Interactive planning and operations using peak load pricing in distribution systems

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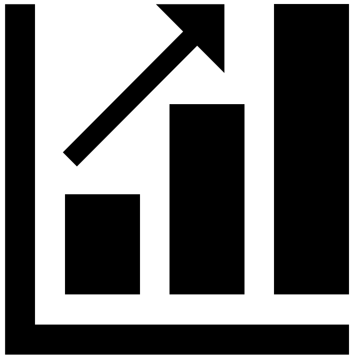
Entering an era of DERs



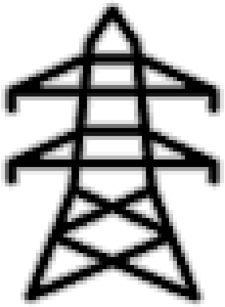
Massive increase of DERs installed[1]

- 2017-2021: 78 GW
- 2021-2026: 175 GW
- PJM installed capacity in 2022: 185 GW

Favorable regulation

- FERC order 2222
- State level electrification standards (both residential and transport)

- Increased controllability and communication ability of DERs



- Need for new power system infrastructure and maintenance of existing fleet

1: https://www.utilitydive.com/news/distributed-energy-is-poised-to-take-center-stage-in-2022-but-policymakers/618331/

Peak Load Pricing

- Marginal cost pricing does not guarantee cost recovery
  - Especially for DERs[2]
  - Corrected through uplift payments[3]

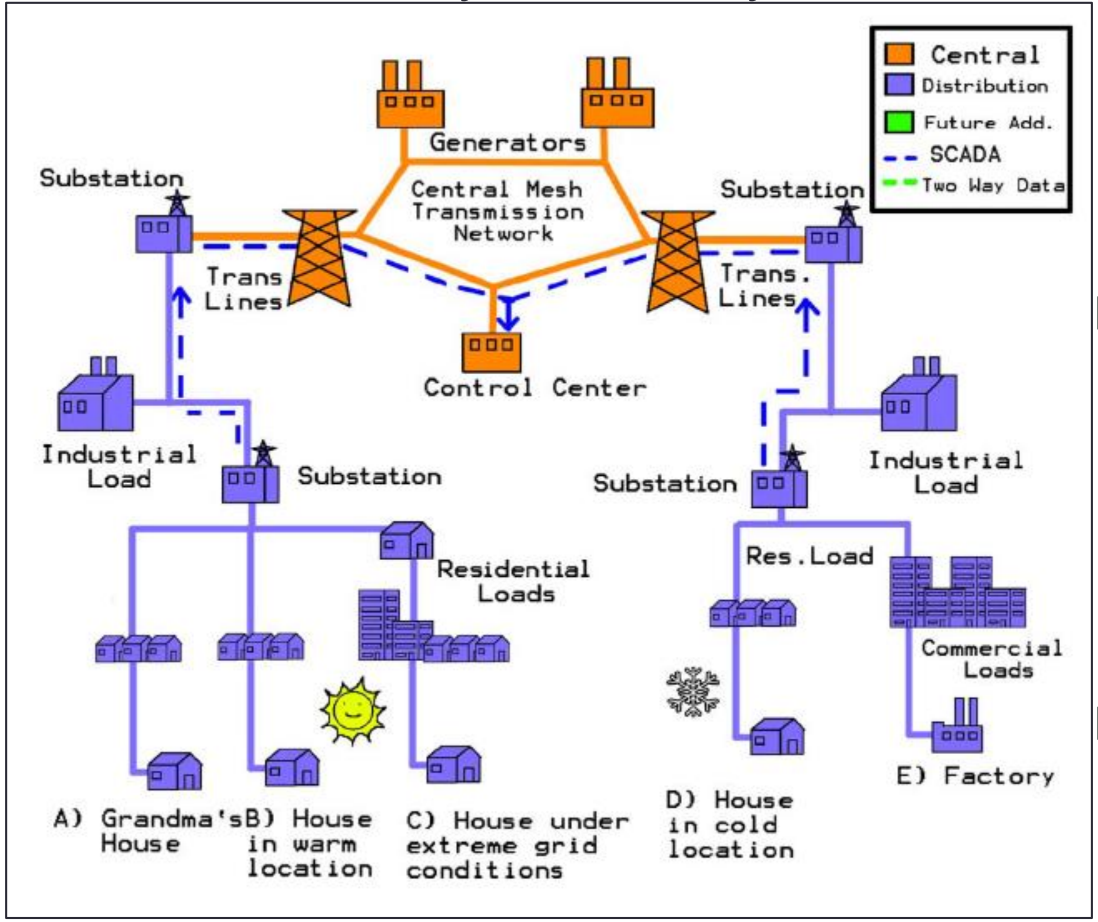
- Peak Load Pricing explicitly considers the capital costs.
  - Removes requirements for uplift payments[4]

- We propose a dynamic application of peak load pricing to distribution system operations and expansion planning using DyMonDS
  - Models trade-offs between costs and different types of network upgrades

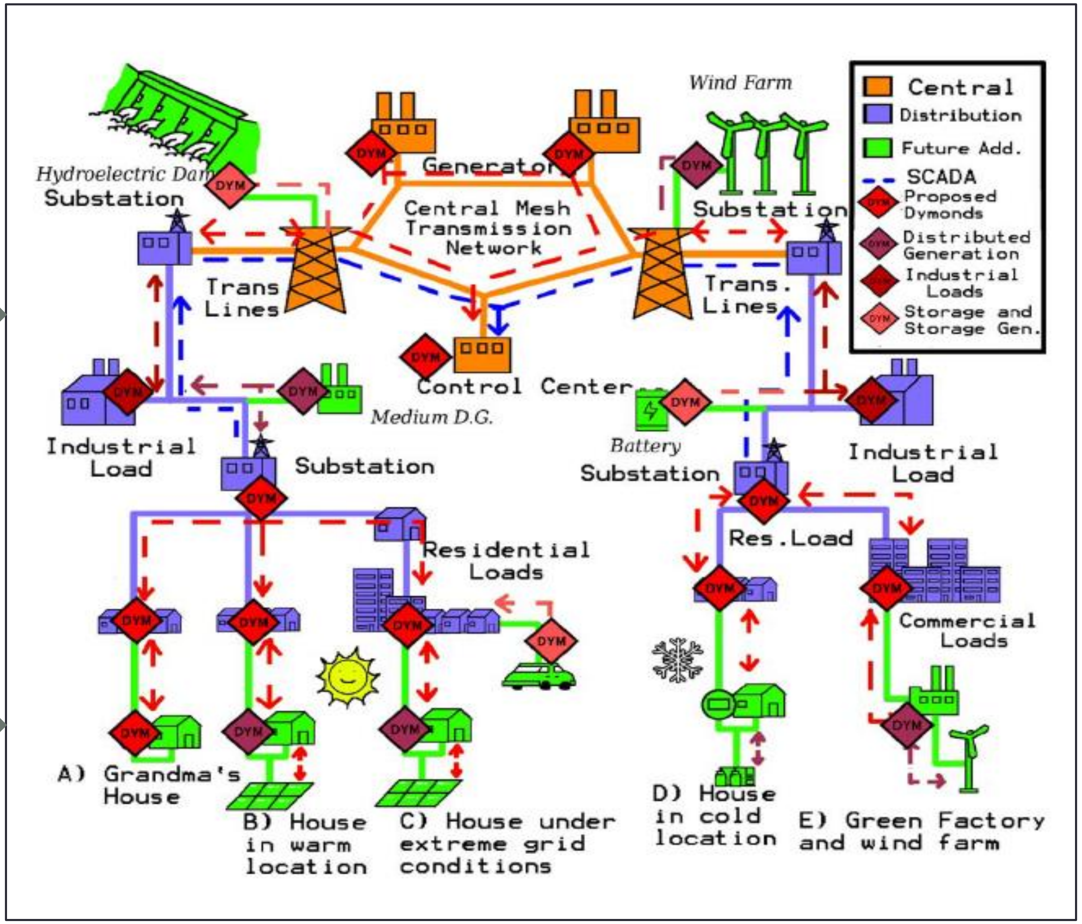
2: doi: 10.5547/01956574.40.3.sbur
3: doi: 10.1007/s11149-019-09385-w
4: doi:10.1109/HICSS.1997.663225

DyMonDS for evolving power systems

Power system of today

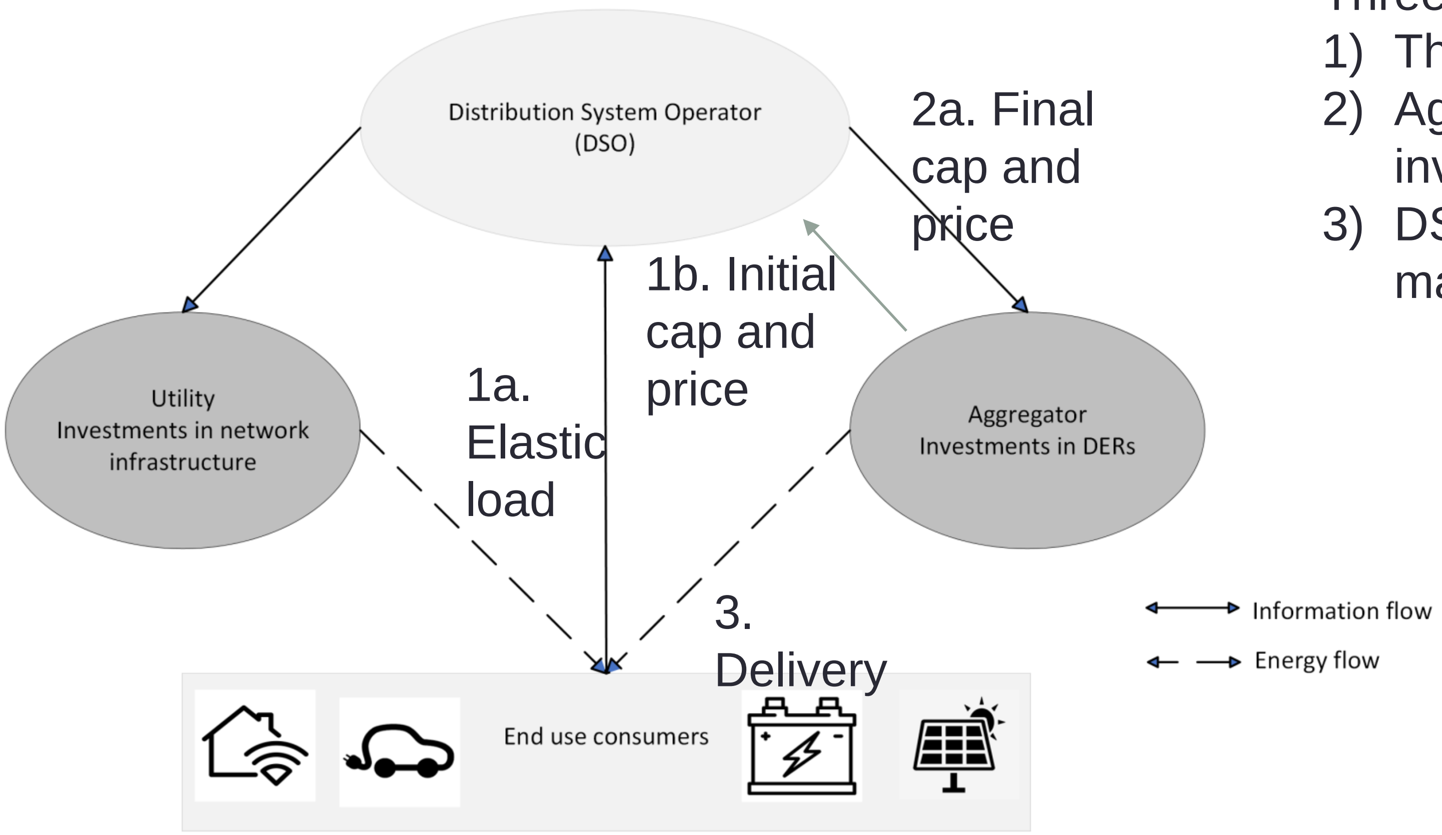


DyMonDS based future power system



Source: 10.1109/JPROC.2010.2089478

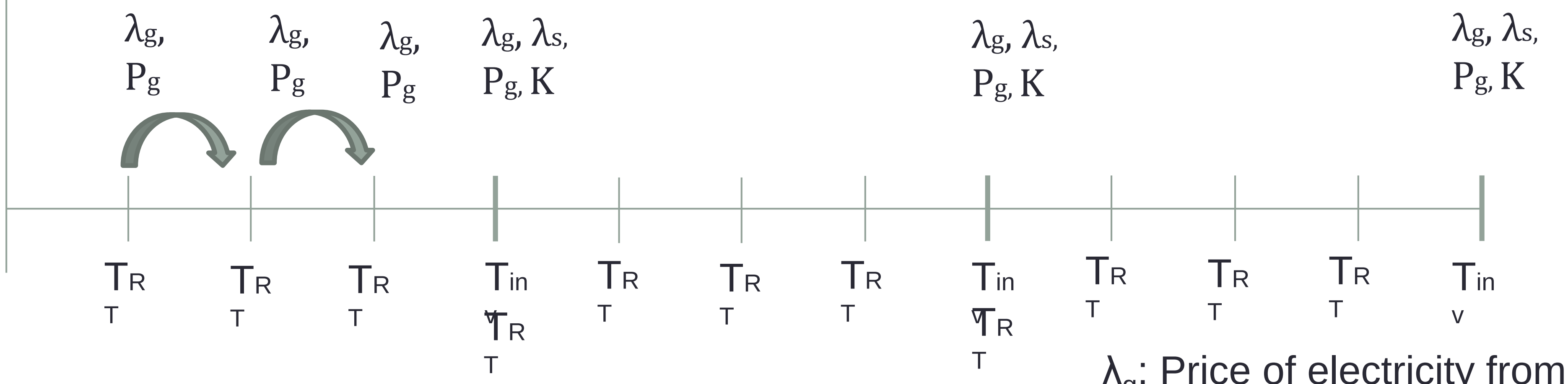
Layout



Three layers to the model
1) The consumers
2) Aggregators/utility- similar but can only invest in certain technologies
3) DSO- oversees the market and clears the market

Timeline

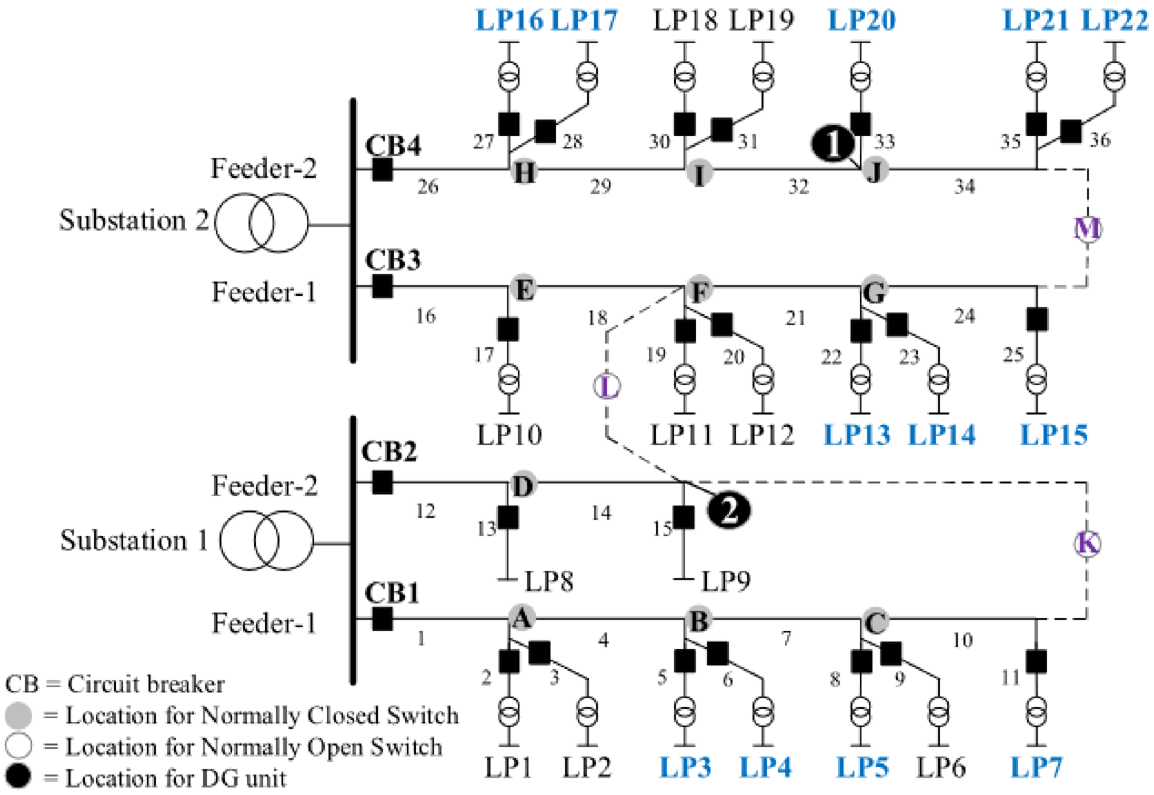
- At each time T_{RT} the bids for generation and demand curves are sent to the DSO who clears the energy balance.
- At each T_{INV} the bids for new capacity (either new switches or new DG capacity) are submitted and the DSO allocates new build capacity



λ_g: Price of electricity from DER g
λ_s: Revenue from infrastructure investment
P_g: Power generated by DER g
K: Magnitude of infrastructure upgrade

Case study

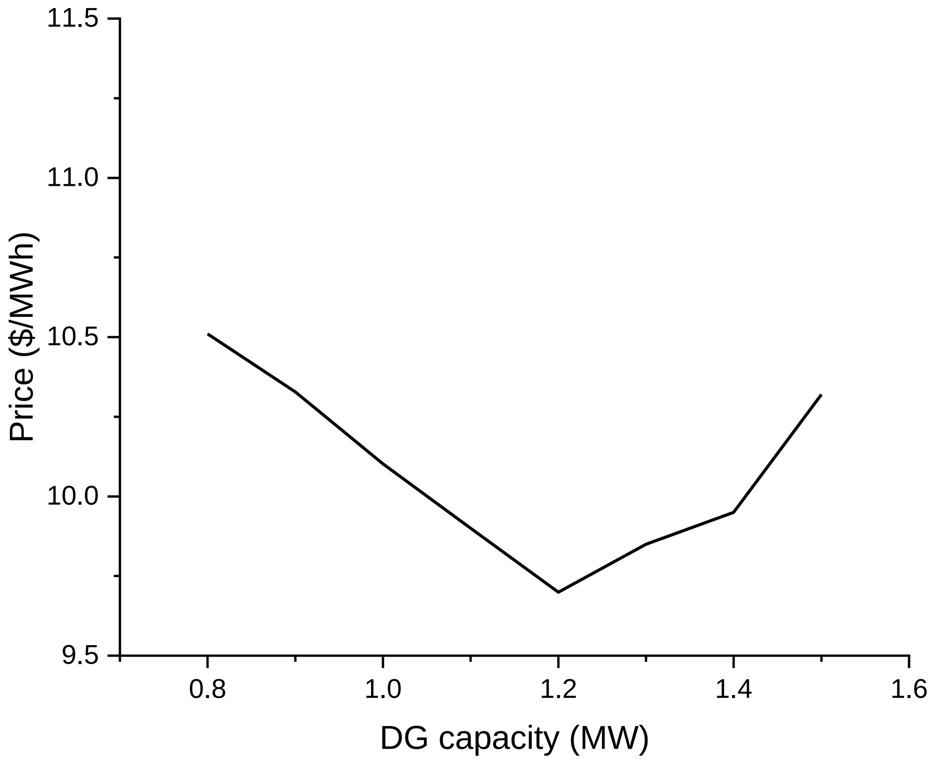
- Used the RBTS[5]
- Tradeoffs in value and consumers served by two technologies to reduce congestion
- Two types of investment:
  - Network switches (both normally open and normally closed)
  - Distributed generation

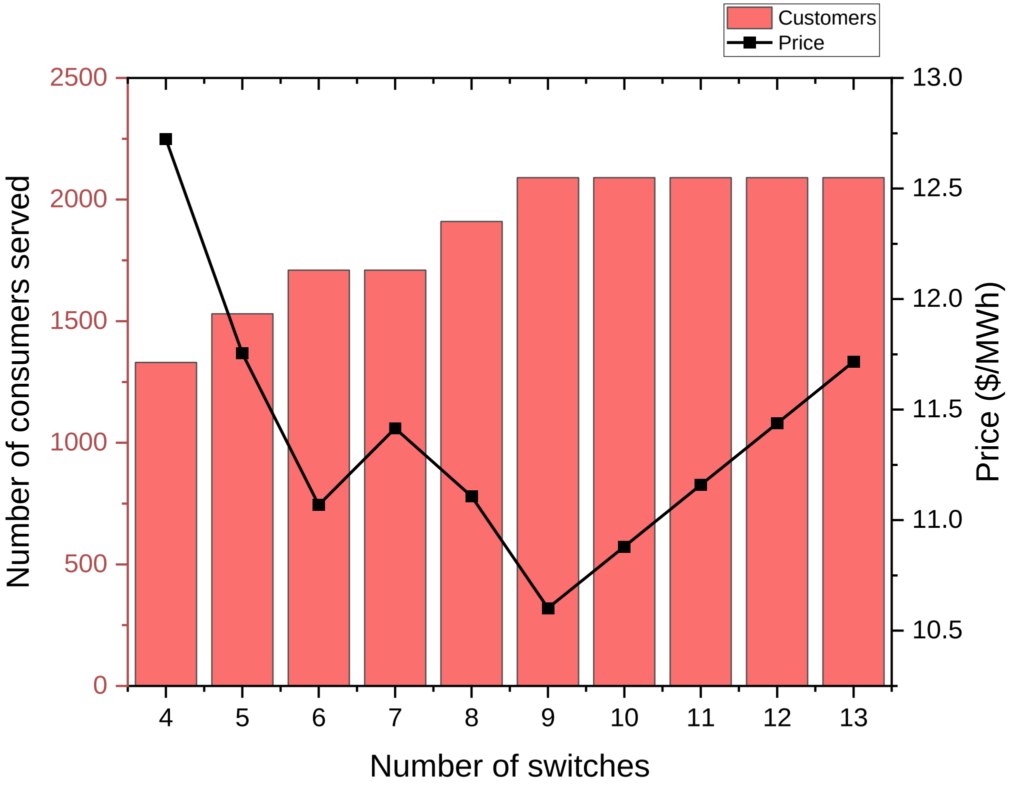


5: doi: 10.1109/TSG.2020.2986651

Results

- Optimal sizing and location of switches and distributed generation according to Long Run Marginal Costs





Number of switches	Number of clients served	Price ($/MWh)	Location of switches
4	1330	$ 12.7235	ABKM
5	1530	$ 11.7541	ABCKM
6	1710	$ 11.0689	ABCHKM
7	1710	$ 11.4156	ABCDHKM
8	1910	$ 11.1073	ABCFGKLM
9	2090	$ 10.6023	ABCFGHKLM
10	2090	$ 10.8809	ABCDFGHKLM
11	2090	$ 11.1596	ABCDEFGHKLM
12	2090	$ 11.4383	ABCDEFGHIKLM
13	2090	$ 11.717	ABCDEFGHIJKLM

Conclusions and future work

- Dynamic operations and planning model for distribution systems using the Peak Load Pricing method using DyMonDS
- Provided the optimal investments in switches or distributed generation.

- Expand on the number of technologies considered and services
- Additionally, the impact of demand response should be included.