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Spatial analyses of smart energy system implementation trough system dynamics and GIS modeling

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The goal of the study

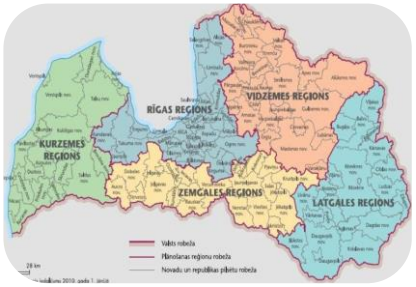
Develop a forecasting tool for energy sector based on spatial parameters

The methodology

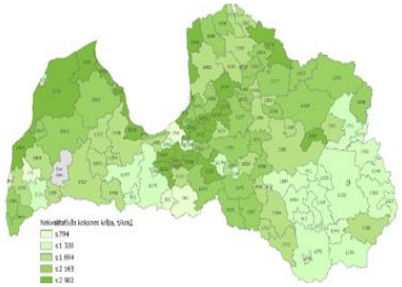
System Dynamics model:
-Complex systems
-Feedbacks
-Delays
-Behaviour over time

Geographical Information System:
-Input data
-Spatial representation

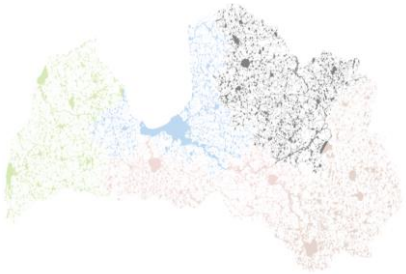
Why coupling SD and GIS for RES modelling?



To evaluate differences in regional energy profiles

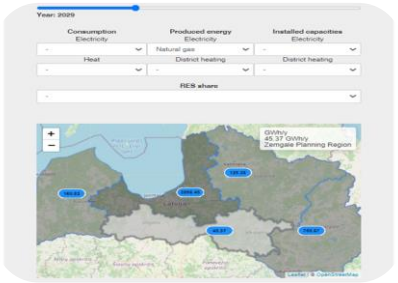


To evaluate the spatial distribution of resources



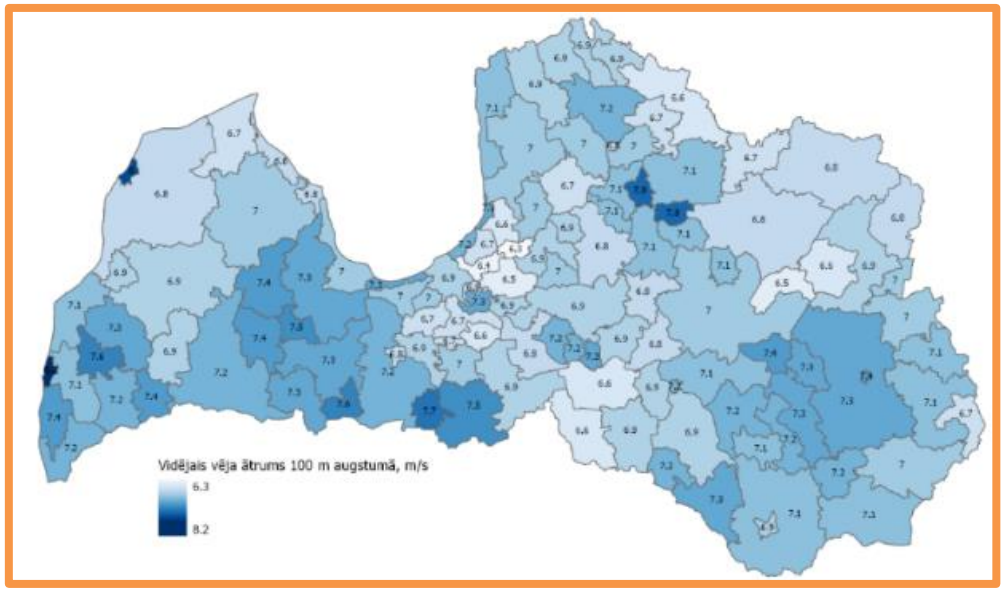
To take into account spatial limitations for RES infrastructure

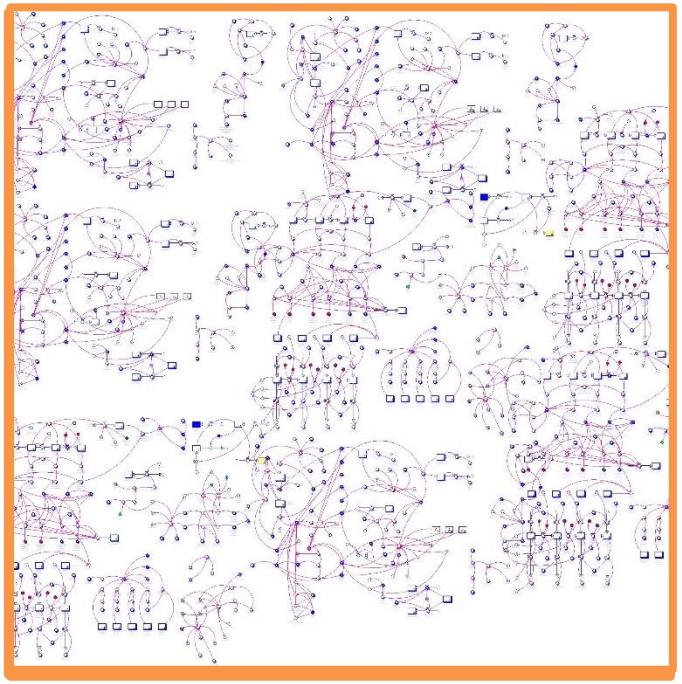
To consider energy transfer limitations and alignment with demand



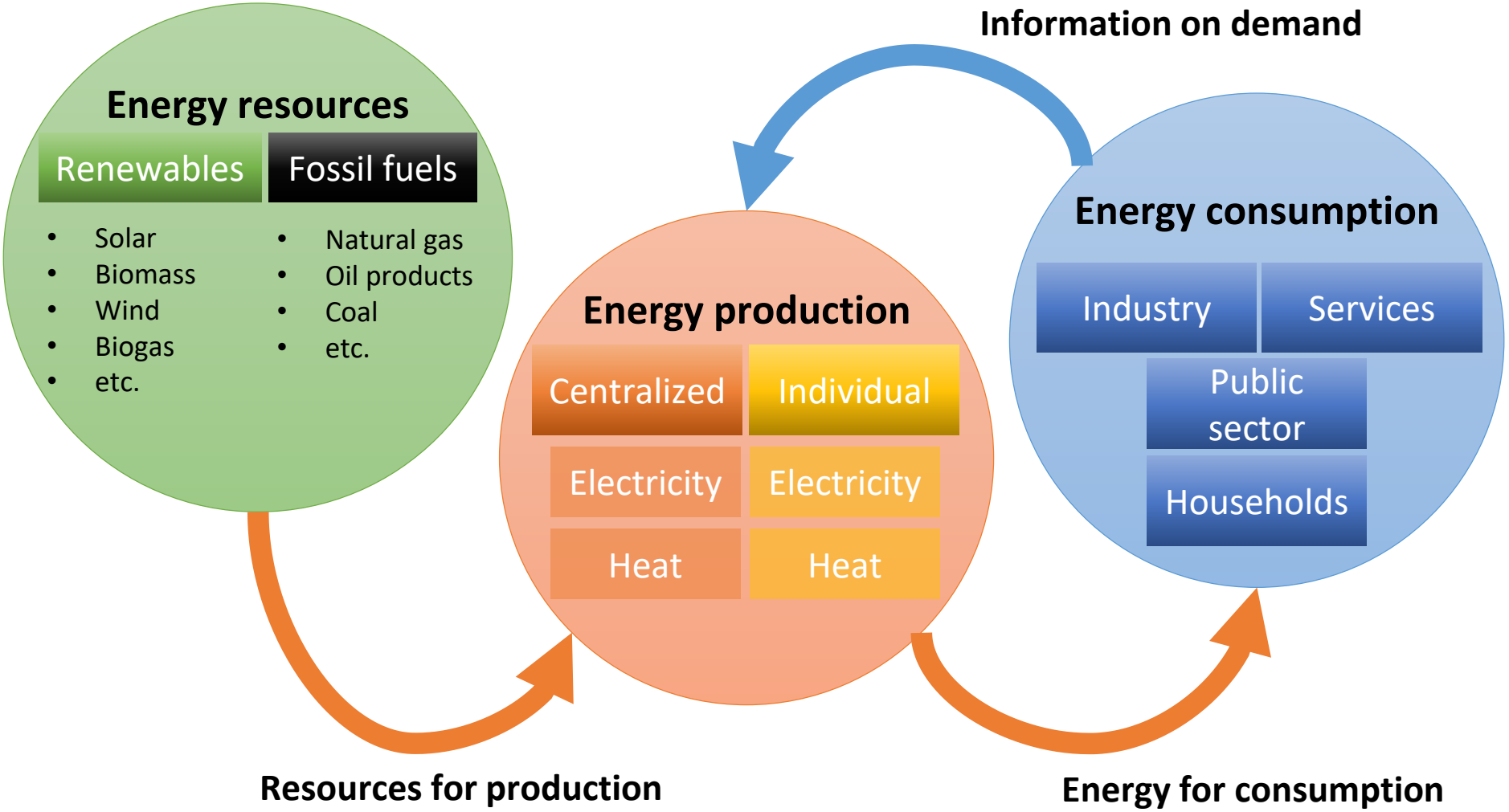
To model future development scenarios in spatial basis

Why coupling SD and GIS for RES modelling?

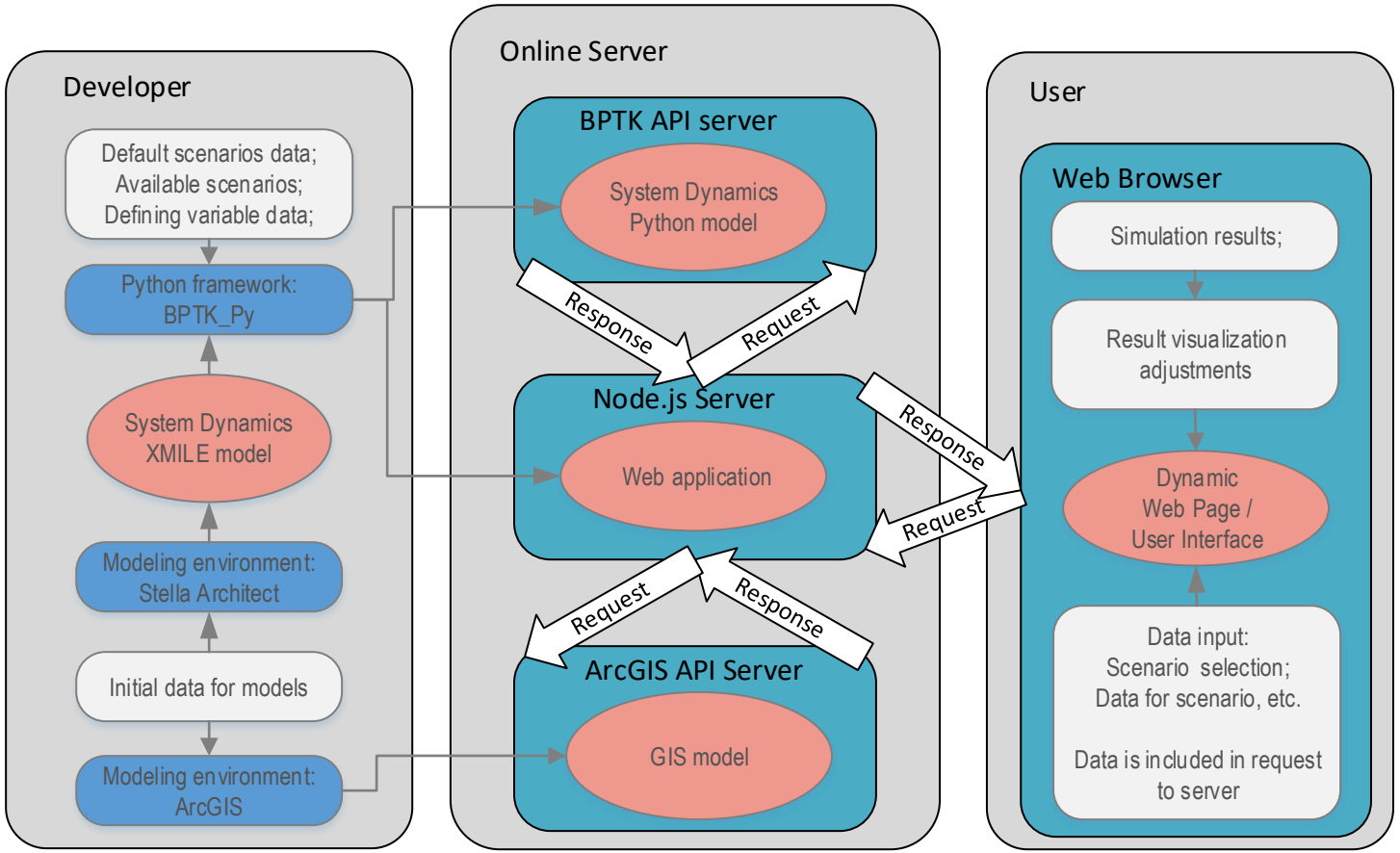




System dynamics model

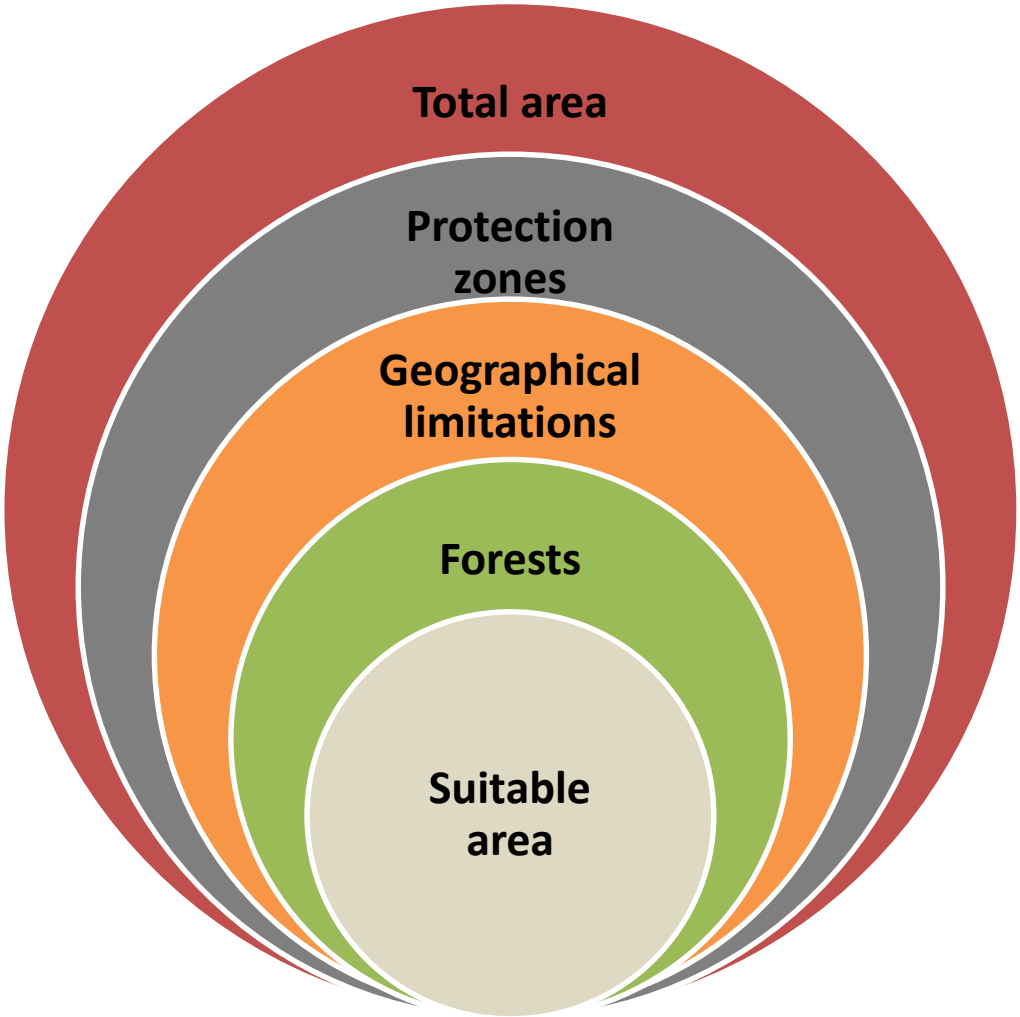


Method for SD and GIS coupling



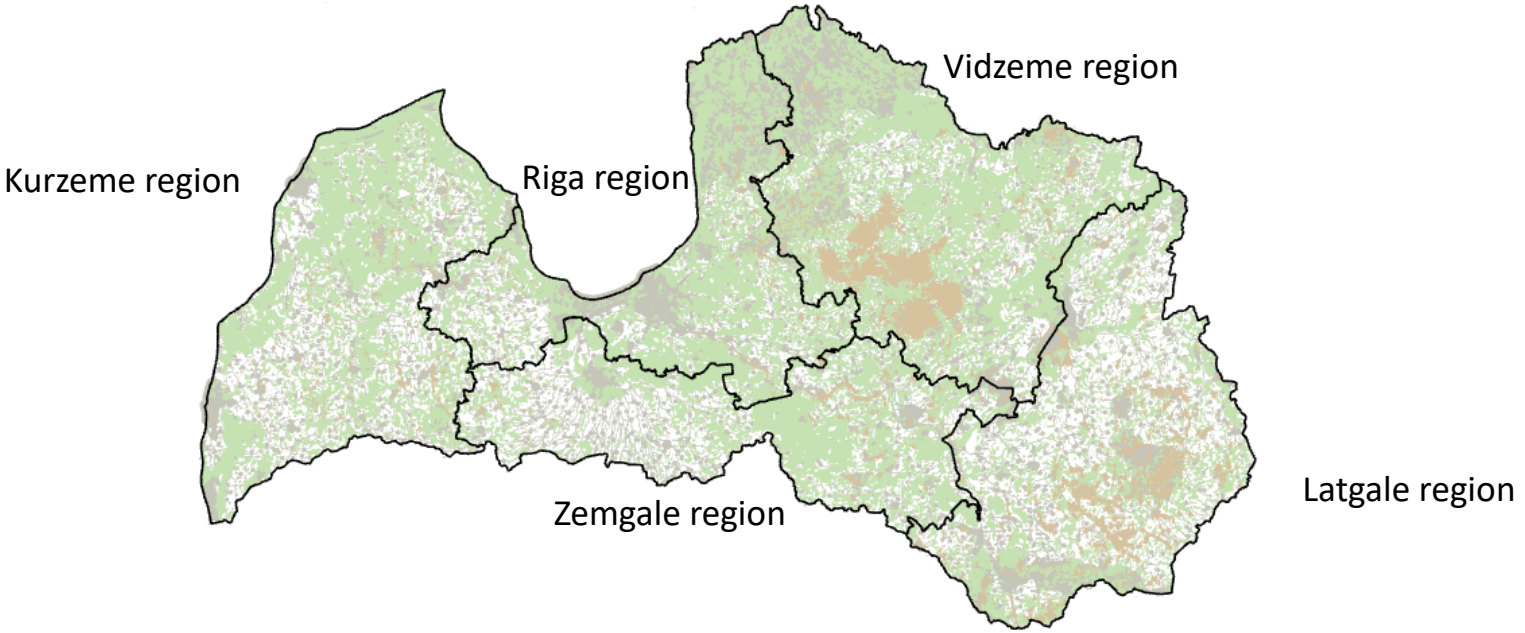
Wind farm modelling example

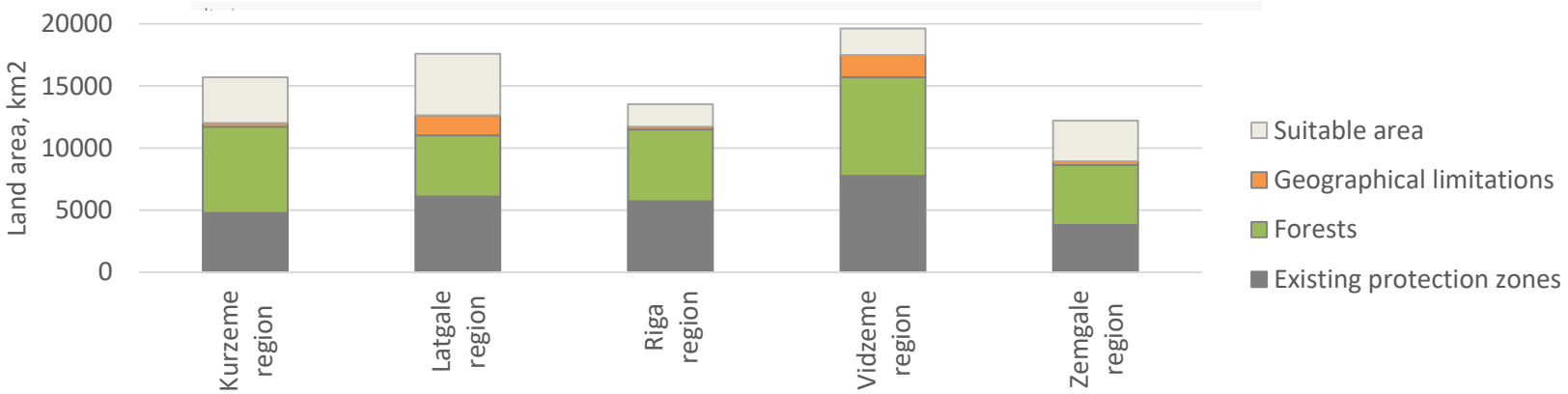
Criteria for wind farm land availability



Objects	Protection zone, m
Cities	2000
Villages	1000
Farmsteads	500
Road	60
Railway	50
Body of water	100
Watercourses	
Category 60-80	300
Category 20-50	100
Category 10	50
Protected land areas	-

GIS simulation of land availability

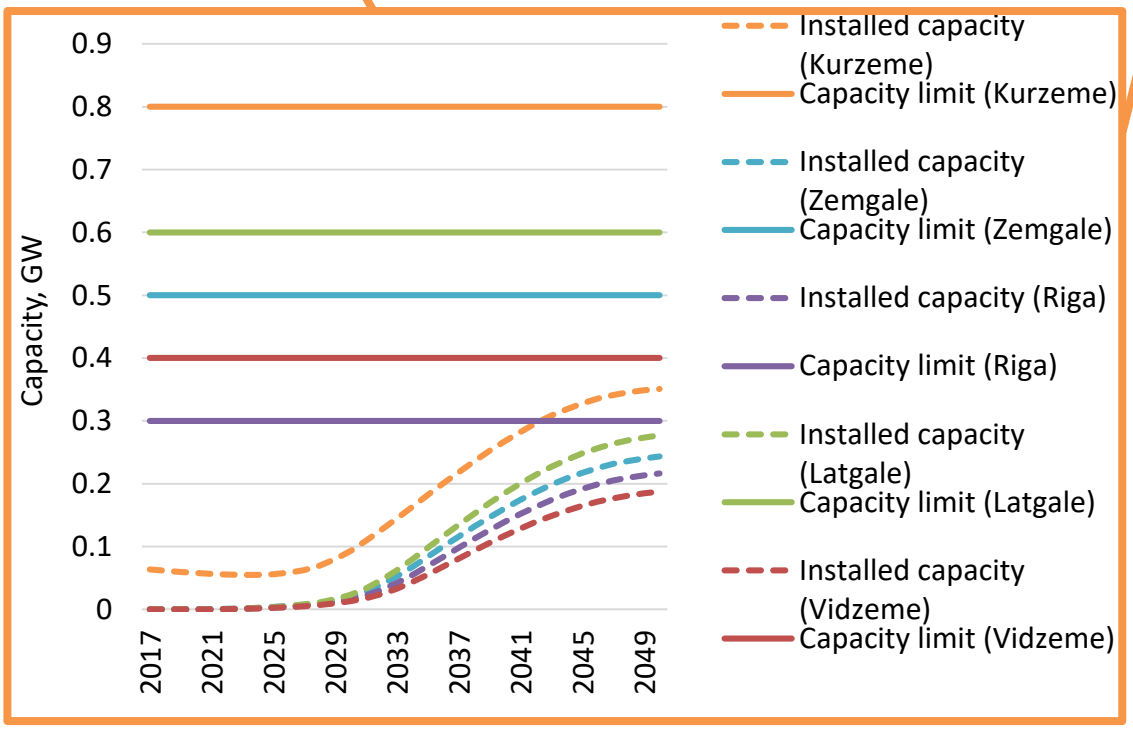




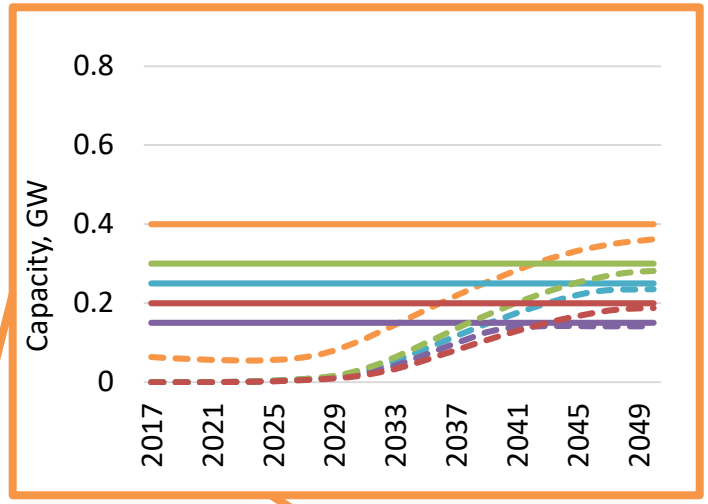
SD results – regional scale

Scenario description	
Scenario 1	Basic scenario
Scenario 2	Available land -50 %
Scenario 3	Available land -75 %

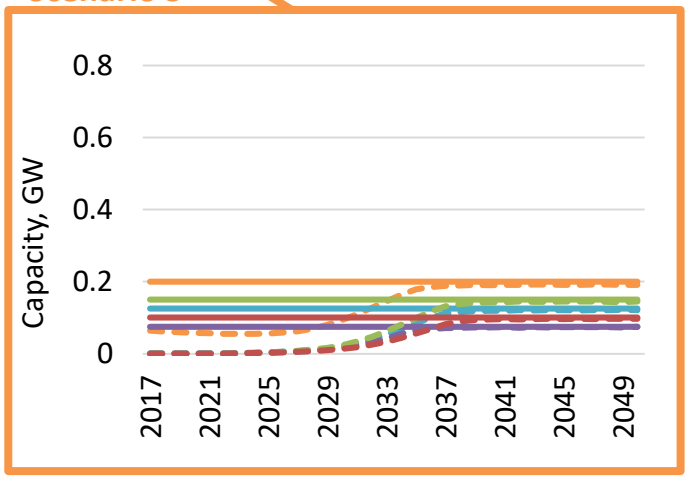
Scenario 1



Scenario 2

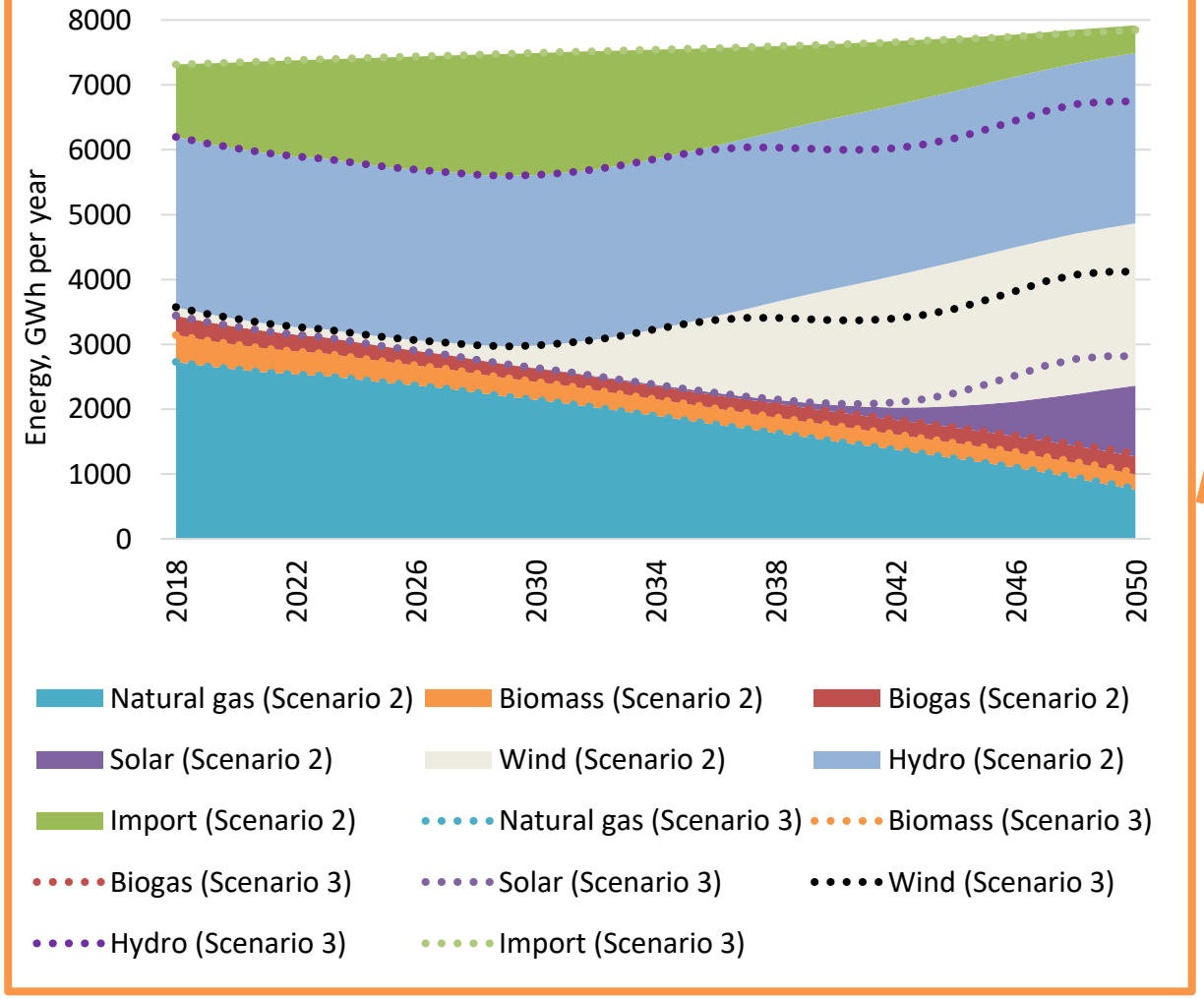


Scenario 3

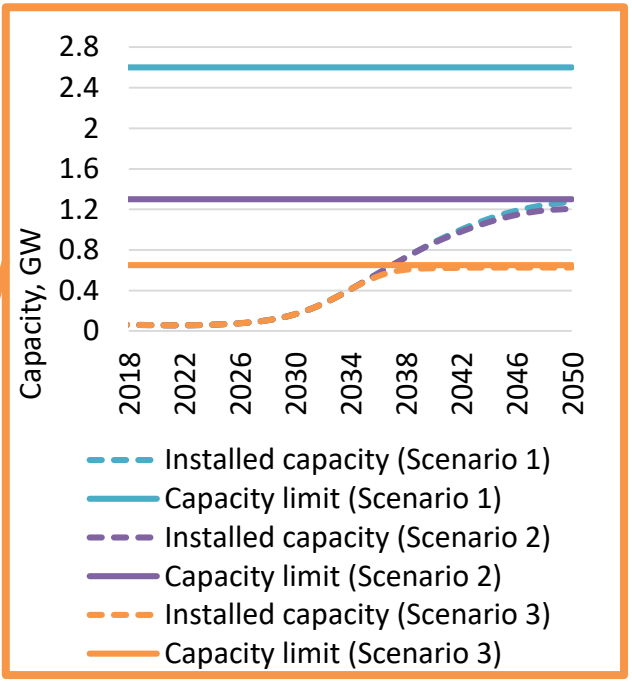


SD results –national scale

Power generation by resource type



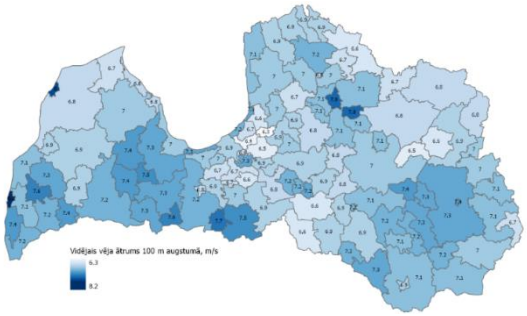
Installed wind capacity and limits



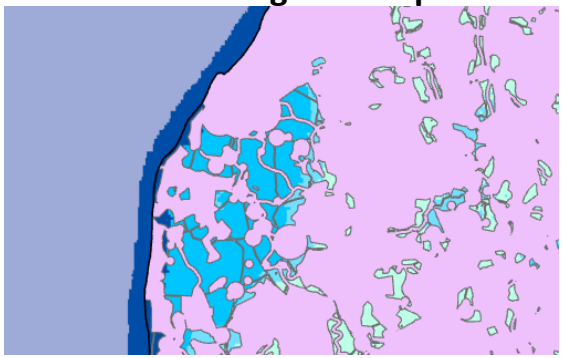
Additional GIS components

Merging Land availability with the wind speed

Average wind speed map

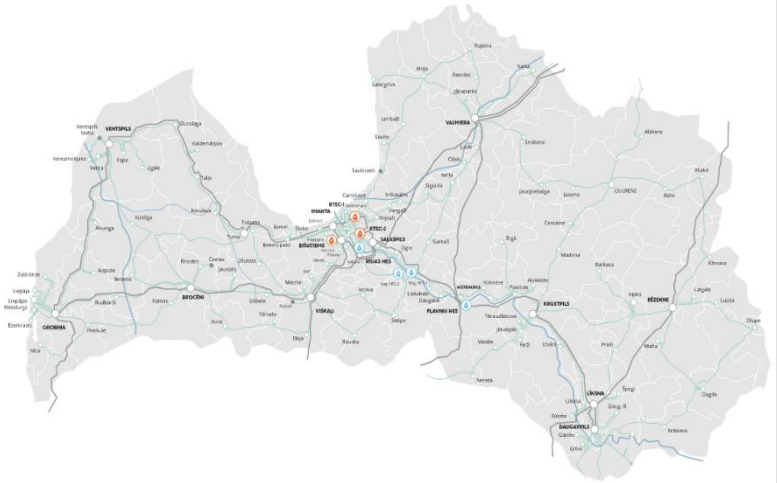


GIS model fragment of available land and average wind speed



Analysing areas with transmission line availability

Transmission line location



Source: AST, https://www.ast.lv/lv/transmission-network-info/parvades-tikls-un-apaksstacijas

Conclusions

- Spatial modeling helps to identify obstacles to the transformation of the energy sector.
- Regional targets may need to be set in order to avoid regional differences in the obtained share of RES.
- Combining SD and GIS models allows spatial regional differences to be taken into account in the modelling process, such as restrictions on the construction of wind farms.
- The merging of SD and GIS models will be continued by integrating the spatial differences regarding the distance from the transmission lines and average wind speeds in the particular territories

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