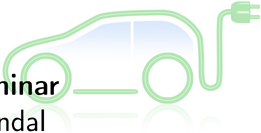
Can we charge everyone's electric vehicles without reinforcing the electric grid?

Salman Zaferanlouei



NTNU Battery Seminar

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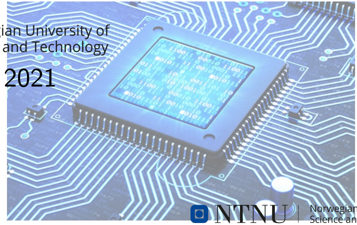

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The answer is yes

Table 1: Charge Scheduling Strategies

Method	Max EV hosting Capacity	
Uncoordinated/Dumb Charging	20%	
Market price based	36%	
Market price and Congestion management based	100%	

The presention goal

- **Purpose:** To show how to coordinate **Batteries in the Grid: (EVs):** Large-Scale EV charge scheduling platform to avoid congestion
- **Phase I:** Background and Motivation
- **Phase II:** EV Statistics
- **Phase III:** Case Study

Project Name:	BATTPOWER
Presentation Time:	10 min

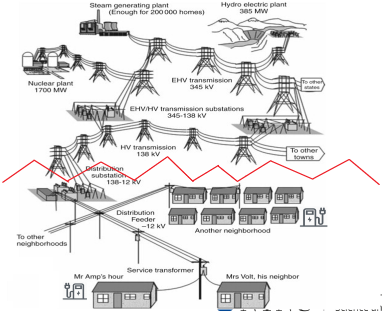
Phase I:
Background and Motivation

Sustainability/Green shift/CO_2 reduction

For many reasons power electricity grid is facing decentralization

- Phasing out coal (carbon-heavy sources of production) and nuclear power plants
- Increase penetration of solar and wind production
- Many other points ...

This chain between large power producers and consumers is weakened.



Background

Items

- Green shift in electircity systems is needed for the reduction of $\mathrm{CO_2}$ emissions

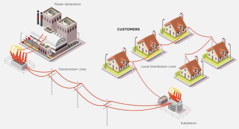


Figure 1: A Typical Power System [Rochester Gas & Electricity]

Background

Items

- Green shift in electircity systems is needed for the reduction of CO_2 emissions
    - Integration of Distributed Energy Resources (DER) is a huge challenge

Note

DER includes Renewable Energy, Energy Storage, Electric Vehicles and Flexible Demand

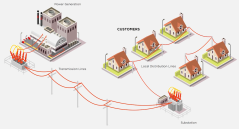
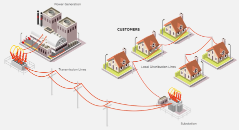


Figure 1: A Typical Power System [Rochester Gas & Electricity]

Background

Items

- Green shift in electricity systems is needed for the reduction of CO_2 emissions
  - Integration of Distributed Energy Resources (DER) is a huge challenge
- Grid companies must be able to analyse the impacts of DER



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Background

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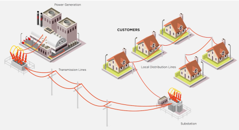
Note

Optimal Power Flow (OPF)solvers are essential



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Background

Items

- Green shift in electircity systems is needed for the reduction of CO_2 emissions
    - Integration of Distributed Energy Resources (DER) is a huge challenge
- Grid companies must be able to analyse the impacts of DER
- The inegration of DER in smart grids calls for **much more sophisticated solvers** for OPF

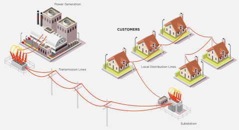


Figure 1: A Typical Power System [Rochester Gas & Electricity]

Challenges in the planning and operation of the grid

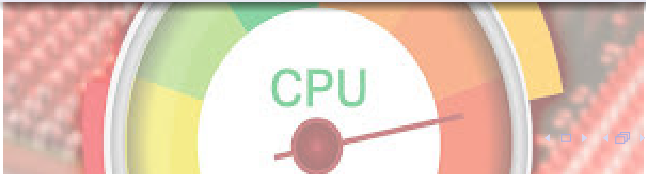
- **Planning:** Optimizing the right type, size and timing of new grid investments
  - Local generation (e.g. PV) and increased load (e.g. EVs) can be located in areas where the grid is weak
  - Energy storage and demand flexibility are alternatives to grid reinforcements
- **Operation:**Optimize the use of controllable assets such as ESS and flexible demand to secure, reliable and economic operation of the distribution grids
  - Making the right use of Demand Response and being able to value the use of end-user flexibility for local or system-wide grid services
  - Simulating and optimizing the grids in the presence of **local markets for energy and flexibility**

Limitations of traditional grid operation and planning

Notes

- Classical single-period OPF does not offer a possibility for optimal operational scheduling of storage and flexible demand
- We therefore aim to develop the foundations for a new generation of Multi-Period OPF (MPOPF) solvers
  i. Solves the OPF problem over several coupled time-steps
  ii. Computation time is an issue when using both commercial or free optimization solvers
- MPOPF is an extremely challenging scientific task:
  i. Nonlinearity
  ii. Large-scale problem with respect with to time and space
  iii. Involves stochastic generations and load
  iv. Security of supply

Hardware is reaching its limit with respect to CPU clock speed



Solution:

High-Performance Solver [1-2]

- Algorithmic design tailored to the conventional OPF algorithms speed-up the solution proposal
  i. A high-performance and memory-efficient sparse algorithm
  ii. Utilizing the structure of the underlying mathematical formulation
- Optimal utilization of **stored energy** and **flexibility** where and when it creates the highest value for the system
- Prototype model shows convincing results for real-sized system with distributed renewables, storages and EVs
- Can be used for grid planning, grid operation and local markets

1. S. Zaferanlouei, H. Farahmand, V. V. Vadlamudi, M. Korpås,"BATTPOWER Toolbox: Memory-Efficient and High-Performance Multi-Period AC Optimal Power Flow Solver", IEEE Transactions on Power Systems, Jan. 16th, 2021.

2. S. Zaferanlouei, et al., "BATTPOWER Application: Large-Scale Integration of EVs in an Active Distribution Grid —A Norwegian Case Study", Electric Power Systems Research

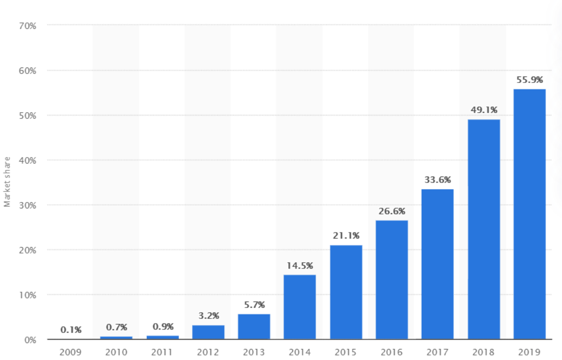
Phase II:

EV Statistics

Statistics

Market Share

Market share of electric cars (BEV and PHEV) in Norway from 2009 to 2019



Statistics

Penetration

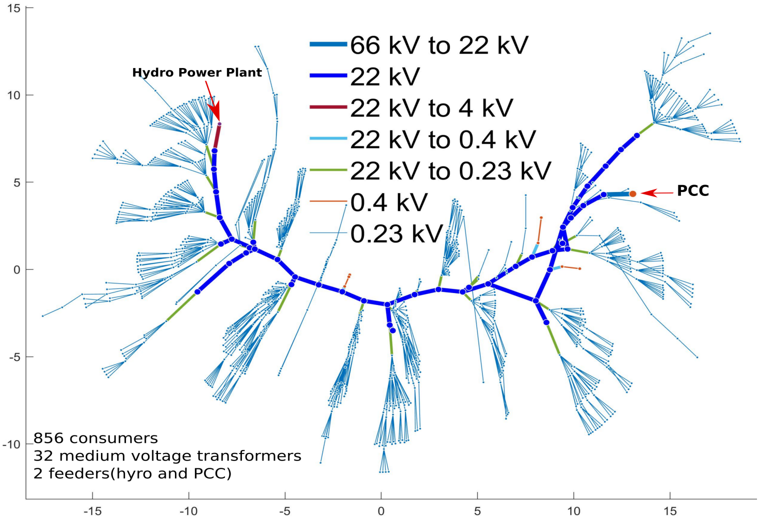
Around 10% EV penetration in Norwegian transport sector. The Norwegian Parliament has decided on a national goal that all new cars sold by 2025 should be zero-emission (electric or hydrogen)[a].

[a] https://elbil.no/

Phase III:

Case Study

Steinkjer Demo: a Real Distribution Grid



Summary

Highlights

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Thank you for your attention!

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