low participation and interest shown by the community was related to the lack of legislation support and information of a technical nature.

Even though the potential for insulating buildings and introducing other building energy efficiency measures in Latvia is great, up till now this has not been noticeably encouraged by policy. Subsidies from the European Regional Development Fund and from the state budget in amount of 63 million EUR was allocated in 2009 for the implementation of activities to increase building energy efficiency for multi-apartment buildings but it has had minor effect on implementation process. Although apartment owners can benefit from implementation of energy efficiency measures, growth in building energy efficiency has been negligible. Since the introduction of energy efficiency policy of more than 30,000 multi-apartment buildings, only about 100 buildings have been made fully energy efficient. This must be increased, because such an increase will significantly reduce the effect of energy on the environment and climate change.

The majority of energy efficiency measures in residential buildings are related to improving the thermal insulation of the building's envelope, and henceforth in the text these measures will be referred to as building insulation.

3. Reference mode

The energy efficiency process for multi-apartment buildings in Latvia up till now has taken place very slowly, and significant changes over time are not noticeable. This is why a representation of hypothesis about possible pattern or hypothetical problem behavior is used to define the reference mode (Ford, 2009). The selected time period for the model is 70 years (from 2010 to 2080). The period before 2010 is not being reviewed because changes in the multi-apartment building energy efficiency process have been minor. It has been assumed that 70 years is a sufficiently long period to be able to evaluate delays and the effect of the policy used.

Figure 3 shows a number of hypothetical multi-apartment building energy efficiency scenarios to be used in the model as base scenarios of reference mode.

1) The first scenario (pessimistic scenario) envisages that building insulation process will continue very slowly and that the affected building area will increase a little each year until it reaches about 5 million m^2 in 2080. Such a scenario could develop if no activities are undertaken to encourage the development of the market.
2) The second scenario (moderate scenario) envisages that the market will develop as an S-shape. In the initial phase it will develop slowly, but over time it will speed up until it reaches 60 million m^2 in 2050. This scenario could develop if there is intervention in the market with just a few policy measures.
3) The third scenario (optimistic scenario) envisages that building insulation will grow as an S-shape, taking place relatively quickly and reaching market saturation – 60 million m2 – around 2030, as a variety of policy measures will foster the development of the market.

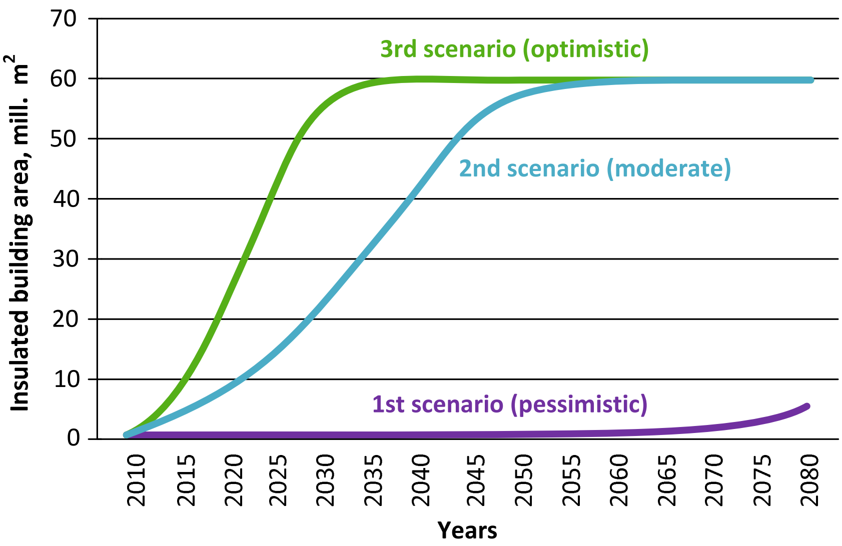

Figure 3. Base scenarios of reference mode describing the hypothetical development of multi-apartment building insulation processes

4. Model description

4.1. Dynamic hypothesis

The building energy efficiency improvement process is technology diffusion in the market (Sterman, 2000). Technology spreads in the market along an S-shaped curve. The structure that creates the S-shaped growth is a combination of reinforcing and balancing feedback loops with the shift of loop dominance as one of stocks is depleted.

4.2. Main stocks and flows

The main stocks are uninsulated buildings (m^2) and insulated buildings (m^2). The insulated buildings are increased by the rate of insulation while the uninsulated buildings are decreased by it. Rate of insulation depends on a number of parameters:

- Awareness – this parameter creates a reinforcing loop – as the number of insulated buildings increases, the frequency of contact between insulated and uninsulated building residents grows, as does the number of residents of uninsulated buildings who accept the idea of introducing energy efficiency measures in their buildings.
- Net benefit – this is each individual's benefit from building insulation, which is made up of the difference between energy costs before insulation and energy costs after insulation, minus investment in the building's insulation. This parameter forms the other reinforcing loop – the more insulated buildings and the lower the insulation costs and also the higher the quality of the insulation work, the more buildings will get insulated.
- Uncertainty costs – in reality, the maximum of technically feasible net benefits are often not reached, since many barriers exist which substantially reduce the net benefits. For example, the energy consumption reduction is noticeably lower than calculated because the quality of the construction works is very low; the actual costs of the energy efficiency measures exceed the estimated costs; time is wasted in overcoming administrative barriers related to the building insulation process; time is wasted in convincing apartment owners to agree on the insulation of a building; time is wasted searching for funding etc. The more of these factors there are, the greater the uncertainty costs. Uncertainty costs are an expression in monetary terms of the existing barriers to building insulation.

Figure 4 shows energy costs before energy efficiency measures and costs after energy efficiency measures. These are made up of the sum of energy costs after the building's insulation, investments, and uncertainty costs. For a person to choose to insulate a building, the costs before the energy efficiency measures must be larger than or equal with the costs after the introduction of the measures. If the costs after the introduction of the measures are greater than the costs before, then the building most likely will not get insulated.

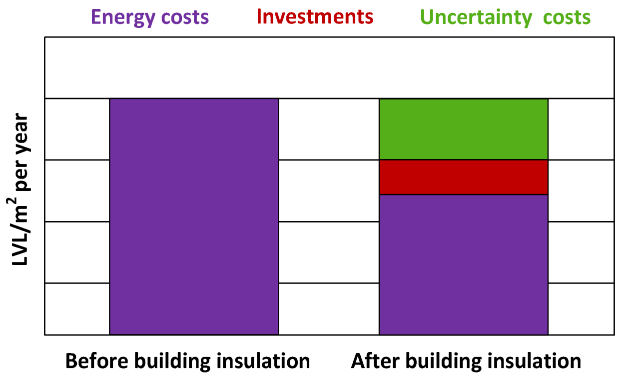

Figure 4. Costs before and after insulation

The net benefits are of varying size, because they are dependent on a variety of factors which change over time: energy tariffs, outdoor and indoor air temperatures and insulation costs. A change in net benefits cannot be perceived by a person immediately; rather, this takes time. For this reason an additional stock is created in the system, namely, ”Perceived net benefits”. The rate of perception is dependent on the perception time. The time required for the perception and processing of information creates information delay. Like net benefits, uncertainty costs are also perceived, processed, and acted upon, which demands time, thus creating an information delay in the system. For this reason the fourth stock is called “Perceived uncertainty costs”.

Figure 5 shows a system dynamics model for building insulation process.

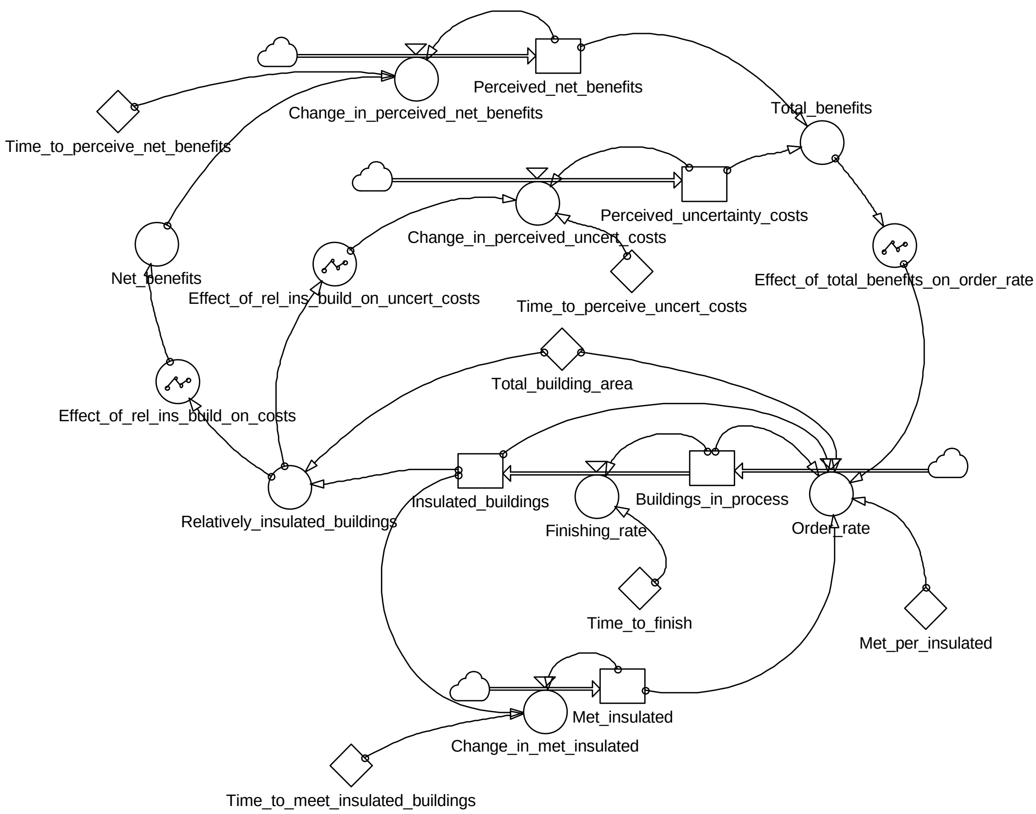

Figure 5. System dynamics model for the building insulation process

4.3. Causal loop diagram

The structure of the hypothetical system, which is transformed in the causal loop diagram, can be seen in Figure 6, and it illustrates the main loops of the hypothetical system's structure.

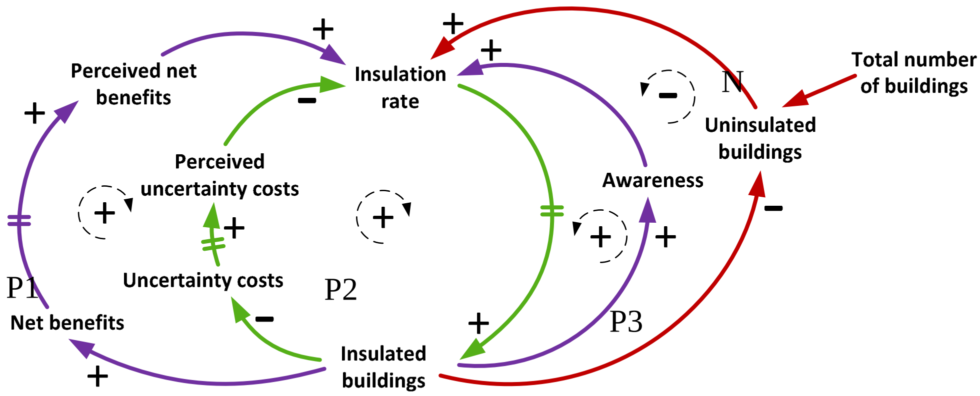

Figure 6. Causal loop diagram for the building energy efficiency process

The causal loop diagram consists of three reinforcing loops and one balancing loop. The most important parameter in these loops is the rate of insulation, that is, the decision to start the insulation process. With an increase in the number of insulated buildings in reinforcing loop P1 (net benefits loop), the net benefits increase. An information delay occurs because the time between the actual event and the moment when it has been perceived by a person is often relatively long. In the model this delay is portrayed in the loop between net benefits and perceived net benefits. This delay can even last for many years, and the possibility of some people completely ignoring this information also exists. With an increase in net benefits, perceived net benefits also increase. With an increase in perceived net benefits, the rate of insulation increases. With an increase in the rate of insulation, the number of insulated buildings increases, although this happens with a delay due to the time needed to perform organizational work and building insulation work (material delay). Many ignore this loop and therefore the process goes very slowly.

With an increase in the number of insulated buildings in reinforcing loop P2 (uncertainty costs loop), uncertainty costs decrease. An information delay occurs because the time between the actual event and the moment when it has been perceived by a person's brain is often relatively long. In the model this delay is pictured in the loop between uncertainty costs and perceived uncertainty costs. This delay can even last for many years, and the possibility of some people completely ignoring this information also exists. With a decrease in uncertainty costs, perceived uncertainty costs also decrease. With a decrease in uncertainty costs, the rate of insulation increases. With an increase in the rate of insulation, the number of insulated buildings increase, although this occurs with a delay (material delay).

With an increase in the number of insulated buildings in reinforcing loop P3 ("word of mouth", or, the information distribution loop), resident awareness increases. With an increase in awareness, the rate of insulation increases. With an increase in building insulation, the number of insulated buildings increases, albeit with a delay.

Balancing loop slows down all three reinforcing loops with a delay. With an increase in the number of insulated buildings, the number of uninsulated buildings decreases. As a result, the rate of insulation decreases, because there are now fewer buildings that need energy efficiency measures. The number of uninsulated buildings is affected by the overall number of buildings. This loop comes into operation very late, only at the very end of the diffusion process.

4.5. Simulation results and reference mode

Created system dynamics model for the building insulation process reproduces the behavior of the base scenarios of reference mode (see Figure 7). The shape of insulated buildings' curve depends on 'time to meet insulated buildings', 'meetings per insulated building area', 'time to finish insulation work', 'net benefits perception time' and 'uncertainty cost perception time'.

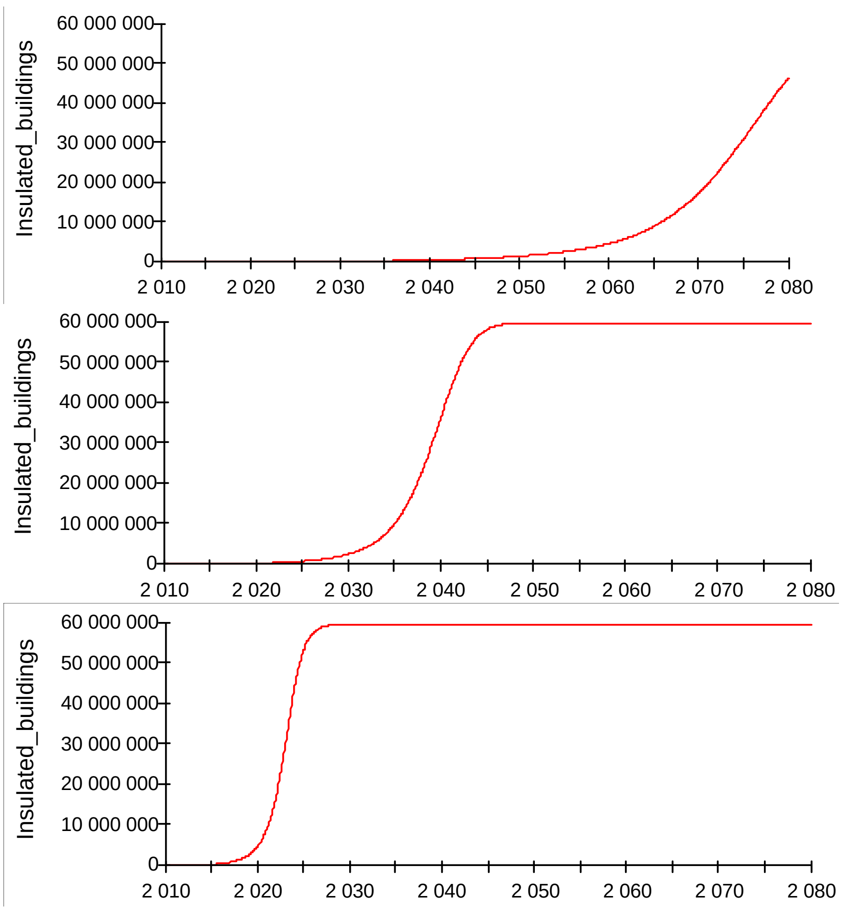

Figure 7. Simulation results of insulation process replicates three base scenarios of reference mode

4.6. Policy development

Various leverage point application methods are used for the inclusion of policy measures in the model: changing values of constants, structures of material stocks and flows, rules of the system, information flow structure, and the strengthening of reinforcing loops.

The causal loop diagram shown in Figure 8 is the same causal loop diagram shown in Figure 6, except that it is supplemented by various policies described in different sources (ADEME/IEEA, 2007; Omidvar, 2010; Liu et al, 2010; Mulder, 2005). These policies are used to change three values: to increase net benefits, to reduce uncertainty costs, and to increase awareness and investment in energy efficiency measures.

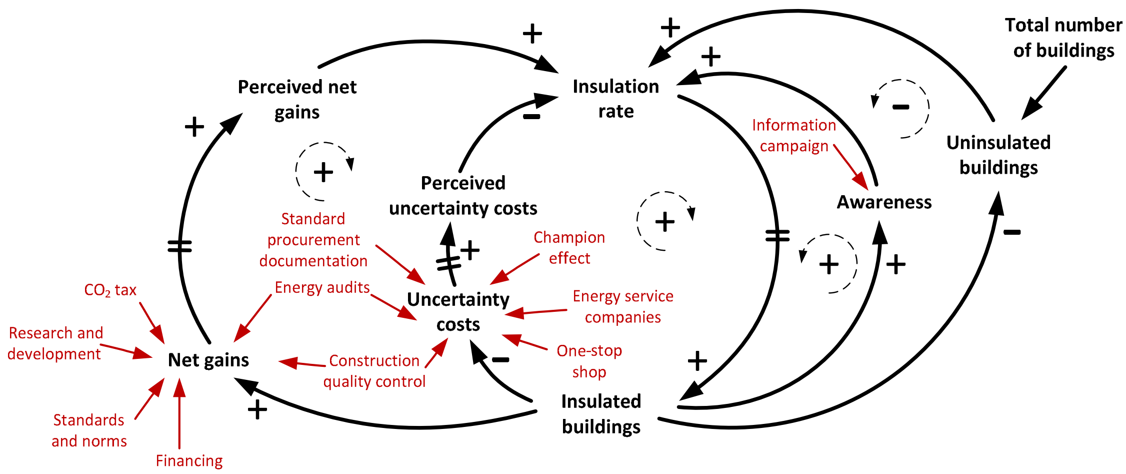

Figure 8. Causal loop diagram, supplemented by policies

Net benefits can be increased under these conditions:

- If energy use standards are developed – the minimum specific energy consumption (kWh/m^2 year) for the implementation of energy efficiency measures in existing buildings is determined by legislation for various buildings, e.g., new buildings. This is a way of ensuring that energy consumption is reduced to the required level; it prevents the possibility that the material or technology used in building construction or energy efficiency measures provides only a small reduction in energy consumption, thereby reducing potential net benefits.
- If high quality energy audits are done – an energy audit is the first step in the introduction chain of energy efficiency measures and the subsequent process is dependent on its quality. A badly done energy audit provides misleading information about the theoretically achievable reduction in energy consumption and the cost required to achieve this reduction. The lower the quality of the energy audit, the smaller the net benefits. Therefore, a national energy audit quality control system must be developed. A national level institution should supervise energy auditors and their work and punish those who do poor quality work. Such a system has successfully functioned in Finland for many years.

- If research and development is supported – this is a policy measure that provides benefits in the long term. The development of new technologies and materials leading to a greater reduction in energy consumption than is provided by current technologies will increase net benefits. A targeted national program supporting research and development is required for the introduction of this policy tool.
- If standard procurement documentation and contracts are developed – the quality of construction is one of the most important factors influencing net benefits. This is directly dependent on the legal relationship between the building owner and the construction company. At the core of this relationship are the building owner's demands regarding the targeted energy consumption reduction and the quality of the construction works related to energy efficiency measures. If this is not included in the procurement documentation, it is very likely that net benefits will be much lower than planned. To remove this barrier, standard procurement and contract documentation must be developed at a national level and made available to every building owner.
- If construction supervision is done – in Latvia, experience in building insulation shows that it is not possible to achieve the planned savings due to low construction quality; the net benefits are lower than those technically possible. This shows that the services of construction supervisors have either not been used in the insulation process or they have been of low quality. A system should be developed to overcome these barriers and to ensure that the work of construction supervisors is controlled. In other words, a national level institution that supervises the work of construction supervisors and punishes those who do poor quality work ought to be created.
- If subsidies are introduced – this policy tool directly influences net benefits: the greater the subsidies, the greater the net benefits.
- If the tariff is increased – the energy tariff is increased through the introduction of a CO_2 tax: the higher the tax, the more savings there are (the higher the net benefits) after a building has been insulated.

A reduction of uncertainty costs reduces barriers to the building energy efficiency process that are related to people's distrust, which is based on incorrect information or a lack of information. Barriers can be reduced in several ways:

- By conducting high quality energy audits – building owners, who in most cases are not specialists in the field of energy efficiency, require objective information about what kinds of measures can be undertaken and what the planned costs and energy savings could be. For this reason energy audits providing this information are required. But for energy audits to be credible, they must be of a high quality, and therefore a national system ensuring control over the conduct of energy audits, supervising energy auditors and their work, and punishing those who do poor quality work must be created Such a measure will reduce uncertainty costs.
- By increasing quality control on construction work – one of the main barriers to the introduction of an energy efficiency project is the risk of low quality construction. Building owners are afraid to implement energy efficiency measures because of the risk that energy consumption will not be reduced as planned and this in turn might affect the future flow of money and will impact plans for paying off loans. The higher the risk, the higher the uncertainty costs.

Therefore, measures to reduce this risk must be taken at the national level, for example, improvement of construction companies' monitoring by the creation of an institutional and legislative base that can successfully address this problem.

- By raising the awareness level – an increase in the awareness level reduces uncertainty costs because the building energy efficiency process is explained to people. The benefits, risks, and other information required by a building owner to be able to decide whether to implement energy efficiency measures is provided.
- By developing a one-stop shop – negotiating the bureaucratic hurdles in the course of implementation of energy efficiency measures is one of the barriers that raises uncertainty costs. One of these hurdles is the approval of project documentation by local councils. Local councils could set up a 'one-stop shop', which would be a customer's only contact point with local council representatives, thereby eliminating many of these hurdles.
- By using the 'champion effect' – the 'champion effect' involves a popular and influential person in the community providing a positive view about the problem's solution. The community then follows suit, and uncertainty costs are immediately reduced.
- By using energy service company (ESCO) services – an ESCO signs a contract for a defined period, investing its resources and recovering them from the saved energy costs. Savings in uncertainty costs are reduced to zero because the ESCO eliminates all of the mentioned barriers. With the use of ESCO the net benefits are zero.

4.7. Overview of the model

The initial model structure described above has been changed, with its principal scheme being shown in Figure 9.

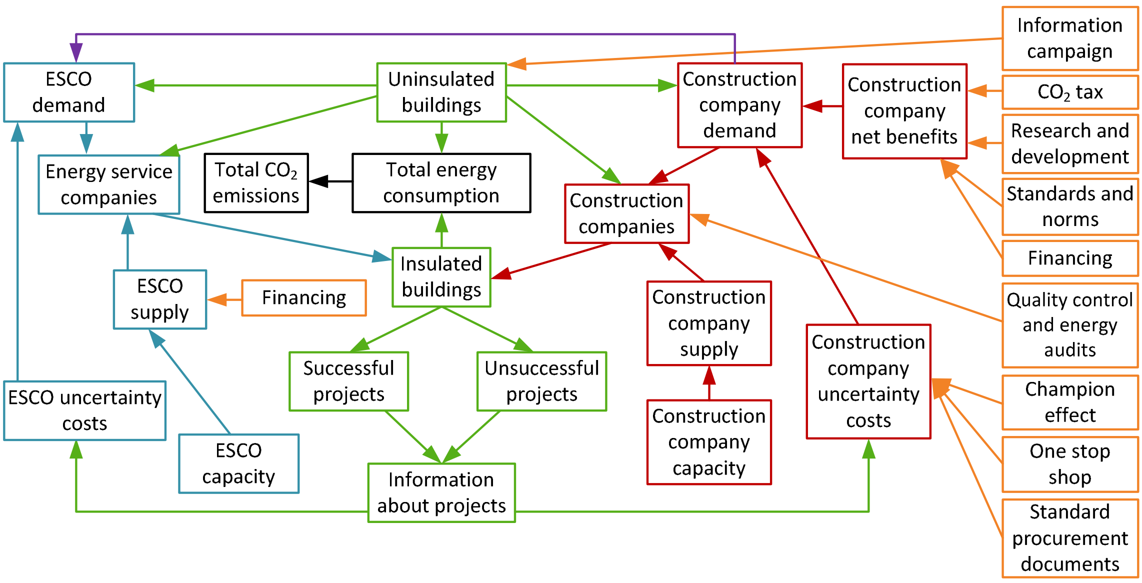

Figure 9. The altered principal scheme of the initial model structure

The stock of uninsulated buildings is divided into two groups in the decision making process: buildings insulated by energy service companies and buildings insulated by construction companies.

Not all buildings insulated are successful projects, and information about these as well as information about successful projects enters the market, where it is received by those building owners who have not insulated their buildings. This information influences the value of uncertainty costs – the more unsuccessful projects, the higher the uncertainty costs and the fewer buildings get insulated. There is a delay in perceiving the successfulness.When more projects then previously expected are successful people slowly adjust their perception to believe that the larger fraction of projects will be completed also in future. When, on the other hand, more projects are less successful than previously expected than people quickly adjust their perception to believe that the smaller fraction of projects will be completed also in future.

While the fraction of successful projects in the ESCO case is simply related to learning effect, based on completed projects, in construction companies the success fraction is also dependant on the prevalence of the experienced companies versus inexperienced companies. When there is a significant growth in the market we can expect that many inexperienced companies enter so as to cause the fraction of successful projects to decrease.

The rate of insulation is dependent on demand and supply for both energy service companies and construction companies, but there are different factors affecting them.

Construction company supply is dependent on company capacity, but the supply by an energy service company is dependent on operations, information, net benefits, and uncertainty costs. The scope of net benefits can be changed by making changes to tariffs, introducing a CO_2 tax, funding research and development, raising standards and normative requirements, and through the receipt of funding or subsidies. Uncertainty costs can be reduced by the introduction of ‘one-stop shop’, the ‘champion effect’, and the availability of standard procurement documentation. Information about unsuccessful energy efficiency projects ends up with quality control institutions, which in turn take action to improve construction company operations and thereby indirectly increase net benefits and reduce uncertainty costs.

Regarding energy service companies, supply is dependent on company capacity and available funding, but demand is dependent on construction company operations and uncertainty costs.

Information campaigns can be used to begin and encourage the recruitment process (making people aware) and it is governed by the uninsulated buildings (area belonging to uninformed people) and perceived successfully insulated area (that gives rise to word of mouth effect).

The fundamental demand loop: when people are recruited which leads to demand, increase capacity, more conversion from uninsulated to insulated which leads to more insulated, which leads to more recruitment. It is balanced by two negative feedback loops: first arising at early stages when capacity is growing very fast - the more you demand, the more inexperienced companies enter the market, the more unsuccessful projects, the smaller demand, the less inexperienced companies comes to market – demand is dampened down. The second negative loop is depletion of project source which means that there will be fewer and fewer houses to insulate.

The more insulations are done, the more experience is gained. Consequently larger fraction of projects is completed and moreover there is less uncertainty in the investments which favors the economic benefits that is expected from insulation projects by the construction companies and thus increases their market share (demand for their services) and thus the project acceptance rate, eventually causing more area to be insulated to the extent that there is building capacity. Capacity adjusts slowly to the demand so that a significant gap may arise between demand and capacity (supply and thus affect the price of insulation in the market) which again dampens the demand through a negative feedback loop so to catch up with demand.

Financing reduces the perceived costs causing the demand for insulation to increase. The potential projects create demand and perceived price comes in. If the price is high, buildings are not insulated. When the price goes down, more of potential projects materialize in a form of demand.

5. Results

5.5. The current energy efficiency policy

The main measures of the current energy efficiency policy in Latvia’s residential sector are as described in Table 1. In 2010, Latvia’s government confirmed that the size of EU structural funds available for multi-apartment building insulation was around 63 million EUR. In the evaluation of current policy, the other measures are not taken into account since their impact in the Latvia’s First Energy Efficiency Action Plan has not been given (it has been determined for the sector as a whole).

Using data from current situation, the result in Figure 10 was obtained. A significant increase in the rate of building insulation is predicted in approximately 2014 through the use of energy efficiency policy measures. Around 2022, the rate of building insulation tails off, because the available co-financing from EU structural funds for building insulation will be exhausted, and the building insulation process will continue slowly. As a result, buildings with a total area of 16.5 million m^2 will be insulated by 2080.

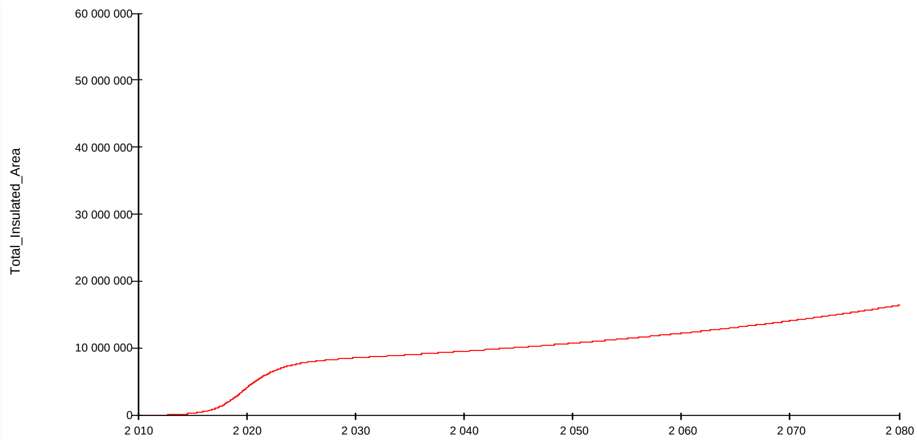

Figure 10. Insulation dynamics as a result of current energy efficiency policy

The parameters that directly influence changes in the insulated area are the demand for building insulation and the supply of building insulation, or, construction companies' capacity.

Figure 11 shows the demand for building insulation and changes in supply if the policy tools from the Latvia's First Energy Efficiency Action Plan are used. Demand for building insulation grows rapidly in the first five years and then tails off. This large demand for building insulation can be explained by the available co-financing for building insulation. Building insulation co-financing has been available in Latvia since 2009 and the trend of simulation results is similar to the trend of number of applications submitted for project co-financing at the Investment and Development Agency of Latvia - the number of applications is smaller at the beginning, but it gradually increases. Construction companies' capacity, or, supply of building insulation, is unable to cope with the large demand due to the delay and only reaches demand after eight years. The fall in demand is related to the depletion of available co-financing funds and the growth in the insulated building area.

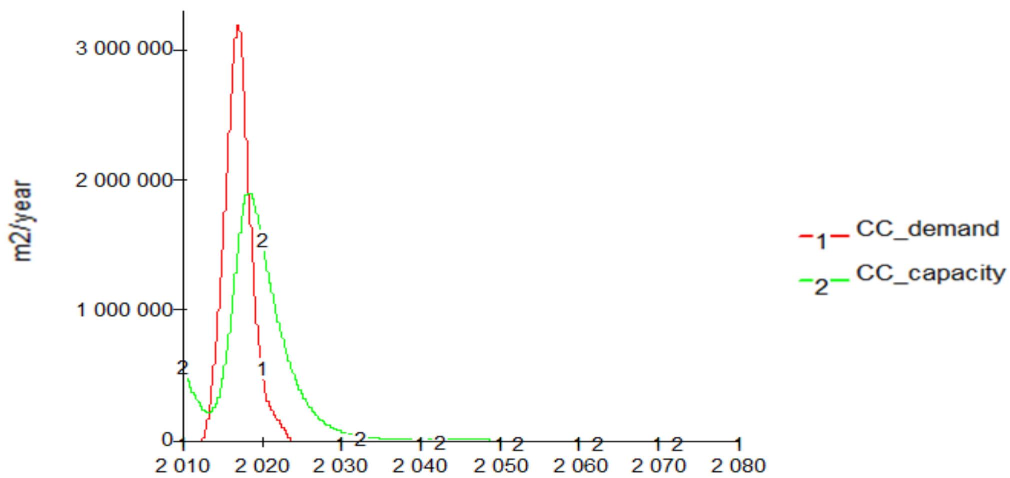

Figure 11. Supply and demand rates for building insulation with current energy efficiency policy

Figure 12 illustrates situation if EU co-financing were not available (No. 2 in the chart). In that case the building insulation process is slow because building insulation is not stimulated. Similar trend of insulation process is observed after the EU co-financing funds are depleted (No. 1 in the chart).

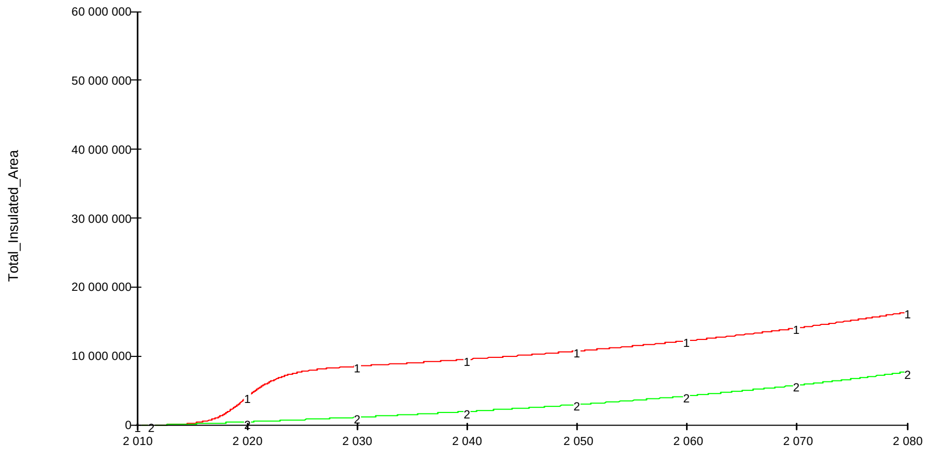

Figure 12. Building insulation dynamics with (No. 1) and without (No. 2) EU co-financing

The goal defined in the Latvia's First Energy Efficiency Action Plan is a reduction of energy use in the residential sector of 2701 GWh by 2016. The simulated heating energy consumption dynamics are illustrated in Figure 13. The figure shows that the heating energy consumption used to heat all buildings in 2010 is 10,800 TWh per year, but employing policy tools from the Latvia's First Energy Efficiency Action Plan, annual heating energy consumption in 2016 will be 10,745 TWh. This amounts in 55 GWh of saved energy, which is only 2% of the planned savings. The required reduction in consumption using this policy could not even be achieved by 2080. This leads to conclusion that these are not the only policy measures that have to be used in energy efficiency policy to achieve the planned goals in Latvia.

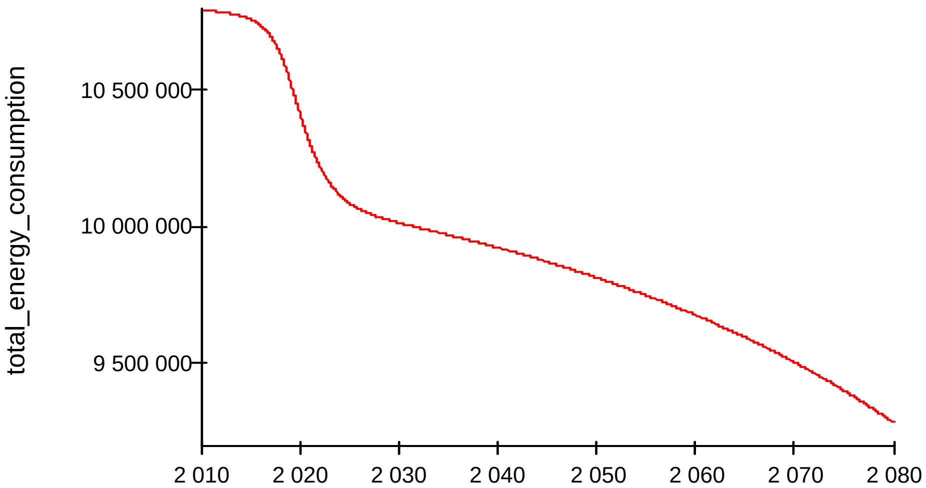

Figure 13. Changes in heating energy consumption (MWh per year)

5.6. Additional energy efficiency policy measures

This chapter describes the results obtained by simulating different energy efficiency tools identified in Chapter 4.5. All of them supplement the energy efficiency policy included in the Latvia's First Energy Efficiency Action Plan.

'One-stop shop'

The impact of 'one stop-shop' operation is evaluated by changing the time necessary to approve all the documents related to building insulation process, which in turn affects uncertainty costs. In modeling the 'one-stop shop', the approval time is reduced (from 0.3 years to 0.1 year), consequently reducing uncertainty costs.

Figure 14 shows that when the one-stop shop is the only energy efficiency policy (there are no EU co-financing funds available), its impact on the insulation process is quite negligible.

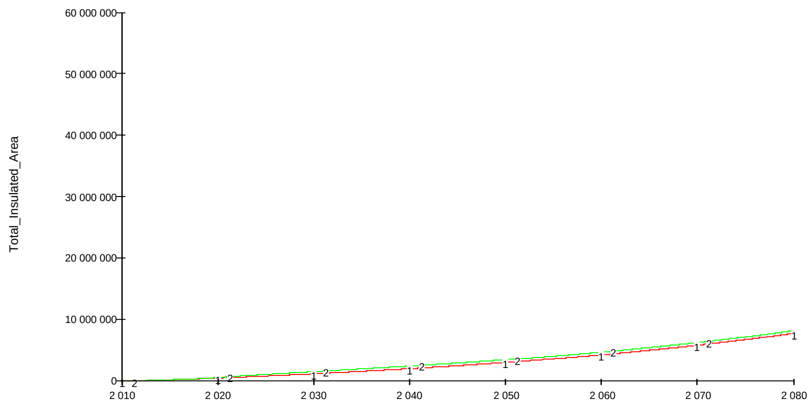

Figure 14. The impact of a one-stop shop on insulated building area if this was the only energy efficiency policy – without (No. 1) and with (No. 2) a one-stop shop

However, if this policy is combined with EU co-financing (see Figure 15), it influences the insulation rate quite significantly. This is because in a diffusion process it is important to achieve as quick a rate as possible in the initial stage. After attaining a certain number of participants (in this case, insulated buildings), the rate of the diffusion process is determined by other factors, resulting in a significantly faster diffusion process. The creation of a 'one-stop shop' has a very significant impact on the development of the building insulation process.

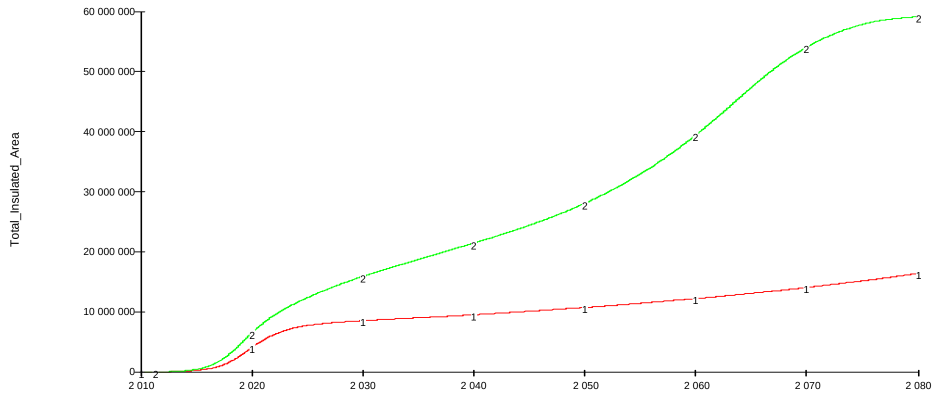

Figure 15. Impact of a one-stop shop on insulated building area – without (No. 1) and with (No. 2) a ‘one-stop shop’

CO_2 tax

To determine the impact of a CO_2 tax on the insulation process, the CO_2 tax values in the model are changed and it is assumed that the CO_2 tax is the same for all consumers independently of the fuel used in a boiler.

Figure 16 shows the results obtained in a simulation - an increase in the rate of building insulation is achieved after the introduction of the CO_2 tax.

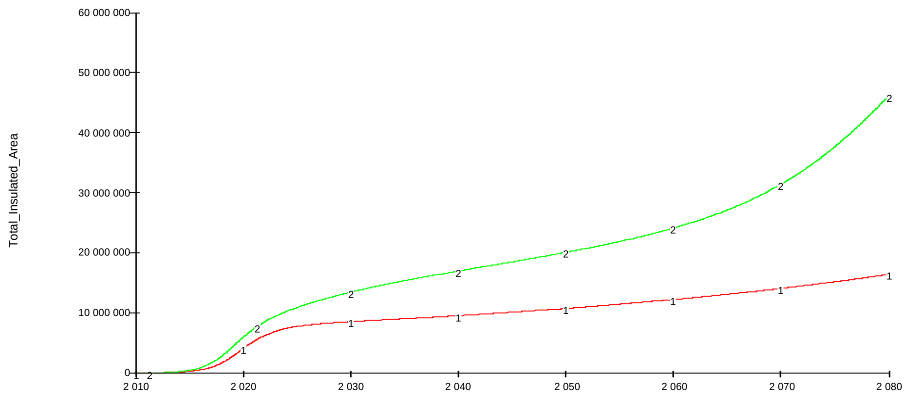

Figure 16. Impact of the introduction of a CO_2 tax on the insulation process (No. 2) and without it (No.1)

Energy efficiency standards and norms

By raising the minimum energy efficiency requirements of buildings, greater heating energy savings are achieved and thereby the net benefits increases and the willingness of residents to pay for building insulation is increased. It is assumed that building energy efficiency requirements are raised every 10 years, and therefore average heating energy consumption to heat buildings decreases by 10 kWh/m^2 per year each time. By raising building energy efficiency standards or requirements in this way, a faster building insulation process is achieved (see Figure 17). The model shows no changes taking place until 2020 because the minimum energy efficiency requirements are not being changed. The building insulation process takes place significantly faster after 2020, when the minimum energy efficiency requirements are raised for the first time.

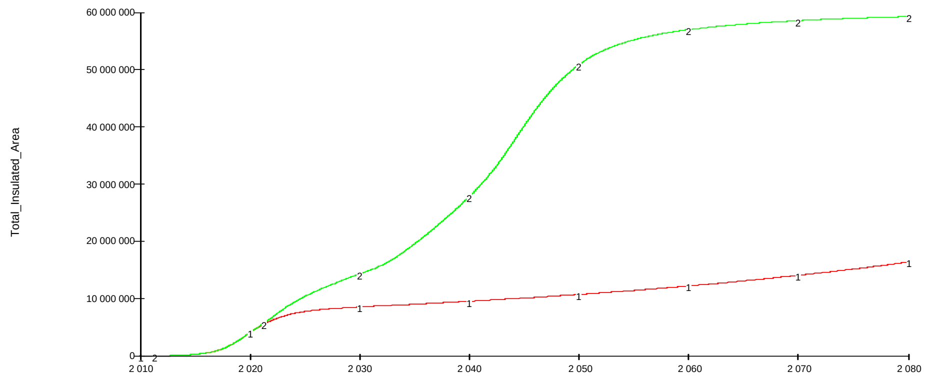

Figure 17. Building insulation dynamics without (No.1) and with (No. 2) increased minimum energy efficiency requirements of buildings

Research and development support

By increasing funding for research and development, new energy saving technologies are developed. If these new technologies are used in buildings, energy consumption is decreased thereby net benefits are increased. The model is based on non-linear effect of investments in research and development on energy savings. Initial value of investments is assumed to be 1.3 million EUR. Figure 18 shows the simulation results when funding for research and development is increased in the model.

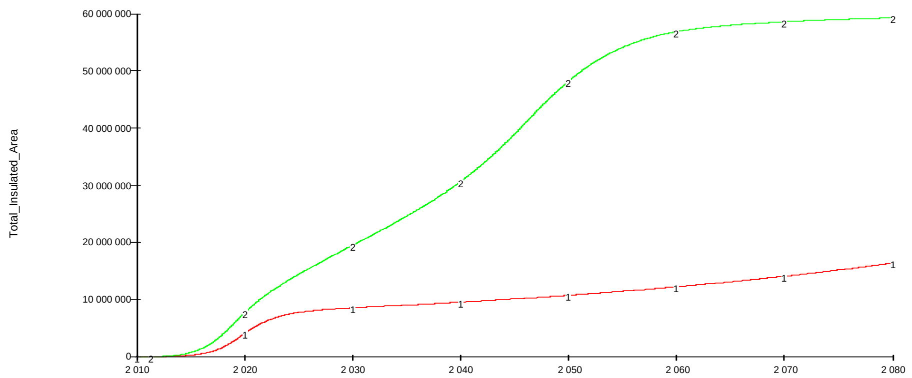

Figure 18. Building insulation dynamics without (No.1) and with (No.2) research and development support

Standard procurement documentation and contracts

Standard procurement documentation and contracts are one of tools that helps to reduce uncertainty costs. It is assumed that standard procurement and contract documentation reduce uncertainty costs by 30%. Figure 19 shows the result of the development of standard procurement documentation and contracts.

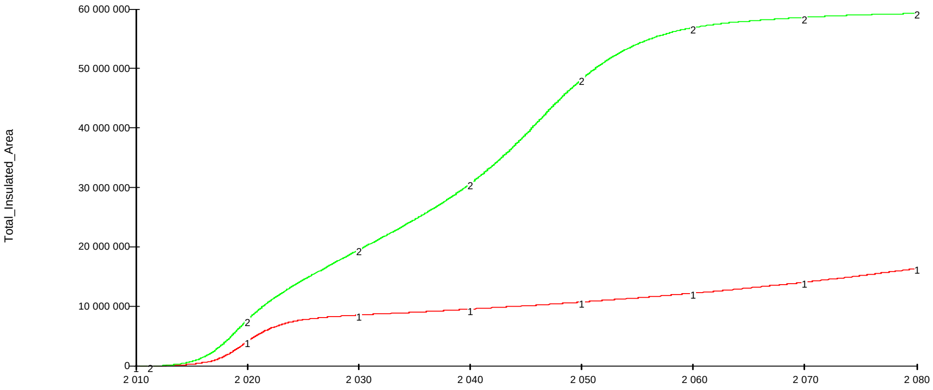

Figure 19. Building insulation dynamics without (No.1) and with (No.2) publicly available standard procurement documentation and contracts

Information campaign

Information campaign is one of policy tools that is used to decrease uncertainty costs. Information campaigns is used to begin and encourage the recruitment process (making people aware) and it is governed by the uninsulated buildings (area belonging to uninformed people) and perceived successfully insulated area (that gives rise to word of mouth effect). The results of implementation of information campaign at the beginning of insulation process can be seen in Figure 20.

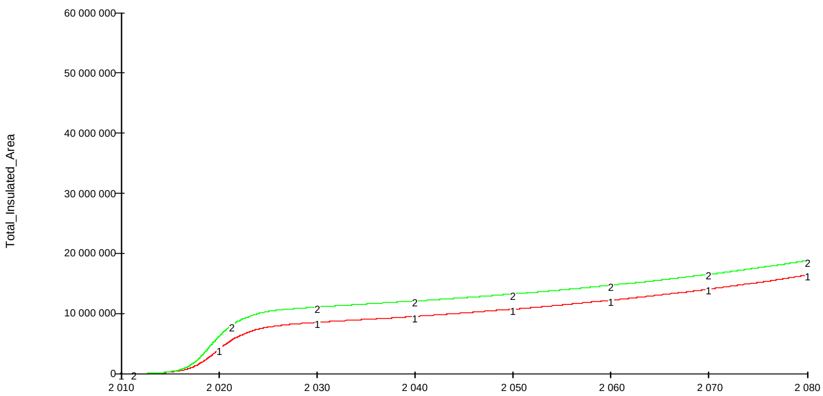

Figure 20. Building insulation dynamics without (No.1) and with (No.2) an information campaign at the beginning of insulation process

Introduction of all policy measures

If all of the previously described and recommended policies are simultaneously introduced, the fastest possible building insulation process is achieved. As the results of this simulation show (see Figure 21) it is possible to complete the implementation of energy efficiency measures in all buildings in no sooner than 30 years.

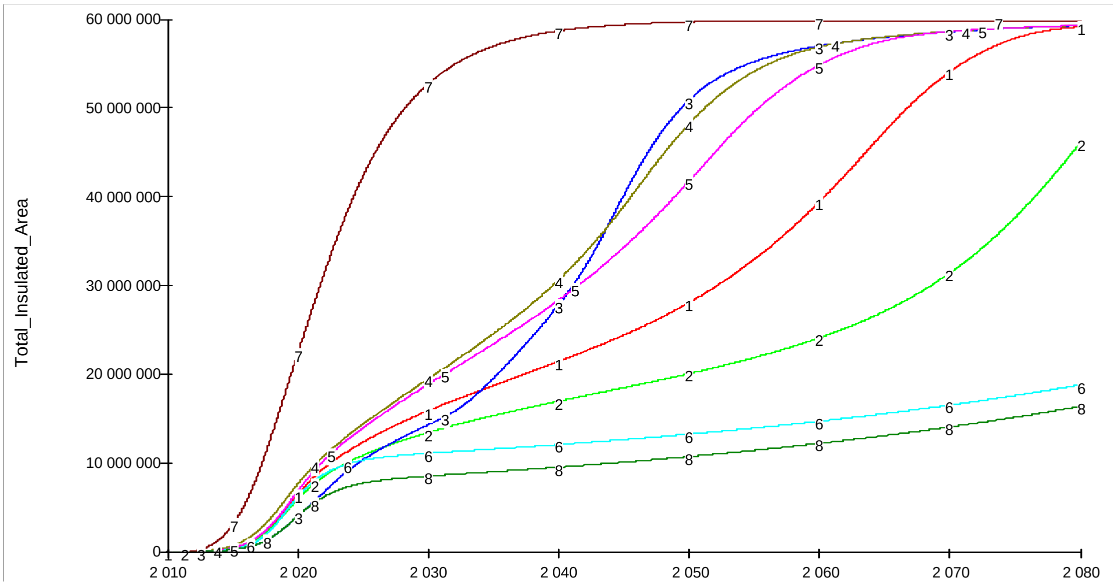

Figure 21. All energy efficiency policies (1- ‘one stop shop’, 2 – CO_2 tax, 3 – increased minimum energy efficiency requirements, 4 - research and development support, 5 - standard procurement documentation and contracts, 6 – information campaign, 7 – combination of all policy tools, 8 – EU co-financing)

Can the predicted reduction in heating energy consumption (2701 GWh) by 2016 in Latvia’s First Energy Efficiency Action Plan be achieved by using all the policy measures simultaneously? In 2010, all building heating energy consumption was 10,800 TWh per year. By using all the previously described policy tools simultaneously, heating energy consumption in 2016 could be 10,217 TWh per year. This amounts to only 583 GWh to be saved by 2016, which is 21.6% of the planned savings. Table 2 shows the impact of each individual energy efficiency policy tool on energy consumption in buildings in 2016 and the implementation of Latvia’s First Energy Efficiency Action Plan.

Table 2: The impact of each energy efficiency policy in buildings by 2016

No.	Energy efficiency policy	Total building energy consumption in 2016, GWh	Energy savings by 2016, GWh per year	Fraction of the First Energy Efficiency Action Plan’s goal, %
1.	Development of ‘one-stop shop’	10 710	90.0	3.3 %
2.	Introduction of CO_2 tax	10 713	86.9	3.2 %
3.	Increase in minimum energy efficiency requirements	10 745	55.1	2.0 %
4.	Increase in research and development support	10 648	152.0	5.6 %
5.	Development of standard procurement documentation and contracts	10 706	93.3	3.5 %
6.	Introduction of information	10 732	68.1	2.5 %

	campaign			
7.	All energy efficiency policies simultaneously	10 217	582.5	21.6 %
8.	Only EU co-financing	10 745	55.1	2.0 %

The required reduction in consumption using this policy could only be achieved by approximately 2020. There are several reasons for that. First, it takes time to start up the insulation process and there is not enough time left until 2016. Second, some other policy tools should be added and simulated to achieve the planned goals.

6. Conclusions

System dynamics approach in the planning process of energy efficiency policy is a valuable tool. It helps to combine and evaluate many variables, feedback loops and non-linear relationships that are part of any end use energy efficiency market.

Developed model is a valuable tool to evaluate and forecast energy efficiency policy and its specific tools, in particular in Latvia where the planning procedures of energy efficiency policy are poor.

The end use energy efficiency goals that Latvia's government has set cannot be reached using policy tools that are planned in the Latvia's First Energy Efficiency Action Plan. The plan has to be revised and supplemented with different other policy tools.

The EU co-financing which is the main policy tool used in the Latvia's First Energy Efficiency Action Plan is short term solution and has no long term effect if used alone.

If additional energy efficiency policy tools to the Latvia's First Energy Efficiency Action Plan are used, only 21.6% of planned savings can be reached by 2016. The required reduction in consumption using this policy set could only be achieved by approximately 2020. The main reasons for that are: it takes time to start up the insulation process and there is not enough time left until 2016, and some other policy tools should be added and simulated to achieve the planned goals.

The building insulation process is a diffusion process therefore it is important to achieve as quick an insulation rate as possible in the initial stage. After attaining a certain number of insulated buildings, the rate of the diffusion process is determined by other factors, resulting in a significantly faster diffusion process.

Acknowledgments

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