SAARC ENERGY CENTRE - TRAINING WORKSHOP

EV Charging and the Grid

Tariff Structures, Load Impact & Distributed Generation Integration (ISMO Perspective)

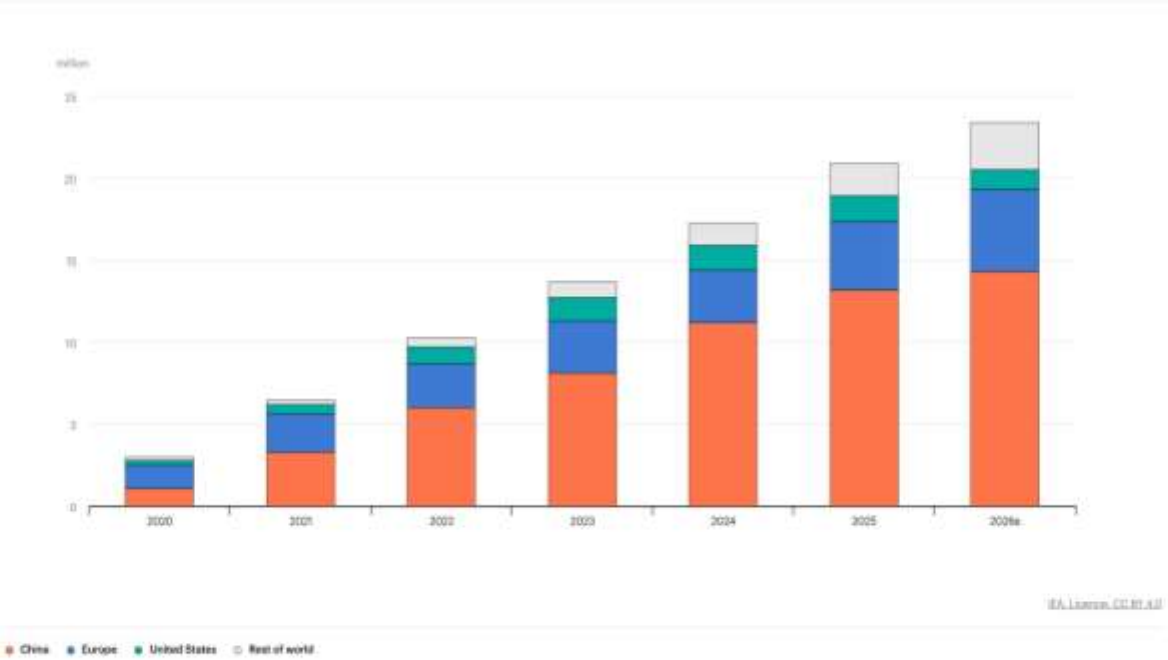
Imtiaz Ahmad, Deputy Director (R&D)
Independent System and Market Operator (ISMO), Pakistan

27-29 August 2026 | Ramada by Wyndham, Islamabad

Presentation Roadmap

GLOBAL LANDSCAPE

Global EV Transition: Electric Vehicles Are Now the Mainstream Choice



>20 M

EVs sold globally in 2025

25%

of new cars sold worldwide were electric in 2025

>7 M

public charging points worldwide at end-2025

Sources: IEA (2026), Global EV Outlook 2026 — Trends in Electric Cars; Electric Vehicle Charging (nearly 1.8 M public chargers added in 2025, +33%).

Pakistan's EV Transition: From Early Adoption to Policy Scale-Up

EV stock has scaled rapidly since 2021

567 2021	→	80,000+ June 2025

Growth is concentrated in 2- and 3-wheelers — making charging demand a distribution-level planning issue.

80,000+
EVs on Pakistani roads by June 2025

65
manufacturers certified for local 2- & 3-wheeler EV assembly (Jul 2025)

30%
target share of new vehicle sales that will be electric by 2030

- Charging infrastructure target
- 3,000 public charging stations by 2030
- PAVE acceleration:
- 40,000 e-2W + 1,000 e-3W allocated in Oct 2025;
- EDB launched a 100,000 e-bike fast-track program in 2026.

Sources: Government of Pakistan, NEV Policy 2025–30 (MoI&P, Aug. 2025); PID (1 Oct. 2025), first PAVE e-balloting; PPRA/EDB (May 2026), 100,000 e-bike fast-track programme.

Pakistan: EV Policy, Targets & Emerging Ecosystem

NEV Policy 2025-30 Targets

2.21 million

total new NEVs targeted 2025-30

2-Wheelers	**2.05 M**
3-Wheelers	**54 k**
4-Wheelers	**99 k**
Buses / Vans	**2.2 k**
Trucks / LCVs	**3.0 k**

Long-term Ambition

2030	30% of new sales electric
2040	50% stated ambition
2050	100% all segments
2060	Net-zero ZEV fleet

Global EV Transition: From Transport Trend to Grid Issue

The questions that are bothering Power System Operators:

When?

Coincidence with evening residential peaks

Where?

Spatial concentration on local feeders

How?

High-power DC creates local voltage stress

Can we control it?

Market rules & smart protocols for flexibility

From Vehicle Counts to Electricity Demand

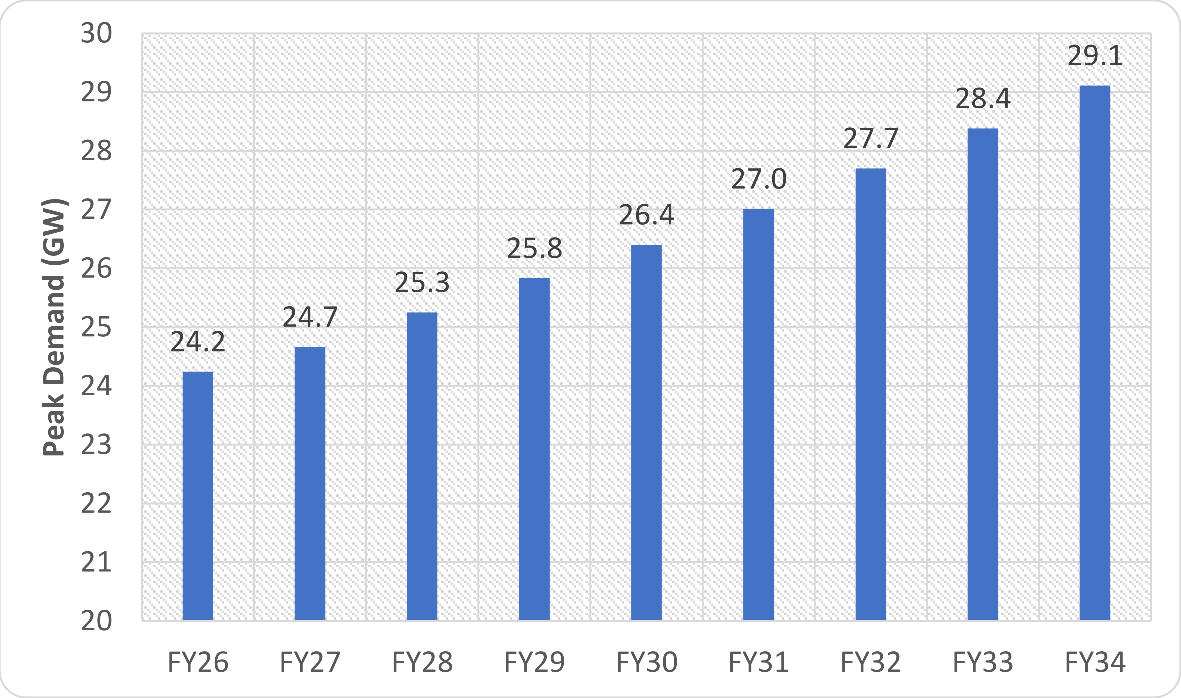
EV penetration > charging energy > charging profile > coincidence with system demand > network impact

EV Fleet Growth	Annual Energy	Charging Profile	System Coincidence	Network Impact
2W / 3W / 4W adoption curves	kWh/km x km/yr x fleet size	Time-of-day & location behavior	Peak / min / ramp contribution	**Feeder, voltage & transformer**

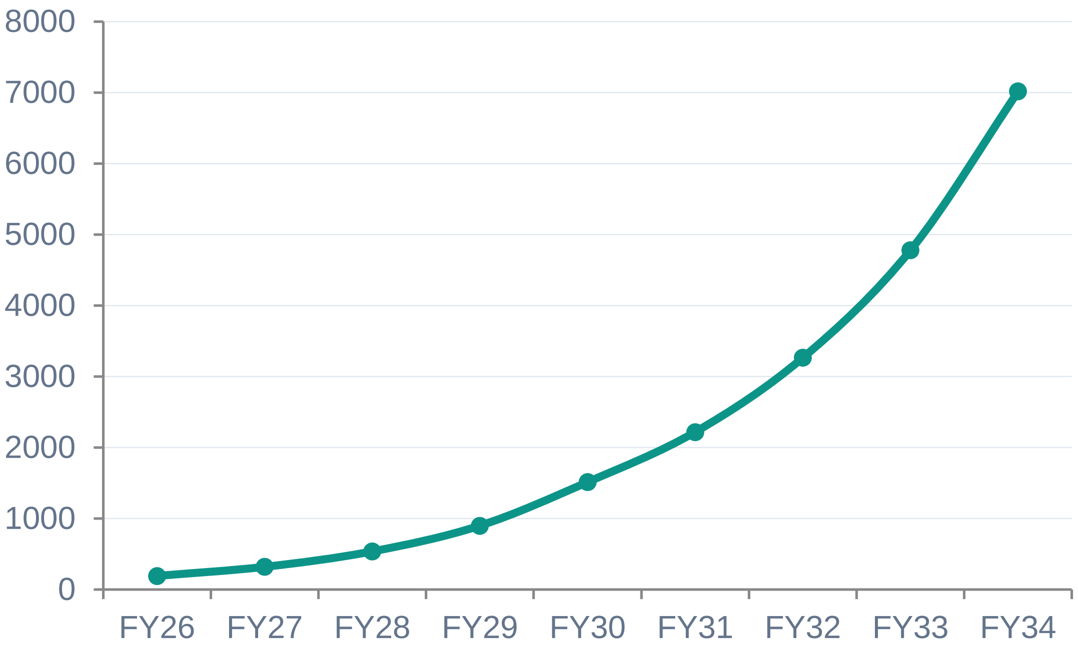
KEY INSIGHT FOR SYSTEM OPERATORS

- Annual energy consumption is only part of the story.
- The timing and location of charging determine the actual impact on generation, transmission and distribution.
- High-power DC and fleet/depot charging can create concentrated demand blocks.
- For ISMO perspective, the critical question is how EV adoption translates into national and distribution-level electricity demand.

Pakistan Electricity Demand Outlook



EV Load Forecast



37x

growth in EV annual energy
FY26 (188 GWh) to FY34 (7,015 GWh)

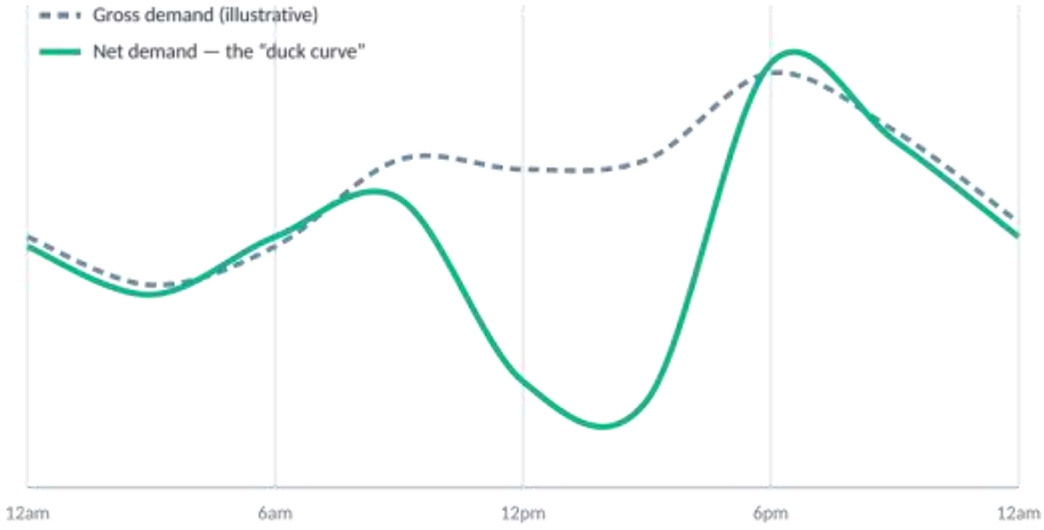
43 to 1,597 MW

peak EV charging demand
contribution FY26 to FY34

0.4 - 0.6 GW

indicative contribution of managed
EV charging to FY34 flexibility portfolio

The Emerging Duck Curve & Minimum Net Load



Illustrative shape — shows how rising distributed solar reshapes the demand the grid must supply.

Operational implications:

- Frequency Cycling and Higher Ramp Rate Requirements
- Minimum-generation constraints
- Low Daytime system inertia; reverse power flow and curtailment risk increase

Source: ISMO Concept Note, System Flexibility and Peak-Shaving Assessment (§5.1–§5.3, §5.7); IGCEP 2026 BAU–DER forecast, FY2026–FY2034.

Minimum Net Load: A Core System-Security Challenge

System vulnerabilities

Inertia

Massive reduction in synchronized online inertia

RoCoF

Extremely tight Rate-of-Change-of-Frequency margins

Must-run

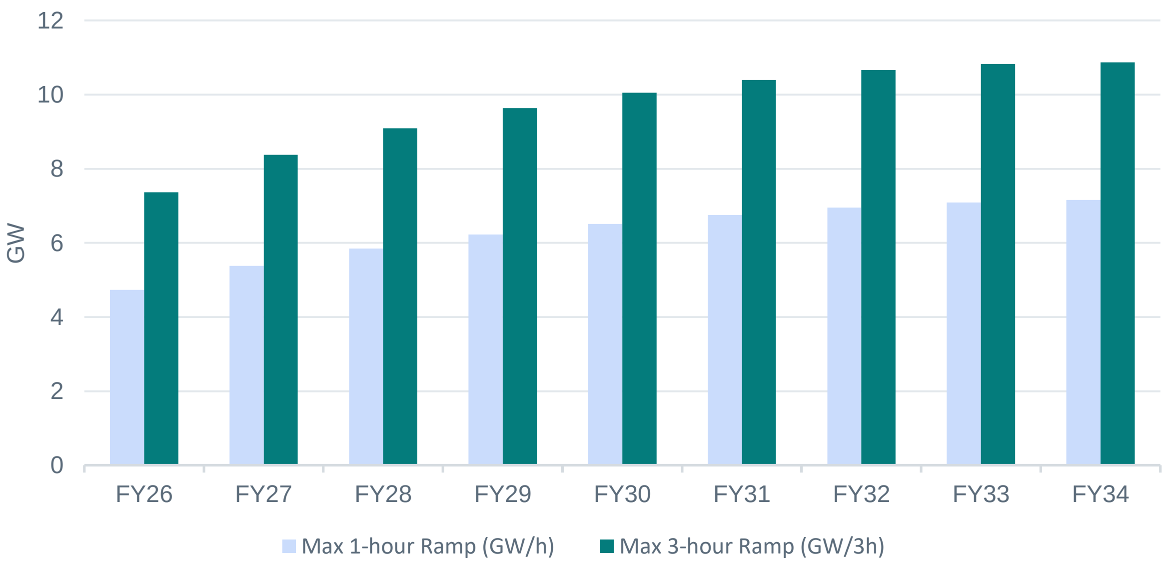
Hydro/thermal min-generation can force solar curtailment

Solution

Lift the trough with midday EV charging (solar-hour tariffs)

The Ramp-Rate Challenge: Sunset DER Drop-off

Case Study: Extreme ramping event



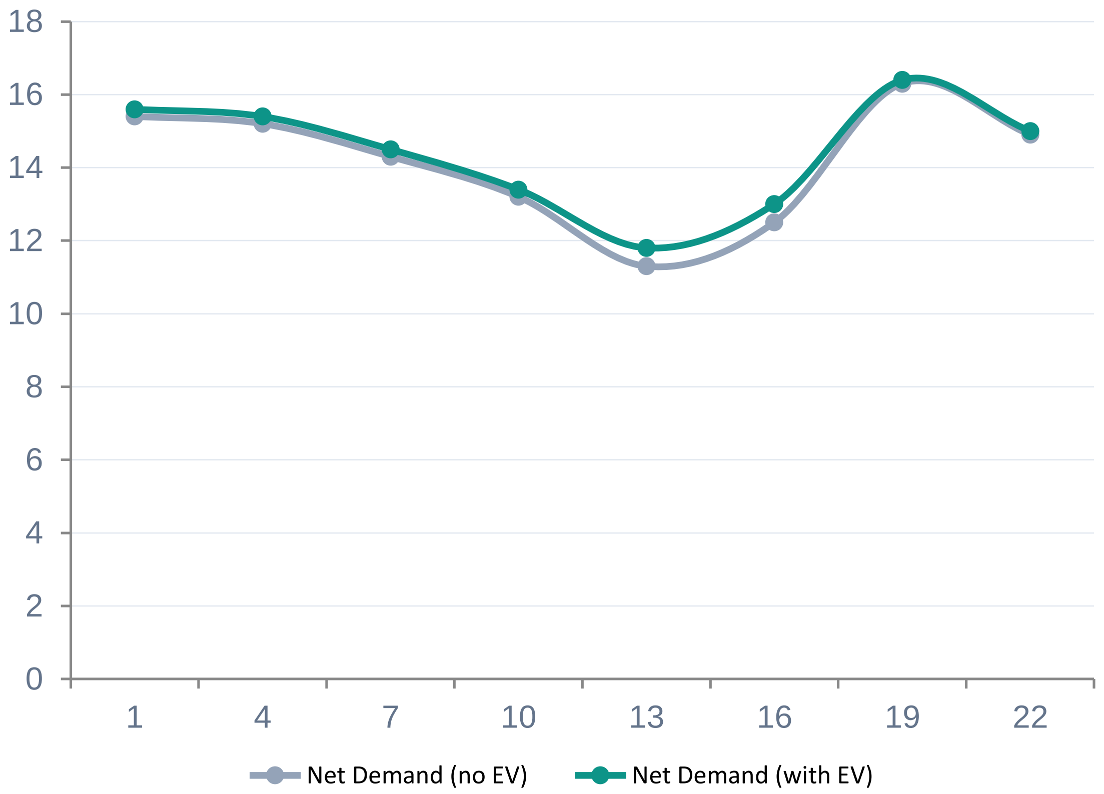
~76% of this extreme ramp is driven by DER withdrawal - not demand growth.

Uncontrolled evening EV charging (6-11 pm) will stack directly on top of this ramp. Managed/smart charging that steers load into midday solar hours is essential to avoid amplifying the most severe ramping events.

Three Charging Behaviours - From Threat to Flexibility Asset

Uncontrolled	Managed (TOU)	Smart (V1G)/Flexible Load	V2G (Future)/FL+Distrbuted Storage
- Plug-in at convenience	- Time-of-use tariffs	- Dynamic, real-time control	- Bi-directional flow
- Often 6-11 pm peak	- Shift to off-peak / midday	- Responds to tariffs & grid	- Vehicle injects power
- Amplifies evening ramp	- Reduces system peak	- Absorbs surplus solar	- Frequency & reserves
- Local transformer overloads	- Simple to implement	- Manages ramp rates	- Virtual power plant
- No system signal	- Near-term priority	- Requires smart chargers	- Needs sandbox & standards

Daytime EV Charging: Solar Valley Filling



Vehicle-to-Grid (V2G): EV Batteries as Grid Assets

Frequency Regulation

EV batteries inject/absorb power within seconds - faster than conventional spinning reserves.

Peak Shaving & Reserves

Aggregated fleets discharge during evening peak, reducing net demand on central plant.

Emergency Backup

Localised backup for homes, depots or critical facilities during outages.

Regulatory Sandbox Needed

No V2G sandbox yet exists in Pakistan - an emerging option worth piloting, not yet mainstream.

Can the Distribution Network Absorb Large-Scale EV Charging?

National generation capacity is in surplus; local distribution grids are the binding constraint.

Transformer Loading

3-5 EVs on one street can overload a 100 kVA transformer

Feeder Thermal Limits

Level-3 (150-350 kW) often needs dedicated feeder upgrades

Voltage Profile

High-power DC causes voltage sag; reverse flow with solar

Phase Imbalance

Single-phase home chargers create uneven loading

Power Quality

Harmonics from power-electronics chargers

Hosting Capacity

Must be assessed spatially, not just nationally

Practical EV Charging Planning Hierarchy

1

EV Forecast

Segment-wise adoption by region

2

Charging Demand

Energy + peak + profile by type

3

Spatial Allocation

Home / workplace / public / highway

4

Feeder Assessment

Transformer & feeder headroom

5

Hosting Capacity

Voltage, thermal, protection limits

6

Reinforcement

Upgrade CAPEX where needed

7

Smart Charging

Controllable chargers & standards

8

Tariff / Control

TOU, dynamic, DR mechanisms

Major Grid-Integration Challenges

Unmanaged charging

Evening peak amplification & local overloads

Transformer clustering

Adoption concentrates in affluent urban pockets

Voltage & power quality

Sag, harmonics, phase imbalance

DER coincidence

Evening EV load stacks on solar drop-off ramp

Data & cybersecurity

Communications, interoperability, control systems

Regulatory gaps

Aggregation, V2G, bi-directional metering, market rules

International Lessons Relevant to Pakistan

Time-of-use tariffs	Proven low-cost lever to shift residential charging away from peak. Simple TOU is the first step before dynamic pricing.
Workplace charging	Aligns charging with solar production. Building-code mandates for parking lots accelerate daytime load.
Managed / smart charging	Standards for controllable chargers and aggregator frameworks unlock flexibility without new generation.
Distribution planning	Spatial EV forecasts and hosting-capacity maps prevent reactive, expensive reinforcement.
Regulatory sandboxes	Pilot V2G and aggregator models with public fleets before scaling; learn technical and commercial rules.
Interoperability	Single national charging-port and communication standard avoids stranded assets and user friction.

EV Charging Tariff Options - Shaping Behaviour

Tariff Type	Behavioural Impact	Grid Value
Flat	Limited incentive to change timing	Neutral / weak
Time-of-Use	Encourages off-peak / midday charging	Strong near-term lever
Dynamic	Reflects real-time system conditions	High flexibility potential
Critical-Peak	Discourages charging on stress days	Peak-event protection
Solar-Hour	Explicitly rewards daytime solar absorption	Duck-curve mitigation
Locational	Signals constrained feeders / substations	Future distribution tool

Proposed Integrated Framework for Pakistan

EV Policy

NEV 2025-30 targets & institutional support

Tariff Design

TOU / solar-hour signals that shape charging

Charging Planning

3,000-station roadmap + grid-integrated siting

Hosting Capacity

DISCO feeder maps & spatial forecasts

Smart Charging

Standards, controllable chargers, aggregators

DER Integration

Solar valley-filling + BESS complementarity

V2G Readiness

Sandbox, bi-directional rules, pilot fleets

System Operation

IGCEP + flexibility portfolio + ISMO oversight

Five Takeaways

EVs are an electricity-system transition

Treat them as flexible demand, not simply additional load.

Timing matters more than volume

Unmanaged charging raises peaks and ramps; smart charging provides flexibility.

Align with solar & DER

Daytime / workplace charging mitigates the duck curve and absorbs surplus solar.

Plan the distribution edge

Spatial forecasts, hosting capacity and smart-charger readiness are essential.

Build the flexibility toolkit

Tariffs > managed charging > aggregation > V2G - sequenced and realistic.

Closing Message

The key question is no longer whether EVs will increase electricity demand.

The key question is whether Pakistan can shape EV charging demand to support a reliable, flexible and renewable-rich power system.

EV Transition > Electricity Demand > Smart Charging > DER Integration > Grid Flexibility

Thank you | Questions & Discussion

Selected References

1. International Energy Agency (IEA), Global EV Outlook 2025.

2. IEA, Electric Vehicle Charging - Global EV Outlook 2025.

3. Government of Pakistan, National Electric Vehicle (NEV) Policy 2025-30.

4. NEECA, Pakistan Electric Vehicles Charging Infrastructure and Battery Swapping Regulations 2024.

5. NEPRA, Federal Government Motion and Policy Guidelines for Rationalization of Tariff for Electric Vehicle Charging Stations, 2025.

6. SAARC Energy Centre, Concept Note: SAARC Training Workshop on Electric Vehicle and its Charging Infrastructure, 27-29 August 2026.