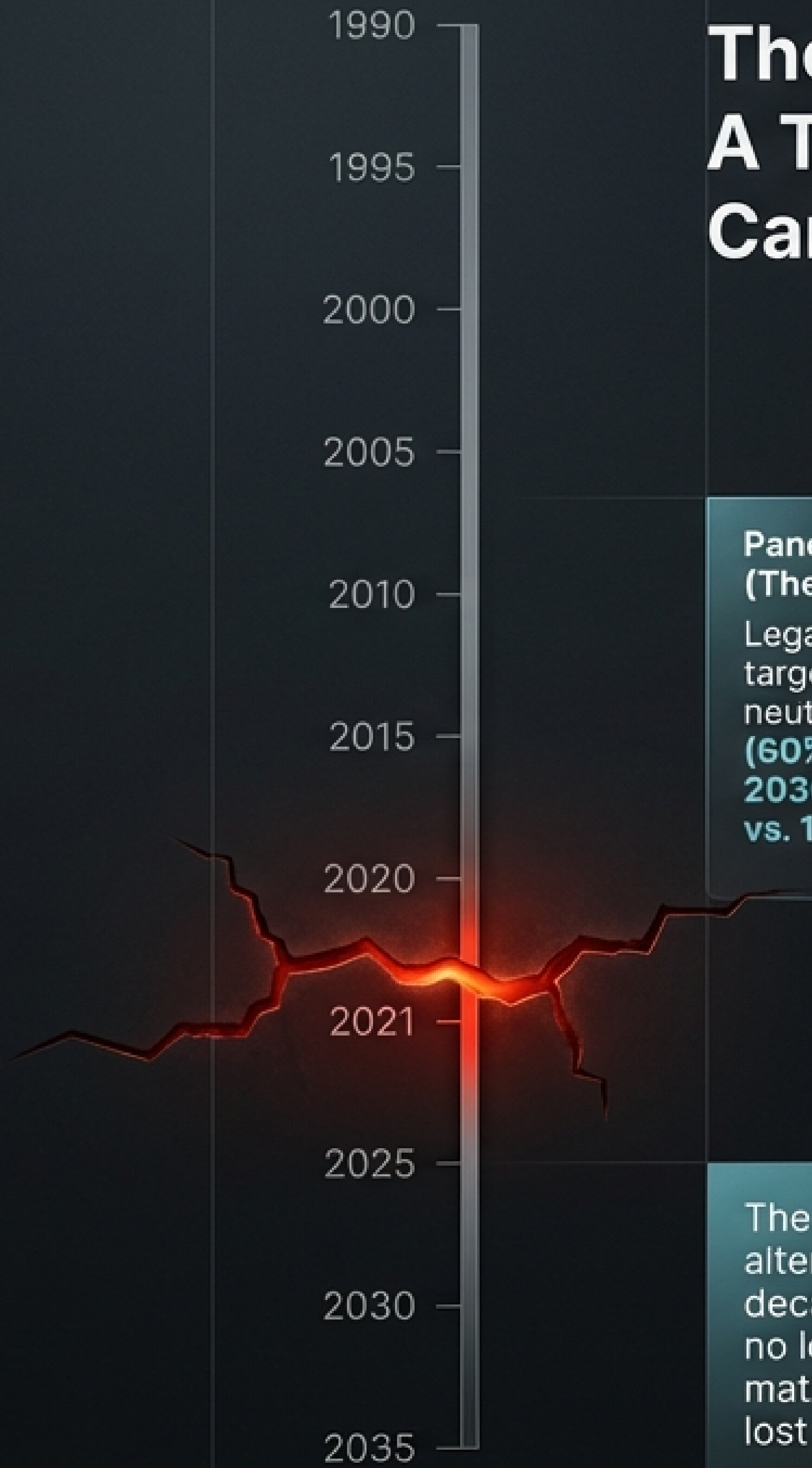
Decarbonising Finland’s Thermal Energy Sector

The Strategic Imperative of Industrial Waste Heat

A Quantitative Analysis of Heating Systems | Executive Briefing



The LULUCF Paradox: A Threat to the 2035 Carbon Neutrality Target

Panel 1
(The Goal)

Legally binding target of carbon neutralty by 2035 **(60% reduction by 2030, 80% by 2040 vs. 1990).**

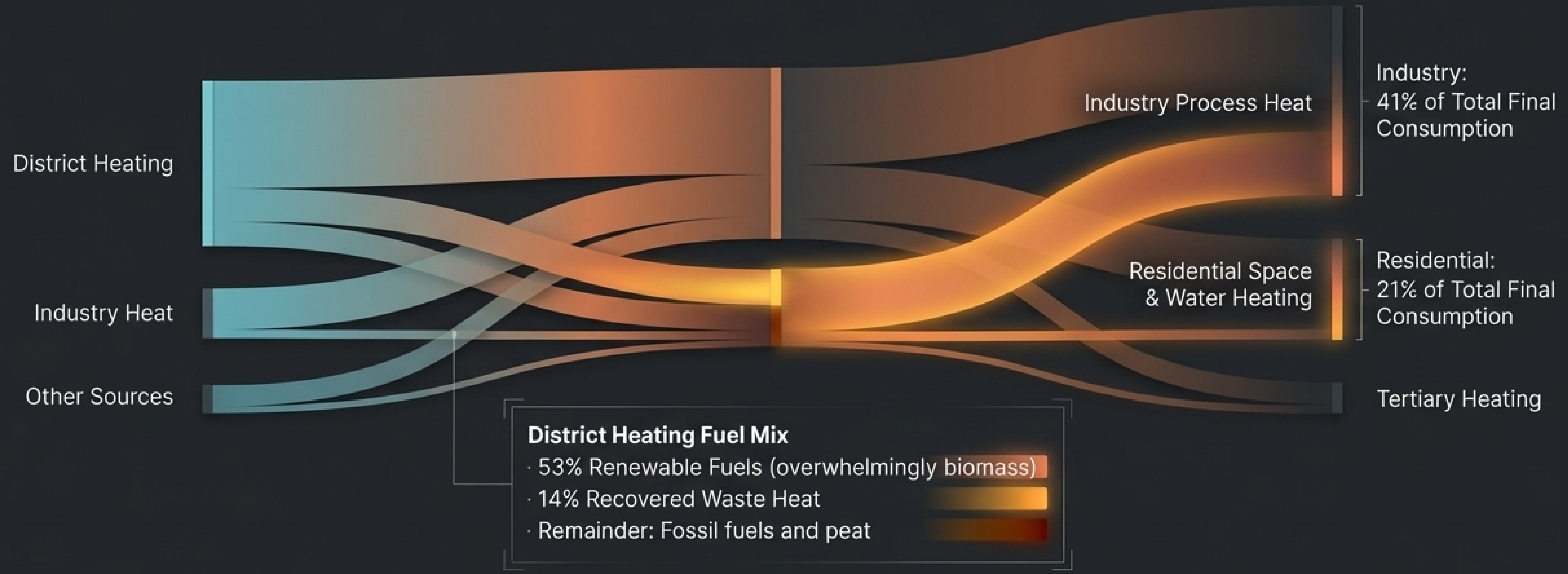
Panel 2
(The Shock)

In 2021, the Land Use, Land-Use Change, and Forestry (LULUCF) sector flipped from a critical carbon sink to a net source of emissions.

The collapse of the forestry sink fundamentally alters the national carbon budget. Deep, rapid decarbonisation in the thermal energy sector is no longer an option; it is an absolute mathematical necessity to compensate for the lost sink capacity.

The Thermal Battleground: Heating the Coldest EU Nation

Finland possesses the highest number of heating degree days (HDDs) in the EU.
Space heating dictates the nation's energy profile.

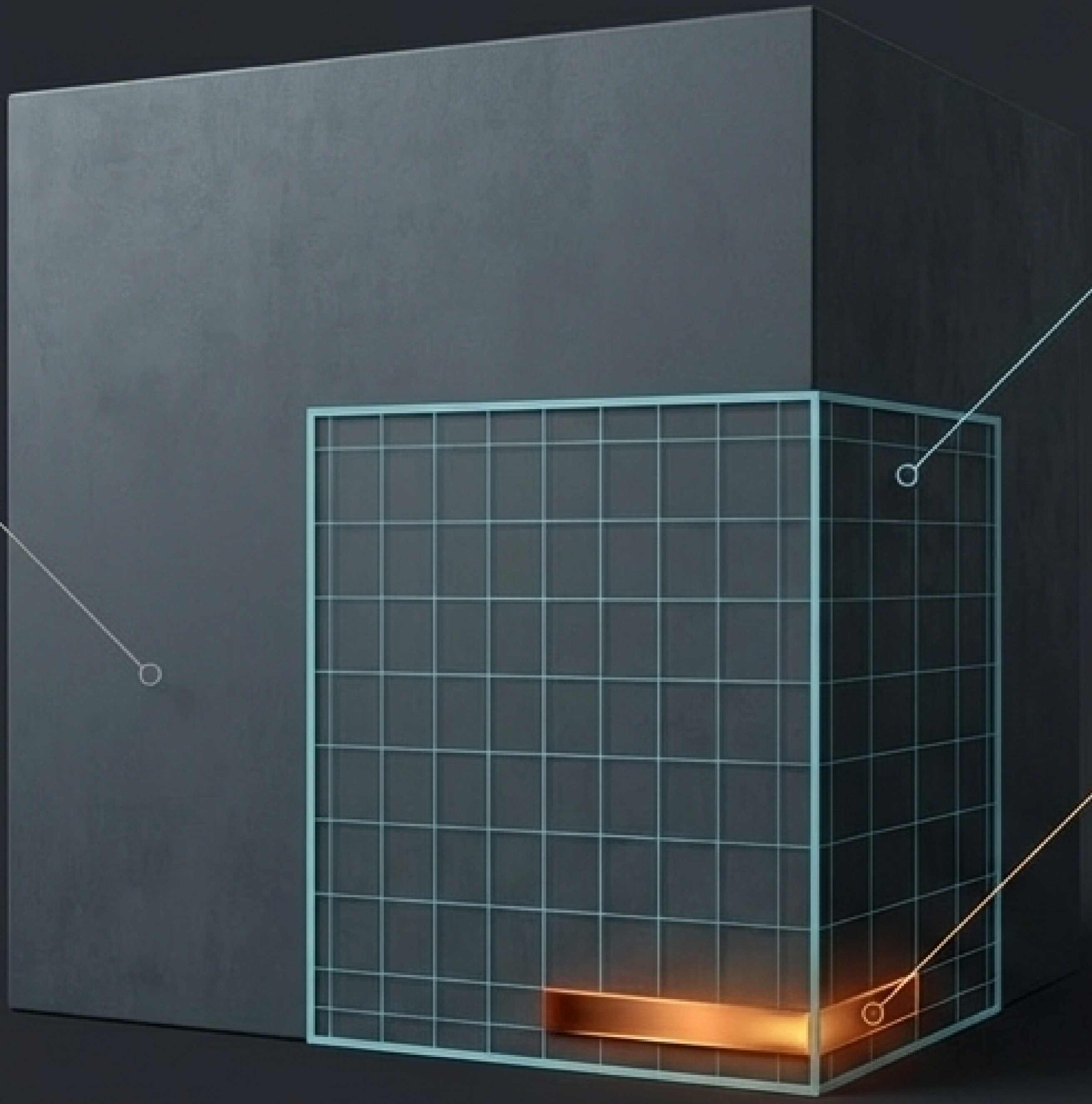


The transition away from coal has been successful, but the resulting heavy reliance on burned forestry biomass now threatens the LULUCF carbon sink.

The 90% Utilisation Gap: Finland's Largest Untapped Resource

130 TWh

Total estimated industrial waste heat generated annually.



~35 TWh

Technically feasible recovery potential.

3.0 TWh

Current utilisation in district heating networks (including just 0.2 TWh from data centres).

Waste heat is currently treated as an overlooked byproduct. Its scale is equivalent to the entire amount of energy previously produced from coal in Finland.

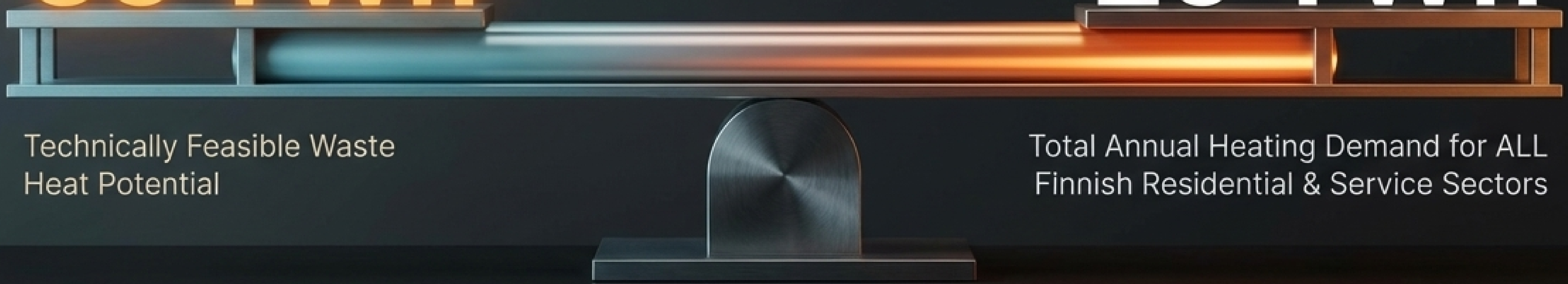
The Thermodynamic Equilibrium

35 TWh

Technically Feasible Waste Heat Potential

29 TWh

Total Annual Heating Demand for ALL Finnish Residential & Service Sectors



“We do not need to burn things to stay warm; we simply need to capture the heat we already make.”

The domestic waste heat resource is theoretically sufficient to replace nearly all combustion-based heating for every home, office, and shop in the nation.

Categorising the Thermal Asset: Sources and Potential

Sector	Technical Potential	Geographic Profile	Utilisation Status
Traditional Industry (Pulp & Paper, Chemicals, Metals)	**15.0 - 20.0 TWh**	Massive volume, but geographically dispersed.	*Part of 3.0 TWh total*
Emerging Tech (Data Centres)	2.0 TWh (rapidly growing)	Consistent, high-quality heat streams, highly concentrated near urban demand.	0.2 TWh
Urban & Municipal (Wastewater, Condensing Power)	Embedded directly within demand centers.	Immediate proximity to existing network.	Part of 3.0 TWh total

Highlight:
The Kilpilahti industrial area project is capable of recovering enough heat for a quarter of the Helsinki metropolitan area.

The Symbiotic Loop: Reframing District Cooling

Concept Explanation

Cooling demand and heating demand are technically the exact same circular process.

District cooling is not a luxury; it is a heat-harvesting mechanism.

Real-World Evidence

Helsinki's DC network capacity exceeds 100 MW (30% market share).

Large-scale heat pumps extract thermal energy from purified wastewater, simultaneously producing chilled water for the city and upgrading captured heat for the District Heating (DH) network.

The Bottlenecks: Geography, Thermodynamics, and Risk

Spatial Disconnect

Major sources of industrial heat are geographically separated from dense urban demand, requiring extensive transmission pipelines.

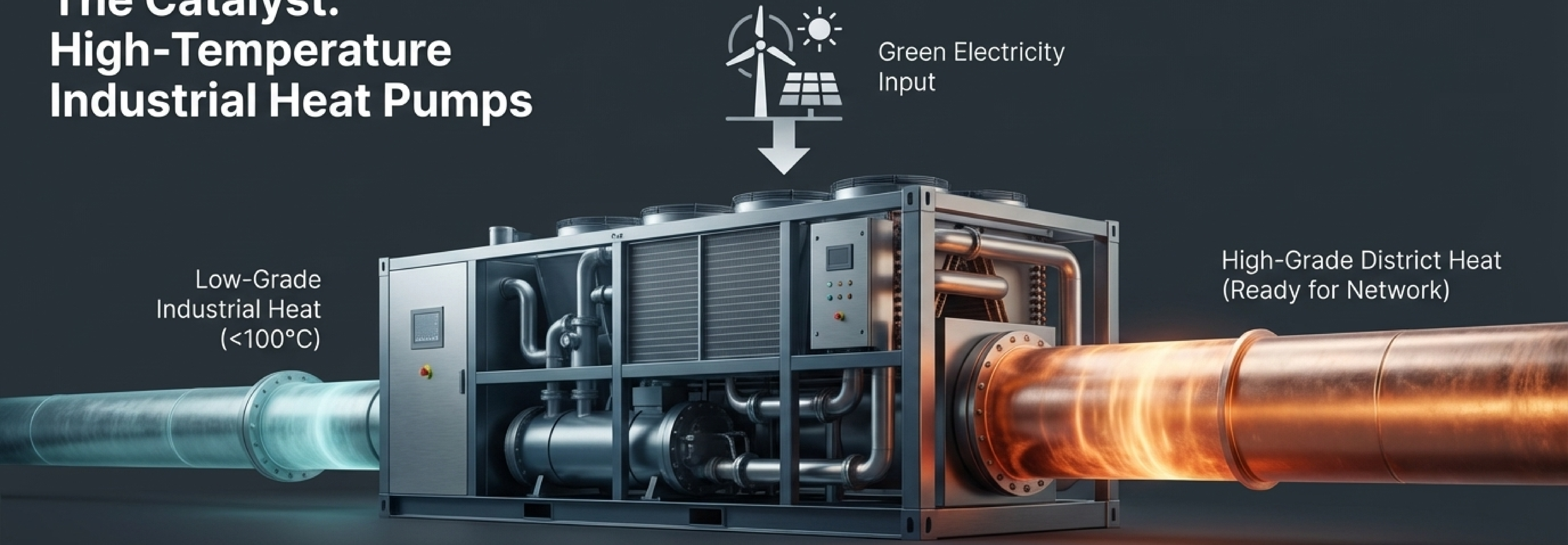
Low-Grade Heat

A significant portion of waste heat sits below 100°C. It is not hot enough for direct injection into existing DH networks without mechanical upgrading.

⚠ The Overarching Barrier: Capex Risk

The high upfront capital expenditure (Capex) for transmission infrastructure and industrial heat pumps creates severe investment risk, stalling deployment despite proven technical feasibility.

The Catalyst: High-Temperature Industrial Heat Pumps



Mechanism

Upgrading abundant, low-grade industrial waste heat to the high temperatures required by legacy urban heating networks.

Context

The rapid proliferation of heat pumps is already underway at the individual level (1.4 million units installed in Finland, 52% sales increase in 2022). This proven technology must now be scaled to the macro-industrial level.

The Enabling Platform: 14,920 Kilometres of Subterranean Infrastructure

1

Finland's District Heating (DH) network supplies **~38%** of total national heating demand.

2

Accounts for **33.6%** of residential final energy use.

2

Accounts for

33.6% of residential final energy use.

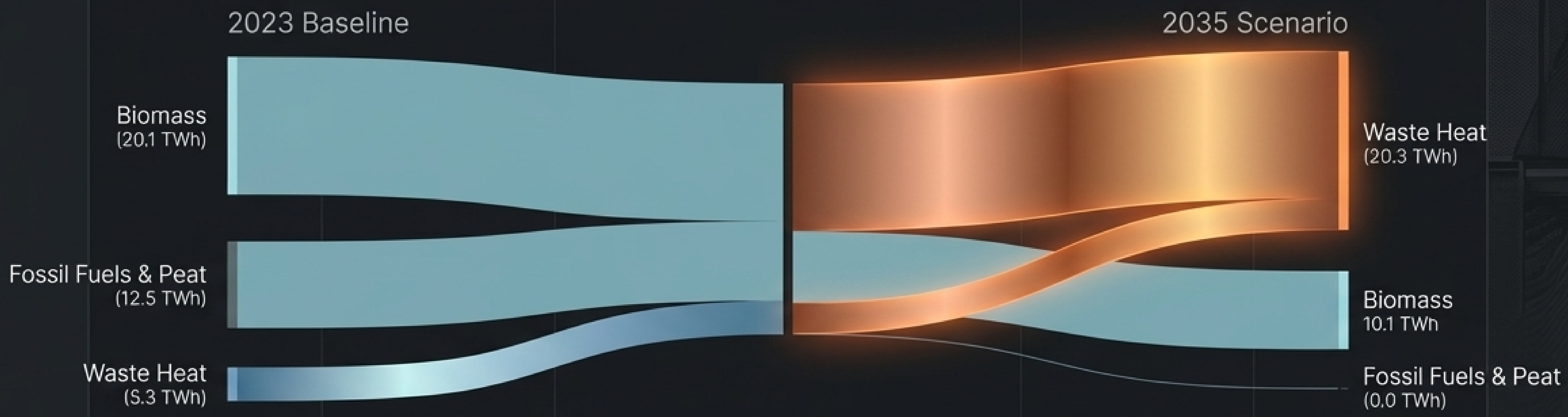
3

Total network trench length is approaching **15,000 km**, with **~23,390 MWth** installed capacity.

Strategic Reframe

The DH network must no longer be viewed as a simple heat utility. It is a foundational, national-level platform for sector coupling, capable of integrating industrial waste, flexible electricity, and urban consumers.

The 2035 Transformation Scenario: Displacing Combustion



The Model

Integrating just **15 TWh of additional waste heat** (less than half the technical potential) yields massive systemic shifts.

The Impact

Biomass reduced by 10.0 TWh: Directly relieves pressure on the forestry sector, aiding the LULUCF carbon sink.

Fossil Fuels & Peat reduced by 12.5 TWh: Complete phase-out of remaining high-emission combustion in the DH network.

A National Policy Blueprint: De-risking and Mandating

Pillar 1: De-risk Strategic Investments

Establish a dedicated national infrastructure fund or implement a Contract-for-Difference (CfD) mechanism for major waste heat projects. This directly addresses the high-Capex bottleneck and provides long-term revenue certainty to catalyze private capital.

Pillar 2: Mandate Heat Integration

Enact regulatory reforms requiring new large-scale energy consumers (specifically data centres > 1 MW) to conduct mandatory feasibility studies for DH network connection. If economically viable, connection becomes a permit condition.

Leading examples: Microsoft & Fortum / Google Hamina.

A National Policy Blueprint: Spatial Planning & Infrastructure

Pillar 3: Integrate Energy & Spatial Planning

Shift from a voluntary, bottom-up municipal approach to a coordinated national framework. Actively mandate the co-location of new industrial facilities and data centres near existing or planned thermal grids to minimize transmission distances.

Infrastructural Priority: ‘Heat Backbone’ Pipelines

Develop major transmission pipelines connecting high-potential industrial clusters (e.g., Kilpilahti, Tornio) directly to high-demand metropolitan DH networks in southern Finland.

From Forgotten Byproduct to Strategic National Asset

Climate Security: Capturing waste heat is the single most direct lever to reduce biomass dependency and restore Finland's critical LULUCF carbon sink.

Energy Security: Eradicates reliance on imported combustion fuels, creating a fully domestic, circular thermal economy.

Economic Advantage: Leverages Finland's cold climate and world-class DH infrastructure as a competitive magnet to attract green, heat-intensive global industries.

The path to 2035 runs directly through our industrial parks and data centres. Ensure no heat is left behind.