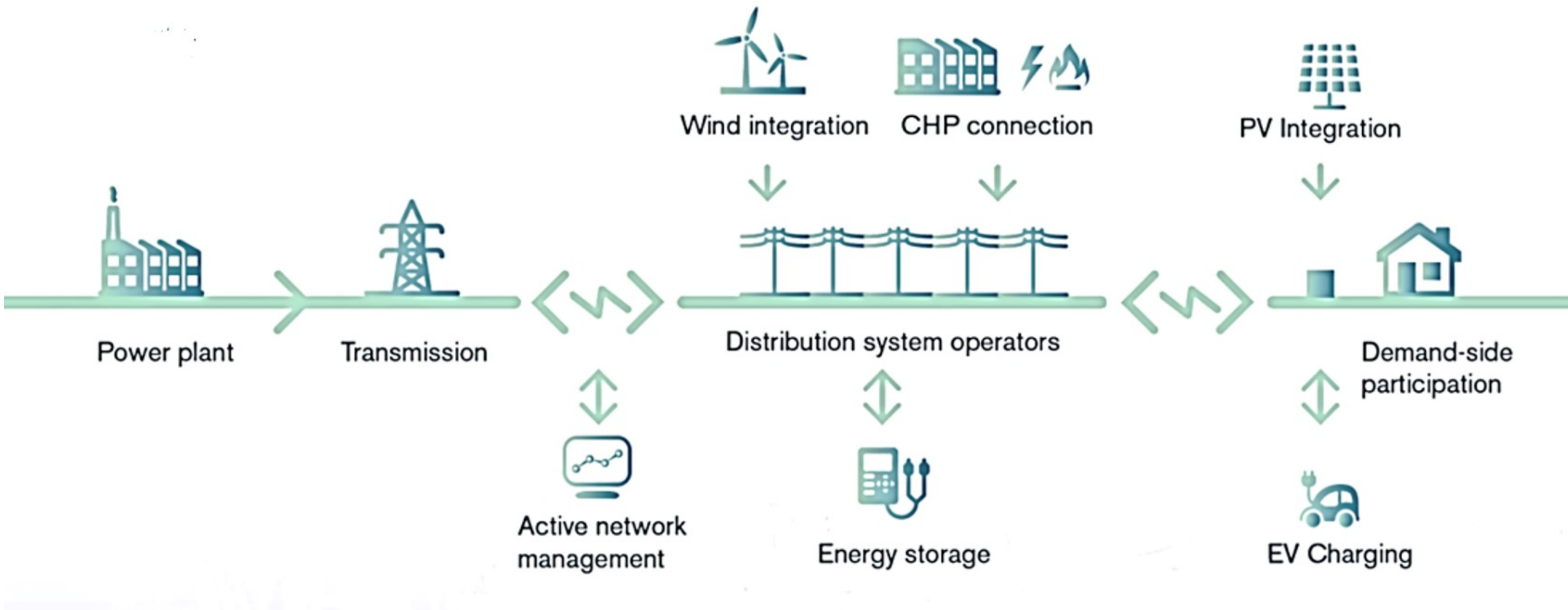
Sajjad Haider

Solving EV charging issues – Peer-to-peer power transactions

Chair of Electrical Power Systems
Technische Universitat Dresden

Smart Grids

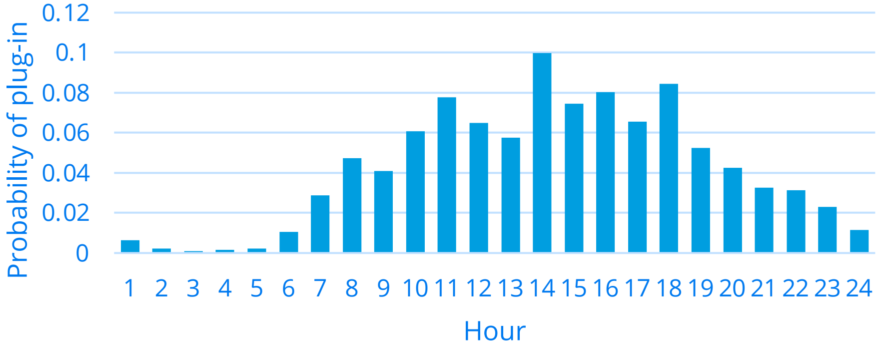


[1]

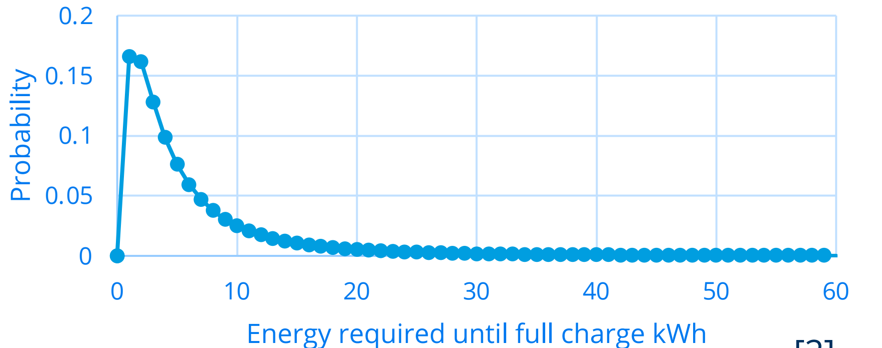
Motivation and theoretical background
Electric Vehicles

- Electric vehicles have lower emissions and are therefore being promoted as future mobility solutions to replace combustion vehicles
- Electric vehicle charging time on normal electrical sockets is 10+ hours
  - Fast charging needed – higher instantaneous power draw (17.5 kW)
  - Plug in probability is time-dependent, peaks according to work schedule
  - Typical driving less than 30km/day ~ 15% of batterry capacity of 60kWh

Electric Vehicle plug-in time distribution

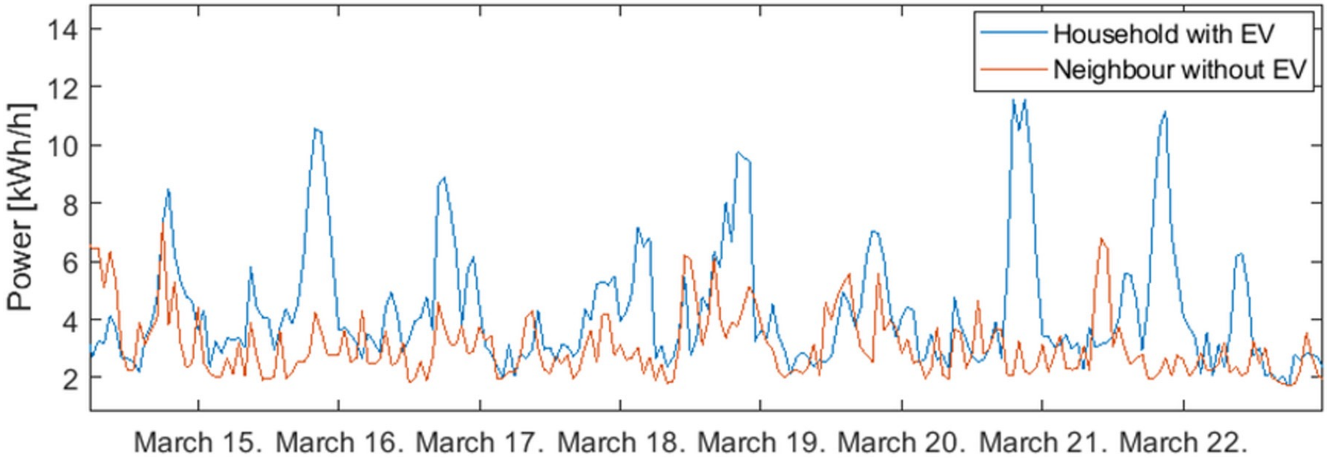


Distribution of Electric Vehicle energy requirement at plug-in time



[2]

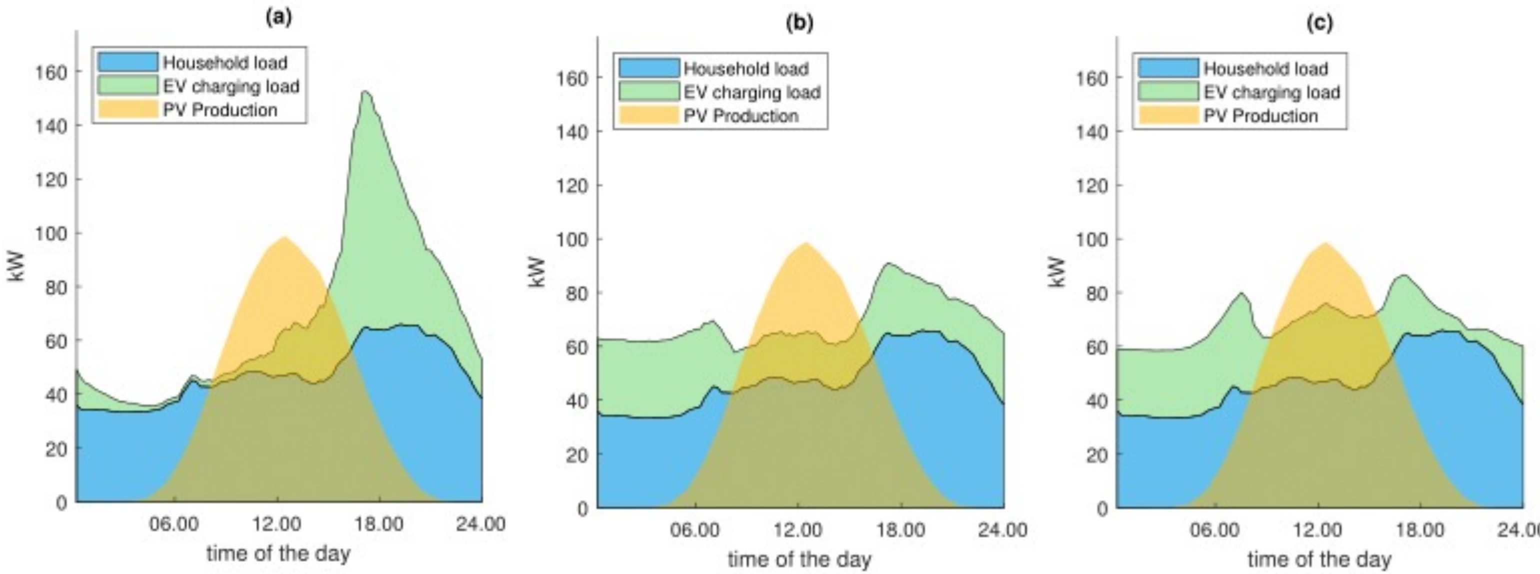
Household Loads v. EV Charging Loads



[3]

Community Charging Approaches in Literature

- When
- How long
- How much
- **Where?**

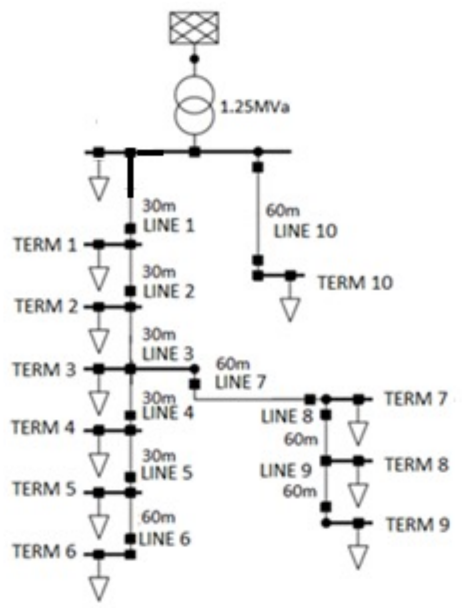


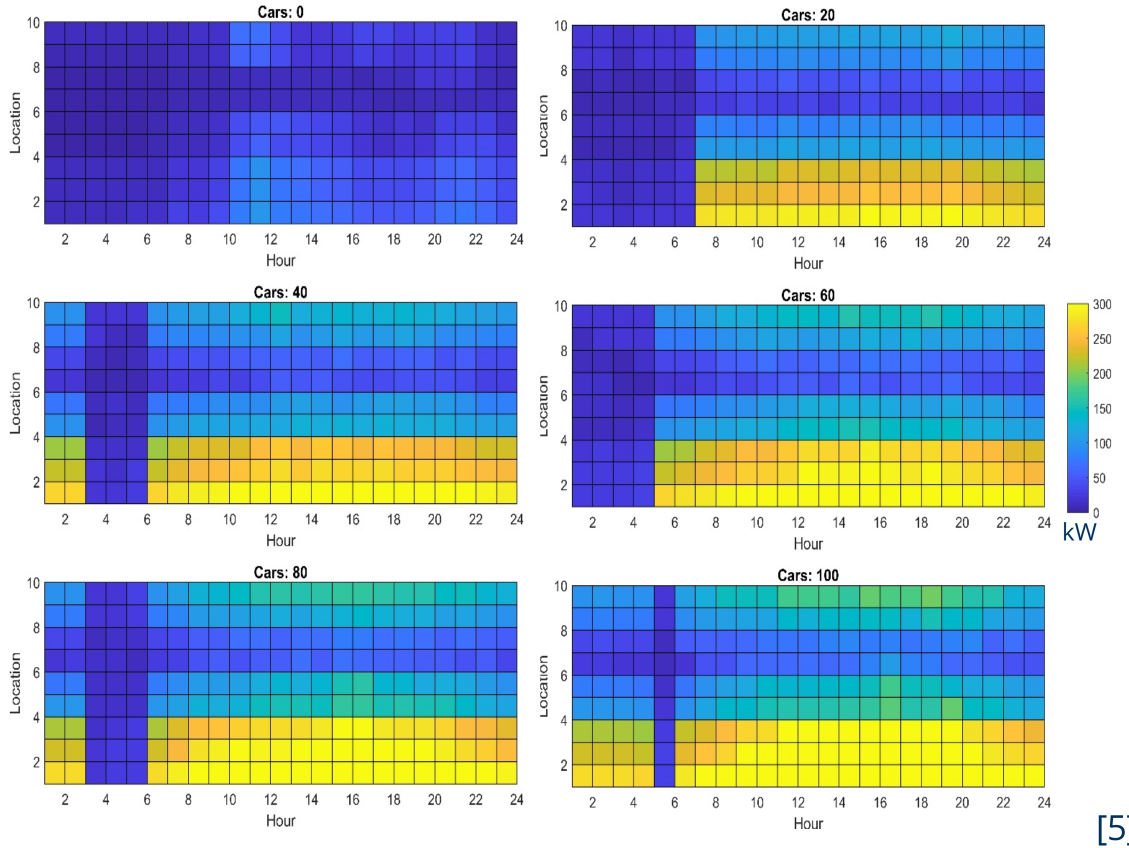
[4]

Behavioural Science: Office/Home/Congestion

Based on grid parameters

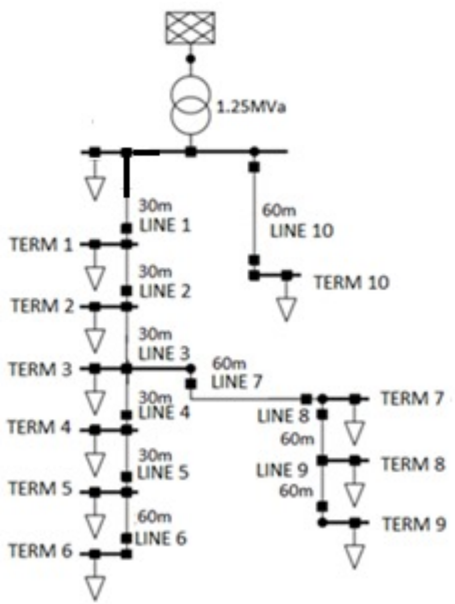
Previous Results
Semi-urban Network – Cable loading

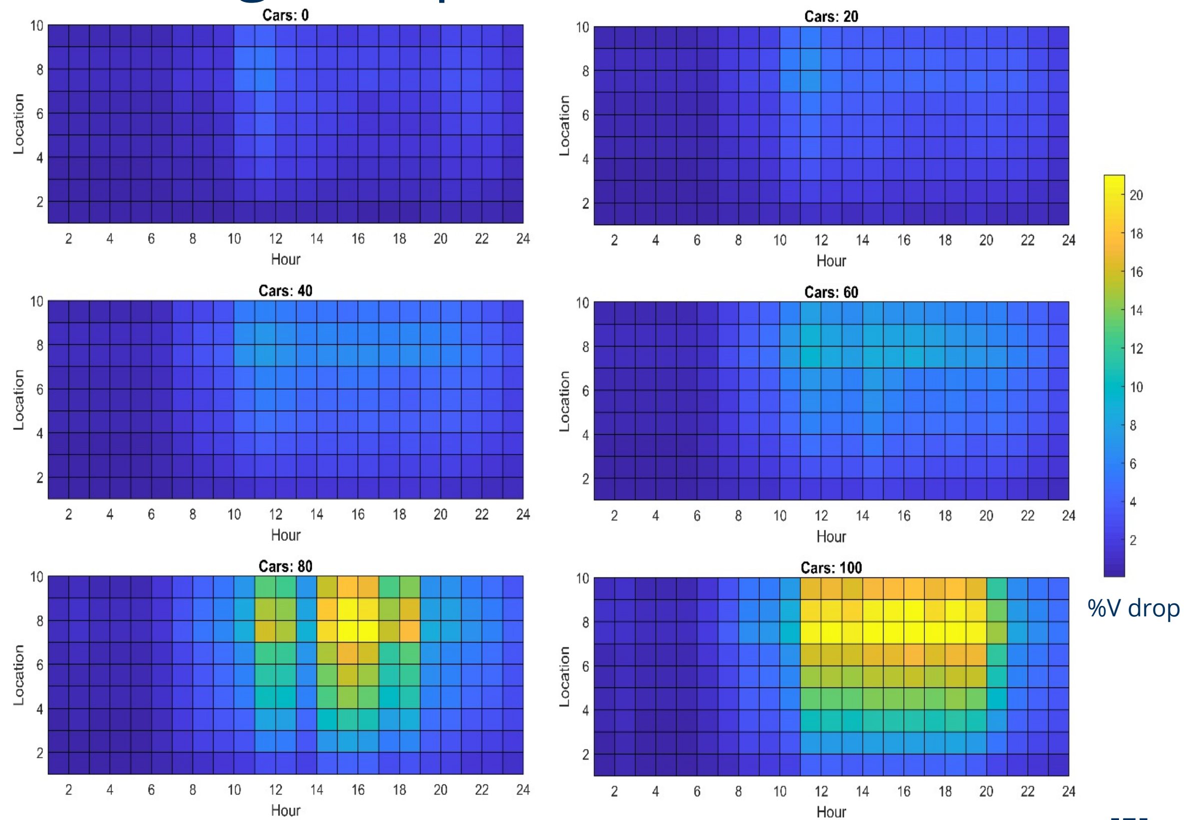




[5]

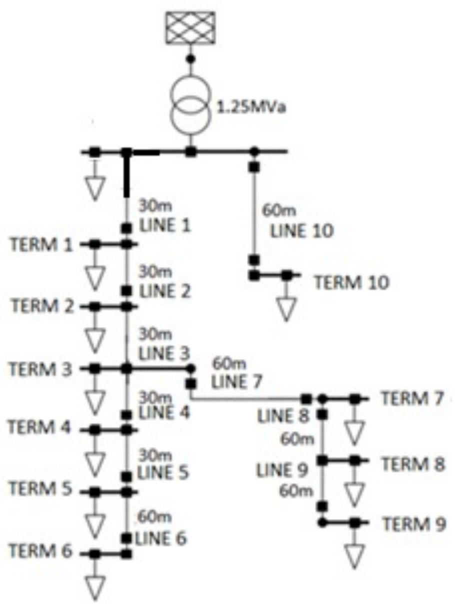
Previous Results
Semi-urban Network – Voltage Drops

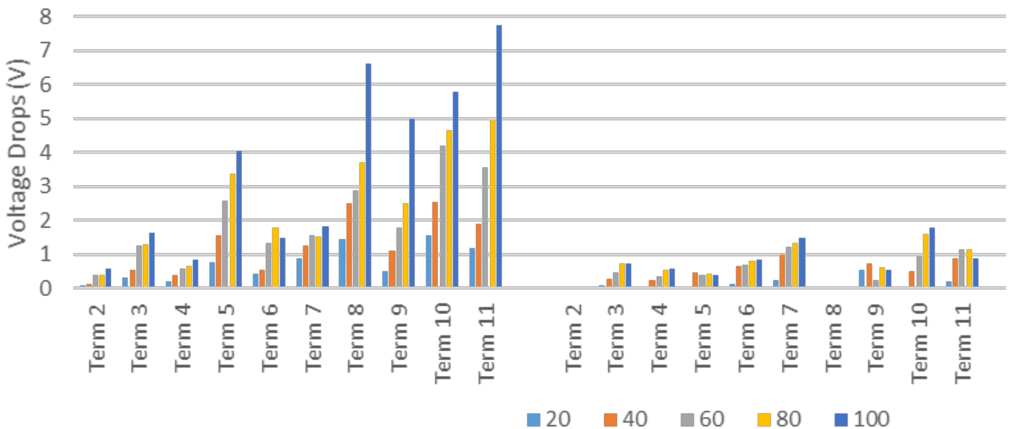




[5]

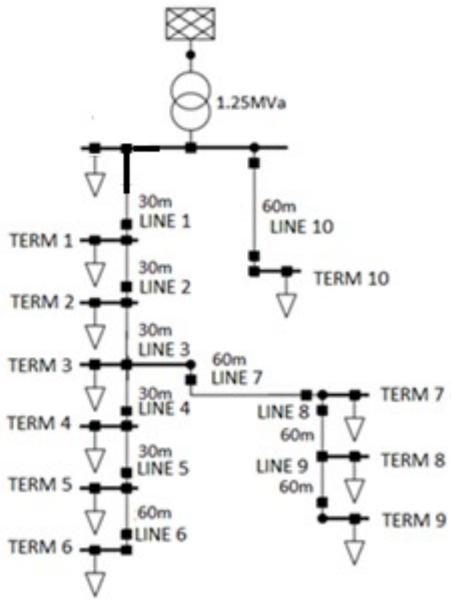
Further steps
Optimization in Spatial Domain

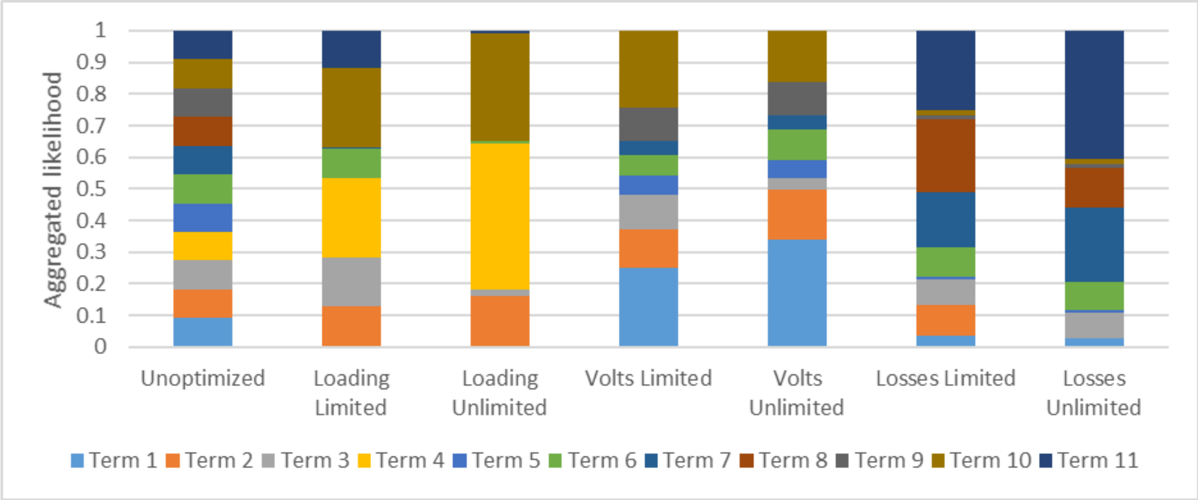




BAU Optimized

[6]


1.25MVa
30m
LINE 1
TERM 1
30m
LINE 2
TERM 2
30m
LINE 3
TERM 3
60m
LINE 7
30m
LINE 4
TERM 4
30m
LINE 5
TERM 5
60m
LINE 6
TERM 6
60m
LINE 10
TERM 10
TERM 7
LINE 8
60m
TERM 8
LINE 9
60m
TERM 9


Aggregated likelihood
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Unoptimized
Loading Limited
Loading Unlimited
Volts Limited
Volts Unlimited
Losses Limited
Losses Unlimited
Term 1 Term 2 Term 3 Term 4 Term 5 Term 6 Term 7 Term 8 Term 9 Term 10 Term 11

[6]

Research Objective(s)

Hypothesis: There is a optimal combination for any network based on the individual characteristics of the network and the number and type of users connected at any moment.

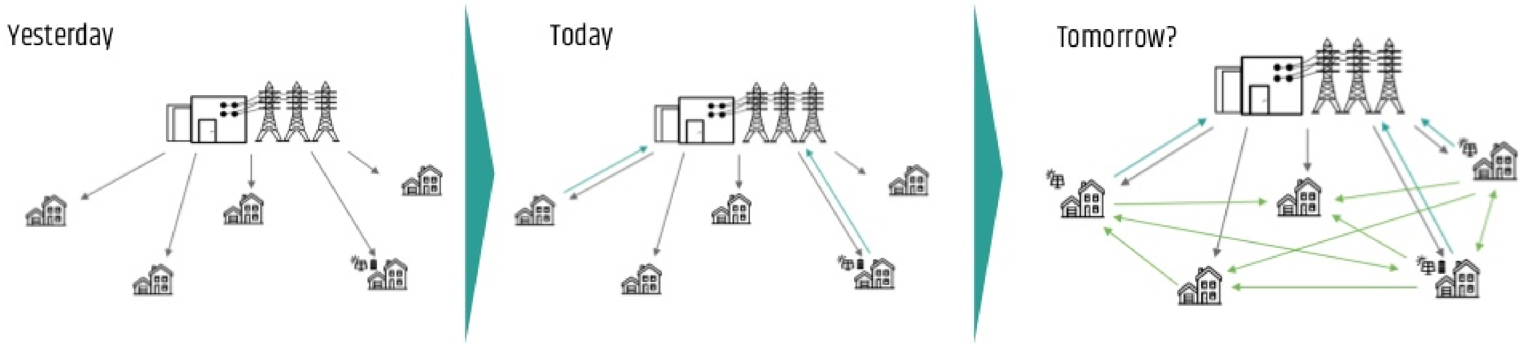
Side Hypotheses:

1. The optimal solution will be based on voltage drops, cable loading, line losses etc.
2. There is a pricing model that will compel users to follow suggested optimal solution
3. The optimal solution is time dependent due to the loads/generators being time dependent
4. LV Charging infrastructure is inherently unfair – location based advantages/disadvantages
5. Introduction of “islanding” is beneficial
6. Users will not be inconvenienced too much

1. Lower loading
2. More islanding
3. Low inconvenience

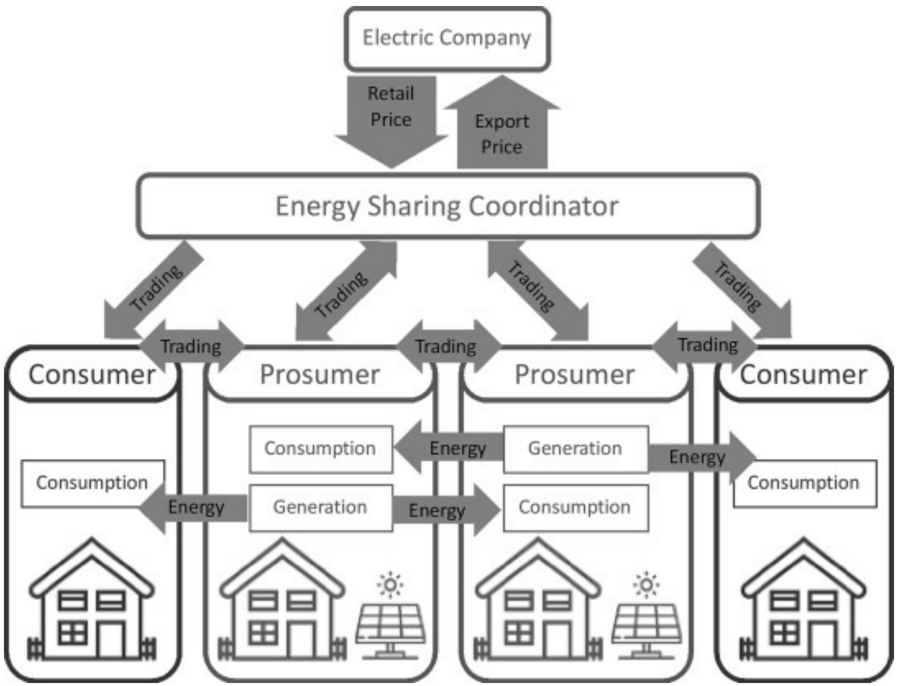
Further steps
Power injection to minimize overloading

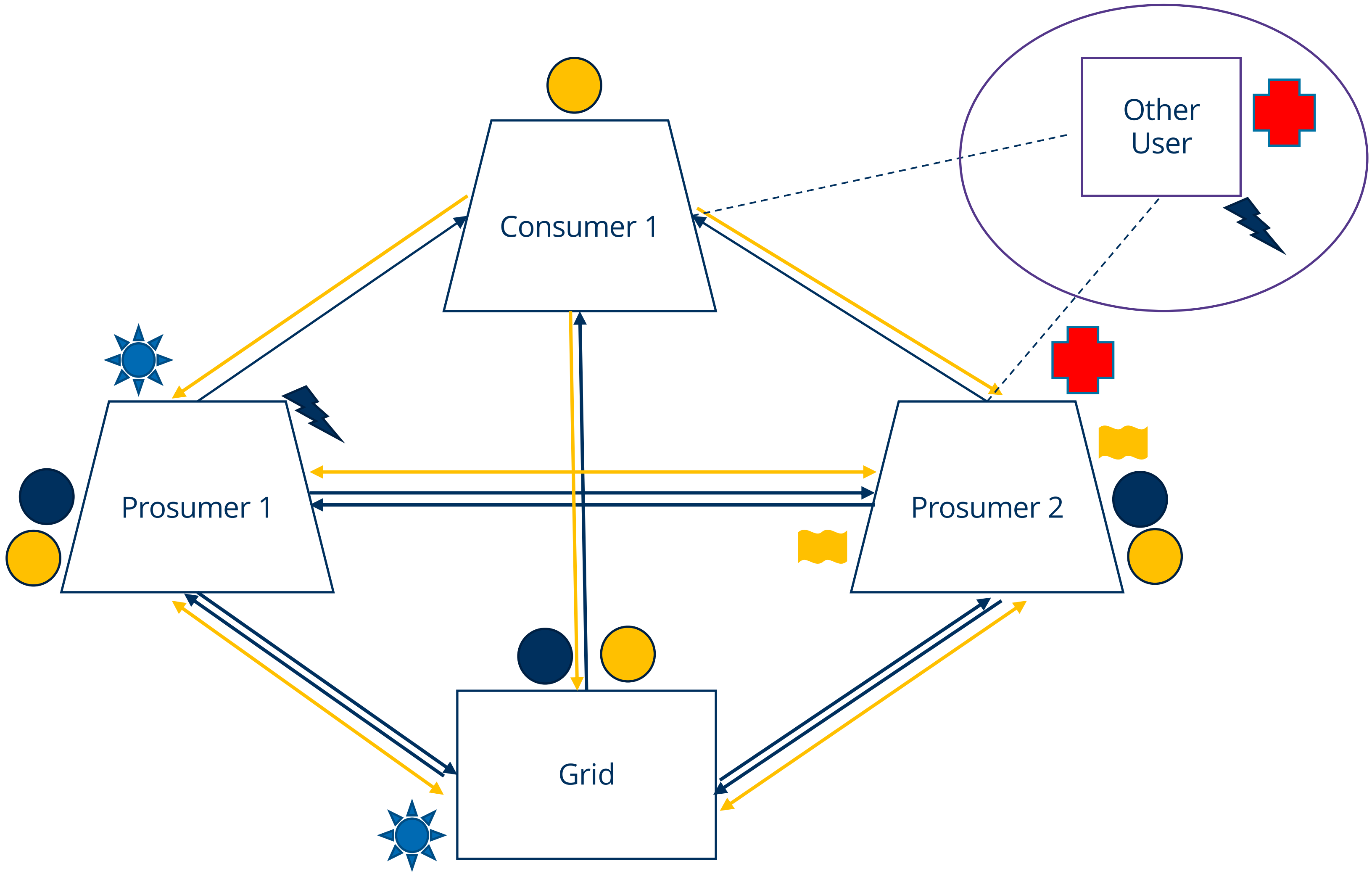
- Injecting active power and reactive power at targeted locations
- Peer to peer power delivery with incentives for spatial positioning can accomplish both
- Decentralized transactions to encourage islanding

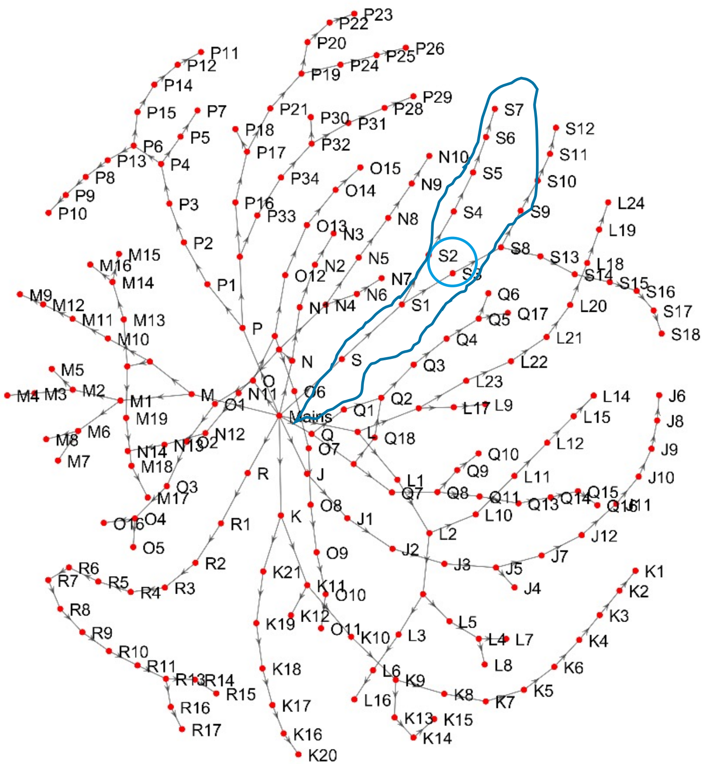


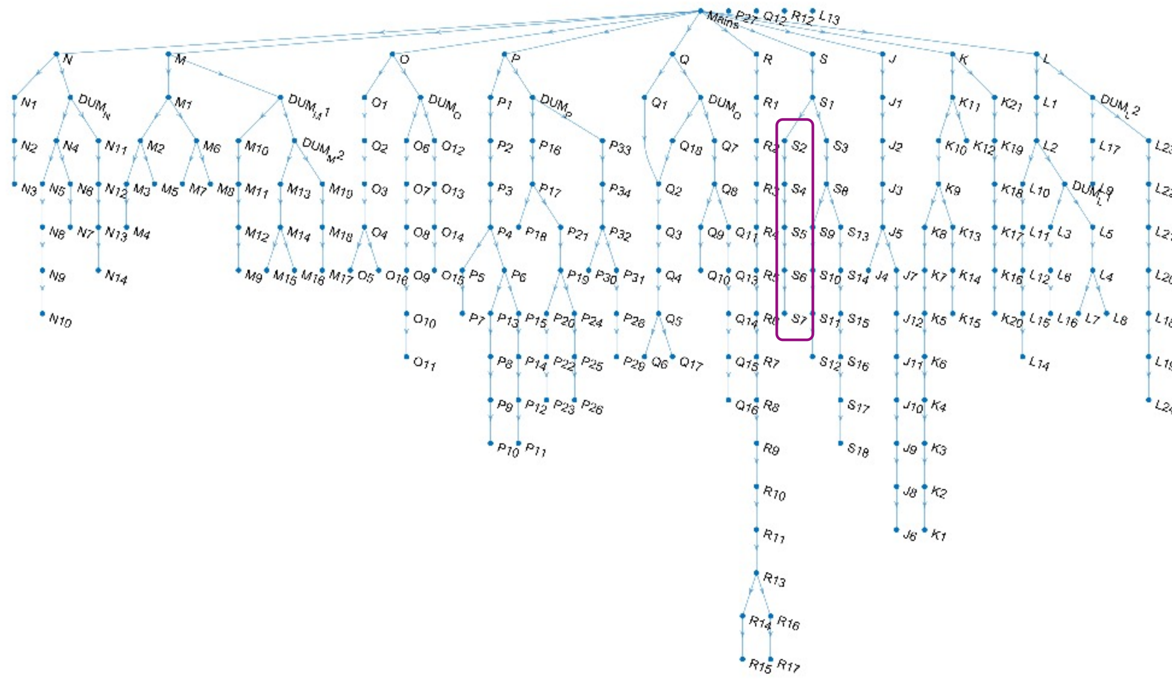
Further steps
Charging and Pricing Strategies

- **Current model**: Pricing per unit of **energy** (kWh)
  - Distribution company puts margin in consumer price of electricity
  - Price **changes with time** on fixed hourly basis
  - Price constant across low-voltage area
- **Proposed model**: Pricing per unit of **energy** (kWh) and one factor dependent on instantaneous peak **power** (kW) and particular location
- Transaction done between consumer and prosumer/grid



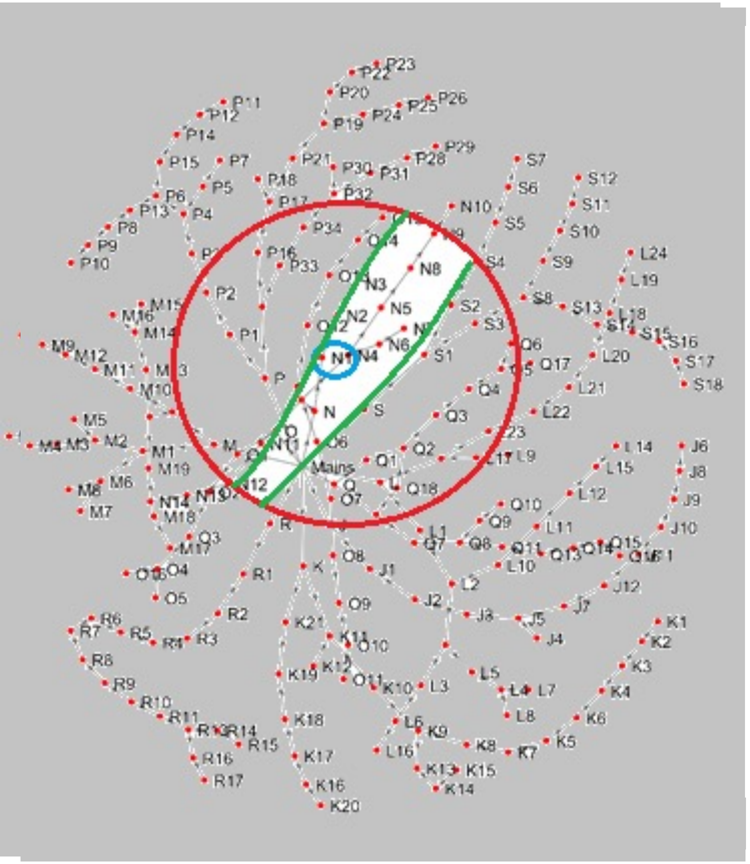

Other User
Consumer 1
Prosumer 1
Prosumer 2
Grid

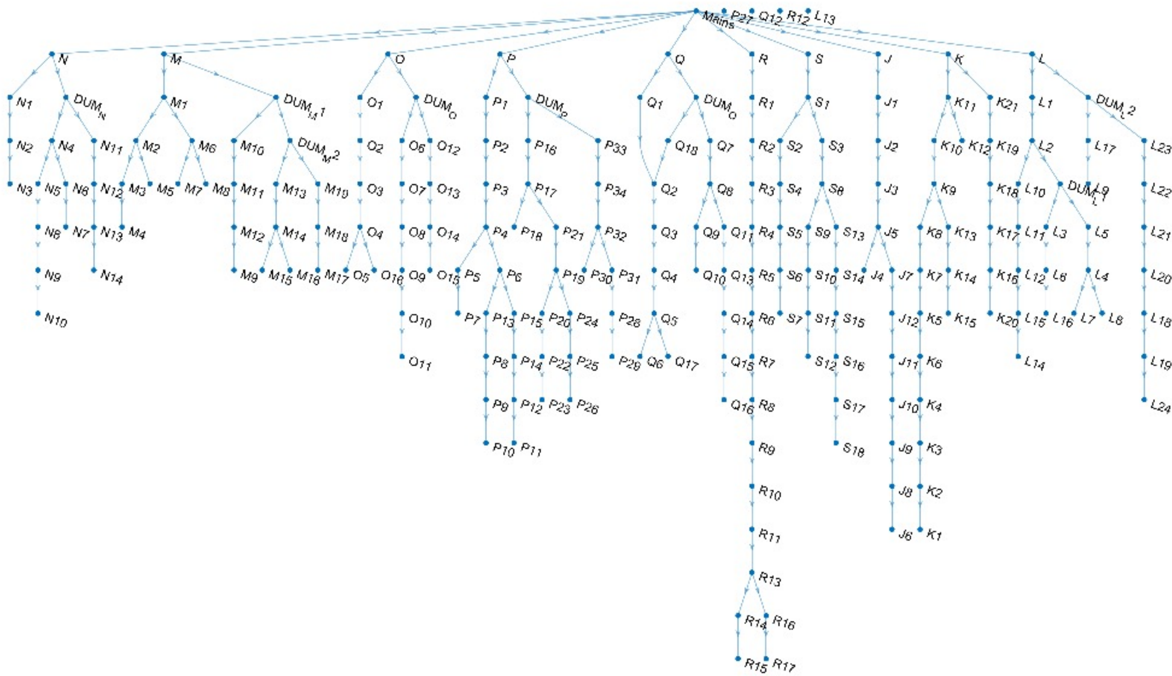




For a load, If every gen can have: 0 – Limit where limit = max_gen (if load>max_gen) or load (if load<max_gen)

Scenarios: 2^{213} =13,164,036,458,569,648,337,239,753,460,458,804,039,861,886,925,068,638,906,788,872,192

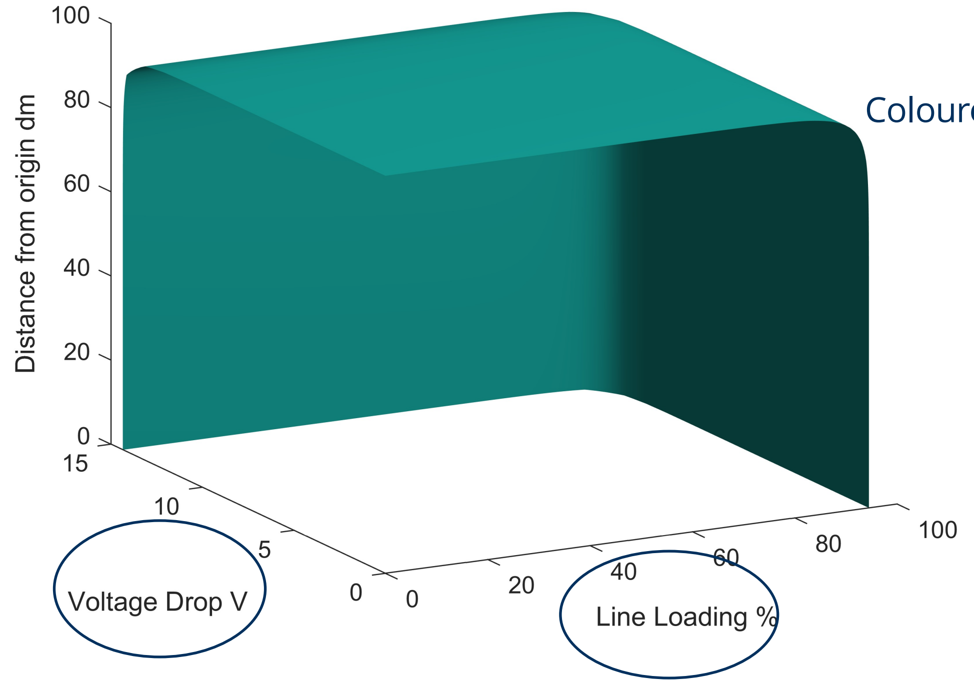




Modelling User Behaviour

Balancing Network Parameters v. User Inconvenience

	Gens	J1	J2	J3	J4	....
Comb. 1	[0001]	0.1	0.2	0.25	0.4	
Comb. 2	[0010]	0.2	0.12	0.64	0.4	
Comb. 3	[0100]	0.4	0.9	0.54	0.42	
....	....					

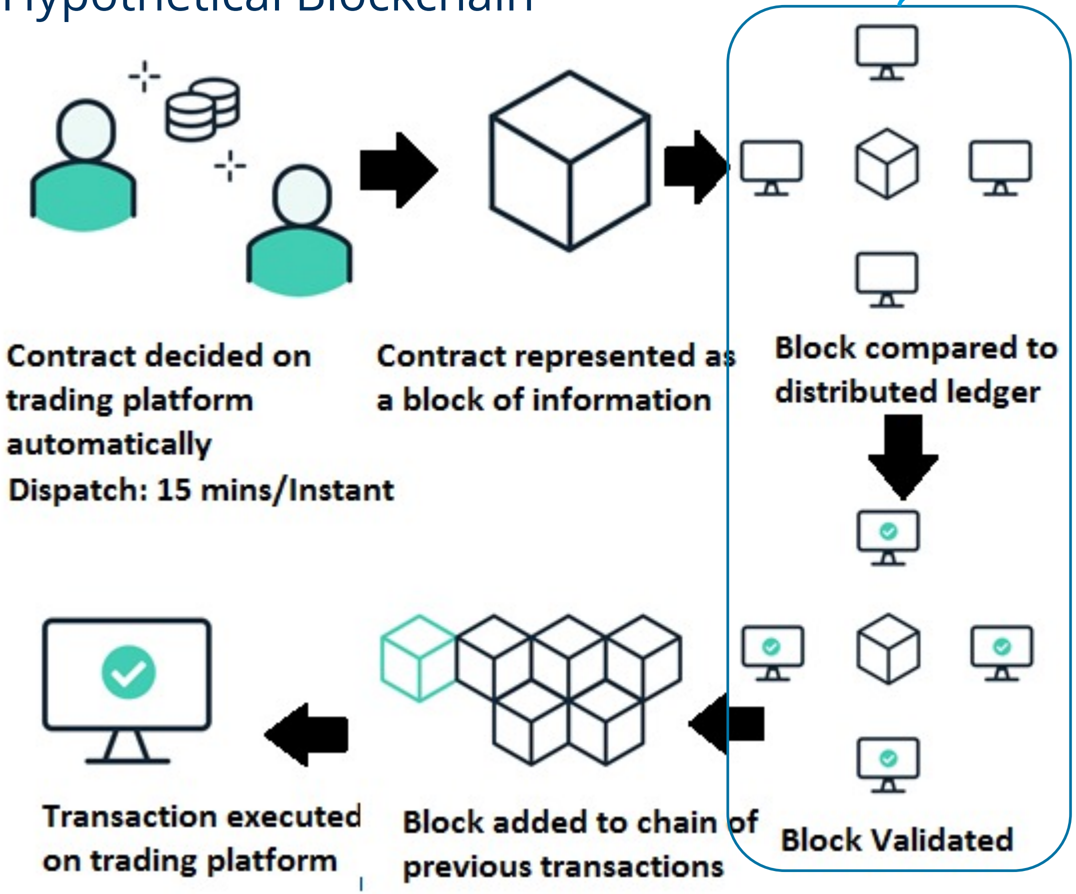


Coloured: Infinite

Dependent on loads, EV charging location, available generation

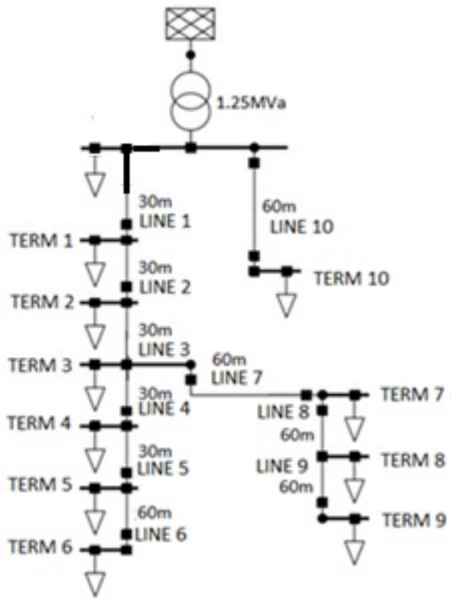
Sample Output
Hypothetical Blockchain

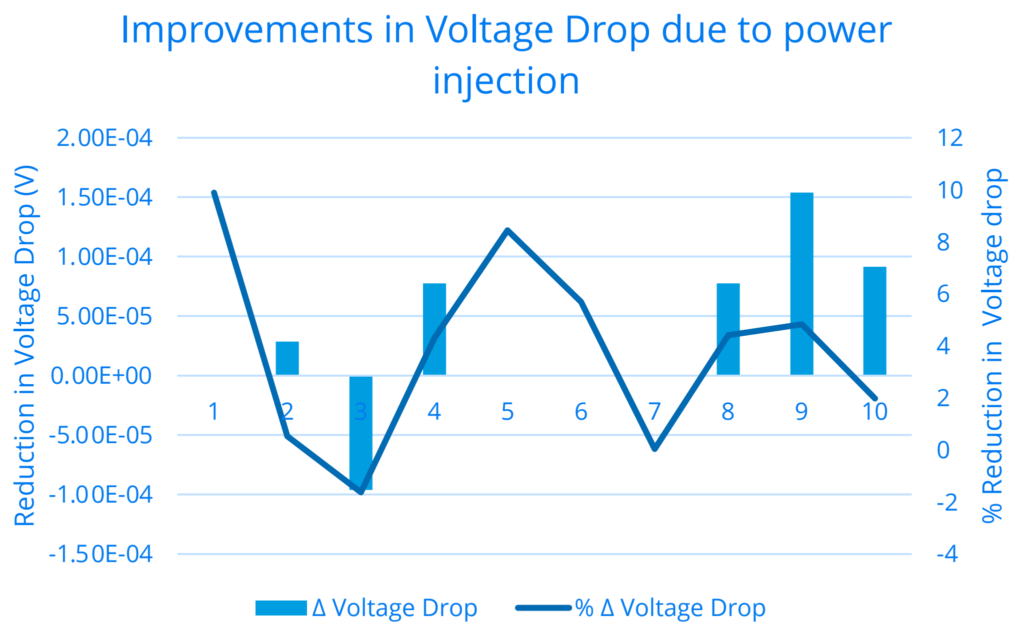
Can be centralized server based



source J1 dest L_J1 1.0
source J11 dest L_J1 1.0
source J12 dest L_J1 1.0
source grid dest L_J1 3.0
source J12 dest L_J10 0.001
source J1 dest L_J11 1.0
source J11 dest L_J11 1.0
source J12 dest L_J12 0.001
source J12 dest L_J2 0.001
source J12 dest L_J3 0.001
source J12 dest L_J4 0.001
source J12 dest L_J5 0.001
car N13 source J1 dest L_S9 0.0175
car K15 source J1 dest L_S9 0.0175
car L9 source J1 dest L_S9 0.0175
car S2 source J1 dest L_S9 0.0175
car Q18 source J1 dest L_S9 0.0175
car P33 source J1 dest L_S9 0.0175
car L16 source J1 dest L_S9 0.0175
car O16 source J1 dest L_S9 0.0175
car P4 source J1 dest L_S9 0.0175
car S2 source J1 dest L_S9 0.0175
source J12 dest grid 0.8190

Sample Output
Improvements in voltage drop





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Thank you for your attention!
Vielen Dank für Ihre Aufmerksamkeit!