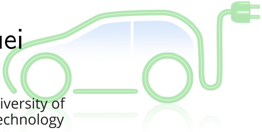
The Applications of High-Performace Optimisation Solver: BATTPOWER



Salman Zaferanlouei

NTNU | Norwegian University of Science and Technology

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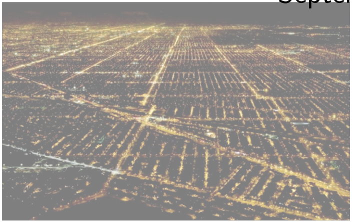
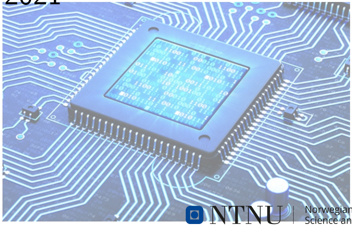




The purpose of this presentation: Results

Table 1: Charge Scheduling Strategies

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

The presention goal

- **Purpose:** To show what can be done with a high perfomance multi-period power flow solver. One example of the possible applications: Large-Scale EV charge scheduling platform to avoid congestion.
- **Phase I:** Background and Motivation
- **Phase II:** Applications
- **Phase III:** Case-Study

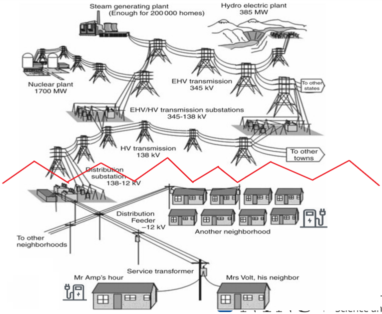
Project Name:	BATTPOWER
Presentation Time:	30 min

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.



Power System— Today

Power System— Future

Background

Items

- Green shift in electircity systems is needed for the reduction of CO_2 emissions

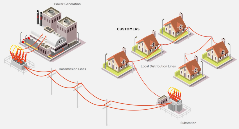


Figure 1: A Typical Power System [Rochester Gas & Electricity]

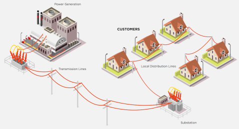
Background

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



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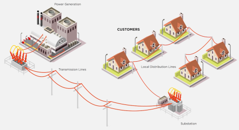
- Green shift in electircity systems is needed for the reduction of $\mathrm{CO_2}$ emissions
  - Integration of Distributed Energy Resources (DER) is a huge challenge
- Grid companies must be able to analyse the impacts of DER



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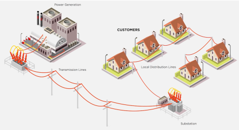
Note

Optimal Power Flow (OPF)solvers are essential



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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
- The inegration of DER in smart grids calls for **much more sophisticated solvers** for OPF

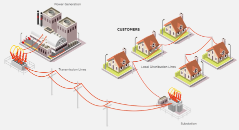


Figure 1: A Typical Power System [Rochester Gas & Electricity]

Challenges in the planning and operation of the grid

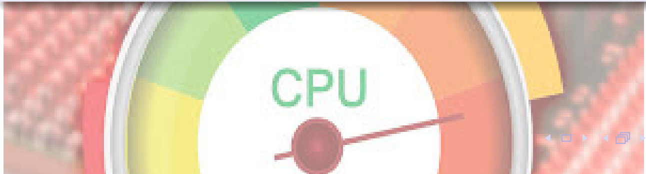
- **Planning:** Optimizing the right type, size and timing of new grid investments
  - Local generation (e.g. PV) and increased load (e.g. EVs) can be located in areas where the grid is weak
  - Energy storage and demand flexibility are alternatives to grid reinforcements
- **Operation:**Optimize the 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
  1. Solves the OPF problem over several coupled time-steps
  2. Computation time is an issue when using both commercial or free optimization solvers
- MPOPF is an extremely challenging scientific task:
  1. Nonlinearity
  2. Large-scale problem with respect with to time and space
  3. Involves stochastic generations and load
  4. Security of supply

Hardware is reaching its limit with respect to CPU clock speed



Solution:

High-Performance Solver [1-2]

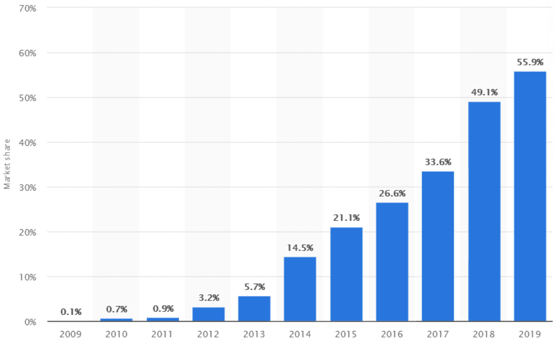
- Algorithmic design tailored to the conventional OPF algorithms speed-up the solution proposal
    i. A high-performance and memory-efficient sparse algorithm
    ii. Utilizing the structure of the underlying mathematical formulation
- Optimal utilization of **stored energy** and **flexibility** where 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

Statistics

Market Share

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



Statistics

Penetration

Around 9% 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/

Motivation

1. Sustainability: Need tools for analysing operating conditions resulting from renewables, EV, storage and flexible demand.

[1] https://www.nve.no/energy-market-and-regulation/retail-market/electricity-disclosure-2018/

[2] https://www.nordpoolgroup.com/Market-data1/Dayahead/Volumes/NO/Hourly/?view=table

[3] http://publikasjoner.nve.no/rapport/2018/rapport2018_74.pdf

[4] Samdal, K., Kjolle, G. H., Singh, B., & Kvitastein, O. (2006, June). Interruption costs and consumer valuation of reliability of service in a liberalised power market. In 2006 International Conference on Probabilistic Methods Applied to Power Systems (pp. 1-7). IEEE.

Motivation

1. Sustainability: Need tools for analysing operating conditions resulting from renewables, EV, storage and flexible demand.
2. Economics: Norway electric industry revenues of 61.6 billion NOK in 2018[1]. 1% savings worth 615 million NOK (estimated using [1] and [2])

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2. Economics: Norway electric industry revenues of 61.6 billion NOK in 2018[1]. 1% savings worth 615 million NOK (estimated using [1] and [2])
3. Reliability: Annual cost of power interruptions to Norway economy is 1600 MNOK/year (estimated using [3] and [4])

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Summary

Highlights

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Thank you for your attention!

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