Kennis voor Klimaat

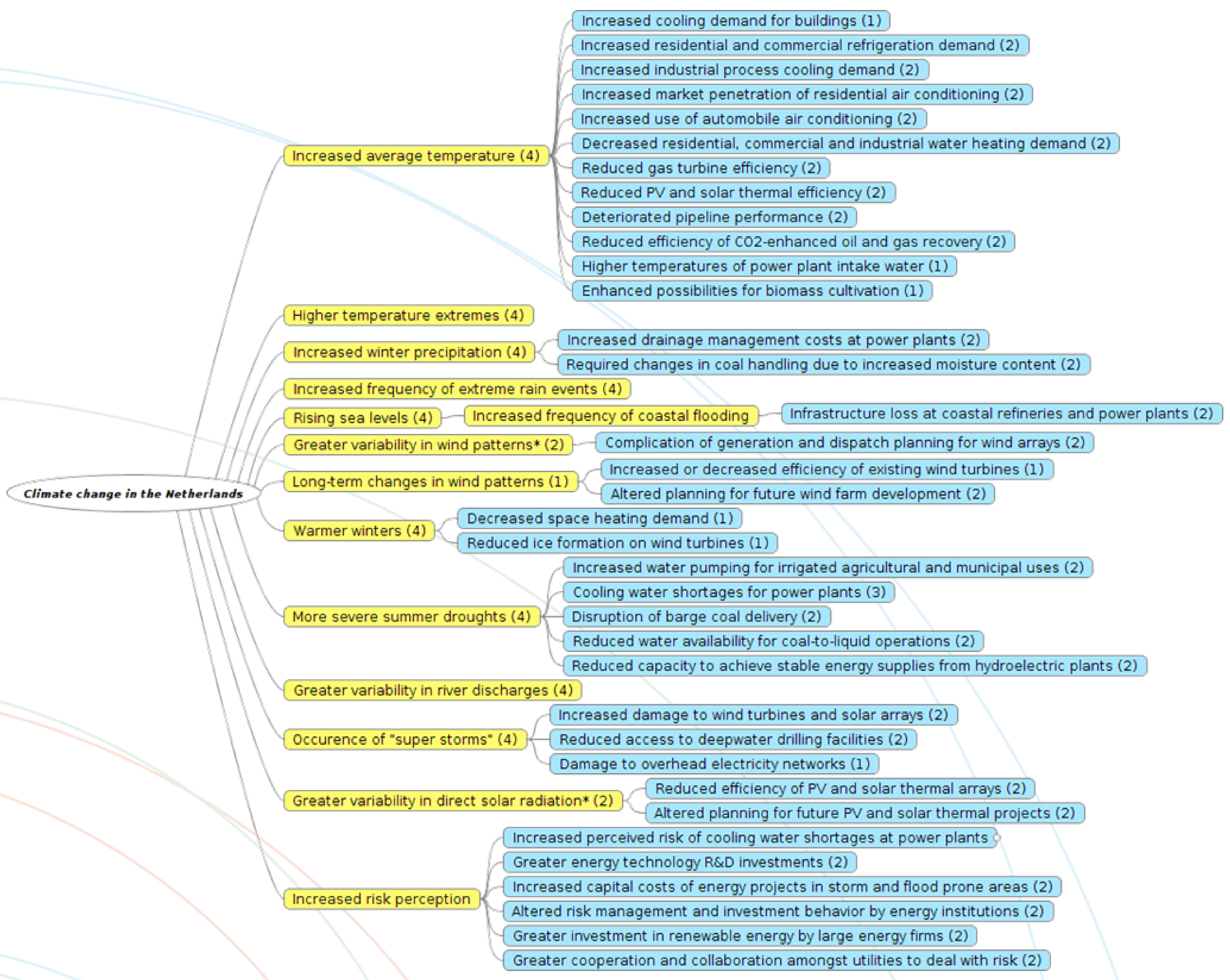
Knowledge for Climate

Theme 5, WP 3.3
Evolving climate change resilient electricity infrastructures

Electricity infrastructures and climate change

The electricity infrastructure is a fundamental backbone of modern society. From the light above our heads to the computers on which we work, a steady supply of electricity is essential for nearly every aspect of our lives. By affecting the range of environmental conditions under which electricity infrastructures must operate, and the frequency with which extreme conditions may occur, climate change poses a potential threat to these systems - from degrading their integrity and performance to causing major blackouts.

How can we ensure that our electricity system is resilient to these effects?



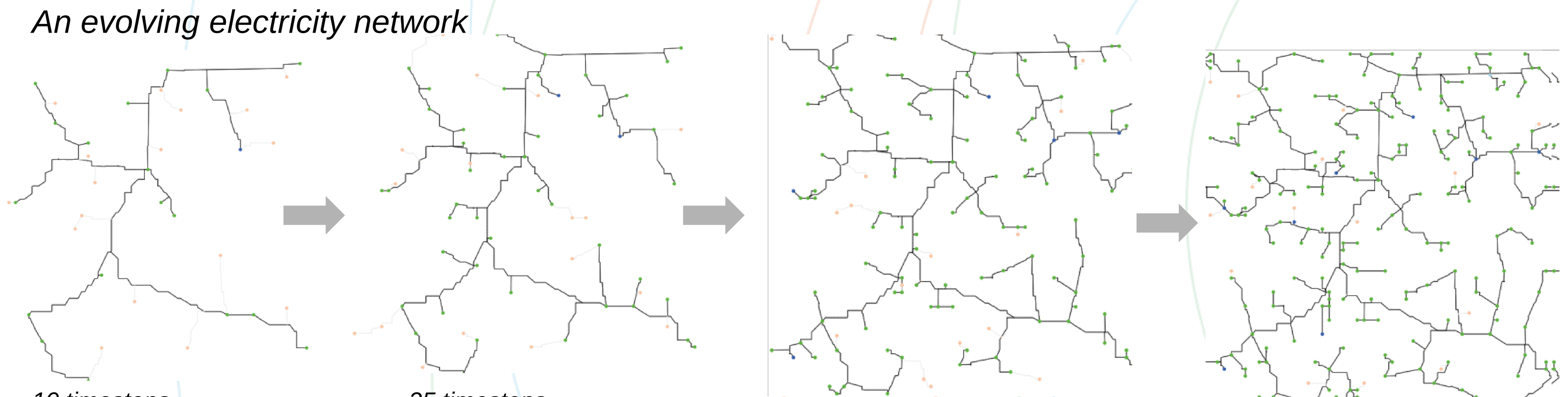
Overview of the anticipated impacts of climate change on electricity infrastructures

Evolving resilient electricity infrastructures

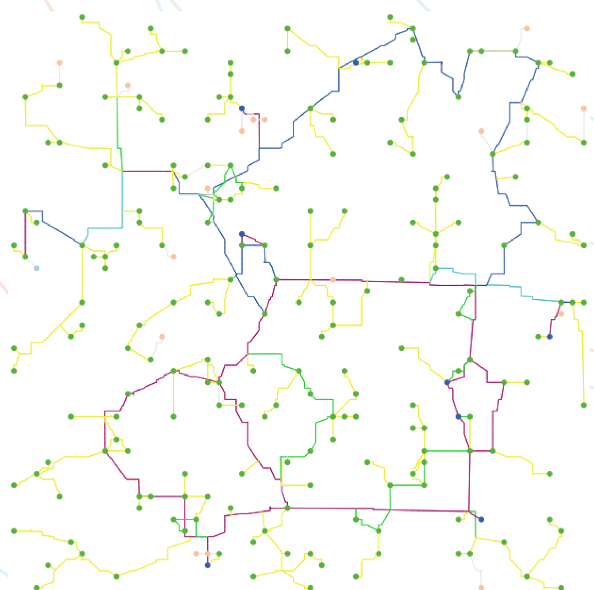
Developing an electricity infrastructure that is resilient to the effects of climate change will not occur overnight. The growth and evolution of an electricity infrastructure is slow and is influenced by a variety of factors unrelated to climate change adaptation – the development of electricity demand, NIMBY-ism, changes in the (geo-)political landscape, innovation in generation and transmission technologies, etc.

Given these constraints, how can we support the evolution of a climate change-resilient electricity infrastructure?

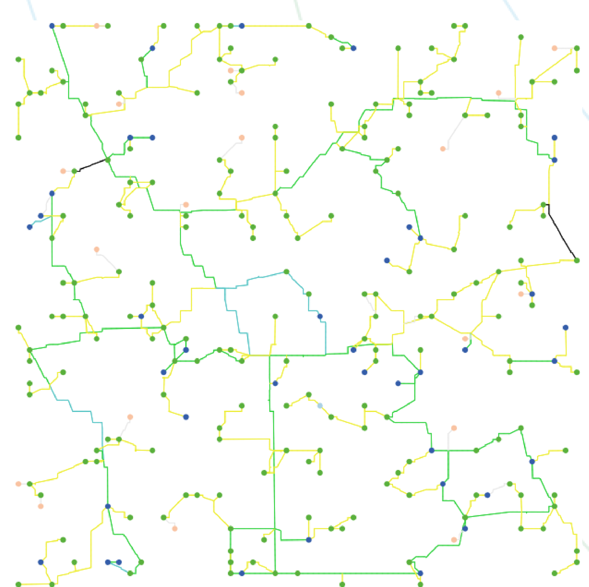
An evolving electricity network



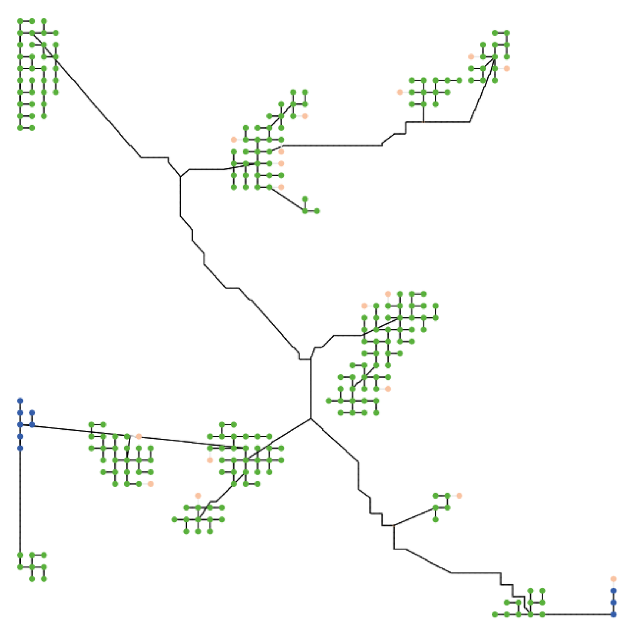
10 timesteps *25 timesteps* *50 timesteps* *100 timesteps*



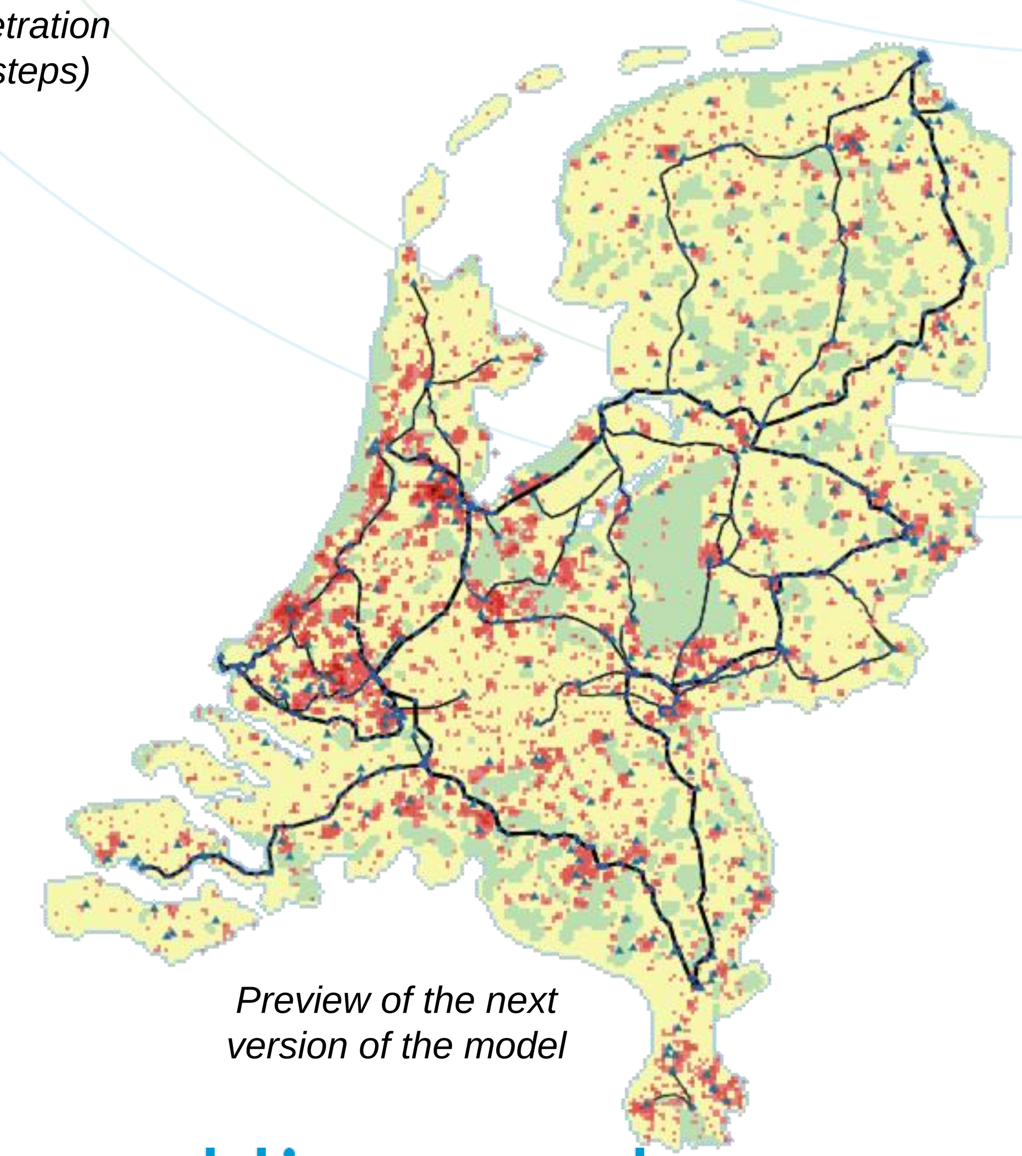
A multi-voltage electricity network (100 timesteps)



An electricity network with high penetration of distributed generation (100 timesteps)



A network with high clustering of supply and demand (100 timesteps)



Preview of the next version of the model

The model

Technique: agent-based modeling
The development of an electricity infrastructure is not determined by any single entity. It occurs as a combined consequence of a multitude of decisions made by a variety of boundedly rational actors over time. To capture this reality, we use a technique called *agent-based modeling*, in which real-world actors are represented as "agents" in a simulation. Using this technique, we capture the growth of an electricity network as a consequence of the decisions made by various actors over time.

Model setup
We represent 3 types of actors in our model - electricity consumers, electricity producers and a grid operator. Each of these agents has a defined set of decision making rules, which causes him to take certain actions.

- *Electricity consumers* invest in new loads (electricity consuming devices) at a user defined rate.
- *Electricity producers* invest in sufficient generation capacity (new generators) to provide for future demand (based on a projection of future demand)
- The *grid operator* has 3 main responsibilities:
  1. Invest in new lines and substations to connect (projected) loads and generators.
  2. Upgrade the capacity and voltage levels of network components to ensure sufficient transmission capacity in the future.
  3. Add redundancy to the network to enhance resilience.

As a consequence of the decisions made by these agents, an electricity infrastructure grows and evolves over time.

Resilience
A resilient infrastructure is one that continues to function and provide a service even as some of its components fail. In this model, resilience is defined as the degree to which consumers' demand for electricity is met despite the random failure of some grid components.

Next steps

In the next steps, we will:

1. Bring this model closer to reality by implementing more detailed technology representations and real-world land-use data for the Netherlands. We will seed the model with a representation of the current Dutch grid and explore the effectiveness of various policies for supporting the evolution of an electricity grid that is resilient to the effects of climate change.
2. Explore the resilience of the Dutch electricity infrastructure under various climate scenarios by exposing our "digitally evolved" electricity networks to various types of extreme weather events and evaluating their performance.

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