ELECTRICITY GRIDS IN EUROPE

Study and key findings

eit Urban Mobility

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Background

Europe's transition to electric vehicles is accelerating faster than most distribution grids were built to handle.

This study models the impact of Battery Electric Vehicle (BEV) growth on urban electricity grids in 64 cities, across 30 countries (EU-27 + Iceland, Liechtenstein, Norway) through 2030, quantifying where reinforcement is needed, what it will cost, and how smart grid management can reduce this cost significantly.

This study was commissioned by EIT Urban Mobility, ChargeUp Europe, and ACEA, and conducted by Siemens. This document represents key findings from the analysis conducted.

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EV growth needs smarter charging and stronger grids

×3.8 BEV VEHICLE GROWTH BY 2030

EU average ramp-up factor, with a range of x3.4–x4.9

EVERY EU CITY AFFECTED

All 64 cities analysed will require reinforcement

LOW-VOLTAGE GRID TAKES THE HIT

75 - 80% of EV investment burden falls on low-voltage

€24.7bn

Physical grid reinforcement scenario, without EV Load Management

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EV Load management can cut costs by €10.6bn

€14.1bn

TOTAL GRID INVESTMENT NEEDED WITH EV LOAD MANAGEMENT.

Instead of building more grid capacity to handle every peak, EV load management **helps spread electricity demand more intelligently**.

EV load management gives the grid **real time visibility of electricity demand and available capacity**.

This enables smarter EV charging, **avoiding peaks and making better use of existing grid infrastructure**.

43%

EU-WIDE COST REDUCTION BY USING LOAD MANAGEMENT INSTEAD OF ONLY PHYSICAL GRID REINFORCEMENT.

Savings by asset type:

High voltage grid **–46%** | **Medium** voltage grid **–44%**
Low voltage grid **–44%**

EV Load Management is the near real-time control of EV charging power to stay within grid capacity while maintaining charging availability. Costs are modelled only for substations that need digitalisation, which reflects targeted investments.

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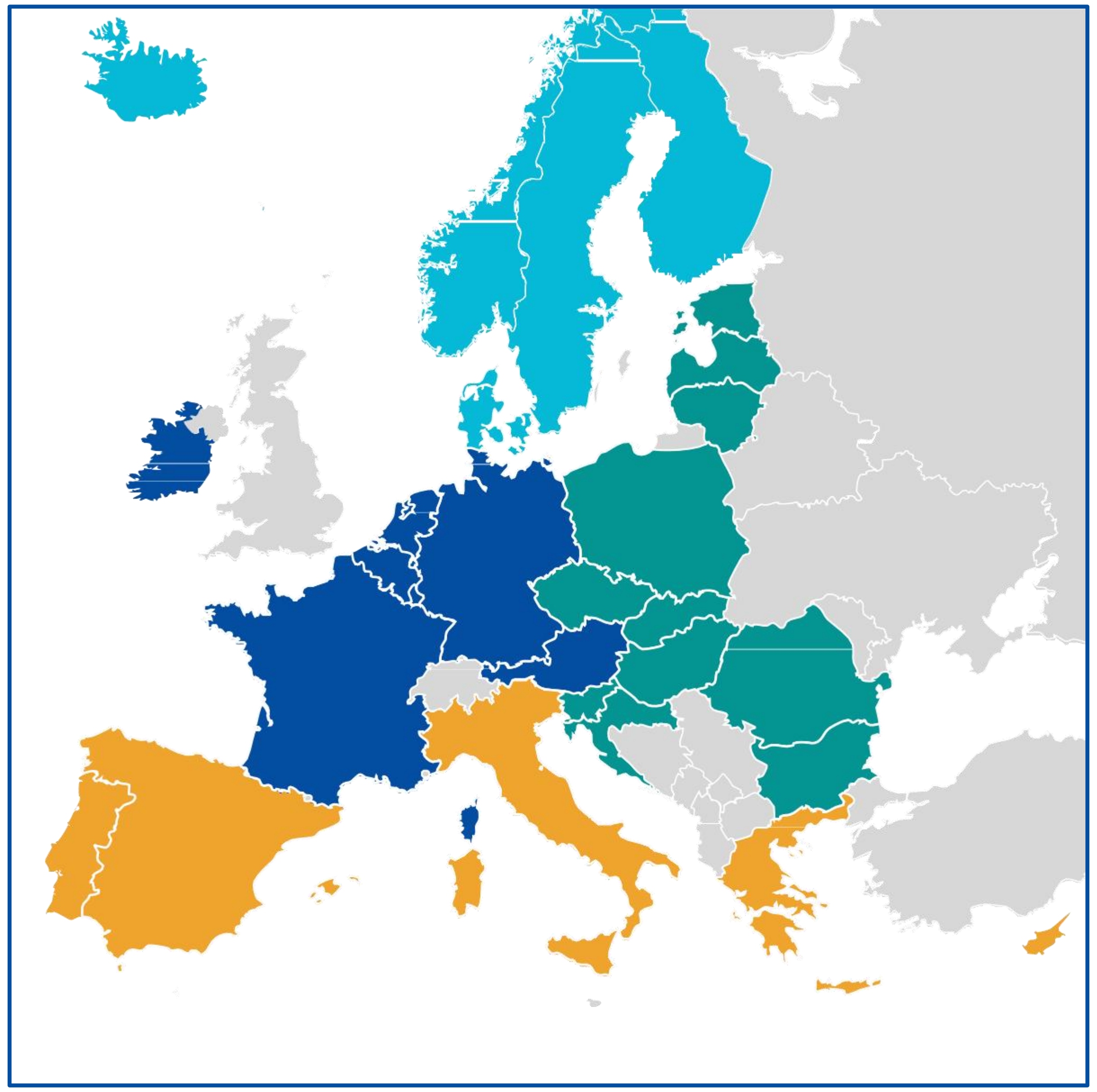
State of play of Europe’s Grids



Central Europe
(8 countries)

Eastern Europe
(11 countries)

Nordic Countries
(5 countries)

Southern Europe
(6 countries)

4 clusters capture the structural differences that matter

Grid infrastructure, battery electric vehicle (BEV) adoption rates, and charging behaviour differ significantly across Europe. The study groups the 30 countries studied into 4 structurally similar clusters that support meaningful comparisons and findings that are relevant for policymakers, distribution system operators (DSOs), and charging point operators (CPOs).

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64 / 64

URBAN CENTRES INCLUDED IN THE MODEL REQUIRE SOME GRID REINFORCEMENT BY 2030

- ✔ Central Europe
- ✔ Eastern Europe
- ✔ Nordic Countries
- ✔ Southern Europe

From the model analysis, 1 in 10 km of Europe's low-voltage grid is projected to fail under EV load without action by 2030

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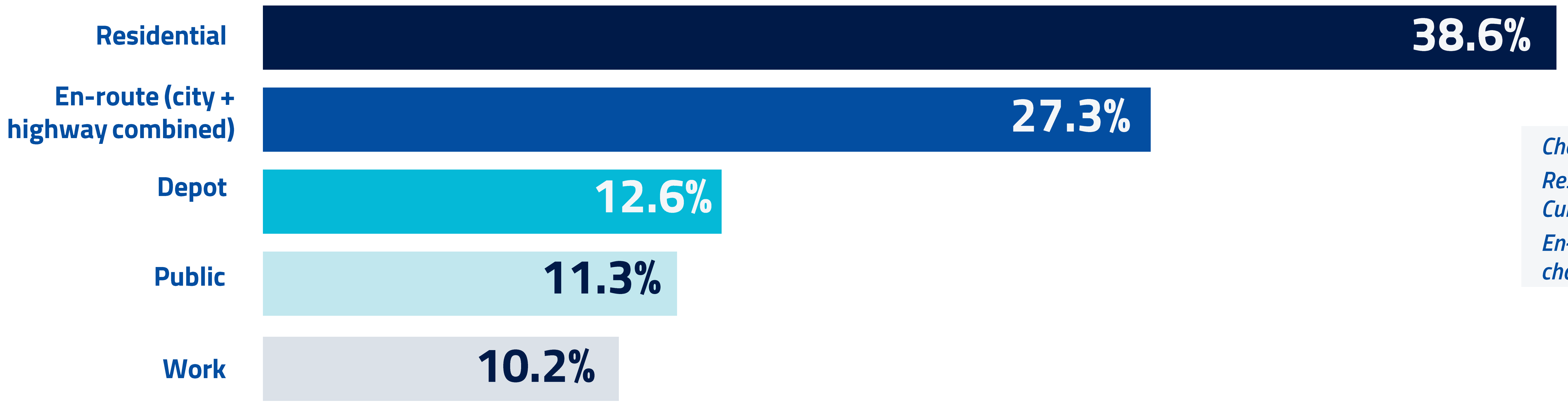
Residential EV charging creates the greatest pressure on low-voltage grids

EU-WIDE EV CHARGING-DEMAND SPLIT BY LOCATION



Charging speeds:

Residential: Primarily slow/medium Alternating Current charging ("longer" duration).

En-route: Covers fast/super-fast Direct Current charging.

38.6% of all EU-wide EV charging demand happens at home, making it the main category of charging. Without reinforcement or load management, the model projects that around 10% of the low-voltage network could exceed its capacity under peak EV demand by 2030.

Based on the 2030 peak-load simulation (scaled from the 64-city analysis). This represents the "design-case" for grid capacity, the moment of maximum pressure rather than a monthly or yearly energy average.

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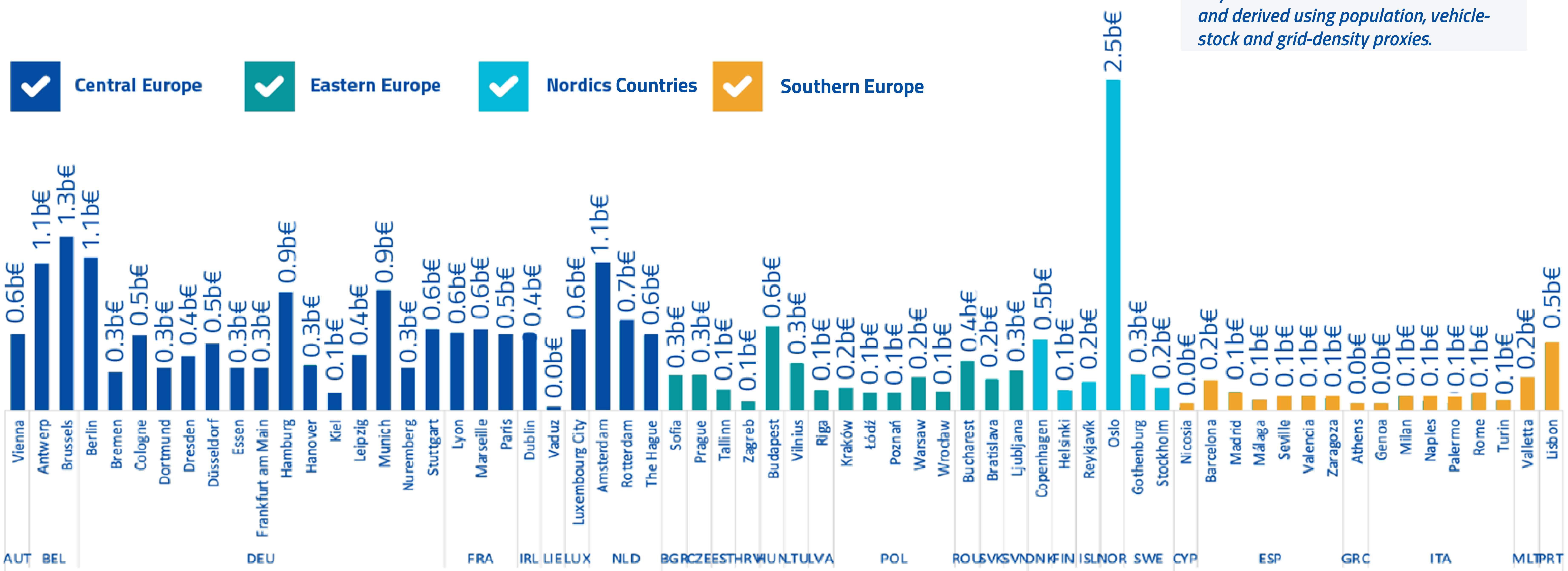
Modelled investment needs vary considerably between locations

City-level estimates are illustrative and derived using population, vehicle-stock and grid-density proxies.



Estimated distribution-grid investment required by 2030 without EV load management, €bn

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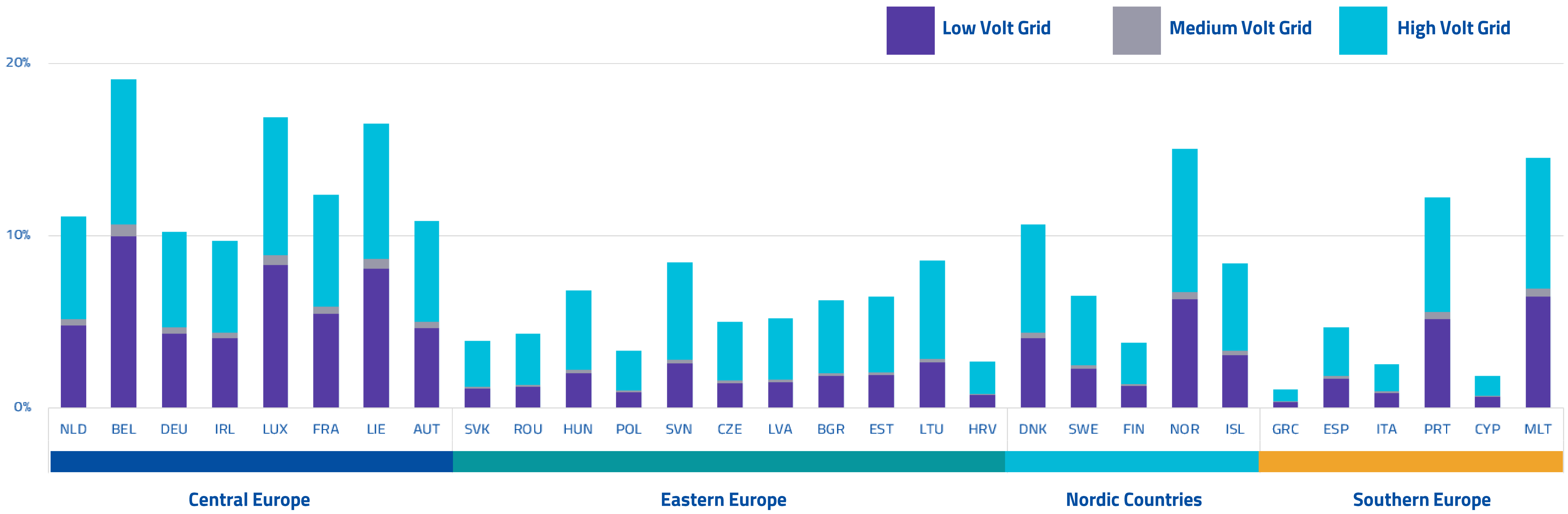
EV load management reduces modelled peak demand, with effects varying across countries and voltage levels

Additional Hosting Capacity = (Peak Power without EV LM - Peak power with EV LM) (Peak Power without EV LM)



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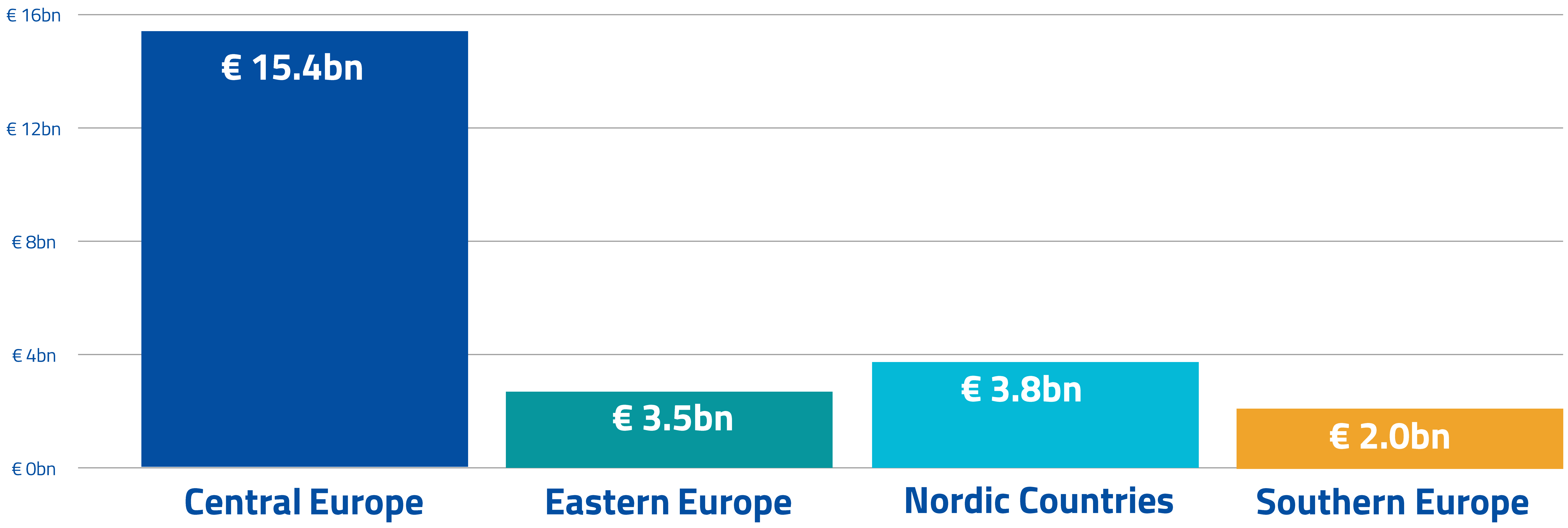
The required grid investments for BEV Integration by 2030



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Home charging is carried out on low-voltage grid, it is the primary stress point of BEV integration

77.7%

SHARE OF TOTAL PHYSICAL GRID REINFORCEMENT INVESTMENT REQUIRED AT THE LOW-VOLTAGE LEVEL

Low Volt Grid

Medium Volt Grid

High Volt Grid

LV investment share varies by cluster: Central Europe 80% | Southern Europe 78% | Nordic Countries 74% | Eastern Europe 72% (EU average 78%). Figures reflect physical grid reinforcement investment share (Conventional scenario), not charging load share.

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Central Europe faces the highest grid investment needs, while Eastern Europe will likely see the fastest EV growth

Central Europe

€15.4bn

HIGHEST ABSOLUTE PHYSICAL GRID-REINFORCEMENT COST OF ANY REGIONAL CLUSTER

Eastern Europe

4.7×

STEEPEST EV FLEET RAMP-UP 2024-2030

At €15bn Central Europe carries the highest grid-reinforcement cost of all clusters, driven by the largest baseline grid infrastructure, highest projected BEV volume, and largest modelled urban population. Nordic Countries €3.8bn | Eastern Europe €3.5bn | Southern Europe €2.0bn. BEV fleet ramp-up 2024–2030: Eastern Europe ×4.7 | Southern Europe ×3.9 | Central Europe ×3.9 | Nordic Countries ×3.8.

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Load Management can make the biggest difference in Eastern Europe

Eastern Europe — Cluster Average

48%

AVERAGE LOAD MANAGEMENT SAVINGS POTENTIAL — THE HIGHEST OF ANY REGIONAL CLUSTER

Croatia — Highest Single Country

53%

THE SINGLE HIGHEST SAVINGS POTENTIAL ACROSS ALL 30 COUNTRIES STUDIED

Load management and smart monitoring cut grid investment needs across every cluster:
Eastern Europe 48% | Southern Europe 43% | Central Europe 42% | Nordic Countries 39% (EU average ~43%).
The modelled scenario includes load management and the monitoring and control infrastructure required to operate it. Physical grid upgrades would still be necessary.

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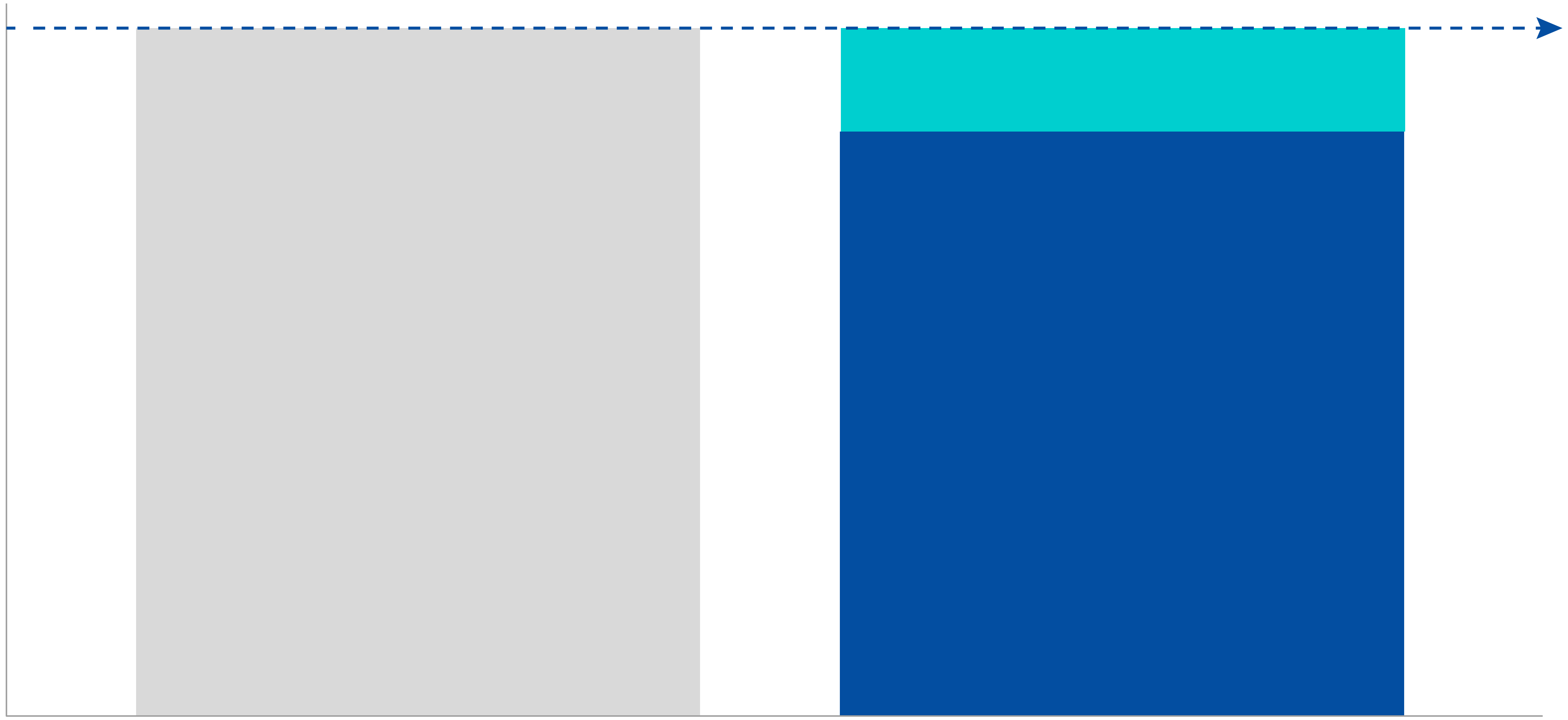
Load management can help low-voltage grids capacity



Standard Charging

Load reaches the grid's operating limit — no room for additional EVs

With Load Management

Frees up ~20% additional capacity for more EVs before the limit is reached

GRID CAPACITY LIMIT

Grid planners call this 'hosting capacity': the additional load a network segment can carry before reaching its operating limit.

LV hosting capacity is the additional demand a network can accommodate before reaching its operating limit. This capacity gain is only realised where measurement and control infrastructure is deployed — without grid digitalisation, EV Load Management delivers 0% benefit.

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Two barriers to realising the €10.6bn potential savings

BARRIER 1 · OPERATIONAL

Only 1 in 5 countries sampled has all four smart charging building blocks in place.*

Country	Controllable consumer devices	Smart meter rollout	Digitalisation strategy	CapEx / OpEx incentives for utilities
GERMANY	✔	✔	✔	✔
NETHERLANDS	—	✔	✔	✔
NORWAY	—	✔	✔	✔
POLAND	—	✔	✔	—
ITALY	—	✔	✔	✔

Germany's regulatory lead reflects a legislative choice yet smart meter rollout remains limited. Operational activation is still a bottleneck across all five countries.

EU legislation (AFIR — Regulation (EU) 2023/1804; RED III) mandates smart-charging-ready infrastructure across Member States, but implementation of the underlying digital and regulatory building blocks remains a national competence, rollout speed and depth vary widely.

*Smart charging building blocks defined as: (1) controllable consumer devices, (2) smart meter rollout, (3) national digitalisation strategy, (4) CapEx/OpEx regulatory incentives. CapEx/OpEx/TotEx: CapEx (Capital Expenditure) / OpEx (Operational Expenditure) / TotEx (Total Expenditure). TotEx = CapEx + OpEx. Countries sampled: Germany, Netherlands, Norway, Poland, Italy. A tick indicates that an enabling framework exists; it does not mean that implementation or deployment is complete.

BARRIER 2 · ECONOMIC

THE RULE

REVENUE-CAP REGULATION

DSO returns are tied to capital invested in the regulated asset base (RAB)

THE BEHAVIOUR

PHYSICAL ASSETS GET FUNDED. SOFTWARE DOESN'T.

EV Load Management — measurement, communications, control software — sits outside the RAB, so it earns no guaranteed return

THE RESULT

€10.6bn SAVING POTENTIAL

In the model, EV load management is the cost-optimal solution, reducing investment needs by around 44%. Yet current regulation may not make it financially attractive for the DSO.

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Roadmap recommendations for smart charging and grid flexibility by 2035

URGENT: 2026–2028

ACTIVATE WHAT THE LAW ALREADY REQUIRES

- **R1** Operationalise smart charging
- **R2** Make grids visible
- **R3** Fund grid investment

ENABLES

BUILD: 2028–2030

BUILD THE REGULATORY AND MARKET ARCHITECTURE

- **R4** Close the interface gaps
- **R5** Publish market design rules

ENABLES

SUSTAIN: 2030–2035

UNLOCK FULL SYSTEM VALUE

- **R6** Unlock system flexibility
- **R7** Incentivise load management

2026 – – – 2027 – – – 2029 – – – 2035

Smart-charging obligations will only deliver if they are backed by measurement and control infrastructure, clear market rules and the right incentives for DSOs.

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Roadmap - URGENT PHASE

R1 OPERATIONALISE SMART CHARGING

Close the enforcement and activation gap in existing legislation

AFIR and RED III already mandate smart charging capability for all new charging points. The legislative foundation exists. What is missing is the operational activation of that capability by DSOs and CPOs. A charger that is technically smart but not actively managed delivers zero grid benefit.

- Require all DSOs to deploy network-oriented EV load control as a minimum operational standard for a target of 2028.
- Mandate verified functional interoperability between charging points, residential chargers, and DSO control systems.

Impact: *EV Load Management could reduce EU-wide LV grid reinforcement costs by 43% — but only if smart charging is activated at scale, not merely introduced.*

R2 MAKE GRIDS VISIBLE

Mandate measurement infrastructure deployment linked to BEV penetration

Smart charging and load control are only possible with adequate grid visibility at the low-voltage level — and that requires far more than household smart meters. Substations, feeders, and MV/LV interfaces all need measurement devices. The countries facing the highest grid investment pressure are also the least equipped to activate demand-side flexibility.

- Achieve 80% smart meter coverage by 2028 and equip all MV/LV substations in areas where BEV penetration exceeds 10%.
- Automatically escalate measurement infrastructure obligations as BEV penetration crosses 10%, 25%, and 50% thresholds.

Impact: *The full 43% LM cost saving is contingent on DSOs having real-time LV grid visibility — without it, smart charging have no practical value from an operational perspective.*

R3 FUND GRID INVESTMENT

Establish a regionally calibrated EU Grid Investment facility for distribution grid reinforcement

Current EU instruments — CEF Energy and the Innovation Fund — do not reach local distribution grids, where EV-driven overloads are concentrated. Investment needs are structurally unequal:

- Establish a dedicated EV Grid Readiness Facility with tiered co-financing calibrated to the four European grid clusters.
- Make both physical reinforcement and grid digitalisation co-eligible — the €10.6b LM savings is only realisable if both are funded in parallel.

Impact: *€10.6bn in avoided grid investment — but only if EU co-financing is extended to distribution networks, and not just transmission networks.*

Roadmap - BUILD PHASE

R4 CLOSE THE INTERFACE GAPS

Build End-to-End regulatory architecture for grid-responsive charging

The current regulatory landscape treats the electricity grid, charging infrastructure, and end-user devices as three separate domains. This fragmentation creates four critical interface gaps — between grid and charging, charging and metering, grid and metering, and system and the end-user — that prevent end-to-end signal propagation. Without closing all four, the load management savings modelled in this study cannot be realised in practice.

- Require DSOs to achieve real-time observability of grid conditions up to the grid connection point, with clear data access rights and consent mechanisms.
- Extend the framework to cover coordinated operation of BEVs, heat pumps, Photovoltaic rooftop and battery storage as a unified distributed flexibility resource.

Impact: *The 40–60% grid reinforcement cost savings are contingent on end-to-end signal propagation across all four interface gaps.*

R5 PUBLISH MARKET DESIGN RULES

Remove market barriers to EV flexibility monetisation

Even where technical flexibility exists, EV owners, CPOs, and aggregators cannot monetise it — electricity market rules create structural barriers: double taxation on bidirectional flows, grid fees that penalise discharge, minimum bid sizes that exclude small assets. Without reform, EV flexibility remains technically available but economically inaccessible. The study quantifies what is at stake: 40–60% cost savings versus conventional grid reinforcement, across all clusters.

- Remove double taxation on bidirectional energy flows and reform grid fee structures to reward grid-responsive assets.
- Reduce minimum bid sizes in flexibility markets and harmonise settlement intervals to 15-minute resolution aligned with EV charging dynamics.

Impact: *40–60% grid reinforcement cost savings are technically available today with some market design reforms*

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Roadmap - SUSTAIN PHASE

R6 UNLOCK SYSTEM FLEXIBILITY

Establish an EU Regulatory Framework for V2X, Heat Pumps, Photovoltaic and battery storage as Coordinated Grid Assets

V2X, and particularly V2G, represents the highest value long term opportunity in the EV grid relationship— transforming a growing fleet of mobile batteries into a dispatchable distributed storage asset. Yet V2G remains commercially non-viable in most of Europe due to three compounding barriers: absent bidirectional hardware standards, no structured market participation pathways, and fiscal barriers that make discharging economically unattractive. A 2030 horizon is the realistic target for a functioning framework — but the regulatory design work must begin now.

- Remove double taxation on bidirectional energy flows for all distributed assets and harmonise metering and settlement rules across EVs, PV, heat pumps, and battery storage.
- Recognise energy management systems and aggregators as critical enabling layers — they must participate in flexibility markets on equal terms regardless of the asset mix they manage.

Impact: *Private BEVs provide daytime flexibility; commercial BEVs provide overnight flexibility a complementary profile that, if unlocked, could reduce peak generation capacity needs across the EU.*

R7 INCENTIVISE LOAD MANAGEMENT

Establish a financial incentive framework for EV load management

EV Load Management delivers 40–60% cost savings versus physical grid reinforcement — but DSOs operate under revenue cap regulation, incentivising investment in physical assets included in their regulated asset base, not in software-based load management solutions. Without financial incentives specifically designed for EV Load Management, DSOs have a structural disincentive to implement it even when it is the cost-optimal solution. Regulation creates obligations; financial incentives change behaviour.

- Include EV Load Management infrastructure in the regulated asset base of DSOs and introduce performance-based incentives linked to peak load reduction and congestion relief outcomes.
- Require Member States to implement time-variable grid tariffs for EV owners and ensure aggregators can access both utility programmes and open flexibility markets with clear value-sharing rules.

Impact: *40–60% cost savings are technically achievable; they will not be realised without correcting the incentive structure that currently makes conventional reinforcement the path of least resistance for DSOs.*

Note: The economic barrier addressed by R7 is active today — but its solution depends on the implementation of R1-R3 first.

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The EU Framework is already there

Recommendation	Legislative basis
R1 · Operationalise Smart Charging	AFIR (EU) 2023/1804; RED III
R2 · Make Grids Visible	Electricity Market Directive (EU) 2019/944
R3 · Fund Grid Investment	AFIR Art. 22(3); CEF Energy Regulation (EU) 2021/1153; Cohesion Fund Regulation (EU) 2021/1058
R4 · Close the Interface Gaps	Electricity Market Directive (EU) 2019/944; Network Code on Demand Response; EMD Reform (EU) 2024/1747
R5 · Publish Market Design Rules	Electricity Market Directive (EU) 2019/944; Electricity Regulation (EU) 2019/943; Energy Taxation Directive; Network Code on Demand Response
R6 · Unlock System Flexibility	ISO/IEC 15118-20; Electricity Market Directive (EU) 2019/944; Network Codes
R7 · Incentivise Load Management	Electricity Market Directive (EU) 2019/944; Network Codes

Legislative references reflect the study's analytical basis. The choice of instrument remains a matter for policymakers, subject to considerations of legal feasibility, proportionality, and subsidiarity.

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