# Data Pack — Europe's Energy Paradigm Shift

Supporting data for research and policy analysis, under a decentralized and grid-edge lens, across EU27 + Europe, what that means for decentralized energy, and how to read the dynamics

## Data & Infrastructure Across Policy & Governance Layers

**Data & Infrastructure Across Policy & Governance Layers** (Digitalization, Decentralization, Regionalization, Sector Coupling, Grid Modernization, Cross-Border Governance, Regeneration, and Strategic Opportunity). It demonstrates that Europe's decentralized energy challenge is institutional rather than technological.

### 1. Quick read: what Europe already has

**Strong foundations**
- Wind and solar are already the cheapest new generation in most markets.
- The Commission's Grids Action Plan calls for faster permitting, smarter planning, digitalization, and collaboration.

**Grid modernization agenda**
- The Commission's Grids Action Plan calls for faster permitting, smarter planning, digitalization, and collaboration.

**Data infrastructure target**
- The target is at least **10% interconnection by 2030** (from capacity to market geometry perspective).

**Market reform is the bottleneck remaining**
- Electricity Market Design reform strengthens long-term markets, but the deeper shift toward resilience is still in early stages.

### 2. System architecture: how decentralized energy actually works

**Suggested Figure 4 — "Four layer decentralized system stack"**

- **Generation layer:** rooftop solar, community energy, microgrids
- **Distribution grid:** DSOs, local constraints, congestion, voltage
- **Flexibility layer:** storage, demand response, EV charging, aggregation
- **Transmission + markets:** TSOs, cross-border flows, balancing/ancillary services

Caption: Key decentralized energy flows between consumers, DSOs, TSOs, markets, and the transmission layer.

### 3. What is available in Europe — concrete building blocks

| Building block | What exists already | Why it matters (policy + market) | Primary sources |
|---|---|---|---|
| **Microgrids / local energy planning** | Hybrid short-duration needs + seasonal flexibility; different network assumptions | Stands where congestion and resilience are the main drivers; grid-edge planning | Article 2 of Electricity Market Design recast; Commission Grids Action Plan; Clean Energy for EU Islands; Clean Energy Transition Partnerships |
| **Interconnected zone** | 24 target of 15% by 2030; capacity cross-zonal interconnection (e.g., Iberian Peninsula) | Interconnections are both a constraint and a strategic lever; changes market geometry and balancing | European Commission Grids Action Plan; ENTSO-E TYNDP |
| **Grid operator digitalization pilots** | Commission "Grids, the energy highways" pilot; ENTSO-E Digital Twin; Horizon digitalization and AI projects | Enables the wire bottleneck: faster planning, better congestion management, and more flexible use of existing grids | EUR-Lex: Commission Recommendation on digitalization of the energy system |
| **Market reform** | Revised electricity market rules; long-term contracts (PPAs, CfDs); Three-year review underway | Key to rewarding flexibility, storage, and local resilience; determines commercial viability | Commission Electricity Market Design proposal; Three-year review |
| **Smart cities and local energy hubs** | Bottom-3 sectors: some Member States above 80%, others below 20% digitalization | Without smart meters, demand response and local flexibility do not scale; data access is the binding constraint | EU 2030 DESI; Smart Cities Marketplace; Digital SME Alliance; Smart cities pilots |
| **Energy storage deployment** | 70 storage demonstrators in pipeline; Commission has tens and billions of euros committed for storage tender | Storage is the "block, shift and shape" layer that makes decentralized generation usable | Commission Grids Action Plan; "Grids, the energy highways" |
| **Net Zero Industry Act (NZIA)** | 40 industrial policy priority for clean energy manufacturing; 90 GW annual capacity target; 85% of annual deployment | Supports supply-chain strategies; not a substitute for market design or permitting reform | Commission NZIA proposal; NZIA implementation guidance |
| **Hydrogen infrastructure + mapping** | European Hydrogen Backbone; Global Hydrogen Review; Infrastructure mapping tools | Relevant for industrial clustering, sector coupling, and long-duration storage | IEA Global Hydrogen Review; European Hydrogen Backbone map |

Future together: the figures above indicate that Europe's challenge has less in technical readiness than in governance, permitting, and market design.

### 4. Europe-wide Electricity Transmission & Interconnection

**What this shows:** Cross-border electricity transmission infrastructure.
**Why it matters:** The constraint is coordination, not infrastructure absence.
Reference: ENTSO-E TYNDP, European Commission Energy Union.

**Energy Sovereignty Index**

Click to see: Overview | Independence | Efficiency | Flexibility | 5-Year

### 5. Regional Differentiation Across Europe

**What this shows:** Strong regional variation in energy and industry.
**Why it matters:** Centralized models struggle in heterogeneous systems.
Reference: EU regional energy and cohesion data.

### 6. Energy System Stack and Value Chain

**What this shows:** Layered system from hardware to services.
**Why it matters:** Value migrates upward to orchestration.
Reference: Energy systems literature.

### 7. Renewables at System Scale: Rising Integration Pressure in Europe

**What this shows:** The share of generation from renewable sources in the EU has been rising steadily, with wind and solar now at 21%.
**Why it matters:** As this transition ramps up, the grid has increasingly shifted from supplying generation to **integrating variability**—grid capacity, congestion management, flexibility markets, and system coordination become the binding constraint.
**Policy relevance:** Grid expansion, market design, and flexibility mechanisms become as decisive as deployment targets.

### 8. Decentralized Energy as a Coordinated System(Aggregation & Market Integration)

**What this shows:** Distributed resources in small distributed quantities, individually too small to participate, are coordinated through **energy hubs and aggregators**, linking physical infrastructure to wholesale markets and market participation.
**Why it matters:** Decentralized energy scales through **aggregation**, not isolated deployment. The system must coordinate flexibility, infrastructure, market participation, dispatchability, and flexibility delivery.
**Policy relevance:** Sovereignty is exercised through **rules, interoperability, and market access** (who can aggregate, bid, connect, set prices, and through energy hubs) ...

**Simulator reference:** Remarkably emergent or **portfolio level**, where aggregated capacity participates, balances, optimizes, and can be coordinated as a fleet.

### 9. EU Grid Planning & Coordination

**What this shows:** EU-level grid planning capacity.
**Why it matters:** Decentralization + fragmentation.
Reference: ENTSO-E, EU Grids Action Plan.

### 10. Aggregation & System Coordination

**What this shows:** Aggregation enables scale.
**Why it matters:** DSO operates within systems.
Reference: Aggregator market design studies.

### 11. EU Project Pipeline

**What this shows:** Existing investment pipeline.
**Why it matters:** Bankability depends on policy.
Reference: ENTSO-E Project Collection.

Hydrogen Backbone
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