KEVIN CAYE

THOMAS KARAOUZENE

LA TRANSFORMATION DIGITALE ✋ DU MONDE DE L'ÉNERGIE

TECH WEEK

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Data science in energy industry

Data science in energy industry

40% of the mondial energy consumption

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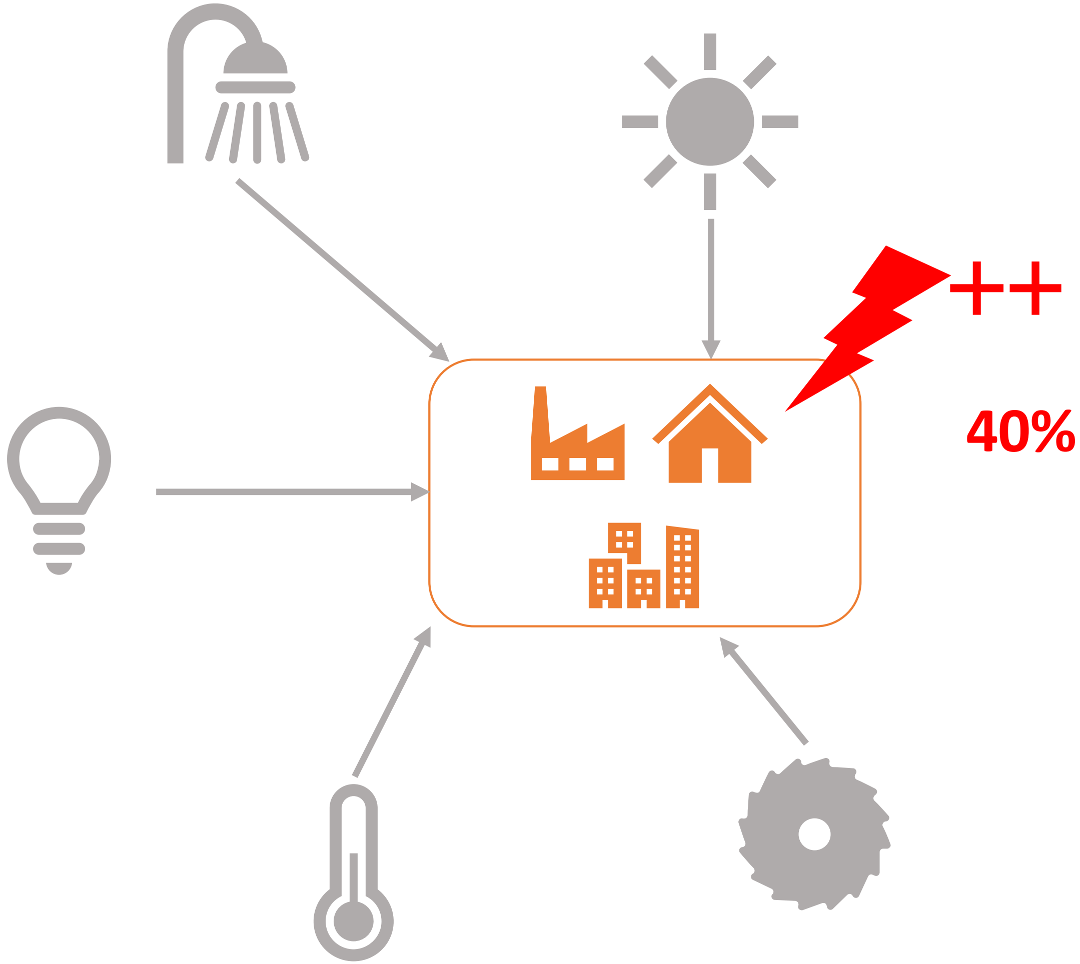
Data science in energy industry



40% of the mondial energy consumption

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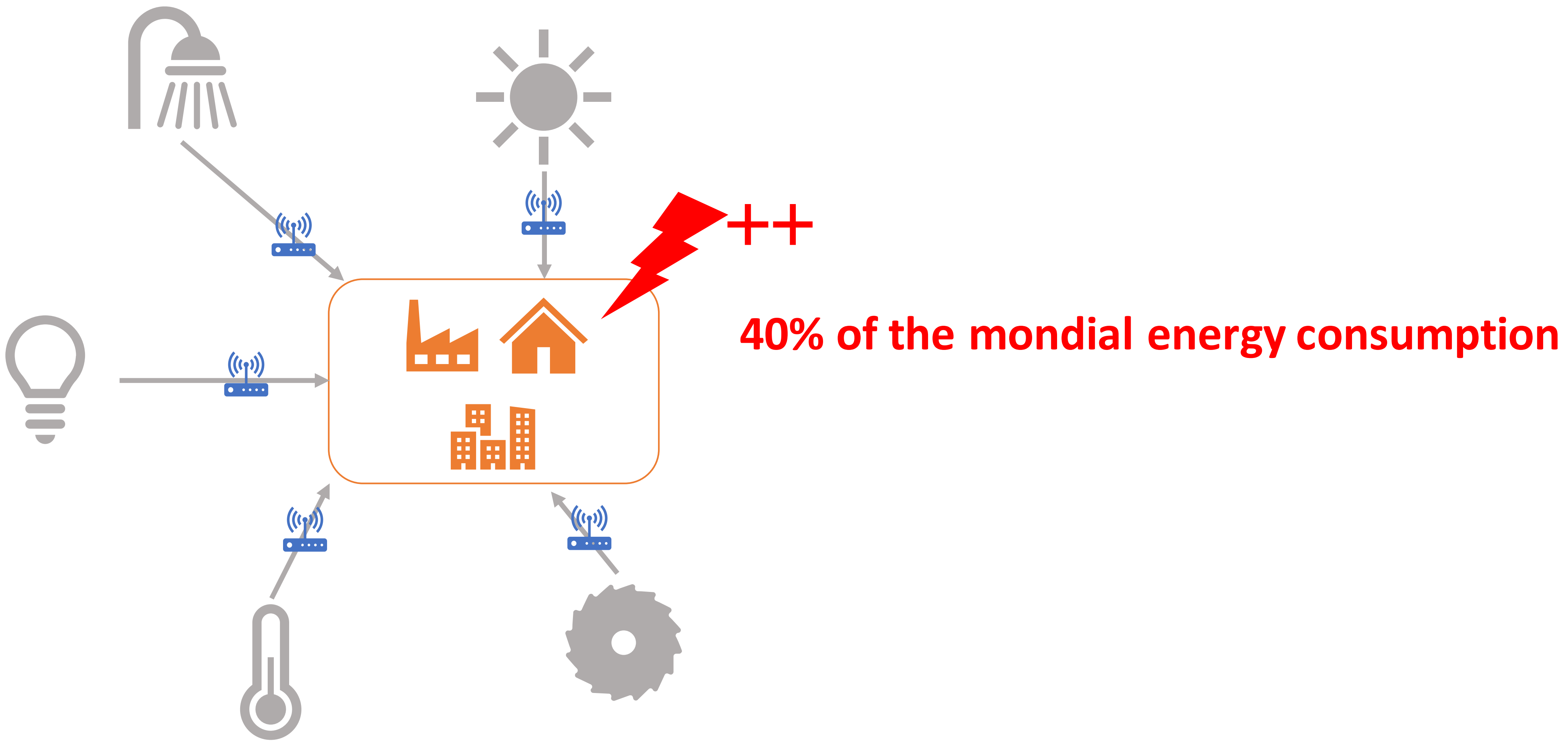
Data science in energy industry



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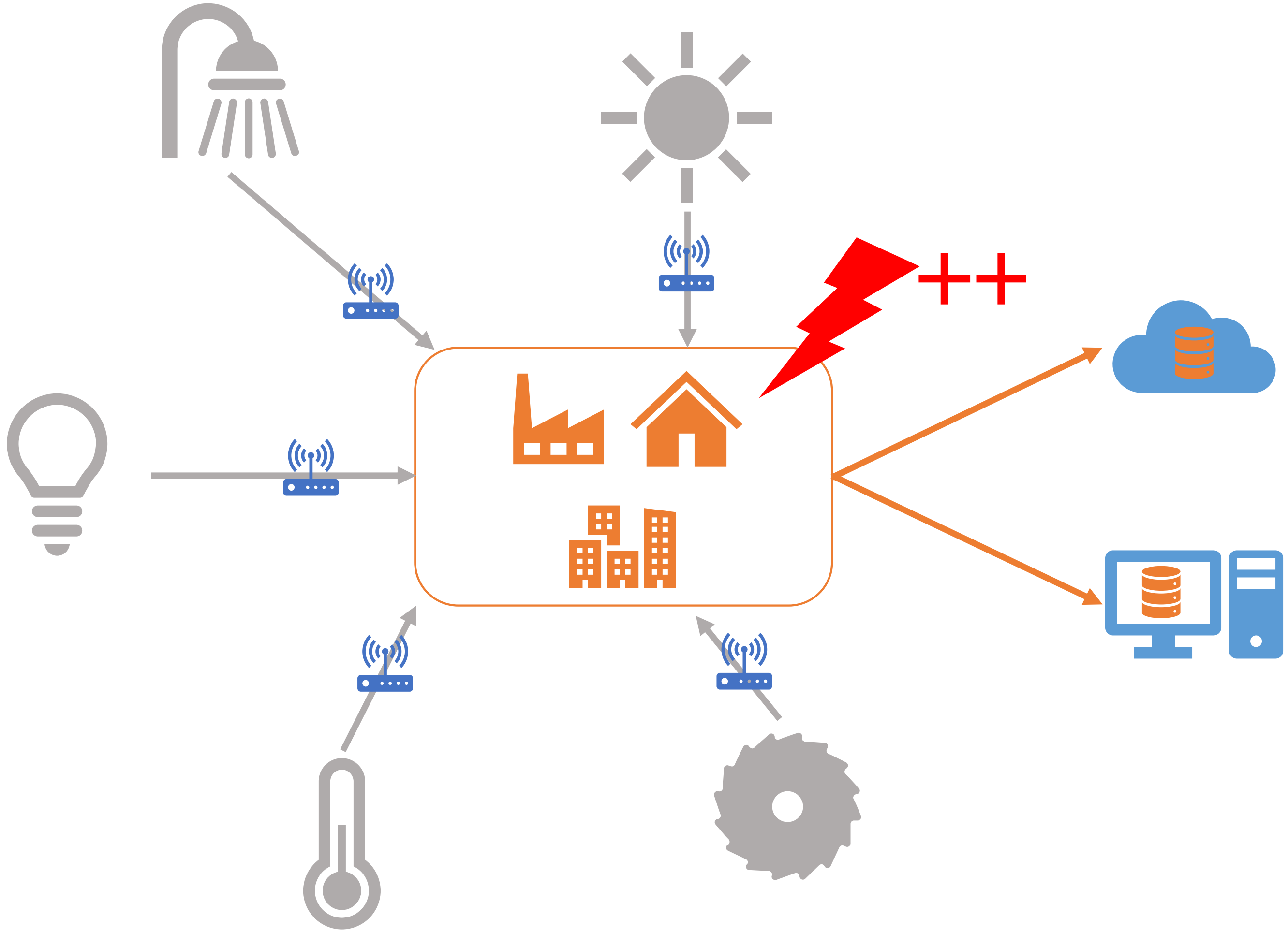
Data science in energy industry



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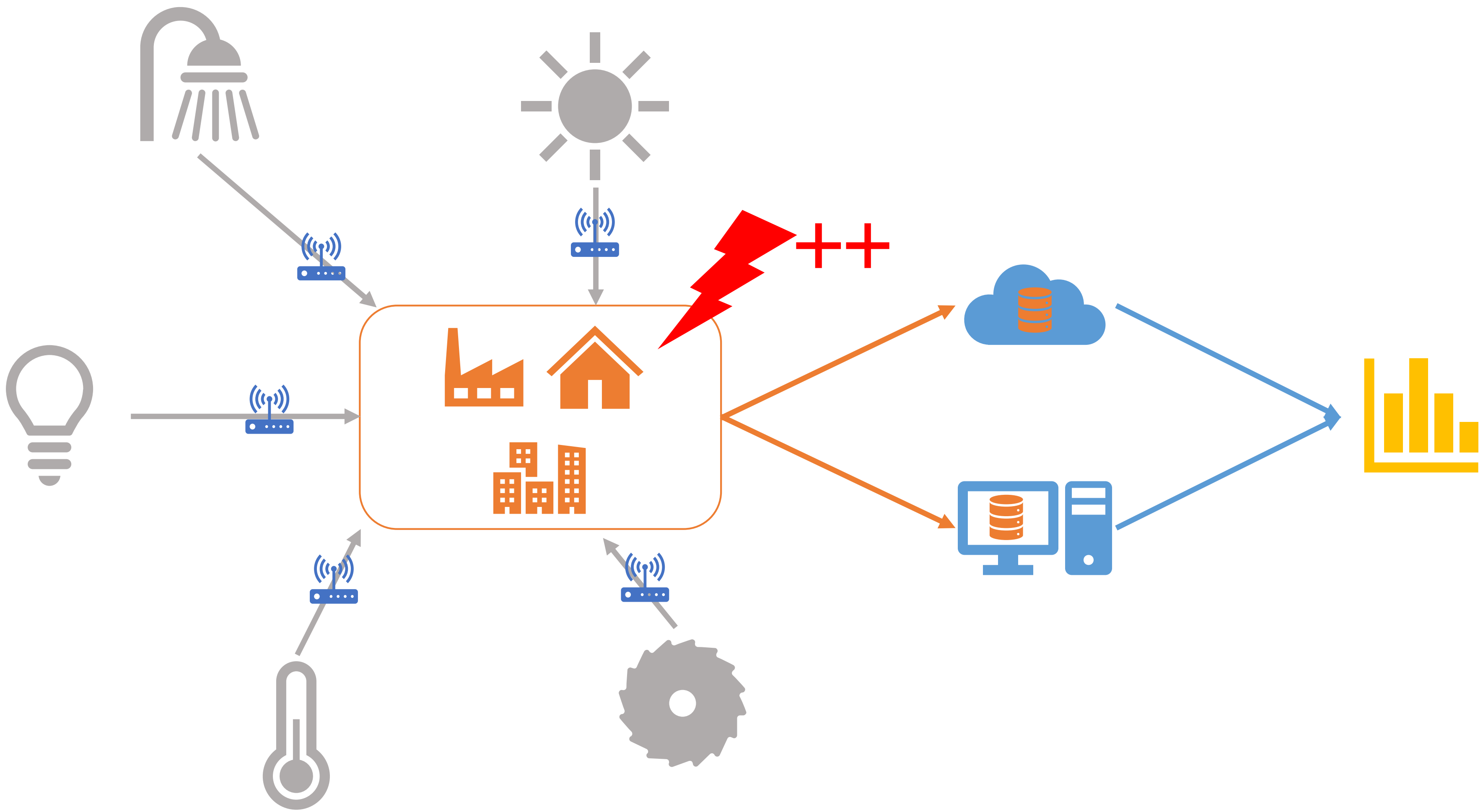
Data science in energy industry



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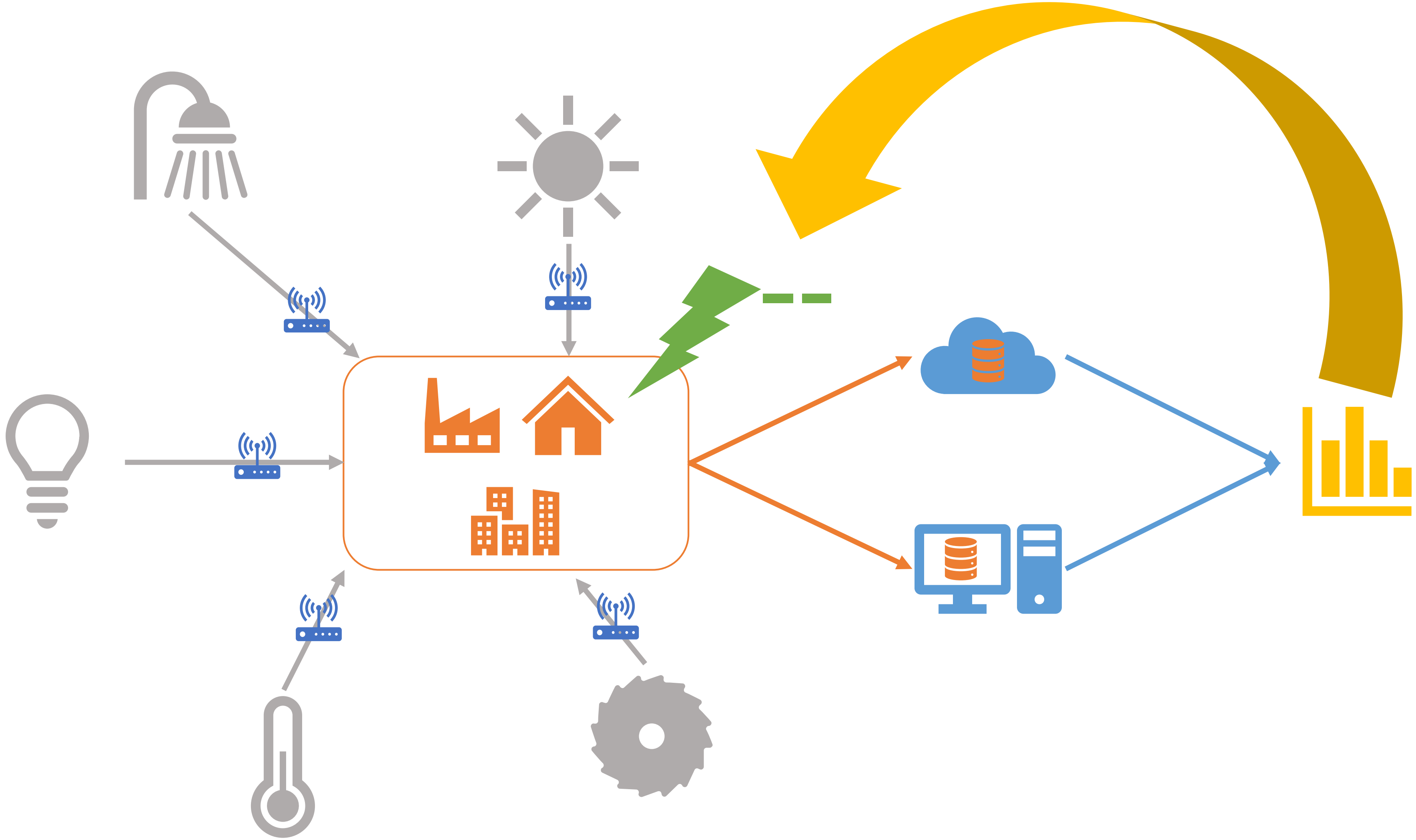
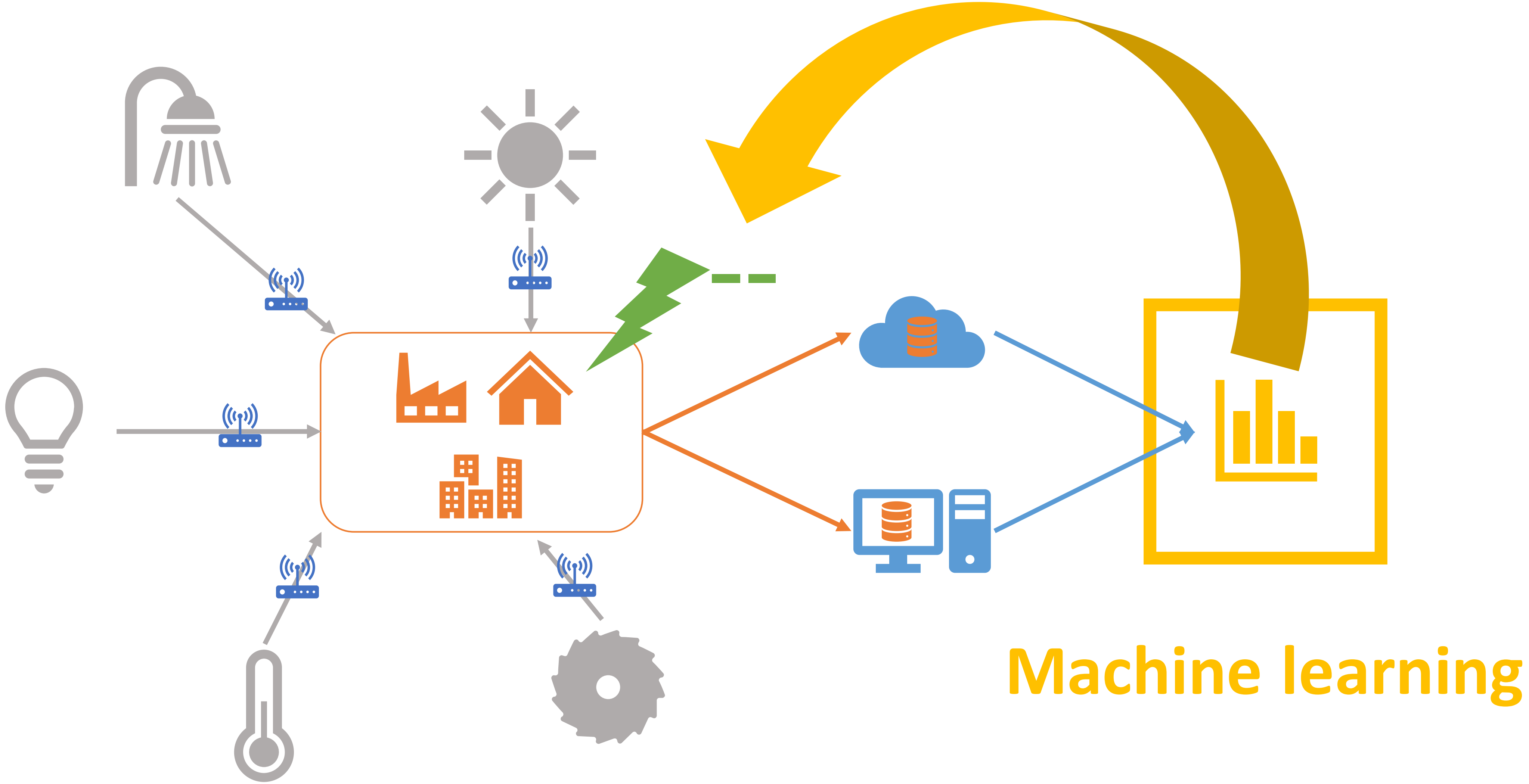
Data science in energy industry



Data science in energy industry



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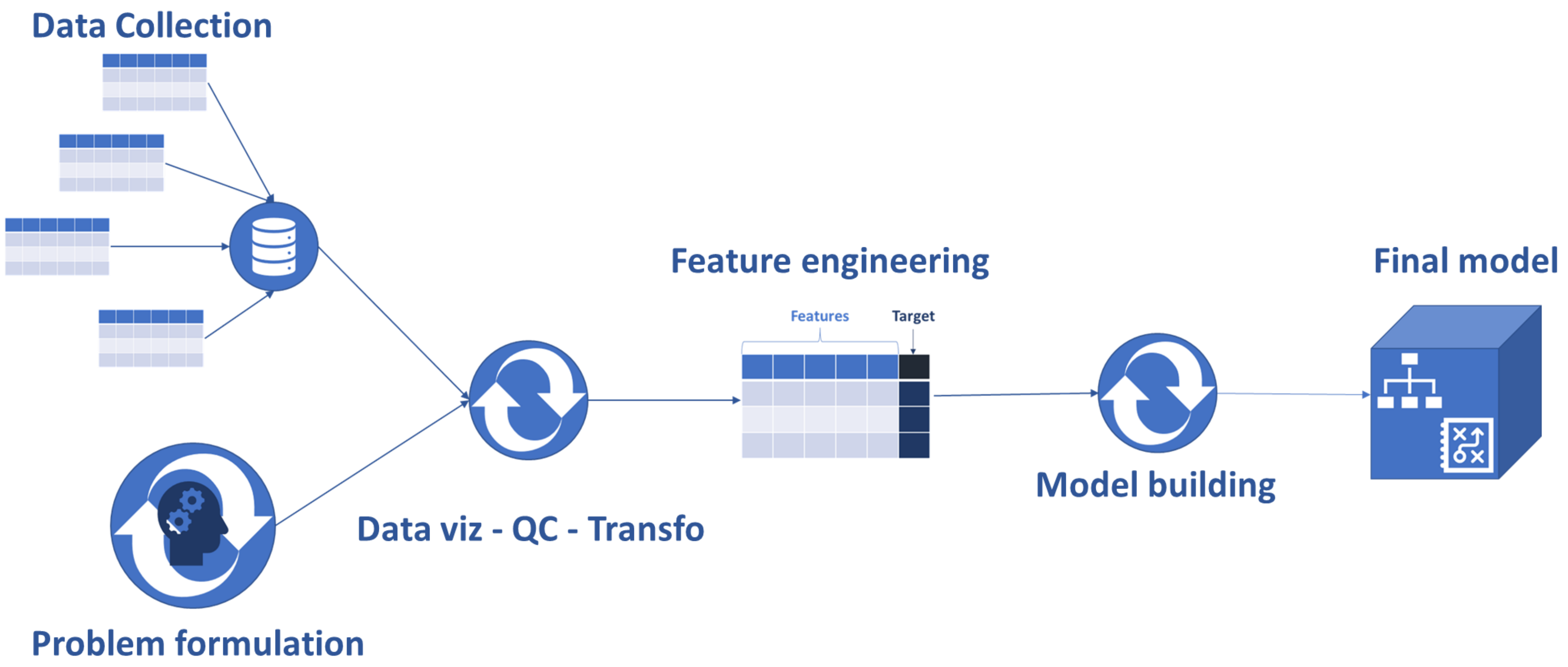
Machine learning challenges



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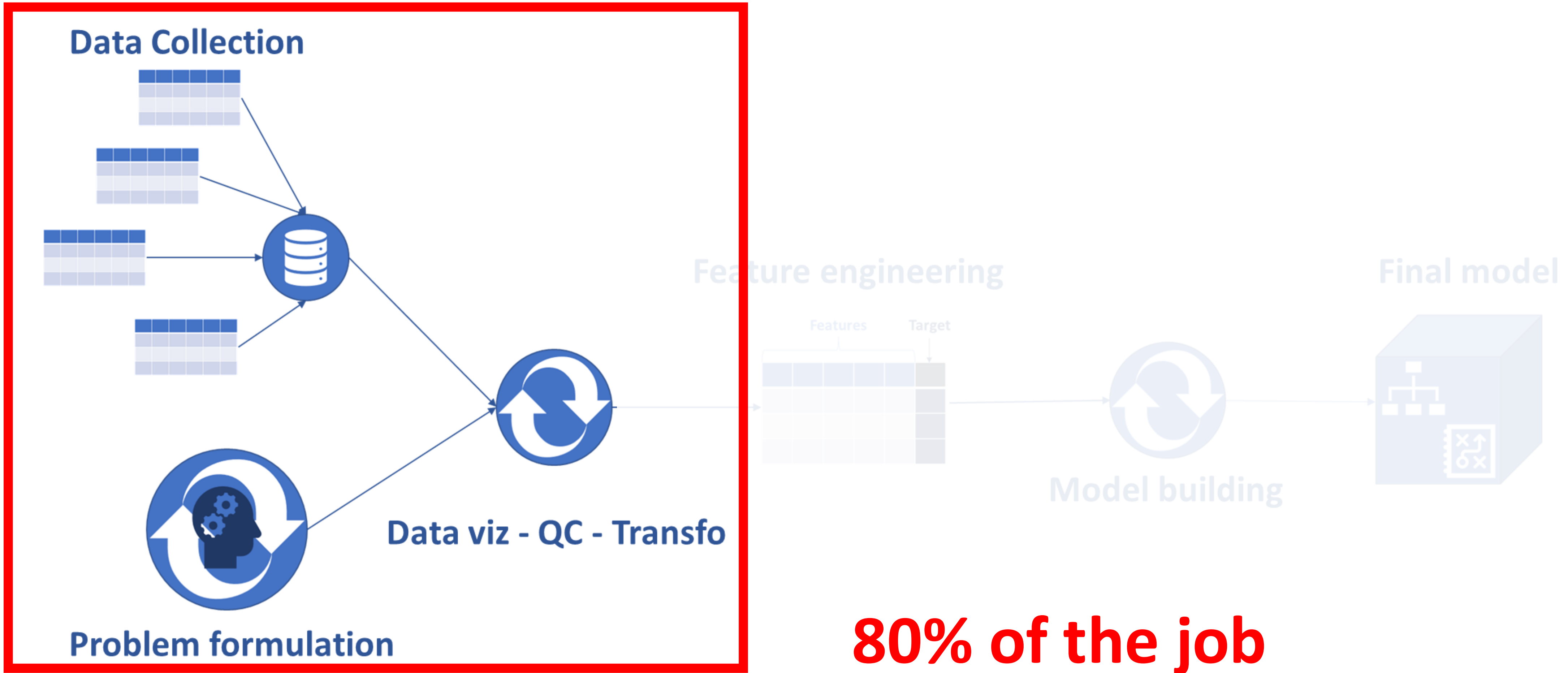
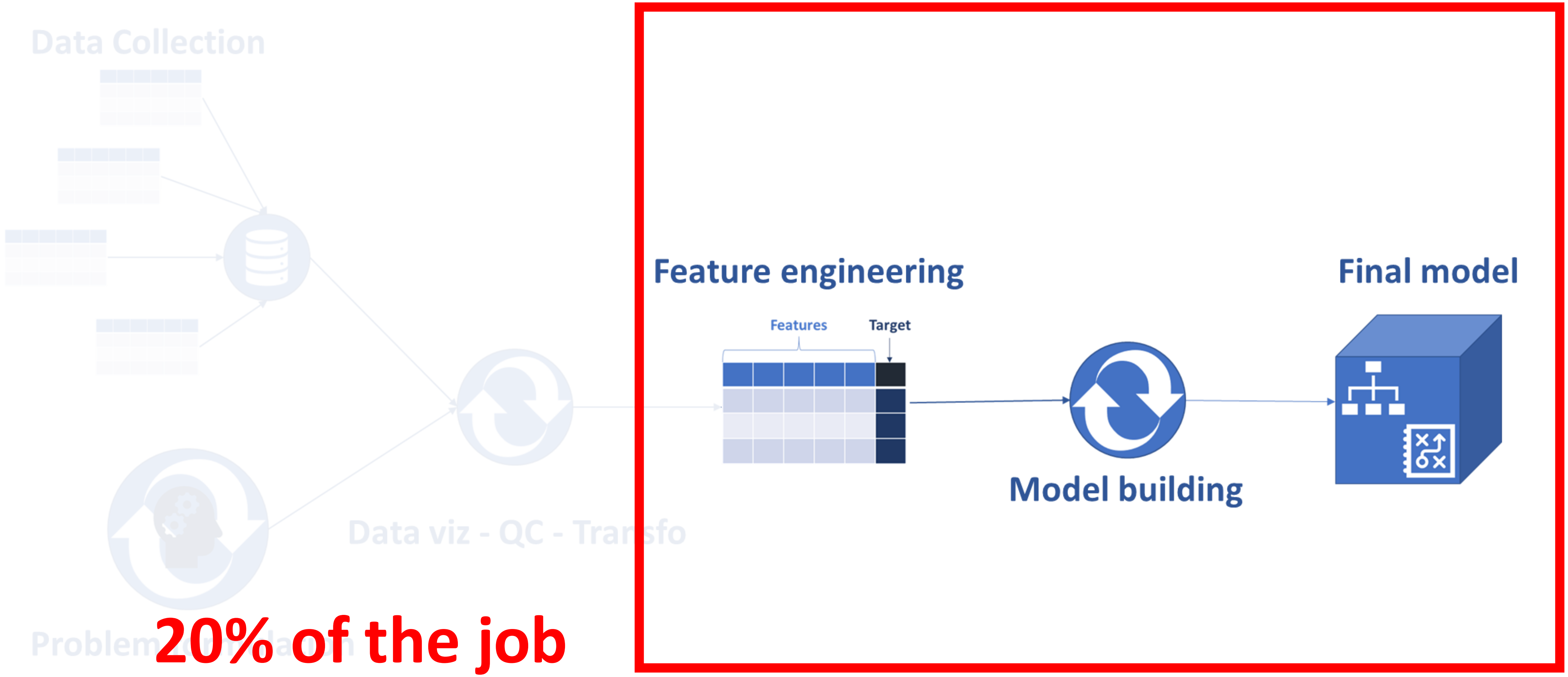
Machine learning challenges



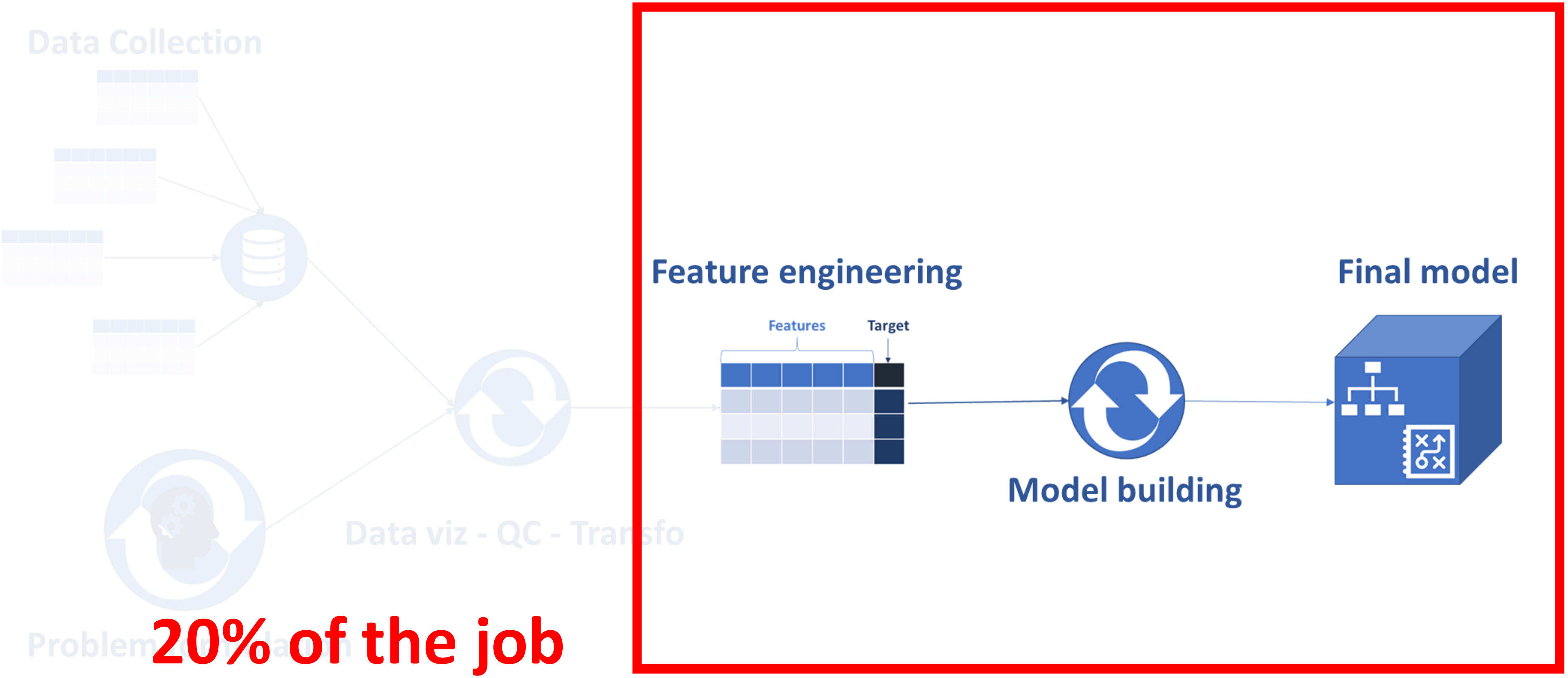
80% of the job

Machine learning challenges



20% of the job

Machine learning challenges



20% of the job

→ **Suitable for competitions**

Quick Facts

PARTICIPANTS	1,034
NO. OF ENTRIES	1,332
PRIZE	€23,000

Quick Facts

PARTICIPANTS	355
NO. OF ENTRIES	170
PRIZE	€23,000

Quick Facts

PARTICIPANTS	1,034
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Why ?

- Critical role in energy efficiency
- Optimize operations of chillers, boilers and energy storage systems
- Baseline for flagging potentially wasteful discrepancies

⇒ Forecasting the use of the electrical energy is the backbone of effective operations

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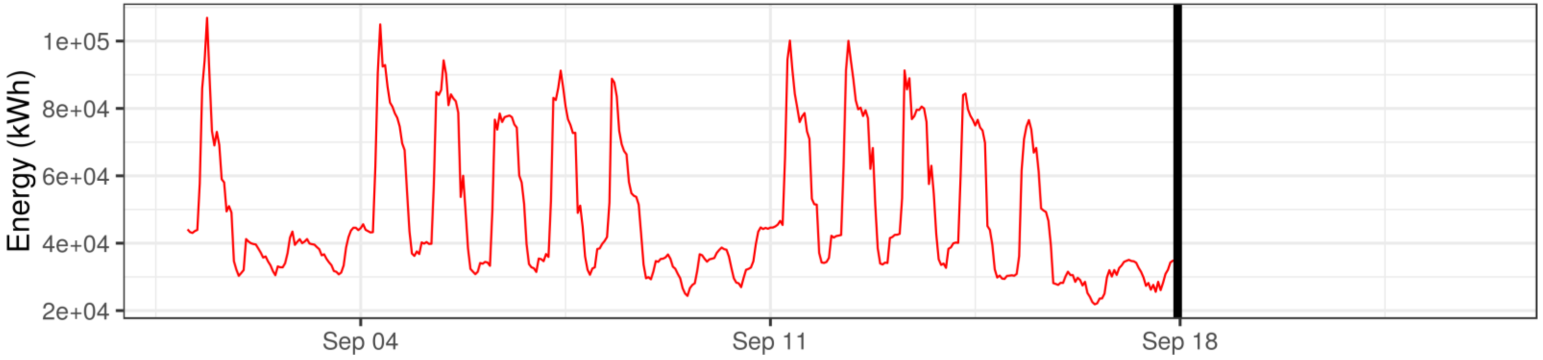
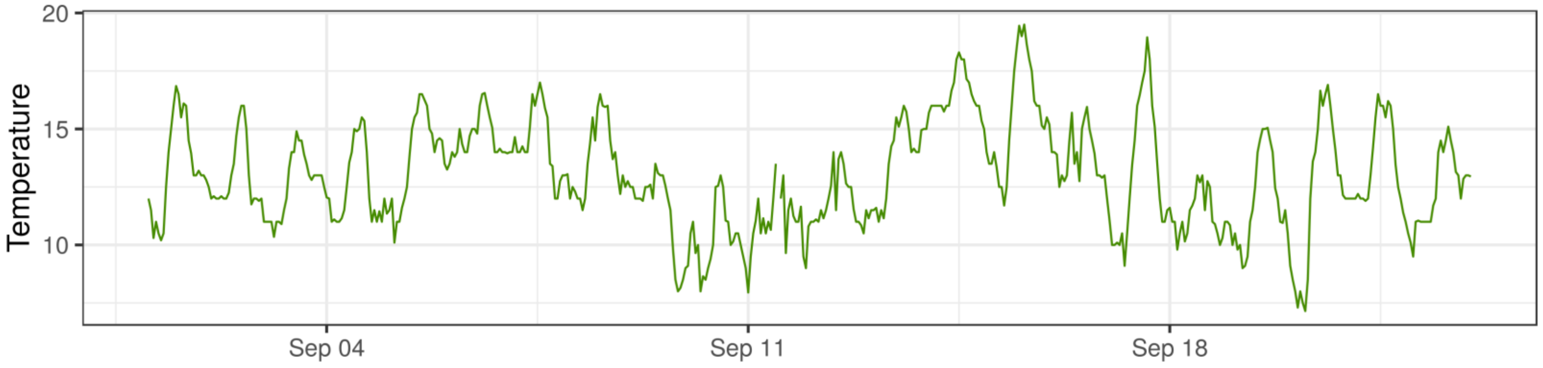
Forecasting building energy consumption





Competition Data

- Energy consumption historic for ~200 buildings
- Temperature

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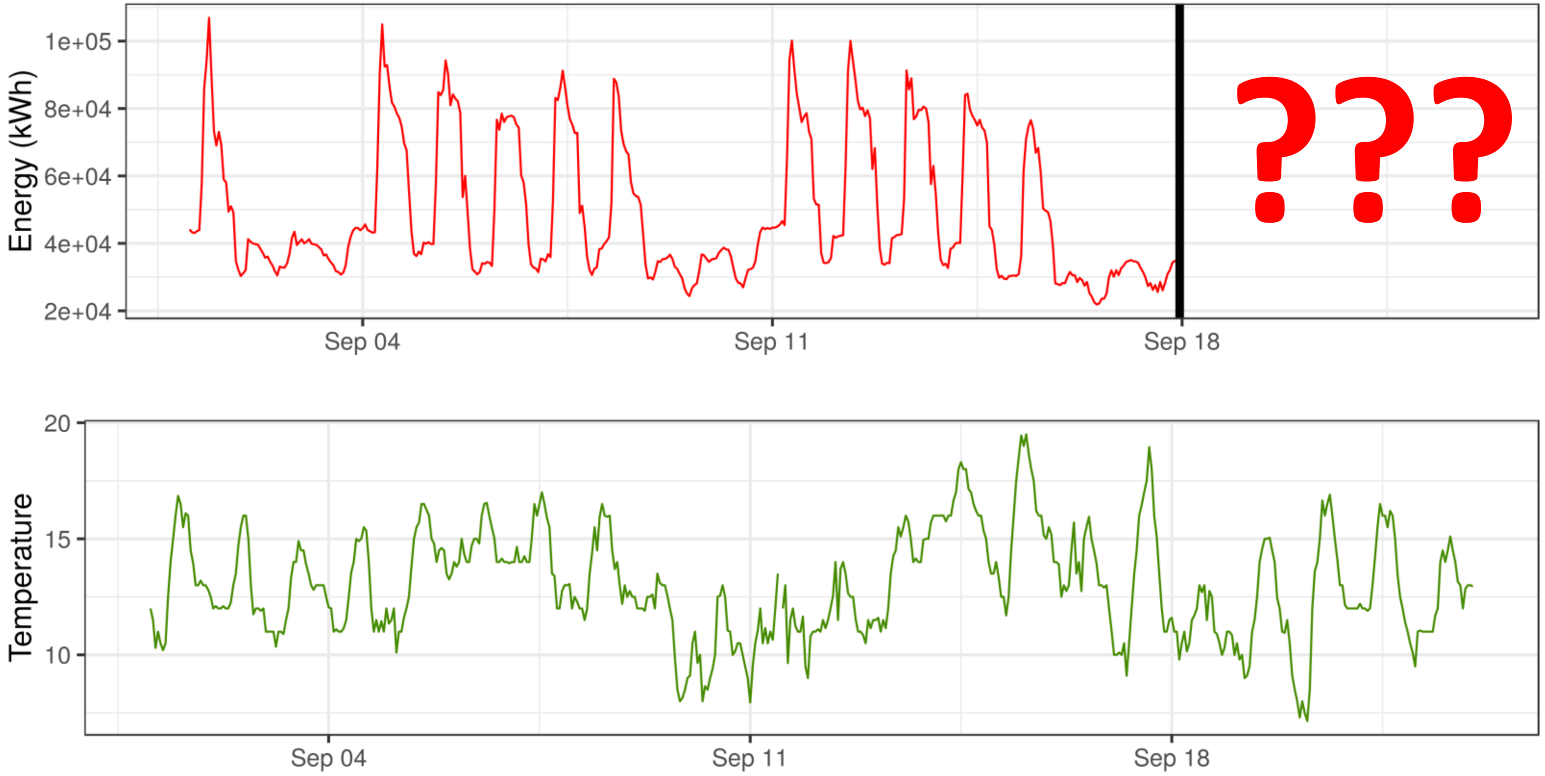
Forecasting building energy consumption



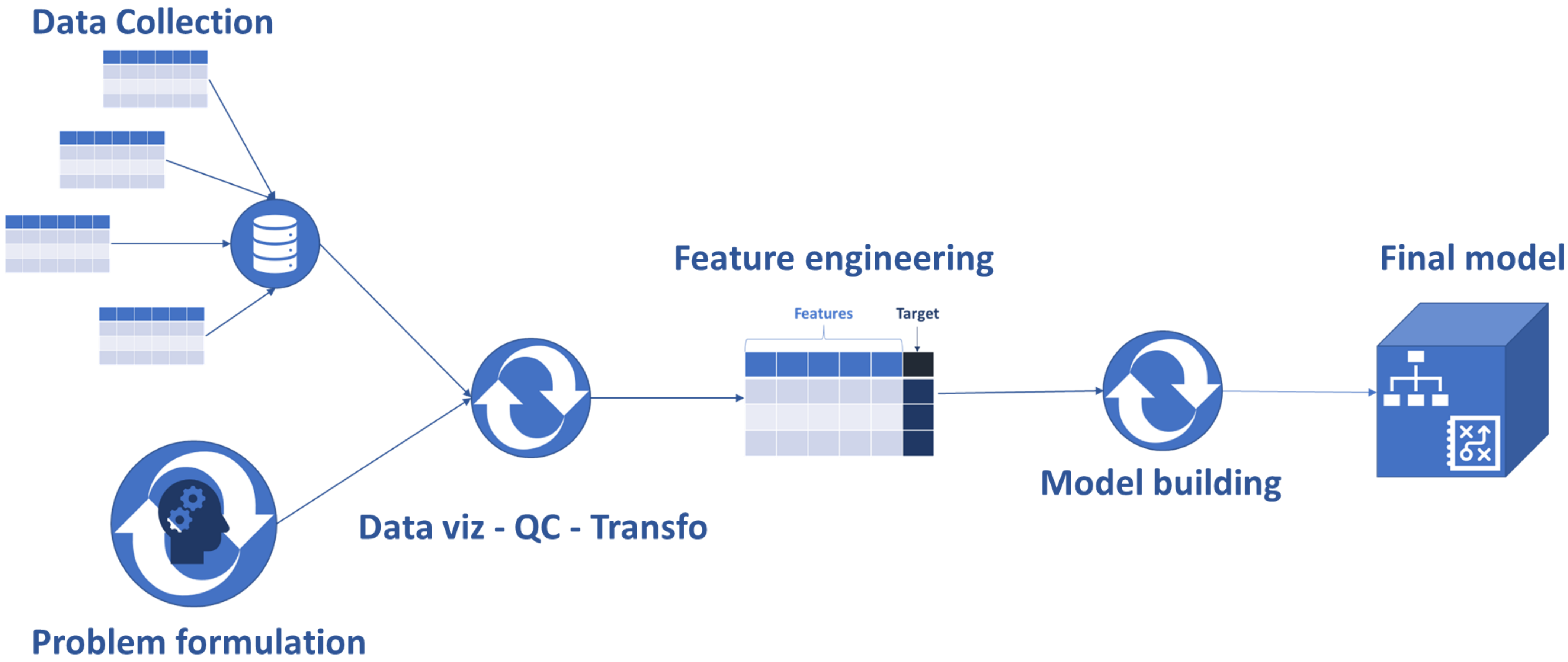
Competition Data

- Energy consumption historic for ~200 buildings
- Temperature

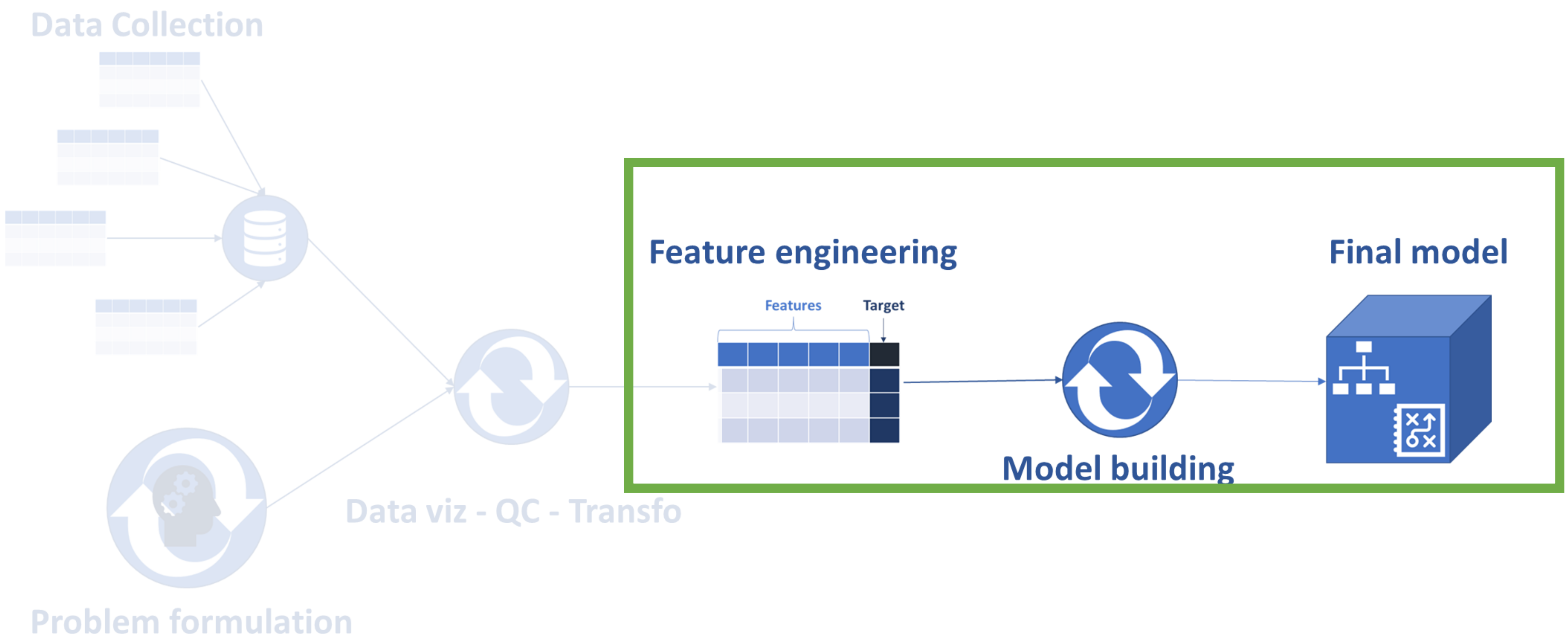
Competition Objective

- Forecast Energy consumtption through different horizons

Winner solution



Winner solution



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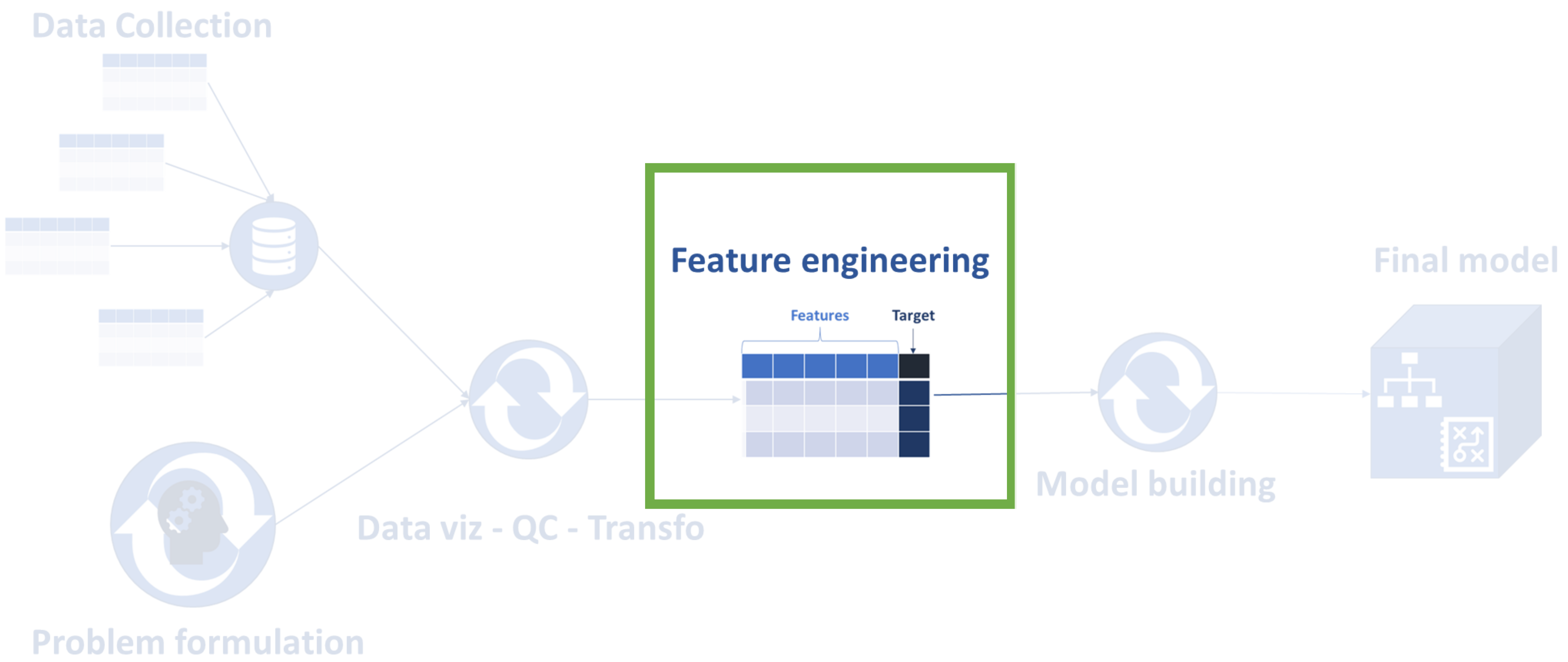

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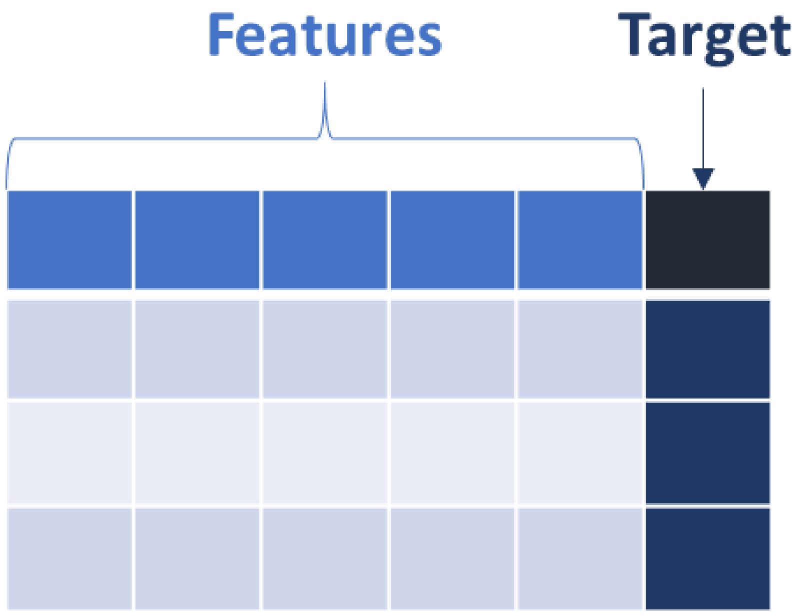
Feature engineering



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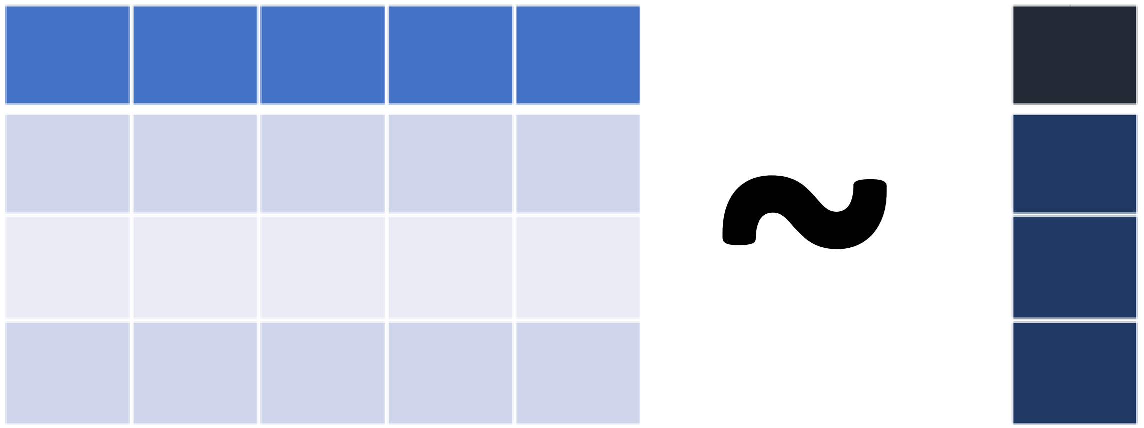
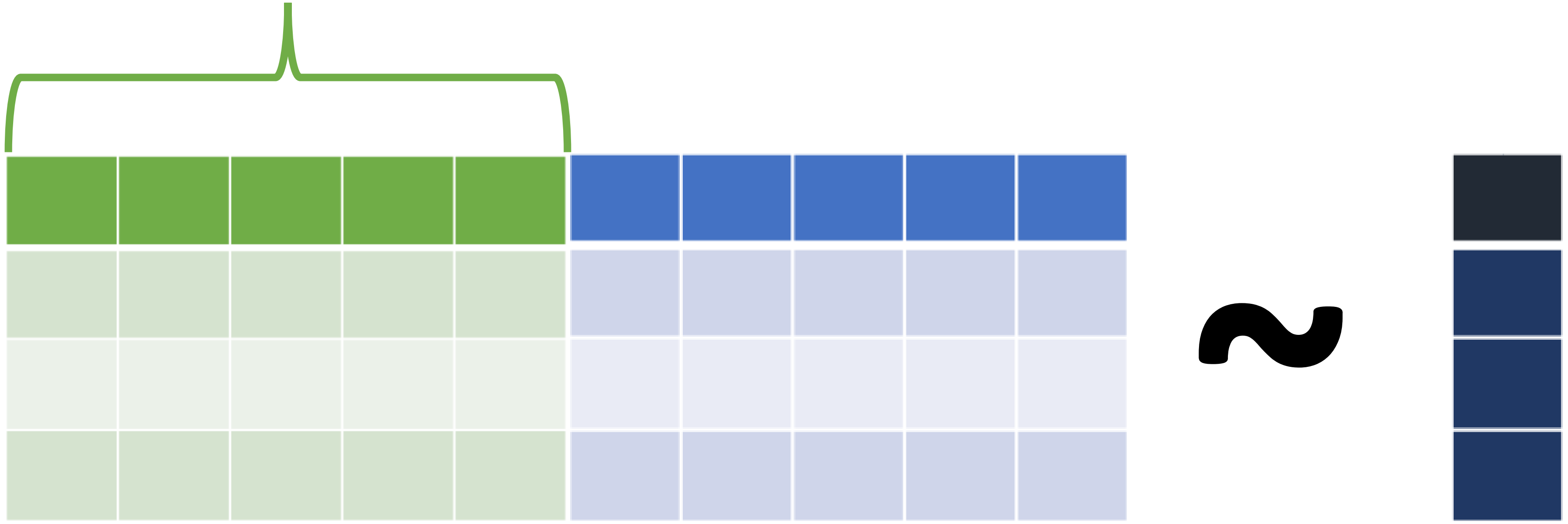


$$X \sim y$$

Feature engineering

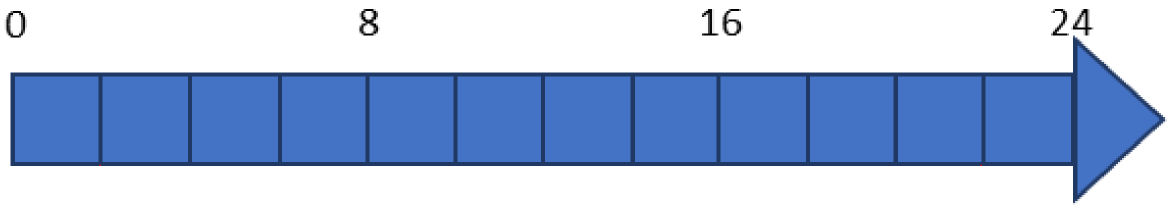
Engineered features



$X \sim y$

Feature engineering

Cyclical time encoding



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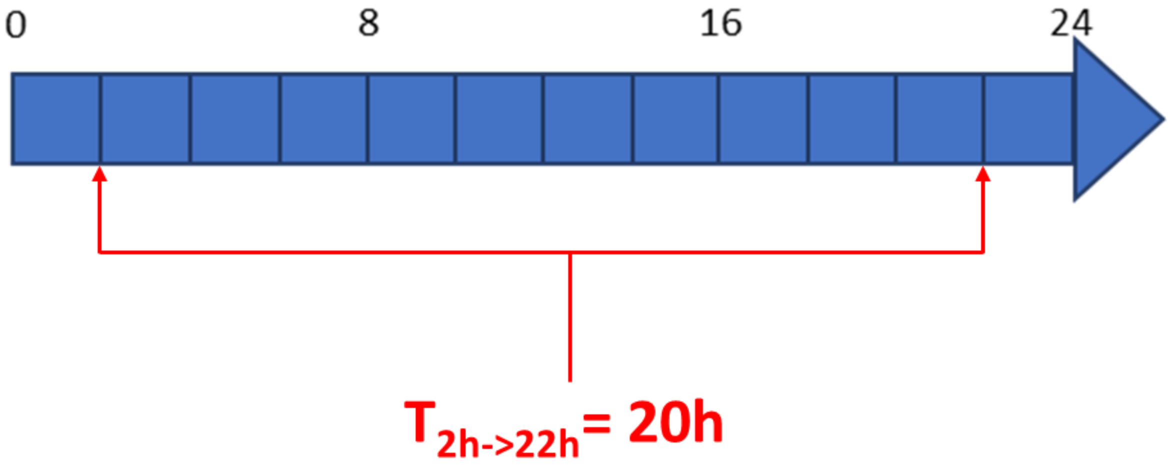
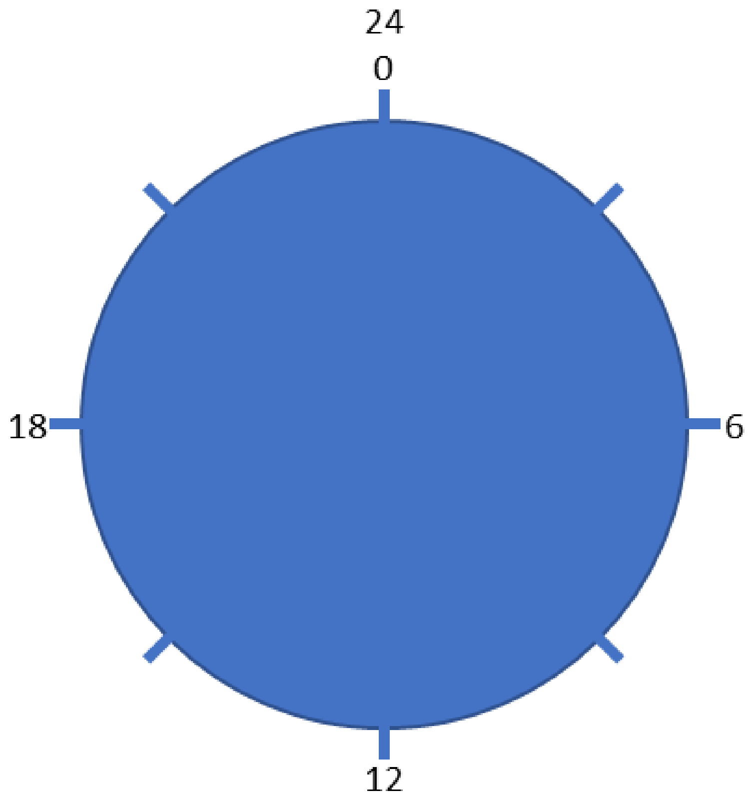
Feature engineering

Cyclical time encoding



Feature engineering

Cyclical time encoding



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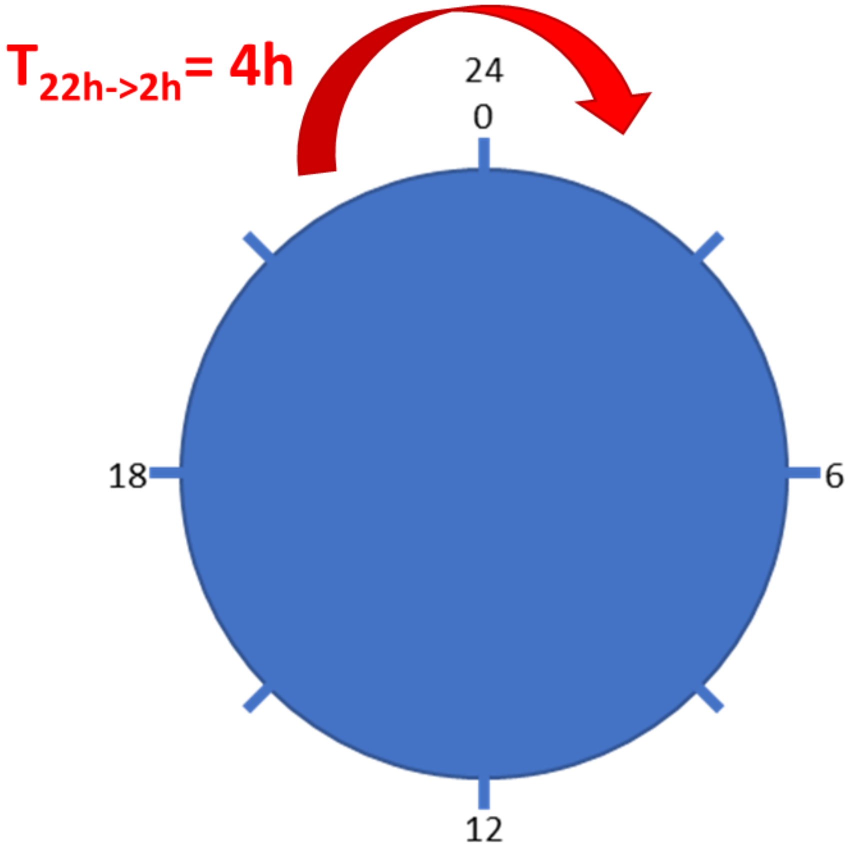
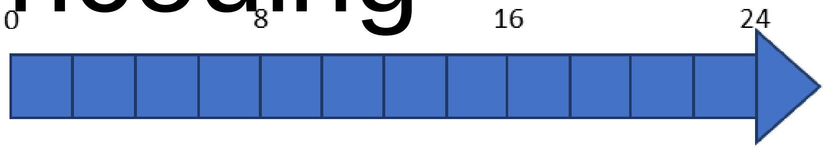
Feature engineering

Cyclical time encoding



Feature engineering

Cyclical time encoding



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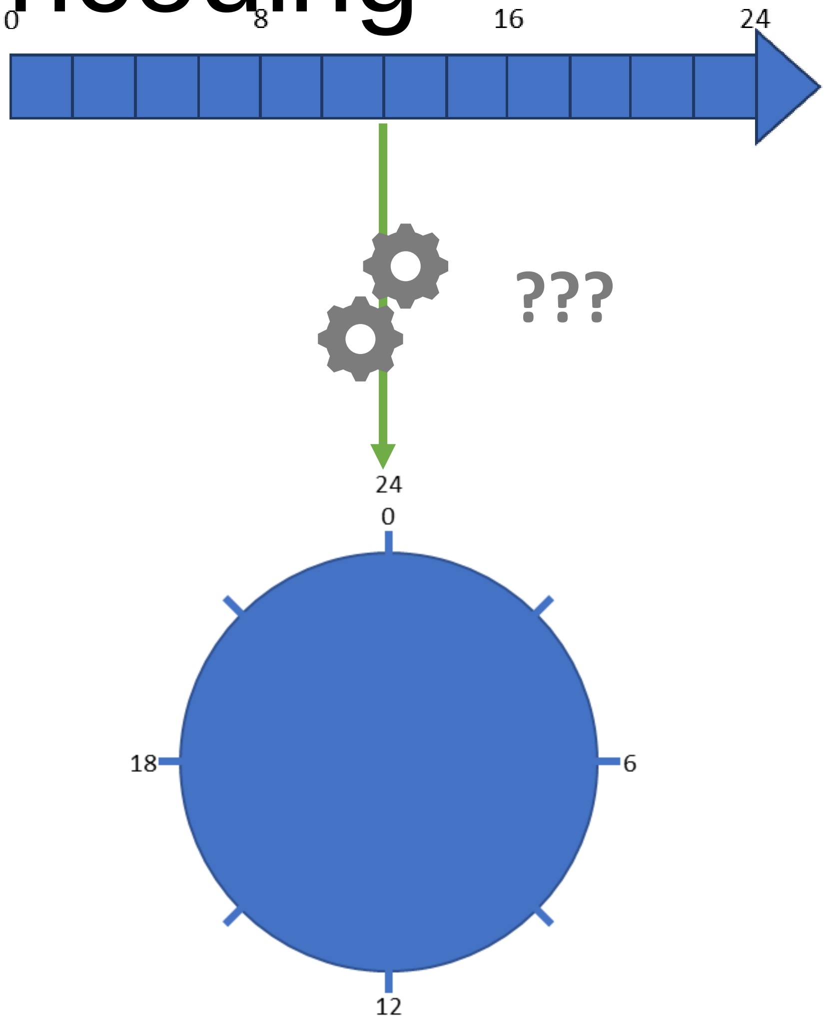
Feature engineering

Cyclical time encoding



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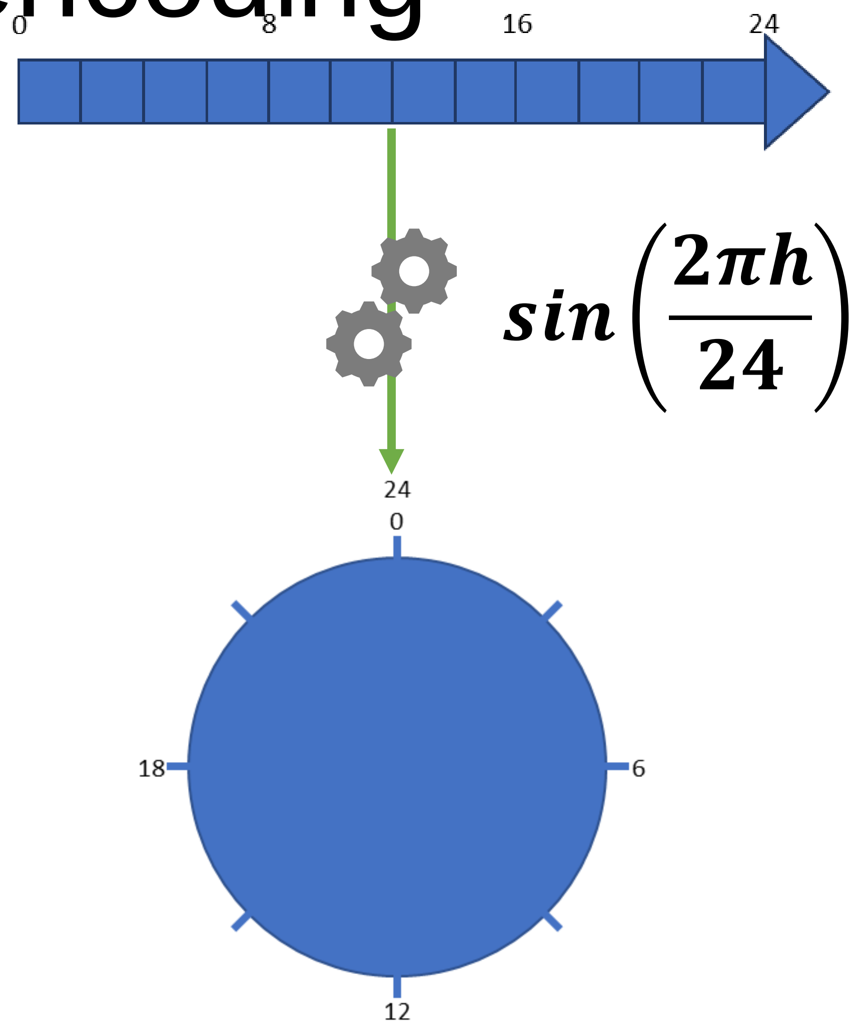
Feature engineering

Cyclical time encoding



$$sin\left(\frac{2\pi h}{24}\right) \quad \& \quad \cos\left(\frac{2\pi h}{24}\right)$$

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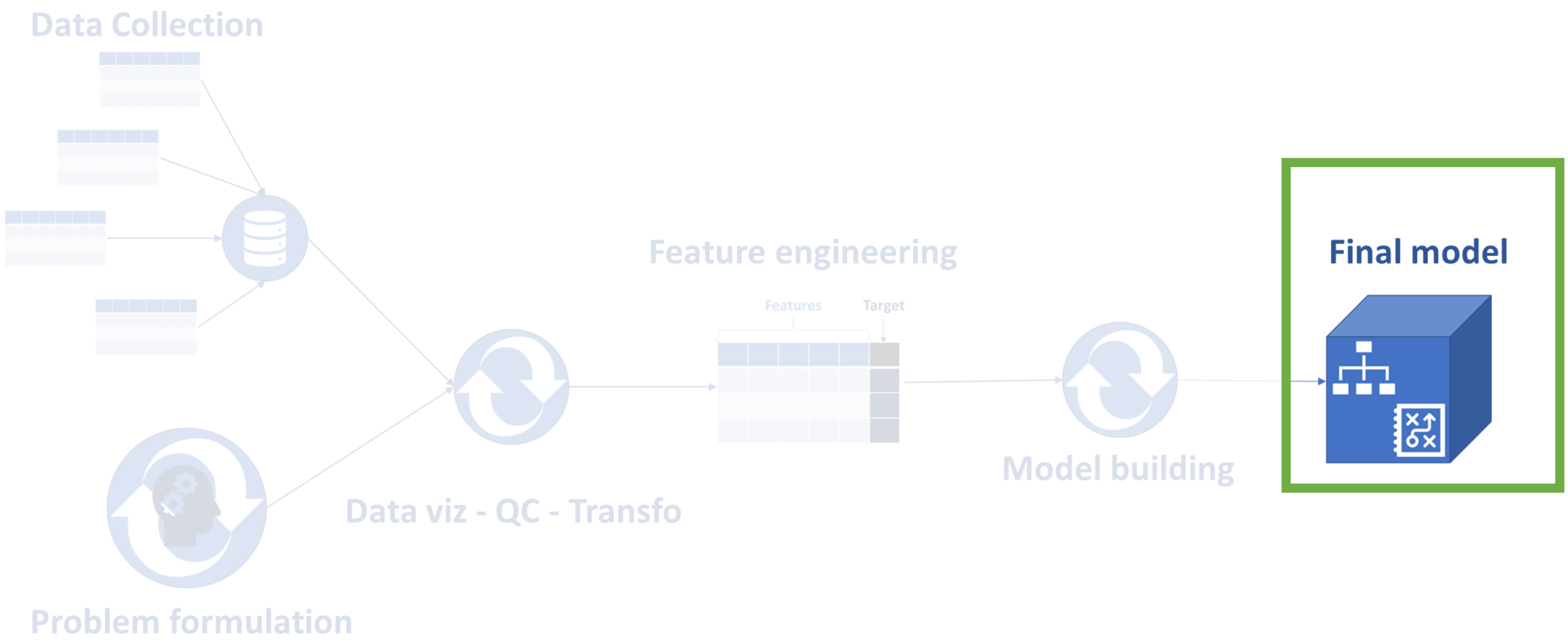
Winner solution



Winner solution

Final model

Boosted trees

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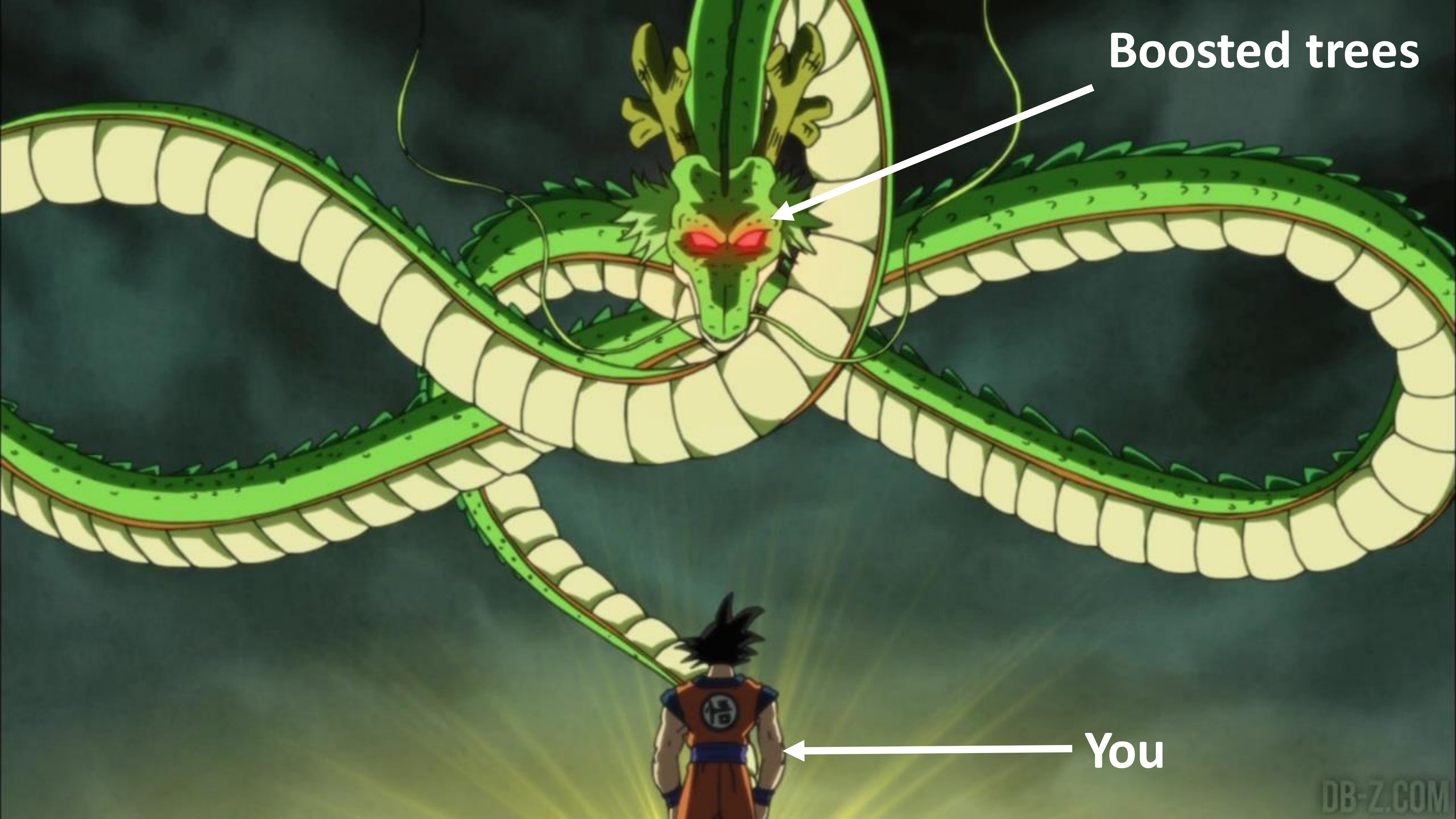
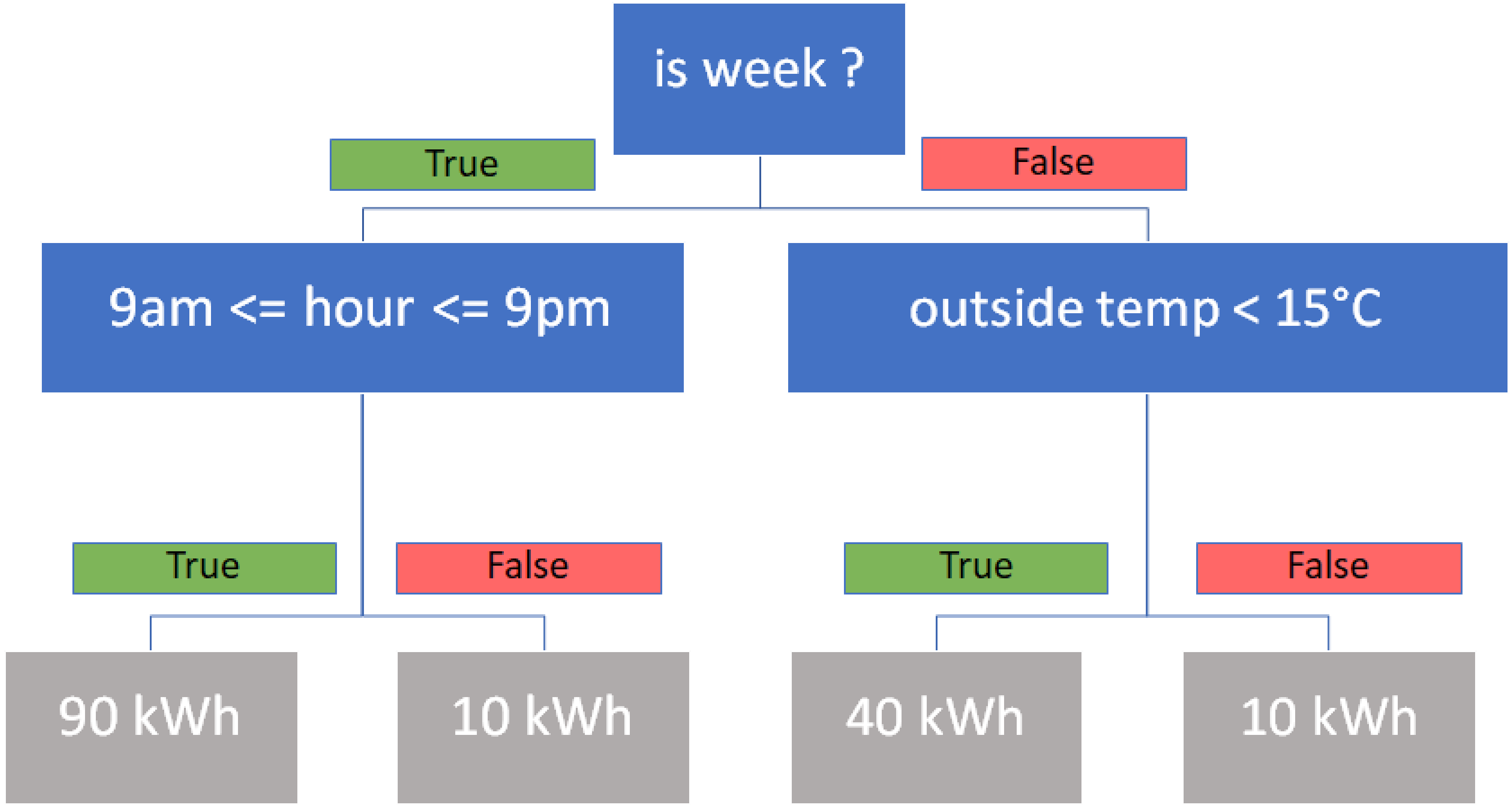

Boosted trees
You
DB-Z.COM

Boosted trees

Decision trees



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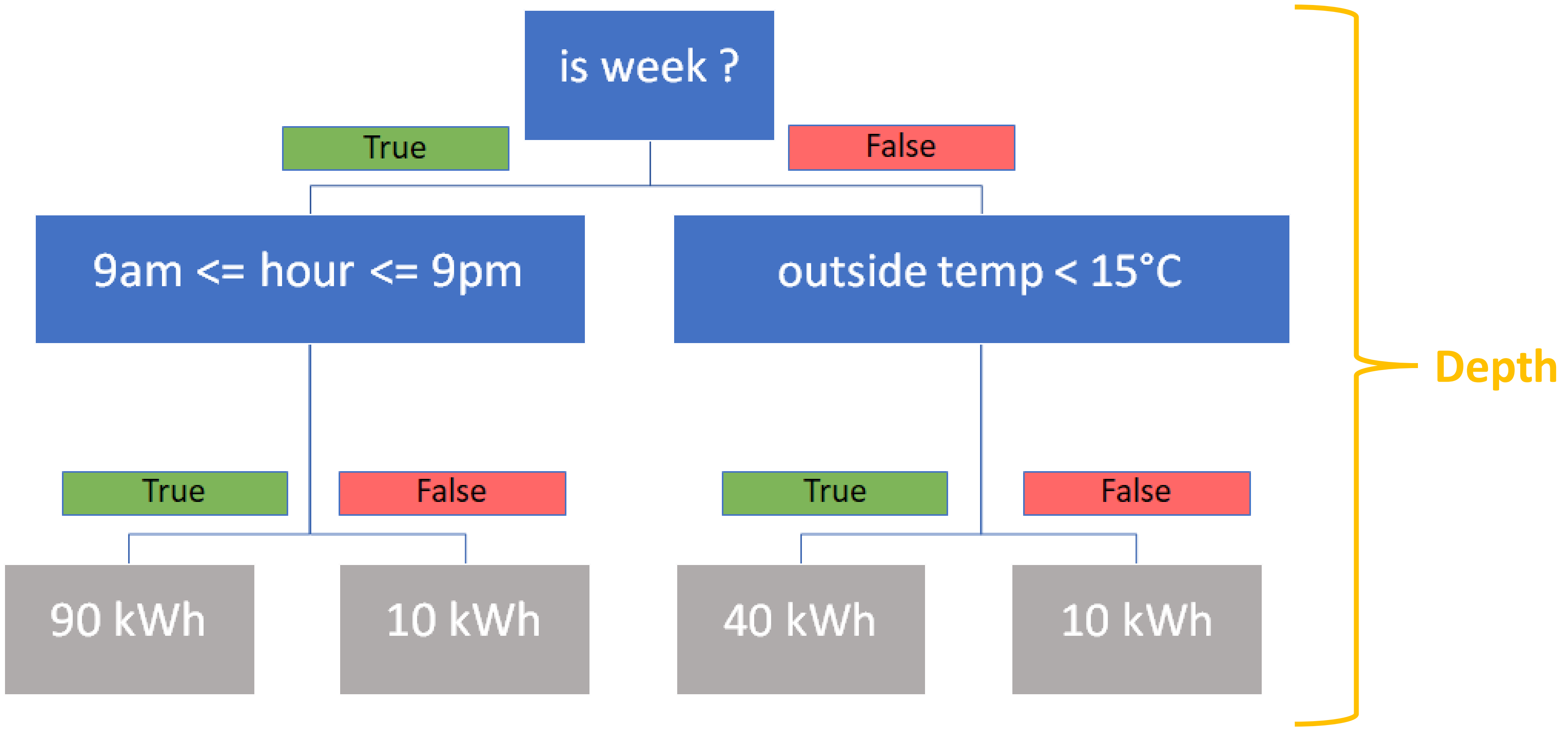
Boosted trees

Decision trees



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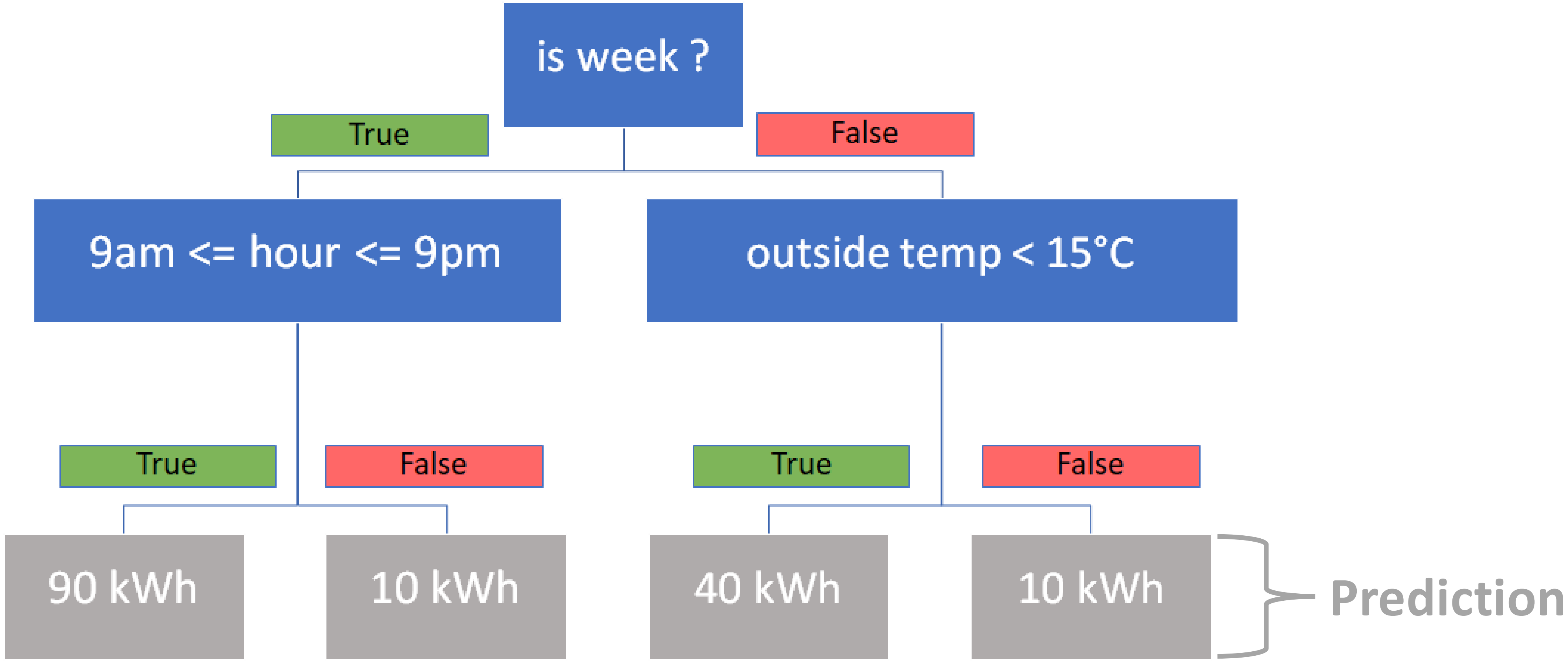
Boosted trees

Decision trees



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Boosted trees

Boosting

90 kWh | 10 kWh | 40 kWh | 10 kWh } Prediction

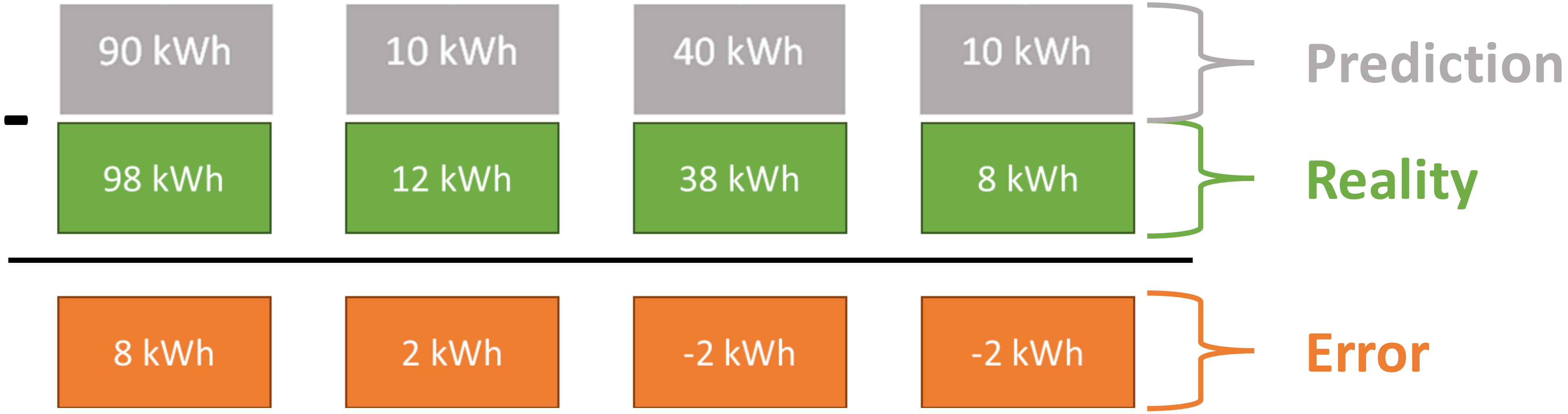
Boosted trees

Boosting

90 kWh	10 kWh	40 kWh	10 kWh	Prediction
98 kWh	12 kWh	38 kWh	8 kWh	Reality

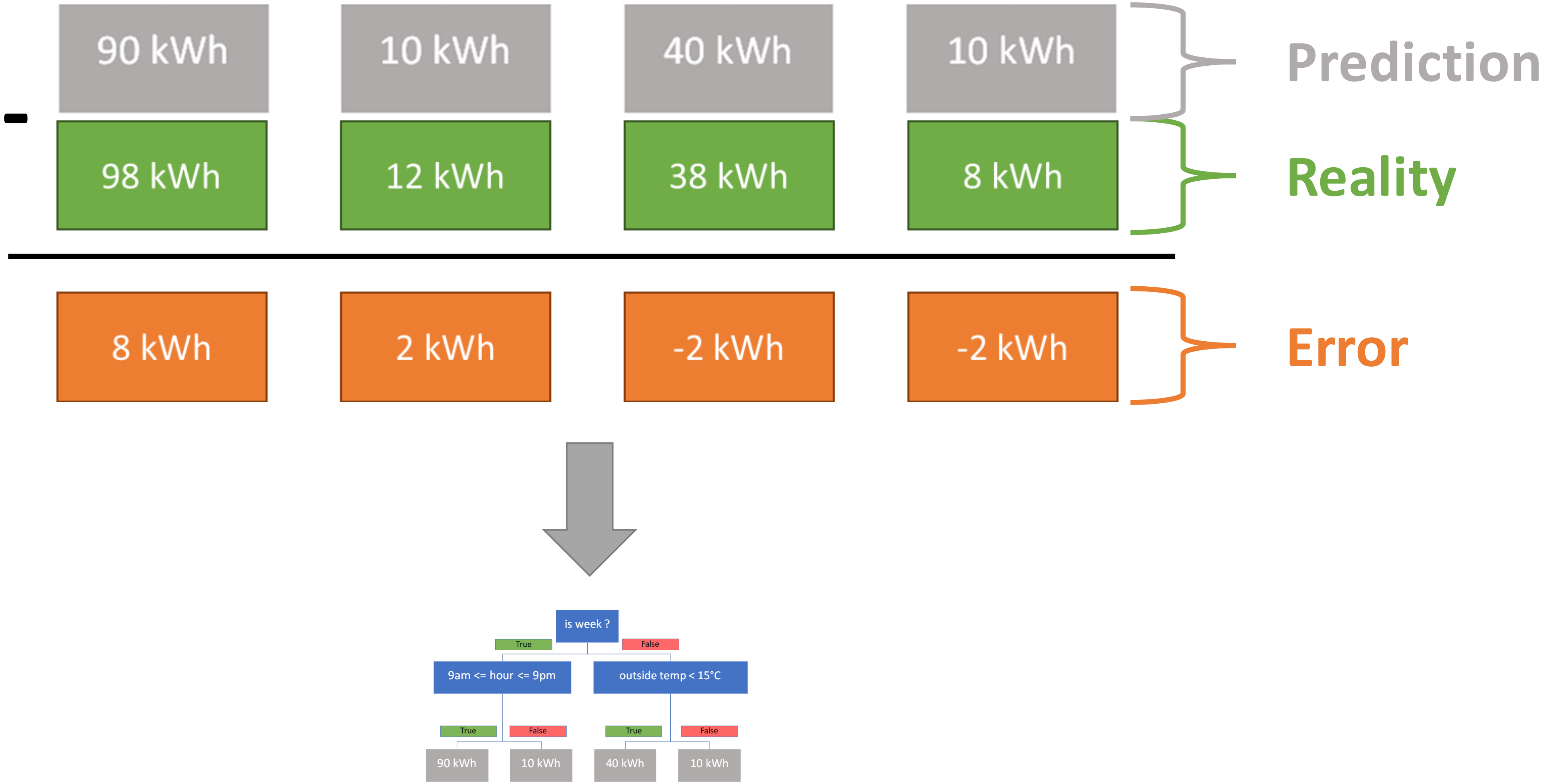
Boosted trees

Boosting



Boosted trees

Boosting



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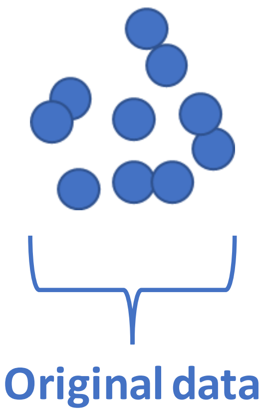
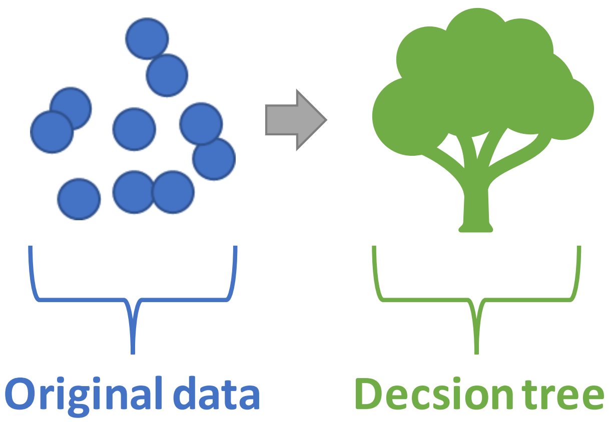
Boosted trees

Boosting



Boosted trees

Boosting



Boosted trees

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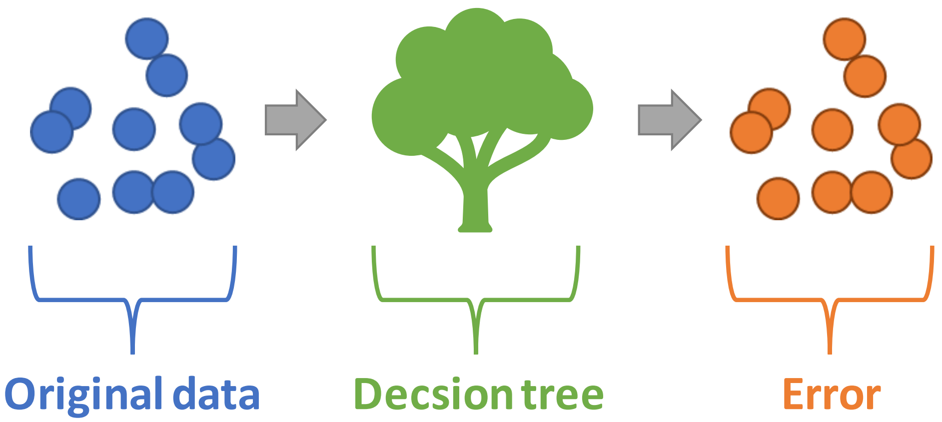
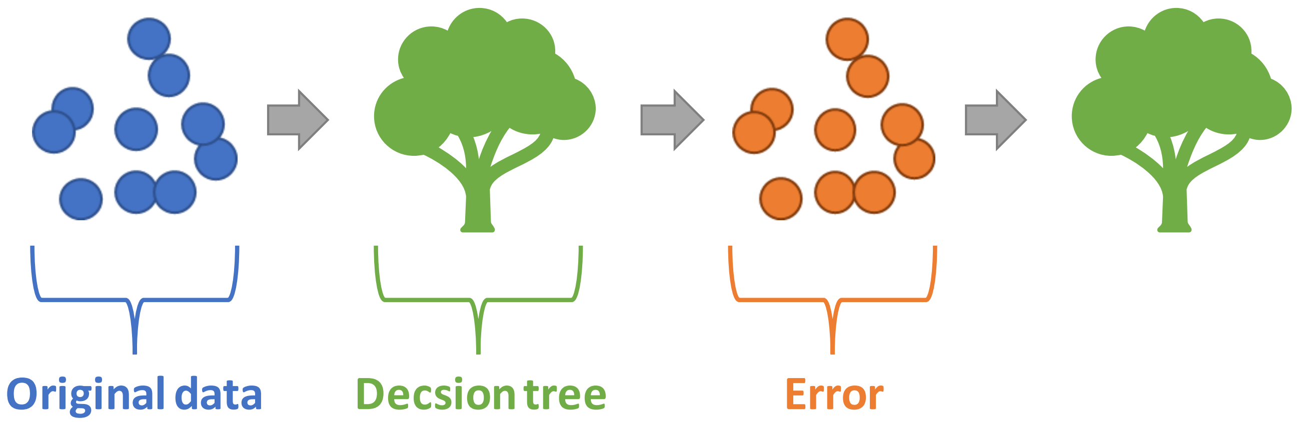


Boosted trees

Boosting



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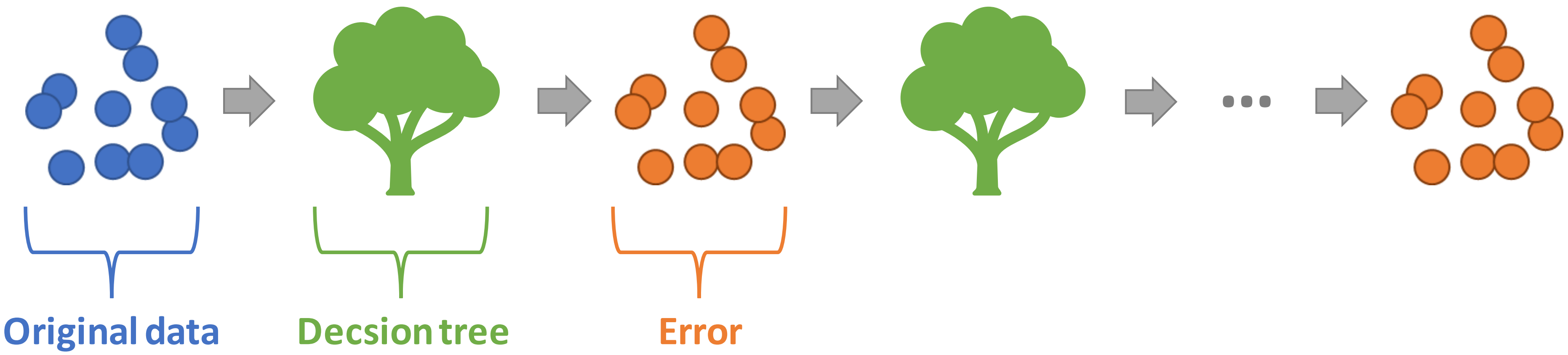
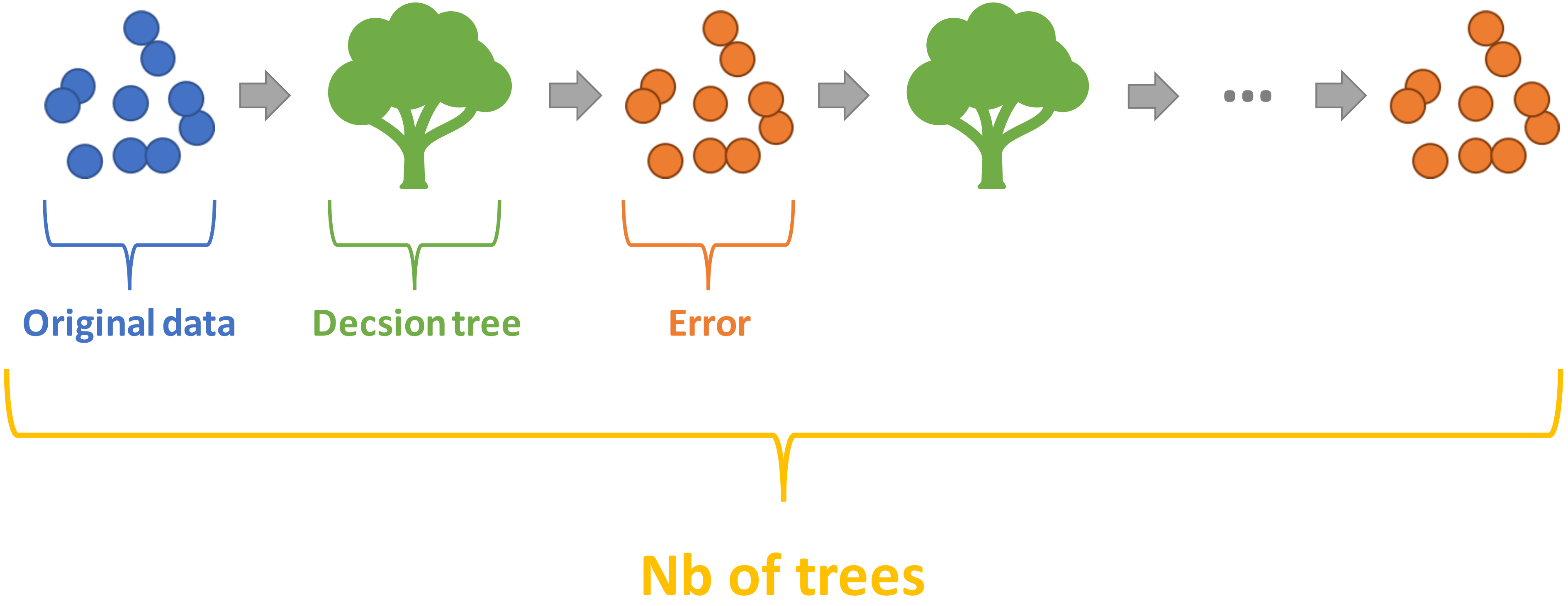
Boosted trees

Boosting



Boosted trees

Boosting



Quick Facts

PARTICIPANTS	1,034
NO. OF ENTRIES	1,332
PRIZE	€23,000

- Improve the state of the Art
- Create a community
- Provide a solution to a typical Energy problematic

➔ This solution can now be used in other context

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Why ?

- Flexibility in energy management is essential for secure supply and increasing the penetration of renewable sources.
- Energy storage and local production can increase smart building flexibility.
- Time of use tariffs can incite use of energy when it is the most available.

⇒ Algorithms can help battery charging systems to be as efficient as possible

Quick Facts

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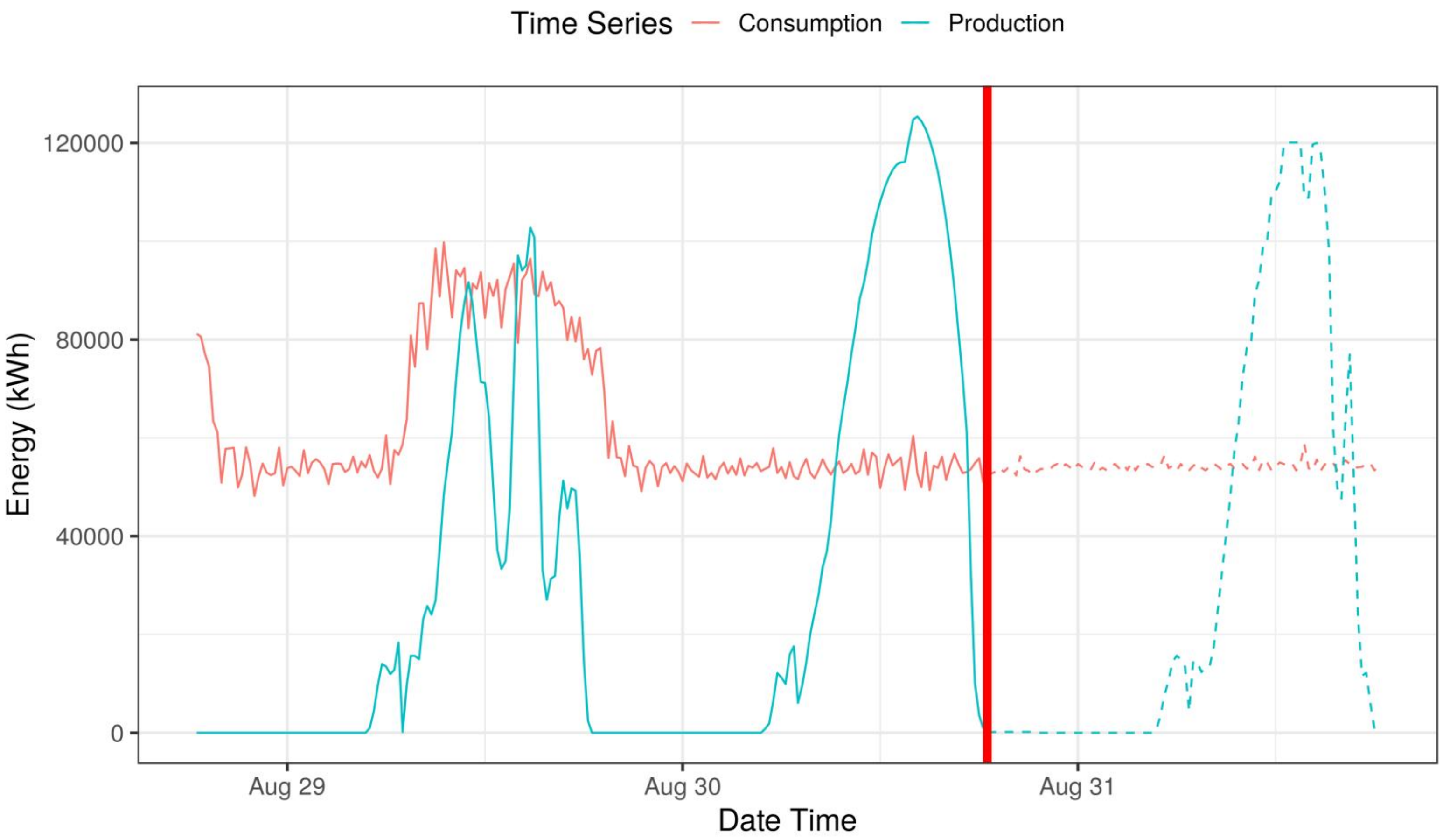
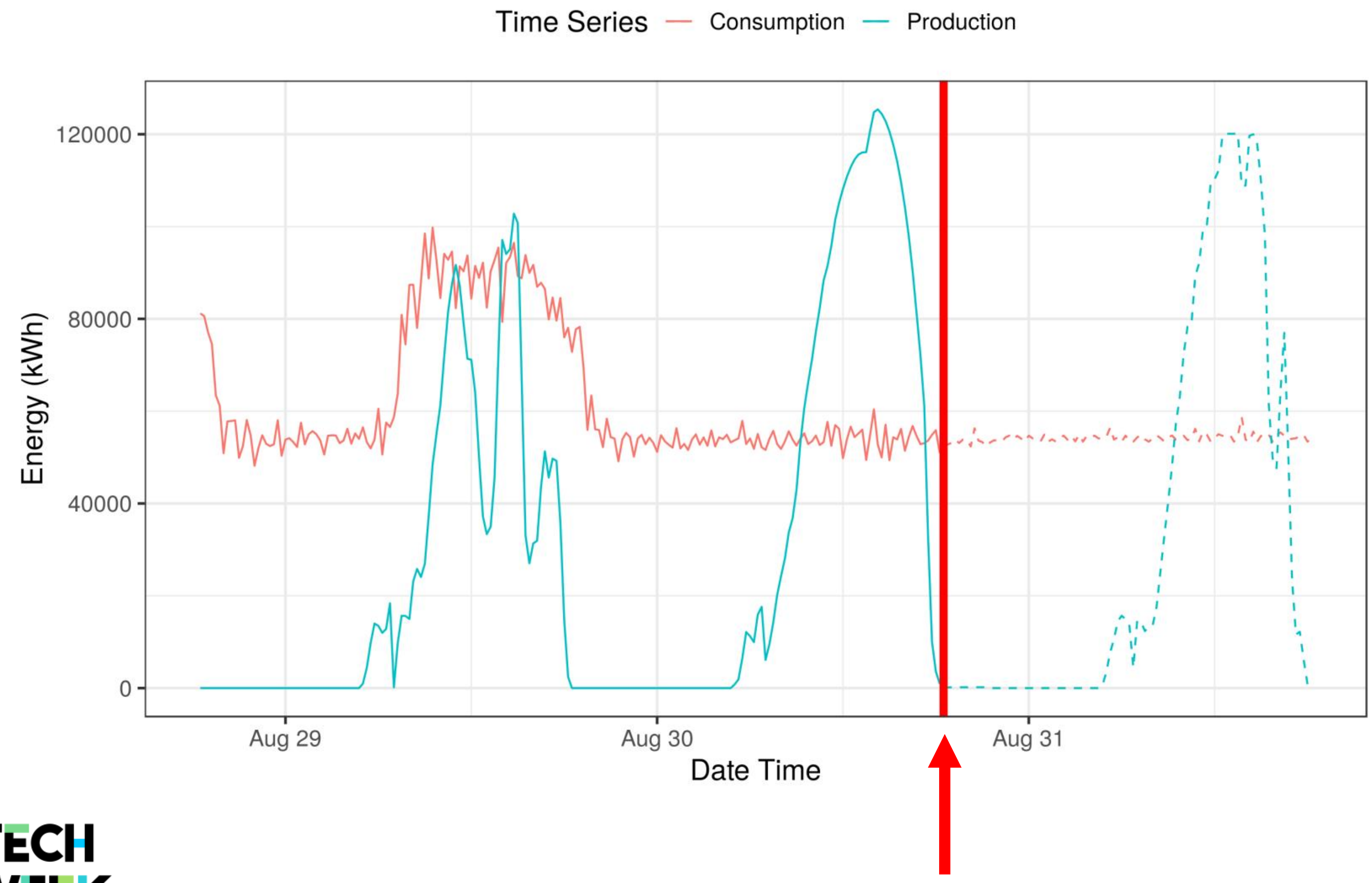
Competition Description



Competition Data

- Actual Consumption and Production (for 11 buildings)
- Forecast for next 24h
- Grid energy price (sell and buy)

Competition Description



How to use the battery for the next 15 minutes ?

Competition Data

- Actual Consumption and Production (for 11 buildings)
- Forecast for next 24h
- Grid energy price (sell and buy)

Competition Objective

- Plannify a battery usage to save money

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Competition Results

Performance Metric

$$Score = \frac{moneyNoBatt - moneySpent}{abs(moneyNoBatt)}$$

where

- $moneyNoBatt$: is the money spent if the site do not have a battery
- $moneySpent$: is the money spent with a battery controlled by the tested algorithm

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Competition Results

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where

- $moneyNoBatt$: is the money spent if the site do not have a battery
- $moneySpent$: is the money spent with a battery controlled by the tested algorithm

Best Competition score: drives **19%** savings with a battery.

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Linear Programming

$$\underset{[\mathrm{grid}_t]_{t \in [0, 24h]}}{\text{minimize}} \qquad \sum_{t=0}^{24h} \mathrm{grid}_t \times \mathrm{price}_t$$

Linear Programming

$$\underset{[\text{grid}_t]_{t\in[0,24h]}}{\text{minimize}} \quad \sum_{t=0}^{24h} \text{grid}_t \times \text{price}_t$$

$$\text{subject to} \quad \text{grid}_t = \text{conso}_t - \text{pv}_t - \text{battery}_t$$

Linear Programming

$$
\begin{aligned}
\underset{[\text{grid}_t]_{t\in[0,24h]}}{\text{minimize}} \quad & \sum_{t=0}^{24h} \text{grid}_t \times \text{price}_t \\
\text{subject to} \quad & \text{grid}_t = \text{conso}_t - \text{pv}_t - \text{battery}_t \\
t \in [0, 24h] \quad & \text{battery}_t \times \rho < \text{max\_power\_battery} \\
& 0 < \text{total\_battery}_t + \text{battery}_t < \text{max\_capacity\_battery}.
\end{aligned}
$$

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Linear Programming

$$
\begin{aligned}
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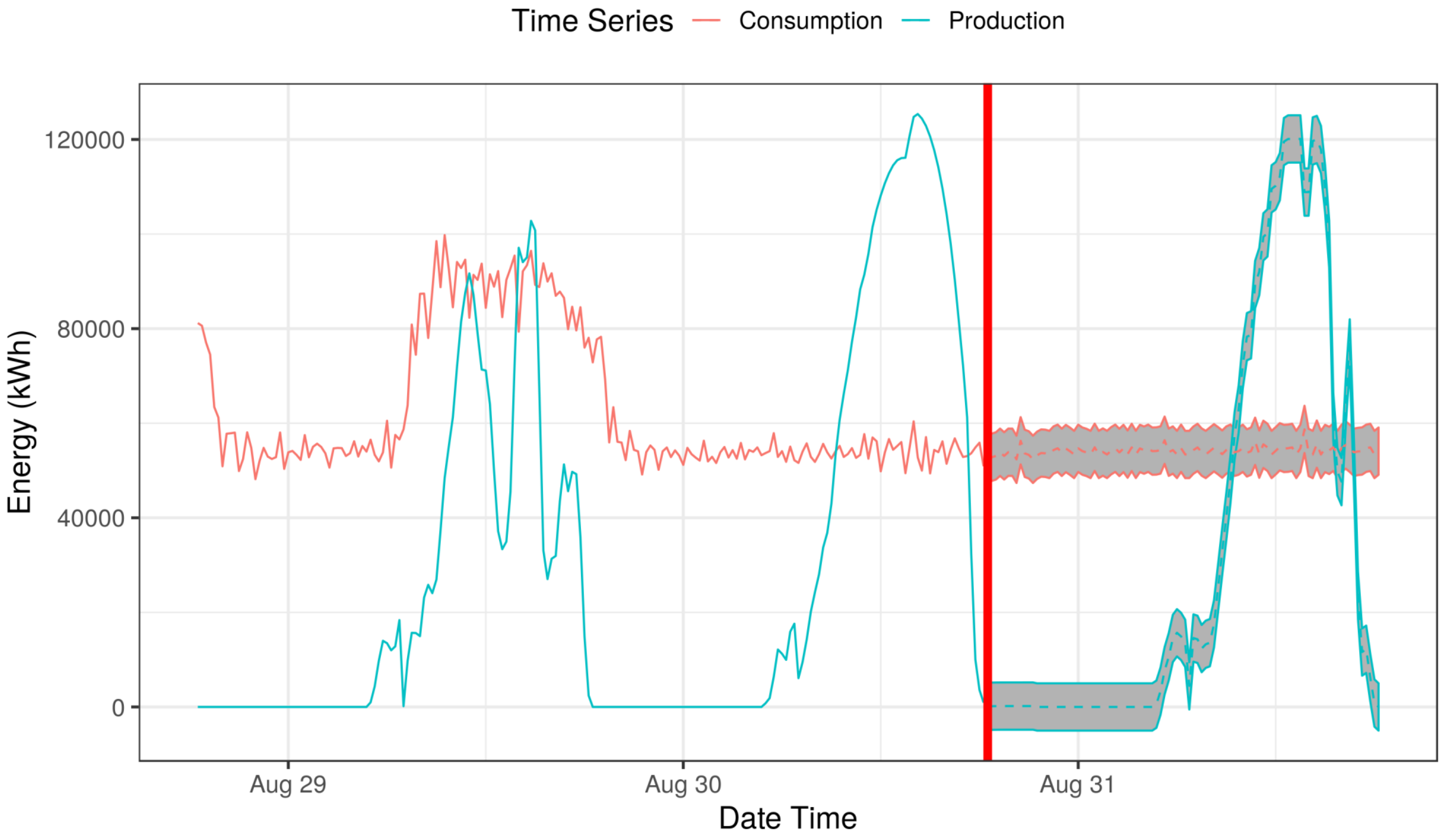
& 0 < \text{total\_battery}_t + \text{battery}_t < \text{max\_capacity\_battery}.
\end{aligned}
$$

<u>Issue:</u> Future consumption and prediction are unknown. We only have forecastings.

Forecasting Error



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Scenario based stochastic programming

$$\underset{[\mathrm{grid}_t^q]_{t\in[0,24h],q\in[-2,2]}}{\text{minimize}} \quad \sum_{t=0}^{24h} \sum_{q=-2}^{2} \mathrm{grid}_t^q \times \mathrm{price}_t$$

Scenario based stochastic programming

$$\begin{aligned} \underset{[\mathrm{grid}_t^q]_{t\in[0,24h],q\in[-2,2]}}{\text{minimize}} \quad & \sum_{t=0}^{24h} \sum_{q=-2}^{2} \mathrm{grid}_t^q \times \mathrm{price}_t \\ \text{subject to} \quad & \mathrm{grid}_t^q = \mathrm{conso}_t^q - \mathrm{pv}_t^q - \mathrm{battery}_t \end{aligned}$$

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Scenario based stochastic programming

$$
\begin{array}{ll}
\underset{[\text{grid}_t^q]_{t\in[0,24h],q\in[-2,2]}}{\text{minimize}} & \sum_{t=0}^{24h}\sum_{q=-2}^{2} \text{grid}_t^q \times \text{price}_t \\
\text{subject to} & \text{grid}_t^q = \text{conso}_t^q - \text{pv}_t^q - \text{battery}_t \\
t \in [0, 24h] & \text{battery}_t \times \rho < \text{max\_power\_battery} \\
q \in [-2, 2] & 0 < \text{total\_battery}_t + \text{battery}_t < \text{max\_capacity\_battery}.
\end{array}
$$

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Results

Scores

Method	Percentage of saving with a battery
Our method	19,6 %
1st competition method	19,4 %
2nd competition method	19,2 %
3rd competition method	19,1

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Results

Scores

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Want to go further ? https://github.com/kaizen-solutions/power-laws-optimization

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- Algorithms driving 19% of savings with a battery
- Algorithms and comparison code are on github

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Conclusion

Business needs

- Business context
- True dataset

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Conclusion

Business needs

- Business context
- True dataset

Open Sources

- Understand Solutions
- Formation

OpenDataSoft

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Conclusion

Business needs

- Business context
- True dataset

Open Sources

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Continuous Improvement

- Compare with existing
- Community

Any questions ?

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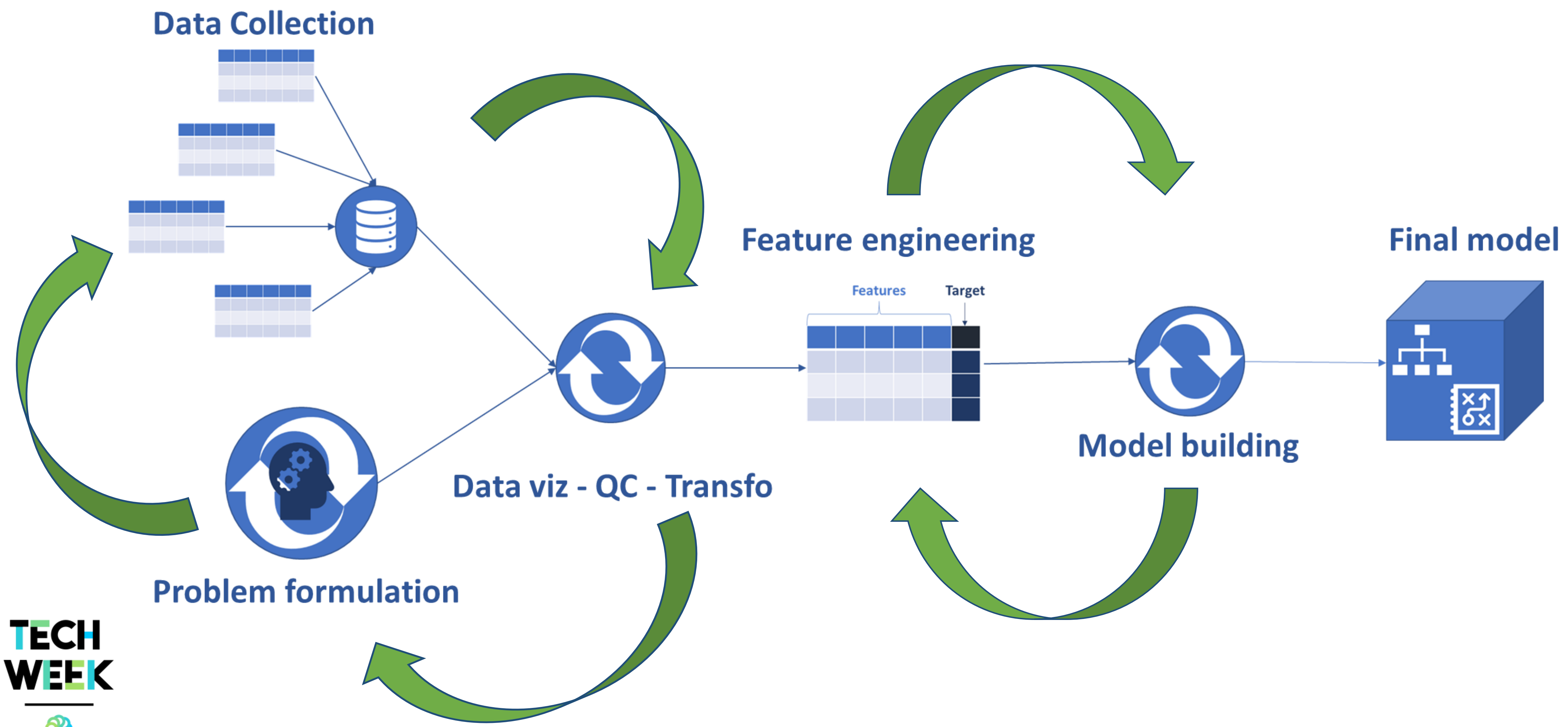
Winner solution



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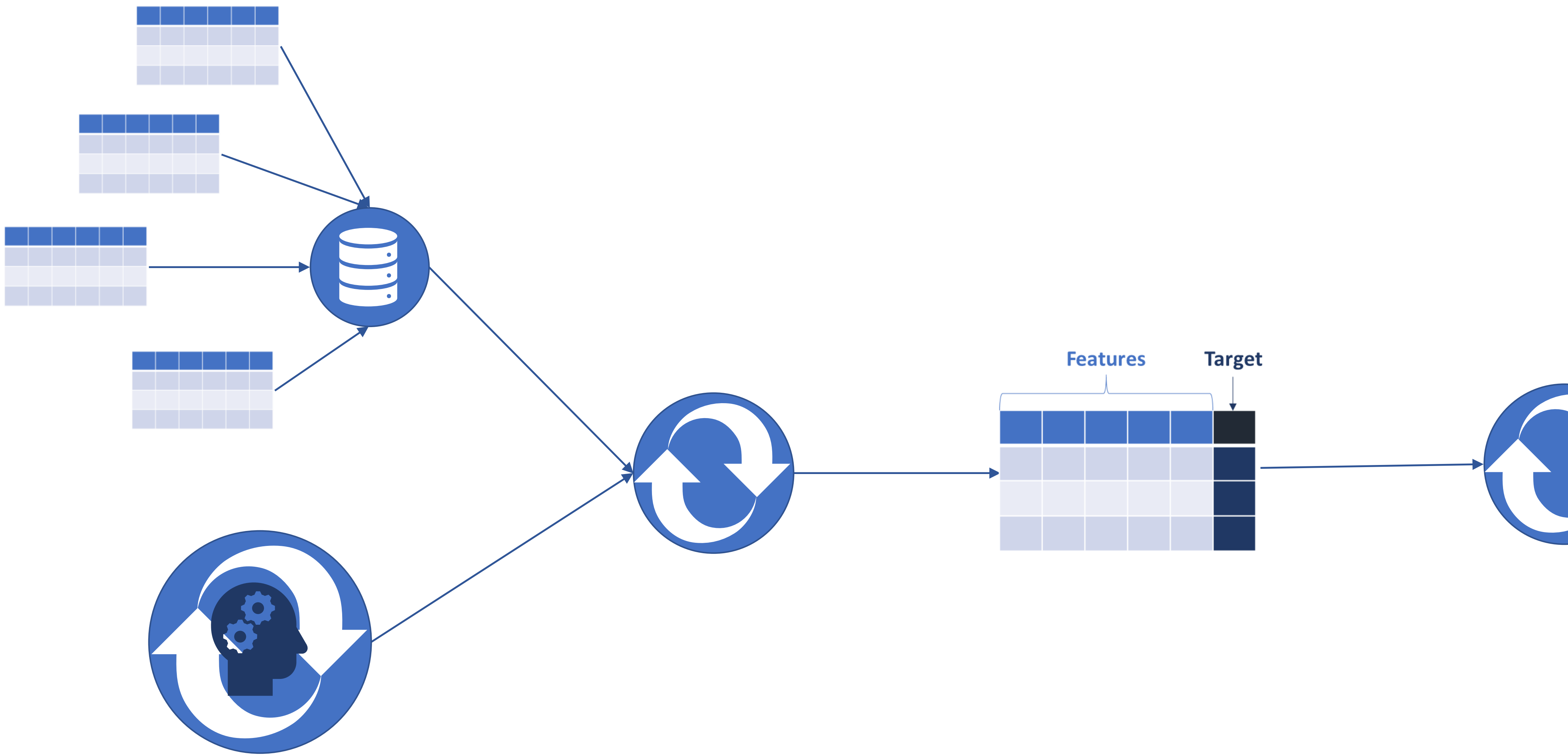

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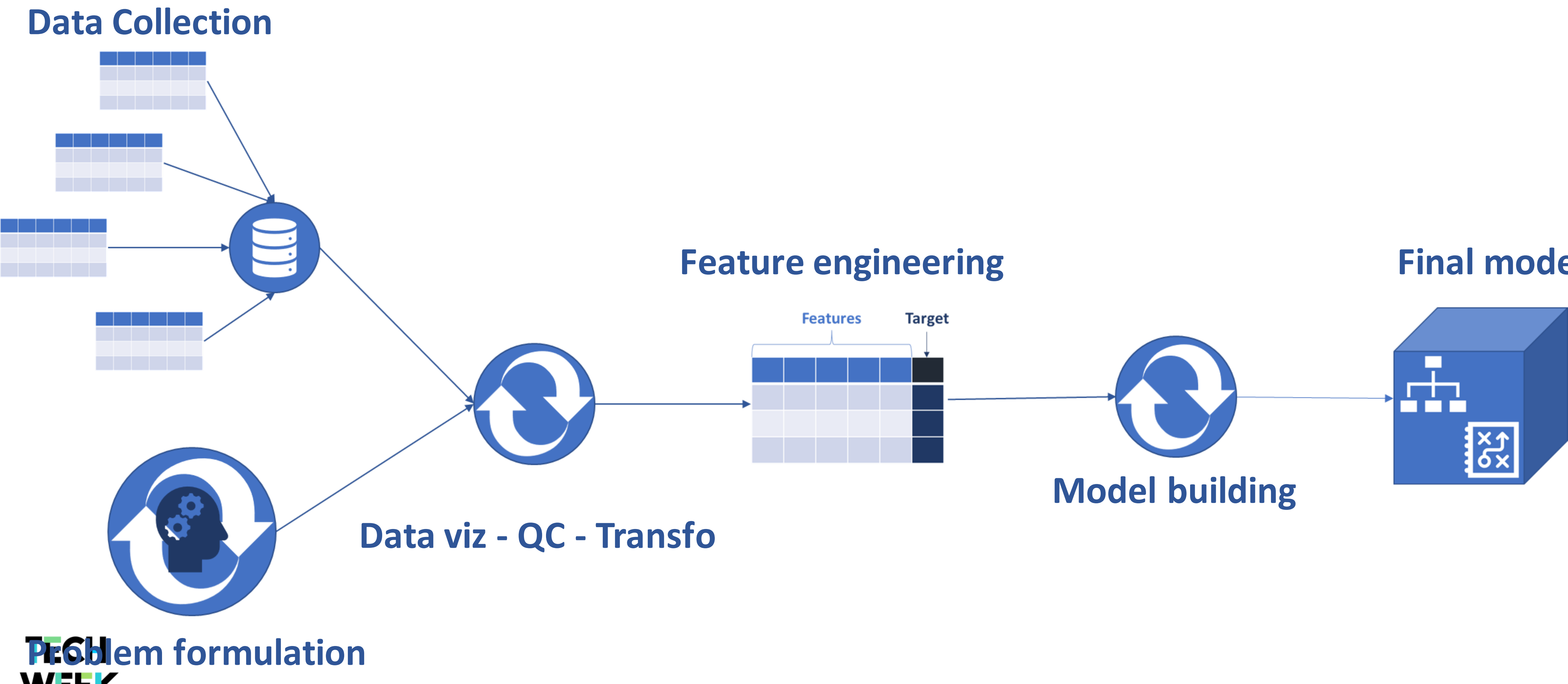
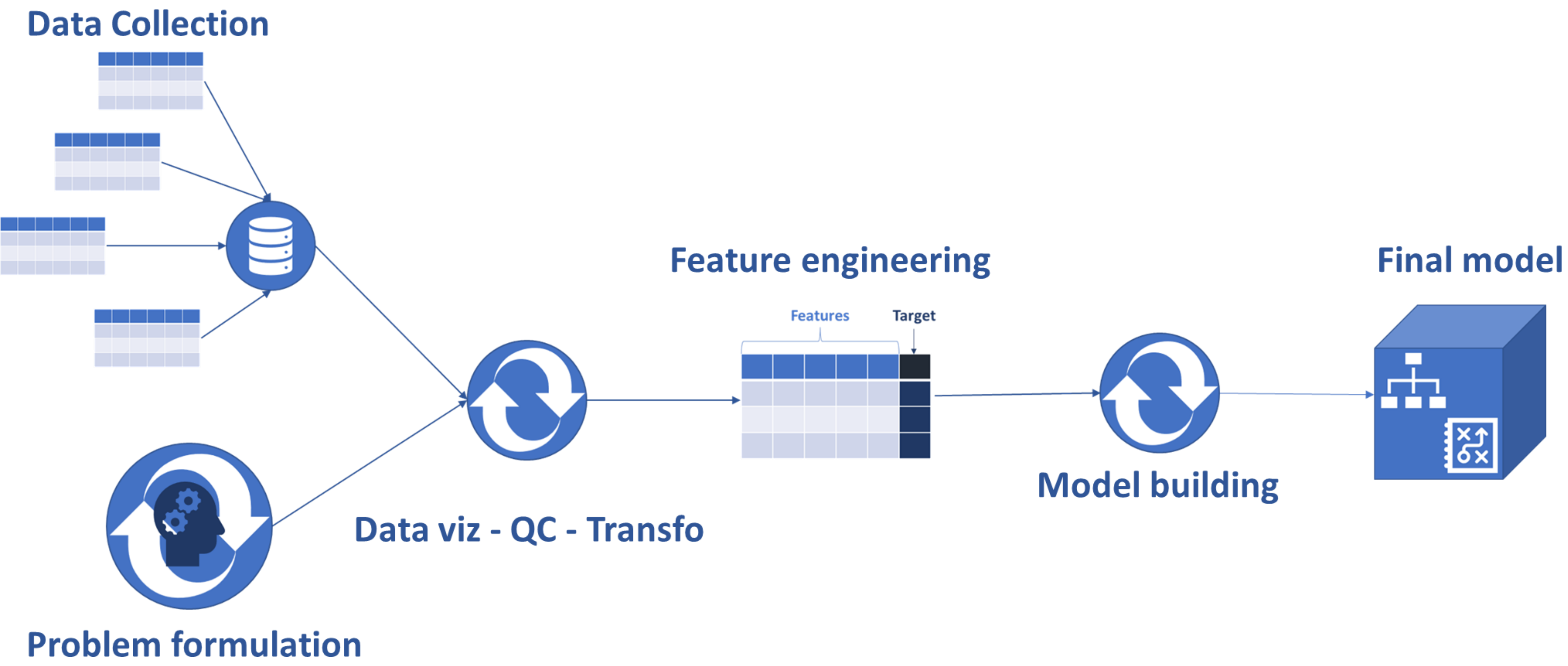

Data Collection
Feature engineering
Features
Target
Final mode
Data viz - QC - Transfo
Model building
Problem formulation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