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Navigating a Turbulent World

Challenges and Imperatives for the Global Energy, Utilities, and Waste Sector – A Danish Perspective

A Strategic Analysis by

KNOWUS

Executive Summary

The global industry for energy, utilities, and waste is in a period of transformation, shaped by a complex interplay between an accelerated yet uneven energy transition, growing geopolitical fragmentation, and an increasing struggle for the planet's limited resources. This report analyzes the systemic challenges that define this new landscape and uncovers the specific implications for Denmark, a country navigating the tension between being a globally recognized green pioneer and a small, open economy deeply exposed to global shocks.

The report's central conclusions reveal a fundamental paradox: Despite record investments in clean energy globally, which exceeded $2 trillion in 2024, global CO2 emissions continue to reach new heights.[1] [2] This trend is driven by a persistent rise in global energy demand, amplified by new, energy-intensive technologies like artificial intelligence (AI) and a general electrification of society.[3] [4] This dynamic reveals that the pace of the transition is not yet sufficient to offset the growing appetite for energy, creating a critical gap between ambitions and realities.

For developed economies, including Denmark, the nature of the challenge has changed significantly. Where the green transition was previously limited by the maturity and cost of technology, the primary bottleneck has now shifted to the physical and regulatory infrastructure. Overloaded power grids, slow approval processes, and a shortage of skilled labor now constitute the most significant barriers to a faster rollout of renewable energy. This requires a strategic shift from a reactive to a proactive approach to infrastructure planning and investment.

Denmark's position is unique. The country is recognized for its ambitious climate goals and its leadership in green technology, especially wind energy. At the same time, this pioneering role reveals the country's vulnerabilities. The rapid internal transition places enormous pressure on the national power grid, and the deep integration into global markets makes Danish industry vulnerable to supply chain disruptions and price volatility in energy and raw materials.

Based on this analysis, the report identifies four strategic imperatives for Danish companies and policymakers. First, there is an urgent need to strengthen national and European resilience in supply chains. Second, an acceleration of investments in critical infrastructure, especially the power grid, is crucial to prevent the green transition from stalling. Third, a systemic and practical implementation of the principles of circular economy is no longer an option but a fundamental necessity to ensure long-term resource and supply security. Finally, Denmark must strategically leverage its position as a pioneer to promote the export of green technology and solutions, which can strengthen both national competitiveness and the global climate effort.

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Part I: The Changing Global Landscape

1. Megatrends and Systemic Shocks

The global arena for energy, utilities, and waste is being shaped by a series of profound and interconnected megatrends. These trends are not isolated phenomena but interact and reinforce each other, creating a landscape of unprecedented complexity and uncertainty. From the escalating realities of the climate crisis to a new geopolitical world order, these forces define the fundamental conditions for businesses, governments, and societies.

1.1 The Inevitability of the Climate Crisis as an Economic Driver

The climate crisis has transcended its status as a distant environmental threat and is now a tangible and pressing economic reality that permeates all aspects of the global economy. With 2024 recorded as the warmest year since measurements began in 1880, the physical consequences of global warming have become a fixed part of the risk landscape for businesses and nations. This development serves as the primary driver behind a fundamental restructuring of global energy systems.

Paradoxically, global CO2 emissions reached a new record level of 37.8 billion tons in 2024, despite significant progress in the deployment of renewable energy sources.[4] This continued rise in emissions reveals a critical imbalance: the growth in clean energy is not yet able to overtake and displace the growing global energy demand, which is still largely met by fossil fuels. This gap between ambition and action underscores the monumental task the world faces.

However, the accelerating crisis is also a powerful catalyst for change. It is driving massive investments in green technology, with the global market for renewable energy expected to reach an annual turnover of $1.5 trillion in 2025.[5] At the same time, it is compelling governments to implement ambitious policy frameworks, such as the EU's Green Deal, which aims for climate neutrality by 2050, and encouraging large corporations like Google and IKEA to commit to ambitious internal climate goals.[6] [7] The climate crisis has thus become the defining economic and political driver of the 21st century, shaping investment flows, technological innovation, and regulatory landscapes on a global scale.

1.2 Geopolitical Fragmentation and Supply Chain Vulnerability

The world has entered a new era of geopolitical instability, where conflicts, trade tensions, and a general fragmentation of the previously globalized order have become the norm. This development has a direct and profound impact on global supply and trade flows, which for decades have been optimized for efficiency and "just-in-time" deliveries. The crises of recent years have brutally exposed the inherent vulnerability of these long and complex supply chains, a reality that has particularly affected small, open economies like Denmark, which are deeply dependent on international trade.

The consequences have been noticeable. Disruptions have led to shortages of everything from microchips to building materials, resulting in production stoppages and delays across industries. At the same time, uncertainty has created significant volatility in energy and raw material prices, putting pressure on companies' finances and contributing to inflationary pressure.

As a direct response to this new reality, a fundamental strategic shift has occurred in the business world. Where the focus was previously primarily on cost minimization, resilience—the ability to withstand and adapt to shocks—has now become a key competitive parameter. Companies are increasingly implementing strategies to strengthen their robustness, including building larger safety stocks and diversifying their supplier base to reduce dependence on single countries or regions. This development has also affected the investment landscape.

Security of supply is now as important a driver for investments in the energy sector as climate considerations, as nations seek to reduce their dependence on imported, often geopolitically unstable, energy.

1.3 "Energy Trilemma" 2.0: Security, Sustainability, and Equity

The classic "energy trilemma"—the constant balancing act between ensuring a stable and secure energy supply, achieving environmental sustainability, and maintaining economically affordable prices for consumers—has been sharpened and expanded in the current global climate. The World Economic Forum highlights that a successful energy transition requires all three dimensions to be addressed simultaneously and in conjunction, as neglecting one dimension will inevitably undermine the others.[8]

However, progress across the trilemma's dimensions is uneven. While the sustainability dimension shows positive trends driven by the growing deployment of renewable energy, security of supply is stagnating in many regions. This is due to a combination of outdated and overloaded power grids, a continued dependence on imported fossil fuels, and insufficient diversification of energy sources.

A new and increasingly central dimension of the trilemma is "equity" - a concept that covers fairness, equality, and an inclusive transition. Here, an alarming global imbalance is revealed. While over 90% of all investments in clean energy in 2024 took place in advanced economies and China, more than 80% of the growth in global energy demand came from developing economies.[9] This deep gap between where capital is invested and where energy needs are growing poses a serious threat to a just global transition. Without a significant scaling up of financing and technology transfer to the Global South, the energy transition risks exacerbating global inequalities and leaving billions of people dependent on fossil fuels.

Table 2: Energy Transition Index (ETI) 2025 - A Snapshot

Country/Region	Overall ETI Score 2025	Sub-score: Sustainability	Sub-score: Security of Supply	Sub-score: Equity
Sweden	Top 1	High	High	High
Finland	Top 2	High	High	High
Denmark	Top 3	High	High	High
Germany	Top 10	High	Medium	High
China	12	Medium	Medium	Medium
Brazil	15	High	Medium	Medium
Average: Advanced Economies	16% above global avg.	-	-	-
Average: Emerging Europe	4% above global avg.	-	-	-
Average: Emerging Asia	7% below global avg.	-	-	-
Average: Sub-Saharan Africa	Below global avg.	-	-	-

Sources: Data for sub-scores are qualitative based on report descriptions. ETI score is relative to the global average.[8]

1.4 Technological Disruption: AI and Electrification as a Double-Edged Sword

Technological innovation is both a solution and a challenge in the global transition. The exponential growth in data-intensive technologies, especially artificial intelligence (AI), combined with a broader electrification of society - from transport with electric vehicles to heating with heat pumps - is one of the primary reasons for the significant increase in global electricity consumption. In 2024, electricity consumption grew by 2.2%, the fastest increase in years.[10] This development creates a double-edged sword.

On one hand, AI and digitalization are crucial tools for optimizing and managing the complex and decentralized energy systems of the future. They can predict production from wind and sun, balance supply and demand in real-time, and increase energy efficiency across sectors.

On the other hand, the energy consumption of the technologies themselves has become a significant challenge. Data centers, which power AI and cloud services, are expected to account for 10% of the global growth in electricity consumption by 2030.[10] This creates a critical paradox: the technology that is essential for accelerating the green transition is also contributing to an increase in total energy consumption to such an extent that it puts enormous pressure on existing power grids. If the expansion of renewable energy cannot keep pace with this new, steep demand curve, there is a risk that the increased need will have to be met by fossil fuels, which directly counteracts climate goals. The challenge, therefore, lies in ensuring that the digital transformation occurs on a foundation of clean energy, so that it becomes an unequivocal ally instead of an adversary in the fight against climate change.

The systemic connection between these megatrends means that the climate crisis can no longer be viewed in a vacuum. It acts as an amplifier, triggering a cascade of interconnected risks. Extreme weather events, driven by climate change, put pressure on critical infrastructure for energy and water. This resource pressure can exacerbate geopolitical tensions, especially in already vulnerable regions, leading to disruptions in the supply chains for energy and raw materials. These disruptions create economic volatility and inflationary pressure, forcing companies to prioritize costly resilience over efficiency. A single climate-related event can thus initiate a chain reaction of geopolitical, supply, and economic shocks, necessitating a much more holistic and integrated approach to risk management.

At the same time, the green transition faces an internal double bind. The technologies necessary for decarbonization - such as solar panels, wind turbines, and electric batteries - are themselves deeply dependent on the systems they aim to transform. First, the production of these technologies requires enormous quantities of critical minerals, whose supply chains are concentrated and geopolitically vulnerable. Second, the electrification of society is driving electricity consumption to record highs, putting enormous pressure on power grids that in many countries, including Denmark, are not designed to handle either the increased amount of fluctuating production or the significantly higher consumption. Without a parallel and proactive investment in both securing raw material supplies and a massive upgrade of grid infrastructure, the transition itself risks being choked by its own success-driven bottlenecks.

Part II: Sector-Specific In-Depth Analyses: Global Challenges

Having outlined the overarching megatrends, this part of the report delves into the specific challenges that define the three central sectors: energy, supply, and resource management. Each sector faces unique pressures, but their fates are inextricably linked. A successful energy transition depends on robust supply chains, and both are conditional on the sustainable management of the planet's resources.

2. The Energy Transition: A Race Against Time

The global energy transition is accelerating, but it is fighting a fierce battle against growing energy demand and systemic inertia. Although progress is significant, a closer analysis reveals a picture marked by serious investment gaps, infrastructural bottlenecks, and new geopolitical dependencies.

2.1 The Investment Paradox and the Global Capital Imbalance

On the surface, the investment landscape for clean energy looks promising. In 2024, over $2 trillion was invested globally in the energy transition, a doubling since 2020.[11] These investments are creating millions of jobs and driving technological innovation in areas such as energy storage and electromobility.

But behind these impressive numbers lies a serious paradox and a deep imbalance. First, the current level of investment is significantly insufficient. International energy agencies like the IEA and IRENA estimate that annual investments of up to $5.6 trillion are needed until 2030 if the Paris Agreement's 1.5-degree target is to be kept within reach.[12] The current effort is thus less than half of what is actually required. At the same time, investments in fossil fuel infrastructure continue, and in 2022, global subsidies for fossil fuels reached a record high, actively working against the transition and distorting the market.[13]

Second, there is a critical geographical imbalance in capital flows. Over 90% of all investments in clean energy are concentrated in advanced economies and China.[9] This is in stark contrast to the fact that the primary growth in energy demand is occurring in developing countries. Africa, a continent with enormous potential for solar and wind energy, receives only 2% of global investments in clean energy.[14] This distortion creates a two-tiered world where rich countries accelerate their transition, while the Global South risks being locked into a fossil-fueled future due to a lack of access to capital.

Table 3: The Global Clean Energy Investment Gap

Investment Area	Current Annual Investment (2024 figures)	Necessary Annual Investment (by 2030 for 1.5°C goal)	Annual Funding Gap
Total Investment in Clean Energy	~$2.2 trillion USD	~$5.6 trillion USD	~$3.4 trillion USD
Of which: Renewable Energy (Solar & Wind)	~$0.5 trillion USD (2022)	~$1.5 trillion USD	~$1.0 trillion USD
Of which: Energy Efficiency & Electrification	~$0.8 trillion USD	-	-
Continued Annual Investment in Fossil Fuels	~$1.1 trillion USD	To be redirected	-

Sources: Figures are based on the latest available data and estimates from IEA and IRENA. The necessary investment is an average to reach the 1.5°C target.[11 12 13]

2.2 Infrastructure as the New Frontline

In the leading economies, including Europe and North America, the primary challenge of the energy transition has undergone a fundamental transformation. Whereas a decade ago it was the price and maturity of technologies like solar and wind that were the limiting factors, the situation today is reversed. Renewable energy is now, in most cases, the cheapest form of new electricity generation. The primary barrier to an accelerated rollout has instead shifted to the physical and regulatory infrastructure that must support it.

The power grid has become the new frontline in the climate battle. In many countries, the grid is designed for a centralized energy system based on a few large power plants. It is simply not dimensioned to handle the massive amounts of decentralized and fluctuating power from thousands of wind turbines and solar parks, which are often located far from consumption centers. This leads to widespread grid congestion, where clean energy must be disconnected from the grid because there is no capacity to transport it.

In addition to the physical limitations, administrative processes pose a serious bottleneck. Slow and bureaucratic approval procedures for both new renewable energy projects and for the necessary expansion of the power grid can delay projects for years. Added to this is a growing shortage of qualified labor - from engineers to installers - needed to build and maintain the new energy infrastructure.

This situation has led to a redefinition of the concept of energy security. It is no longer just about having access to fuels, but equally about having a robust, flexible, and digital power grid that can ensure a stable supply in a world powered by renewable energy. The existing infrastructure, both the physical in the form of power grids and gas pipelines and the regulatory in the form of approval processes, is a relic of a centralized, fossil-based energy world. This "lock-in" effect now constitutes the most significant barrier to a rapid transition in the Western world. Even if politicians set ambitious targets for the expansion of renewable energy, and the market is ready with investors to build solar and wind farms, these projects hit a wall. The power grid is not dimensioned to transport the electricity from the new production sites, which are often in rural areas, to the major consumption centers in cities and industrial areas. At the same time, outdated legislation and local objections can drag out the approval processes for both energy projects and grid expansion for years. Without a radical reform of planning and approval processes and a transition from a reactive to a proactive approach to grid investments, the existing infrastructural and regulatory inertia will effectively slow the pace of the transition, regardless of how cost-effective renewable technology becomes.

2.3 The Raw Material Race and the Green Technology's Material Dependence

The energy transition is, in essence, a material transition. The shift from an energy system based on the combustion of coal, oil, and gas to a system based on solar panels, wind turbines, batteries, and power grids requires enormous quantities of specific minerals and metals. This has created a global race for access to critical raw materials such as lithium, cobalt, nickel, copper, and rare earth elements.

This new material dependence introduces a new form of geopolitical vulnerability. The extraction and especially the processing of many of these critical minerals are highly concentrated in a very few countries, creating a risk of supply disruptions due to political instability, trade conflicts, or the deliberate use of resources as a political weapon.

This realization has led to a shift in the political priorities driving energy investments. Where the focus was previously almost exclusively on climate and CO2 reduction, the agenda has now expanded to include strategic autonomy and industrial competitiveness. Nations and regions, including the EU, are working intensively to secure their supply chains, build local production capacity for things like batteries, and diversify their import sources. This new focus on resilience and security of supply for critical materials has become a central and defining part of the global energy transition, underscoring that the energy system of the future must not only be green, but also robust.

3. Supply and Logistics: Vulnerabilities in a Fragmented System

The global supply chains that form the backbone of world trade are under unprecedented pressure. The combination of geopolitical tensions, the after-effects of the pandemic, and the increasing frequency of climate-related disruptions have revealed deep vulnerabilities in a system that was long optimized for efficiency rather than robustness.

3.1 Geopolitics' Direct Impact on Energy and Raw Material Flows

In an increasingly fragmented world, geopolitics is no longer a background factor but a direct and often disruptive force shaping the global flows of energy and raw materials. Conflicts and the resulting sanctions have an immediate effect on the availability and price of vital resources like oil and natural gas. This not only creates short-term uncertainty but can also have long-term consequences for the energy transition.

A clear example is the significantly increased demand for liquefied natural gas (LNG) in Europe and Asia as a direct consequence of the need to replace Russian pipeline gas. This development has reshaped global energy markets and led to massive investments in new LNG infrastructure, such as terminals and ships. Although this has been necessary to ensure short-term security of supply, it also creates a risk of a new "lock-in" effect, where we commit to fossil fuel infrastructure for decades to come, potentially delaying the full transition to a renewable energy system. Geopolitical considerations thus force nations to make decisions that may conflict with long-term climate goals.

3.2 Price Volatility and Inflationary Pressures

The repeated disruptions in global supply chains have had a direct and noticeable effect on prices. Bottlenecks in production and transport have led to significant price increases for a wide range of raw materials, components, and energy. For Danish industry, the rising raw material costs, driven by high energy prices, were the single biggest challenge in the period 2021-2023 - even more significant than the COVID-19 pandemic itself. A full 83% of Danish industrial companies reported this as a primary concern.[15]

Although the most acute supply crisis began to subside during 2023, it has left lasting marks on the economy. The prices of many industrial raw materials, such as metals and wood, have stabilized at a level significantly higher than before the crisis. This new cost structure puts persistent pressure on companies' margins and contributes to a generally higher level of inflation. The increased volatility and uncertainty also make it harder for companies to plan and invest, which can dampen economic growth.

3.3 Digitalization and Cybersecurity

As supply chains and energy systems become more complex and data-driven, digitalization is accelerating. The implementation of technologies like the Internet of Things (IoT), blockchain, and smart grids creates significant efficiency gains, improves traceability, and enables more dynamic resource management.

However, this increased digital interconnectedness also opens up a new and serious vulnerability: cyberattacks. Critical infrastructure within the energy and utility sectors has become a primary target for state-sponsored hacker groups and criminal organizations. A successful attack can have catastrophic consequences, from power outages to the paralysis of ports and logistics networks. The scale of this threat is enormous. It is estimated that the annual global costs associated with cybercrime will reach a staggering $10.5 trillion in 2025.[16] Securing the digital infrastructure against these threats has therefore become a crucial and costly task, fundamental to maintaining both security of supply and the general functioning of society.

4. Resources, Waste, and Water: From Linear to Circular Management

The traditional linear economic model, based on a "take-make-dispose" logic, has reached its end. In a world with a growing population and increasing pressure on the planet's limited resources, a transition to a circular model, where materials are kept in circulation, is no longer a niche idea but an economic and environmental necessity. At the same time, the water crisis is emerging as an often-overlooked but critical factor for both energy and supply security.

4.1 The Potential and Implementation Barriers of the Circular Economy

The principle of a circular economy is to eliminate waste and pollution through design, to keep products and materials in use at their highest value for as long as possible, and to regenerate natural systems. This paradigm shift from a linear to a circular model is crucial for decoupling economic growth from the consumption of new raw materials.

The potential is enormous. A fully implemented circular economy is estimated to have a global value of up to $7.9 trillion by 2050, driven by material savings, new business models, and increased resource productivity.[17] By reusing, repairing, remanufacturing, and recycling materials, companies can reduce their exposure to volatile raw material prices and strengthen their supply security.

However, the transition is associated with significant systemic barriers. It requires a fundamental redesign of products so they are easy to disassemble, repair, and recycle. It requires new business models where companies, for example, sell a service (e.g., lighting) instead of a product (a light bulb), thereby retaining ownership and responsibility for the materials. And it requires a massive investment in infrastructure for collection, sorting, and processing of waste, as well as a well-functioning market where secondary raw materials can compete with virgin materials on both price and quality.

The global economy faces a triple resource squeeze that threatens both the green transition and general security of supply. First, the energy transition is creating an exponential increase in demand for critical minerals, whose supply is concentrated and geopolitically uncertain. Second, many regions that are rich in solar energy and thus have the potential for green hydrogen production are also facing severe water shortages. This creates a direct conflict between future energy and water supplies. Third, in densely populated countries like Denmark, there is intensified competition for land. Agriculture, nature and biodiversity, urban development, and now also massive installations for solar cells and wind turbines are competing for the same limited space. A sustainable strategy can therefore not solely focus on CO2 reduction. It must necessarily integrate a holistic resource strategy that recognizes materials, water, and land use as equal and interdependent constraints. In this context, the circular economy is no longer just an advantage, but a fundamental necessity to loosen this resource squeeze.

4.2 The Waste Hierarchy in Practice: Challenges with Recycling

Despite ambitious political goals for increased recycling, there is a significant gap between vision and reality globally. Large quantities of valuable materials still end up in incineration plants or landfills. The challenge lies in converting waste into a clean and high-quality resource that can be used in new production.

This is complicated by several factors. Many modern products are designed for single use or consist of complex composite materials that are difficult or impossible to separate. Contamination in waste streams, where different material types are mixed, can degrade the quality of the recycled material and make it unsuitable for high-value applications. In addition, many parts of the world lack the necessary infrastructure for effective collection and advanced sorting. Overcoming these practical barriers is crucial to be able to move up the waste hierarchy, from incineration and landfill towards real recycling and circularity.

4.3 The Global Water Crisis: An Overlooked Dimension of Supply Security

Water is the most fundamental of all resources, but its role in global supply security is often overlooked. Water is a critical input factor in virtually all economic sectors: from agriculture and food production to industry and, not least, energy production, where it is used for cooling thermal power plants and is a prerequisite for the production of green hydrogen via electrolysis.

The world is facing an escalating water crisis. In 2022, 2.2 billion people lacked access to safe drinking water, and a full 3.5 billion lacked access to basic sanitation.[18] Climate change is drastically worsening the situation by altering precipitation patterns, increasing the frequency of droughts and floods, and putting further pressure on already stressed water systems. The UN predicts that nearly half of the world's population will live in areas with high water stress as early as 2030.[19]

The investment needed to solve this crisis is astronomical. The World Bank estimates that investments of over $1.37 trillion are needed to achieve the UN's Sustainable Development Goal 6 of clean water and sanitation for all. Current global investments must be sextupled to reach this goal.[20] Without a massive and coordinated effort, water insecurity will increasingly pose a serious risk to food security, public health, economic growth, and social stability on a global scale.

Part III: The Danish Nexus: Challenges and Opportunities in a Pioneer Country

Denmark holds a unique position in the global landscape. As a recognized green pioneer with some of the world's most ambitious climate goals, the country serves as a laboratory for the green transition. This position offers significant opportunities for technological development and export, but it also clearly reveals the national bottlenecks and vulnerabilities that an accelerated transition entails. This part of the report analyzes the specific challenges and opportunities Denmark faces in the tension between national policy and global realities.

5. Denmark's Energy and Climate Policy at a Crossroads

Denmark's climate policy is defined by a high degree of ambition, anchored in the Climate Act. This ambition is now being tested against the practical and economic realities associated with transforming an entire energy system at an accelerated pace.

5.1 Ambitions vs. Realities: Analysis of Denmark's Climate Goals

Denmark has committed to some of the world's most ambitious climate goals: a reduction of greenhouse gas emissions by 70% in 2030 compared to 1990 levels, achieving climate neutrality by 2045, and a target of 110% reduction (i.e., net-negative emissions) by 2050.[21] These goals position Denmark as a global leader but also create an enormous implementation task.

According to the latest government projections, based on already enacted policy, Denmark is on track to achieve a 78% reduction by 2035.[22] Although this exceeds the 2030 target, it also shows that there is a significant gap to the even higher ambitions advocated by green organizations and parts of the political landscape. The think tank CONCITO recommends a target of 90% reduction by 2035 to maintain Denmark's role as a pioneer and ensure a credible path to climate neutrality.[23]

However, closing this gap from 78% to 90% is associated with significant costs and challenges. The Danish Council on Climate Change estimates that the additional socio-economic costs of reaching a 90% target will be approximately 45 billion DKK in present value by 2035.[22] To achieve these further reductions, it will be necessary to significantly accelerate efforts in areas that are technologically and politically complex. This includes a massive scaling up of carbon capture and storage (CCS), especially from waste incineration and industry, as well as a more extensive transformation of agriculture, which is expected to account for 80-90% of the remaining emissions in 2050.

One of the biggest risks of further tightening national targets is the phenomenon of "carbon leakage," where climate-polluting production, for example in agriculture or industry, moves abroad to countries with more lenient climate regulations, resulting in no or a negative global climate effect. In addition, there is a concern that a forced transition will increase Denmark's dependence on imported biomass, whose sustainability may be questionable. Balancing national ambitions with global realities and socio-economic responsibility is the central challenge for Danish climate policy in the coming years.

Table 4: Danish Climate Target Scenarios for 2035

Scenario/Target	Reduction Target in 2035 (vs. 1990)	Status/Source	Estimated Socio-economic Cost (Present Value to 2035)
Current Policy (Projection)	78%	Government/Climate Council	Baseline
Climate Council Scenario	85%	Climate Council	approx. 19 billion DKK (additional)
CONCITO Recommendation	90%	CONCITO/Climate Council	approx. 45 billion DKK (additional)
Official 2030 Target (reference)	70%	Climate Act	-
Official 2045 Target (reference)	100% (climate neutrality)	Government Platform	-

Sources: Costs are the additional costs beyond the baseline scenario for current policy.[22] [23]

5.2 The Backbone of the Grid: The Massive Investment Need

The power grid is the backbone of the green transition, but in Denmark, this backbone is under historical pressure that threatens to slow the entire transition. The political ambitions of a fourfold increase in onshore green power production and a massive expansion of offshore wind farms can only be realized if the electricity can be transported from the production sites to the consumers. This requires an unprecedented expansion and modernization of both the transmission and distribution grids.

According to an analysis by Green Power Denmark, new investments in the electricity distribution grid alone of between 49 and 57 billion DKK are needed by 2030 to handle the increased amount of green electricity and the rising electrification.[24] Energinet, which operates the transmission grid, expects to invest 45 billion DKK in the period 2024-2027 alone.[25] These enormous sums illustrate the scale of the infrastructural task.

One of the biggest barriers is the current regulatory model, which is largely reactive. This means that grid companies typically only begin the time-consuming process of planning and building new grid capacity after receiving a concrete application from a developer of a solar or wind farm. This creates long waiting times - often several years - where fully functional energy plants cannot be connected to the grid, which is a huge socio-economic loss. There is therefore an urgent need to transition to a more proactive and long-term planning model, where grid expansion occurs ahead of development, based on political goals and market forecasts.

Furthermore, a large part of the existing Danish power grid, which was established in the mid-20th century, is facing a natural replacement cycle. There is thus a significant reinvestment need that comes on top of the investments necessary for the green transition. Handling this dual task - modernization and massive expansion - under a tight time pressure is the single biggest challenge for the realization of Denmark's climate goals.

5.3 Future Technologies in a Danish Context

To achieve its long-term climate goals, Denmark is dependent on the development and scaling of a range of new energy technologies. In particular, Power-to-X, CCS, and a modernized district heating sector play key roles in the national strategies.

Power-to-X (PtX): PtX, the process where green electricity is converted via electrolysis into hydrogen and further into green fuels like ammonia and methanol, is considered crucial for decarbonizing sectors that are difficult to electrify directly, such as heavy road transport, shipping, and aviation. Denmark has significant potential to become a leading nation in PtX due to the country's large and growing resources of cheap wind energy. The challenges, however, are great. The technology is still relatively expensive, and large-scale production requires an even more massive expansion of renewable energy than already planned, as well as the establishment of a completely new infrastructure for hydrogen transport and storage. To kick-start the market and drive down costs, the Danish state has initiated a series of tenders to support the first large PtX plants.

CCS (Carbon Capture and Storage): To achieve climate neutrality and net-negative emissions, it is necessary, according to both the Climate Council and CONCITO, to remove CO2 from the atmosphere or directly from emission sources. CCS technology, where CO2 is captured from, for example, chimneys and stored permanently underground, is essential for handling the remaining emissions from processes that are difficult to convert, such as waste incineration, cement production, and certain biogenic emissions from agriculture. The primary challenges are the high costs associated with both the capture and storage processes and the need to develop and approve a safe infrastructure for CO2 transport, either via pipelines or ships.

District Heating: The Danish district heating sector, which supplies over 64% of all households, is a cornerstone of the energy system. The sector is in the midst of a fundamental transformation. The traditional production based on combined heat and power, which utilizes surplus heat from electricity production (often from burning biomass), is becoming less profitable in an electricity system dominated by wind and solar. The future of district heating lies in increased electrification through the installation of large heat pumps that can utilize heat from wastewater, seawater, or the air, as well as in the use of geothermal energy and surplus heat from industry and data centers. The technological challenges are significant, especially in relation to maturing technologies like seawater heat pumps and large-scale geothermal energy, with which there is still limited experience in Denmark. At the same time, there is a need to lower the supply temperature in the existing district heating networks to increase the efficiency of heat pumps, which may require investments in the building stock. Uncertain economic framework conditions and complex regulation pose further barriers to the multi-billion DKK investments that this transition requires.

6. Danish Industry in the Global Squeeze

As a small, open, and highly specialized economy, Denmark is deeply integrated into global markets. This integration is the source of the country's prosperity, but it also constitutes a significant vulnerability in a time of increased global instability. Danish industry is navigating a complex landscape, shaped by global supply crises, an increasingly comprehensive set of EU regulations, and an intense international race for green markets.

6.1 Consequences of Supply Chain Disruptions and Energy Prices

The global crises of recent years have clearly demonstrated Denmark's vulnerability. A study from Statistics Denmark shows that rising energy prices were the single biggest challenge for Danish industry in the period 2021-2023 - even more significant than the COVID-19 pandemic itself.[15] This dependence on global energy markets has a direct impact on production costs and thus competitiveness.

At the same time, supply shortages have affected two-thirds of Danish companies that import goods, forcing them to rethink their value chains. The crises have exposed the risks of being dependent on a few suppliers in distant regions and have spurred a movement towards increased resilience. Companies are now actively working to diversify their supplier networks and build larger inventories to withstand future shocks. This transition is costly but is increasingly seen as a necessary investment in long-term survival.

6.2 The EU's Green Regulation: Opportunity and Burden

The EU's ambitious climate policy, led by the 'Fit for 55' package and the new 'Clean Industrial Deal', largely shapes the framework conditions for Danish industry. On one hand, the common European framework creates a large and predictable home market for Danish companies' green technologies and solutions. The common regulation ensures fair competition and drives a broad demand for the products and services where Denmark has a position of strength.

On the other hand, the extensive regulation also entails a significant administrative and economic burden. Danish companies must navigate an increasingly complex web of requirements for documentation, reporting, and conversion of production processes. A central concern for Danish industry is maintaining its global competitiveness at a time when other major economies, such as the USA with its 'Inflation Reduction Act', are offering massive subsidies for green production. The relatively high European energy prices, combined with a heavy regulatory burden, pose a real risk that investments and jobs will move out of Europe. Ensuring that the EU's green ambitions go hand in hand with strong industrial competitiveness is one of the most important political tasks in the coming years.

6.3 Export Opportunities for Danish Green Technology

Amid the global challenges, there are also significant opportunities for Denmark. The country's historical investment in green energy has created a cluster of world-leading companies, especially in wind energy, but also in energy efficiency, district heating, and increasingly new technologies like Power-to-X. These positions of strength represent enormous export potential in a world that is increasingly demanding solutions to the climate crisis.

Exporting green technology and know-how is not just a commercial opportunity; it is also a central part of Denmark's contribution to the global climate effort. By delivering solutions that enable CO2 reductions in other countries, Denmark can have a climate impact that extends far beyond the reductions achieved within its own borders. Supporting and promoting this export is therefore a strategic priority that unites economic interests with climate policy goals and strengthens Denmark's brand as a global green leader.

Denmark's position as a green pioneer creates a unique dilemma. The ambitious climate policy and the rapid internal transition mean that Denmark is facing the challenges of the future before most other countries. This speed reveals and amplifies national bottlenecks, especially in the power grid, which is now under extreme pressure that threatens to slow the transition itself. At the same time, the heavy reliance on renewable energy and imported technology components increases the Danish economy's vulnerability to global shocks in supply chains and price fluctuations in energy and raw materials. The central strategic challenge for Denmark is therefore twofold: partly to translate political ambition into physical and regulatory implementation power at a pace that matches the speed of the transition, and partly to build national resilience against the global shocks that the transition itself helps to amplify.

7. Circular Transition and Waste Management in Denmark

The transition to a circular economy is a central pillar of Denmark's green transition. The goal is to move away from a linear use-and-dispose culture towards a system that minimizes waste and maximizes the value of resources. However, the implementation of this vision has proven to be a complex process that encounters practical barriers in the transition from national strategies to local reality.

7.1 From National Plans to Local Implementation

Denmark has an ambitious national action plan for a circular economy, running from 2020 to 2032. The plan has a special focus on three resource-heavy sectors: biomass, construction, and plastics. The vision is clear: the waste sector must be climate-neutral by 2030, and 80% of all plastic waste must be sorted out from incineration so that it can be recycled instead.[26]

The need for this transition is pressing. Denmark has one of the highest material consumptions per capita in Europe, which underscores the great potential for improvement. A successful transition can not only reduce the environmental and climate impact but also strengthen the competitiveness and supply security of Danish industry by reducing dependence on imported virgin raw materials.

Table 5: Danish Recycling Targets for Household-like Waste

Waste Fraction	Current Recycling Rate (latest data)	EU Target 2025	EU Target 2030	EU Target 2035
Household-like waste (total)	Close to target	55%	60%	65%
Plastic packaging	Below target	50%	55%	-
Paper and cardboard packaging	Met	75%	85%	-
Metal packaging	Met	70%	80%	-
Glass packaging	Met	70%	75%	-

Sources: Status on recycling is based on the Danish Environmental Protection Agency's projections, which indicate that the targets for 2025 and 2030 for household-like waste as a whole are expected to be met, but that there are specific challenges, especially for plastic.[26]

7.2 The New Sorting Requirements: Barriers in Practice

One of the most concrete steps in the action plan has been the introduction of uniform requirements for both households and businesses to sort waste into 10 different fractions. However, the implementation of these requirements has revealed a significant gap between political ambition and practical reality.

For municipalities, the rollout has been a massive logistical challenge. Short deadlines, complex procurement processes for collection, and a lack of specialized garbage trucks and containers have meant that a majority of the country's municipalities have had to apply for exemptions from the original deadlines.

For businesses, the new rules have created similar challenges. An analysis from the Danish Chamber of Commerce shows that 3 out of 10 companies are not even aware of the new requirements, more than a year after they came into effect.[27] For the companies that are aware of the rules, the primary barriers are purely practical: lack of physical space for the many new waste containers, especially in urban areas, and the costs associated with the new handling. A particular challenge lies in customer and guest areas such as shops, hotels, and restaurants, where companies find it extremely difficult to get customers to sort their waste correctly, which degrades the quality of the collected materials.

This situation illustrates a classic "last mile" problem. Even with a well-formulated national strategy, the success of the circular economy is ultimately determined by the logistics at street level and the behavior of the individual citizen and company. Without sufficient guidance, practical support, and the right incentives, the ambitious recycling goals risk being undermined by implementation difficulties.

7.3 The Potential for Resource Productivity and Supply Security

Despite the implementation challenges, a successful circular transition holds significant potential for Denmark. By creating well-functioning cycles for materials, Denmark can reduce its dependence on imported raw materials, many of which are subject to price volatility and geopolitical uncertainty. This can strengthen national supply security and make Danish industry more robust.

There is also significant economic potential. Analyses have shown that there is considerable value in utilizing waste streams as a resource. Particularly within the construction, food, and machinery industries, there is potential to create new business models and increase resource productivity, which can lead to both economic gains and environmental improvements. Realizing this potential, however, requires that the barriers to implementation are overcome and that a strong and stable market for secondary raw materials is created, where recycled products can compete with new ones.

Conclusion and Strategic Recommendations

The global arena for energy, supply, and waste is undergoing a fundamental and irreversible transformation. The analysis shows a landscape defined by a series of deep and interconnected tensions: between climate ambitions and an ever-growing energy demand; between the benefits of globalization and the fragmenting forces of geopolitics; and between technological possibilities and infrastructural limitations. For Denmark, this new reality means that the role of a green pioneer is both a unique opportunity and a source of unique vulnerabilities. Navigating this complex terrain successfully requires a clear strategic direction and an acknowledgment that the solutions of the past are not sufficient to meet the challenges of the future.

Based on the report's analysis, four overarching strategic imperatives are proposed to guide Danish decision-makers and business leaders in the coming years.

Strategic Imperative 1: From Reactive to Proactive Infrastructure Planning The single biggest bottleneck for Denmark's green transition is the insufficient capacity in and the reactive expansion of critical energy infrastructure, especially the power grid. To prevent the transition from stalling, a fundamental shift in approach is necessary.

- **Recommendations:**
    - **National Infrastructure Pact:** The government, in collaboration with the industry and relevant parties, should develop a long-term and binding national plan for the expansion of the power grid, hydrogen infrastructure, and CO2 storage facilities. This plan must be based on long-term political goals and scenarios for 2040 and 2050, not on short-term and reactive needs.
    - **Fast-track Approval Processes:** A "fast-track" administrative process should be established for critical green infrastructure, equating the expansion of the power grid with other critical societal projects like motorways and railways. This must significantly reduce the processing times for both renewable energy projects and grid reinforcements.
    - **Investment Security:** The economic regulation of grid companies must be reformed to create the necessary incentives and financial security to make the massive, proactive investments that the future requires.

Strategic Imperative 2: Strengthening National and European Resilience Geopolitical instability and the vulnerability of global supply chains are a new permanent reality. Strengthening robustness is no longer a cost but a crucial investment in supply security and competitiveness.

- **Recommendations:**
    - **Strategic Stockpiling and Diversification:** Danish companies, supported by national and European frameworks, should continue the work of diversifying their supply chains for critical raw materials and components. The establishment of strategic stocks for the most critical inputs should be considered.
    - **Promoting European Production (Reshoring/Nearshoring):** Denmark should actively work to ensure that the EU's industrial policy (e.g., 'Clean Industrial Deal') supports the build-

up of European production capacity in strategic technologies such as batteries, electrolysis plants, and solar cells to reduce dependence on Asia.

- **Raw Material Diplomacy:** Stronger strategic partnerships must be established with resource-rich and politically stable countries outside Europe to ensure a more diversified and secure supply of critical minerals.

Strategic Imperative 3: Operationalizing the Circular Economy The transition to a circular economy is essential for tackling resource scarcity and waste problems, but the current implementation is hampered by practical "last mile" problems. A more targeted and pragmatic effort is needed.

- **Recommendations:**
  - **Targeted Guidance and Support for SMEs:** Industry-specific and easily understandable guidelines should be developed to help small and medium-sized enterprises, in particular, to implement the new sorting requirements and identify circular business opportunities.
  - **Investment in Technology and Infrastructure:** Public and private investment should be made in advanced sorting and recycling technology that can handle complex waste streams (e.g., plastics) and produce high-quality secondary raw materials.
  - **Create a Market for Secondary Raw Materials:** Stronger economic incentives must be introduced, for example, through differentiated taxes, requirements for the use of recycled material in public procurement, and an extended producer responsibility that makes it economically attractive for companies to use recycled materials instead of virgin ones.

Strategic Imperative 4: Leveraging Denmark's Pioneer Position Denmark's leading position in green technology is a national strength that must be strategically exploited to drive economic growth and global climate action.

- **Recommendations:**
  - **Strategic Export Promotion:** A unified national strategy for the export of green energy technology should be formulated, focusing on areas where Denmark has particular strengths, including wind, PtX, and energy efficiency. This involves a strengthened effort from export credit and investment funds.
  - **Partnerships for Global Rollout:** Denmark should actively use its diplomatic influence and its government-to-government collaborations to help developing countries create the right framework conditions for investments in renewable energy, thereby creating new markets for Danish technology.
  - **Research and Innovation:** To maintain the technological lead, massive investment must continue in the research, development, and demonstration of the next generation of green technologies, including energy storage, advanced PtX, and CCS.

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