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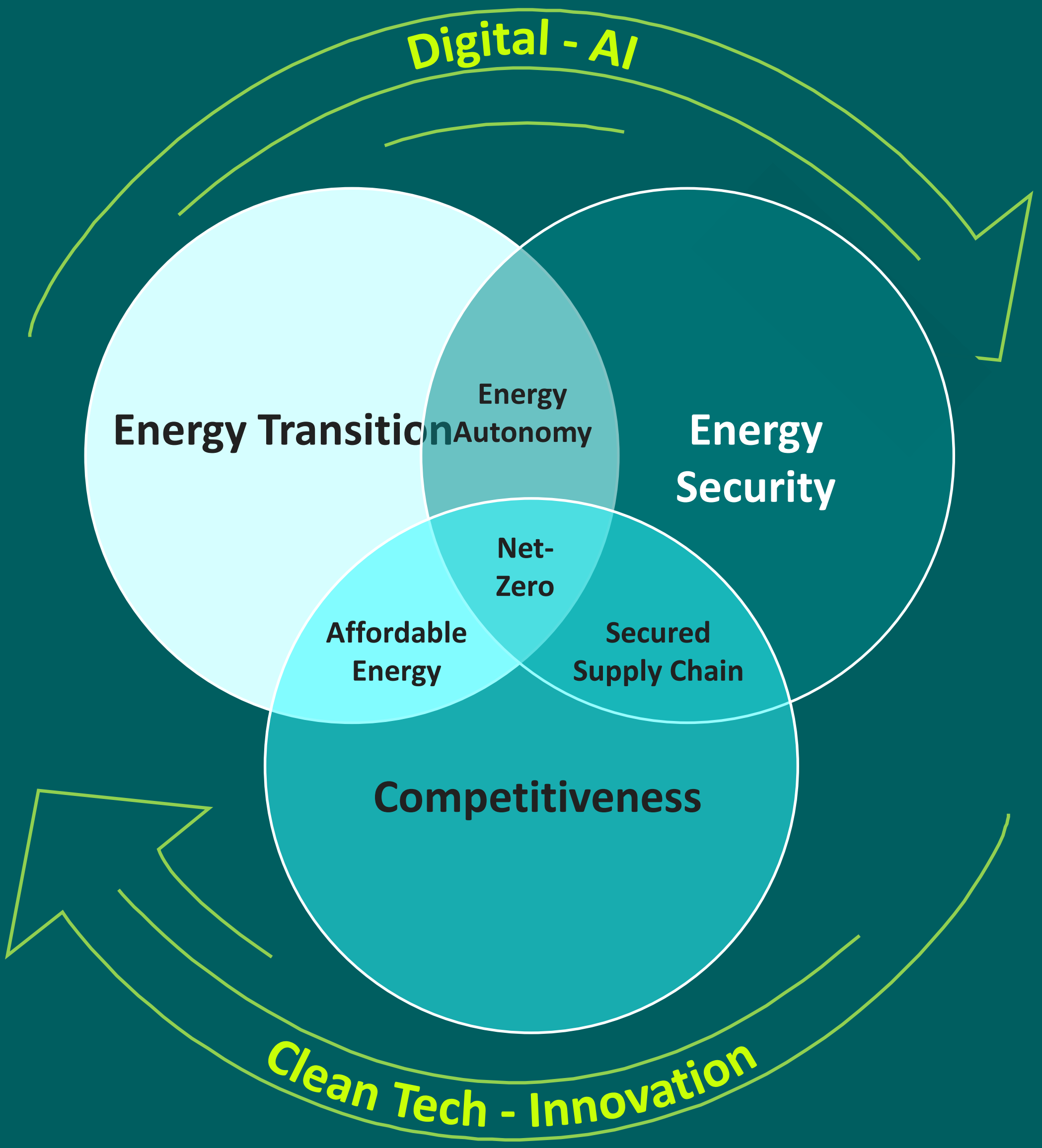
ELECTRICITY SECURITY ADVISORY BOARD

9 September 2025

The changing nature of reaching net-zero



New mega-trends are challenging the power grids resiliency

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DISRUPTION VELOCITY

- Increase in Nature extreme disruptions (severe weather, natural disasters, geomagnetic storms, wildlife)
- Ramp-up of armed and hybrid conflicts (terrorism, sabotage, cybersecurity threats)

ELECTRIFICATION DENSITY

- Exponential growth of grid assets
- Increased technical failures with growing grid complexity
- Human factor / mistake

DECARBONIZATION VARIABILITY

- Higher variability of load and generation
- Distributed-Energy Resources with bidirectional energy flows

Interco. enhances electricity security at macro-level

Benefits from higher interconnection:

1. More efficient use of resources

Surplus of one region benefiting to shortage of another

2. Redundancy in case of crisis

Reduce widespread blackouts + restoration capacity

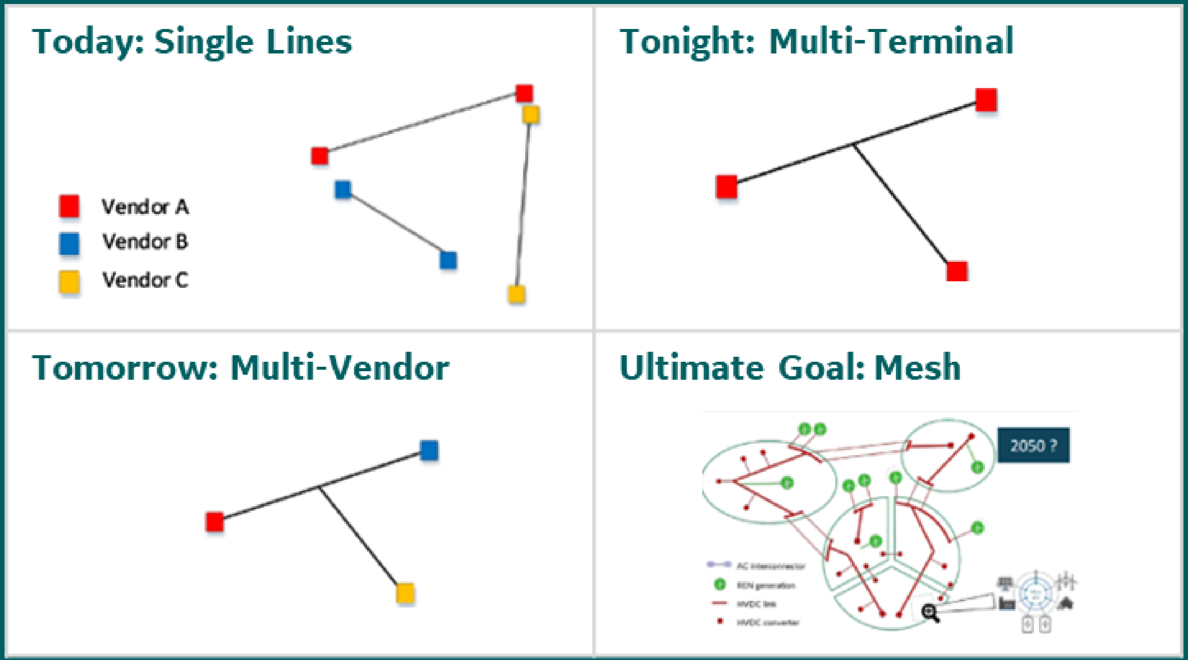
3. Diversity of supply

Reduce dependency on a single source of energy

4. Balancing variability of renewables

Regional weather (solar/wind) fluctuations smooth out

- Reduces systemic risk of widespread blackouts, while optimizing energy usage/cost
- Proven positive correlations between interconnection and network reliability



Back-to-Back HVDC systems and future Mufti-Terminals HVDC shape the future of European interconnected SuperGrid

Highly interconnected (>40%)

20 min / annum of system average duration interruption

Isolated, marginally interco.

273 min / annum of system average duration interruption

Better to have MESHED grids rather than MESSY grids

Decentralization brings some advantages at micro-level

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Benefits from decentralized power grids:

1. Lower vulnerability against threats

Less single-point failures affecting larger number of end-users

2. Local resilience

Microgrids can island during power grid failures

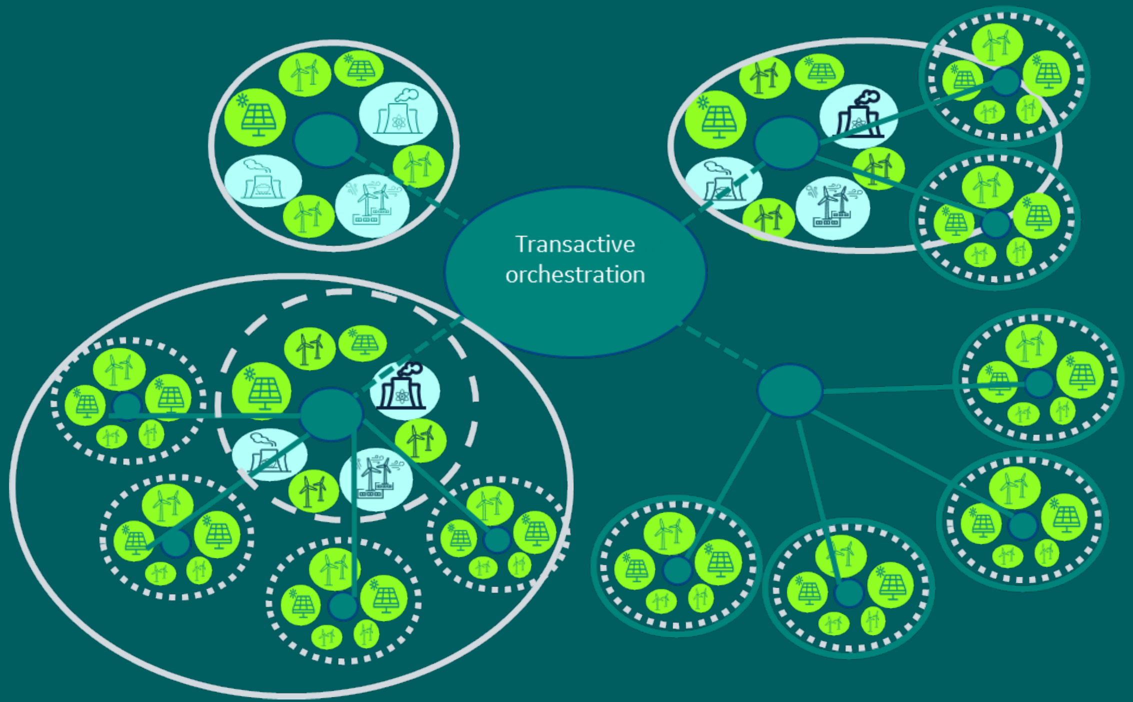
3. Better flexibility

Local generation/storage can respond / restore faster

4. Faster energy access

Remote regions cannot rely only on fragile transmission lines

- Increased resiliency due to reduced dependence on the wider network
- More manageable integration of renewables at smaller scale
- Allow faster and flexible recovery



GEV Zonal autonomous controls (ZAC) contribute to manage decentralized energy resources

…but it has it's set of challenges:

- Need for quick islanding solutions
- Intermittency of renewables
- Economics of building and operating such systems

Network Availability = Reliability x Maintainability requires both approaches … but also some complementary levers

Best of both approaches ….

- Interconnections correlates with better grid stability … reliability offering macro-resilience
- Decentralization correlates with better grid flexibility … maintainability for micro-resilience

The strongest resilience comes from combining:
a well-meshed backbone for balancing
+ some degree of decentralized resources for
local autonomy.

… with some additional energy security levers

- Grid upgrades and intelligent infrastructures
- Grid hardening and physical resilience
- Grid Stability and Energy Storage solutions
- Advanced Cybersecurity
- Secured and robust supply chains

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