The role of dynamic electricity price contracts to utilise residential demand-side response

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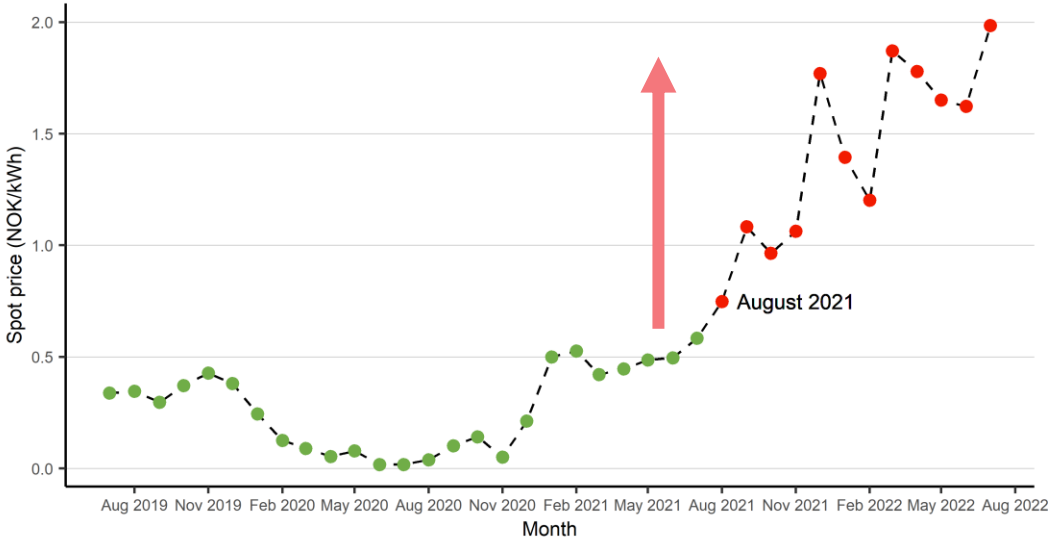
Electricity price crisis in Norway

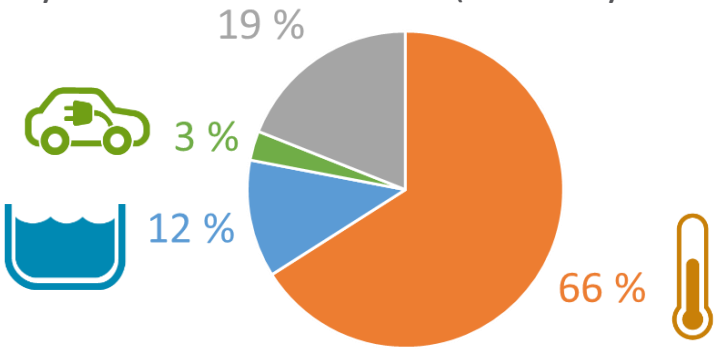
- 5 bidding areas in day-ahead market
- Electricity spot price trippled (end-user price doubled) in South-Norway



Characteristics Norwegian households

- Electricity contracts:
  - **100 %** smart meters
  - **75 %** electricity contracts tied to spot price
- Highly electrified households:
  - Ca. 80 % with electric heating (direct and heating pump)
  - Ca. 80 % with electric warm water boiler
  - Ca. 16 % with electric cars

  - Yearly electricity demand: **16.000 kWh** (Germany: 3.100 kWh)



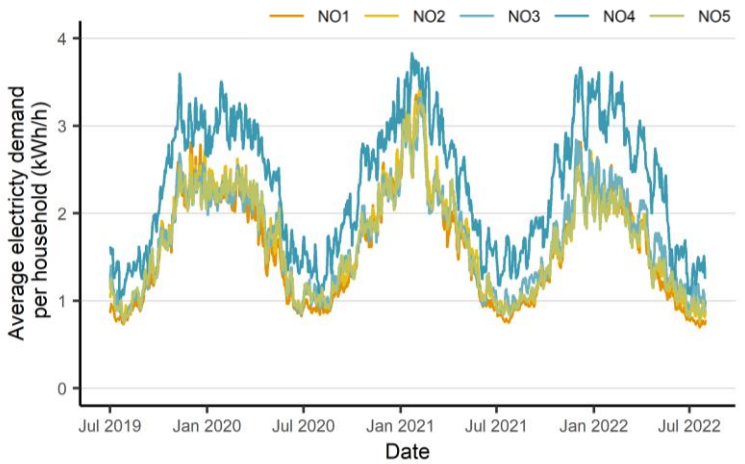
What residential electricity demand response could be observed in the crisis?

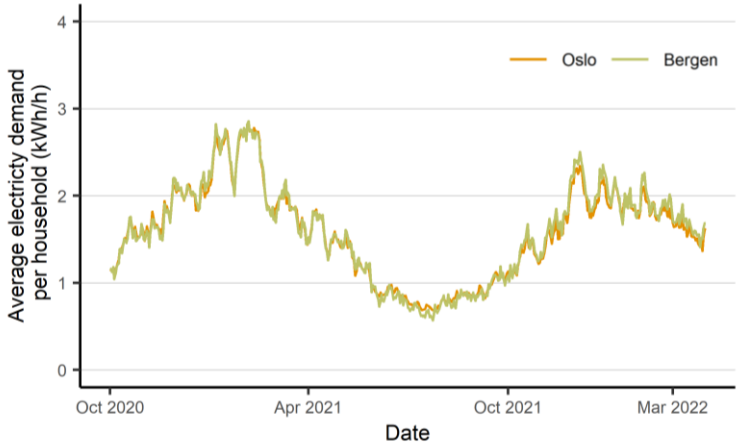
- Energy savings?
- Short-term response to variable electricity prices?
- Additional response from household subgroups?
  - Real-time price information
  - Smart charging of electric cars
- Analysis area South Norway (NO1, NO2, NO5)

Data

- Survey*
  - 4,446 answers
- Hourly residential electricity consumption data*
  - Per bidding area: July 2019 – July 2022
  - Per household: October 2020 – March 2022
    - 1,136 households
    - Oslo and Bergen
- Outdoor temperature
- Covid stringency indicator

*Data will be published in *Zenodo* and *Data in Brief*

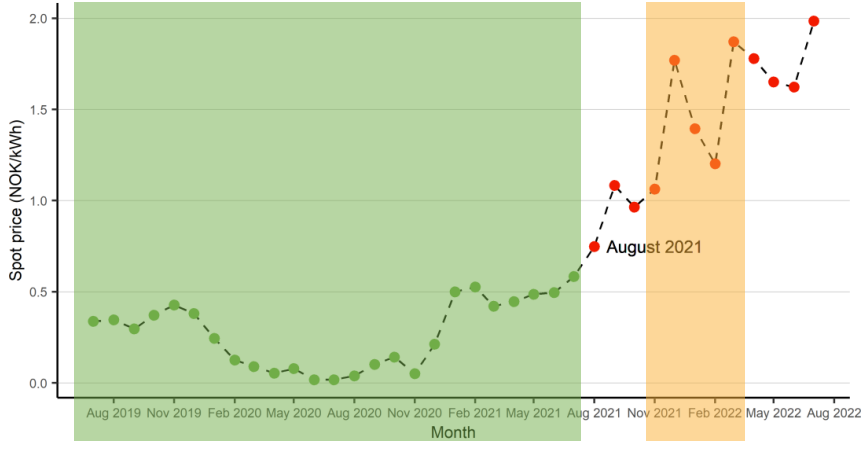




Econometric analysis

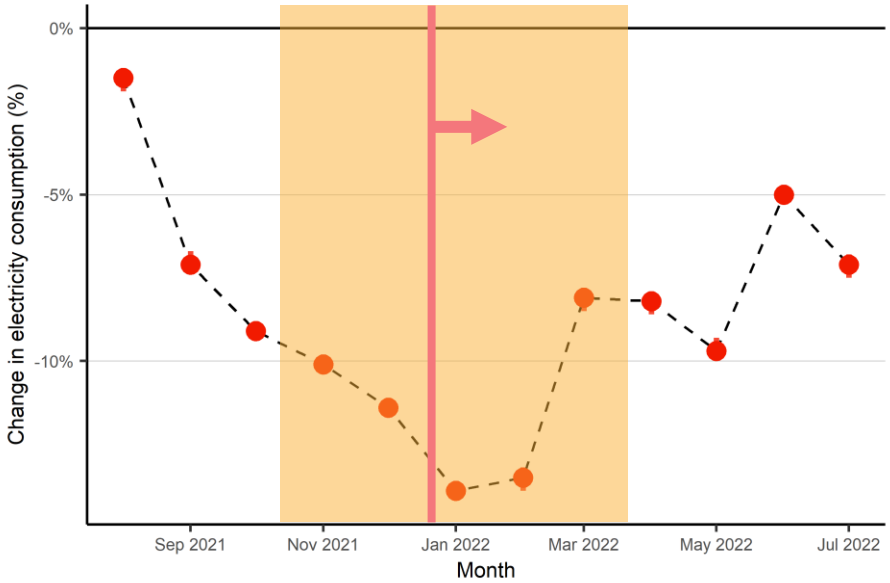
- Weighted least square model:
  - Independent variable: Logarithm of electricity consumption
  - Control variables: outdoor temperature, month, weekdays, hour, holidays, Oxford covid stringency indicator

- Period comparison with dummies:
  - Reference period: Time before price shock (august 2021)
  - Winter period: November 2021 – March 2022



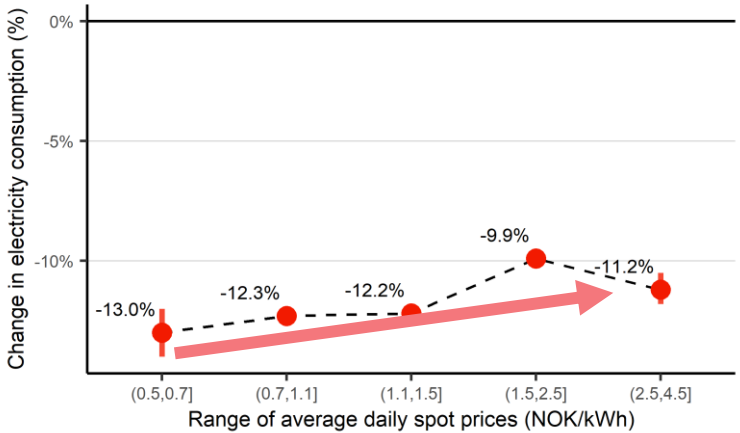
Quick and significant savings

Average reduction: 11.4 %



- Eletricity savings vary from month to month
- Electricity cost supporting scheme from January 2022

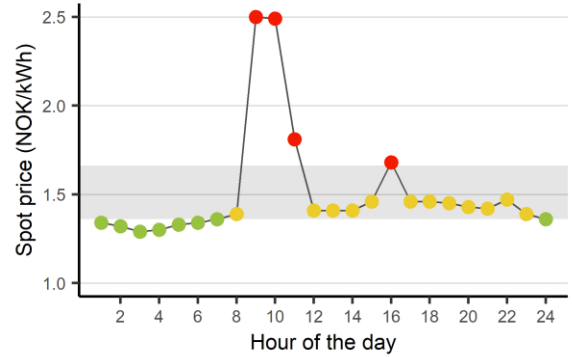
Short-term price response: Day-to-day



Average daily price

- Higher daily electricity prices do not lead to higher savings
- Even lower response observed
- **No** short-term price response

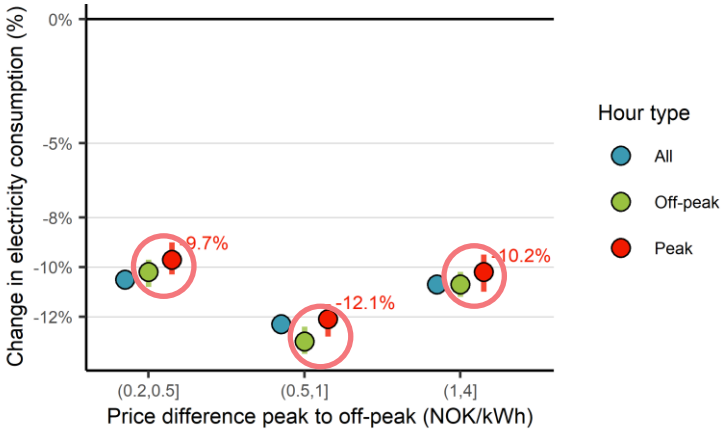
Short-term price response: Intraday



Definition hours

Hour type

- Normal
- Offpeak
- Peak

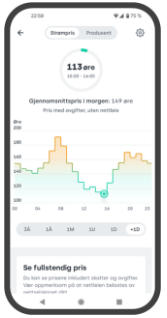


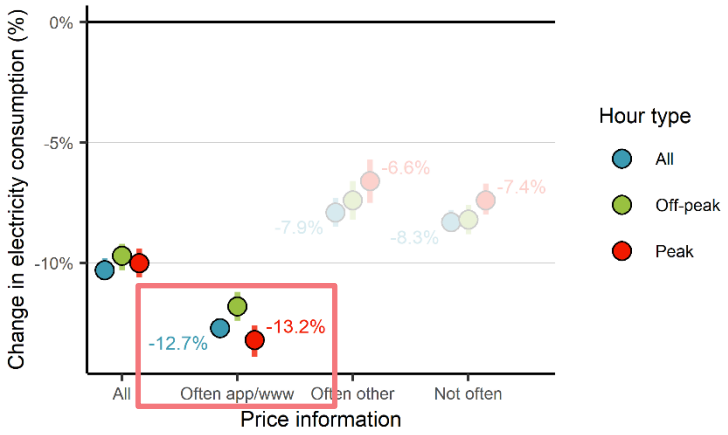
Hour type

- All
- Off-peak
- Peak

- Lower electricity reductions in peak price hours
  - Peak: 10.5 %
  - Off-peak and Normal: 11.5 %
- Increased price differences do not lead to higher response in peak compared to off-peak
- **No** short-term price response

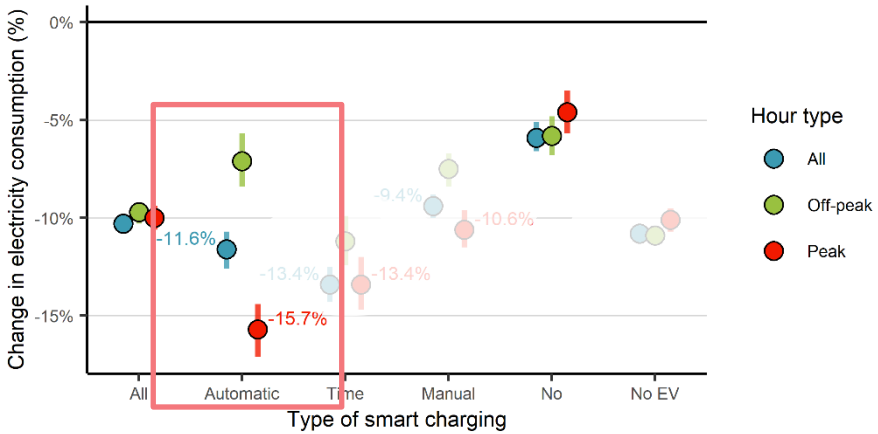
Household subgroups: Real-time price information





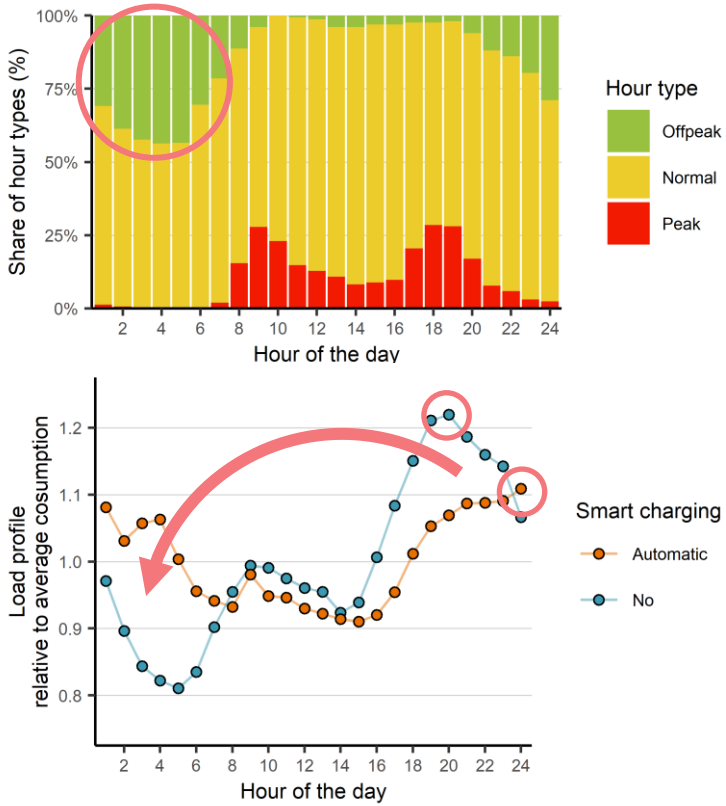
- Price information:
  - Often via app or internet: 42 %
  - Often by other means: 11 %
  - Not often: 47 %
- Active households with price information via app/internet
  - Larger reductions in general
  - Larger reductions in peak hours than in off-peak hours

Household subgroups: Smart charging electric car



- Charging types:
  - Automatic: 12 %
  - Scheduling: 63 %
  - Non-smart: 25 %
- Automatic charging has largest reductions in peak hours with 15.7 %
- Significant load shifting from peak to off-peak hours with automtic smart charging

Household subgroups: Smart charging electric car



- Significant load shifting from peak to off-peak hours with automatic smart charging
- New load peak lower than previous load peak

Conclusion

- Dynamic electricty price contracts are an effective tool for utilising demand response

- Spot price contracts pass prices immediately to customers:
  - Quick response and energy savings after price shock

- Hourly price variations does not affect average household:
  - No short-term price response

- However, larger effects expected in a future with "smart households":
  - Real-time price information: minor short-term price response
  - Automatic smart charging: large short-term price response