DLMP of Competitive Markets in Active Distribution Networks: Models, Solutions, Applications, and Visions

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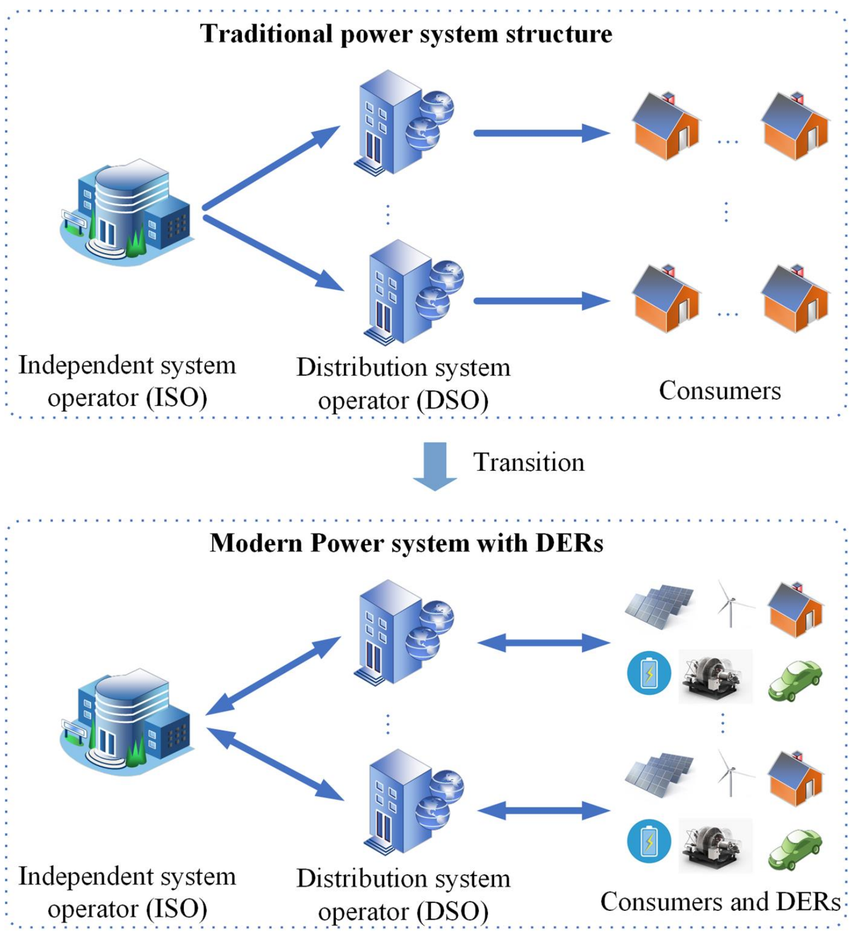
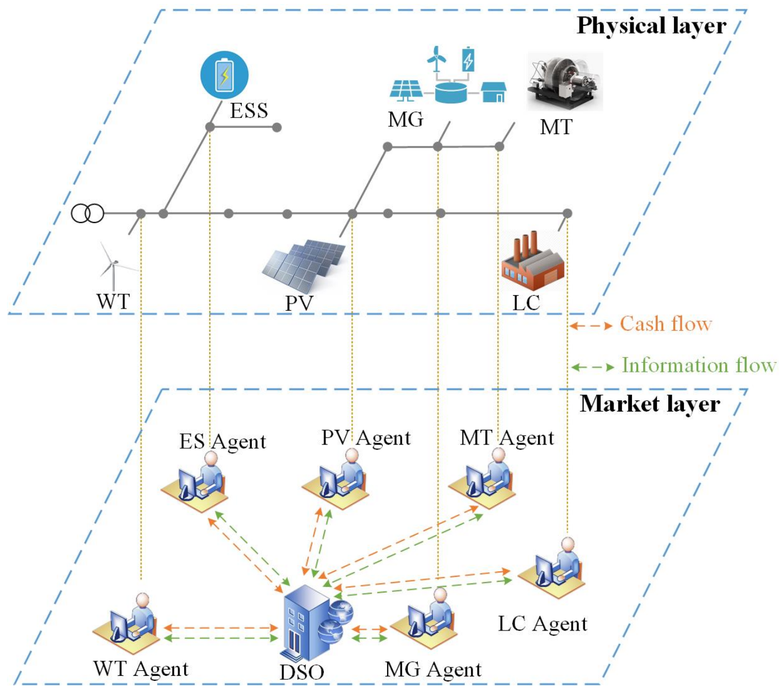
Background

- Traditionally, distribution systems are unidirectionally structured and operate with uniform electricity prices across all system nodes.
- The adoption of distributed energy resources (DERs) propels a shift from passive to active distribution network (ADN) operations.
- Distribution-level or local markets have been proposed to optimally coordinate these DERs in recent years.
- Distribution locational marginal price (DLMP) has been proposed as a promising price.

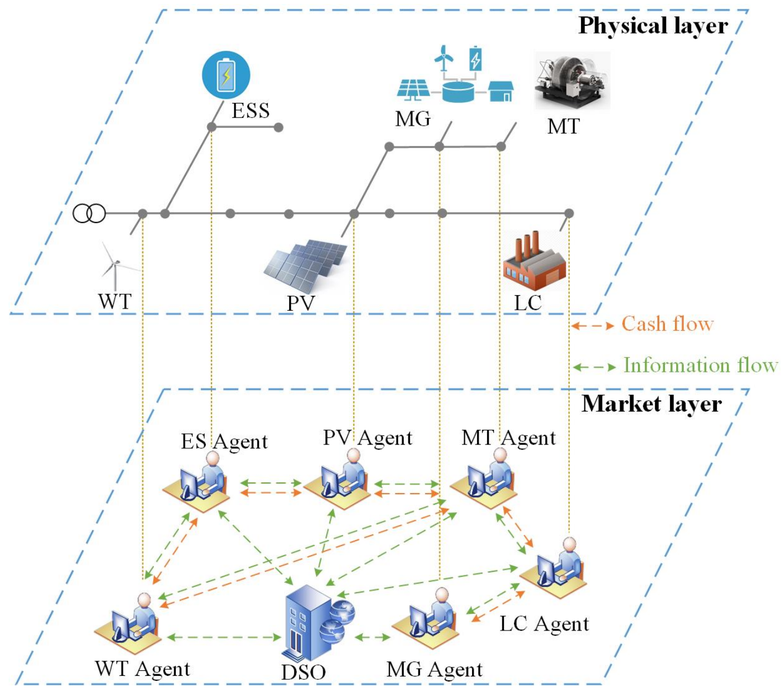
Power system transition



Pool-based market architecture



P2P market architecture



Modeling details and comparisons

Refs.	Power losses	Congestion	Voltage	Renewable energy uncertainty	Demand uncertainty	Phases	Transformer degradation	Active power	Reactive power	Reserve
[8]	✓	✓	✓	--	--	1	--	✓	✓	--
[30]	✓	--	✓	--	--	1	--	✓	✓	--
[86]	--	✓	--	--	--	1	--	✓	--	--
[87]	--	✓	--	--	--	1	--	✓	--	--
[88]	✓	✓	--	--	--	1	--	✓	--	--
[33]	✓	✓	✓	--	--	1	--	✓	✓	--
[62]	--	✓	--	✓	✓	1	--	✓	--	✓
[50]	✓	✓	✓	✓	--	1	--	✓	✓	✓
[51]	--	--	✓	✓	--	1	--	✓	✓	✓
[35]	✓	--	✓	--	--	3	--	✓	✓	--
[36]	✓	--	✓	--	--	3	--	✓	✓	--
[37]	✓	--	--	--	--	3	--	✓	✓	--
[63]	✓	✓	✓	--	--	1	✓	✓	✓	--
[89]	✓	--	✓	--	--	1	--	✓	✓	--
[90]	✓	--	✓	--	--	1	--	✓	✓	✓

Different relaxation methods

Categories	Specific methods	Refs.
Linearization	DCOPF	[86][87]
	Linearized Distflow	[8][65] [67][74]
	Polygonal approximation	[8][50]
	Modified DistFlow	[64]
	LPF-D, LF-D	[30][36][68]
	Taylor approximation	[69][70][71]
	Data-driven linearization	[72][73]
Convexification	SDP	[76][77][78][83][84]
	Moment relaxation-based SDP	[79]
	SOCP	[80][83][84][85][91]
	Sequential SOCP	[82]

Summary and comparison of solution methods

Categories	Algorithms	Pros	Cons	Refs.
Centralized methods	Programming-based	Can find the global optimum if the problem is convex.	High computation burden in a large-scale problem.	[36][81][98] [99][107]
	Metaheuristic	Can find a sub-optimal solution even if the problem is nonconvex .	High computation burden due to a large group of populations.	[97][108]
Distributed methods	ADMM	Can decompose a problem into sub-problems and protect data privacy.	The convergence rate of ADMM is not always satisfactory.	[110][111][112] [113][114][115] [116][117]
	ATC	Suitable for hierarchical design optimization problems.	Implementation is complex, may not handle a meshed network.	[118][119][120] [121][122][123]
Decentralized methods	PMP	High computational efficiency due to in-parallel solution of sub-problems.	Information exchange among sub-problems is complex.	[124][125] [126][127]
	APP	An early algorithm that makes decomposition possible.	Information exchange among sub-problems is complex.	[128][129] [130][131]

Conclusions

- This work reviewed the current progress toward the distribution-level market.
- A typical market-clearing model was established.
- DLMP was expressed explicitly, and its features to other electricity tariffs were discussed.
- This work reviewed the state-of-the-art solution methods to solve the market model.
- Various DLMP-related applications in operation and planning were discussed.