EASY-RES

SUMMER SCHOOL
“ENABLING DRES TO OFFER ANCILLARY SERVICES”
20TH – 24TH SEPTEMBER 2021

The Solution for Voltage Regulation in MV and LV Distribution Grids

Dr. Georgios C. Kryonidis // 22-09-2021

This project has received funding from the European Union´s Horizon 2020 Programme for research and innovation under Grant Agreement no 764090.

Audience Q&A Session

ⓘ Start presenting to display the audience questions on this slide.

Outline

- Problem Formulation
- State-of-the-art solutions
- The EASY-RES approach for the voltage regulation in MV grids
- Bi-objective optimal voltage regulation
- The EASY-RES approach for the voltage regulation in LV grids

Problem Formulation

Conventional (passive) distribution grids

Design assumption: Unidirectional power flow scheme from utility to end-users

Operational objective: Maintain voltages within permissible limits (EN 50160 [2])

Means of achieving (MV grids)

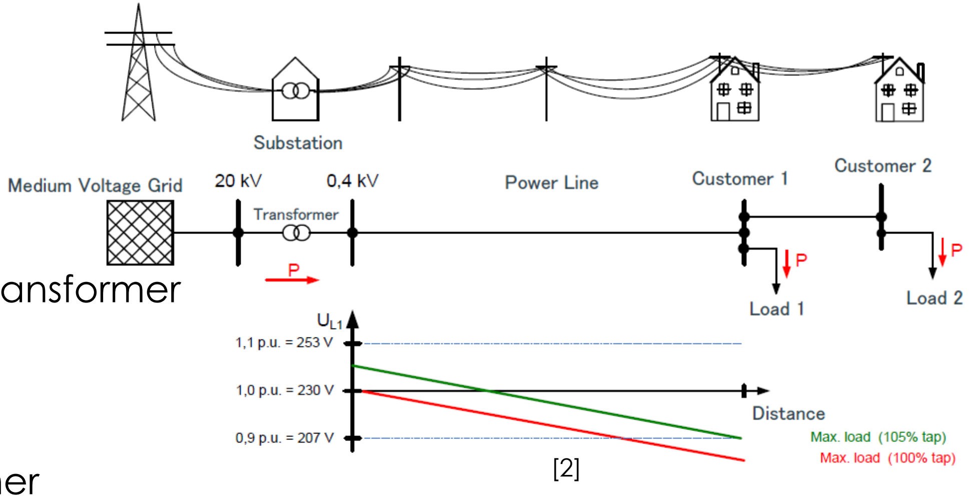
Substation/feeder capacitors

Step voltage regulators (SVRs)

On-load tap changer (OLTC) of HV/MV transformer

Means of achieving (LV grids)

Off-load tap changer of MV/LV transformer



[1] Voltage Characteristics of Electricity Supplied by Public Distribution Networks, Standard EN 50160, 2010.

[2] B. Ernst, EPIA-EDSO for Smart Grids Conference on Grid Management

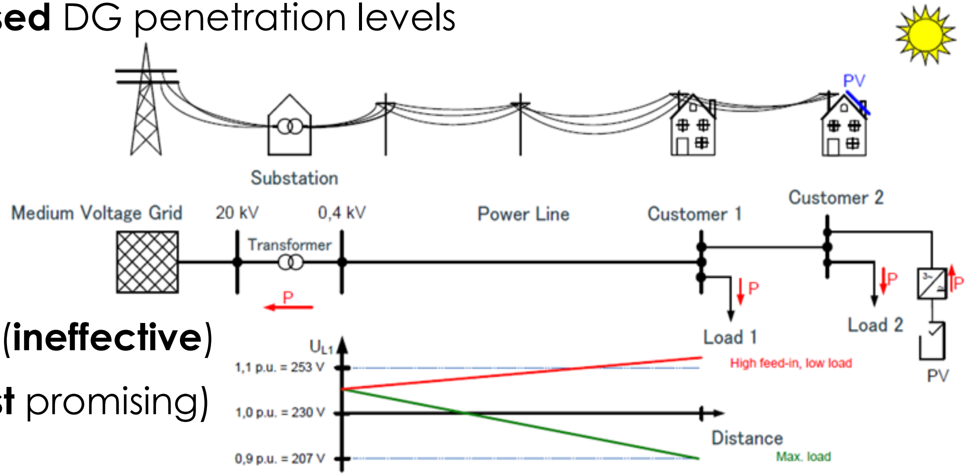
Problem Formulation

Transition to active distribution grids

Advent of distributed generation (DG)

New operational challenges: Bidirectional power flow → **overvoltages**

Important **limiting** factor towards **increased** DG penetration levels



[1]

Possible (conventional) **solutions**

Grid **reinforcement** (**unaffordable** cost)

Use of conventional network **equipment** (**ineffective**)

Active participation of DG units (the **most** promising)

[1] B. Ernst, EPIA-EDSO for Smart Grids Conference on Grid Management

State-of-the-art solutions

Active vs Reactive power for voltage regulation

Active power-based methods

Generation curtailment [1]

Demand response (DR) [2]

Use of energy storage systems [3]

Reactive power-based methods (**Volt/Var problem**)

Use of the **available** reactive power of DG units [4]

[1] R. Tonkoski, L. A. C. Lopes, and T. H. M. El-Fouly, "Coordinated active power curtailment of grid connected PV inverters for overvoltage prevention," IEEE Trans. Sustain. Energy, vol. 2, no. 2, pp. 139–147,

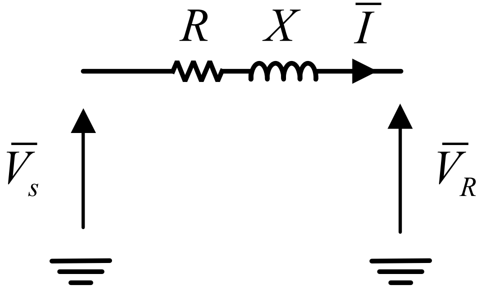
[2] Q. Xie, H. Hui, Y. Ding, C. Ye, Z. Lin, P. Wang, Y. Song, L. Ji, and R. Chen, "Use of demand response for voltage regulation in power distribution systems with flexible resources," IET Gener., Transm. Distrib., vol. 14, no. 5, pp. 883–892, 2020.

[3] Y. Guo, Q. Wu, H. Gao, X. Chen, J. Østergaard, and H. Xin, "MPC-based coordinated voltage regulation for distribution networks with distributed generation and energy storage system," IEEE Trans. Sustain. Energy, vol. 10, no. 4, pp. 1731–1739, 2019.

[4] Y. Wang, T. Zhao, C. Ju, Y. Xu, and P. Wang, "Two-level distributed volt/var control using aggregated PV inverters in distribution networks," IEEE Trans. Power Del., vol. 35, no. 4, pp. 1844–1855, 2020.

State-of-the-art solutions

Active vs Reactive power for voltage regulation



Angle difference between Vs and Vr

Active power at R

Reactive power at R

$$V_R = V_S \cos\theta - \frac{PR + QX}{V_R}$$

$$\sin\theta = \frac{PX - QR}{V_S V_R}$$

$\theta \ll 1$ →

$$V_R = V_S - \frac{PR + QX}{V_R}$$

$$\theta = \frac{PX - QR}{V_S V_R}$$

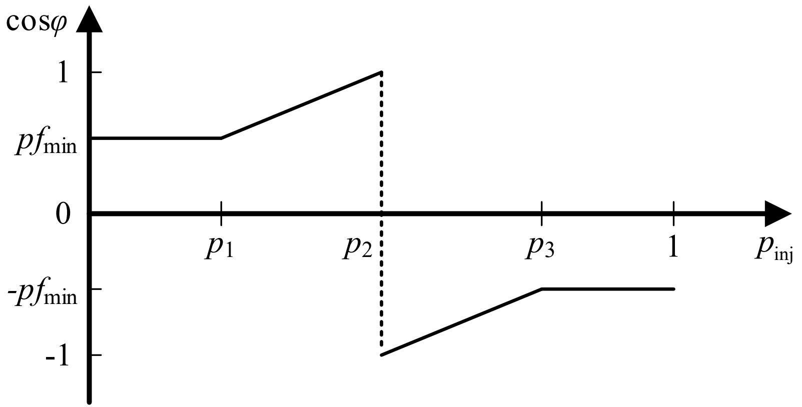
R > X (LV grids) → Active power is more effective than reactive power

X > R (MV grids) → Reactive power is more effective than active power

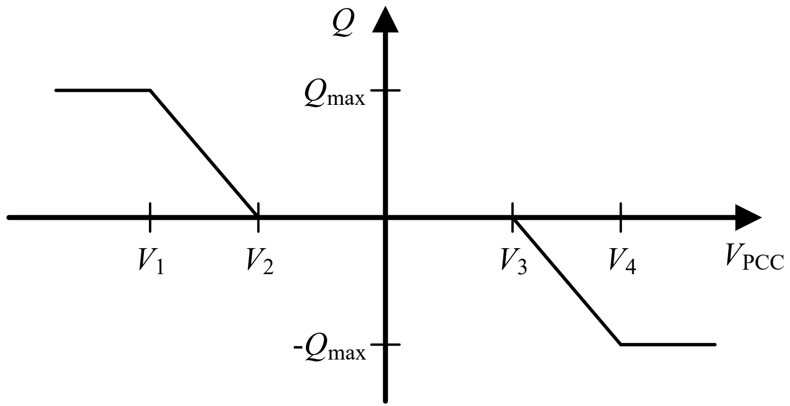
In any case, **priority** should be given to the **reactive power** against active power to **minimize/avoid** generation curtailment, storage utilization, DR usage

State-of-the-art solutions

Decentralized control schemes



Power factor with respect to active power injection [1],[2]



Reactive power with respect to the PCC voltage [2],[3]

[1] Technische Richtlinie Erzeugungsanlagen am Mittelspannungsnetz, "Richtlinie f¨ur anschluss und parallelbetrieb von erzeugungsanlagen am mittelspannungsnetz, ausgabe juni 2008," Bundesverband der Energie-und Wasserwirtschaft e.V. (BDEW), Tech. Rep., June 2008.

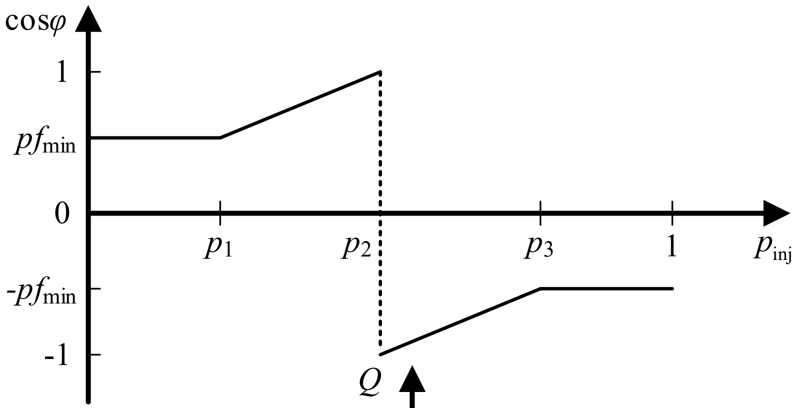
[2] Comitato Elettrotecnico Italiano, "Regola tecnica di riferimento per la connessione di Utenti attivi e passivi alle reti AT ed MT delle imprese distributrici di energia elettrica," Tech. Rep. CEI 0-16, Sept. 2014.

[3] North American Electric Reliability Corporation (NERC), "Interconnection requirements for variable generation," Tech. Rep., Sept. 2012.

State-of-the-art solutions

Decentralized control schemes

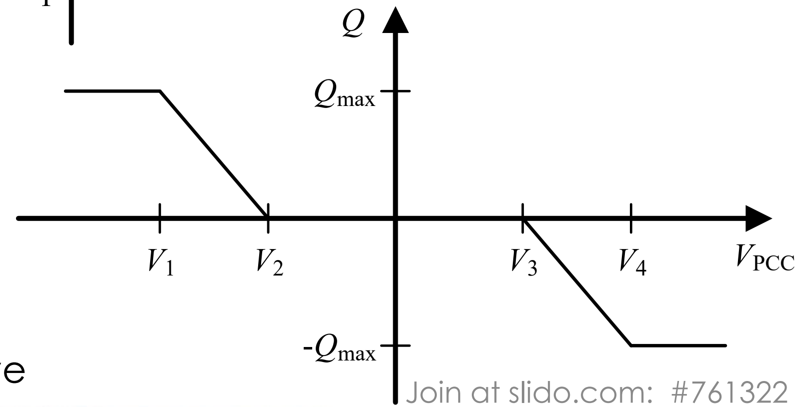
Main drawbacks



cosφ(P)

Reactive power is always **non-zero**

Network operating condition is **ignored**



Q(V)

The reactive power exchange is activated **before** exceeding network voltages

Uncoordinated operation in a distribution grid

Need to add a **system-oriented** operational objective

State-of-the-art solutions

Optimal voltage regulation (Volt/Var problem)

Mathematical Formulation

$$\min P_{loss} = \min \sum_{i\in N}\sum_{j\in N}\left[a_{ij}\left(P_iP_j + Q_iQ_j\right) + \beta_{ij}\left(Q_iP_j - P_iQ_j\right)\right]$$

→ **Objective function**

$$P_i = V_i \sum_{j\in N}\left[V_j\left(G_{ij}\cos\left(\theta_i - \theta_j\right) + B_{ij}\sin\left(\theta_i - \theta_j\right)\right)\right]$$

$$Q_i = V_i \sum_{j\in N}\left[V_j\left(G_{ij}\sin\left(\theta_i - \theta_j\right) - B_{ij}\cos\left(\theta_i - \theta_j\right)\right)\right]$$

Nodal power injections

$$P_i = \sum_{j\in N} P_{ij} = P_{g,i} - P_{c,i}$$

$$Q_i = \sum_{j\in N} Q_{ij} = Q_{g,i} - Q_{c,i}$$

$$\alpha_{ij} = \frac{R_{ij}}{V_iV_j}\cos\left(\theta_i - \theta_j\right)$$

$$\beta_{ij} = \frac{R_{ij}}{V_iV_j}\sin\left(\theta_i - \theta_j\right)$$

Auxiliary coefficients

$$Q_{\min,i} \le Q_{g,i} \le Q_{\max,i}$$

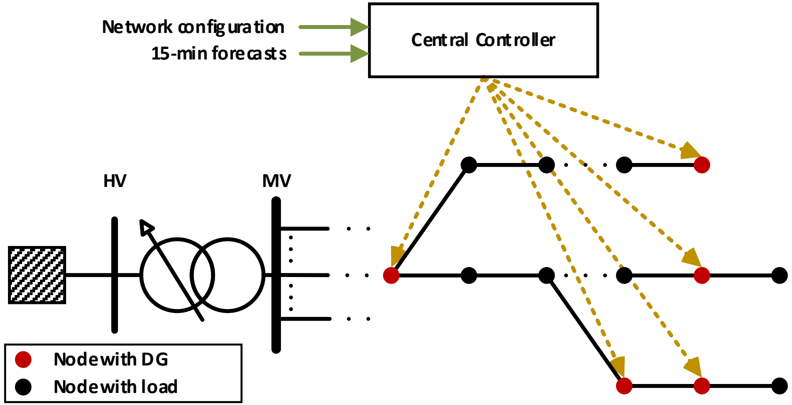
$$V_{\min} \le V_i \le V_{\max}$$

Operating constraints

State-of-the-art solutions

Optimal voltage regulation (Volt/Var problem)

Current approach [1]: Use a centralized controller that solves the optimal voltage regulation problem (near optimal solution)



Main drawbacks

Complete knowledge of network parameters

Susceptible to **single-point failures**

Perfect forecast is needed

Computationally **intensive** process (especially in large-scale, unbalanced grids)

[1] K. E. Antoniadou-Plytaria, I. N. Kouveliotis-Lysikatos, P. S. Georgilakis, and N. D. Hatziargyriou, "Distributed and decentralized voltage control of smart distribution networks: Models, methods, and future research," IEEE Trans. Smart Grid, vol. 8, no. 6, pp. 2999–3008, Nov. 2017.

State-of-the-art solutions

Distributed control schemes

Category 1: Offline implementation [1]-[4]

Use of **distributed algorithms (ADMM)** to iteratively solve an optimization problem

During the solution process, **no control actions** are performed by DG units

After the algorithm is converged, DG units **switch** to a new operation point

Application under fast, time-varying operating conditions **highly questionable**

[1] Y. Wang, T. Zhao, C. Ju, Y. Xu, and P. Wang, "Two-level distributed volt/var control using aggregated PV inverters in distribution networks," IEEE Trans. Power Del., vol. 35, no. 4, pp. 1844–1855, 2020.

[2] C. Feng, Z. Li, M. Shahidehpour, F. Wen, W. Liu, and X. Wang, "Decentralized short-term voltage control in active power distribution systems," IEEE Trans. Smart Grid, vol. 9, no. 5, pp. 4566–4576, 2018.

[3] P. Li, C. Zhang, Z. Wu, Y. Xu, M. Hu, and Z. Dong, "Distributed adaptive robust voltage/var control with network partition in active distribution networks," IEEE Trans. Smart Grid, vol. 11, no. 3, pp. 2245–2256, 2020.

[4] Z. Tang, D. J. Hill, and T. Liu, "Fast distributed reactive power control for voltage regulation in distribution networks," IEEE Trans. Power Syst., vol. 34, no. 1, pp. 802–805, 2019.

State-of-the-art solutions

Distributed control schemes

Category 2: Online implementation [1]-[5]

The reactive power of DG units is **updated** at each iteration (**online ADMM**) by **combining local measurements** and **information** received by neighbouring DG units

Small convergence speed

Assumptions on network modeling. **Linearized** network models are used

[1] Y. Wang, M. H. Syed, E. Guillo-Sansano, Y. Xu, and G. M. Burt, “Inverter-based voltage control of distribution networks: A three-level coordinated method and power hardware-in-the-loop validation,” IEEE Trans. Sustain. Energy, vol. 11, no. 4, pp. 2380–2391, 2020.

[2] Z. Tang, D. J. Hill, and T. Liu, “Distributed coordinated reactive power control for voltage regulation in distribution networks,” IEEE Trans. Smart Grid, vol. 12, no. 1, pp. 312-323, Jan. 2021.

[3] X. Hu, Z. W. Liu, G. Wen, X. Yu, and C. Liu, “Voltage control for distribution networks via coordinated regulation of active and reactive power of DGs,” IEEE Trans. Smart Grid, vol. 11, no. 5, pp. 4017–4031, 2020.

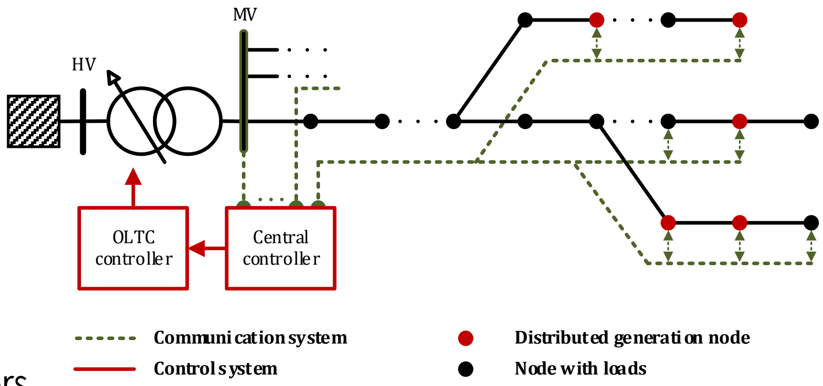
[4] H. J. Liu, W. Shi, and H. Zhu, “Distributed voltage control in distribution networks: Online and robust implementations,” IEEE Trans. Smart Grid, vol. 9, no. 6, pp. 6106–6117, 2018.

[5] J. Li, C. Liu, M. E. Khodayar, M. Wang, Z. Xu, B. Zhou, and C. Li, “Distributed online VAR control for unbalanced distribution networks with photovoltaic generation,” IEEE Trans. Smart Grid, vol. 11, no. 6, pp. 4760-4772, Nov. 2020.

The EASY-RES Approach

Optimal voltage regulation in MV grids

Motivation: Develop a **new** voltage control method with **reduced** computational complexity that **minimizes** network losses [1]



Main characteristics

Hybrid centralized/decentralized method

Participation of **industrial/commercial** customers

Central controller that **coordinates** the operation of DG units, specific MV loads, and OLTC of the HV/MV transformer

[1] G. C. Kryonidis, C. S. Demoulias, and G. K. Papagiannis, "A new voltage control scheme for active medium-voltage (MV) networks", Electric Power Systems Research, vol. 169, pp. 53 - 64, Apr. 2019.

The EASY-RES Approach

Optimal voltage regulation in MV grids

Theoretical Background

Voltage regulation at **node v** by modifying the reactive power at **node q** (3 cases)

Use **LinDistFlow** equations to evaluate the **impact** of the location of **node q** on voltage regulation and network losses

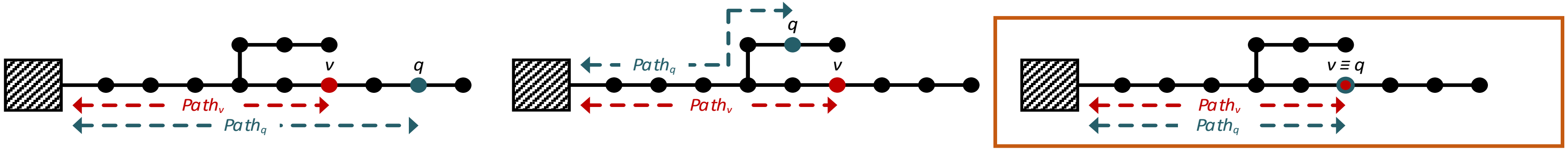
Reactive variation at **node q**

$$\Delta Q_q = \frac{V_0}{\sum_{i \in Path_q \cap Path_v} X_i} \Delta V_v$$

Network losses:

$$P_{loss}^{tot} \approx \frac{1}{V_0^2} \left[\sum_{i \in N} R_i \tilde{A}_i^2 + \sum_{i \in Path_q} R_i \left(\tilde{B}_i + \Delta Q_q\right)^2 + \sum_{i \in N \setminus Path_q} R_i \tilde{B}_i^2 \right]$$

Best solution



The EASY-RES Approach

Optimal voltage regulation in MV grids

Main concept

Step 1: Find the node with the **maximum** network voltage

Best candidate for overvoltage (regulating node)

Step 2: Check for overvoltage

Step 3: Absorb reactive power

Step 4: Termination criteria

Voltage is finally **regulated**

Maximum network voltage **moves** to another node → **Step 1**

The EASY-RES Approach

Optimal voltage regulation in MV grids

Participation of DG units

Need to be **oversized** to provide reactive power even under **maximum generation** conditions

Safe side

$$D_i = \sqrt{1 + \left(\frac{R_i}{X_i}\right)^2}$$

Participation of MV loads

To overcome the **limited** reactive power availability of DG units

In case the maximum network voltage occurs at a **consumption node**

The EASY-RES Approach

Optimal voltage regulation in MV grids

On-load tap changer (OLTC) operation

$$tap^{t+1} = \begin{cases} tap^{t} + 1, & \text{if } \mathbf{V}^{t+1} \quad V_{\min} \ \&\& \ \mathbf{V}^{t} \quad V^{set} \\ tap^{t} - 1, & \text{if } \mathbf{V}_{mv}^{t+1} > V_{\min} \ \&\& \left(\mathbf{V}^{t} < V_{\min} \ || \ \mathbf{V}^{t+1} < V^{set}\right) \\ tap^{t}, & \text{otherwise} \end{cases}$$

The EASY-RES Approach

Optimal voltage regulation in MV grids

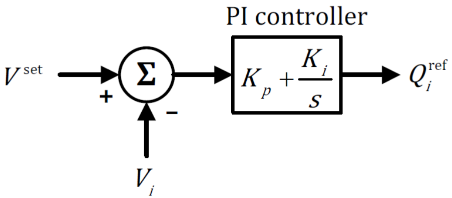
Implementation of the proposed concept (DG units)

Step 1: Acquire local measurements

Step 2: Address overvoltage with a **time delay**

Determined by the **central controller**

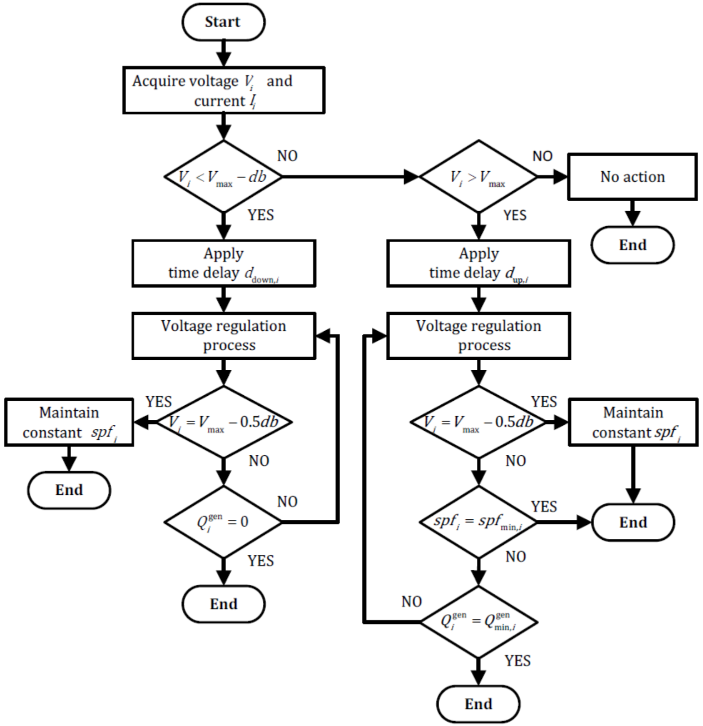
Coordinate the **response** of DG units



Step 3: Additional termination criterion

Network section power factor

Avoid **unnecessary** reactive power consumption



The EASY-RES Approach

Optimal voltage regulation in MV grids

Time delay determination

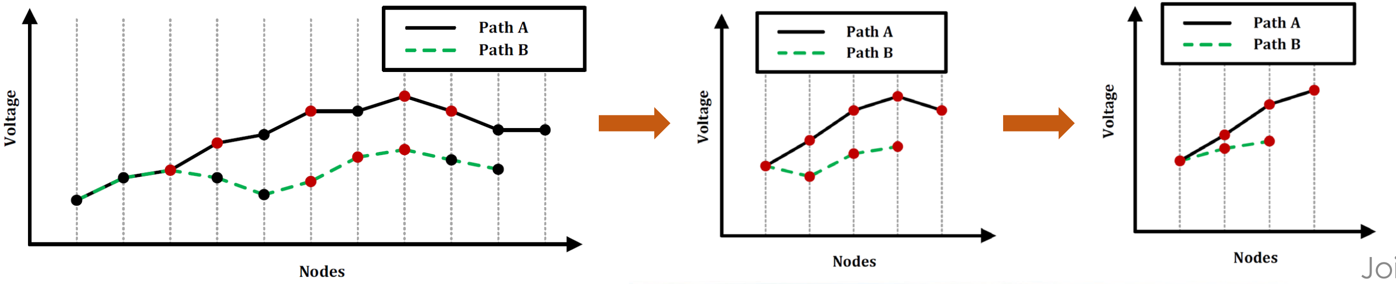
Network voltages are **structured** in a **tree** presenting the same topology with the network

Tree simplification by omitting nodes to form a strictly increasing voltage profile

The following conditions should be met

1) Equal time delays to the DG units of the same level nodes

2) In each path, time delays are sorted based on the voltages



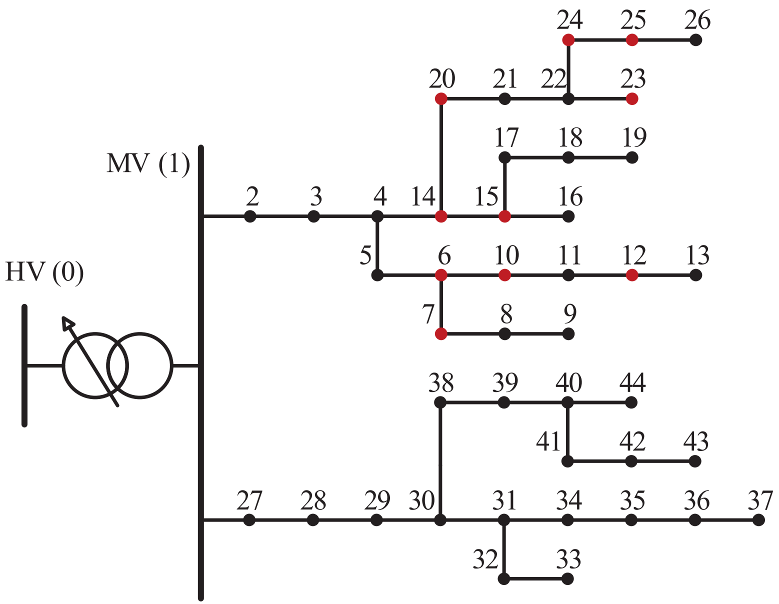
The EASY-RES Approach

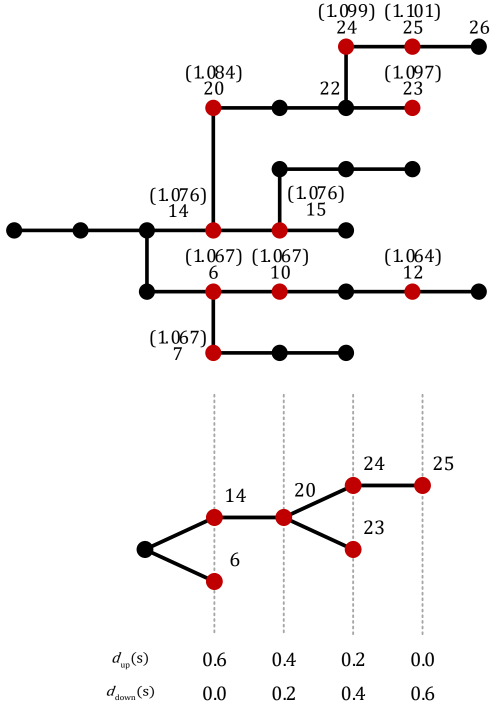
Optimal voltage regulation in MV grids

System Under Study (45 nodes)

10 PV units

33 loads

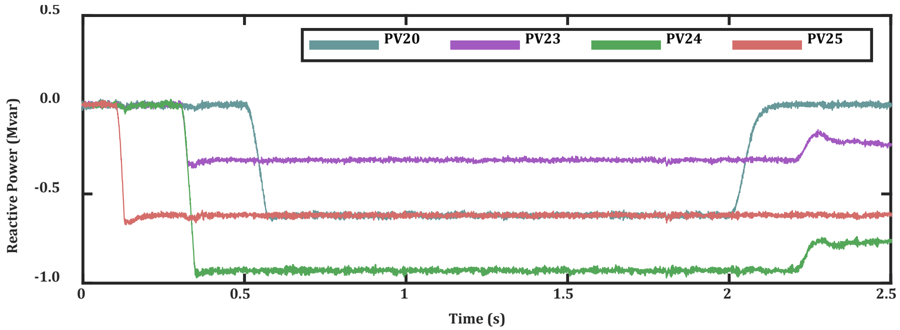


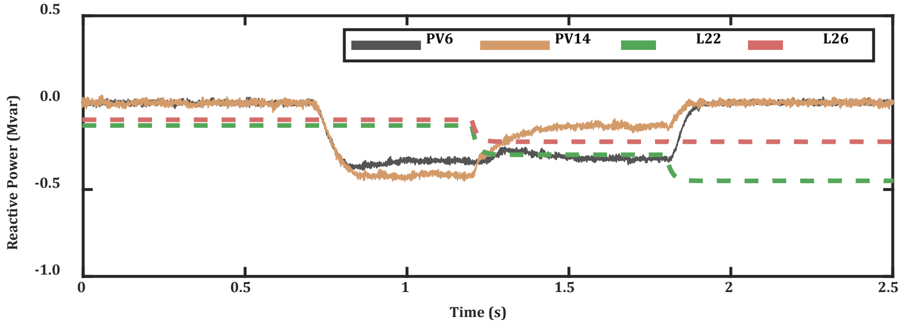


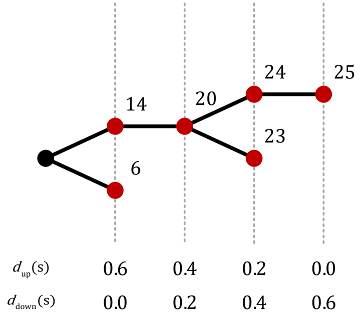
The EASY-RES Approach

Optimal voltage regulation in MV grids

Short-term evaluation



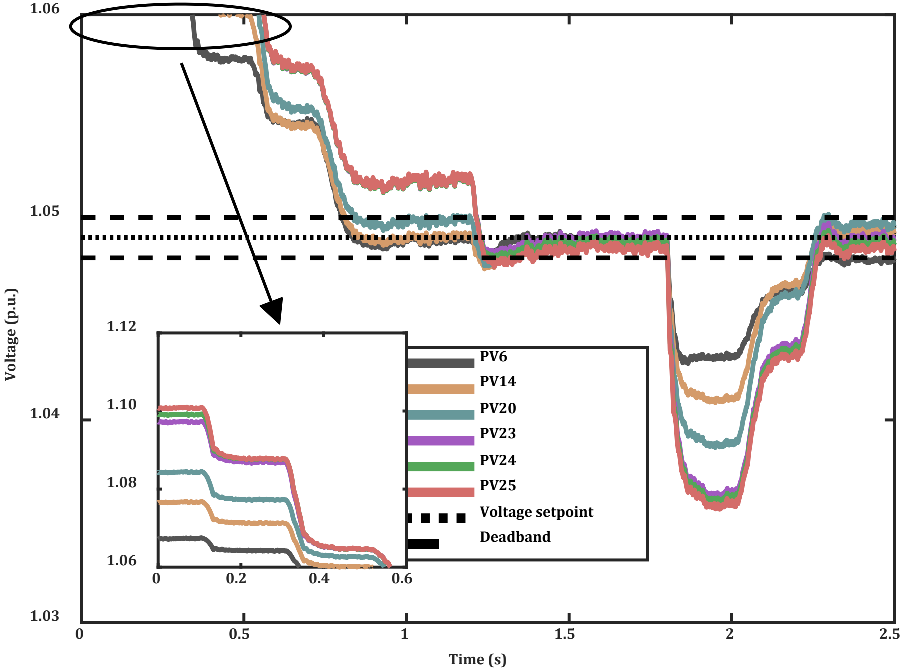


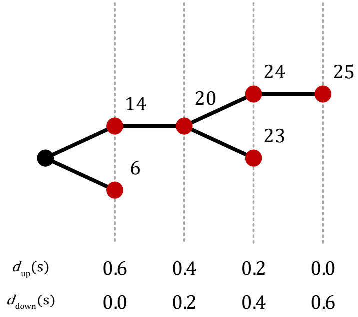


The EASY-RES Approach

Optimal voltage regulation in MV grids

Short-term evaluation

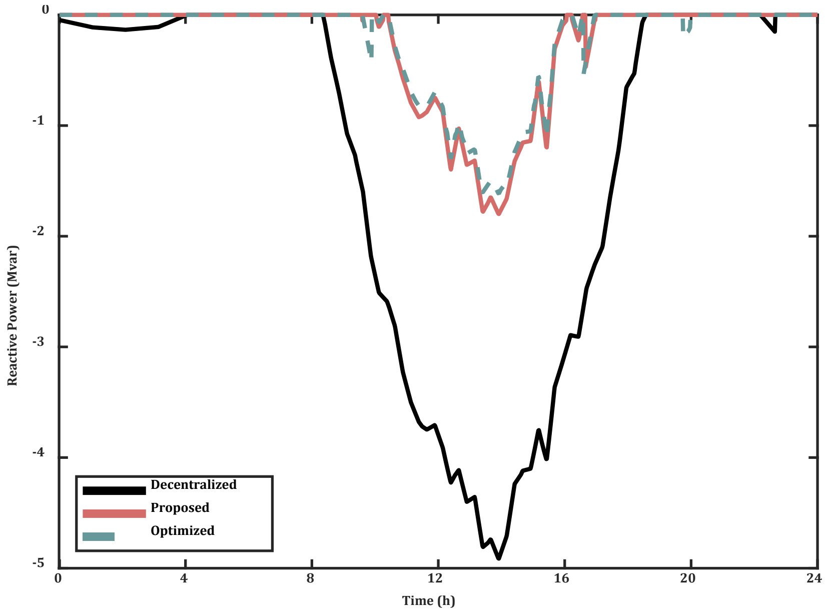


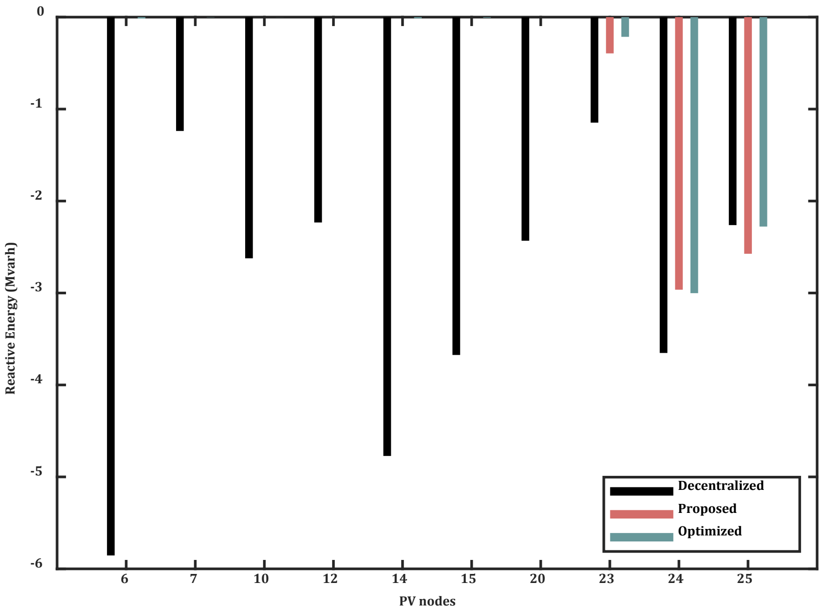


The EASY-RES Approach

Optimal voltage regulation in MV grids

Long-term evaluation

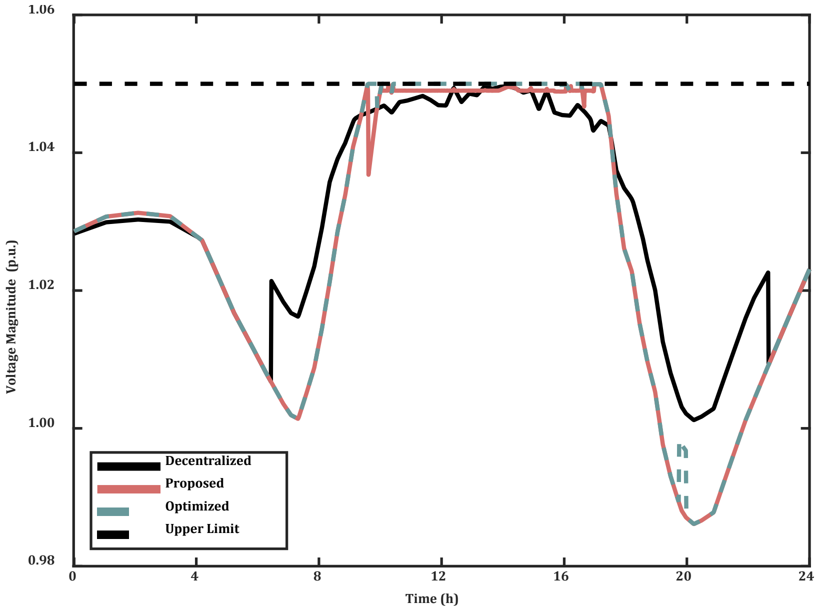


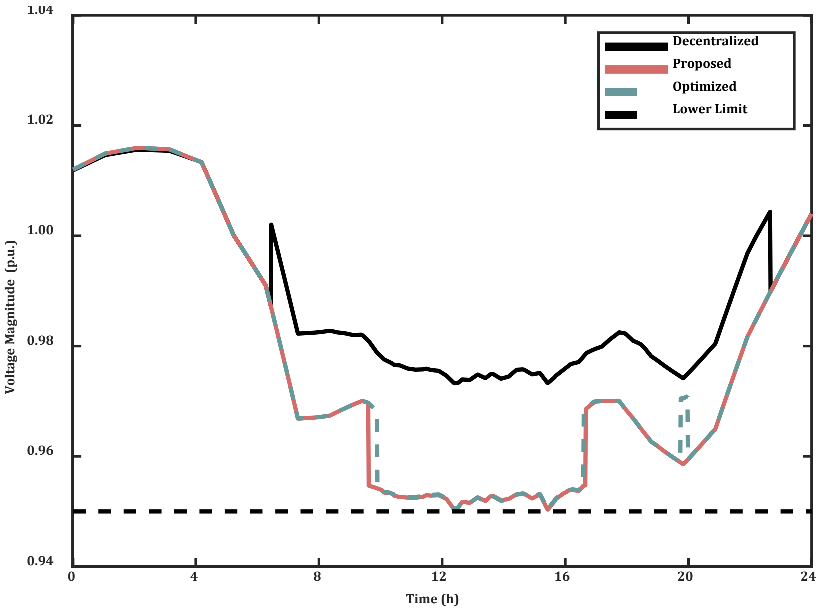


The EASY-RES Approach

Optimal voltage regulation in MV grids

Long-term evaluation

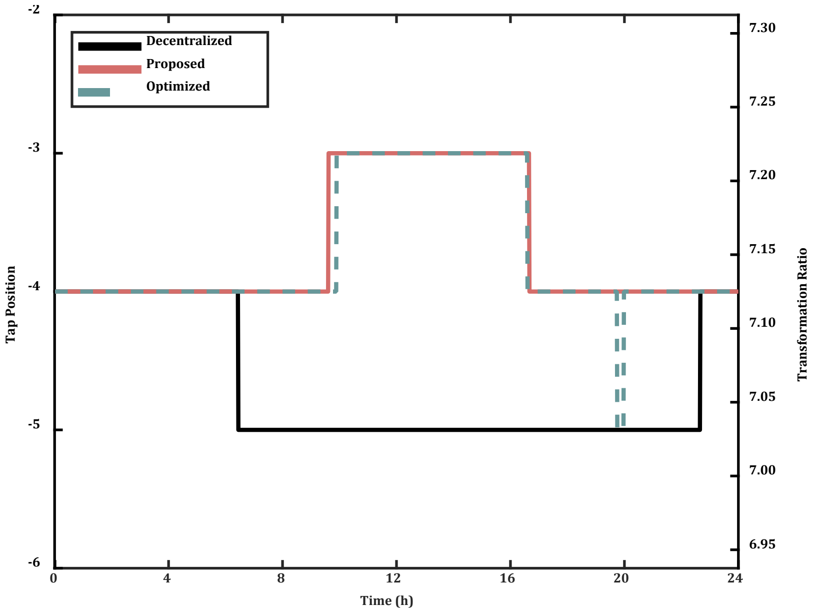


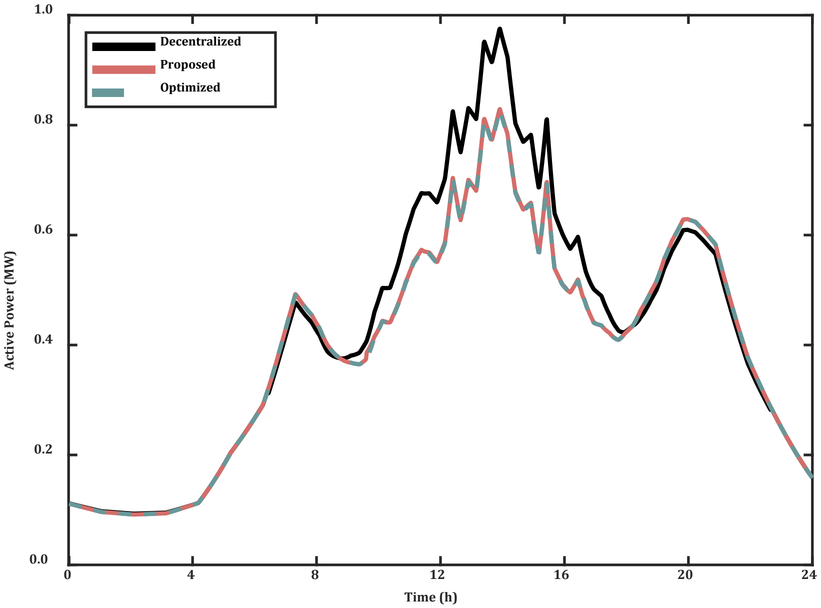


The EASY-RES Approach

Optimal voltage regulation in MV grids

Long-term evaluation





The EASY-RES Approach

Optimal voltage regulation in MV grids

Long-term evaluation

Daily energy losses (MWh)

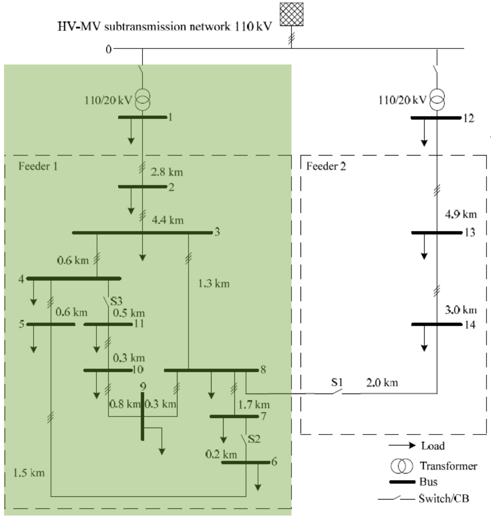
	Decentralized	Proposed	Optimized
45-Bus	10.309	9.596	9.579
Diff. (%)	+7.62	+0.18	0.00

The EASY-RES Approach

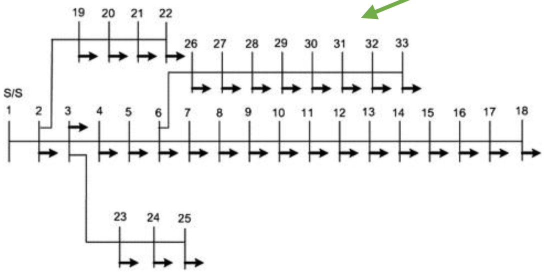
Optimal voltage regulation in MV grids

Verification of the proposed solution using benchmark MV networks

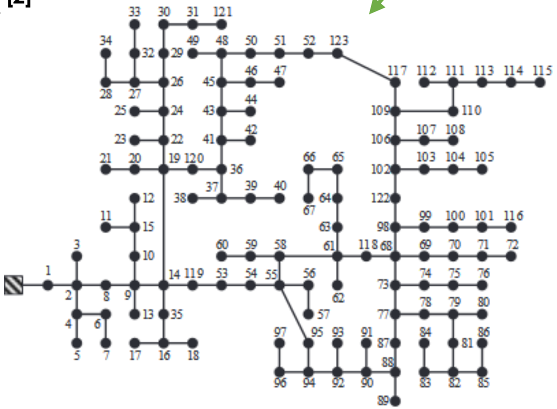
CIGRÉ [1]



33-Bus network [2]



IEEE 123-Bus network [3]



[1] 1Task Force C6.04, "Benchmark systems for network integration of Renewable and distributed energy resources," Tech. Brochure 575, CIGRÉ, Apr. 2014.

[2] M. E. Baran and F. F. Wu, "Network reconfiguration in distribution systems for loss reduction and load balancing", IEEE Trans. Power Del., vol. 4, no. 2, pp. 1401 - 1407, Apr. 1989.

[3] X. Chen, W. Wu, and B. Zhang, "Robust restoration method for active distribution networks, "IEEE Trans. Power Syst., vol. 31, no. 5, pp.4005–4015, Sept 2016.

The EASY-RES Approach

Optimal voltage regulation in MV grids

Verification of the proposed solution using benchmark MV networks

Daily energy losses (MWh)

	Decentralized	Proposed	Optimized
CIGRÉ	16.666	13.350	13.306
Diff. (%)	+25.25	+0.33	0.00
33-Bus	3.474	3.042	3.028
Diff. (%)	+14.73	+0.46	0.00
123-Bus	17.37	16.88	16.87
Diff. (%)	+2.96	+0.06	0.00

Superior performance compared to **optimization-based** methods in terms of low computational complexity and immunity to forecast errors

Outperforms the well-established **decentralized** methods due to the coordinated operation among DG units, Loads and OLTC

State-of-the-art solutions

Bi-objective optimal voltage regulation (OVR)

Mathematical Formulation

$$\min w_1 Taps + w_2 E_{loss} = \min w_1 \sum_{t\in T} \left| tap^t - tap^{t-1} \right| + w_2 \sum_{t\in T} \sum_{i\in N} \sum_{j\in N} \left[a^t_{ij} \left(P^t_i P^t_j + Q^t_i Q^t_j \right) + \beta^t_{ij} \left(Q^t_i P^t_j - P^t_i Q^t_j \right) \right]$$

→ **Objective function**

$$P^t_i = V^t_i \sum_{j\in N} \left[V^t_j \left(G_{ij} \cos\left(\theta^t_i - \theta^t_j\right) + B_{ij} \sin\left(\theta^t_i - \theta^i_j\right) \right) \right]$$

$$Q^t_i = V^t_i \sum_{j\in N} \left[V^t_j \left(G_{ij} \sin\left(\theta^t_i - \theta^t_j\right) - B_{ij} \cos\left(\theta^t_i - \theta^i_j\right) \right) \right]$$

Nodal power injections

$$P^t_i = P^t_{g,i} - P^t_{c,i}$$

$$Q^t_i = Q^t_{g,i} - Q^t_{c,i}$$

$$V^t_{sb} = V^t_{hv} / \left[m \left(1 + tap^t \delta / 100 \right) \right]$$

→ **OLTC operation**

$$\alpha^t_{ij} = \frac{R_{ij}}{V^t_i V^t_j} \cos\left(\theta^t_i - \theta^t_j\right)$$

$$\beta^t_{ij} = \frac{R_{ij}}{V^t_i V^t_j} \sin\left(\theta^t_i - \theta^t_j\right)$$

Auxiliary coefficients

$$Q^t_{\min,i} \le Q^t_{g,i} \le Q^t_{\max,i}$$

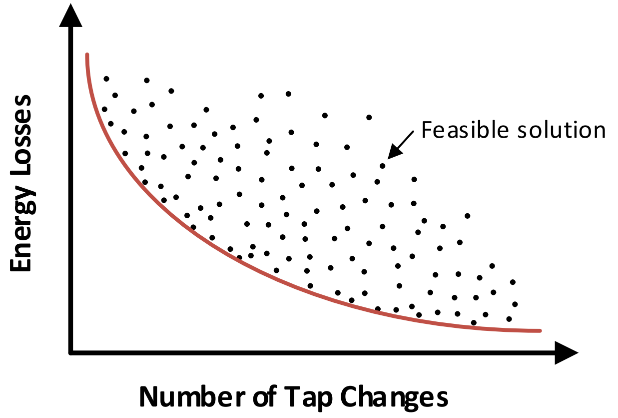
$$V_{\min} \le V^t_i \le V_{\max}$$

Operating constraints

The EASY-RES Approach

Bi-objective optimal voltage regulation

Derivation of the Pareto-front solutions



Main control variables

Reactive power of DG units

OLTC of HV/MV transformer

Drawbacks of the solutions proposed in the literature [1]-[3]

Increased computational complexity

Time-consuming process

Sensitive to forecast errors

[1] W. Sheng, K. y. Liu, S. Cheng, X. Meng, and W. Dai, "A trust region SQP method for coordinated voltage control in smart distribution grid," IEEE Trans. Smart Grid, vol. 7, no. 1, pp. 381–391, Jan. 2016.

[2] Y. Tang, K. Dvijotham, and S. Low, "Real-time optimal power flow," IEEE Trans. Smart Grid, vol. 8, no. 6, pp. 2963–2973, Nov. 2017.

[3] Z. Yang, H. Zhong, A. Bose, T. Zheng, Q. Xia, and C. Kang, "A linearized OPF model with reactive power and voltage magnitude: A pathway to improve the MW-only DC OPF," IEEE Trans. Power Syst., vol. 33, no. 2, pp. 1734–1745, Mar. 2018.

The EASY-RES Approach

Bi-objective optimal voltage regulation

Two-stage solution [1]

First stage

Sensitivity theory is employed to **linearize** the network operation

The linearized OVR problem is **solved** multiple times to obtain the **candidate** OLTC operating plans (COOPs)

Objectives

$$\min w_1 Taps + w_2 E_{loss}$$

$$Taps = \sum_{t \in T} \left| tap^t - tap^{t-1} \right|$$

$$E_{loss} = \sum_{t \in T} \left[P^t_{loss,pf} \left(a + btap^t \right) + \sum_{i \in N_{dg}} l^t_i Q^t_{dg,i} \right]$$

Loss sensitivity: l^t_i

Network operation

$$V^t_i = V^t_{pf,i} \left(c + dtap^t \right) + \sum_{j \in N_{dg}} s^t_{ij} Q^t_{dg,j}$$

Voltage sensitivity: s^t_{ij}

Operating constraints

$$Q^t_{\min,i} \le Q^t_{g,i} \le Q^t_{\max,i}$$

$$V_{\min} \le V^t_i \le V_{\max}$$

[1] G. C. Kryonidis, C. S. Demoulias and G. K. Papagiannis, "A Two-Stage Solution to the Bi-Objective Optimal Voltage Regulation Problem," in IEEE Transactions on Sustainable Energy, vol. 11, no. 2, pp. 928-937, April 2020.

The EASY-RES Approach

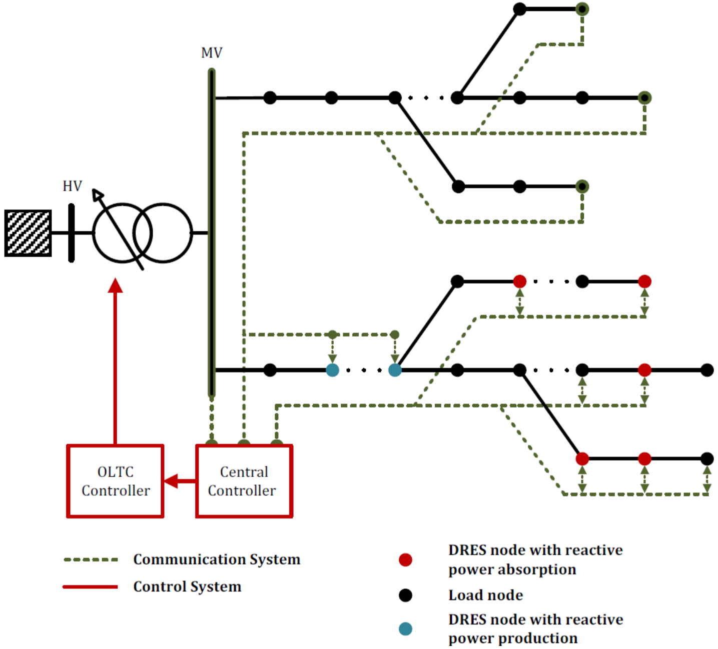
Bi-objective optimal voltage regulation

Two-stage solution [1]

Second stage

For each **COOP**, an **enhanced** version of the EASY-RES approach for the voltage regulation is **used** aiming to **minimize** the network losses

Finally, the **Pareto-front** is obtained and DSOs have a clear overview of the **trade-off** between the optimization objectives to **decide** the most preferable solution

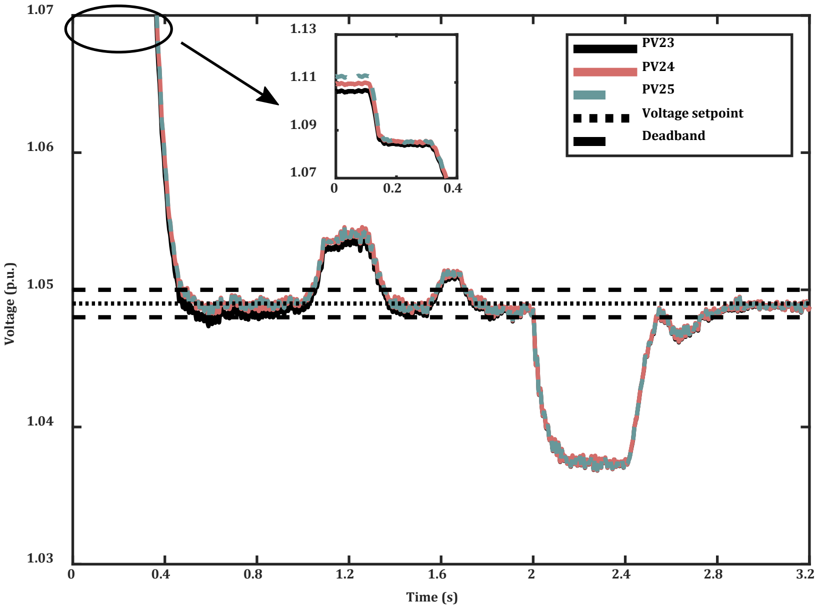


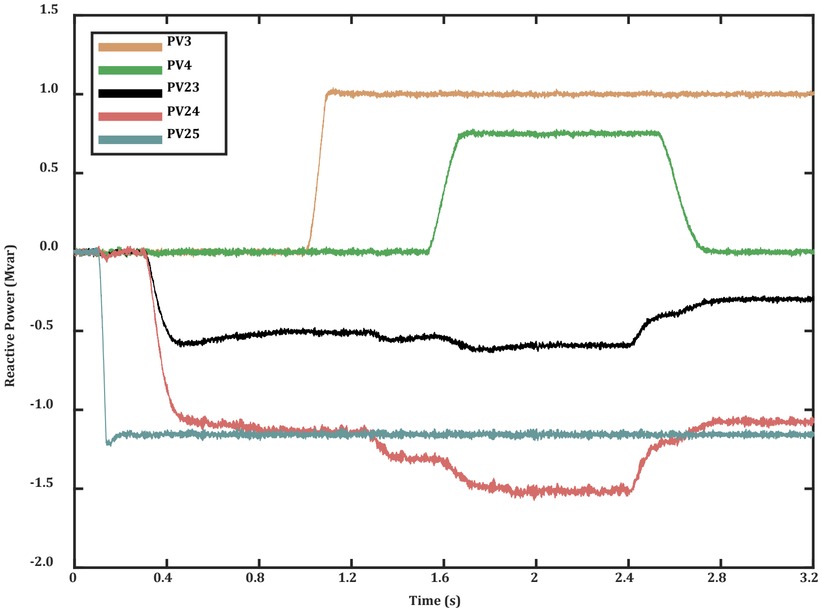
[1] G. C. Kryonidis, C. S. Demoulias and G. K. Papagiannis, "A Two-Stage Solution to the Bi-Objective Optimal Voltage Regulation Problem," in IEEE Transactions on Sustainable Energy, vol. 11, no. 2, pp. 928-937, April 2020.

The EASY-RES Approach

Bi-objective optimal voltage regulation

Short-term evaluation

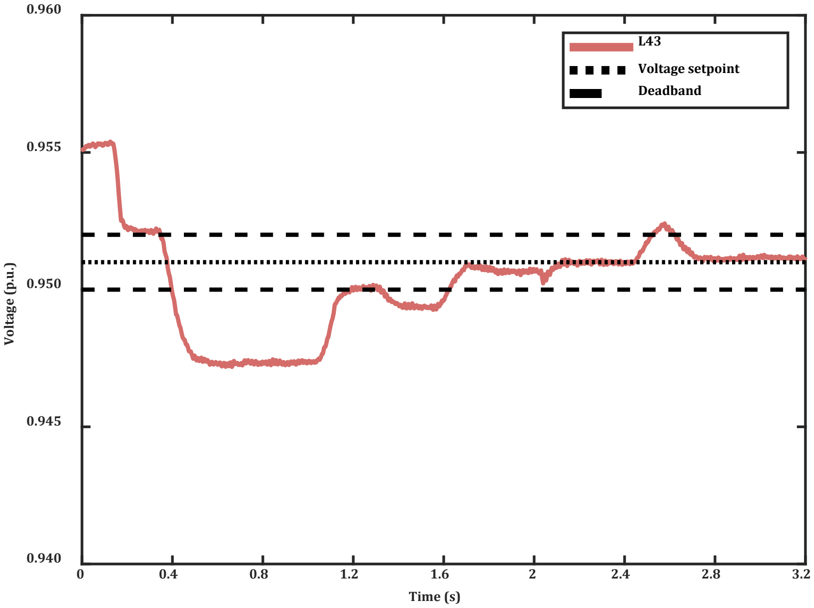


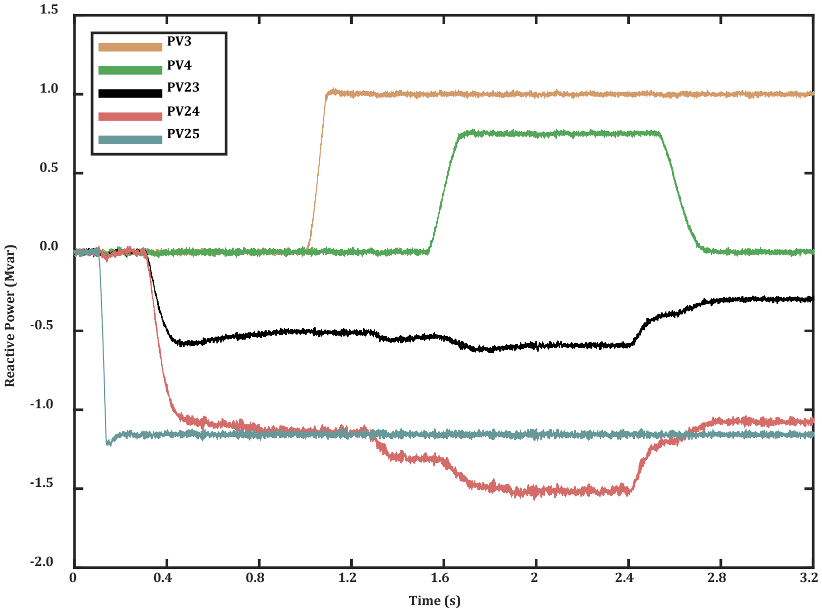


The EASY-RES Approach

Bi-objective optimal voltage regulation

Short-term evaluation

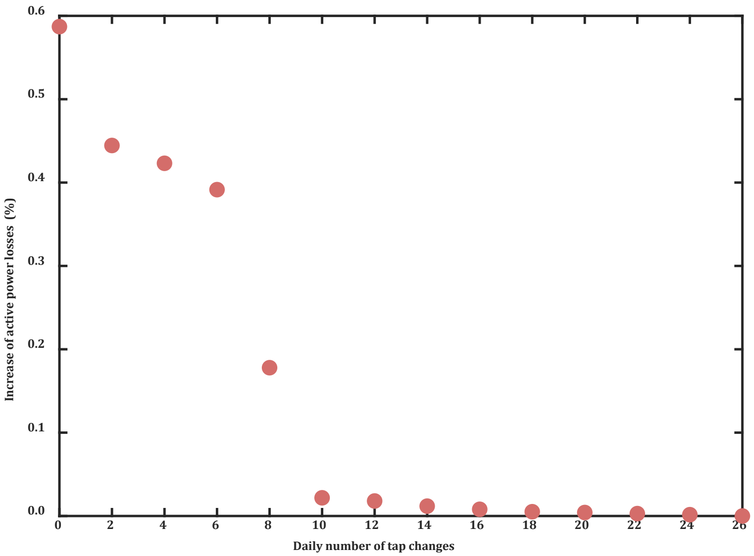


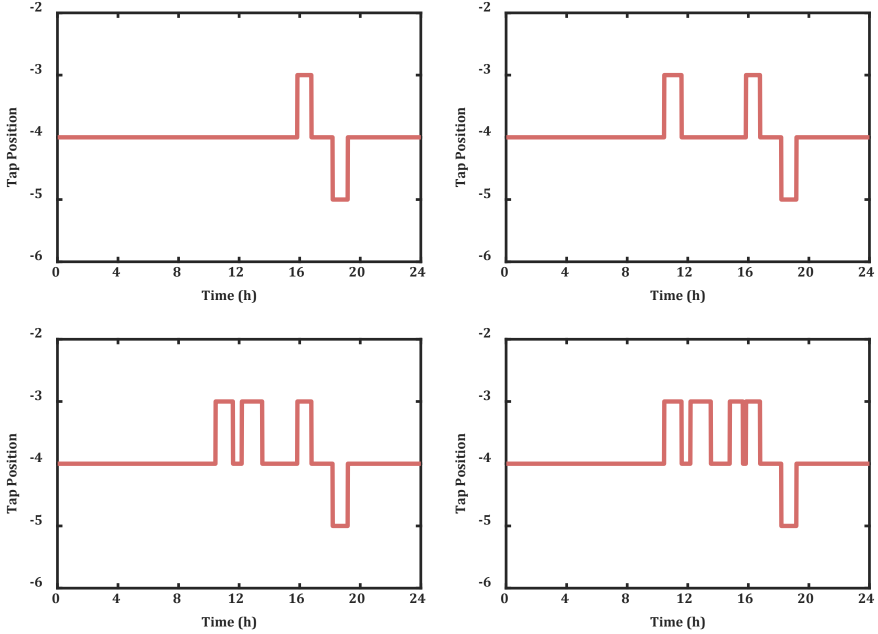


The EASY-RES Approach

Bi-objective optimal voltage regulation

Long-term evaluation (First stage)

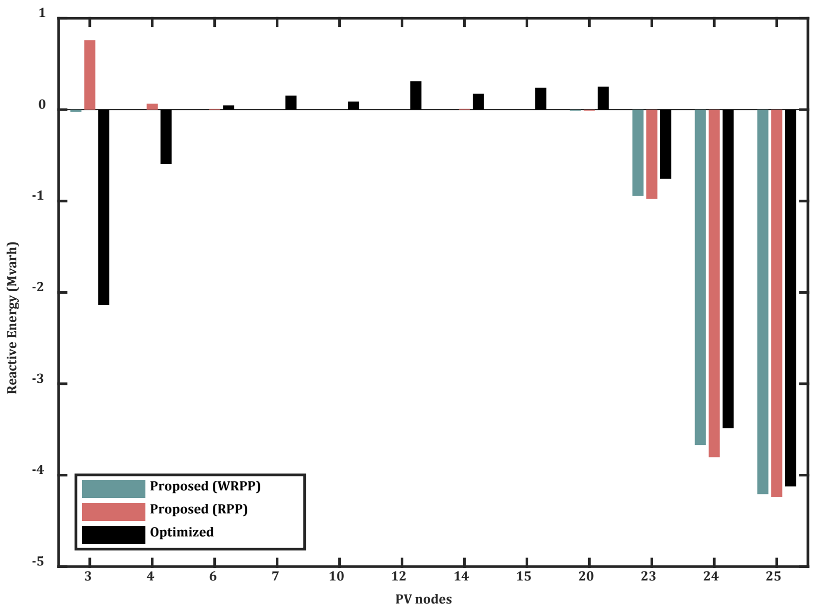


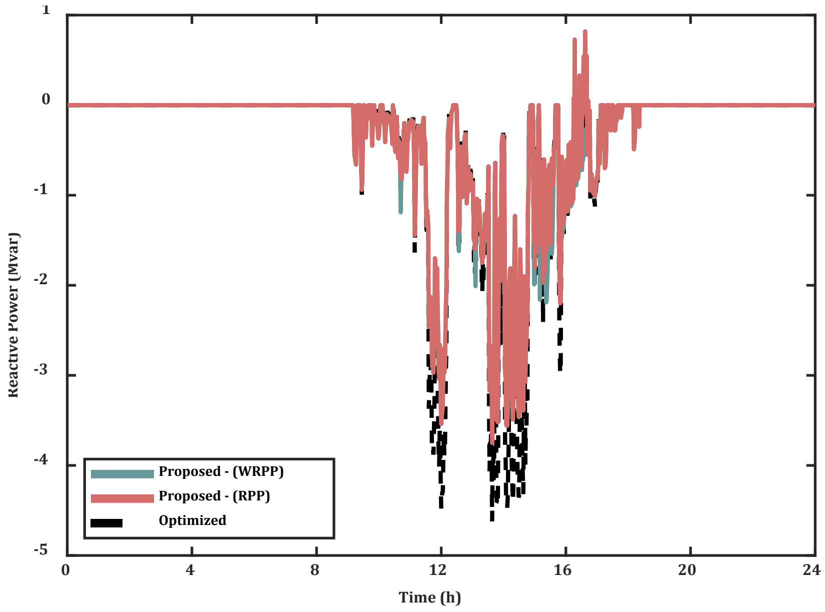


The EASY-RES Approach

Bi-objective optimal voltage regulation

Long-term evaluation (Second Stage)

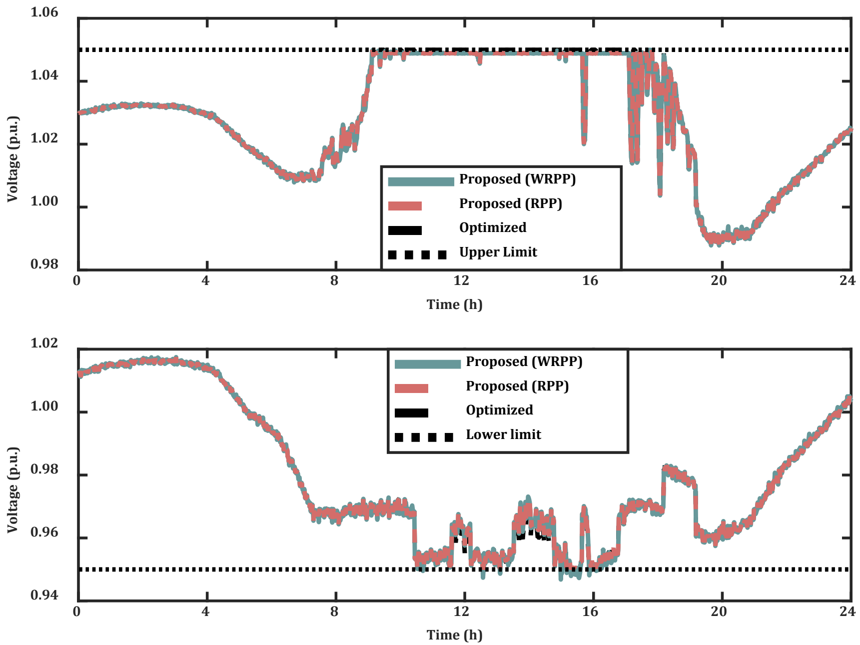


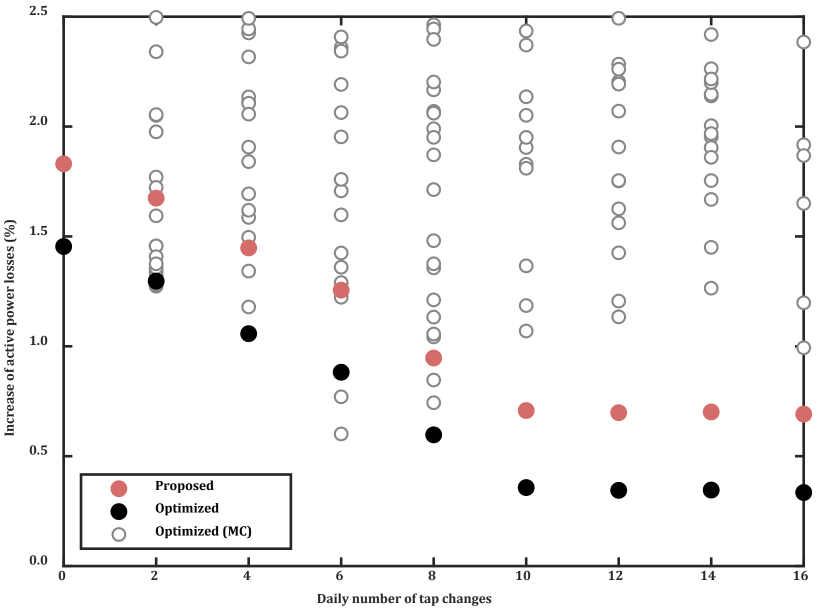


The EASY-RES Approach

Bi-objective optimal voltage regulation

Long-term evaluation (Second Stage)

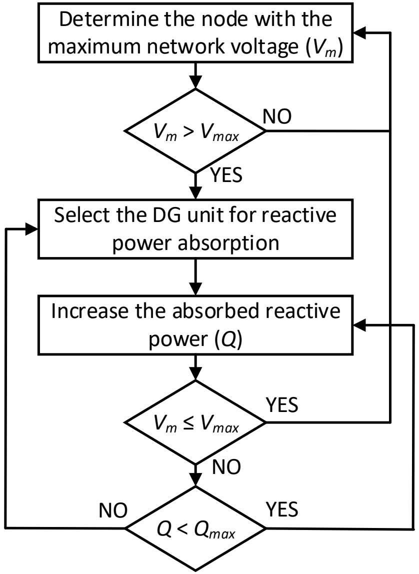




The EASY-RES Approach

Optimal voltage regulation in LV grids

Motivation: Address the **increased DG oversizing** in LV grids needed to implement the EASY-RES approach developed for MV grids



Main idea [1]**:** Additional **help** from neighboring DG units

Main concept

Step 1: Determine the node with the maximum network voltage

Step 2: Check for overvoltage mitigation

Step 3: Select the DG unit that will tackle the overvoltage

Step 4: Overvoltage mitigation process (**positive-sequence**)

Step 5: Check if voltage is regulated

Step 6: Check is there is available reactive power

[1] G. C. Kryonidis et al., "Distributed Reactive Power Control Scheme for the Voltage Regulation of Unbalanced LV Grids," in IEEE Transactions on Sustainable Energy, vol. 12, no. 2, pp. 1301-1310, April 2021

Optimal voltage regulation in LV grids

Condition to be met during the selection process

DG unit with available reactive power

DG unit with maximum dV/dQ sensitivity factor

Distributed implementation

Every DG unit **broadcasts** continuously its PCC voltage across the LV network (every time slot t_b)

Clear overview of the voltages at the **most critical** network nodes

DG prioritization

Starting from the node with the **maximum** sensitivity factor

Use of **time-delays** between two sequential activations (t_d)

$t_b < t_r < t_d$: where t_r is the response time of each DG unit

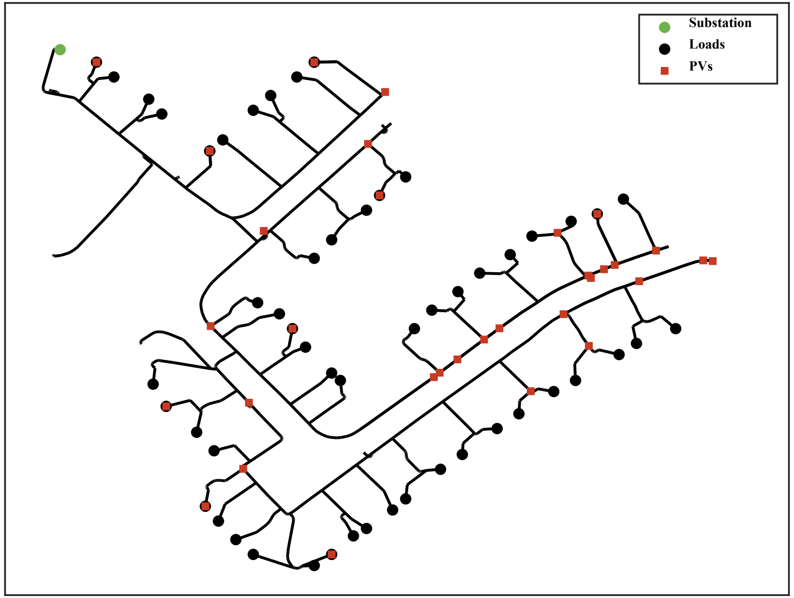
The EASY-RES Approach

Optimal voltage regulation in LV grids

System under study (IEEE European LV test feeder)

55 single-phase loads

32 three-phase PV units



Examined scenarios

HQV: Decentralized Q(V)

PWTV: Proposed with target voltage (TV)

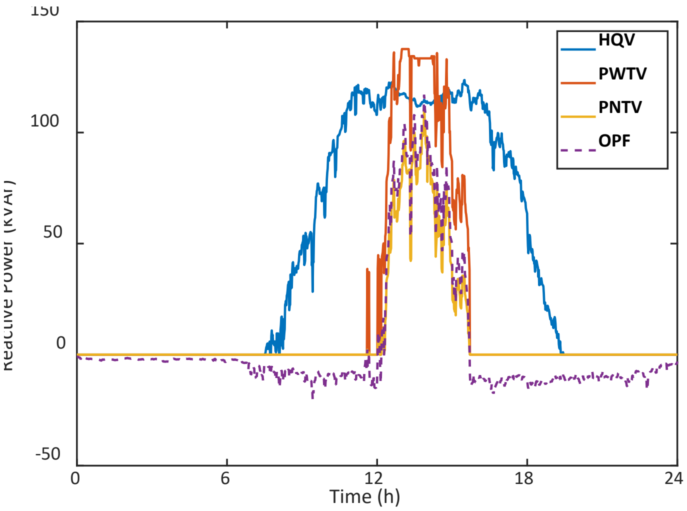
PNTV: Proposed without TV

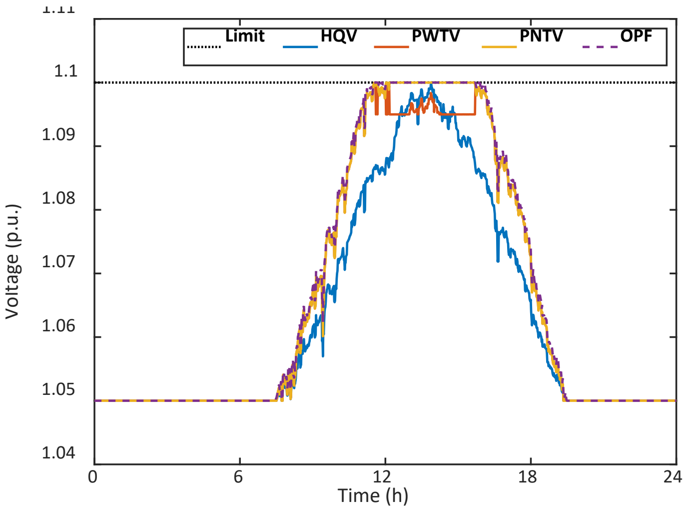
OPF: Centralized solution

The EASY-RES Approach

Optimal voltage regulation in LV grids

Long-term evaluation





Scenario	HQV	PWTV	PNTV	OPF
Losses (kWh)	82.02	63.42	56.21	55.43
Difference (%)	+47.97	+14.41	+1.41	-

The Consortium

This project has received funding from the European Union´s Horizon 2020 Programme for research and innovation under Grant Agreement no 764090.

Thank you!

Dr. Georgios C. Kryonidis

Affiliation:	Department of Electrical & Computer Engineering, Aristotle University of Thessaloniki
E-Mail:	kryonidi@ece.auth.gr
EASY-RES website:	http://www.easyres-project.eu/

Audience Q&A Session

ⓘ Start presenting to display the audience questions on this slide.

slido

Assuming the voltage regulation in a distribution grid with X > R, the reactive power is

ⓘ Start presenting to display the poll results on this slide.

The decentralized Q(V) droop method leads to

ⓘ Start presenting to display the poll results on this slide.

slido

In the EASY-RES approach for the voltage regulation of MV grids, scope of the OLTC is to

ⓘ Start presenting to display the poll results on this slide.

slido

In the EASY-RES approach for the bi-objective optimal voltage regulation of MV grids, the linearized grid model is used

ⓘ Start presenting to display the poll results on this slide.

The EASY-RES approach for LV grids aims to regulate

ⓘ Start presenting to display the poll results on this slide.