

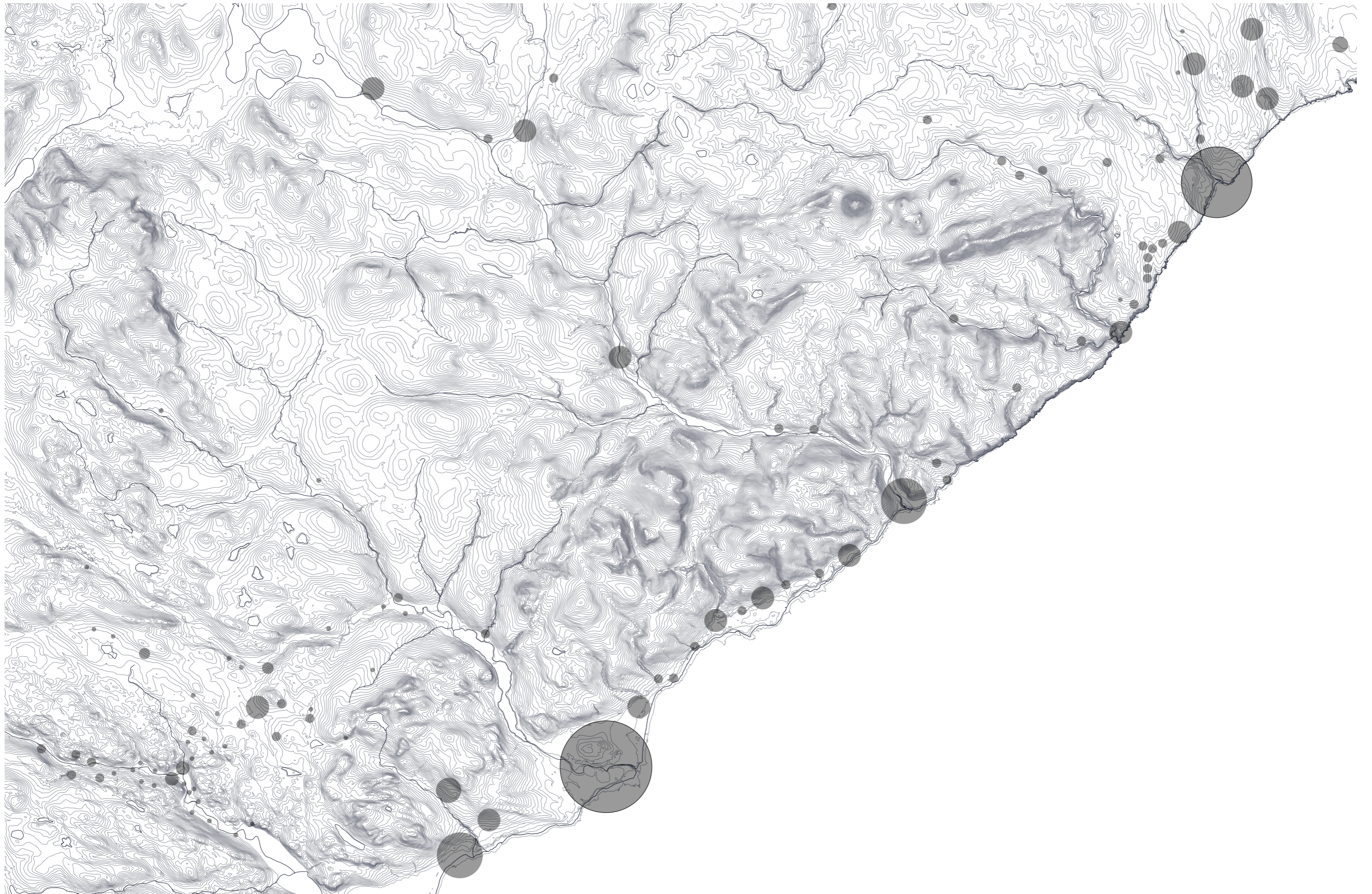
Early on in the analysis, it was decided that the project research should include a large water body. This is because the 'weak link' in renewable wind energy generation - the Highlands' natural talent besides hydroelectricity - is its intermittency. In other words, electrical output does not always match consumption patterns. In order for the thesis to positively contribute to an existing body of knowledge, it is important that project address this issue. As such, the strategic choice to intervene in an area that has a blue infrastructure with lochs was to involve pumped hydro storage.

This is a mechanism that stores excess off-peak grid power, by pumping water from a low-level reservoir (or a loch) to a high-level reservoir. The electrical power used to pump the water is stored as potential energy. When electrical demand is higher than electrical production, the water is released down hill; kinetic energy powers a turbine that is connected to a generator, creating electricity. This system is one of the most efficient ways of storing energy, working at 70-80% efficiency.

#### Sutherland Blue Infrastructure

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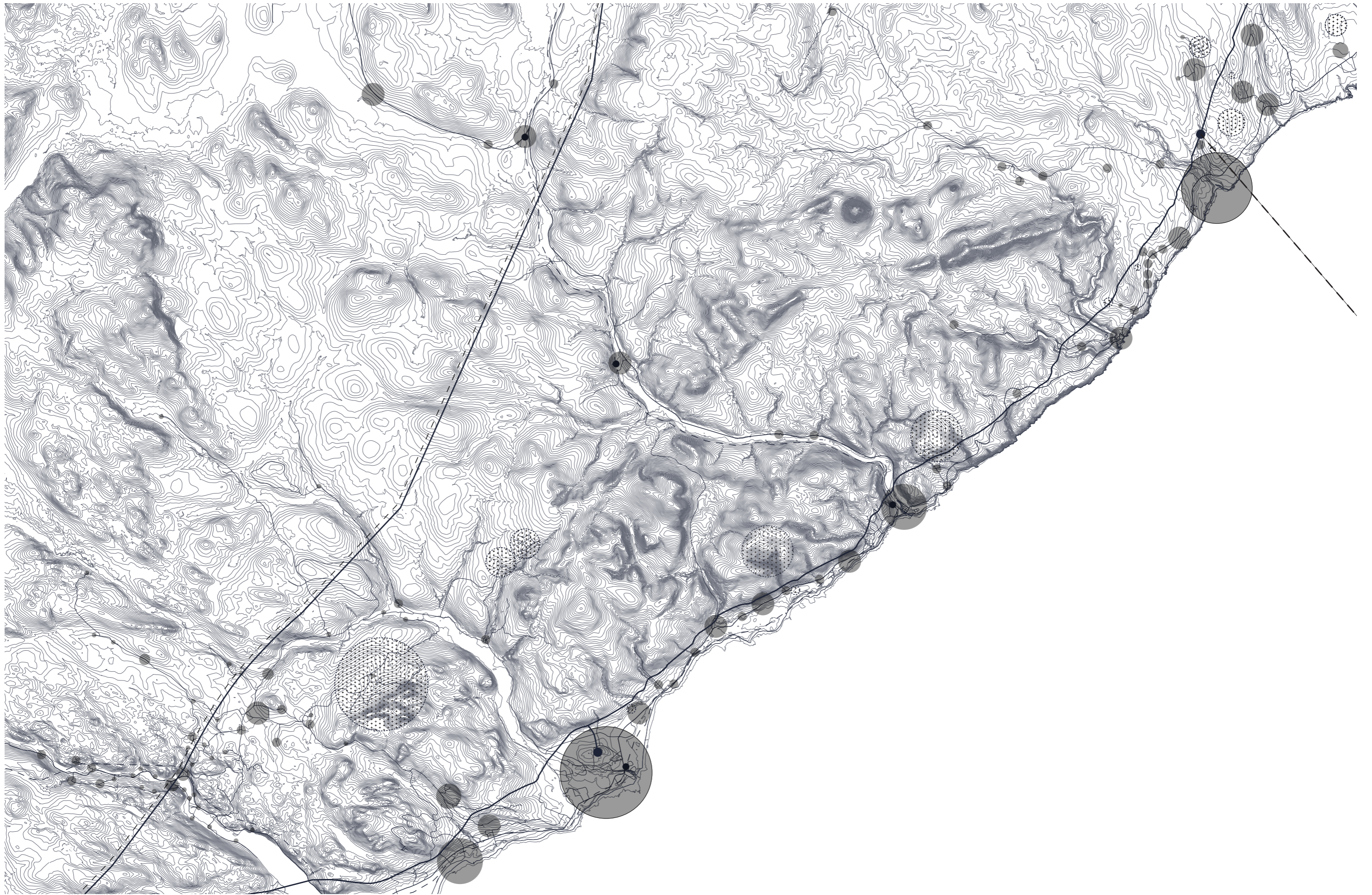
- existing settlements
- major rivers and streams



In addition to analysing the regions' existing natural infrastructures, the areas man-made infrastructures were also mapped in order to effectively develop three energy scenarios. Firstly, the grid infrastructure was analysed. A 132kV transmission line currently runs through the three sea-side towns, with two 132kV sub-stations in Dunbeath and Brora. Another 275kV transmission line runs through the northwestern side of the county. The region's transport infrastructure was also mapped; in order to speculate where urban growth might occur, main road and railway lines were established.

Sutherland electrical grid and transport infrastructure  
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- |                                  |                           |
|----------------------------------|---------------------------|
| ● existing settlements           | -- existing power cable   |
| ● railway station                | ● 132kV sub-station       |
| --- railway                      | — 132kV distribution line |
| — roads                          | ≡ 275kV transmission line |
| ● existing and planned windfarms |                           |



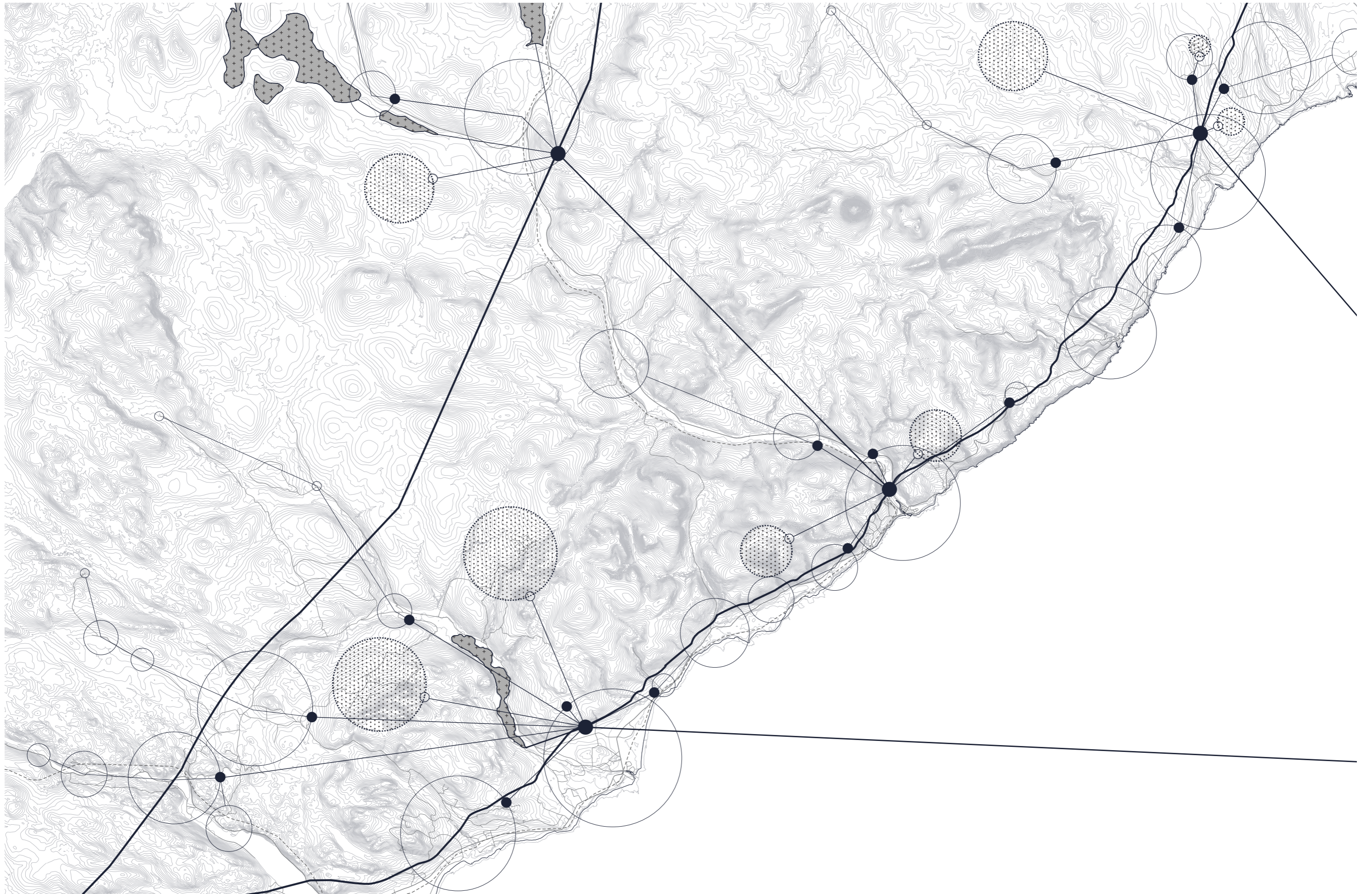
In order to avoid redundancy in the system due to temporal stresses, it is important to understand the electrical infrastructure as a complex and open system.

The infrastructure should be made up of semi-autonomous sub-systems, which include varying scales of production. This can range from regional or national control systems, down to community and individual process-response systems.

By introducing more small-scale, decentralised electrical technologies into the grid, evolutionary resilience is inherently introduced into the system; autonomous 'energy islands' exist within a larger complex, infrastructural system that can continuously respond to changes throughout time.

Central Place Theory

*Walter Christaller*



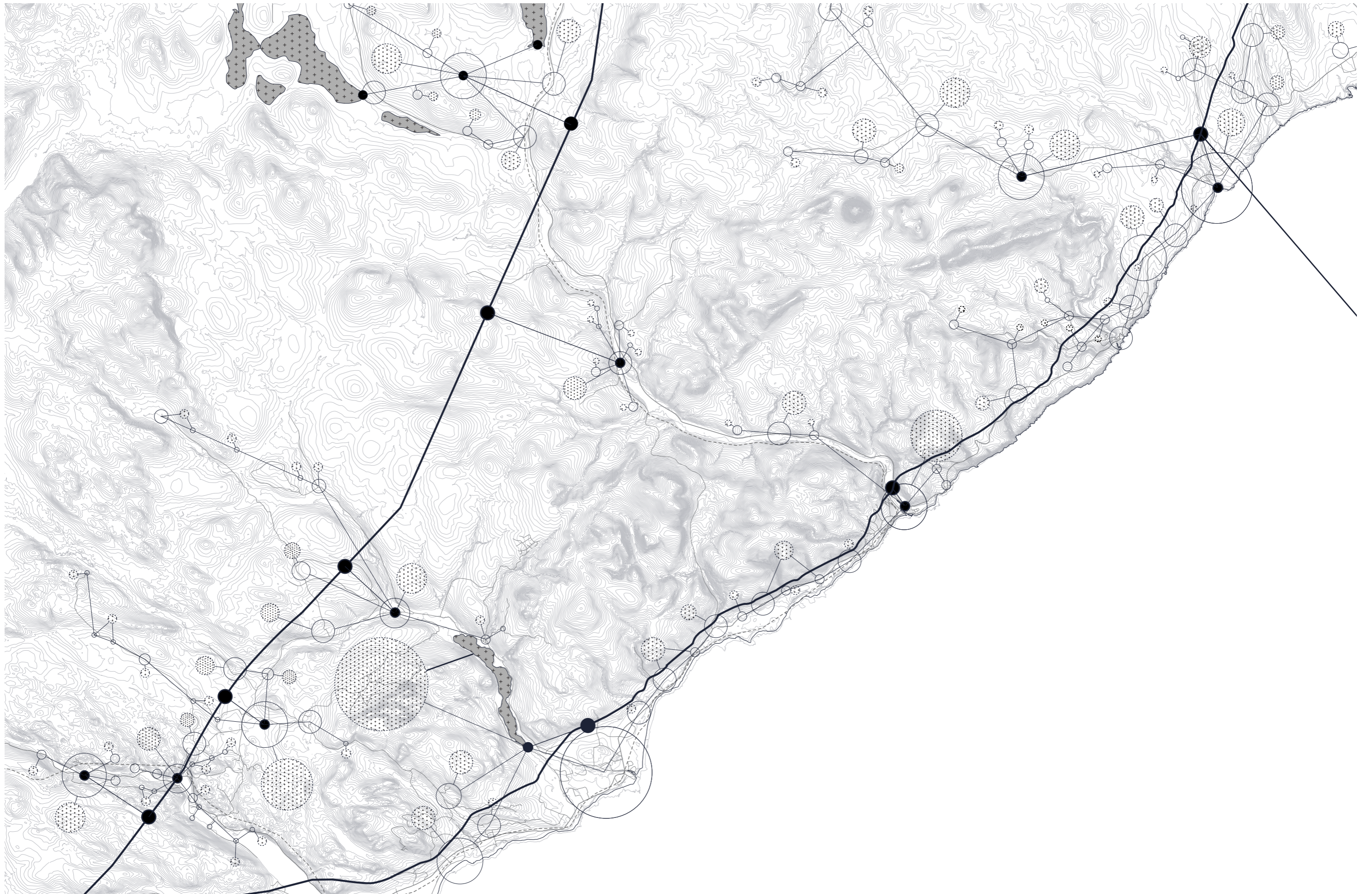
This decentralised scenario is characterised by:

- i. A single offshore landing point in Dunbeath, connecting its sub-station to Beatrice using the existing export cable.
- ii. Urban sprawl around the existing road infrastructure.
- iii. Settlements are placed on higher altitudes to avoid issues with increased flooding, due to climate change predications.
- iv. Every settlement has its own autonomous REIT.

#### Scenario B: Decentralised

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- |                             |                                 |
|-----------------------------|---------------------------------|
| ○ settlements               | ● sub-station                   |
| --- railway                 | — 400kV transmission line       |
| — roads                     | — distribution line             |
| ● terrestrial wind farms    | — low voltage distribution line |
| ● pumped electrical storage |                                 |



This distributed (a combination of centralisation and decentralisation) scenario is characterised by:

- i. An offshore landing point in Brora, connecting its sub-station to Moray West.
- ii. Urban sprawl around the existing road infrastructure.
- iii. Settlements are placed on higher altitudes to avoid issues with increased flooding, due to climate change predications.
- iv. Communities locally own autonomous RETs.

In order to develop the project further, the mixed scenario is chosen for further investigation. In choosing this scenario, the thesis takes a position on the need for multi-functionality and integration of the electrical infrastructures within landscapes. The following booklet and the beginning of the infrastructural design focuses on Brora.

#### Scenario C: Distributed

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- |                             |                                 |
|-----------------------------|---------------------------------|
| ○ settlements               | ● sub-station                   |
| --- railway                 | — 400kV transmission line       |
| — roads                     | — distribution line             |
| ● terrestrial wind farms    | — low voltage distribution line |
| ● pumped electrical storage |                                 |

