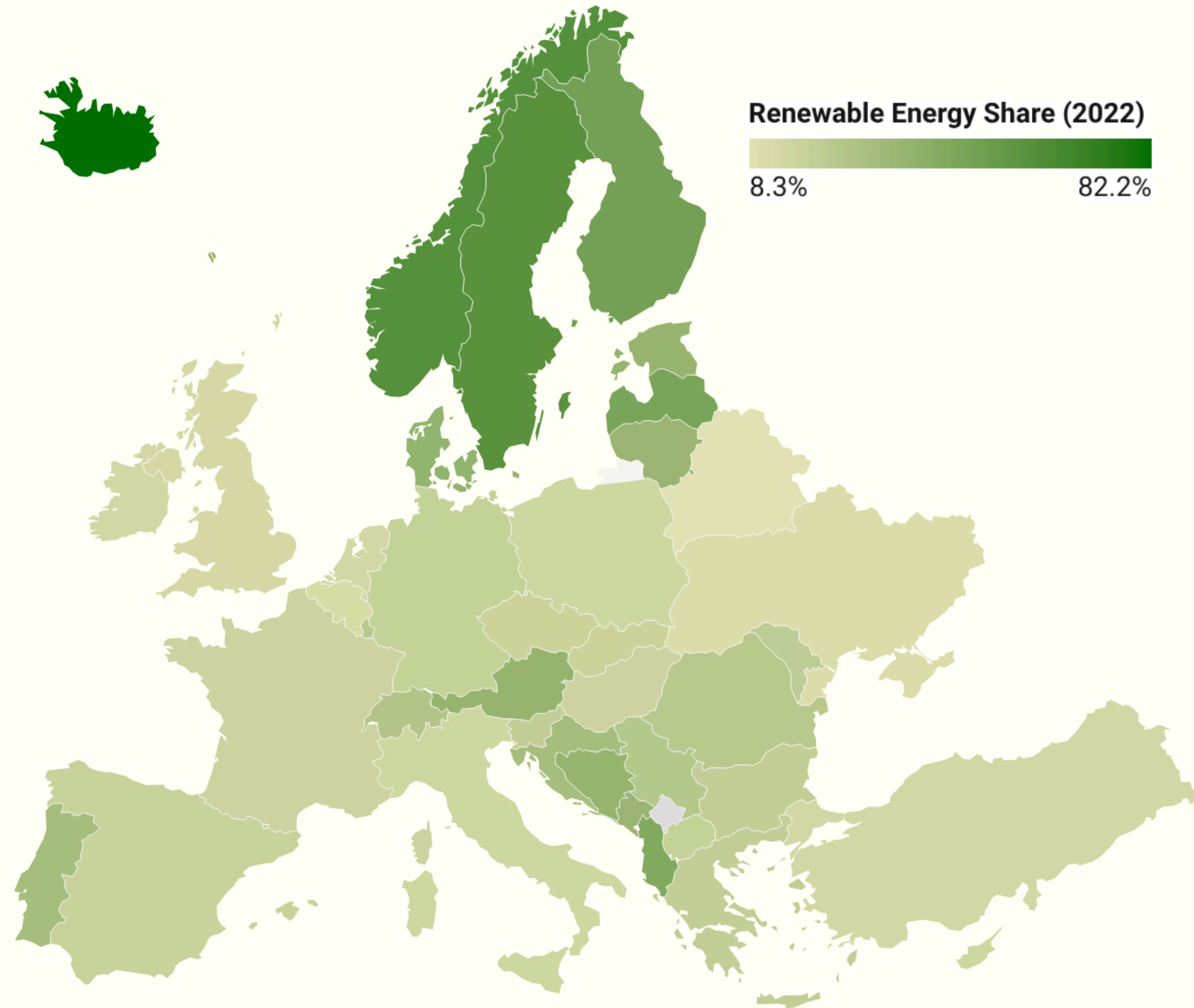


The Green Divide

Europe's Two-Speed Transition to 2030

By Lorenzo Lecci



Research Questions

Primary Research Question

Against the backdrop of the European Green Deal, is the continent converging towards a unified energy model, or is a structural 'Green Divide' widening between the resource-rich North and the rest of Europe?

Secondary Research Questions

To answer this, the analysis breaks down the transition into four logical dimensions:

- **The Trajectory (Dynamics):** Is the performance gap between Northern leaders and the rest of Europe a static legacy of the past, or a dynamic trend?
- **The Anatomy (Sectors):** Is this divide uniform across the economy, or is it driven by specific bottlenecks? Specifically, is the stagnation in the Transport sector masking the progress made in Electricity, creating a misleading picture of success?
- **The Consequence (Geopolitics):** Does a country's position in the Green Divide matter for its national security? Did high renewable shares actually act as a "shield" against import dependency during the 2022 Russian gas crisis?
- **The Reality Check (Italy Focus):** How do these continental forces play out in a major industrial economy? Has Italy managed to decouple its growth from fossil fuels, or did it simply swap oil for natural gas without achieving true independence?

About Data I: Selection & Context

Data Selection

- **Core Datasets (EU Focus):** I selected two complementary **Eurostat** metrics:
 - **nrg_ind_ren (Renewable Share):** Used as the primary indicator for all temporal and sectoral trends.
 - **nrg_ind_id (Energy Import Dependency):** Integrated to analyze the correlation between green adoption and national resilience.
- **Geospatial Focus (The Map):** For the Choropleth map, I selected **UNECE** (SDG Indicator 7.2.1). Unlike Eurostat, UNECE offers broader pan-European coverage (including non-EU Balkan & Eastern states), allowing for a more complete visualization of the continental "Green Divide".
- **National Focus (Italy):** For the deep dive on Italy, I switched to **Our World in Data** (OWID). Eurostat historical data is fragmented pre-2004, whereas OWID provided a continuous, granular time-series necessary for long-term trend analysis.

Access & Constraints

- **Licensing:** All datasets (Eurostat, UNECE, OWID) are released under open licenses (**CC BY 4.0** or **equivalent public domain**), allowing for academic reuse.
- **Fragmentation:** Integrating three different sources required harmonizing conflicting ISO country codes (e.g., UNECE uses strict ISO-3166 while Eurostat uses custom codes like "EL" for Greece).

About Data II: Quality & Limitations

Inherent Data Issues

- **Statistical Breaks (RED II):** The transport sector series exhibits a statistical break around 2020 due to the new calculation methodology enforced by the *RED II Directive*. Impact: While this affects strict year-on-year precision, the long-term stagnation trend remains valid for interpretation.
- **Outliers:** The *nrg_ind_id* dataset contains distortive values, specifically for Norway, which presents a negative dependency rate of $\sim -700\%$ (massive net exports). This creates a visualization challenge, potentially skewing the scale for import-dependent nations.

Data Structure Noise

- **Aggregates:** The raw datasets include non-sovereign entities (e.g., "EU27_2020", "Euro Area") mixed with country data.
- **Flags:** Eurostat employs non-numeric flags (e.g., ":" for missing data, "d" for definition differs) within numerical columns, preventing immediate statistical operations.
- **Geopolitical Coverage Gaps:** Post-Brexit data discontinuity affects the United Kingdom in Eurostat time-series. Similarly, Switzerland data is not consistently available in the *nrg_ind_ren* dataset. Consequently, these nations are excluded from the 'Western Europe' aggregate in temporal analyses to ensure statistical consistency.

Methodology I: Stack & Acquisition

The Tech Stack

- **Processing Engine:** Python (Jupyter Notebook) was used for the entire ETL pipeline to ensure full reproducibility.
- **AI Assistance:** Gemini 3 Pro and Claude Sonnet 4.5 were utilized for code optimization, debugging complex Eurostat formatting, and drafting the report in professional academic English.
- **Visualization Tools:**
 - **Datavrapper:** Used exclusively for the Choropleth Map (UNECE data).
 - **Flourish:** Used for all statistical charts (Eurostat/OWID data).

Data Acquisition Strategy

- **Automated Retrieval:**
 - **Eurostat:** Bulk programmatic download (.gz TSV files) and SDMX API calls using the Python requests library.
 - **OWID:** Direct fetch from the official [GitHub raw repository](#).
- **Direct Export:**
 - **UNECE:** Manual export of the standardized CSV dataset from the UNECE SDG Database (Indicator 7.2.1), subsequently processed in Python for ISO code alignment.

Methodology II: Data Processing

Data Cleaning

- **Parsing:** Deconstructed complex Eurostat strings, splitting combined dimensions (freq, unit, geo) into distinct columns using vectorised string manipulation.
- **Noise Removal:**
 - **Filtering:** Programmatically removed aggregate geo-codes identified in the analysis phase (e.g., "EU27") to isolate sovereign states.
 - **Type Casting:** Forced coercion of columns to numeric float, treating specific Eurostat flags (":") as NaN to prevent calculation errors.

Advanced Transformations

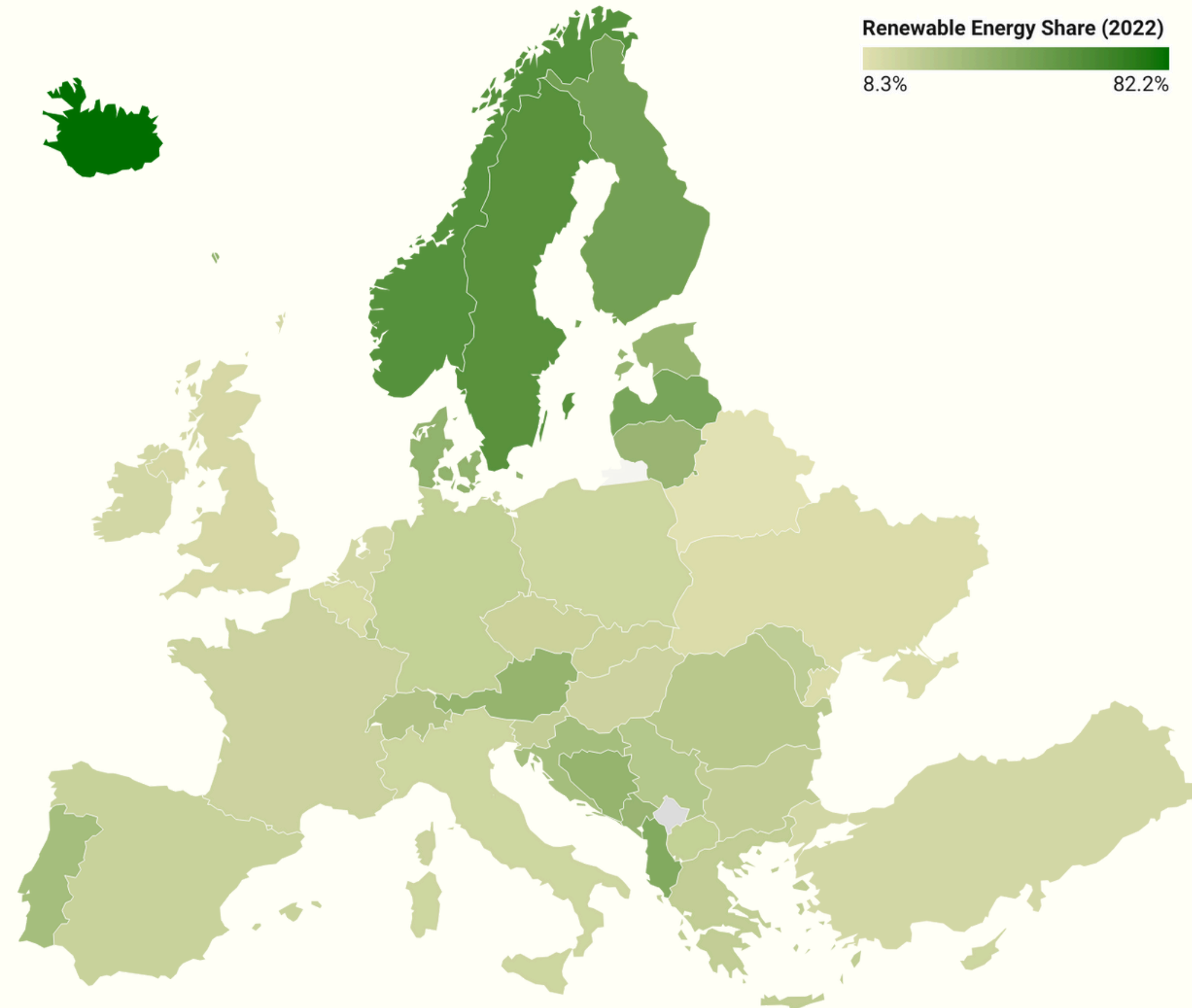
- **Reshaping:** Utilized Pandas melt to convert "wide" formats (years as columns) into the "long" format required by Flourish.
- **Merging:** Performed inner joins between Renewable Share and Import Dependency datasets based on geo and year keys for scatter plot generation.
- **Custom Metrics:**
 - **Regional:** Mapped countries to macro-regions via dictionary logic to calculate dynamic means.
 - **Growth:** Calculated the delta between start and end years programmatically to derive slope chart metrics.

The Geographic Context

The geospatial analysis (2022) reveals a stark "Green Gradient" across the continent.

- **The Nordic Leaders:** The Northern countries (Iceland, Norway, ...) operate in a different league, consistently exceeding 60-70% renewable shares thanks to massive hydro and geothermal resources.
- **The Continental Lag:** The rest of Europe struggles to keep pace. Whether looking at the industrial West, the sunny South, or the East, the vast majority of nations remain trapped in the 15-30% range, far behind the Northern outliers.
- **Insight:** The "Green Divide" is predominantly latitudinal. It is not an East-West gap, but a divide between the resource-rich North and the rest of the continent.

Geography as Destiny? The North-South Green Divide



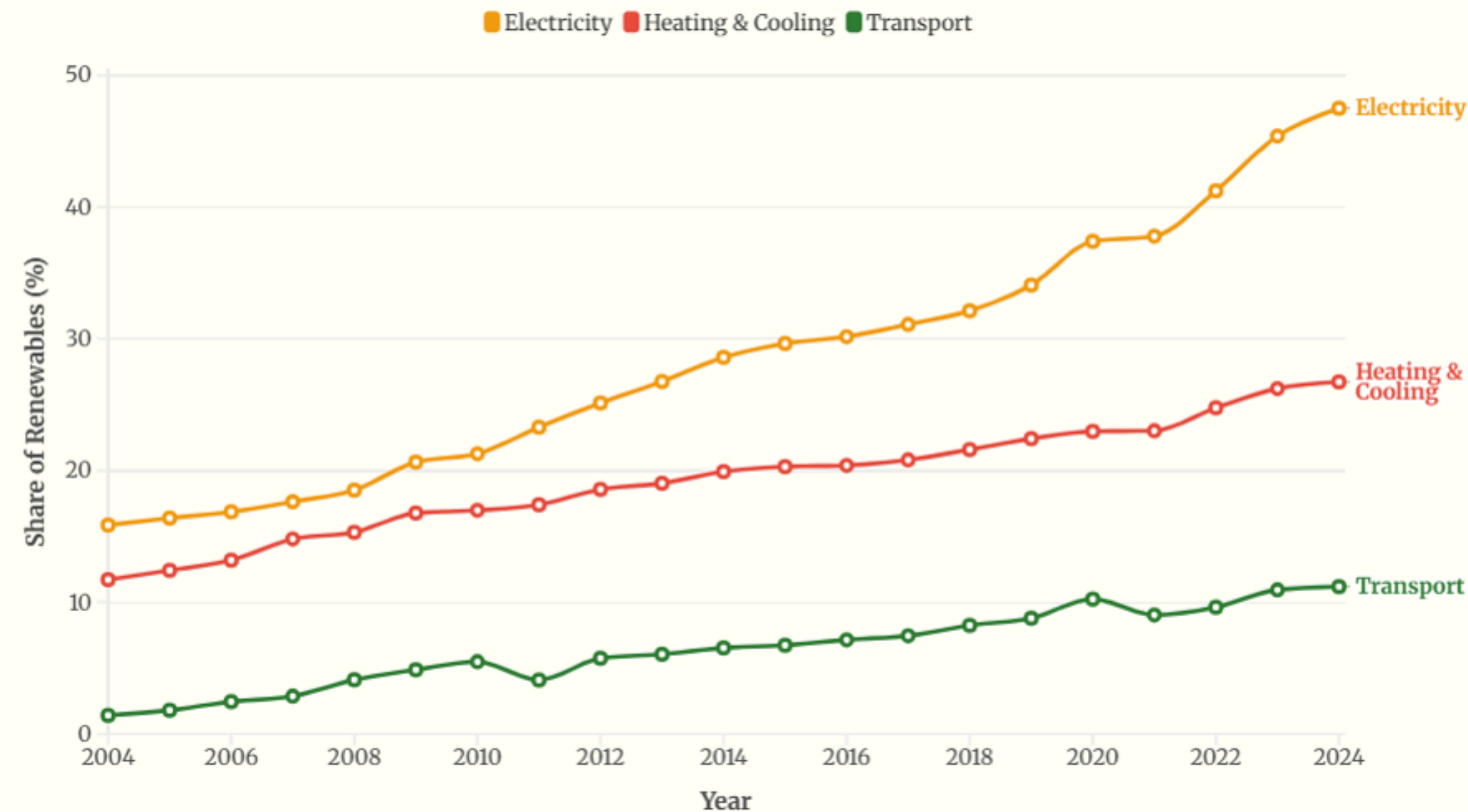
Author: Lorenzo Lecci | **Source:** UNECE

The Sectoral Anatomy

Before analyzing regional trends, it is crucial to understand the technological drivers. Decomposing the aggregate data reveals a massive structural imbalance.

- **The Supply-Side Success:** The Electricity sector exhibits exponential growth, rising from ~15% to nearly 45%. This confirms that the EU policy framework has successfully incentivized wind and solar deployment.
- **The Demand-Side Failure:** In stark contrast, the Transport sector (Green line) remains the "sick man" of the transition. The curve is alarmingly flat, barely crossing the 10% threshold despite two decades of policy efforts.
- **Insight:** We are greening the grid but failing to decarbonize mobility. This sectoral lag acts as a heavy anchor on the overall performance of many nations.

EU27 Renewable Energy Share by Sector (2004-2024) 



Author: Lorenzo Lecci | **Source:** Eurostat

The Widening Gap

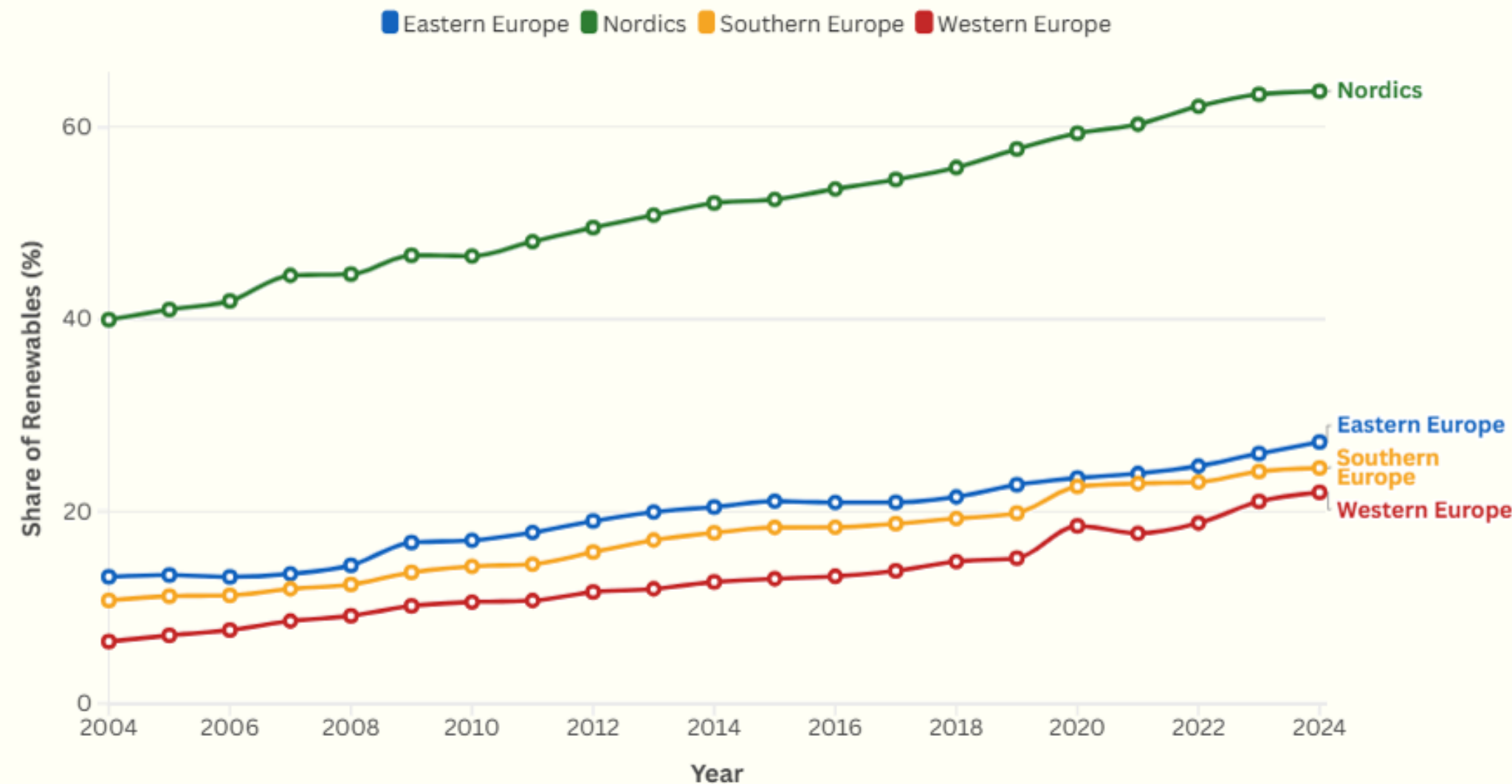
Is the continent converging toward a unified energy model? The temporal analysis refutes this hypothesis, highlighting a phenomenon of divergence.

- **The Nordic Breakaway:** The Nordics (Green line) are not just leading; they are accelerating. Their trajectory is decoupling from the rest of the continent, compounding their early advantage.
- **The "Three-Speed" Europe:** Below the leaders, we observe distinct stratifications. Southern and Western Europe follow parallel, moderate growth paths, while Eastern Europe (Blue line) shows the flattest trajectory, indicating systemic difficulties in scaling renewable infrastructure.
- **Insight:** The "Green Divide" is not closing. Instead of a catch-up effect, we are witnessing a "winner-takes-all" dynamic where resource-rich nations pull further ahead.

The Green Divide Over Time

eurostat 

Regional trends in renewable energy share (2004–2024)



Author: Lorenzo Lecci | **Source:** Eurostat

Nordics: SE, FI, DK, NO, IS.

Western Europe: DE, FR, BE, NL, LU, AT, IE.

Southern Europe: IT, ES, PT, EL, HR, SI, MT, CY.

Eastern Europe: PL, CZ, HU, SK, RO, BG, EE, LV, LT.

Velocity & Acceleration

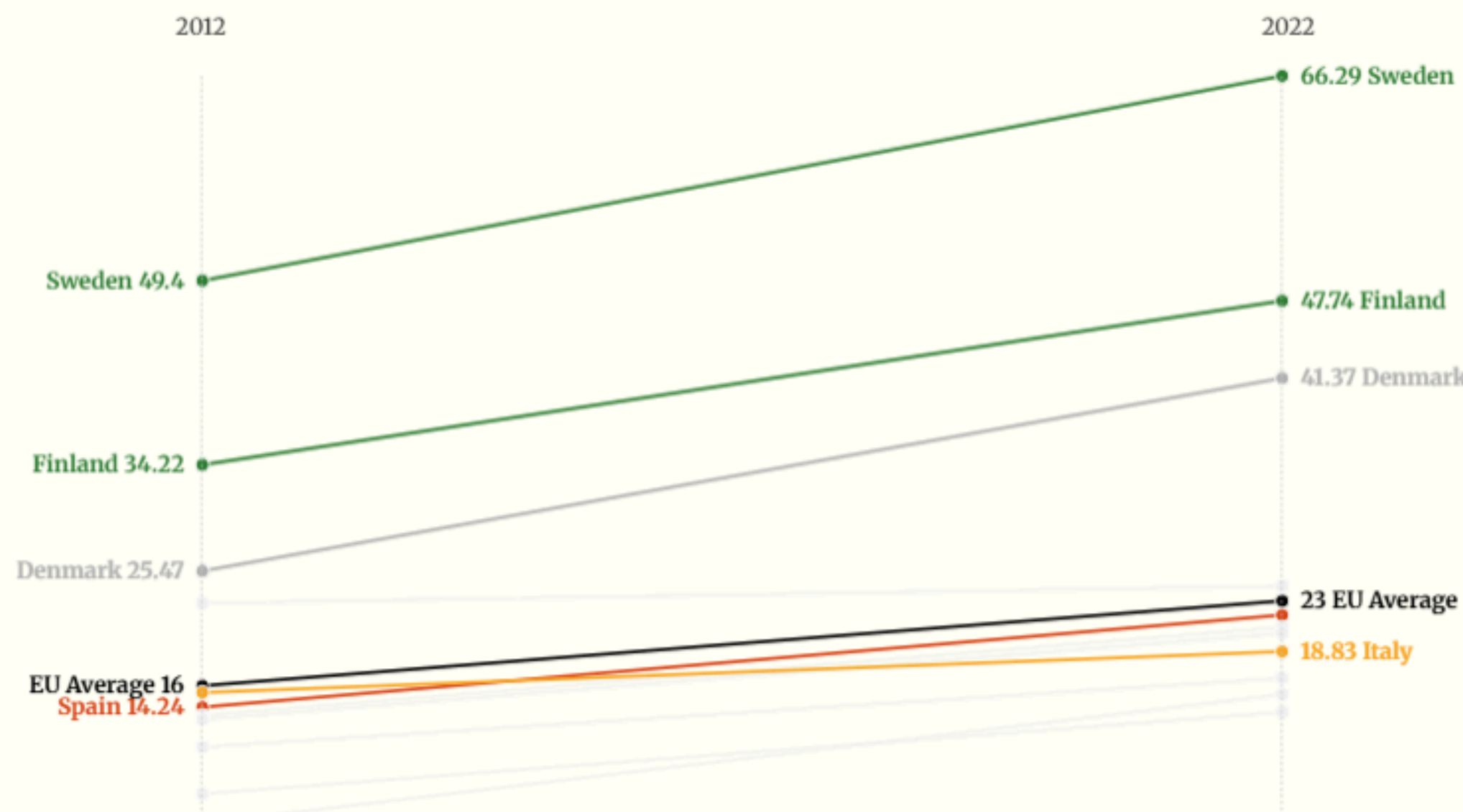
This slope chart isolates the velocity of the transition during the critical "Decade of Action" (2012–2022).

- **The Leader Sprints:** Sweden (top line) demonstrates that high saturation does not stall growth; despite starting from a dominant position, it continues to climb steeply.
- **The Fast Movers:** Spain (Red line) emerges as a standout performer with a steeper slope than the EU Average, reflecting aggressive recent solar policies.
- **The Moderate Middle:** Italy (Yellow line) tracks slightly below the EU average slope. Its pace is linear rather than exponential, suggesting a "steady but slow" transition that risks falling behind fast-movers like Spain.

A Multi-Speed Transition

Comparative analysis of renewable growth rates across Europe (2012–2022).

eurostat 



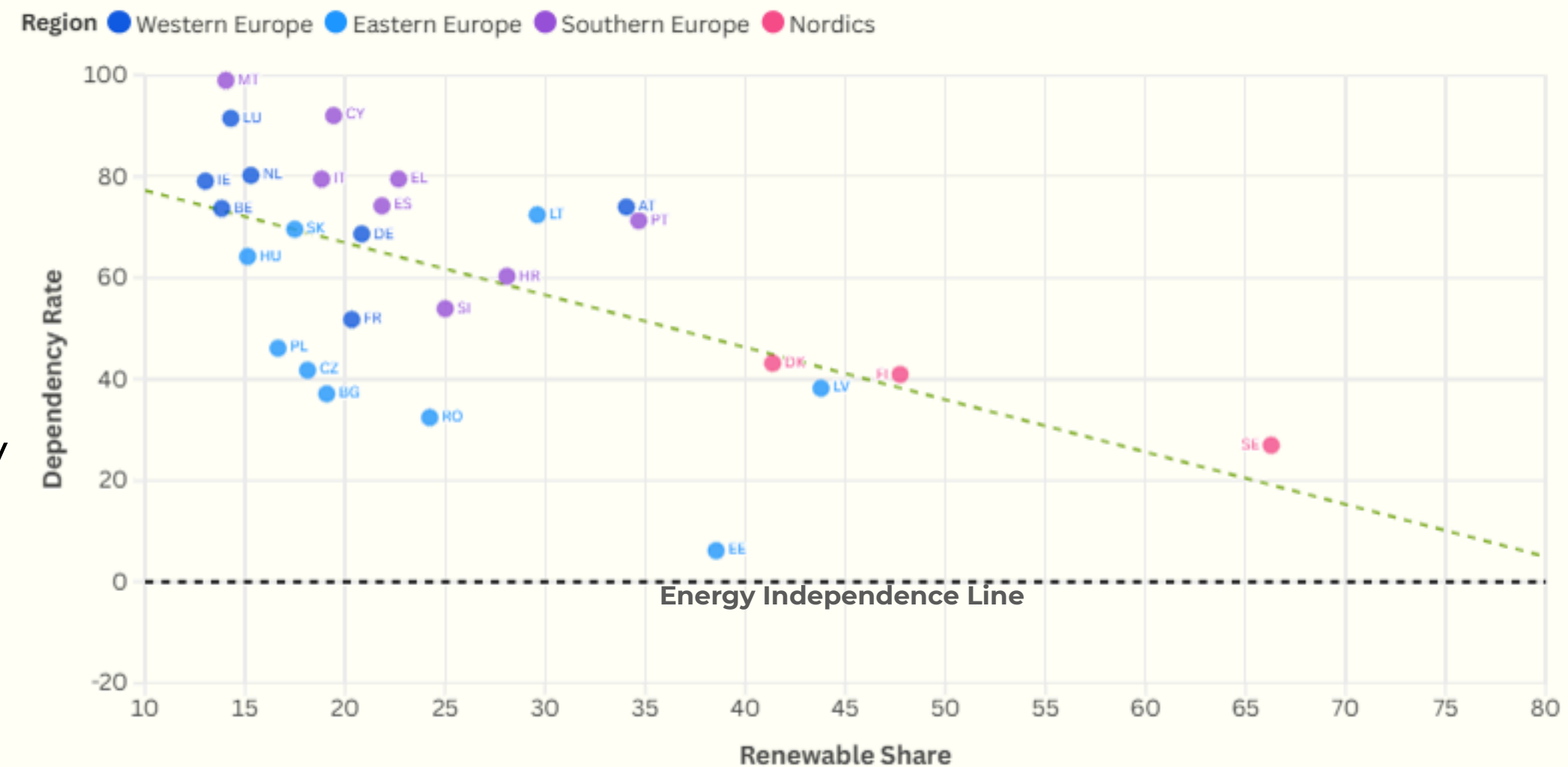
Author: Lorenzo Lecci | **Source:** Eurostat

Geopolitics & Security

The 2022 energy crisis redefined renewable energy from an environmental luxury to a critical national security asset.

- **The Inverse Correlation:** The scatter plot demonstrates a strong negative correlation: countries with higher renewable shares exhibit significantly lower fossil fuel import dependency (see the **green trend line**).
- **The "Danger Zone":** Major economies like Italy and Germany occupy the top-left quadrant (High Dependency and Moderate Renewables). This structural exposure made them the primary targets of the gas price shock.
- **The Nordic Shield:** The Nordics were structurally shielded. Their energy independence is not just a climate statistic but a geopolitical firewall.

Renewables vs. Dependency: The European Landscape



Norway (NO) is a significant outlier with a net export rate of approx. -700%; it isn't displayed for readability. Negative values indicate net energy exporters.

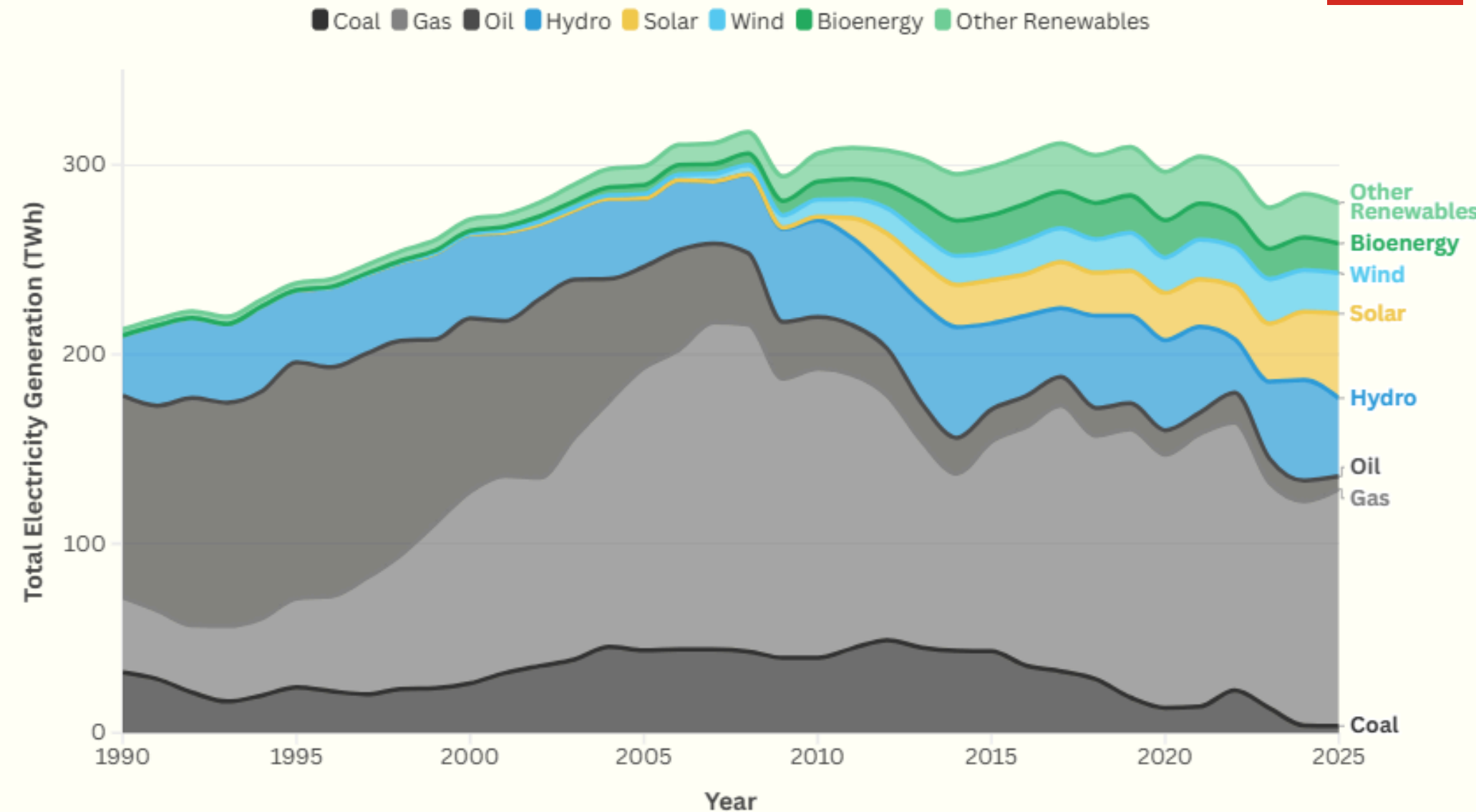
Author: Lorenzo Lecci | **Source:** Eurostat

National Case Study: Italy

Zooming in on Italy offers a pragmatic view of the transition's friction points in a major industrial economy.

- **The Gas Trap (1990–2010):** The chart highlights Italy's historical strategic pivot from Oil to Natural Gas. While this reduced carbon intensity initially, it created a massive baseload dependency that persists today.
- **The Renewable Layering:** While Solar and Wind have expanded significantly since 2010, they are largely covering new demand or fluctuating peaks rather than structurally displacing the gas wedge.
- **Insight:** Renewables have successfully displaced coal and oil, but have not yet eroded the strategic dependence on Natural Gas, which remains the dominant baseload required for true energy autonomy.

Italy's Electricity Generation Mix (1990–2025)



Author: Lorenzo Lecci | **Source:** Our World in Data

Conclusions & License

The State of the Union

- **A Structural Divide (Not Just Policy):** The data refutes the hypothesis of convergence. The gap between Northern Europe and the rest of the continent is widening, driven by geography and the compounding effect of early adoption. We are witnessing a "multi-speed" Europe where the leaders are decoupling from the rest.
- **The Sectoral Asymmetry:** The transition is currently unbalanced. We are revolutionizing the supply (Electricity generation) while leaving the demand (Transport) virtually untouched. Without a technological breakthrough in mobility, the 2030 targets remain mathematically improbable for many member states.
- **Security is the New Driver:** The post-2022 landscape proves that the "Green Divide" is a matter of national resilience. As shown by the correlation analysis, accelerating renewables is no longer just about climate compliance; it is the only viable path to geopolitical autonomy for import-dependent nations like Italy.

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