System dynamics model analysis of pathway to 4th GDH systems in the Baltic States

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Goal of research

To evaluate policy tools to reach 4 generation DH system by use of system dynamics model.
Current Situation in the Latvian District heating

Share of fuels in Latvian DH

- Fossil fuel%
- Renewable fuel, %

Year:
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013

Total fuel, %

- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100
4GDH elements of the existing system: the consumer

- Heating substation
- Low energy buildings
  - LBN 002-01
  - 80 kWh/m²
- Passive building
  - 15 kWh/m²
- Low energy buildings
  - 45 kWh/m²
- DH consumer
- Low temperature heaters
Creation of dynamic hypotheses

The diffusion of 4GDH concept within traditional DH:

- a renewable energy technology,
- low temperature networks
- low energy consumers

Causal loop diagram representing the relationships between the total capacity of installations and investment and depreciation flows.

"System Dynamics" edited by A. Blumberga, RTU, 2011
Causal loop

Investment in gas boiler technologies

Heat tariff of gas

Heat consumption

Heat losses in networks

Gas boiler capacity

Heat network temperature

Capacity of renewable energy sources

Investment in renewable energy technologies

The share of gas technology

Heat tariff of renewable energy sources

The share of renewable energy sources

N1

P1

+Gas boiler capacity

+Heat network temperature

-
Model verification

![Graph showing heat tariff trends over years: 2010 to 2014.]

- **Gadi Tariff of JSC "Rīgas Siltums"**
- **Tariff of system dynamic model**
# Description of Scenarios

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<th>Scenarios</th>
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<td>5th scenario</td>
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<td>6th scenario</td>
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</tbody>
</table>

B - biomass; S- solar collector; HP – heat pump; 1- activ; 0- non activ
Hypothetical scenarios compared with the model results

Historical data

Future scenario

Fossil fuel share for DH, %

1990 2000 2010 2020 2030 2040 2050 2060

Pessimistic scenario
Moderate scenario
Optimistic scenario

1 scenario
2 scenario
Conclusions (1)

1. The modeled scenarios show that the pace of 4GDH implementation depends on the policies used by each country. Subsidies are the most effective mechanisms for increasing of renewable energy share.

2. The developed system dynamic model could be applied to other heating systems if corresponding initial data and other renewable technologies are added.

3. In the base scenario 68,4 % renewable share was achieved, thus confirming the hypothesis. Results are based on existing industry development pace and on fuel and technology cost dynamics. The proportion of biomass is projected to increase till 2024 but then part of renewable resources are replaced by solar energy technologies.
Conclusions (2)

4. The transition to a low-temperature regime (60/30) at different share of renewable energy (60%, 80%, 95%) was included in system dynamics model. Thermal regime change increases the efficiency of renewable technologies, but does not change the share of renewable energy in the common system. Policy instruments contribute to a faster transition to a low-temperature regime.

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