ENTSO-E TYNDP 2026 System Needs Methodology

Public consultation response

Reference ANON-VZG4-FCQ3-R

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Electrification Systems | Grid Integration | Energy Transition Policy

Respondent Background

I write as an independent infrastructure strategist specialising in electrification systems, grid-integrated mobility, and energy transition policy across European and international markets. My recent working papers, *The Urban Blind Spot: Aligning Electrification Ambition with Distribution Reality* (SSRN, February 2026) and *Sequencing Electrification Under Distribution Congestion* (SSRN, March 2026), examine emerging structural constraints at the distribution layer as electrification accelerates across transport, heating, and digital infrastructure.

Both papers analyse how distribution network capacity, rather than generation adequacy, is increasingly becoming the operational bottleneck in dense metropolitan electrification systems.

Executive Position

The TYNDP System Needs Methodology is a foundational instrument for identifying where European electricity infrastructure must evolve to support the energy transition. Its transmission-level focus is both necessary and well established.

The TYNDP 2026 scope of studies document defines the System needs study as showing “where reinforcing cross-border transmission capacities throughout Europe could improve the cost-efficiency of the overall European energy system,” with methodology focused on “the combination of potential increases in cross-border capacity that minimise the total system costs.” This framing is appropriate and necessary for its stated purpose.

However, the same document defines a system gap as “a missing capacity to achieve a target, or to achieve a technical-economic optimum in line with policy targets.” The submission argues that distribution-level delivery constraints in metropolitan electrification clusters constitute precisely such gaps, missing capacity to achieve targets, and that the current cross-border focus on the methodology means these gaps are structurally outside its detection range, even as they are already beginning to materialise.

As electrification accelerates simultaneously across transport, digital infrastructure, and building heating systems, infrastructure pressure is increasingly emerging not at the cross-border transmission layer but within medium and low-voltage distribution networks serving dense urban regions.

Recent congestion challenges reported by distribution system operators in the Netherlands, Ireland, and parts of Germany suggest that these dynamics are already emerging despite adequate national generation capacity.

A System Needs framework calibrated primarily to transmission adequacy may therefore fail to surface emerging electrification constraints until they materialise as:

Connection delays

Reactive network reinforcement

Spatial inequality in electrification deployment

Given that the TYNDP 2026 System Needs Study assesses system development toward the 2040 horizon, electrification demand growth will increasingly concentrate at the transmission-distribution interface well before that date.

This submission identifies three methodological blind spots and proposes three practical adjustments that would allow the System Needs Methodology to better capture these emerging constraints.

Figure 1-*Emerging Constraint at the Transmission-Distribution Interface*

The TYNDP 2026 methodology represents an important step forward in integrating sector coupling into system planning, particularly through the explicit modelling of hydrogen systems and the role of electrolysers as flexible demand.

This approach reflects a broader shift toward viewing electrolysers not only as industrial assets, but as system-balancing resources capable of absorbing surplus renewable generation and contributing to overall system efficiency.

However, the operational availability of these flexibility resources is not determined solely by system-level conditions such as generation surplus or price signals.

Electrolysers, like other large flexible loads, are physically connected at specific nodes within the network, often at transmission or medium-voltage levels in industrial clusters, port regions, or coastal energy hubs. Their ability to operate as modelled therefore depends on whether sufficient network capacity exists at these connection points to deliver electricity when required.

In situations where transmission capacity is available, but downstream network constraints are present, these assets may not be able to respond to system signals as assumed within the optimisation framework.

This introduces a potential divergence between **modelled flexibility** and **physically deliverable flexibility**.

Within the current optimisation structure, constraints that are not explicitly represented in the model are implicitly treated as non-binding. As a result, flexibility resources such as electrolysers may be assumed to be fully dispatchable under system conditions where local network constraints could, in practice, limit their utilisation.

The implication is not that the modelling approach is incorrect, but that certain constraints affecting the real-world deployment of flexibility resources may fall outside the current system boundary.

As the role of hydrogen in balancing renewable variability expands toward the 2040 horizon, ensuring that the assumed availability of flexibility aligns with network accessibility conditions at key nodes may become increasingly important for maintaining consistency between model outcomes and deployable system configurations.

Observation 1: EV Demand Modelling Treats Electricity as a Volume Variable - It Is Also a Topology Variable

ENTSO-E’s own scope document acknowledges that the System Needs study will answer the question: “In a future where EU targets are met, what cross-border infrastructure would maximise the cost-efficiency of Europe's energy system?" This framing correctly identifies cross-border infrastructure as the study's primary output. However, the demand inputs that generate the system needs, specifically EV charging demand, are modelled as aggregate national consumption figures fed into market simulation tools. The topology of that demand, meaning where within the system it actually concentrates, is not a variable in the cross-border optimisation. (Arya, 2026(a)) (Arya, 2026(b))

Current TYNDP scenario modelling incorporates electric vehicle adoption as an aggregate annual electricity demand increment. This approach is appropriate for transmission-level generation adequacy assessment but is structurally insufficient for identifying where infrastructure stress will actually emerge.

EV charging demand is not simply additional electricity consumption. It is demanding compression, high per-unit power draw, behaviourally synchronised timing, and geographic concentration at low-voltage nodes within apartment-dominated urban districts. In dense European cities where the majority of households lack private parking access, charging demand does not distribute evenly across millions of private connections. It concentrates on shared infrastructure nodes, curbside clusters, underground parking facilities, and public fast-charging hubs, each served by a small number of distribution transformers.

At the distribution level, simultaneous charging behaviour creates transformer utilisation patterns that differ materially from aggregate electricity demand growth. A typical European urban distribution transformer rated at 400-630 kVA serving a multi-apartment block may currently operate at 35-45% peak utilisation. If 25-35% of households within the same service area adopt EVs without private home charging and rely on shared evening charging infrastructure, peak transformer utilisation can exceed 80-90% during synchronised charging windows (18:00–22:00). This stress pattern emerges well before aggregate electricity demand growth appears significant at the transmission modelling scale.

The difference between 30% EV penetration in a low-density suburban environment with private driveways and 30% EV penetration in Amsterdam, Rotterdam, or Copenhagen is not a difference of degree in the system needs model; it is a fundamentally different topology of demand. The transformer stress curve under apartment-concentrated simultaneous charging is non-linear in ways that aggregate consumption figures do not capture.

These dynamics illustrate a structural limitation of modelling electrification demand primarily as an aggregate energy variable. While this approach is appropriate for transmission adequacy analysis, it does not capture the spatial topology of demand that determines where infrastructure stress actually emerges within urban distribution networks.

Recommendation 1:

Introduce Urban Electrification Archetypes in Scenario Modelling

TYNDP scenario development should incorporate differentiated electrification demand archetypes reflecting urban form and housing typology. At a minimum, EV charging demand modelling should distinguish between:

- **Private residential charging environments** (detached or driveway-enabled housing);
- **Shared residential charging environments** (multi-apartment buildings without private parking access);
- **Public urban fast-charging clusters** (curbside infrastructure and high-turnover charging hubs).

These archetypes generate materially different load profiles and transformer utilisation patterns. Integrating these electrification archetypes into demand modelling would allow the System Needs Methodology to surface **distribution-level stress signals** that are currently invisible within transmission-scale modelling assumptions.

Observation 2: Data Centre Baseload and EV Peak Compression Are Competing for the Same MV Headroom; The Methodology Does Not Model Their Interaction

The TYNDP methodology and scenario framework have begun to acknowledge data centre electricity demand as a growing uncertainty in future demand projections. However, the interaction between data centre baseload growth and EV charging peak compression at the distribution layer represents a structurally distinct planning challenge that is not addressed at the transmission modelling scale.

Data centres connected at medium-voltage or high-voltage nodes within FLAP-D markets like Frankfurt, London, Amsterdam, Paris, and Dublin introduce persistent, continuous baseload demand that reduces available MV headroom. EV charging demand then compresses peak load onto substations whose headroom has already been partially absorbed by data centre baseload. The resulting compound utilisation pressure at the MV layer is non-linear and cannot be derived by summing the two demand curves independently.

In Ireland, data centres already represent approximately 22% of total national metered electricity consumption, a structural shift that occurred within a decade. The FLAP-D metropolitan regions are experiencing the early phases of an equivalent concentration. When distribution system operators in these regions receive simultaneous connection requests from data centre operators and charging infrastructure providers competing for the same MV substation headroom, the System Needs Methodology provides no visibility into how these demands interact at the nodal level.

When these loads converge within the same metropolitan infrastructure footprint, transmission-level adequacy may coexist with **distribution-level connection constraints**, creating a planning visibility gap within the current System Needs framework.

The TYNDP 2026 methodology places increasing emphasis on sector coupling, particularly through the integration of hydrogen systems and the modelling of electrolysers as flexible demand capable of absorbing surplus renewable generation.

This represents a significant evolution in system planning, positioning electrolysers not only as industrial assets but as system-level balancing resources that contribute to overall optimisation outcomes.

However, the operational behaviour of these flexibility resources is contingent not only on system-level conditions, but also on their physical accessibility to the network at specific connection points.

Electrolysers are typically located in industrial clusters, port regions, or coastal energy hubs, where they connect at transmission or medium-voltage levels. Their ability to respond to surplus generation or price signals therefore, depends on whether sufficient network capacity exists at these nodes to deliver electricity when required.

In cases where transmission capacity is available, but downstream network constraints are present, these assets may not be able to operate as assumed within the optimisation framework.

This creates a potential divergence between **modelled system flexibility** and **physically deliverable flexibility**.

Within the current optimisation structure, constraints that are not explicitly represented in the model are implicitly treated as non-binding. As a result, flexibility resources such as electrolysers may be assumed to be fully dispatchable, even when local network limitations could in practice restrict their utilisation.

The implication is not that the modelling approach is incorrect, but that certain constraints affecting the real-world deployment of flexibility resources may fall outside the current system boundary.

As the role of hydrogen in balancing renewable variability expands toward the 2040 horizon, ensuring that assumed flexibility availability aligns with network accessibility conditions may become increasingly important for maintaining consistency between model outcomes and deployable system configurations.

While emerging system configurations may increasingly position electrolysis closer to renewable generation sources, including offshore environments, and utilise hydrogen transport infrastructure to deliver energy across regions, this does not eliminate the role of network accessibility in determining system performance.

Rather, it shifts the point at which infrastructure constraints manifest.

In such configurations, system performance becomes dependent not only on electricity network optimisation, but also on the availability, capacity, and coordination of hydrogen transport, storage, and end-use or reconversion infrastructure at demand locations.

As a result, the underlying requirement remains consistent: energy must ultimately be delivered in a usable form at specific nodes within the system.

Constraints at these delivery points, whether electrical or hydrogen-based,therefore remain critical in determining the real-world deployability of system configurations that may appear optimal at a modelling level.

Recommendation 2:

Identify Metropolitan Interface Zones

Cross-Referencing TYNDP scenario demand projections for data centre growth in FLAP-D markets against the hosting capacity maps that DSOs in those regions are now required to publish under Article 31 of the Electricity Directive can provide data for efficient planning.

Mapping these clusters would allow planners to identify locations where persistent data centre baseload and electrified transport demand are likely to compete for the same medium-voltage distribution capacity.

This approach would not require ENTSO-E to model distribution networks directly. Rather, it would allow the System Needs Methodology to identify **metropolitan interface zones** where transmission adequacy may coexist with distribution congestion.

This cross-referencing exercise should produce a published Metropolitan Interface Zone map as part of the TYNDP 2026 Infrastructure Gaps Report, providing DSOs, charge point operators, and municipal planners with a shared visibility tool for identifying where transmission adequacy coexists with distribution delivery risk.

Observation 3: The Reinforcement Gap Is a System Needs Issue, Not Only a Regulatory Issue

The TYNDP System Needs Study is designed to identify infrastructure gaps, where transmission capacity is insufficient to meet the needs of the future energy system. The reinforcement gap described in my working papers is an analogous but under-recognised infrastructure gap at the distribution layer: the temporal misalignment between electrification adoption velocity and distribution reinforcement velocity.

European distribution networks require €375-425 billion in investment by 2030. Approximately 40% of the distribution infrastructure is more than 40 years old. Permitting timelines for distribution reinforcement range from four to ten years. Electrification policy mandates, AFIR charging targets, building renovation requirements, and industrial decarbonisation commitments operate on legislative cycles of three to five years.

ENTSO-E has itself acknowledged this boundary in prior TYNDP documentation, noting that "the system needs methodology is based on cross-border capacity increases" and therefore "does not capture entirely the potential benefits of non-transmission technologies that do not translate into an increase of cross-border network capacity." The reinforcement gap at the distribution layer is precisely such a non-transmission constraint; it does not show up as a cross-border capacity shortfall, yet it directly determines whether EU electrification targets are achievable in practice. (ENTSO-E , 2025) (ENTSO-E , 2020)

The 2040 horizon chosen for TYNDP 2026 makes this more consequential, not less. ENTSO-E's own rationale for the 2040 focus is that it provides enough lead time for stakeholders to "take action, by proposing solutions to tackle identified gaps, considering that developing and building infrastructure projects take 10 years or more." Distribution reinforcement permitting timelines in dense urban environments range from four to ten years. The window for proactive alignment is the same window TYNDP 2026 is designed to inform. A gap that is invisible to the methodology but requires the same lead time as the infrastructure the methodology is designed to plan for is not a minor omission; it is a planning blind spot with operational consequences within the study's own stated horizon.

The structural consequence is that demand growth legislated in the current policy cycle will concentrate at distribution nodes whose reinforcement has not yet begun. This is not a generation adequacy problem. It is not a transmission capacity problem. It is a distribution delivery problem, and it will determine the practical pace of the energy transition in dense urban systems well before the TYNDP 2040 horizon.

The System Needs Methodology, by focusing on cross-border and transmission-level gaps, does not surface this constraint class. The TYNDP's own finding that "adequate transmission capacity exists" can therefore coexist with widespread distribution-level deployment failure, connection delays, stranded charging infrastructure, and spatial inequality in electrification access.

Without visibility into this reinforcement gap, system-level adequacy assessments risk **overstating the practical deployability of electrification infrastructure**, particularly within dense urban regions.

This temporal misalignment is not hypothetical; my operational experience deploying grid-connected infrastructure in regulatory environments where adoption velocity has repeatedly outpaced reinforcement capacity demonstrates that the consequences are cumulative, spatially uneven, and politically consequential once they become visible to end users.

Recommendation 3:

ENTSO-E could collaborate with E.DSO and national DSO associations to develop a **Distribution Readiness Indicator** for metropolitan electrification clusters.

This indicator would assess whether distribution reinforcement timelines and available connection capacity are sufficient to translate transmission-level electricity availability into deployable electrification infrastructure.

A pilot implementation in three to four high-concentration electrification regions (for example, the Netherlands Randstad, where the Dutch DSOs have already reported unprecedented connection queues exceeding several gigawatts of industrial demand; the Dublin metropolitan area, where data centres now represent over 22% of the national electricity consumption; and the Frankfurt digital infrastructure corridor, a primary FLAP-D concentration point) would generate empirical evidence to inform future TYNDP system needs assessments.

Concluding Observation

The TYNDP System Needs Methodology was designed to identify transmission infrastructure gaps across Europe's interconnected power system. That mission remains essential.

However, the nature of electrification is evolving.

The next phase of the energy transition will not be defined primarily by cross-border transmission adequacy, but by the ability of metropolitan distribution systems to translate system-level electricity availability into usable electrification infrastructure on the ground.

Transmission adequacy without distribution readiness creates a planning illusion: electricity appears available at the system level while electrification projects encounter connection delays at the local level.

As electrification accelerates simultaneously across transport, heating, and digital infrastructure, the **transmission–distribution interface** will increasingly determine whether Europe's 2040 electrification ambitions are achievable in practice.

Integrating distribution-level signals into the System Needs Methodology would allow TYNDP to remain the central strategic planning instrument guiding Europe's energy transition in this new phase.

References

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