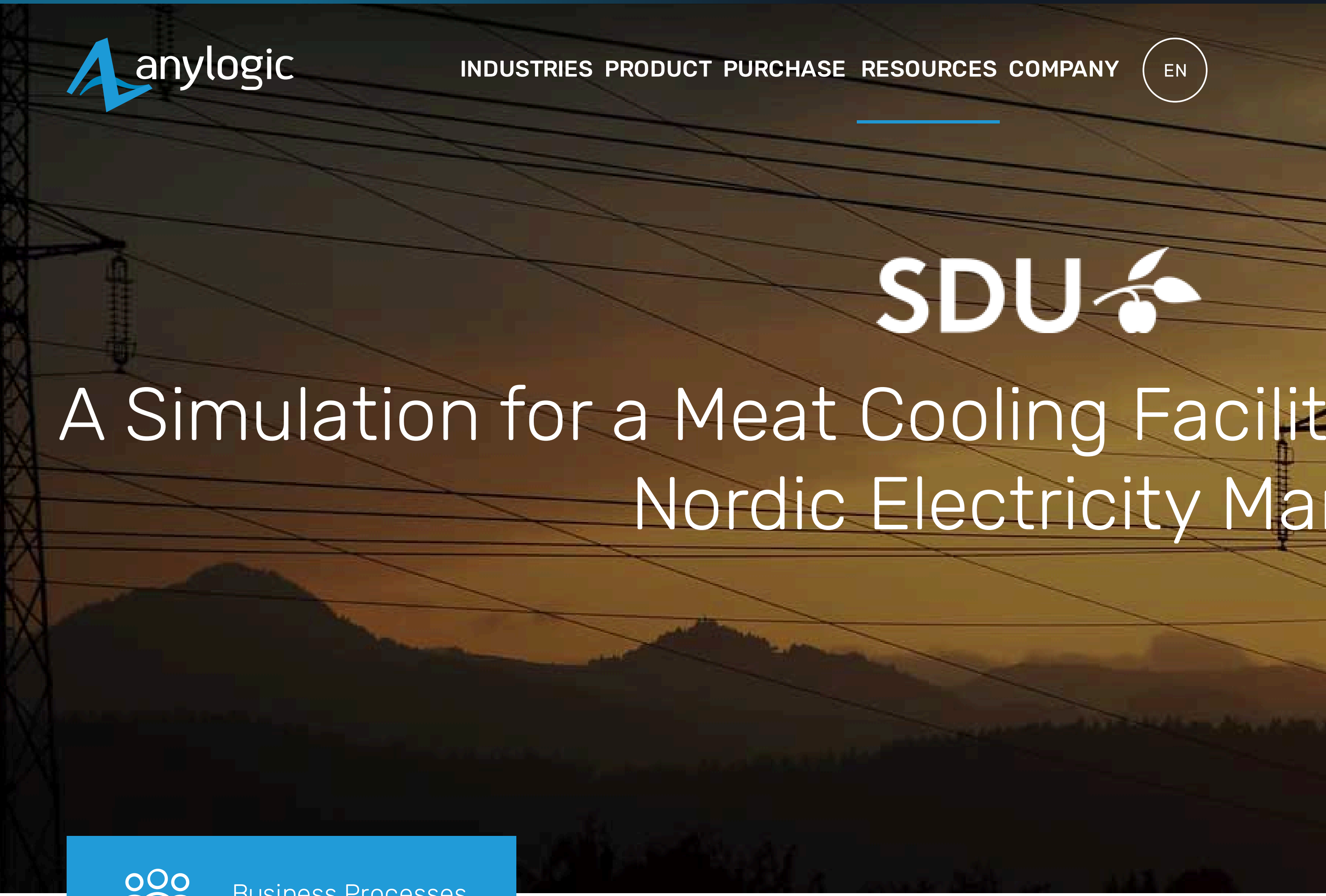


SDU

A Simulation for a Meat Cooling Facilit Nordic Electricity Mar

Business Processes

A power grid is simply one big interconnected machine. Whenever someone turns on a light switch, someone on the other side has to increase production. This is a simple case of supply and demand. However, this balancing act is becoming more uncertain and unpredictable because of the emergence of renewables. So, it requires new solutions such as batteries which can store energy, hydrogen, and even super connected grids linking countries.

The raw material, which in this case is meat cuttings, is received by the industrial consumer and needs to be stored in a cooled room before it is processed. In the system, there is a maximum and minimum temperature threshold within which the meat can be stored. So, the temperature can be changed depending on the power grid's needs in order to provide a stable service.

For the electricity supplier, the prices vary depending on the time of the day, for example, the early morning and evening are more expensive, while the consumer has fixed prices. If the consumer accepts flexible prices, they can choose to use more electricity. In this case it means increasing the temperature in the cooling room during the non-peak hours in the grid, and reducing the temperature in the cooling room during peak hours. This will ease the electricity consumption during peak hours.

This analysis of demand response using simulation focused on a single industrial consumer, which was a Danish company in the meat processing industry. With simulation it is possible to compare different scenarios: to vary parameters and see how the modeled system responds.

AnyLogic simulation software was the best option to simulate this demand response effect because of the following advantages it brings to an analysis:

- Descriptive simulation approach in order to compare results of different operational conditions and help decision making in a multivariate program.
- Discrete-event simulation as timing is crucial for

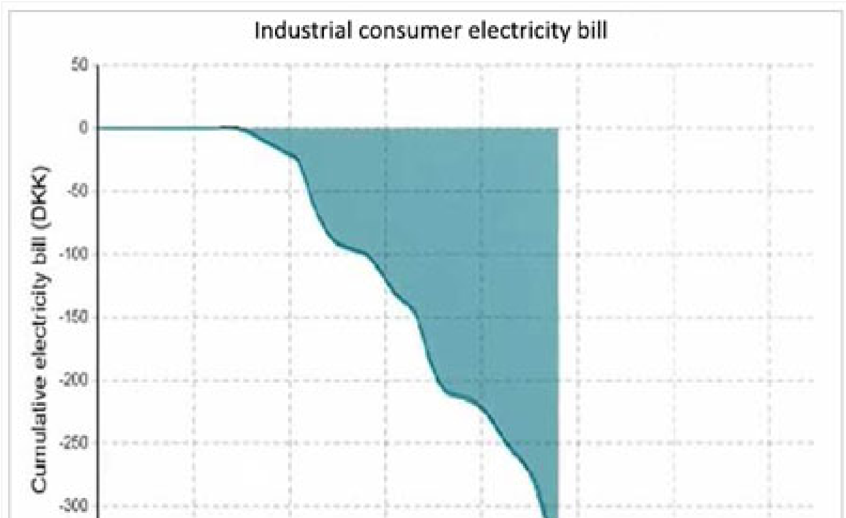
following ways:

1. Evaluate the current potential using a simulation experiment

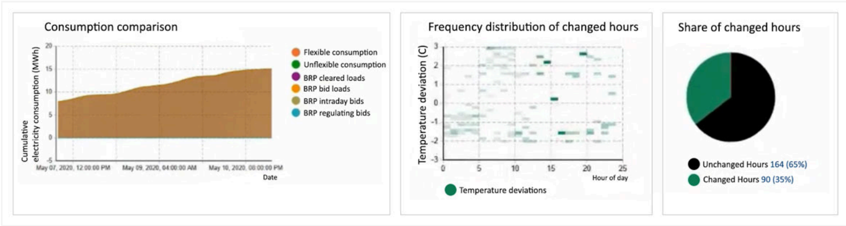
   In this experiment, a market-based explicit direct response strategy was chosen. This means participating in the market directly as a consumer without involving the electricity supplier. It is explicit because it is clear and direct without other assumptions. The consumer is then interested in the results which are broken down into two sections:

   - The Financial impact of demand response which includes the cumulative and daily results.
   - The Process impact of demand response where the cumulative and real-time results are displayed.

Financial impact of demand response - Cumulative results

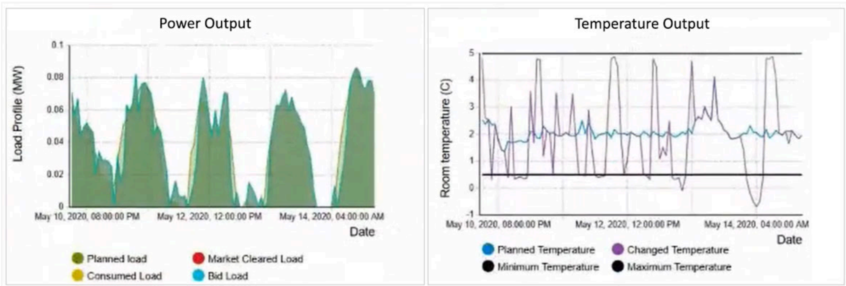


Process impact of demand response - Cumulative results



The histogram on the left shows the overall supply of electricity, and is used to ensure that the consumer supplies the same amount of energy. The second histogram shows deviations in temperatures. The third diagram illustrates the share of changed hours

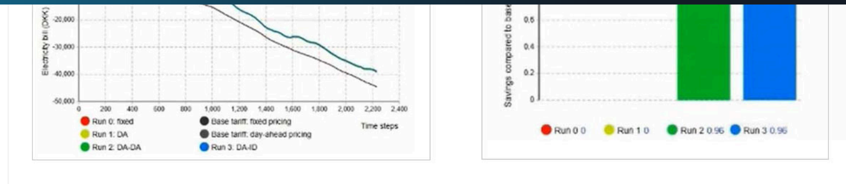
Process impact of demand response – Real-time results



These histograms show the power and temperature output initially and then on different loads

2. Evaluate different market options using a CompareRuns experiment

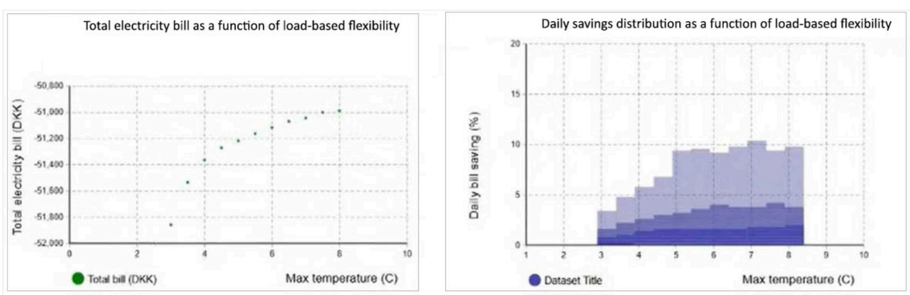
   Here the user can compare different scenarios, which is where the power of simulation comes in.



The first results on the left show how the electricity bill evolves over time, when using different market strategies. While the results on the right show the relative savings for the different market strategies

3. Evaluate operational flexibility using a ParameterVariation Experiment

   This example showed an increase in the maximum temperature parameter of half a degree. As a result, the consumer can bid more on the electricity market and make a certain amount of savings. There is, however, a saturation effect. This means that the more the consumer increases the temperature, the less marginal benefits they receive. From this, the industrial consumer would understand that increasing the temperature by another half a degree wouldn't reduce costs.



The histogram on the left shows how the maximum temperature can vary, and using this information the second histogram can be modeled over different days to show the

the electricity market.
- Consumer-centric approach, focusing on the results for the industrial consumer and not for the grid operator, yet at the same time continuing to model the logic of all the other market players.
- Modular approach, because different business models are tested, shifting the roles and distributing them to different agents.

Finally, a larger aim has been identified to apply this simulation to a number of different consumers in two different contexts – the Danish and the Chinese market. Here the usefulness of the modular approach can be seen because the two markets are quite different in structure, yet the interfaces can be quickly switched from one agent to the other. These can then be implemented in many different industrial processes.

The case study was presented by Nicolas Fatras, PhD student, Center for Energy Informatics, University of Southern Denmark at the AnyLogic 2021 Conference.

The slides are available as a PDF.

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