Nordic Council of Ministers

Nordic Cities and GHG Emissions Reduction

Aligning with the UNFCCC COP29 Mitigation Work Programme for Climate-Resilient Urban Development

Contents

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1. Introduction

Cities are at the forefront of global climate change efforts, contributing to approximately 70% of global greenhouse gas (GHG) emissions as of 2020, according to the IPCC.[1] Rapid urban population growth, land expansion, and the increasing demands of urban infrastructure are driving these emissions. By 2050,[2] cities will house 70% of the global population, with The United Nations estimating that urban infrastructure equivalent to the size of the Swedish capital Stockholm will be constructed weekly until 2050, underscoring the importance of sustainable construction practices. This highlights the critical need for sustainable urban development practices.

Urban areas are not only major GHG contributors but are also highly vulnerable to climate extremes like heatwaves. The Intergovernmental Panel on Climate Change (IPCC[3]) has emphasized that achieving net-zero emissions will require deep decarbonization and systemic transformation of cities. Addressing GHG emissions in buildings and urban infrastructure involves the integration of low-carbon materials, energy efficiency measures, and resilient design practices. This report focuses on key solutions to urban emissions, presented through the lens of the 2024 dialogue of the Sharm el-Sheikh mitigation ambition and implementation work programme (Mitigation Work Programme, MWP) for COP29 in line with the overarching theme of "Cities; Building and Urban System" and its three primary sub-themes: Spatial Planning and Low-Carbon Infrastructure, Electrification and Net-Zero Energy Sources, Enhancing Carbon Storage through Green and Blue Infrastructure, and Circular Economy in the Built Environment. While circular economy practices are not explicitly outlined in the MWP, their inclusion reflects the increasing recognition of their importance in promoting resource efficiency, waste reduction, and sustainable urban development. The Nordic experience, as shared during COP29, provides an exemplary framework for addressing these challenges.

Presented at COP29, this report draws on insights from a comprehensive consultation process funded by the Nordic Council of Ministers and conducted by Arup. Engaging over 500 stakeholders across academia, municipalities, industry, and supply chains, this process involved a series of workshops designed to capture a diverse range of views. This report emphasizes the unique Nordic context, detailing

1. IPCC, 2023: Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647 IPCC_AR6_SYR_LongerReport.pdf
2. Urban Development Overview (worldbank.org)
3. IPCC_AR6_WGIII_Chapter08.pdf

both the challenges and opportunities in implementing sustainable urban practices.

The insights and recommendations presented reflect participant contributions, though they do not necessarily represent the views of the Nordic Council of Ministers or member governments. The Nordic Council of Ministers, intergovernmental forum, complement the Nordic Council, inter-parliamentary forum, to promote cooperation among Denmark, Finland, Iceland, Norway, Sweden, Greenland, The Faroe Islands and Åland, aligning with the Nordic Vision 2030[4]: to become the most sustainable and integrated region in the world by 2030. Representatives from all five countries participated in the project's steering group led by the Nordic Visions' project Climate transition in the Nordics and the Working Group for Climate and Air under the Nordic Council of Ministers (NCM), contributing contacts, relevant documents, and feedback. Several of the steering group members also participated in the focus groups.

1.1 Report Structure Overview

This report is structured around four main areas:

1. Spatial Planning and Low-Carbon Infrastructure
2. Electrification and Switching to Net-Zero Emission Resources
3. Enhancing Carbon Storage through Green and Blue Infrastructure
4. Circular Economy in the Built Environment

These topic areas were dictated by the 2024 Mitigation Work Programme (MWP) for COP29, with the additional inclusion of considerations regarding the circular economy. Each section provides a comprehensive examination of critical components related to the transition toward sustainable urban development in the Nordic countries.

1. **Main Findings**
   Each section begins with the main findings relevant to the topic area, highlighting current trends, challenges, and insights derived from research and expert opinions.
2. **Opportunities and Best Practices**
   This chapter offers an overview of best practices and opportunities for implementing sustainable strategies at both national and local levels. It addresses key areas such as spatial planning, electrification, and carbon storage, showcasing successful initiatives and potential pathways for advancement.
3. **Main Barriers**

4. Our Vision 2030 | Nordic cooperation (norden.org)

The report discusses the significant challenges cities face when transitioning to low-carbon infrastructure. Key barriers include balancing urban growth with environmental protection, misconceptions about the quality of circular practices, and fragmented regulations. It emphasizes the need for collaborative approaches, robust Life-Cycle Analysis (LCA), and cohesive strategies to overcome these obstacles.

4. **Recommendations**
   Tailored recommendations are presented to enhance the development and implementation of climate policies in the Nordic countries. These are organized by the levels of governance – national, regional, and local – highlighting the necessity for coordinated action to achieve deep decarbonization and meet the unique needs of various communities.

By following this structure, the report aims to provide a holistic view of the challenges and opportunities in advancing sustainable urban development while contributing to the overarching goals of the MWP for COP29.

Photo: Mads Schmidt Rasmussen/norden.org

2. Nordic context

The Nordic countries have distinguished themselves through their ambitious emission reduction goals and actions, demonstrating a strong commitment to a sustainable, low-carbon future. Each nation has outlined bold plans for the coming decades, going beyond many global targets to set even higher standards. For example, while the EU aims for a 40% reduction in emissions by 2030 (from 1990 levels), many Nordic countries have set even more aggressive targets.[5] The Danish government has proposed to move the net zero target forward to 2045 and set a new net-negative target of 110% in 2050. Iceland is aiming for carbon neutrality by 2040, Finland by 2035, and Sweden has committed to reaching net zero emissions by 2045. Norway's carbon neutrality by 2030 is particularly remarkable, as it involves offsetting any remaining greenhouse gas emissions by investing in projects like renewable energy initiatives abroad.[6]

However, beyond these national commitments, many Nordic cities have developed progressive and highly ambitious climate plans that surpass even these national targets. Cities like Copenhagen, Oslo, and Helsinki have been at the forefront of climate action over the past decade, driving innovation in sustainable urban development, transportation, and energy use. For example, Copenhagen has committed to becoming the world's first carbon-neutral capital by 2025[7] in energy production and usage, through initiatives like expanding district heating systems, investing in offshore wind farms, and promoting cycling as the primary mode of transport. Meanwhile, Oslo's climate budget has set a framework for the city to halve its emissions by 2023, with a strong focus on electrification of transportation and emission-free construction sites. These city-level plans are often more target-oriented and adaptable, responding directly to local challenges and opportunities. They offer a roadmap that is both pragmatic and visionary, setting milestones that not only align with but often exceed national goals. The successes of these cities demonstrate the critical role urban centers play in accelerating the transition to a low-carbon economy, and they offer scalable models for other regions to follow.

These national and city based strategies are not only ambitious but also deeply interconnected with efforts to enhance urban sustainability. As we transition to discussing the Mitigation Work Programme (MWP) topic for 2024 focusing on Cities: Buildings and Urban Systems the Nordic countries' national targets have

5. Policy Brief: Nordic Stocktake and Visions – Pathways to Climate Neutrality (norden.org)
6. Norway's eighth national communication (regjeringen.no), https://pub.norden.org/temanord2023-545/index.html
7. Copenhagen – CNCA (carbonneutralcities.org)

significant implications for urban planning and infrastructure. Nordic countries are embedding their emission reduction goals into urban planning by developing low-carbon infrastructure, such as energy-efficient buildings and green spaces, to enhance quality of life and cut emissions. Central to these efforts is the electrification of urban systems and a shift to net-zero emission resources like renewable energy. For example, the City of Copenhagen's 2035 Climate Plan[8] aims to extend the goal from the 2025 climate plan, becoming climate positive on energy production and usage and additionally halve the carbon emissions from citizens by 2035. The plan includes initiatives like retrofitting buildings for energy efficiency, expanding cycling infrastructure, and increasing the use of renewable energy sources, such as wind and solar power. It should be noted that 2035 Climate Plan is an update on the previously ambitious target from Copenhagen in their 2025 Climate Plan to reach carbon neutrality by 2025,[9] but further extending the challenge by introducing scope 3 emissions for citizens and becoming energy positive.

Additionally, many Nordic cities are investing in green and blue infrastructure – such as parks, green roofs, and wetlands – to boost carbon storage and urban resilience. A notable initiative is Oslo's policy called the Blue-Green Factor (Blågrønn Faktor), [10] which requires new developments to include both green and blue infrastructure elements such as green roofs, water features, and permeable surfaces that enhance stormwater management and improve urban biodiversity. High energy and carbon taxes in the Nordics further support the transition to renewable energy and sustainable practices, such as Iceland's carbon tax and Climate Action Plan[11] focusing on reducing emissions from transportation and promoting renewable energy, primarily geothermal and hydropower, and promoting energy-efficient buildings and electric vehicles. Similarly, Sweden's Climate Law and carbon tax,[12] which is one of the highest in the world, has been pivotal in reducing greenhouse gas emissions. The tax incentivizes industries and individuals to transition to renewable energy and adopt more sustainable practices.

By integrating these national targets with city planning, the Nordic countries demonstrate a holistic approach to climate goals and urban development. They encompass a wide array of measures, from tangible funding mechanisms for hard infrastructure to knowledge networking exchanges and practical tools or "urban labs" for experimentation. One example is through projects like Helsinki's Carbon-neutral 2035 plan[13] which involves a range of measures, including promoting energy-efficient construction, transitioning to electric public transportation, and enhancing green spaces throughout the city. One specific project is the

8. Climate Plan 2035 | Urban Development (kk.dk)
9. The CPH 2025 Climate Plan | Urban Development (kk.dk)
10. 202308_Vervoort_-Green-roofs-in-Oslo-by-2030_-understand-their-impacts-through-life-cycle-assessment.pdf (urbag.eu)
11. Government of Iceland | Climate Change
12. Sweden's carbon tax - Government.se
13. Carbon_neutral_Helsinki_Action_Plan_1503019_EN.pdf (carbonneutralcities.org)

redevelopment of the Kalasatama district,[14] a smart city project that integrates sustainable building practices and energy-efficient technologies.

And finally, although not explicitly included in the MWP, the incorporation of circular economy principles recognizes the importance of resource efficiency and waste reduction in urban development. The circular economy has emerged as a crucial component in the Nordic countries' approach to sustainability. Circular economy practices focus on maximizing resource use throughout the lifecycle of materials, promoting reuse, recycling, and reducing waste, which aligns well with the region's climate goals. As cities seek to transition to low-carbon infrastructures, integrating circular economy strategies can significantly enhance the effectiveness of existing policies and practices. For example, the perception that new construction is superior to circular practices, like reuse and modular building, often hinders progress. This challenge underscores the need for standardized regulations that prioritize functionality over prescriptive details and advocate for a cultural shift towards sustainable building practices. By fostering collaboration among stakeholders and emphasizing life-cycle analysis (LCA) in decision-making, Nordic cities can better evaluate the environmental impact of construction and embrace more sustainable solutions.

Photo: Yadid Levy/norden.org

14. Smart Kalasatama - Smart City District of Helsinki | Knowledge Hub | Circle Economy Foundation (circle-economy.com)

3. Spatial Planning and Low-Carbon Infrastructure

3.1 Main findings

The Nordic region emphasizes spatial planning as a key strategy for achieving low-carbon urban development, integrating environmental considerations into urban planning to reduce emissions and improve quality of life. Key approaches include compact, mixed-use urban designs that promote sustainable mobility and improve public health, as exemplified by Bergen's smart mobility hubs[15] and Oslo's electrification of public transport.[16] Digital tools also enhance energy efficiency and sustainability, as seen in Helsinki's Kalasatama[17] district. Nordic cities lead in low-carbon construction, with modular and adaptable buildings cutting emissions by up to 60% and progressive use of low-carbon materials, showcased by Gothenburg's Hoppet[18] preschool and Norway's Mjøstårnet[19] tower. In addition, The Centre for Public-Private Innovation (CO-PI[20]) plays a crucial role in Copenhagen by fostering these advancements by driving collaboration between public and private sectors across Denmark to develop innovative solutions for societal challenges, including sustainable construction. Challenges remain, including balancing urban growth with environmental protection, retrofitting infrastructure, overcoming misconceptions about modular construction, and navigating fragmented regulations and rigid building codes. Nonetheless, progressive national strategies, such as Denmark's forthcoming stricter CO_2 limits for new buildings declining from twelve kg/m^2/per year until 7.1 kg/m^2/year on average in 2025,[21] continue to push sustainability forward.

3.2 Opportunities and best practices

The Nordic region prioritizes spatial planning to achieve low-carbon urban development.[22] By integrating urban planning with environmental considerations, many Nordic cities reduce emissions and enhance residents' quality of life.

15. Smart Mobility | Nordic Smart City Network (nscn.eu)
16. Oslo's 'Climate Budget' Is Building a Cleaner City | World Resources Institute (wri.org)
17. Smart Kalasatama | Nordic Smart City Network (nscn.eu)
18. Hoppet - Sweden's first fossil-free preschool | News - Smart City Sweden
19. Mjøstårnet (moelven.com)
20. Together for emission-free work machines – Centre for Public-Private Innovation (co-pi.dk)
21. Danish Political Agreement Tightens the Limit Values for New Buildings and Extends the Impact | Nordic Sustainable Construction
22. Nordic Declaration on Low Carbon Construction and Circular Principles in the Construction Sector | Nordic cooperation (norden.org)

- **Compact and Mixed-Use Development:** Many Nordic cities focus on compact, mixed-use urban forms to reduce transportation needs and promote sustainable mobility options like cycling and walking. This approach enhances public health through increased physical activity, improves air quality by reducing vehicle emissions, lowers energy bills, and creates jobs in local businesses and services.

  Case study: Smart Mobility (Bergen, Norway)[23]
  Mobility hubs in Bergen integrate car-sharing stations with public transport, bike routes, bike parking, real-time transport info, and pedestrian access. The city opened its first hub in Møllendal in May 2018, marking the first of its kind in Norway. Currently, nine more hubs are being planned or implemented, each featuring car-sharing spaces, bike parking, pedestrian access, and proximity to public transport. The hubs are customized to fit local needs, such as including underground trash collection and rentable bike hangers in Møllenpris.

- **Public Transport and Active Mobility:** Investment in reliable, low-emission public transport systems and pedestrian infrastructure has significantly cut urban transport emissions. These investments contribute to better public health by reducing air pollution, improve air quality in urban areas, decrease household energy bills by reducing expenses (such as reliance on private vehicles), and generate employment opportunities in the transport and infrastructure sectors.

  Case study: City of Oslo (Norway)[24]
  Oslo drives widespread electrification of public buses, trams, ferries, private delivery vehicles, and heavy-duty construction machinery through public procurement and incentives. The city has implemented variable congestion charges targeting diesel vehicles and incentivizes contractors to use electric machinery in municipal projects. Oslo also promotes sustainable transport by adding 100 kilometers of cycling lanes, leading to a 51% increase in cycling since 2016, while also reducing street-side parking, converting them into bike lanes. Street transformations have made walking and cycling safer, with significantly reduced pedestrian and cyclist deaths. Additionally, electric charging stations are widely available for private vehicles.

- **Smart Cities and Digitalization:** The region invests in using digital tools for smart urban planning, optimizing energy use, and improving efficiency. This digitalization supports enhanced public health through improved environmental monitoring, better air quality from optimized energy systems, reduced energy bills due to efficient resource use, and job creation in the technology and data analytics sectors.

23. Smart Mobility | Nordic Smart City Network (nscn.eu)
24. Oslo's 'Climate Budget' Is Building a Cleaner City | World Resources Institute (wri.org)

Case study: Smart Kalasatma (Helsinki, Finland)[25]
Kalasatama, a former brownfield district in Helsinki, was transformed into an experimental innovation platform from 2013, co-creating urban infrastructure and services with local stakeholders. The district actively promotes the sharing economy, with residents using digital applications to share cars and parking spaces. Smart locks in new buildings allow flexible use of various spaces for different activities. Kalasatama also features a smart grid that supports real-time smart metering, electric vehicle networks, and new electricity storage solutions. The area is powered by a solar plant and connected to an energy-efficient district heating and cooling grid.

- **Integrated Spatial Planning:** Strategies such as high-density residential and job areas, mixed land use, and transit-oriented development (TOD) can reduce GHG emissions by more than 20% by 2050. These planning strategies improve public health by lowering pollution levels, enhance air quality, reduce energy bills, and create jobs in construction, urban planning, and local businesses.

  Case study: Västra Hamnen (Malmö, Sweden)[26]
  Västra Hamnen is a model for integrated spatial planning with high-density residential and job areas, mixed land use, and transit-oriented development (TOD). The district features a mix of residential, commercial, and office spaces, encouraging walking and cycling. It is well-served by public transport, reducing car dependency. These planning strategies improve public health, enhance air quality, lower energy bills, and create jobs in construction and local businesses.

- **Modular and Adaptable Buildings:** Modular and adaptable buildings are key to reducing carbon footprints. By designing structures that can be relocated and reused, emissions can be cut by up to 60% compared to permanent buildings, with reuse potentially reducing footprints by 90–92%. This approach improves public health by decreasing construction-related pollution, enhances air quality, lowers energy bills through efficient use of materials, and generates jobs in modular construction and design.

  Case Study: Rikshospitalet (Oslo, Norway)
  The company Adapteo provided a modular building floor on the roof of an existing hospital to allow for more office space. The retrofit can be relocated and reused, offer up to 60% lower carbon footprints compared to permanent structures. Reusing these modules can cut the footprint by 90–92%.

- **Low carbon buildings materials:** Many Nordic cities are leading the way in adopting low-carbon building materials to advance sustainable construction

25. Smart Kalasatama | Nordic Smart City Network (nscn.eu)
26. Västra Hamnen - Innovative district in Malmö | GuidebookSweden (guidebook-sweden.com)

practices. By using innovative, low-impact materials and techniques, these cities significantly reduce the climate impact of their buildings. This approach not only lowers the carbon footprint of construction but also enhances public health through reduced pollution, improves air quality, and cuts energy bills due to more efficient buildings. Additionally, it creates job opportunities in the sustainable building sector and supports the development of eco-friendly urban environments.

Case Study: Gothenburg's Hoppet preschool (Gothenburg, Sweden)[27]
Gothenburg's Hoppet preschool, Sweden's first nearly fossil-free building, exemplifies advancements in sustainable construction. Completed in 2021, it welcomes 144 children and reduces the climate impact of building materials by 70% compared to traditional methods. This was achieved through conscious material choices and careful planning. Supported by the EU's Northern Connection project, 27 suppliers from five countries contributed innovative solutions. The building features low-carbon materials, reused products, and locally sourced wood, showcasing the potential of fossil-free construction without compromising quality.

Case Study: Mjøstårnet (Brumunddal, Norway)[28]
Mjøstårnet, completed in March 2019, is the world's tallest timber building at 85.4 meters. Located in Brumunddal, near Oslo, this 18-storey tower symbolizes sustainable construction using local materials. It houses a hotel, apartments, offices, a restaurant, and a wooden swimming hall. Built with glulam and Cross Laminated Timber (CLT) by Moelven Limtre, Mjøstårnet holds a Guinness World Record and has received multiple awards, including the New York Design Awards and Council on Tall Buildings and Urban Habitat's (CTBUH) Award of Excellence.

Case Study: Fyrstikkbakken 14 (Oslo, Norway)[29]
Fyrstikkbakken 14 is built in CLT and low-carbon concrete and has an energy consumption in operation that corresponds to a minimum of near-zero energy. In total, the reduction of GHG is 53% compared to a business-as-usual reference building. The housing project experiments with new forms of housing, and is particularly known for the concept of dividing meters – square meters you share with others.

- **Progressive National building strategies:** Nordic countries are advancing national building strategies to enhance sustainability and reduce carbon emissions in the construction sector. These strategies typically include stricter CO_2e limits for new buildings, with progressive targets that tighten over time. By implementing rigorous standards and emission limits, these

27. Hoppet - Sweden's first fossil-free preschool | News - Smart City Sweden
28. Mjøstårnet (moelven.com)
29. https://www.futurebuilt.no/Forbildeprosjekter#!/Forbildeprosjekter/Fyrstikkbakken-14

countries aim to significantly improve climate performance across a substantial portion of new constructions. This approach helps reduce construction-related emissions, improve air quality, lower energy bills through more efficient building practices, and create jobs in the green construction sector.

Case Study: Denmark National Strategy for Sustainable Construction (Denmark)[30]

Starting in July 2025, Denmark will enforce a stricter CO_2e limit of 7.1 kg CO_2e/m^2/year on average for new buildings, exceeding the 2021 strategy targets. The agreement introduces varied limits for different building types and also includes limitation on emissions from the construction phase. For example, large single-family homes will face progressively tighter limits, reaching 5.4 kg CO_2e/m^2/year by 2029. This ensures that 85% of new constructions will achieve better climate performance than in 2021.[31]

3.3 Main Barriers

Cities transitioning to low-carbon and sustainable infrastructure face considerable challenges in balancing urban growth with environmental protection. As urban areas expand, safeguarding natural landscapes while retrofitting existing infrastructure with low-carbon alternatives demands significant investment and coordination. Competing land uses often hinder the implementation of green and blue infrastructure, essential for enhancing urban ecosystems and carbon storage. Moreover, the long-term sustainability of these projects can be compromised by insufficient maintenance and a lack of community engagement, making it imperative for urban planners to prioritize these elements alongside infrastructure development.

3.4 Recommendations

1. **Facilitate National Knowledge Sharing Mechanisms**
    - Establish mechanisms for sharing best practices on climate policy implementation, with updates every two years.
    - Translate guides and resources for broader accessibility.
    - Organize national events for discussing challenges and successes in climate goals.

30. Danish Political Agreement Tightens the Limit Values for New Buildings and Extends the Impact | Nordic Sustainable Construction
31. https://www.futurebuilt.no/Forbildeprosjekter

2. **Integrate Accountability and Monitoring into Climate Policy**
    - Develop guidelines for incorporating climate considerations into major policy documents.
    - Create working groups to monitor climate-related targets in government initiatives.
3. **Utilize Data for Impact Assessments**
    - Allocate resources for gathering regional climate data to inform urban planning and decision-making.
4. **Support Climate-Responsive Infrastructure Planning**
    - Encourage climate-resilient infrastructure in local planning, aligning projects with national climate goals.
5. **Implement Compact, Mixed-Use Urban Development**
    - Focus on high-density, mixed-use urban areas to minimize transportation needs and promote sustainable mobility.

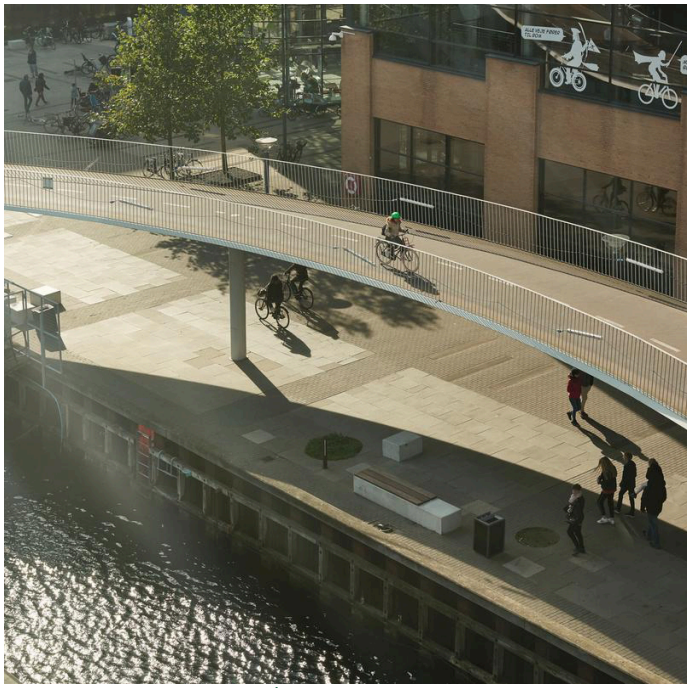

Photo: Ricky John Molloy/norden.org

4. Electrification and Switching to Net-Zero Emission Resources

4.1 Main findings

Nordic countries are at the forefront of transitioning to net-zero emission energy sources, with electrification playing a central role in urban decarbonization. Significant progress has been made in integrating renewable energy, such as Reykjavik's[32] geothermal district heating system, which powers 90% of the city's heating needs and contributes significantly to electricity generation. District heating and cooling systems, such as those used in Sweden's Sara Kulturhus[33] further reduce emissions by utilizing renewable energy and advanced technologies like AI. In the transport and construction sectors, cities like Oslo are rapidly decarbonizing through the adoption of electric machinery and emission-free construction policies made possible by the Norwegian state owned fond ENOVA[34] supporting purchases of emission-free machinery, as demonstrated by Oslo's emissions-free construction initiative and projects like Stovner Bad[35] and Miljøgate.[36] Heat pump technology also plays a crucial role in reducing reliance on fossil fuels, exemplified by Oslo's Tøyenbadet[37] swimming centre, which integrates renewable energy and water recycling. However, challenges remain, including the need for grid modernization to handle increased electrification and ensuring that the transition remains affordable and equitable for all.

4.2 Opportunities and best practices

Nordic countries lead in the transition to net-zero emission energy sources, including electrification, as a key strategy for urban decarbonization.

- **Renewable Energy Integration:** Significant progress has been made in integrating wind, and hydro, power, and geothermal energy into urban systems.

32. Green by Iceland - 90% of house heating in Iceland is geothermal! (islandsstofa.is)
33. Sara kulturhus's energy solution is sustainable and kind - Sara kulturhus
34. https://www.enova.no/om-enova/
35. Stovner Bad - Oslo Municipality
36. Anlegg Øst well underway with the electrical construction work at Gran | Norwegian Public Roads Administration (ntb.no)
37. New Tøyenbadet - Oslo municipality

Case study: Reykjavik's Geothermal District Heating System (Iceland)[38]
The geothermal district heating system in Reykjavik is a leading example of renewable energy integration. Geothermal energy not only provides 90% of the city's heating needs but also contributes 20–25% of Iceland's electricity generation. This extensive use of geothermal resources reduces reliance on fossil fuels, enhances energy efficiency, and improves air quality. The integration of geothermal energy into both heating and electricity systems significantly lowers greenhouse gas emissions, reduces energy bills for residents, and supports job creation in the renewable energy sector.[39][40]

- **District Heating and Cooling:** Adoption of district heating and cooling systems supplied by renewable energy has reduced building emissions.

Case study: Sara Kulturhus (Skellefteå, Sweden)[41]
The cultural centre "Sara Kulturhus" in the Swedish town Skellefteå is one of the world's tallest wooden buildings at 20 stories tall. The building features solar panels and batteries, and a heat pump system. Even the sprinkler system is powered by renewable energy. It uses AI technology optimizes building operations by analysing performance and external factors, ensuring maximum comfort and energy efficiency with minimal human intervention. Sara Kulturhus also shares excess electricity with the city and stores it in on-site batteries. All waste heat is reused, and the building operates on 100% renewable energy.

- **Electrification of Transport and Construction Equipment:** Rapid growth in electric vehicle adoption, supported by extensive charging infrastructure and incentives, facilitates the decarbonisation of urban transport and construction.

Case study: Oslo's Emissions-Free Construction Policy (Oslo, Norway)
Norway's capital city Oslo aims to make all municipal construction projects emission-free by 2025. Construction machinery accounts for nearly a fifth of the city's CO_2 emissions. To address this, Oslo requires zero-emission construction processes, including electric machinery and emission-free transport. Stovner Bad, a new swimming pool facility being built in Oslo, is a key example[42] using electric and biodiesel-powered equipment, with plans to be fully emission-free by 2025. This initiative supports Oslo's broader goal of reducing greenhouse gas emissions by 95% by 2030.

38. Green by Iceland - 90% of house heating in Iceland is geothermal! (islandsstofa.is)
39. https://www.government.is/topics/business-and-industry/energy/geothermal/
40. https://www.government.is/publications/reports/report/2022/10/06/The-State-and-Challenges-of-Energy-Affairs/
41. Sara kulturhus's energy solution is sustainable and kind - Sara kulturhus
42. Stovner Bad - Oslo Municipality

Case study: Miljøgate (Gran, Norway)[43]
Achieved 98% emission-free status, incorporating hydrogen charging tests. This project is the first in Norway where machine operators have access to a hydrogen-powered heavy-duty truck charger. The charger generates electricity without greenhouse gas emissions. The Norwegian Public Roads Administration and Hafslund are testing this hydrogen-powered charging point in the project.

Case study: Sophies Minde School (Oslo, Norway)[44]
The Sophies Minde project, converting an old clinic into a nursery and maternal health centre, is 100% emission-free. Thanks to The City of Oslo's climate policy, construction uses electric machinery and other methods to eliminate greenhouse gas emissions. This approach has significantly reduced noise and fossil fuel use, leading to improvements across various sectors and serving as a model for other cities.

- **Heat pumps:** Heat pump adoption, using them extensively for efficient heating and cooling. These systems, which transfer heat from air, ground, or water, reduce reliance on fossil fuels and lower emissions. Technological advancements, government incentives, and integration with renewable energy sources have driven their success, setting a model for other regions.

  Case study: Tøyenbadet (Oslo, Norway)[45]
  One of Norway's most modern and energy-efficient swimming centres. It features the use of environmentally friendly materials and recycling, including wood in parts of the building. The facility is being built as an energy-efficient passive house, incorporating heat pumps, energy wells, solar energy, and district heating. A blue-green roof will manage stormwater, enhance air quality, and boost biodiversity. The new swimming facility will also reuse treated rainwater for the pool, reducing reliance on the public water supply. Additionally, the construction site is fossil-free, utilizing only electric and biofuel-powered machinery.

4.3 Main Barriers

The transition toward electrification is a critical component of achieving net-zero emissions. However, cities must confront challenges related to grid capacity and stability to ensure that the infrastructure can support increased demand. Affordability and equity are also pressing concerns, as the transition can disproportionately affect low-income communities. Additionally, uncertainty

43. Anlegg Øst well underway with the electrical construction work at Gran | Norwegian Public Roads Administration (ntb.no)
44. Oslo's 'Climate Budget' Is Building a Cleaner City | World Resources Institute (wri.org)
45. New Tøyenbadet - Oslo municipality

regarding the future of carbon capture and negative emissions technologies adds complexity to the decarbonization process, necessitating cohesive strategies that integrate these technologies while addressing social and economic disparities.

4.4 Recommendations

1. **Invest in Nationwide Electrification and Renewable Energy Integration**
    - Increase investments in renewable energy sources and upgrade national grid capacity to meet electrification demands.
2. **Public Transport Electrification Policies**
    - Mandate public transport electrification by a specific year, with investment in infrastructure and zero-emission targets for heavy-duty vehicles.
3. **Decarbonize Local Public Transportation Systems**
    - Invest in electrified public transport while promoting cycling lanes and pedestrian infrastructure.
4. **Electrify Construction Equipment at Local Level**
    - Set local targets for zero-emission construction sites using electric or biodiesel-powered machinery.

Photo: Sigurður Ólafsson/norden.org

5. Enhancing Carbon Storage through Green and Blue Infrastructure

5.1 Main findings

Nordic cities are increasingly integrating green and blue infrastructure to enhance carbon storage, biodiversity, and climate resilience. Urban green spaces and forests, such as those in Stockholm's Hammarby Sjöstad,[46] help sequester carbon and mitigate heat islands, while blue infrastructure, exemplified by Oslo's River Renewal Project,[47] improves flood resilience and water quality. The use of bio-based building materials is also gaining traction, as seen in Denmark's Biological House *"Det Biologiske Hus"*,[48] which offers sustainable construction alternatives that contribute to carbon reduction. However, challenges like competing land use, maintenance needs, and regulatory barriers complicate implementation. Projects such as Heidelberg Cement's carbon capture and storage initiative and AquaGreen's biochar technology demonstrate the potential for industry-led innovations to drive sustainability. These technologies reduce CO_2 emissions, produce renewable energy, and enable more resource-efficient urban development. Key enablers for scaling these solutions include supportive policies, green financing, and community engagement, alongside short-term interventions like climate budgeting, preferred procurement practices, and design competitions.

5.2 Opportunities and best practices

Many Nordic cities integrate green and blue infrastructure to enhance carbon storage, improve biodiversity, and increase climate resilience.

- **Urban Green Spaces and Forests:** Parks, green roofs, and urban forests are crucial for carbon sequestration and mitigating urban heat islands.

46. Hammarby Sjöstad, Stockholm, Sweden | Urban Green-blue Grids (urbangreenbluegrids.com)
47. Oslo_Reopening_Waterways (urban-waters.org)
48. Det_Biologiske_Hus.pdf (3xn.dk)

Case study: Hammarby Sjöstad (Stockholm, Sweden)[49]
Hammarby Sjöstad is a pioneering eco-district in Stockholm that integrates extensive urban green spaces, including parks and green roofs. The development emphasizes carbon sequestration and reduces urban heat islands through its green infrastructure. These spaces improve air quality, provide recreational areas, and enhance urban biodiversity while contributing to the district's overall sustainability.

- **Blue Infrastructure:** Enhancing water bodies in urban areas supports carbon sequestration, flood resilience, and water quality.

Case study: The River Renewal Project (Oslo, Norway)[50]
Oslo's River Renewal Project enhances rivers and waterways by improving water quality, creating natural flood defences, and integrating blue infrastructure. A notable example is the Teglverksdammen Project, completed in 2015, which reopened 650 meters of the Hovinbekken stream with a NOK 110 million investment. It features natural cleaning systems and has become a popular area for recreation and biodiversity. Since 2016 there is a NOK 140 million City Investment Budget to support carbon sequestration and flood resilience.

- **Biobased Building Materials:** Sustainable materials like hemp insulation, cork, and wood fibre are leading a shift towards environmentally friendly construction practices.

Case Study: The Biological House "Det Biologiske Hus" (Middlefart, Denmark)[51]
This sustainable housing concept is built entirely from bio-based materials sourced from agricultural waste, such as grass, straw, seaweed, and eelgrass. Designed with Cradle-to-Cradle principles, the house is fully biodegradable at the end of its lifecycle. It introduces a new construction method to Denmark's prefabricated housing market, focusing on material upcycling and closed material cycles. The modular design offers a concrete solution to future climate and economic challenges while maintaining high architectural quality.

Case Study: Heerup Skole (Copenhagen, Denmark)[52]
Heerup Skole is a school being developed as a two-story building constructed with Cross-Laminated Timber (CLT), showcasing a commitment to sustainability. The project emphasizes the use of emissions-free machinery, limited to under 2.5 tons, aligning with modern environmental standards. This approach not only reduces the carbon footprint of the construction process

49. Hammarby Sjöstad, Stockholm, Sweden | Urban Green-blue Grids (urbangreenbluegrids.com)
50. Oslo_Reopening_Waterways (urban-waters.org)
51. Det_Biologiske_Hus.pdf (3xn.dk)
52. School expansion - Heerup school - Christensen & Co (ccoarch.com)

but also highlights the school's dedication to incorporating sustainable materials and practices.

Case Study: Herrestaskolan (Barkarbystaden, Sweden)[53]
Herrestaskolan, completed in 2016, is Sweden's first school built entirely with cross-laminated timber (CLT). The 8,200m² building uses 3,100m³ of timber, including both CLT and glulam, and features a sports hall, library, and canteen. Designed to be energy self-sufficient, the building stores 2,500 tons of CO_2 and meets the highest Swedish sustainability certification.
Herrestaskolan is a central part of the community and has become a model for sustainable wood construction, showcasing how public procurement can drive innovation in low-carbon building.

5.3 Main Barriers

Implementing green and blue infrastructure is vital for enhancing carbon storage in urban environments. However, the effectiveness of these initiatives is often hindered by competing land uses and concerns about their long-term viability. To maximize the benefits of such projects, urban planners must prioritize the maintenance of green spaces and foster community engagement. By building local support and ensuring that these initiatives align with community needs, cities can enhance the effectiveness and sustainability of their green and blue infrastructure efforts.

5.4 Recommendations

1. **Develop National Strategies for Urban Planning and Resilience**
    - Set targets for integrating green and blue infrastructure into urban planning to enhance carbon sequestration.
2. **Increase Investment in Green and Blue Infrastructure**
    - Expand urban green spaces to reduce heat islands and enhance carbon storage while restoring rivers and wetlands.
3. **Strengthen Public-Private Partnerships for Green Financing**
    - Foster collaboration between the public and private sectors to develop and maintain green and blue infrastructure projects, leveraging green bonds and sustainability-linked loans to secure funding.

53. FULLTEXT03.pdf (diva-portal.org)

4. **Mandate Life-Cycle Analysis (LCA) for Urban Development**
    - Integrate life-cycle assessments into all large-scale urban planning projects to assess the environmental impact from material selection to long-term energy use, incentivizing the use of sustainable materials like Cross-Laminated Timber.

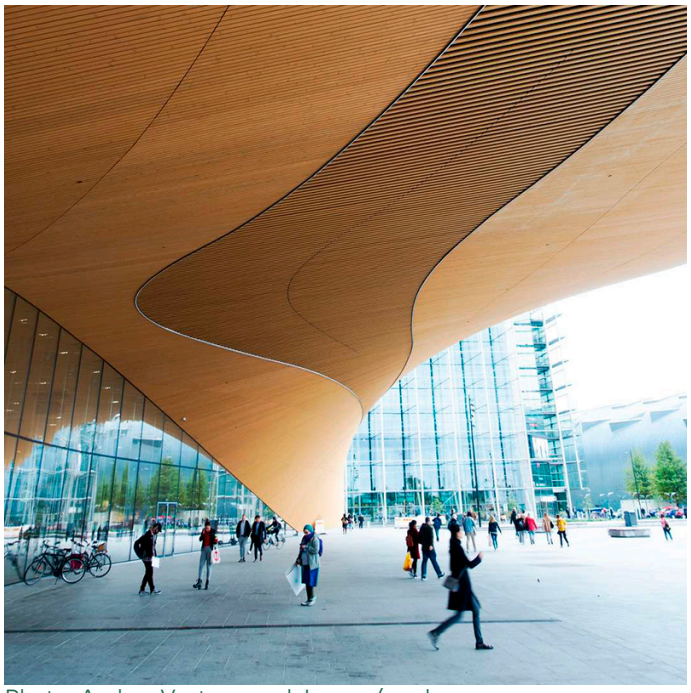

Photo: Anders Vestergaard Jensen/norden.org

6. Circular Economy in the Built Environment

6.1 Main findings

Nordic cities are increasingly advancing circular business models (CBMs) to create sustainable built environments by reducing emissions, minimizing waste, and promoting material reuse. Initiatives across Denmark and Sweden, such as the Circular Business Lab, exemplify collaboration in driving circular transformation. Despite this progress, challenges remain, including a lack of standardized legislation for reused materials and financial incentives to enhance competitiveness against new materials. Key enablers for scaling CBMs include clear policies, financial incentives, and collaboration among stakeholders. Digital platforms like Palats and Excess Material Exchange are facilitating material reuse, showcasing the potential for a circular economy in the built environment. Short-term actions, such as fast-tracking regulations and showcasing successful case studies, are essential to push CBMs beyond pilot phases and ensure their integration into urban development.

6.2 Opportunities and best practices

The Nordic region is at the forefront of integrating circular economy principles into the built environment, focusing on reducing waste, promoting resource efficiency, and rethinking the lifecycle of buildings and infrastructure. By adopting circular practices, Nordic cities aim to minimize the environmental impact of construction while maximizing material reuse and extending the life of buildings.

- **Material Reuse, Recovery, and Circular Demolition and Design:** Nordic cities are increasingly promoting the reuse of construction materials by encouraging deconstruction over traditional demolition. This shift allows valuable materials to be recovered and reused in new projects, thereby reducing the demand for virgin materials, cutting emissions associated with material extraction, and creating local jobs in material recovery and refurbishment. This approach also emphasizes innovation in building design, ensuring that structures are adaptable, repairable, and easier to deconstruct at the end of their lifecycle.

  Case studies: Bruks-specialisten (Sweden)

[54] **& Continuum (Various geographies)**[55]

Bruks-specialisten specializes in the reuse of bricks, emphasizing the importance of conserving valuable building materials. Continuum works across various sectors to develop circular business models and facilitate collaborations that drive sustainable practices. These efforts contribute to a more sustainable construction industry by highlighting the value of material recovery.

Case study: Pohjois-Hervanta School (Tampere, Finland)[56]

In Tampere, the old Ahvenisjärvi School was demolished to pave the way for a new building grounded in circular economy principles. The demolition revealed reusable elements such as air conditioners and windows, while concrete was crushed for use in other city projects. Despite challenges with interim storage and reuse planning, the project emphasized Design for Disassembly (DfD), aiming to make future repairs and adaptations easier. This positive initiative is expected to yield valuable insights on extending building lifecycles and enhancing material reuse in future construction projects.

- **Circular Economy Transition:** Nordic initiatives are increasingly focused on facilitating the transition to a circular economy by bridging the gap between academia and industry. This approach promotes collaboration among businesses and research organizations to innovate and implement sustainable practices that drive systemic change.

  Case Study: Circular Business Lab (RISE, Sweden)[57]

  RISE, an independent research organization in Sweden, has established the Circular Business Lab as a collaborative innovation space for companies seeking to transition toward a circular economy. The lab operates on a membership basis, currently engaging 12 organizations and fostering a cluster approach to address specific circularity challenges. Key initiatives include exploring alternative business models in sectors such as furniture and electronics, conducting workshops to develop methodologies for evaluating circular versus linear business practices, and performing benchmarking studies to analyze successful strategies. This model not only enhances knowledge sharing but also positions RISE as a leader in driving sustainable innovation across industries, promoting long-term partnerships to tackle shared challenges in the pursuit of a circular economy.
- **Circular Business Support Initiatives:** Nordic organizations are pioneering efforts to support businesses in transitioning to circular economy practices, emphasizing collaboration and innovation. By providing resources, platforms,

54. More about Bruks-specialisten
55. Find out more about Continuum
56. FULLTEXT01.pdf (diva-portal.org)
57. Swedish research creating sustainable growth | RISE

and expert guidance, these initiatives help companies adopt sustainable business models and reduce environmental impact in the built environment.

Case studies: Danish Design Centre[58] **& Cradlenet**[59]
The Danish Design Centre plays a vital role in helping businesses explore and implement circular business models through workshops and consultancy. It fosters collaboration among design professionals to promote sustainability in product development. Similarly, Cradlenet focuses on advancing circular practices and material reuse by connecting stakeholders and sharing knowledge on sustainable initiatives. Together, these organizations exemplify a commitment to driving systemic change across industries.

- **Innovative Business Models and Sustainable Product Development:** New business models and sustainable product development strategies are emerging in the Nordic region, promoting circularity by offering flexible solutions for product use and ownership, and prioritizing sustainability in design.

  Case studies: Nornorm (Denmark)[60] **& Home.Earth (Sweden)**[61]
  Nornorm introduces a Product-as-a-Service model for office furniture, allowing companies to rent furniture instead of purchasing it, thereby promoting reuse and sustainable design. Home. Earth focuses on exploring circular practices in the built environment, providing resources and insights to stakeholders about sustainable construction practices. These initiatives highlight the shift toward innovative, circular business models in the region.

  Case studies: Fagerhult (Sweden)[62] **& Ecophone (Sweden)**[63]
  Fagerhult specializes in energy-efficient lighting solutions designed with circularity in mind, emphasizing product longevity and recyclability. Ecophone focuses on acoustic roofing solutions that incorporate sustainable materials, promoting waste reduction and resource efficiency in construction. These companies demonstrate how circular economy principles can be integrated into product development to enhance sustainability in the built environment.
- **Digital Platforms for Material Reuse:** Digital platforms are essential in facilitating the mapping and reuse of construction materials, enabling a circular economy by making reclaimed materials accessible for new projects. These platforms reduce waste and encourage resource efficiency in construction.

  Case studies: Zupply

58. Learn more about Danish Design Centre
59. Explore Cradlenet
60. Find out more about Nornorm
61. Visit Home.Earth
62. Explore Fagerhult
63. Learn more about Ecophone

[64] **(Denmark), Excess Material Exchange (Sweden), Palats (Sweden)**[65]
Zupply is a digital platform that maps and connects suppliers of building materials with those seeking reclaimed resources, promoting reuse across the construction sector. The Excess Material Exchange operates a marketplace for recovered construction materials, allowing businesses to list surplus materials for reuse, reducing waste and fostering sustainability. Palats provides a similar service in Sweden, focusing on the reuse of building materials. These platforms are instrumental in driving the circular economy in the built environment.

Case studies: Loopfront (Norway)[66] **& CCbuild (Norway)**[67]
Loopfront and CCbuild are platforms that facilitate the digital exchange of reused building materials, connecting suppliers with buyers and promoting the adoption of reclaimed resources in construction projects. These initiatives significantly contribute to reducing waste and enhancing the circular economy in the built environment.

6.3 Main Barriers

Incorporating circular economy principles into the built environment presents both opportunities and challenges. Key barriers include value loss and increased risks associated with traditional construction practices, which emphasize linear models of resource use. Adopting circular business models (CBMs) requires a collaborative, interdisciplinary approach, with early analysis and an understanding of existing conditions being crucial for success. A prevalent misconception is that new construction is inherently superior to circular practices, such as reuse and modular buildings, often viewed as lower quality. This perception, compounded by fragmented regulations across municipalities, limits the widespread adoption of modular construction.

To address these challenges, there is a pressing need for standardized regulations that focus on functionality rather than rigid technical details, along with efforts to shift public and policy attitudes toward sustainable solutions. Additionally, conducting extensive life-cycle analyses (LCA) is essential for accurately assessing the advantages of biobased materials, considering their environmental impacts throughout their entire lifecycle – from raw material extraction to use, disposal, and potential reuse.

64. The Hub | zupply
65. Visit Palats
66. Check out Loopfront
67. Explore CCbuild

6.4 Recommendations

1. **Promote Circular Economy in Construction**
    - Develop strategies for material reuse with clear guidelines and standardize low-carbon construction practices.
2. **Develop National Circular Economy Strategies for the Built Environment**
    - Mandate circular practices across construction, establishing regulations for material reuse in public projects.
3. **Support Local Low-Carbon Building Material Initiatives**
    - Create local initiatives prioritizing low-carbon and locally sourced materials in public projects.
4. **Electrify Construction Equipment at Local Level**
    - Mandate circular principles in local public procurement processes for construction projects.
5. **Implement Local Take-Back Schemes for Building Materials**
    - Support local schemes for construction companies to return used materials for refurbishment.

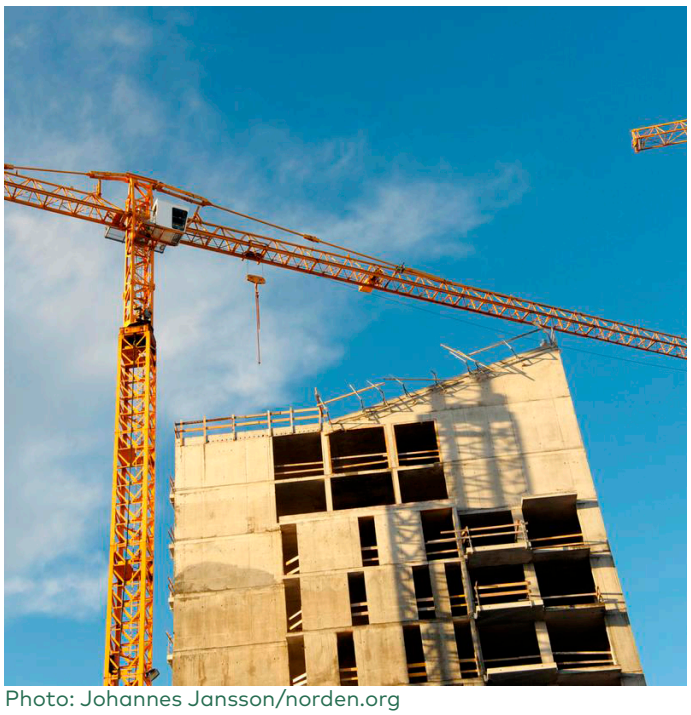

Photo: Johannes Jansson/norden.org

7. Conclusion

The Nordic region's approach to spatial planning, renewable energy, electrification, and green infrastructure serves as a powerful blueprint for cities worldwide striving toward net-zero emissions. These nations have not only established ambitious emission reduction targets but have also demonstrated that effective urban policies can drive innovation and sustainability. The integration of circular economy principles further enhances their strategies, enabling a more efficient use of resources and a reduction in waste.

However, the path to achieving these goals is fraught with challenges, including the necessity for substantial investments, coordinated actions across multiple sectors, and policies that promote an equitable transition for all residents. The findings presented in this report highlight the importance of fostering collaboration among stakeholders, standardizing regulations, and enhancing public understanding of sustainable practices to overcome these barriers.

The 2024 Mitigation Work Programme's focus on cities, buildings, and urban systems offers a critical opportunity to leverage the Nordic experiences and catalyze the deep decarbonization and systemic transformation required for creating sustainable, resilient urban futures. As cities globally confront the realities of climate change and urbanization, they can draw invaluable lessons from the Nordic model, adapting its insights to local contexts to drive meaningful progress toward a more sustainable and inclusive world. This approach not only promises to reduce greenhouse gas emissions but also enhances the quality of life for urban residents, fostering vibrant communities that are prepared for the challenges of the future.

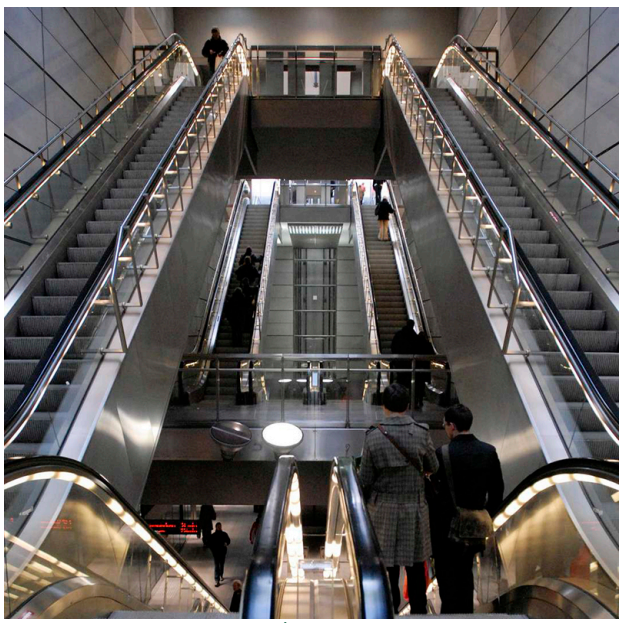

Photo: Johannes Jansson/norden.org

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Hannah Sutton

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Nordic co-operation

Nordic co-operation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and the Faroe Islands, Greenland and Åland.

Nordic co-operation has firm traditions in politics, economics and culture and plays an important role in European and international forums. The Nordic community strives for a strong Nordic Region in a strong Europe.

Nordic co-operation promotes regional interests and values in a global world. The values shared by the Nordic countries help make the region one of the most innovative and competitive in the world.

The Nordic Council of Ministers
Nordens Hus
Ved Stranden 18
DK-1061 Copenhagen
pub@norden.org

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