Power Engineering
Academic Study Group

Warsaw University of Technology

Optimization of combined heat and power plant with heat accumulator: How we won a hackathon.

25th February 2020

Warsaw University
of Technology

Agenda

1. Municipal heating systems
2. Hackathon
3. Results and conclusions

1. Municipal heating systems

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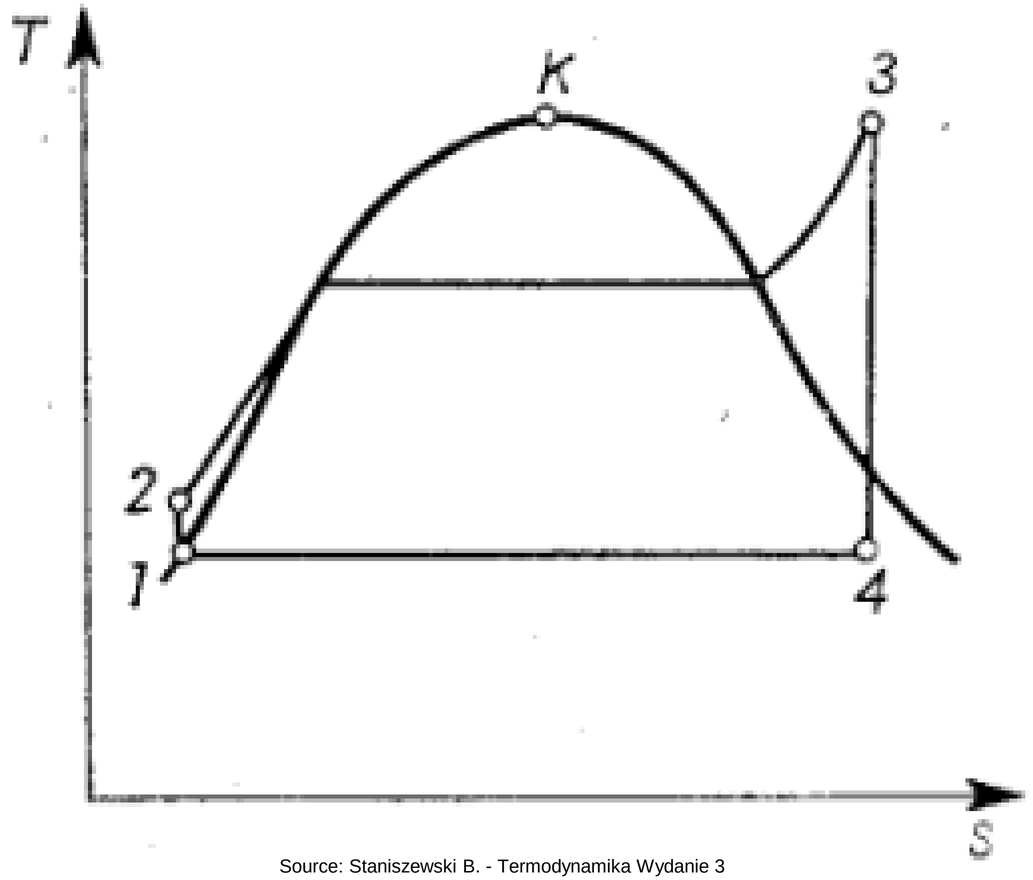
Large - scale energy system:

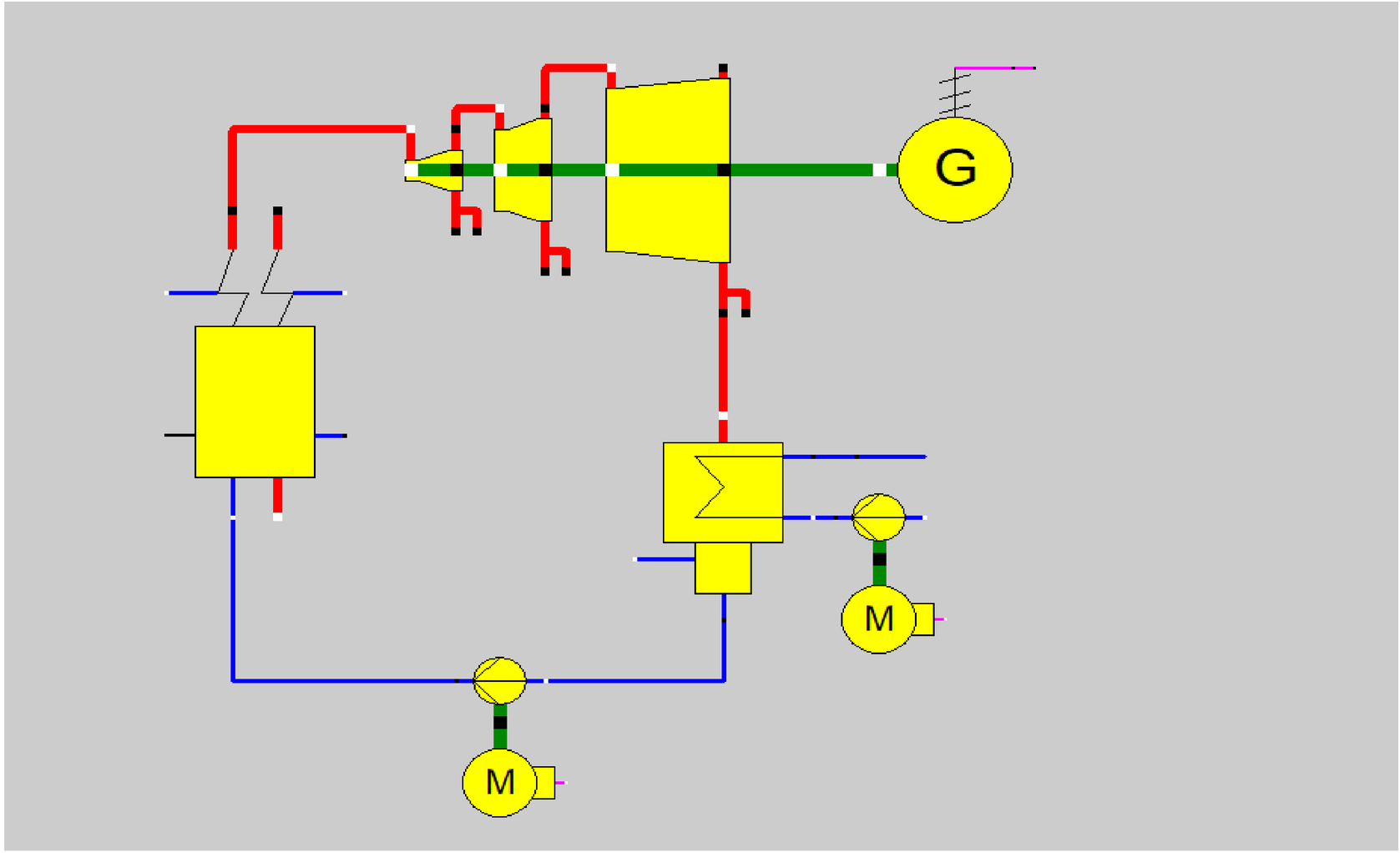
- Power plant
- Heating plant
- CHP plant

The Rankine cycle: steam turbine system



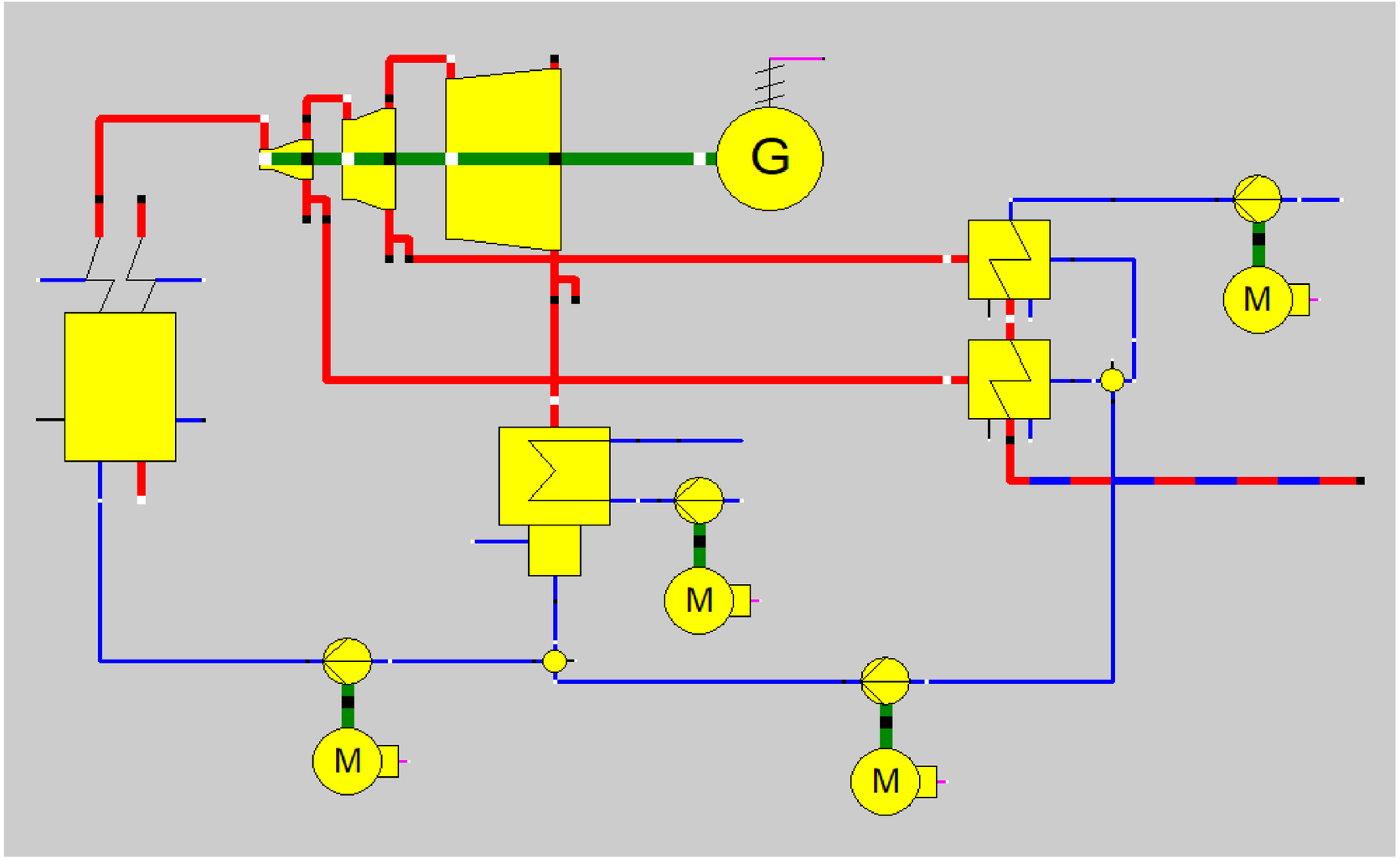
Source: Staniszewski B. - Termodynamika Wydanie 3

Steam turbine unit



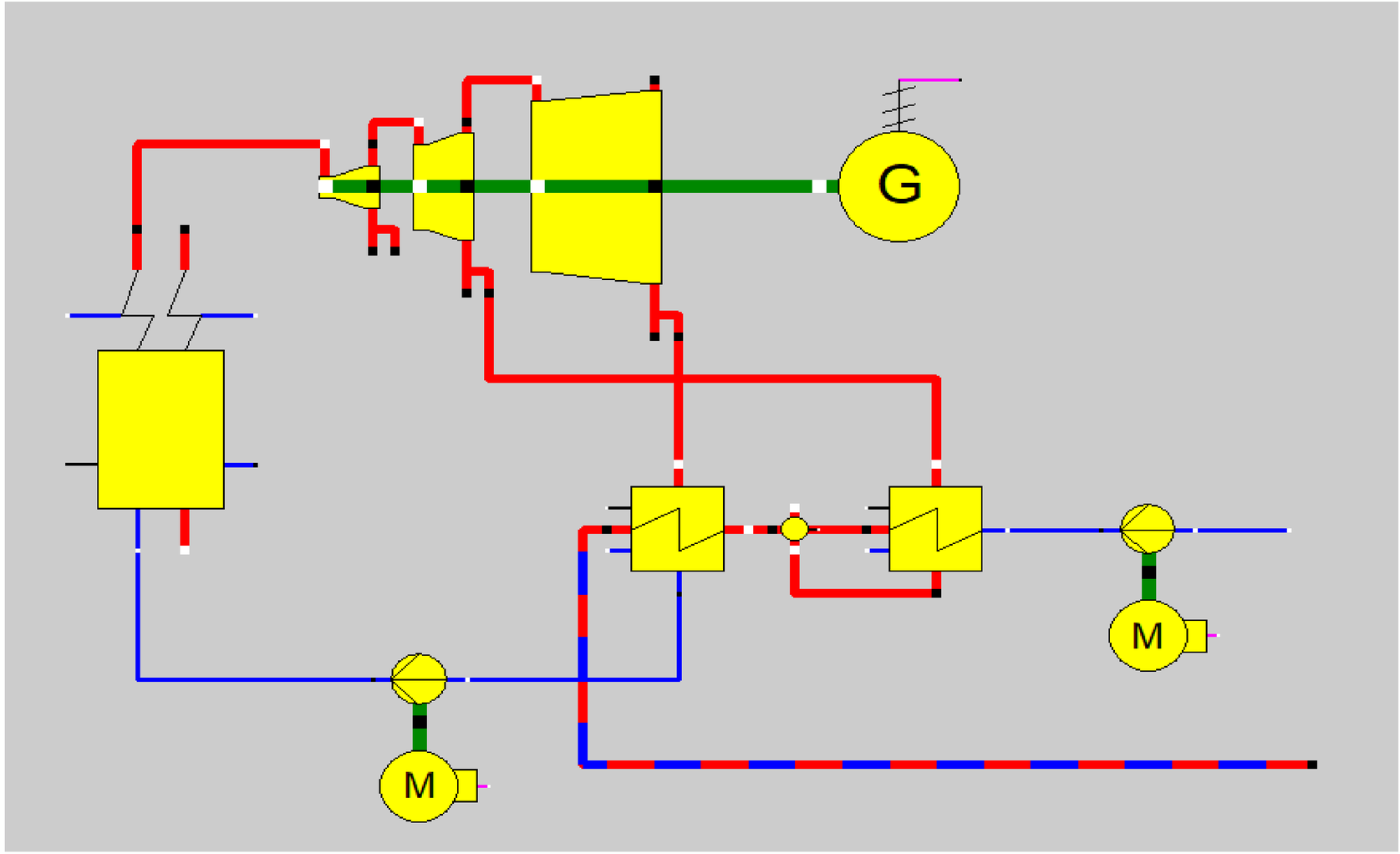
Source:EBSILON®Professional 12

Steam condense turbine CHP unit



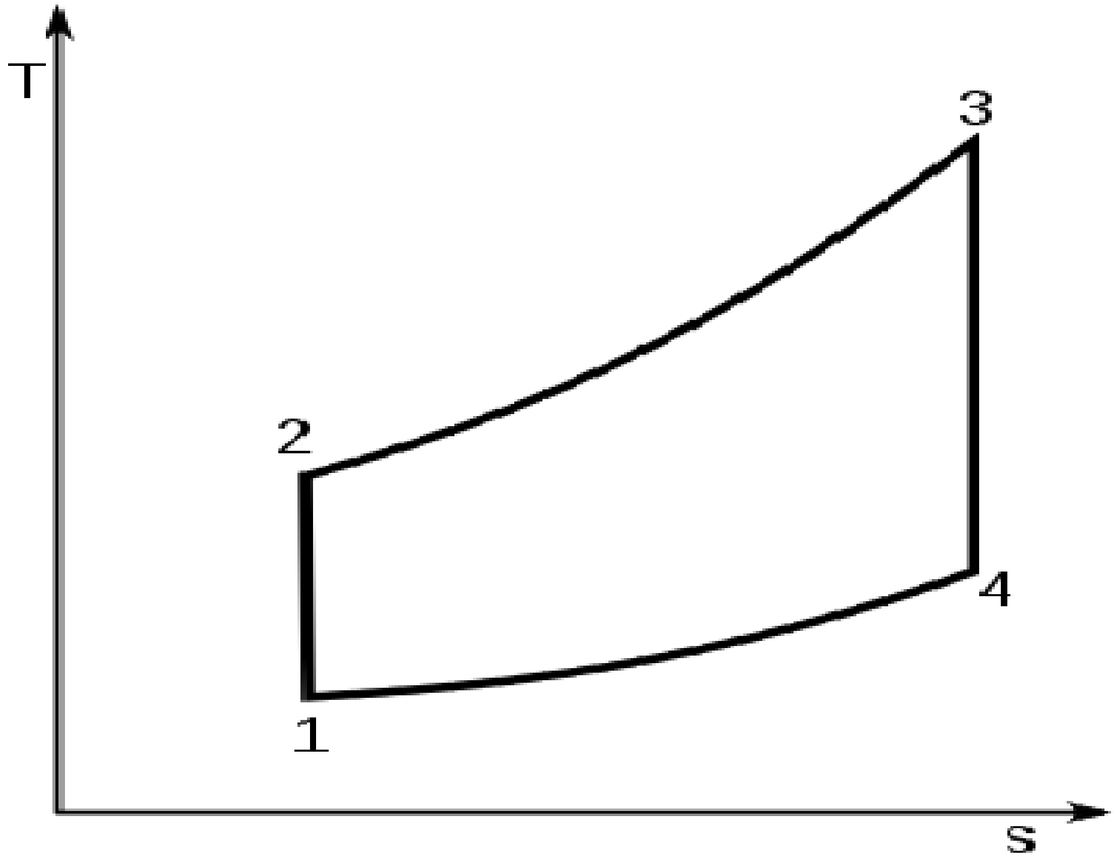
Source:EBSILON®Professional 12

Steam back-pressure turbine CHP unit



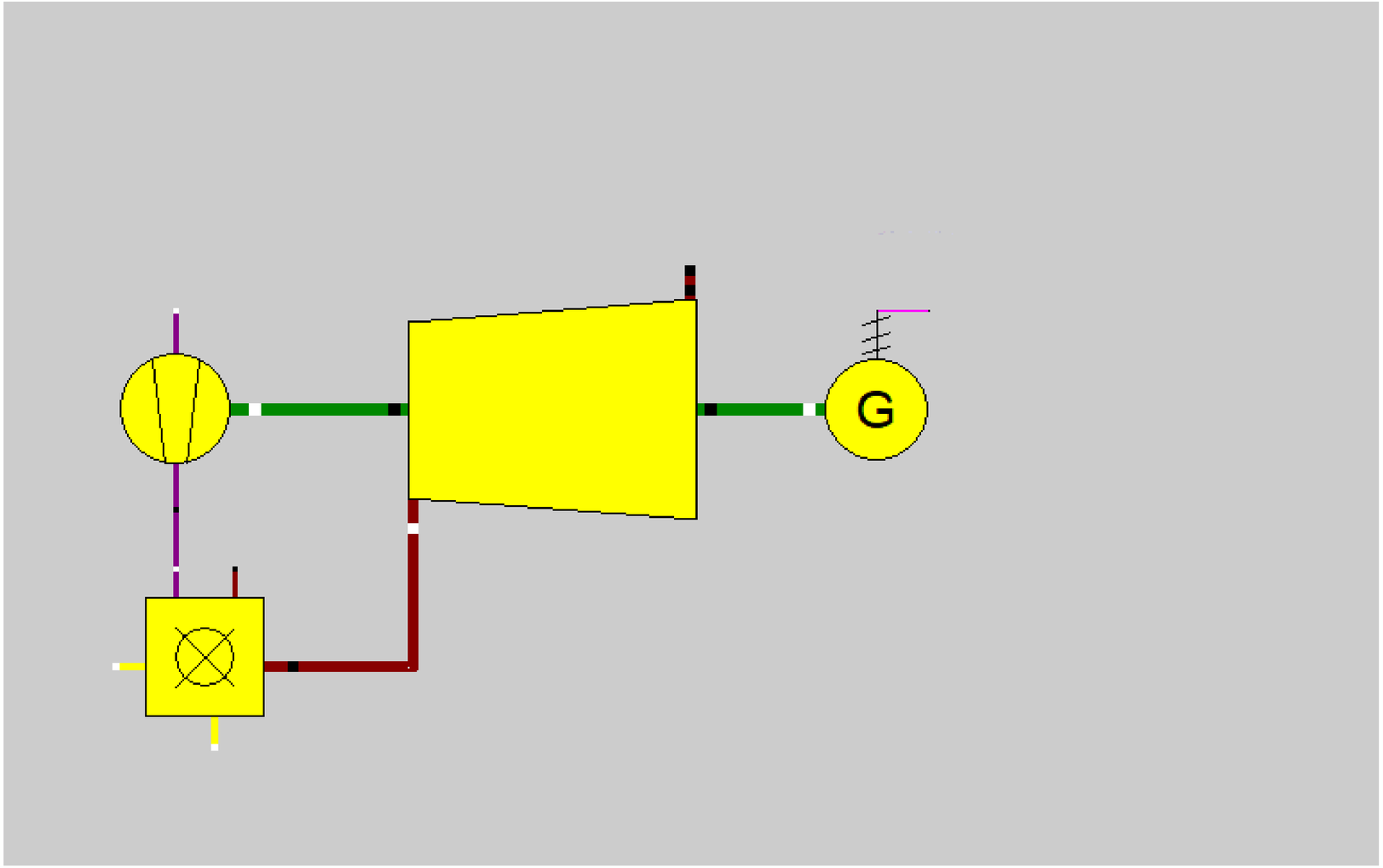
Source:EBSILON®Professional 12

The Brayton cycle: gas turbine system



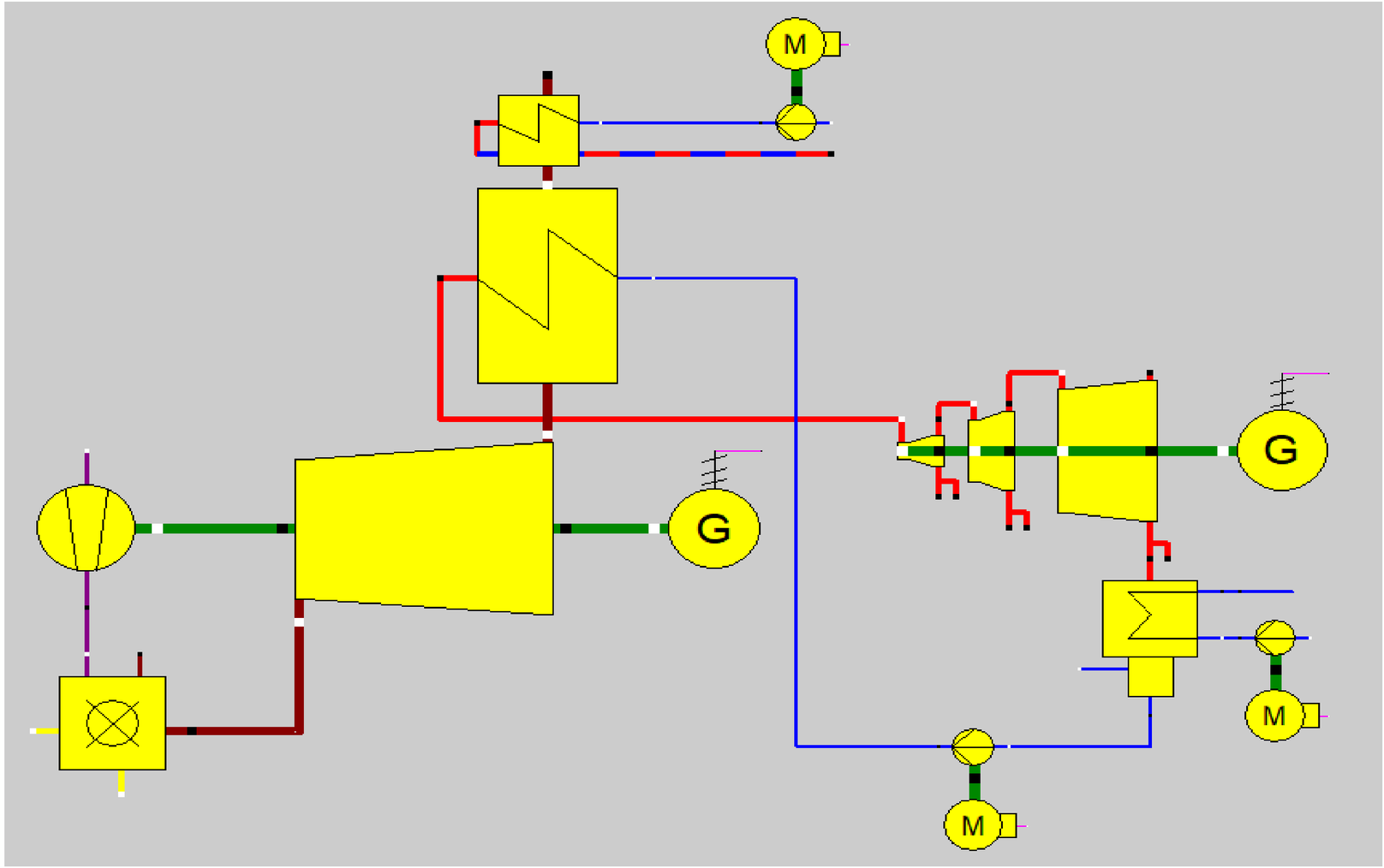
Source: https://qph.fs.quoracdn.net/main-qimg-af9fc305ea6848b52226b218e9d76e7e.webp

Gas turbine unit



Source:EBSILON®Professional 12

Gas turbine CHP unit



Source:EBSILON®Professional 12

CHP plant with hot water accumulator

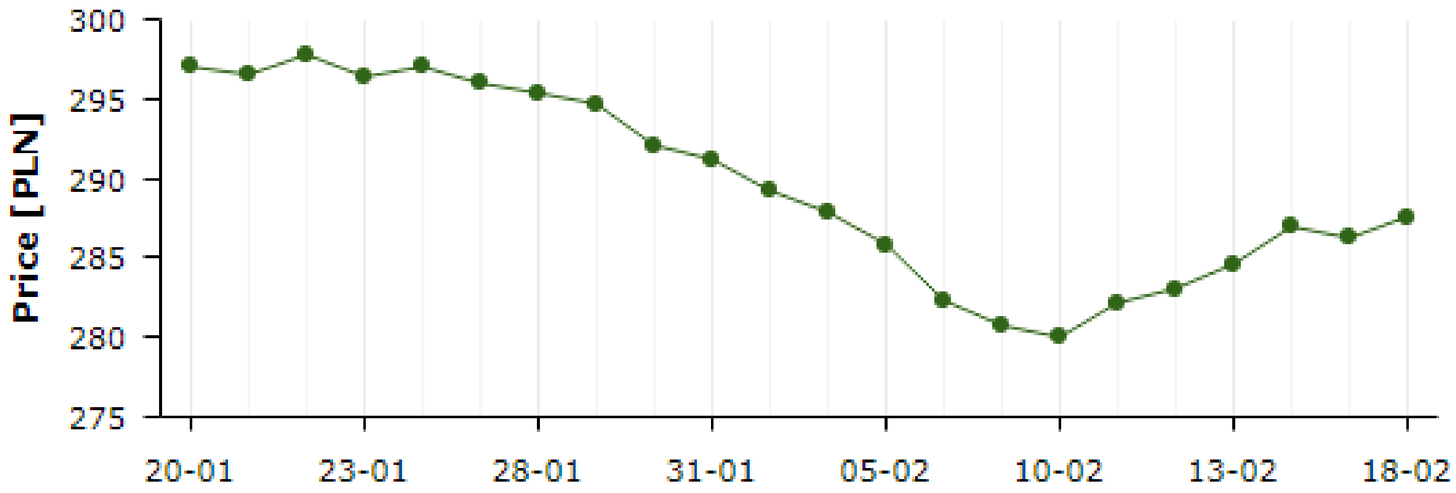
Source: https://torun.wyborcza.pl/torun/7,48723,21671359,nowa-elektrocieplownia-w-toruniu-za-550-mln-zl-juz-dziala-zdjecia.html?disableRedirects=true

Real-life CHP plant consists of:

- Gas turbine unit
- Steam condense turbine unit
- Steam back-pressure turbine unit
- Combination of above units

When using heat storage, we are:

- Covering the heat demand fully and
- Optimizing the profit and
- Reducing the number of starts.



Source: TGE.pl, PEAK5_Y_21

2. Hackathon

Rafał Chabasiński

Source: https://akceleratorpge.pl/hackathon

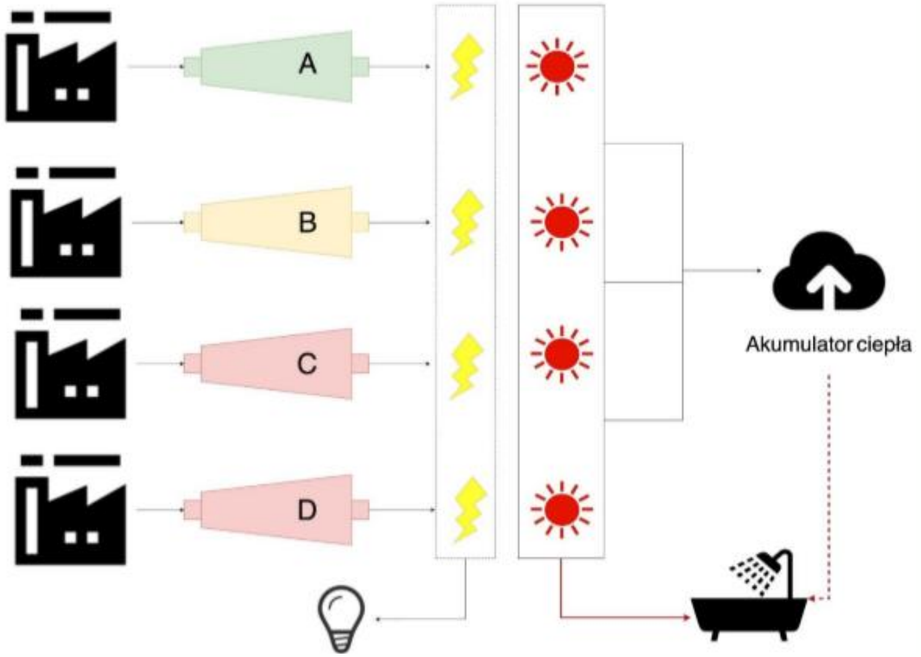
Place and time

- 13-14 December 2019 in AGH energy center, Cracow
- 20 hours to come up with the solution
- Efficient energy and time management
- Dealing with lack of sleep

Source: https://www.agh.edu.pl/centrum-energetyki/

Task

- 4 different heat and power units
- Heat accumulator
- Many restrictions, requirements and variables
- Satisfying heat needs for every hour of the year
- Maximing profit from heat and electricity production



Source: Hackathon EnergyHackOn materials

Python language

- Vast amount of libraries perfectly suitable for operating on data
- Conciseness and quick development
- Easy to debug (due to interpreter)

Source: http://www.howcsharp.com/146/scipy.html

Restrictions and how to deal with them

- Power plants not available at certain times of the year
- Having to wait for power plants to be available again after stopping them
- Eliminating unavailable power units from algorithm

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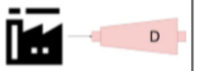
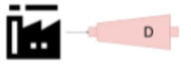
2179				 Akumulator ciepła
2180				
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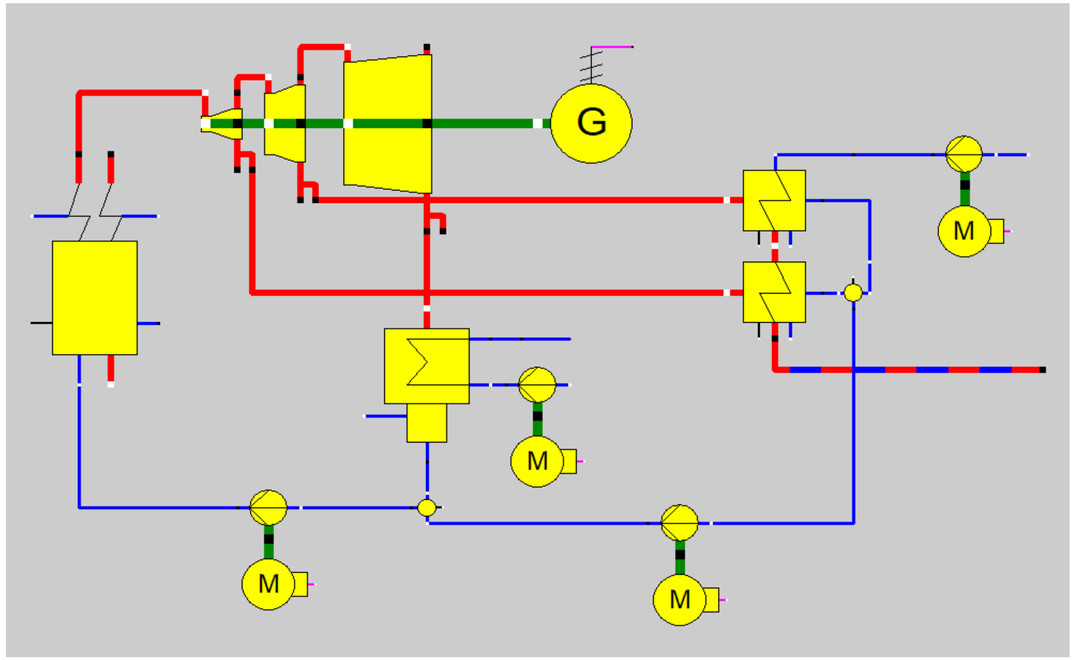
Source: Hackathon EnergyHackOn materials

Dealing with harsh situations

- Hourly demand for heat spikes and drops
- Always keeping accumulator level in certain safe zone
- Always meeting requirements, but at the same time maximizing the profit

Prioritising power units

- Eliminating constant switching between identical units
- Giving higher priority to very efficient and life-saving unit



Source:EBSILON®Professional

Profit optimization

- Producing most energy and charging accumulator when price is high
- Discharging accumulator when price is low
- Avoiding often startups

3. Results and Conclusions

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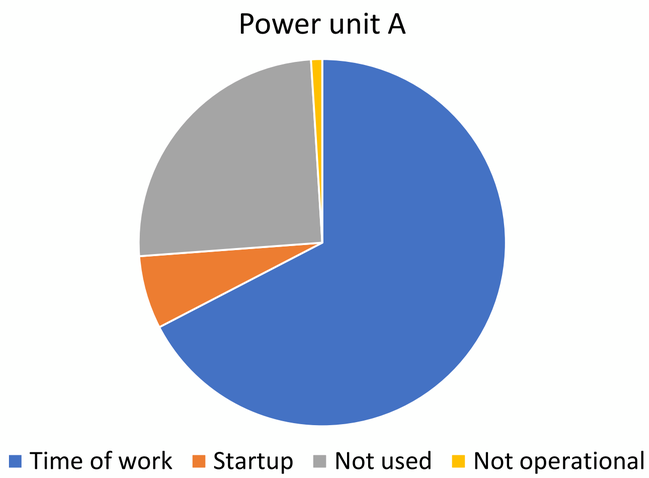
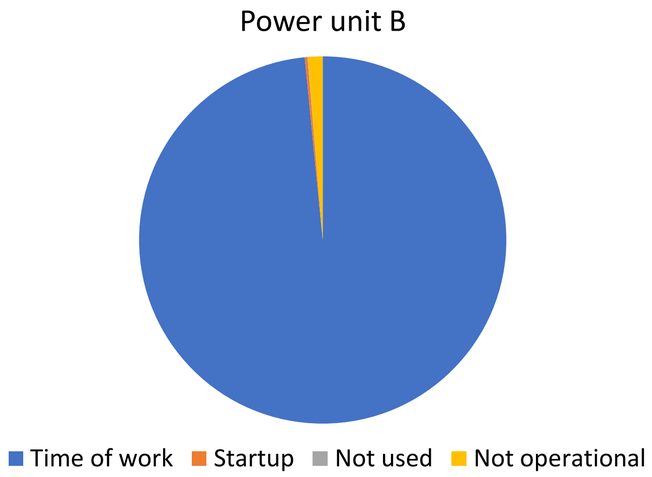
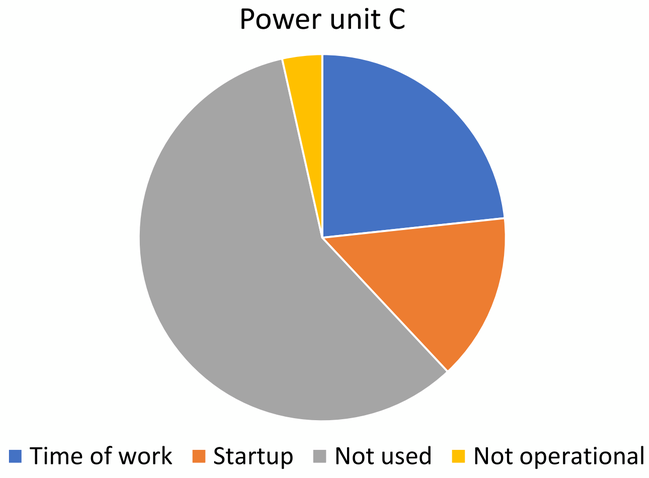
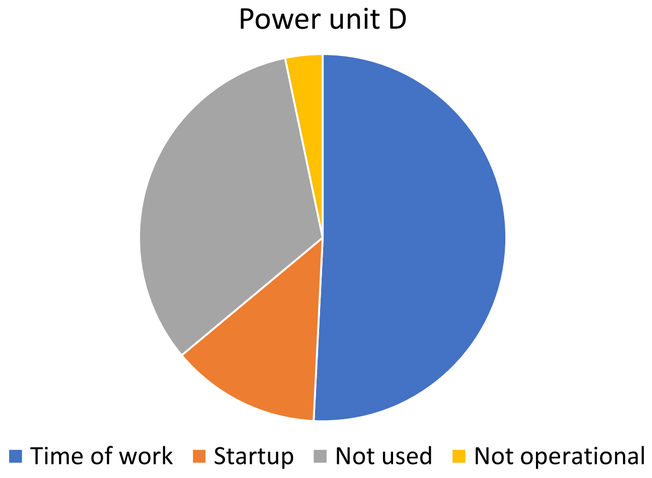
Units’ work time









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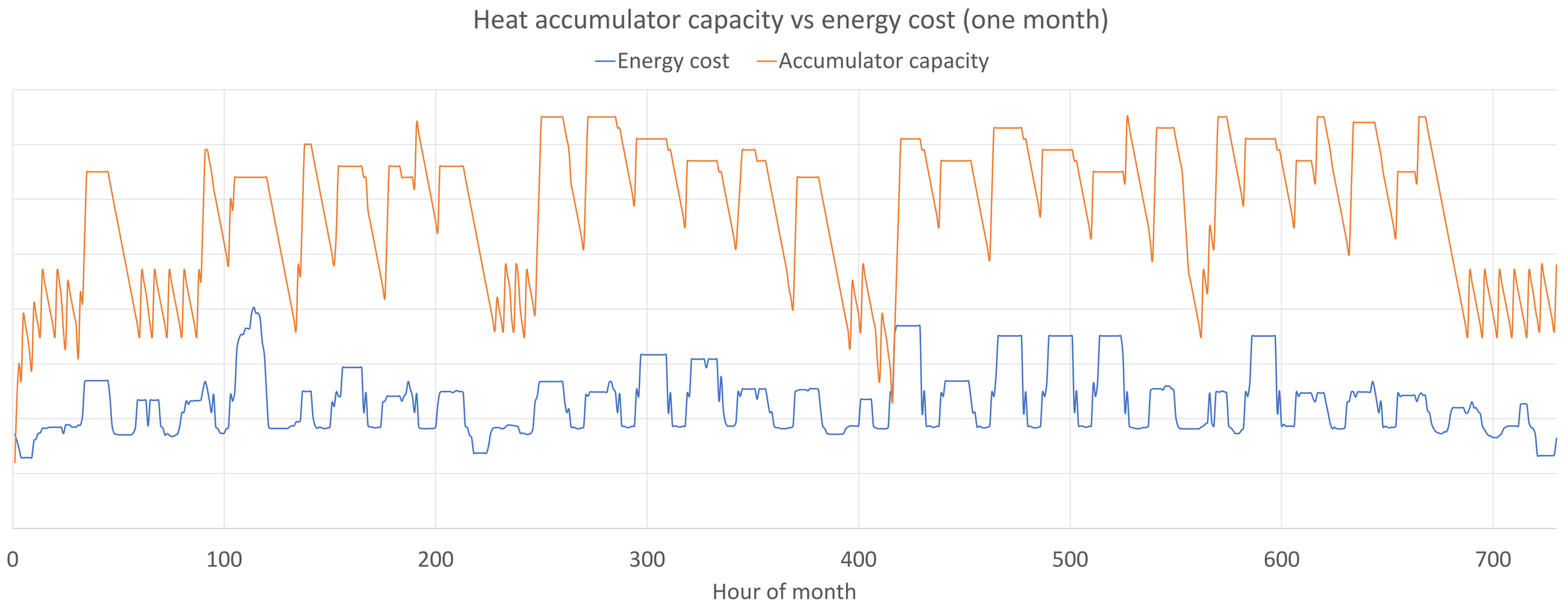
Heat accumulator



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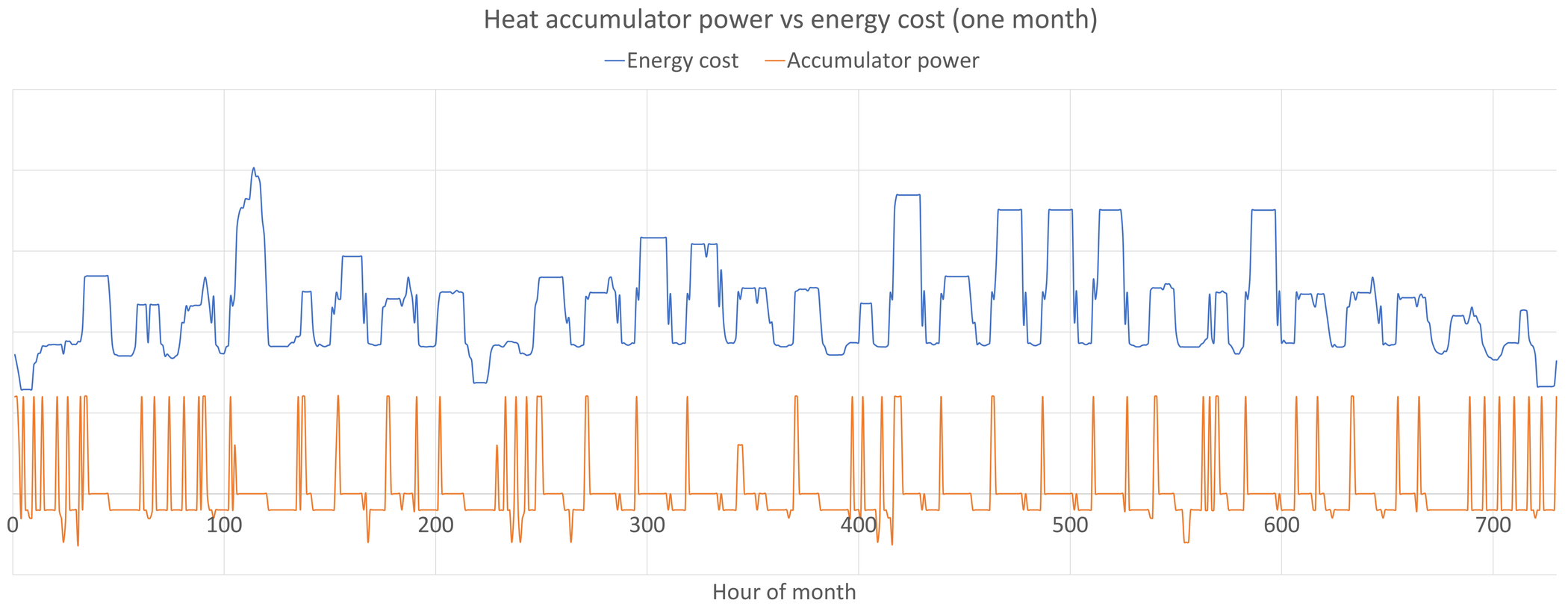
Heat accumulator



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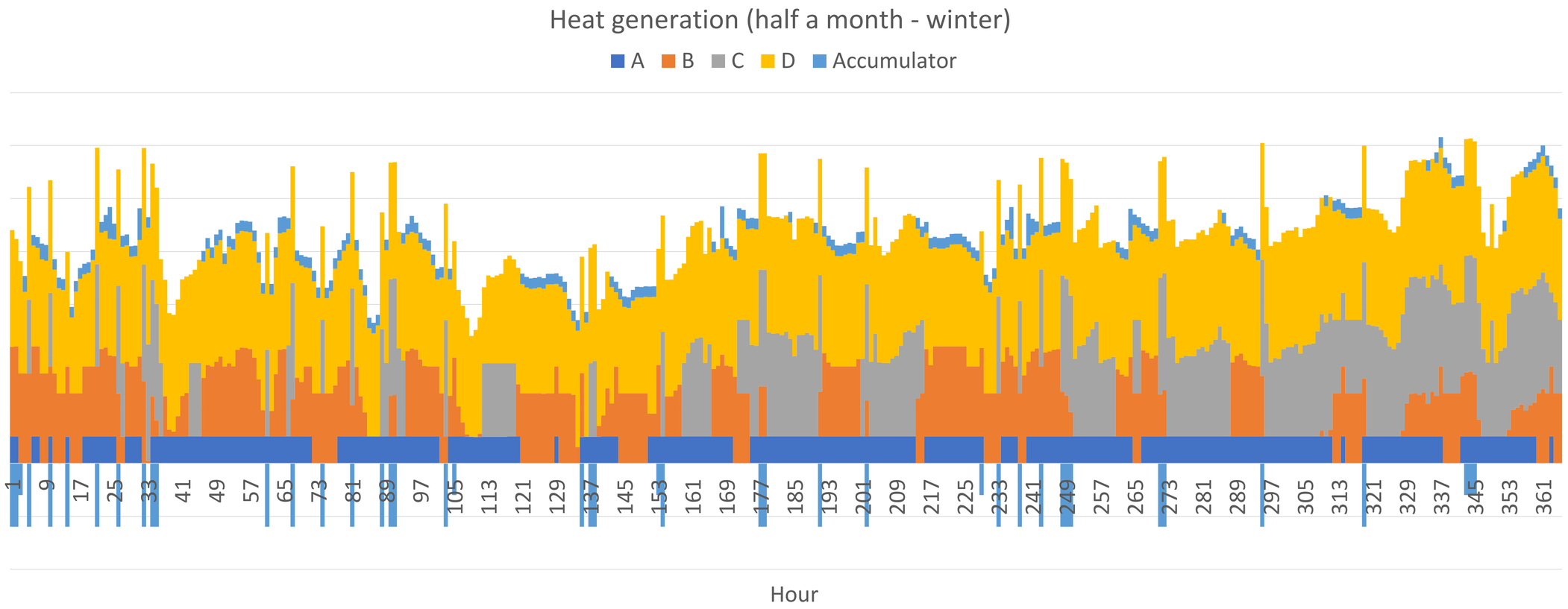
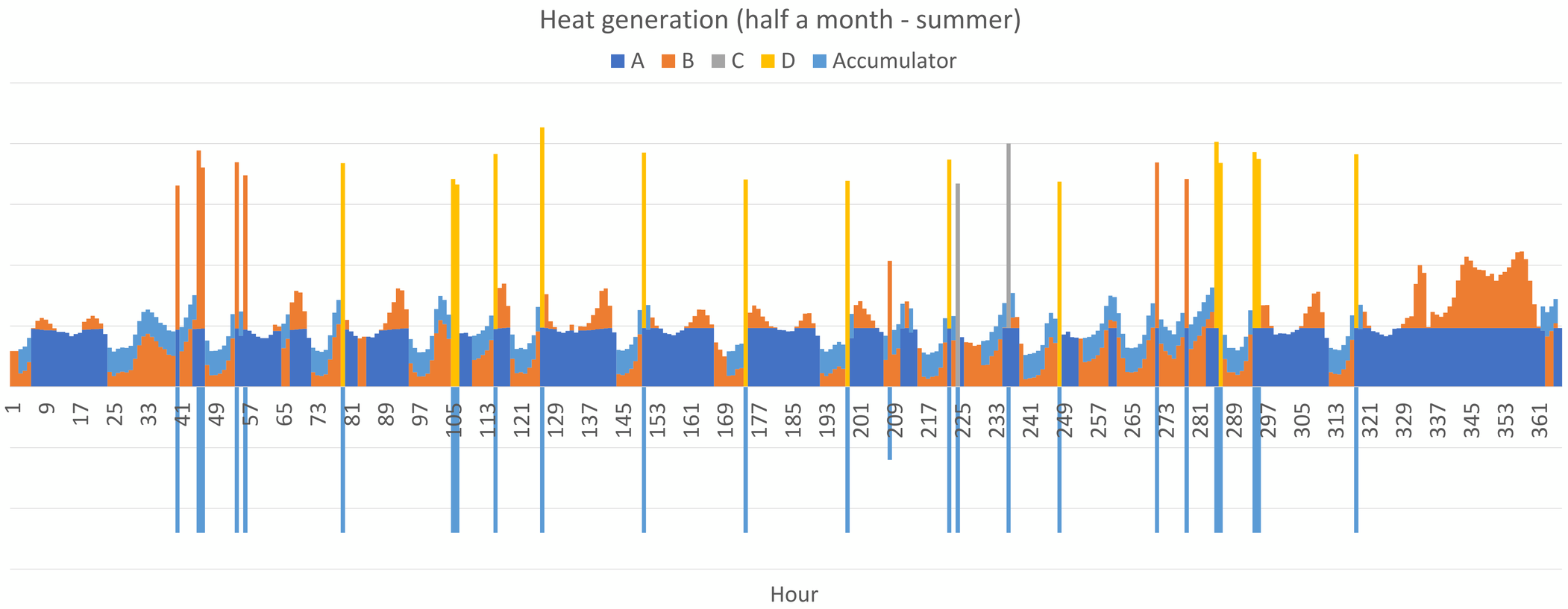
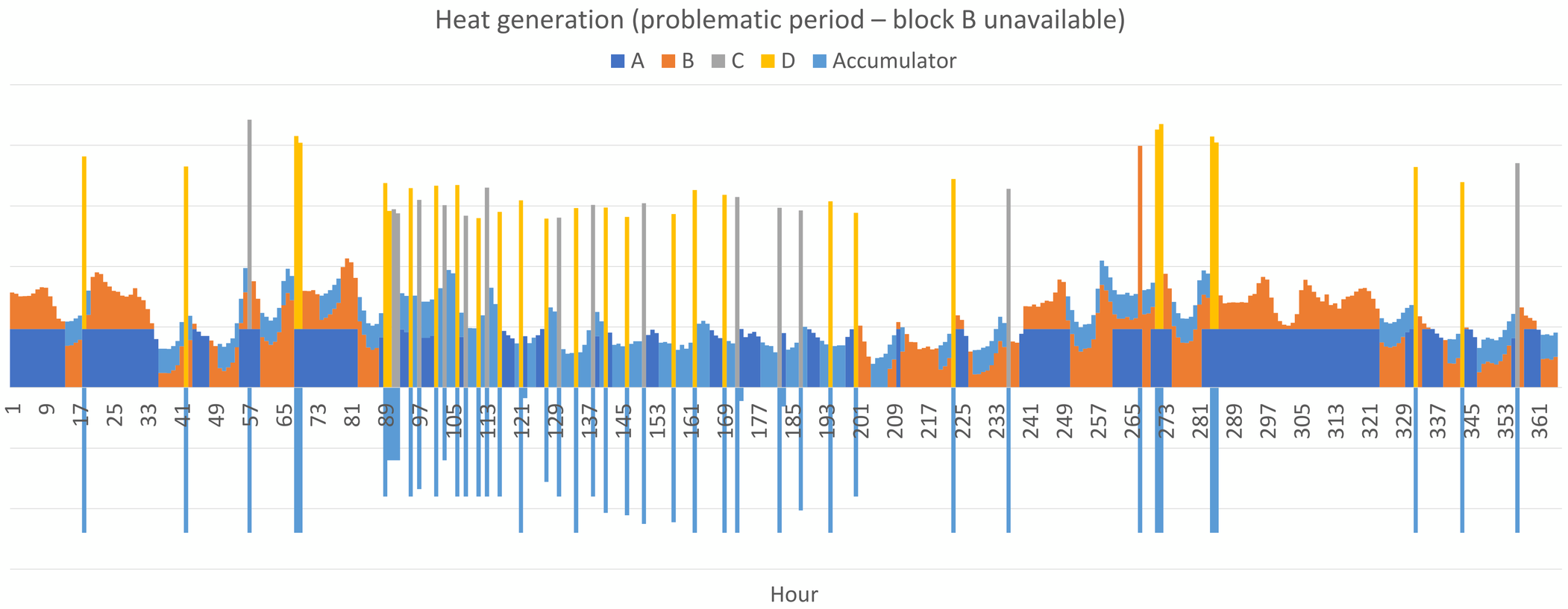
Heat generation



Heat generation



Heat generation



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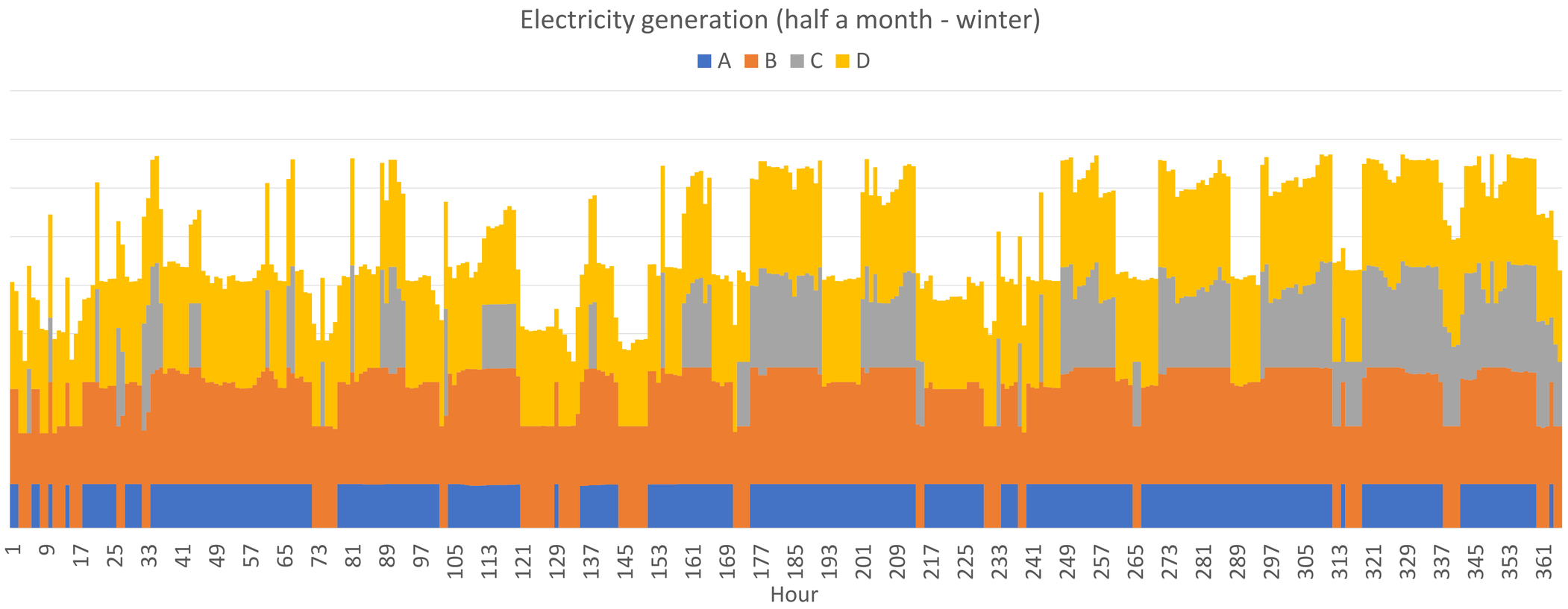
Electricity generation



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Successes

- 100% heat generation safety
- Units’ availability is fully respected
- Times needed for startup are fully respected
- Partially optimized share of heat production
- Partially optimized cooperation with heat accumulator

Special thanks

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Thank you for your attention

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