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Thermal predictions

Christian Sloper

Overview

- Business case
- Technical solution
- Lessons learned

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Project: «Robotstyring Fjernvarme»

Incinerators

- To avoid landfills filling up, waste is destroyed in incinerators.

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Incinerators

- **This creates heat.**

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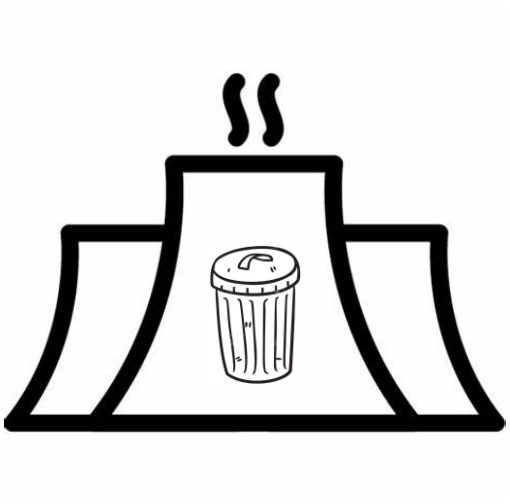
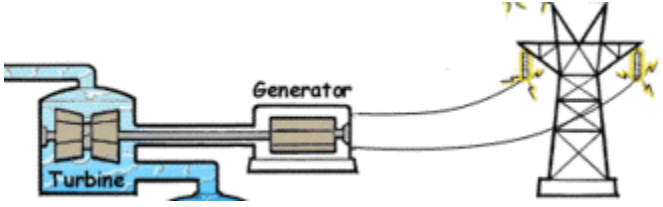
Incinerators

- This creates heat. Heat is used to boil water.

Incinerators

- Hot water can be used to either: run a turbine





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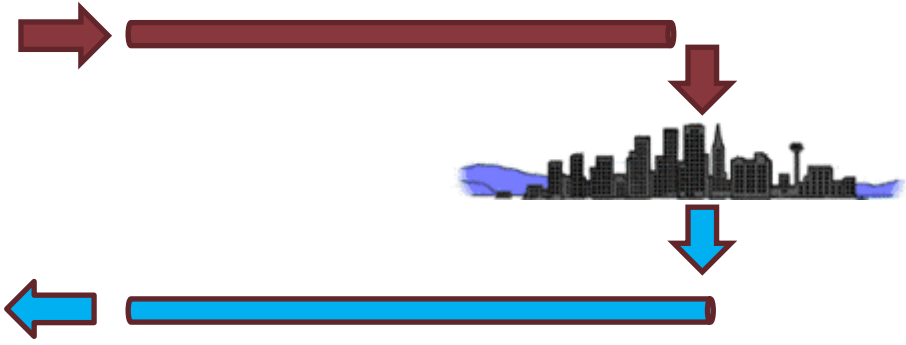
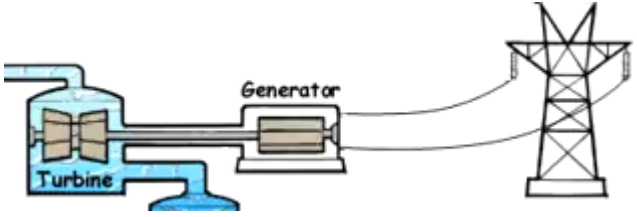
Incinerators

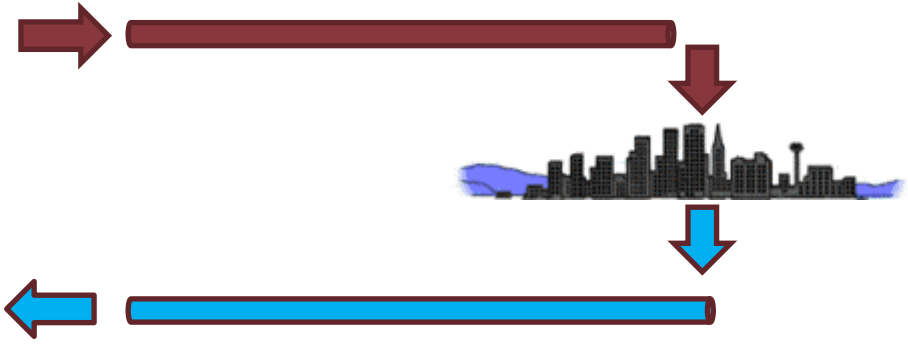
- Hot water can be used to either: run a turbine or district heating.

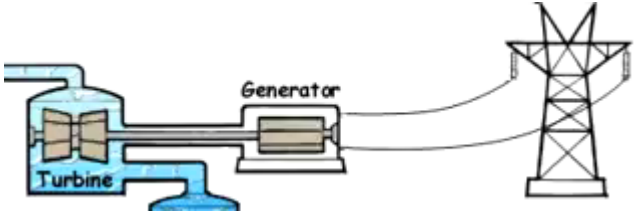




The internal power plant

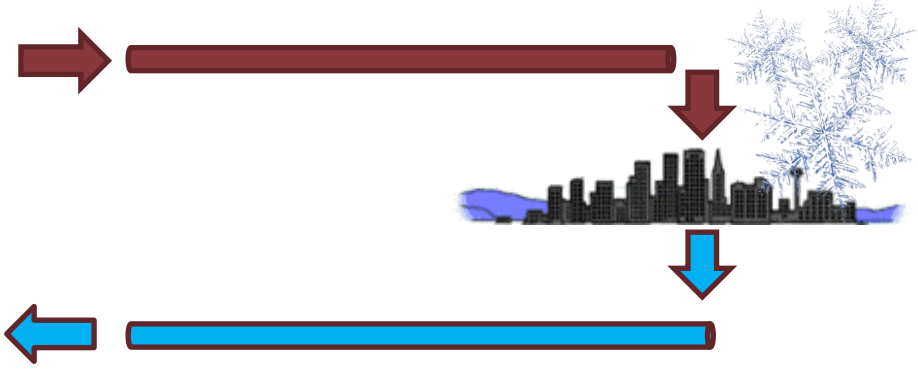
- Hot water can be used to either: run a turbine or district heating.

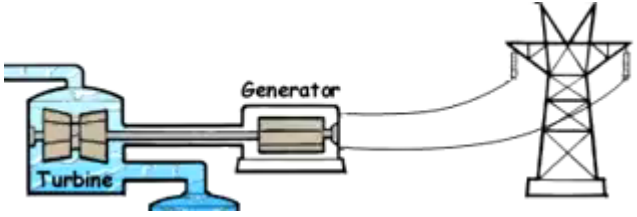




Thermal power plant

- In cold periods, the district might need more heat.





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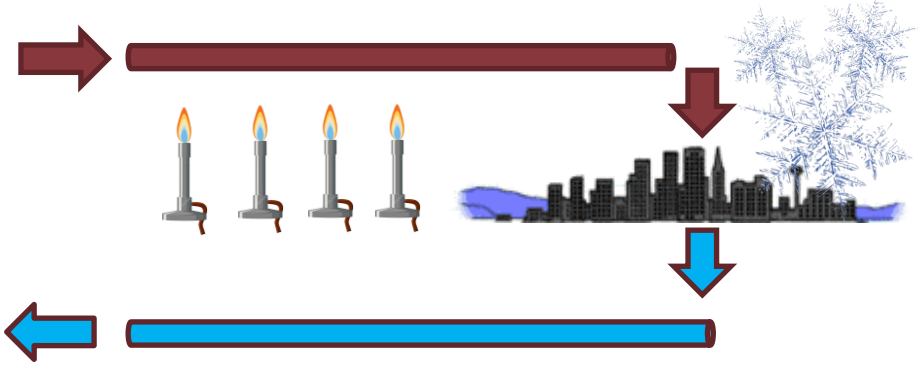
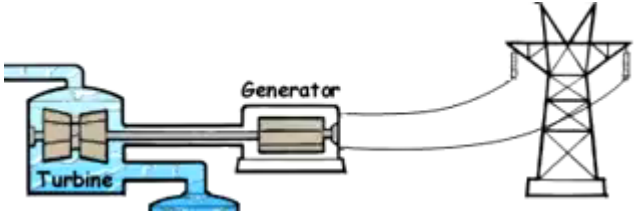
Thermal power plant

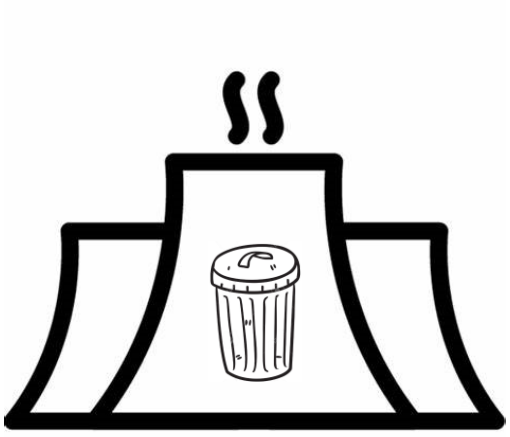
- In cold periods, the district might need more heat. Burn fuel to satisfy customers.

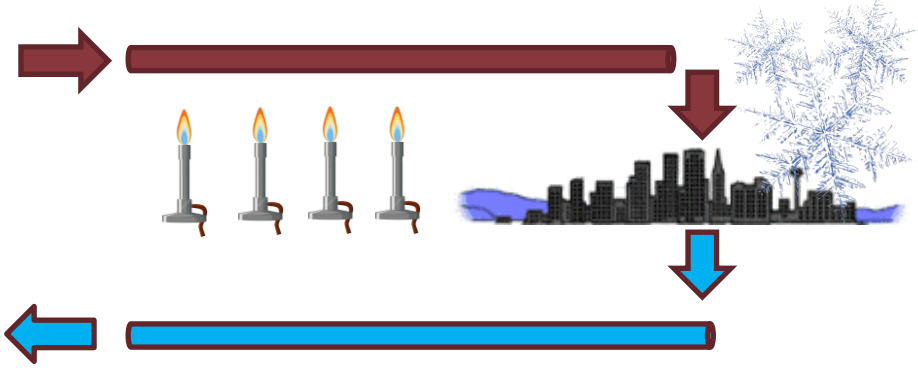


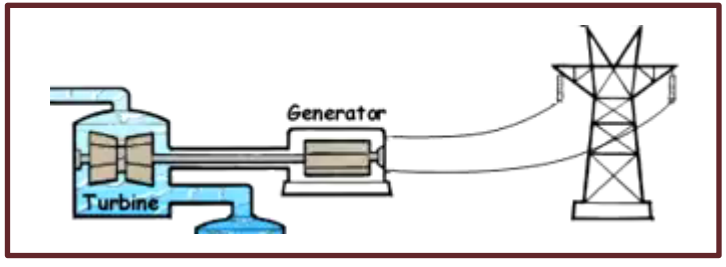


Thermal power plant

- **Two main decision problems: when to use the turbine**







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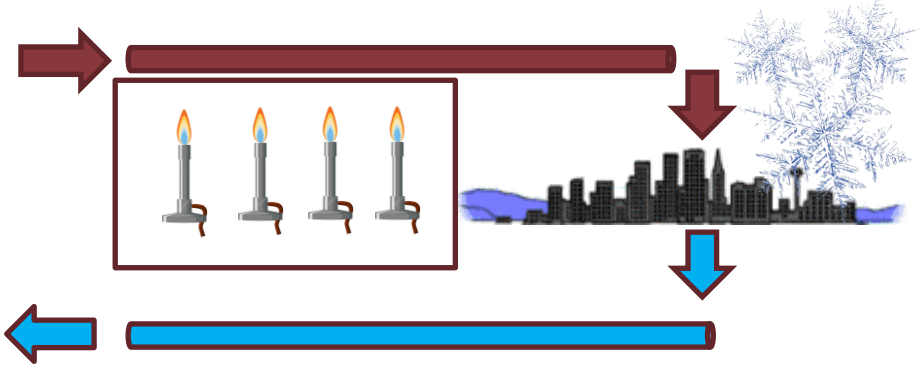
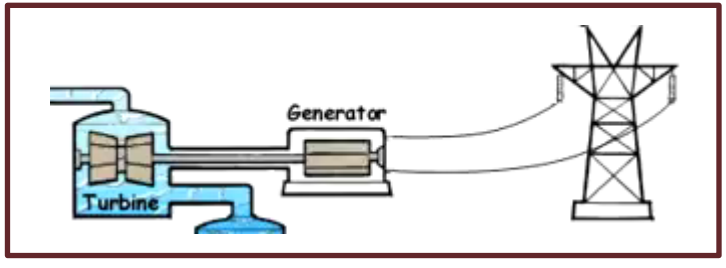
Thermal power plant

- **Two main decision problems: when to use the turbine and when to start the burners.**





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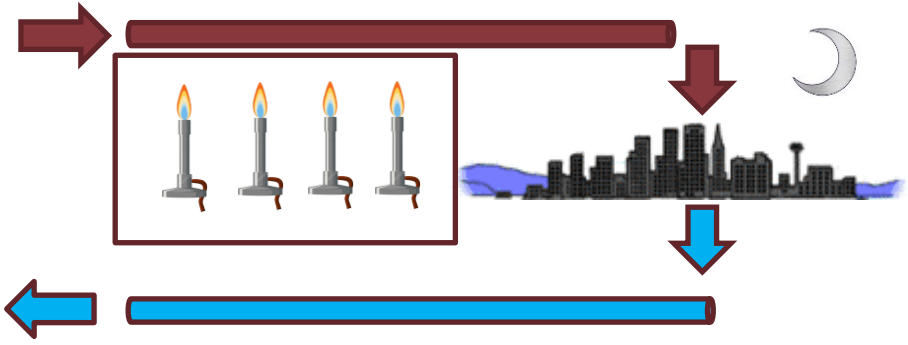
Problem #1 – when to start burners

- At night, when the need is low, heat is accumulated in the pipes.



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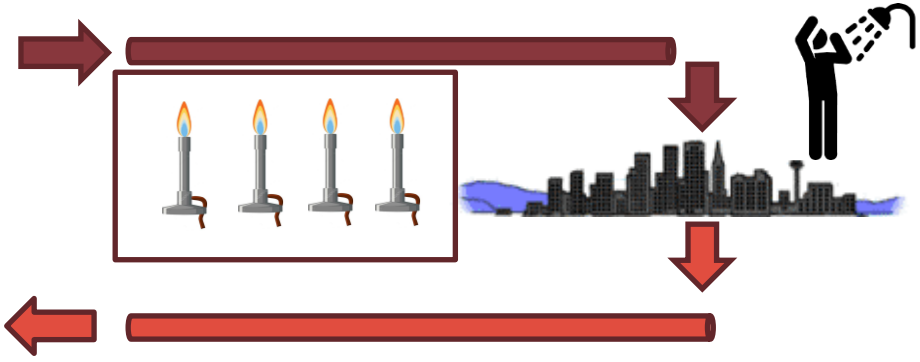
Problem #1 – when to start burners

- In the morning, this heat is spent.

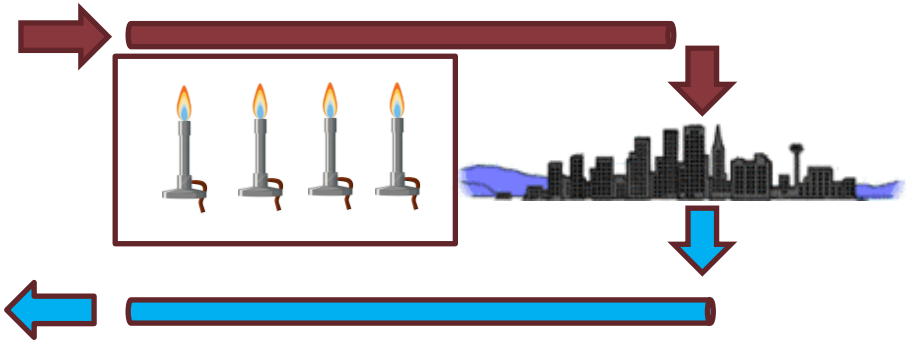


Problem #1 – when to start burners

- **As an operator, decide: Enough accumulated heat?**

Do nothing, risk running out of heat.

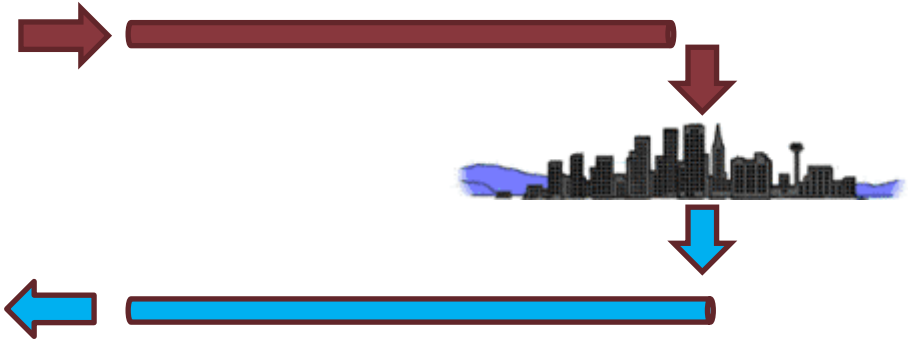
Start burners, risk wasting fuel.



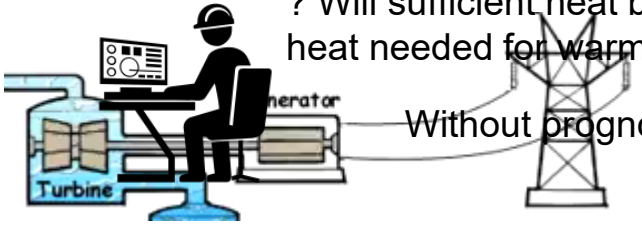
Without prognosis: Operator is conservative. Overuse of burners

Problem #2 – when to use turbine

- **Turbine turns heat into electricity (for sale).**



Startup time is 2~4 hours
Requires a lot of heat



? Will sufficient heat be available in 4 hours? Risk using heat needed for warming.

Without prognosis: Starts late and shuts down early.

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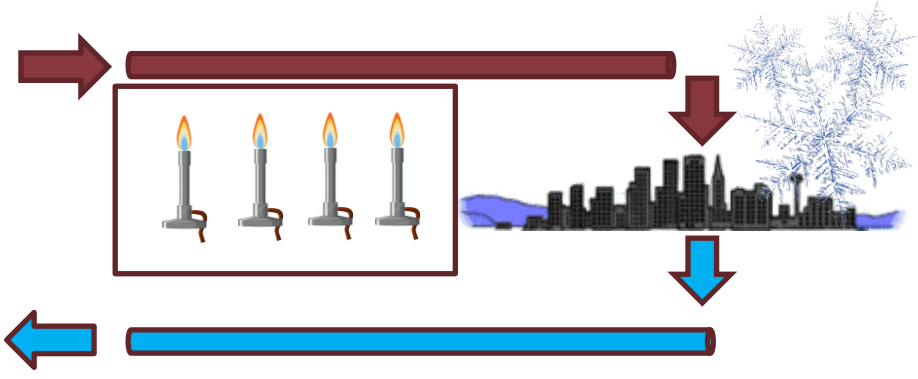
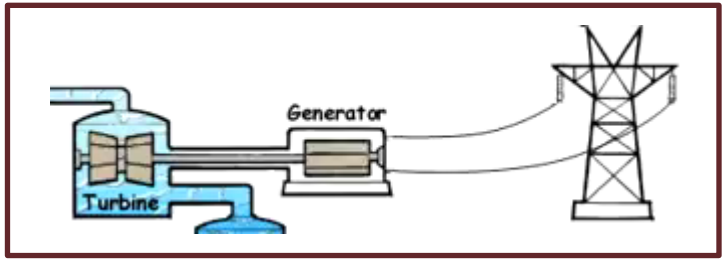
Business Case - Prognosis

- Both of these decisions become easier if you know how much heat is required tomorrow.





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Creating a forecast model

- Using a database of 65000 hours of recorded customer usage.
- Weather data from 2011-2018 from Yr.
- Some engineered features regarding time

- We applied a neural net based on Long Short Term Memory.
  - This was super hot in 2016
  - Now seemingly outdated

- We created a back-end engine that continually produce new forecast and serves them to power plant operators.

Key Components

Azure Data Lake for storage

Stores 66 000 datapoints at 1hz resolution
Cheap and reliable

Databricks for datawrangling

Easy Spark installation
Delta Lake has been very useful

Modelling in tensorflow

Tensorflow.Keras gave us LSTM models
Later models in project also used XGBoost

Mixed Integer Programming in Google OR-tools

Used in combination with ML models. Very easy to implement and solve MIP problems.

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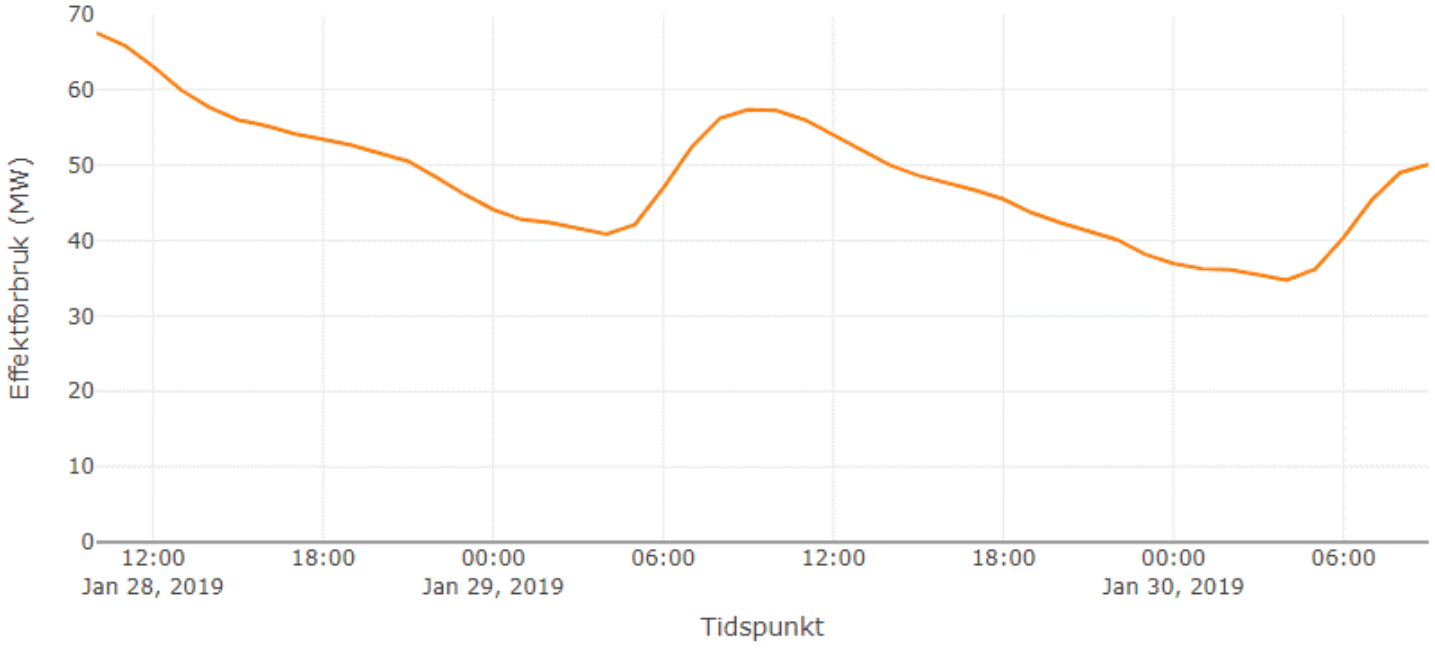
Building a forecast model



Good accuracy given good weather predictions.

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Using a forecast model

- Armed with a forecast model:
  - Operators braver – use accumulated energy more often. Reduced use of fossilized fuel.
  - Operators more focused on using the turbine.

- However:
  - System still required deep domain knowledge from the operator
  - In-experienced/new operators struggled to adopt technology

- Second generation:
  - Created an expert system, calculating exactly when to start and when to stop turbine

- Third generation:
  - Used forecast together with Mixed Integer Programming to calculate optimal mix of fuel.

«The cat» - Expert system for turbine

Turbinrådgivers anbefaling:

Kjør turbin

Stopp turbin

Anbefalt start	Anbefalt stopp
Ukjent Ukjent	Ukjent Ukjent

Strømpris	Inntekt siste 24 timer
5 øre/kWt	0.00 NOK

Buffer	Forventet produksjon
0.0 MW	60.0 MW

Why did it work

- There is relatively few random variables in the system.
- Domain knowledge experts were present and very interested throughout the project.
- Willingness to challenge existing knowledge

Environmental benefits

- What can you do to help reducing emiss

Buy an electric car
(~400 kg CO2)

Give up meat
(~650 kg CO2)

Do ML
(~250 000 kg CO2)

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Take away

- **Small machine learning projects can be local and economically viable.**
  - **Real results appeared after ~ 3 months of work.**
  - **Project investment cost recovered within 1 year.**

- **Solutions must be:**
  - **integrated in customers existing software (this is time consuming)**
  - **very easy to use**

The end ☺

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