Transitioning Energy (and) Landscapes

Exploring infrastructural, architectural + landscape symbiosis

Territory | Scottish Highlands, North Sea

Transitioning Energy and Landscapes
Exploring infrastructural, architectural + landscape symbiosis

Research Booklet

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North Sea: Landscapes of Coexistence

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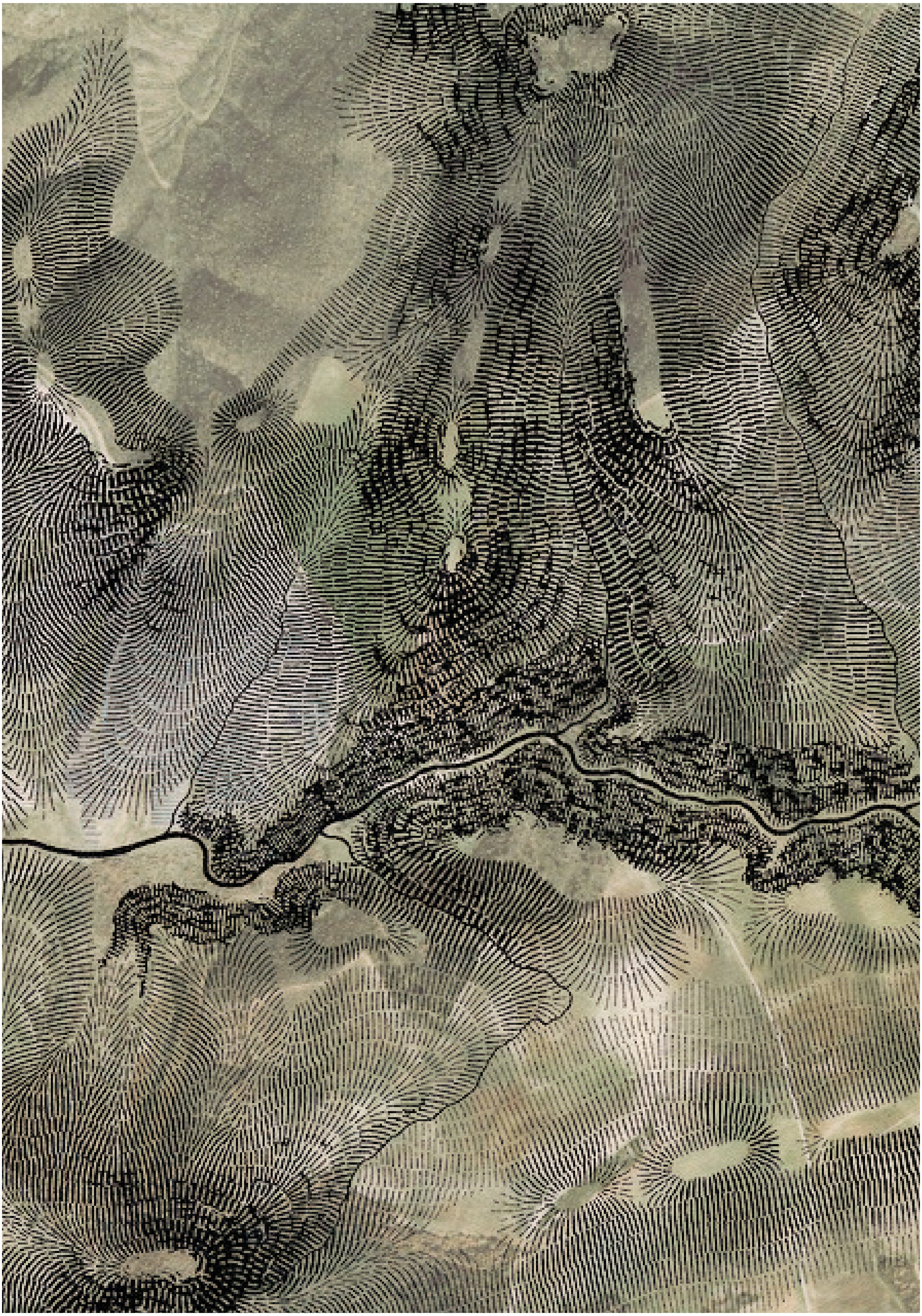
Abstract

The North Sea region's energy transition has begun. The prospect of how it will happen and what it will look like, however, is still shrouded in uncertainty. What is clear is that this is a mammoth project of unprecedented scale. The sheer quantity of renewables we need to integrate into our energy infrastructures will transform our peri-urban and rural landscapes as we know them. A new spatial order will arise: one of energy landscapes.

This thesis has investigated this infrastructural and morphological transition through a transcalar 'research by design' approach. It has endeavoured to re-establish the role of architecture as an infrastructural enabler in a projected (extreme flooding and drought) scenario, developing a transcalar spatial order in the Scottish Highlands region of Brora. The project's agency culminates in striving to achieve symbiosis between the infrastructural design of a proposed hydro-electric energy network, the receiving landscape and the habitable space needed for existing local life. The design focuses on water and electricity delivery to an existing distillery in the area, while also reinterpreting the typological arrangement of the distillery to be as energy efficient as possible. Ultimately, it seeks to break down the cultural divide between 'urban' and 'landscape'.

Key words: energy landscapes, landscape as infrastructure, hydro-electricity, Brora distillery

Introduction



This is the first of a three booklet series, illustrating a somewhat hopeful project that deals with the energy transition and Scotland's beautiful landscape. This book encapsulates the research done during the Transitional Territories MSc3 period, even though it does not all directly impact the project development that will be laid out in the following two books. I have decided to include it nevertheless, because it is priceless knowledge that is important to me. Without this research, I would not have shaped my position of thought for the rest of the year.

I would like to extend my gratitude to my tutors, who have helped me to build this project over the past year: firstly, to Nicola Marzot, for his unyielding vision and enthusiasm; secondly, to Taneha Bacchin, for her dedication, patience and constant support; and finally to Sjap Holst, for the numerous design iterations he sat through with me. I would also like to thank my studio peers, for their generous sharing of thoughts and help.

The Project's Relevance

Architecture is a multifaceted field, one which deals with a multiplicity of disciplines, themes and issues. This is one principle reason why the architectural profession lies at the heart of one of the most significant paradigm shifts our generation will inaugurate: the energy transition. To borrow Sijmon's words: "the energy transition is not your average subject; it actually alters the foundation of the power system"1 and power systems determine the development of virtually every aspect of a society.

With this in mind, my graduation project aims to explore the role architects can play in this transition and what knowledge systems we can employ to contribute to it. It seeks to explore how we can advance our discipline, by acknowledging its inherent potentials and limitations, to ensure it bears agency in this mammoth challenge. In this regard, the project subscribes to *Transitional Territories*' ontological understanding of architecture as an agent for larger, and ever-fluctuating, urbanisation and infrastructural processes. This stems from the studio's recognition of cities and urban landscapes as complex systems that are rooted in a temporal dimension. If the efficacy of our discipline is to evolve in response to the transition, then so must its academic episteme. As such, it is essential to undertake the right kind of research in response to clear hypotheses, questions or concerns that contribute to existing bodies of knowledge. The identified knowledge gap that this project seeks to contribute to is the role of architectural design in ensuring a qualitative morphology of our landscapes.

Within this scope, my design thesis will address the spatiotemporal dimension of the energy transition, exploring possibilities for resulting energy landscapes in the Scottish Highlands. Rather than seeing architecture as the building of object-space entities, it is being interpreted as an enabler within a hydro-electrical infrastructure. Architectural practice should involve itself with the unlocking, enabling and remoulding of urbanisation forces and interactions, which depend on the physical constructions that house them, in time and space. Once we value architectural design as 'a cognitive process', the malleability of 'design as thinking' becomes a tool that eases interaction with such complex topics as the energy transition. This is especially true when the project has not been tackled using a multidisciplinary approach. When dealing with extensive issues that exists within complex systems and ecologies, knowledge production benefits from multidisciplinary input because it encourages dialectical thinking. I believe that this is the way forward for all disciplines that can contribute to the energy transition. With this in mind, I relish the opportunity to integrate building science, landscape, urbanism and scientific academia into my design process.

I The North Sea

The energy transition

From Extractivism to Renewable Regeneration: A political stance

The North Sea region's energy transition has begun, though the prospect of how it will happen and what it will look like is shrouded in uncertainty. Architecture lies at the heart of this most significant paradigm shift, one which our generation will inaugurate. A reciprocal relationship exists between the way societies use energy and space; the production of energy is situated in the realm of spatial design. It is therefore not an overstatement to suggest that, in this century, our civilisations will witness the emergence of a new spatial order.

A Cultural Shift

"*Energy and space change each other, and they change together over the course of history. It is not far-fetched to divide human history into periods based on the dominant form of energy, and each energy period also has its own characteristic spatial manifestations. We can characterize the period beginning in about 1800 as the era of 'fossil expressionism'.*"[1]

Extractivism is the underlying process that has conditioned western societies' interaction with the environment and its resources. Its roots lie in the Enlightenment and the Age of Discovery, when humanity saw itself as superior over 'nature'. Landscapes became a romanticised backdrop to human life or became a nidus of primary resources. Since the industrial revolution and the birth of global consumerism, extractivism has evolved to encapsulate the way in which modern societies perceive the environment: as a stockpile of resources for urbanisation.

The energy transition to renewable energy is challenging this to its core. As Dirk Sijmons highlights in his book *Landscape and Energy: Designing Transition*, up until recently energy generation and supply has been kept discreetly separate from our everyday lives. In the current landscape, electrical and heat generation only becomes visible as a tiny fire or plume of smoke on a horizon when a plant is fired up. Even further from our awareness are the mines and wells that produce the fossil-fuels these plants run off. Indeed, "*our energy supply is embedded in a global system in which we do not have to know the origin of the oil or coal that drives our way of life, or the effects that mining has on the scenic qualities of those faraway places. Thanks to this concealment, our landscape is largely an illusory one.*"[2] In the past few decades, the illusion of being able to generate energy for our consumption demands without touching our landscapes is being broken. The energy transition brings energy production, in its true scale and quantity, into full view. It is breaking down this disconnect between energy consumption and production, because the renewable energy technologies (RETs) are 'in our back yards'.

An Infrastructural + Architectural Response

This shift in cultural mindset is poised to happen, especially if society can fully accept that urbanisation is directly intertwined with our landscapes. The emergence of a new renewable energy infrastructure will, in fact, be the emergence of a new landscape infrastructure; the boundaries between settlements and their hinterlands – between 'urban' and 'nature' – will begin to blur. The research that drove this project aims to investigate the potentials of this new spatial order, where: urban morphology is landscape morphology; and where infrastructural success is dependent on site-specific solutions that take advantage local ecological, climatic and topographical potentials. As Walter Benjamin said, "*technology is not the mastery of nature but of the relation between nature and man*"[3].

Territorial Analysis

The studio research began at the territorial scale, by collecting data on the altering ecological and geological processes in the North Sea. Four groups (biotopes, climate, flows and geomorphology) extrapolated and projected this data using cartographic techniques, culminating in a studio Atlas.

The maps, particularly the gas and oil infrastructure map, highlight the extent of energy extraction and generation that occurs in the North Sea. The illustrated energy infrastructures are a manifestation of northwest Europe's intensive extractivist practices; the North Sea is the most urbanised maritime body in the world. Due to its resource-rich physiography, the 'extended urbanisation'[4] of anthropogenic industries into its waters is unparalleled – 27% of its seabed is covered in oil and gas pipelines alone.

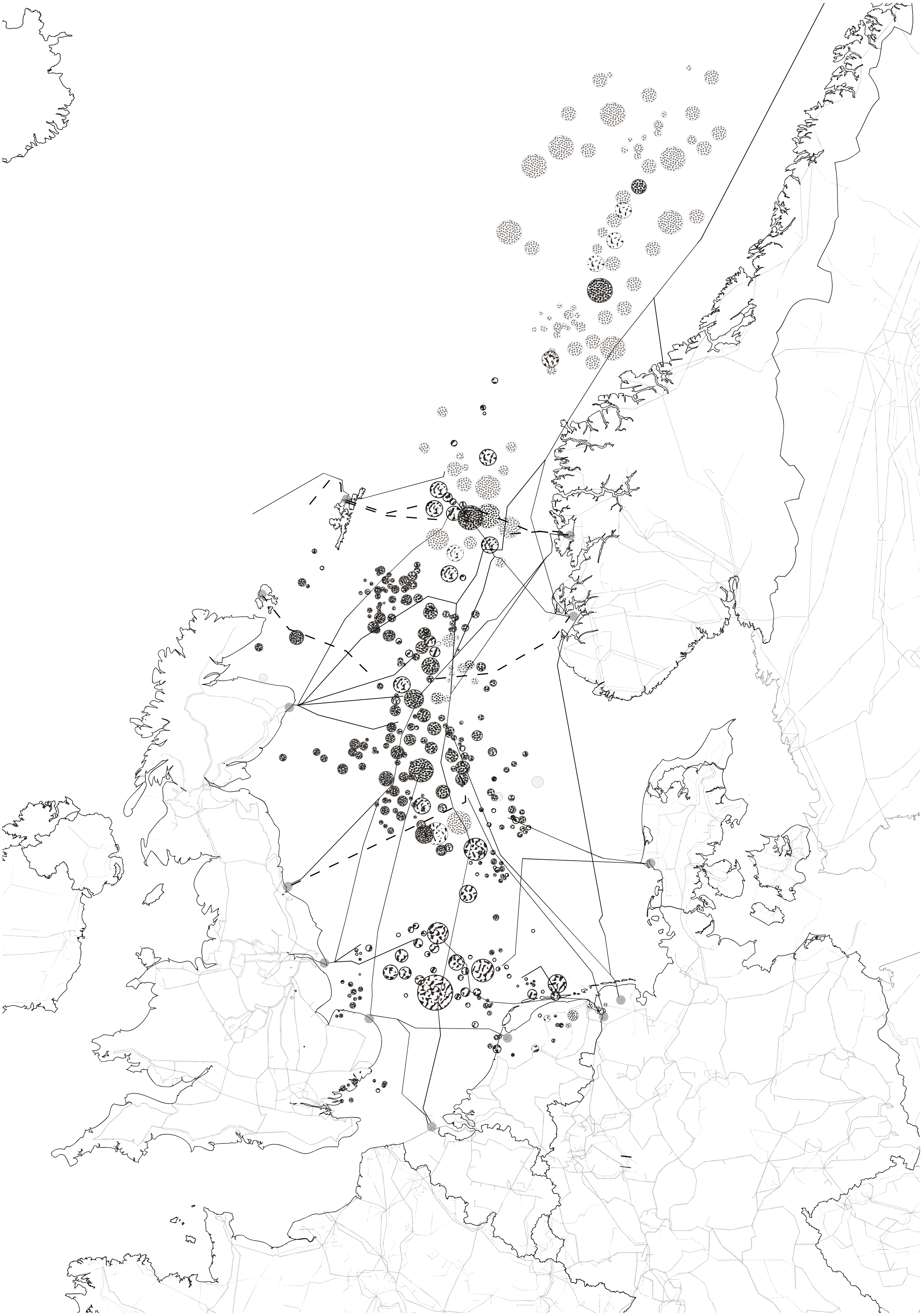
Most of the transitional processes that were researched during the exercise are all being exasperated by climate change, which is manifesting in an average sea and land temperature rise, with increased flooding in winter and droughts in summer. The North Sea countries are responding to the threats of climate change by using the region's 'natural talent' to generate renewable energy: wind. The following maps illustrate that a monumental number of offshore wind farms are being constructed or are in planning, in order to meet the countries' energy demands and adhere to the EU 2050 renewable energy targets.

Through this, it can be surmised that a large portion of the regions' future energy production will be generated from these centralised wind turbines. In turn, in order to export the electricity from these offshore farms to terrestrial sub-stations, an overhaul of many existing transmission networks will be necessary in order to accommodate this increase in electrical capacity. Furthermore, since the distances between the wind farms and the landing sub-station is so large, export cables will need to transmit high voltages to minimise distribution losses. In response to this, the argument for terrestrial generation and, possibly, decentralisation is given impetus, since distributed networks suffer less distribution losses and create redundancy in networks.

Oil and gas infrastructure

1:6000000
Atlas

- oil platforms
- gas platforms
- gas and oil fields
- potential oil fields
- oil pipes
- gas pipes



Existing and planned offshore wind farms

1:6000000

Atlas

- existing offshore wind farms
- planned offshore wind farms

The North Sea countries currently consume 550TWh per year for electriciy, heat and fuel. In order to meet the EU 2050 energy targets, *IABR: 2050 – An Energetic Odyssey*[5] suggests that 75% of the region's energy production must be generated through renewable energy sources.

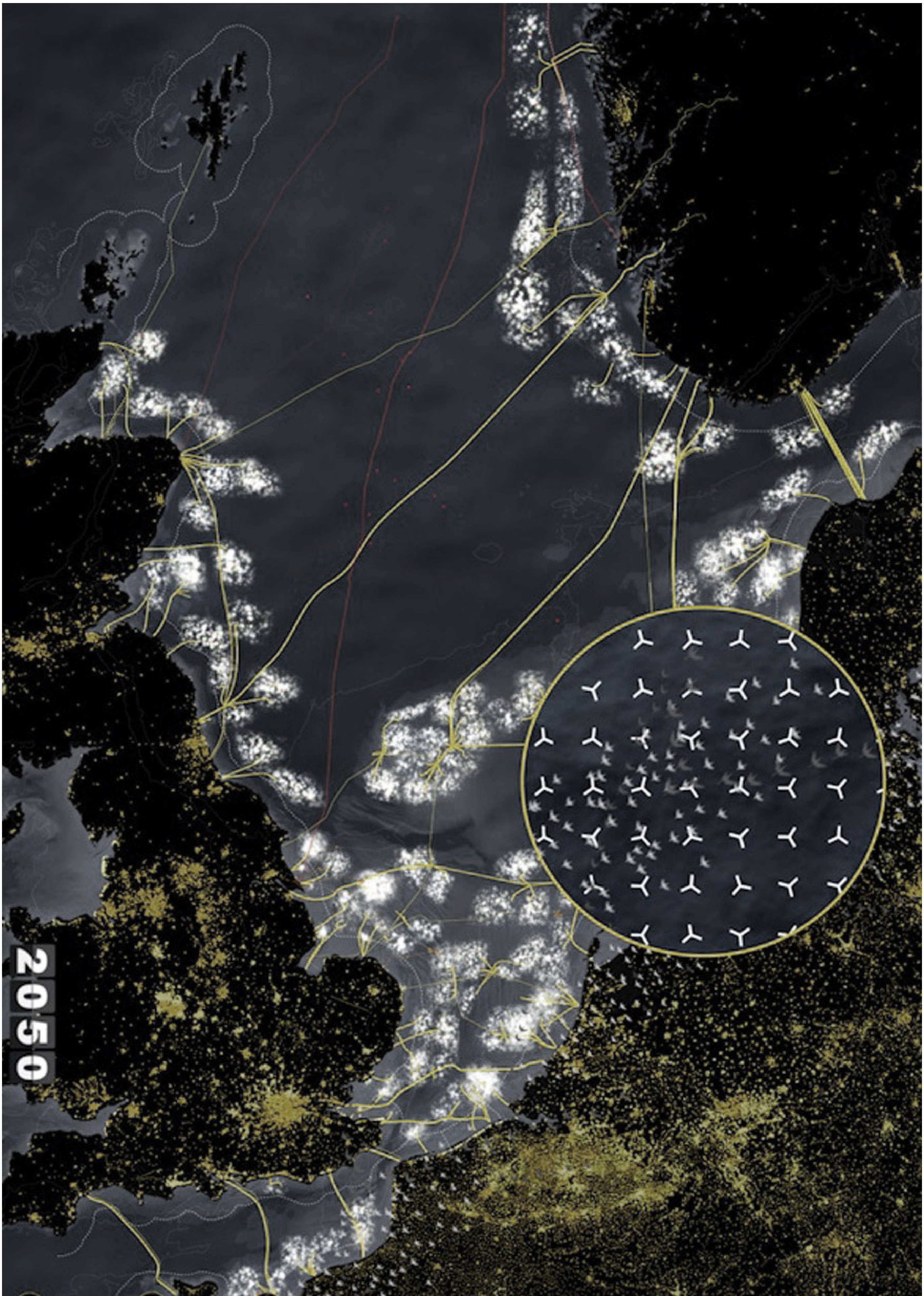
In order to achieve this, a quantum leap in renewable energy production and energy savings must be made by 2050, namely:

i. A 30% reduction of total energy demand (1500 TWh/year) relative to 2015, which will be achieved through energy efficiency measures.
ii. Approximately 90% of the region's current electricity demand, that is 30% of the total energy demand (1200 TWh/year), will be generated through centralised, offshore wind farms. This will will cover 20% approximately of North Sea's surface.
iii. The remaining energy demand (1400 TWh/year) will be generated through a patchwork infrastructure of large and small, centralised and decentralised renewable energy incentives.

The baseline energy scenario will be used a basis for this project.

IABR: 2050 - An Energic Odyssey

IABR, H+N+S, Tungsten


2050
Windfarms
International

II Sutherland, The Highlands, Scotland

Renewable energy scenarios

This next chapter in the project's research explored the future of energy landscapes in Sutherland, Scotland. Moray Firth was chosen as a starting point for the investigation for the following reasons:

i. Its terrestrial surroundings are mostly peri-urban and rural.
ii. There are three large-scale offshore wind farms planned for the area.
iii. Presents a landscape with potential for pumped electrical storage, due to its topographical qualities and water infrastructure.
iv. These geographical features are often located in areas of outstanding natural beauty, landscapes that societies associate as 'emotional' and cultural heritage landscapes. Many tensions that surround renewable integration occur in these types of areas.

The project's regional scale research began by identifying the existing primary transmission lines of the electrical network in the Scottish Highlands, and locating the export cable of an existing demo offshore wind farm that has significant growth potential. By highlighting a potential secondary landing point for electrical export, an area of intervention was established. Brora was been chosen as the secondary landing point because of its connection to Loch Brora and its proximately to existing and planned onshore wind farms.

Once the existing infrastructures in the region were mapped, three clean energy scenarios were produced. Each map will illustrate a different network organisation: the first showing a centralised terrestrial grid; the second a decentralised terrestrial grid; and the third a combination of both. The production of these network maps establish key infrastructure design requirements, including the RETs themselves, cabling, sub-stations (step-up or step-down) and electrical storage facilities. The issue of critical infrastructures is considered in the building of these scenarios, addressing system redundancy through design that achieves to incorporate evolutionary resilience.

Further-to-this, historical morphological precedents were used as an urban theory buttress to develop these scenarios. Archizoom's *No-Stop City* as *"an instrument of emancipation"*[6] was used to inspire the superimposition of a new spatial order, or indeed a grid, that allows for semi-autonomy. This is an important aspect of the network design in order to avoid system redundancy. Secondly, the Disurbanist School provide a theoretical precedent for urban morphology in rural environments. Disurbanism suggests that growth should follow main infrastructural axes, where productive facilities are available. Interestingly, Disurbanism was developed as a response to the electrification of the Soviet Union.

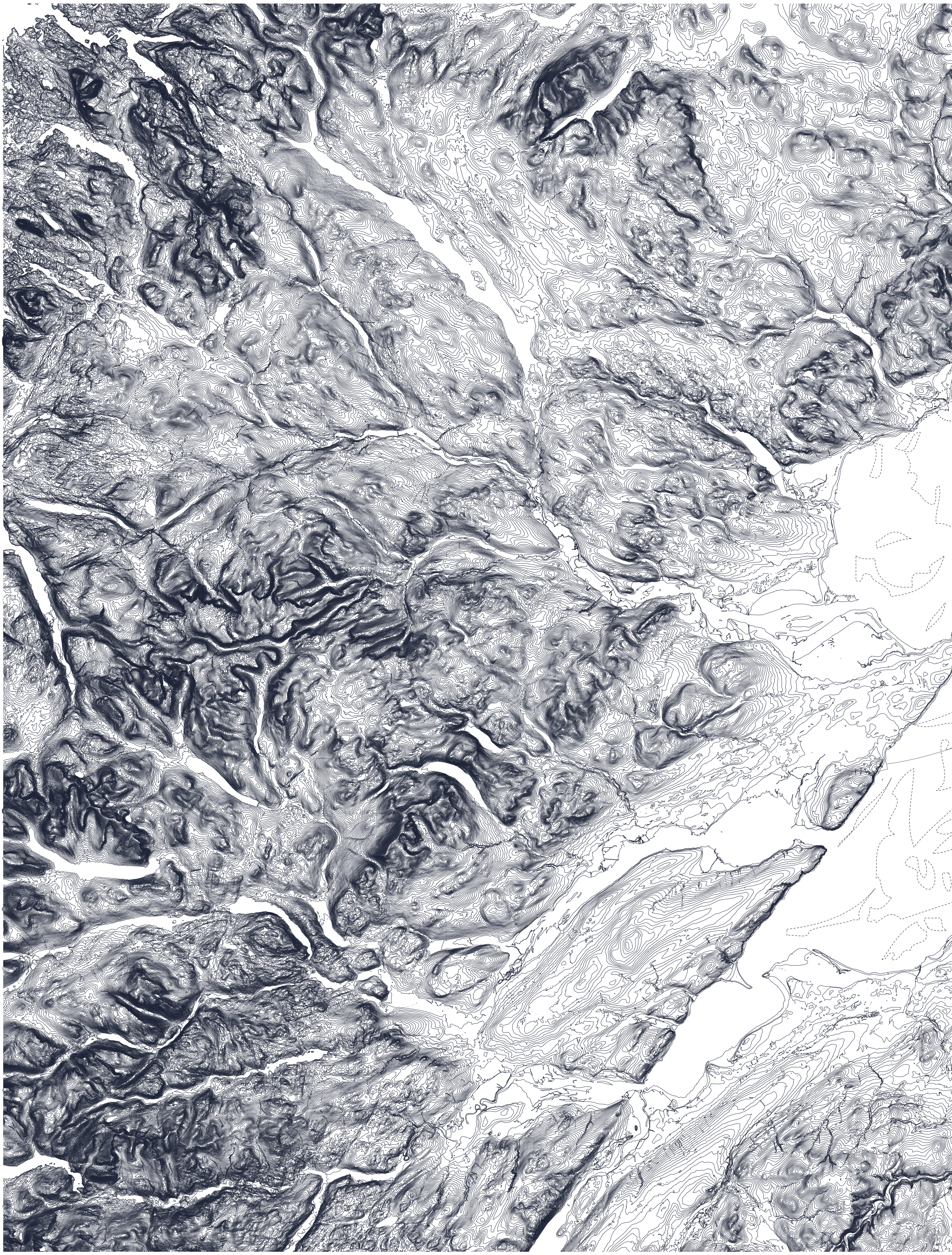
Moray Firth currently hosts 2 demo offshore wind turbines in an existing oil field: Beatrice. The field is being decommissioned and will be replaced by the Beatrice offshore wind farm (588MW), alongside Moray East (952MW) and Moray West (1116MW) offshore wind farms. The mammoth projects will have a combined electrical output of 2656MW.

The field has an existing export cable that lands in Dunbeath, Sutherland. This has been used as a starting point for the analysis; focusing on the region and its landscape potentials, two river-side towns that have water infrastructures connecting to large lochs reside further down the coastline. These villages are called Helmsdale and Brora, the latter being the southernmost settlement. These three settlements, along with Loch Nan Clar, established a triangle of 'intervention'.

Moray Firth, Highlands, Scotland

1:500000

- Beatrice oil platforms
- oil pipeline landing point
- Beatrice demo wind turibines
- Dunbeath; cable landing point
- export cable
- planned Moray West offshore windfarm (1116MW)
- planned Moray East offshore windfarm (952MW)
- planned Beatrice offshore windfarm (588MW)
- Brora; proposed Moray West cable landing point
- proposed export cable



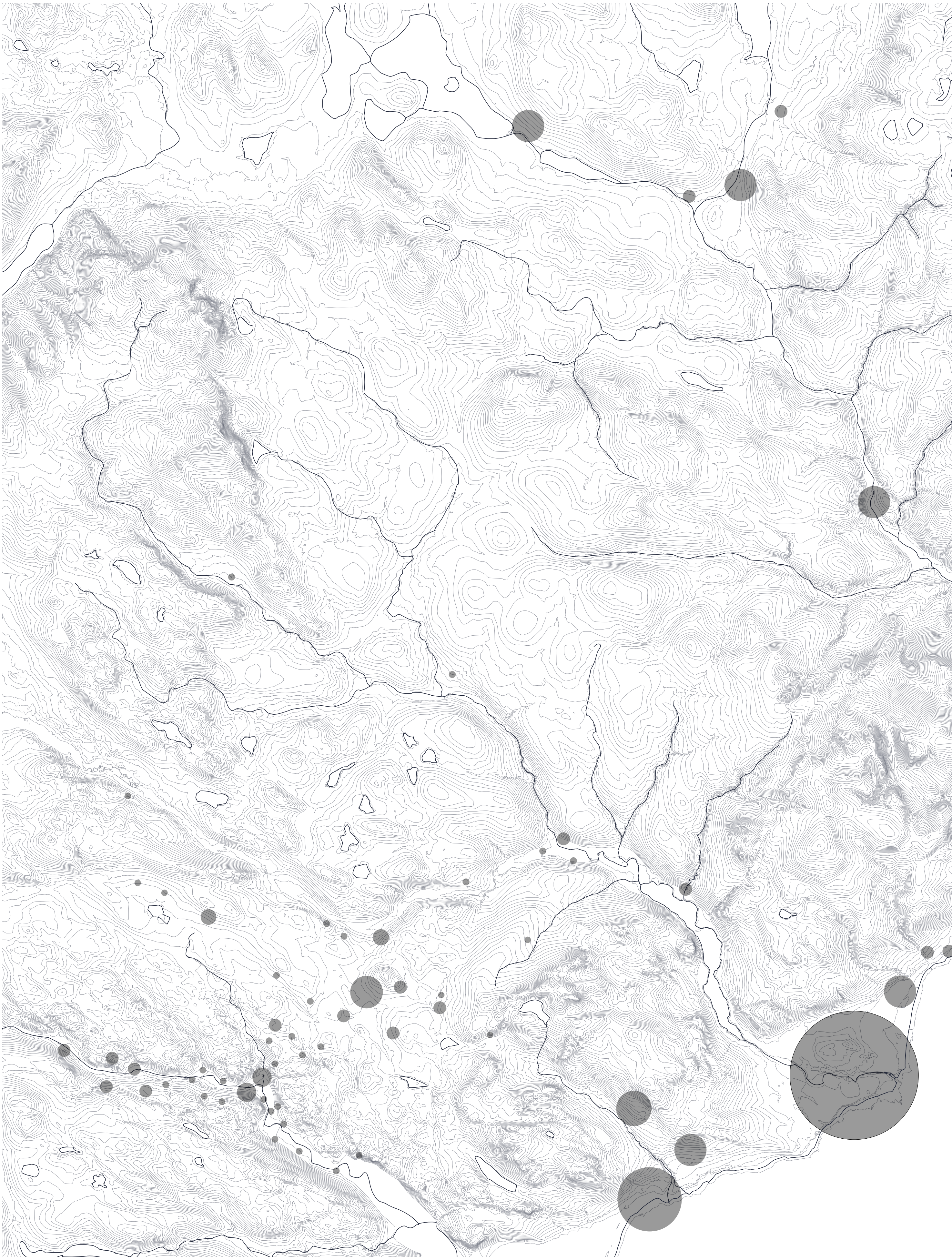
Early on in the analysis, it was decided that the project research should include a large water body. This is because the 'weak link' in renewable wind energy generation - the Highlands' natural talent besides hydroelectricity - is its intermittency. In other words, electrical output does not always 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

1:250000

● existing settlements
— major rivers and streams

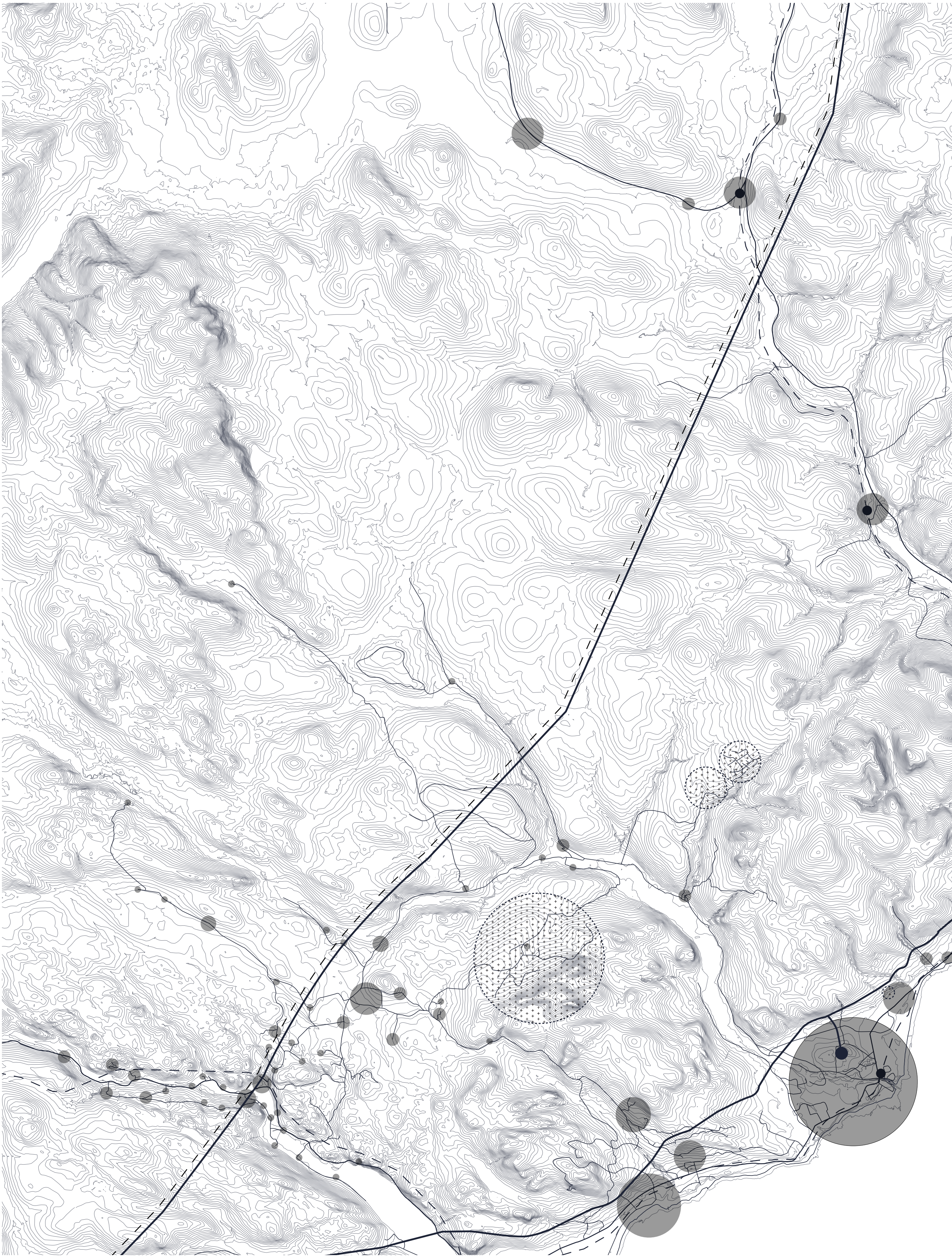


In addition to analysing the regions' existing natural infrastructures, the areas man-made infrastructures were also mapped in order to effectively develop three energy scenarios. Firstly, the grid infrastructure was analysed. A 132kV transmission line currently runs through the three sea-side towns, 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 where established.

Sutherland electrical grid and transport infrastructure

1:250000

- existing settlements
- railway station
- railway
- roads
- existing and planned windfarms
- existing power cable
- 132kV sub-station
- 132kV distribution line
- 275kV transmission line



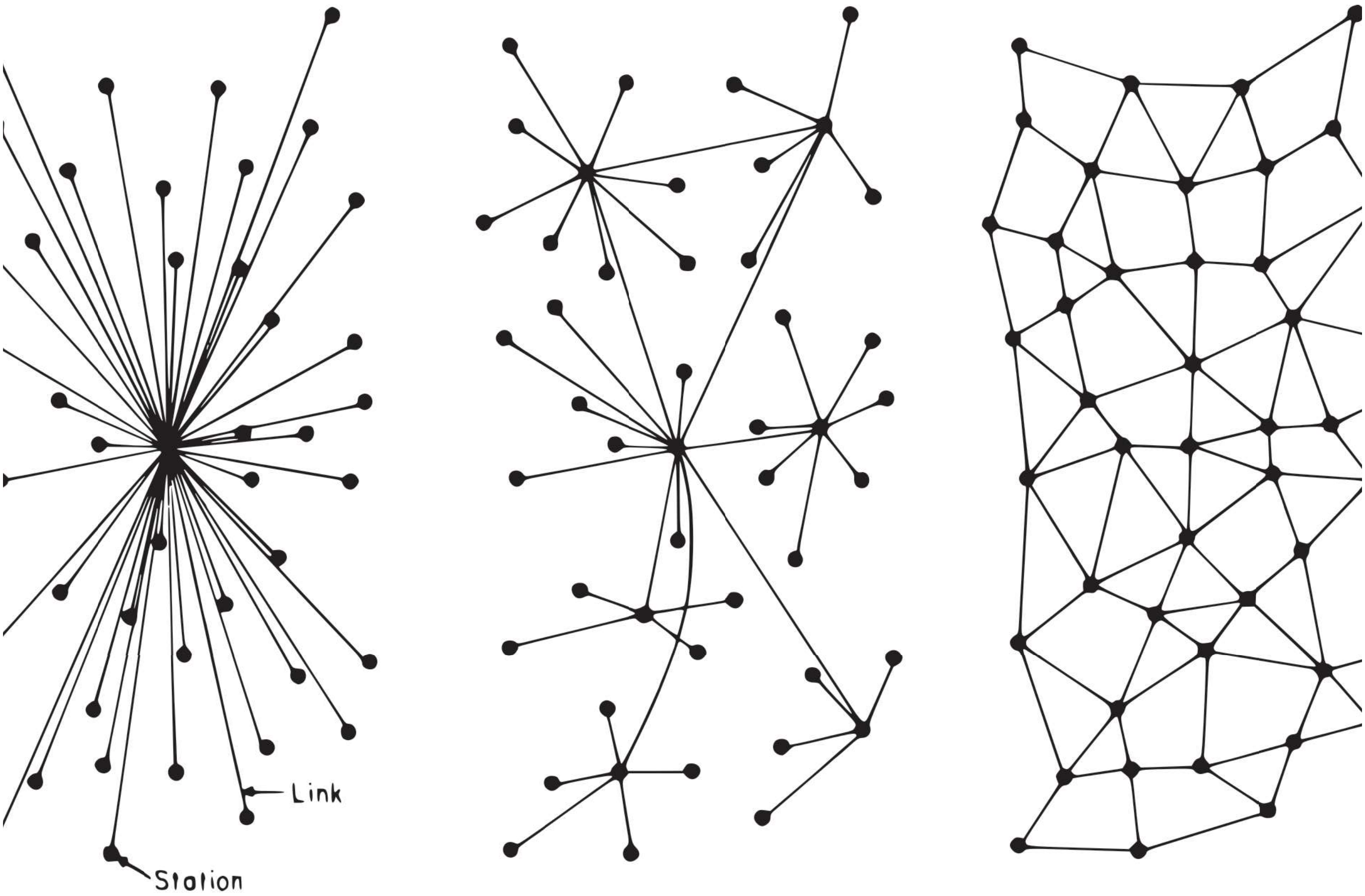
In order to avoid redundancy in the system due to temporal stresses, it is important to understanding the electrical infrastructure as a complex and open system.

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

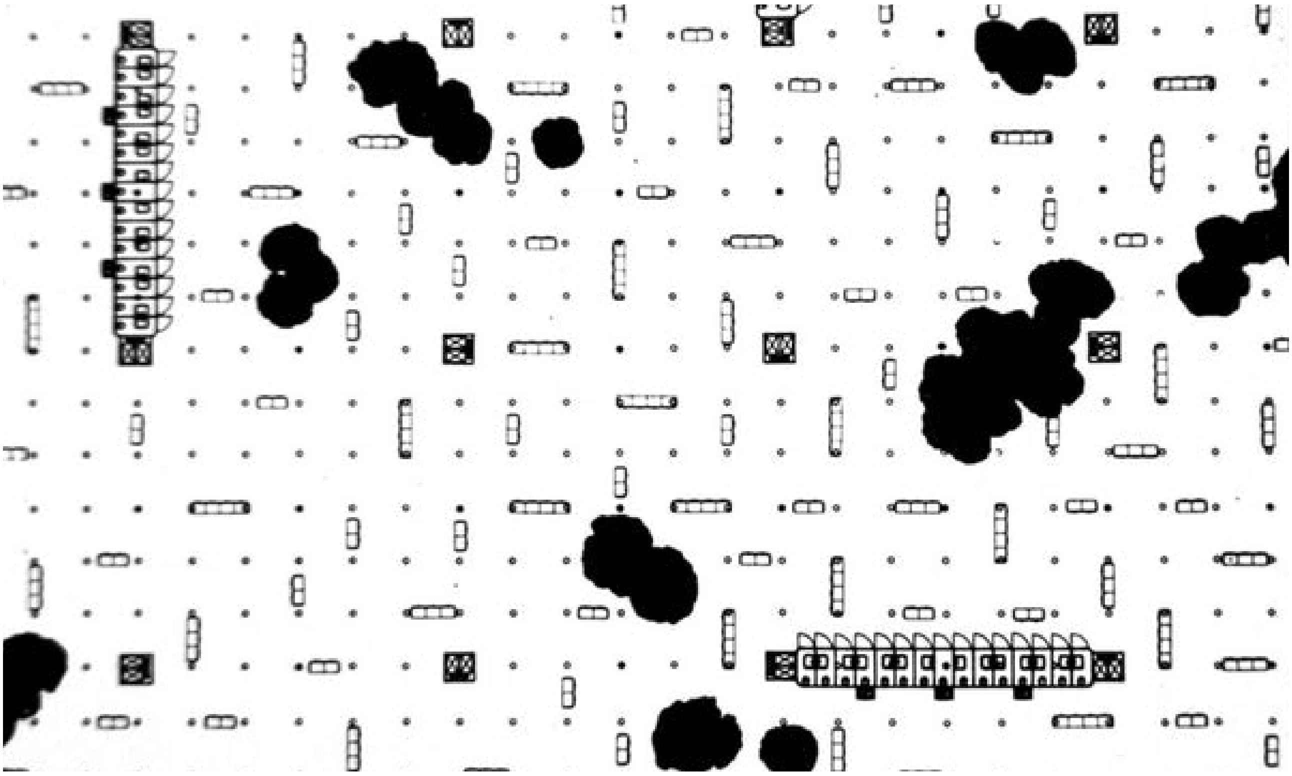
Walter Christaller



CENTRALIZED
(A)

DECENTRALIZED
(B)

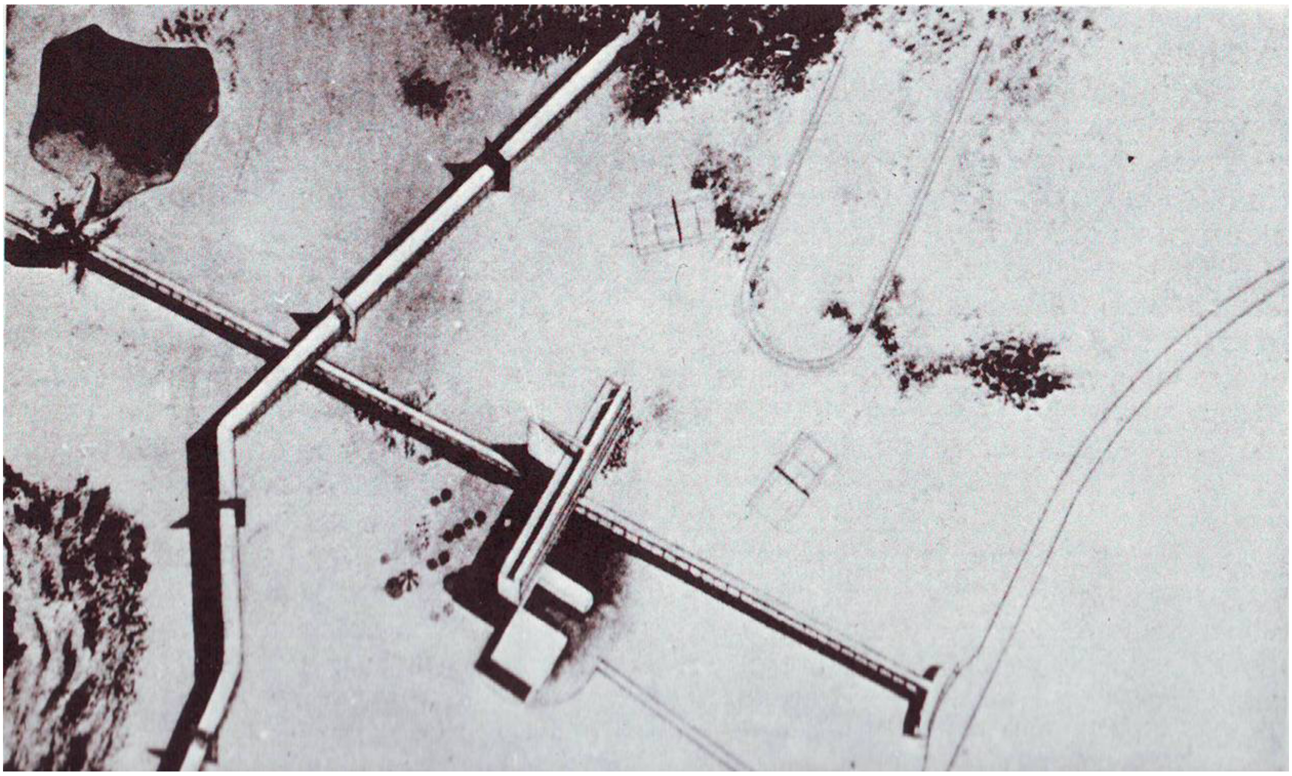
DISTRIBUTED
(C)



No-Stop City

Archizoom

"The No-stop City is an instrument of emancipation"



Green City, 1930

Mikhail Barsch and Moisei Ginzburg, Disurbanist School

"the total liberation of humanity from the chain of the past could not be accomplished without suppressing the antithesis between city and country."

The following scenarios are centred around five rules of growth, prioritised respectively: *existing infrastructure; density; slopes; water; and places of higher attraction.* New settlements are placed on slopes to avoid flooding, which is predicted to rise in the future with climate change. Furthermore, the chosen slopes allow for buildings with north-south orientation, to provide better internal environment conditions.

This centralised scenario is characterised by:

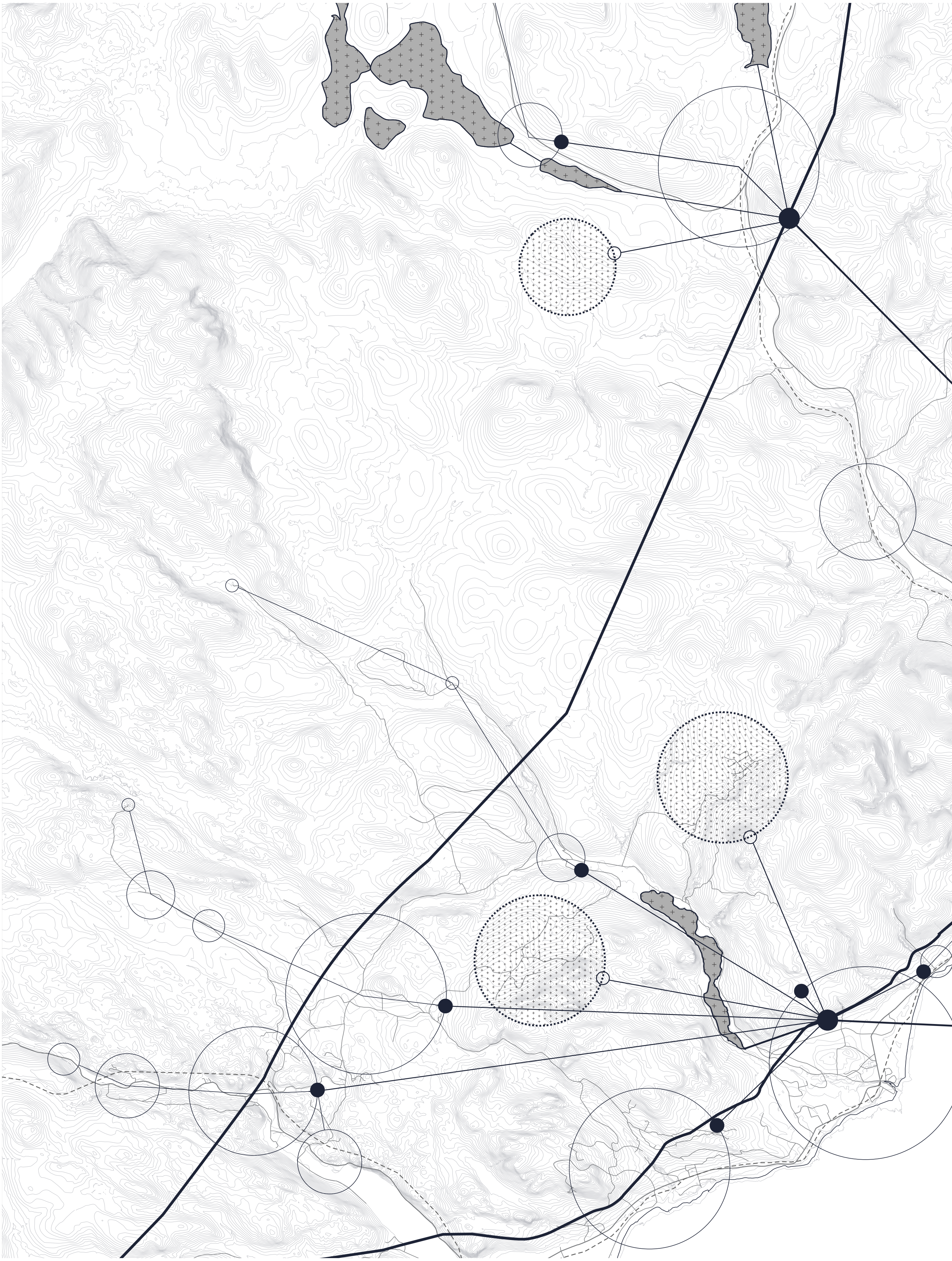
i. An offshore landing point in Brora, connecting its sub-station to Moray West.
ii. The densification of existing settlements.
iii. The decommissioning of small, decentralised wind turbines and the building of new large onshore wind farms.

Scenario A: centralised

1:250000

○ settlements
--- railway
— roads
● terrestrial wind farms
● pumped electrical storage

● sub-station
▬ 400kV tranmission line
— distribution line
— low voltage distriubution line



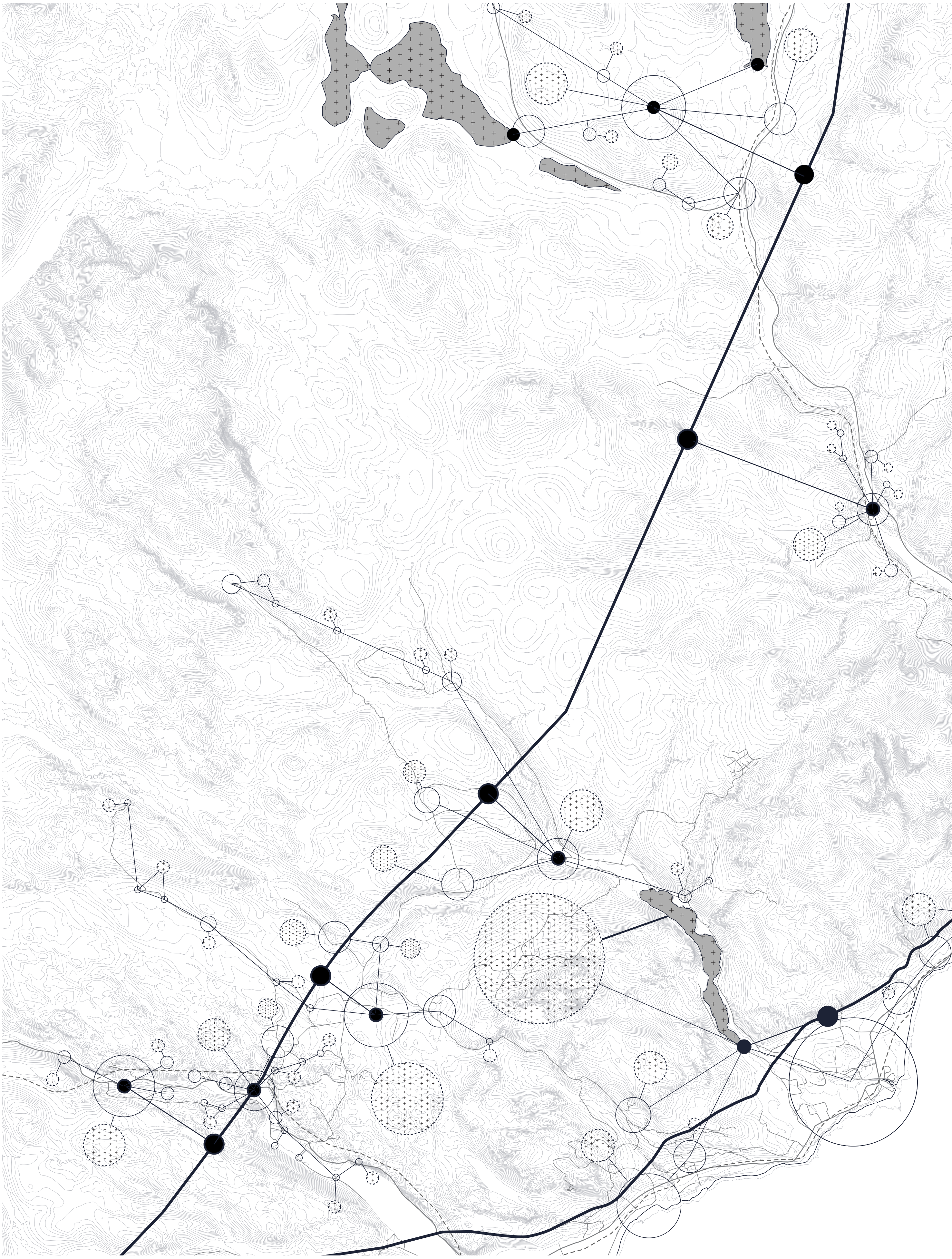
This decentralised scenario is characterised by:

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 RET.

Scenario B: Decentralised

1:250000

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



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

1:250000

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

II.I Problem Statement + Research Question

Problem Statement

To reiterate *IABR:2050 – An Energetic Odyssey* proposal as a baseline for the project's research, centralised offshore wind farms could potentially meet roughly half of the North Sea countries' energy demands by 2050. The spatial implications of this are understood, with almost 20% of the sea's surface being devoted to this mammoth project. Further-to-this, it is expected that a terrestrial patchwork infrastructure of centralised and decentralised RETs will cover the remaining 50% of electrical demands. We can speculate that dense urban areas have limited spatial capacity to accommodate these systems; this thesis therefore hypothesises that many large-scale renewable incentives will occur in low density peri-urban and rural landscapes.

This therefore begs the question: what spatial and infrastructural implications will the energy transition have through the production of energy landscapes? With this in mind, what is the role of the designer? It is not in quantitative engineering; I believe that it is extensive planning and qualitative design integration, to ensure the morphological amelioration of our landscapes. This thesis will reflect on this through the notions (or design lenses) highlighted below, using 'research by design' through scenario building to investigate how an efficient and effective spatial order can be achieved through transcalar design:

Landscape Infrastructure

By connecting decentralised RETs within the electrical grid, a new spatial order will arise: one of energy landscapes. This requires a dialectic relationship between the RETs, their supporting infrastructure and the receiving landscape: the landscape becomes part of the infrastructure.

Multi-functionality

Moreover, in order to ensure efficient use of space in an ever-increasingly urbanised world, the use of a multi-functional landscape infrastructure, that is a hydro-electric infrastructure, will endeavoured to be used if possible.

Landscape Morphology as Urban Morphology

With this in mind, the perceptive cultural divide between 'urban' and 'landscape' is challenged; landscapes cease being an unseen resource highway and backdrop to urban life. Rather it is seen as part of urbanisation, one which is more ecologically and temporally sensitive.

Infrastructural Scale Research Question

Can the energy transition in the Scottish highlands result in a new spatial order, which is characterised as an energy landscape that uses the landscape's characteristics to support its infrastructural quality?

Sub-questions

i. Can research by design through scenario building result in a multifunctional infrastructure that blurs the boundaries between the 'urban' and 'landscape' and respond to upcoming climate change stresses?

ii. By establishing critical physical requirements in the network, which have both technical function and architectural requirements, can a categorised design syntax – a system of knowledge – be developed that conflates with the region's site-specific geographical potentials?

iii. Can a qualitative symbiotic relationship between the infrastructure's architectural space, the locality's habitable space and the site's topography be achieved through the agency of design?

Quantity over Quality

Manipulated image

John Robert Cozens, 1783-1788

III References

Endnotes

[1] Dirk Sijmons, *Landscape and Energy – Designing Transition* (Rotterdam: NAI Publishers, 2014), 10.

[2] Sijmons, *Landscape and Energy – Designing Transition*, 17.

[3] Walter Benjamin, *Reflections* (New York: Schocken, 1978).

[4] Ross Exo Adams, *Mare Magnum: Urbanisation of Land and Sea* (Ames: Iowa State University, 2017).

[5] IABR, "2050 – An Energetic Odyssey: the video", accessed December 24, 2018, https://iabr.nl/en/film/2050_webvideo

[6] Architizer, "Retrospective: Archizoom And No-Stop City", accessed November 5, 2018, https://architizer.com/blog/practice/details/archizoom-retrospective/

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