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Identifying Representative Weeks for the Nordic Power Sector with Time-Series Clustering **(topic presentation)**

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17.6.2024

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Background – Nordic power sector

- The Nordics form a synchronous grid
  - Consists of zones connected by transmission lines
  - Each zone has its own hourly day-ahead price

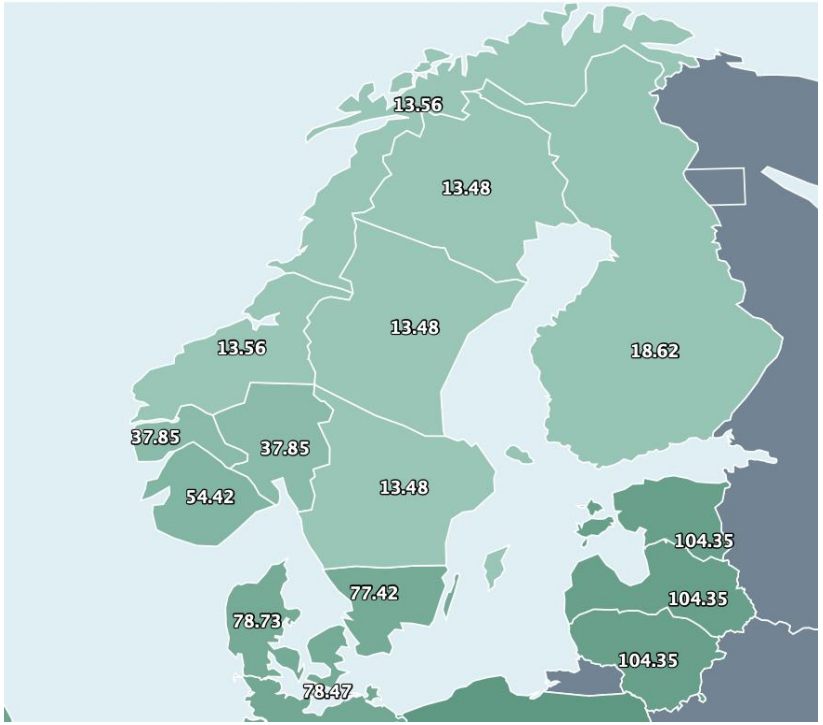

Figure 1. Average Nord Pool Day-ahead prices for the Nordics on 6.6.2024 (Referenced from the Nord Pool Group's maps service)

Background - Model

- Modeling the Nordics in 2023 with a Nash-Cournot model
  - Nash equilibrium =

    No single agent can improve its outcome by changing strategy
  - Cournot competition =

    Companies compete on amount of output, simultaneously and independently

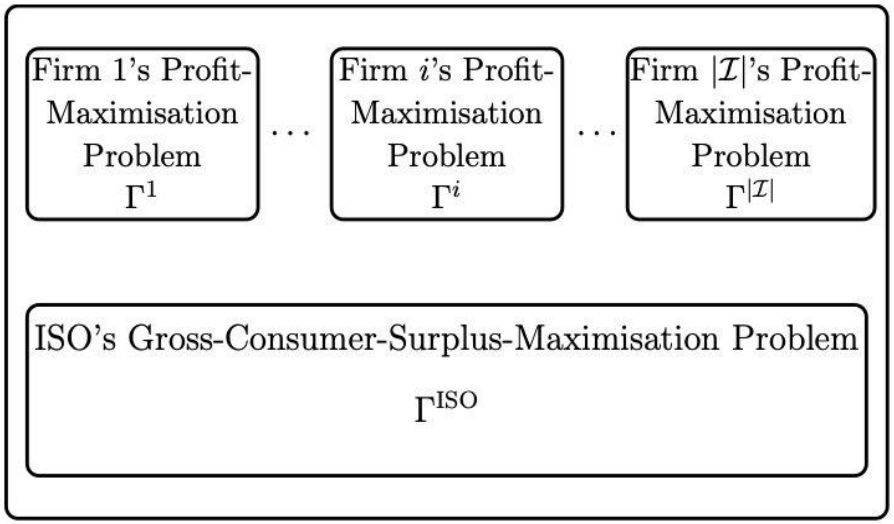

Figure 2. Framework of the optimization problem (Hassanzadeh Moghimi et.al 2023)

Background – Finding the equilibrium

- Optimization problems for the agents
  - System operator: Maximize consumer surplus
  - Firms: Maximize profit
- Many variables influence their decisions
  - Availability of energy: Solar, wind, hydro and others
  - Demand: Hourly, daily and seasonal changes
- This is reflected in the constraints and objective function
  - Makes solving the equilibrium computationally challenging
  - Reformulate the problem into a single quadratic program

Clustering

- Aim: Simplify the QP problem instance, by reducing the temporal dimension
- Finding a representative week for each season by
  1. Grouping data into weeks
  2. Grouping weeks into seasons
  3. Applying clustering algorithms to select a representative week, that captures the features of the data

1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49	50	51	52

Weeks of one color are represented by one representative week
Blue = Winter,
Green = Spring,
Red = Summer,
Orange = Fall,
*Breaks between seasons illustrative

Goals

- Finding representative weeks for the year
  - Reducing the 365 • 24 = 8 760 hours in the year to 4 • 7 • 24 = 672.
  - One week for each of the 4 seasons
- Comparing results of...
  - … studying how data clusters without predefined seasons
  - … using different similarity measures (alternatives to euclidean distance)
  - …. testing different weights for variables to see which ones are significant for the results

Tools

- GAMS
  - General Algebraic Modeling System
  - System for optimization
- R/Python packages

Dataset

- Dataset collected this summer
- From energy agencies, ISOs and firms

Schedule

- June-August:
  - Working on data collection
  - Literature review
  - Making a plan for methodology
  - Learning how to use GAMS
- August-September
  - Applying plans to data
  - Results section
- September-October
  - Finishing the writing

Literature

- Virasjoki, V., Siddiqui, A. S., Zakeri, B., & Salo, A. (2018). Market Power with Combined Heat and Power Production in the Nordic Energy System. *IEEE Transactions on Power Systems*, *33*(5), 5263–5275.
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- Reichenberg, L., Siddiqui, A. S., & Wogrin, S. (2018). Policy implications of downscaling the time dimension in power system planning models to represent variability in renewable output. *Energy*, *159*, 870–877.
- Teichgraeber, H., & Brandt, A. R. (2019). Clustering methods to find representative periods for the optimization of energy systems: An initial framework and comparison. *Applied Energy*, *239*, 1283–1293.