KEVIN CAYE

THOMAS KARAOUZENE

LA TRANSFORMATION DIGITALE ✋ DU MONDE DE L'ÉNERGIE

TECH WEEK

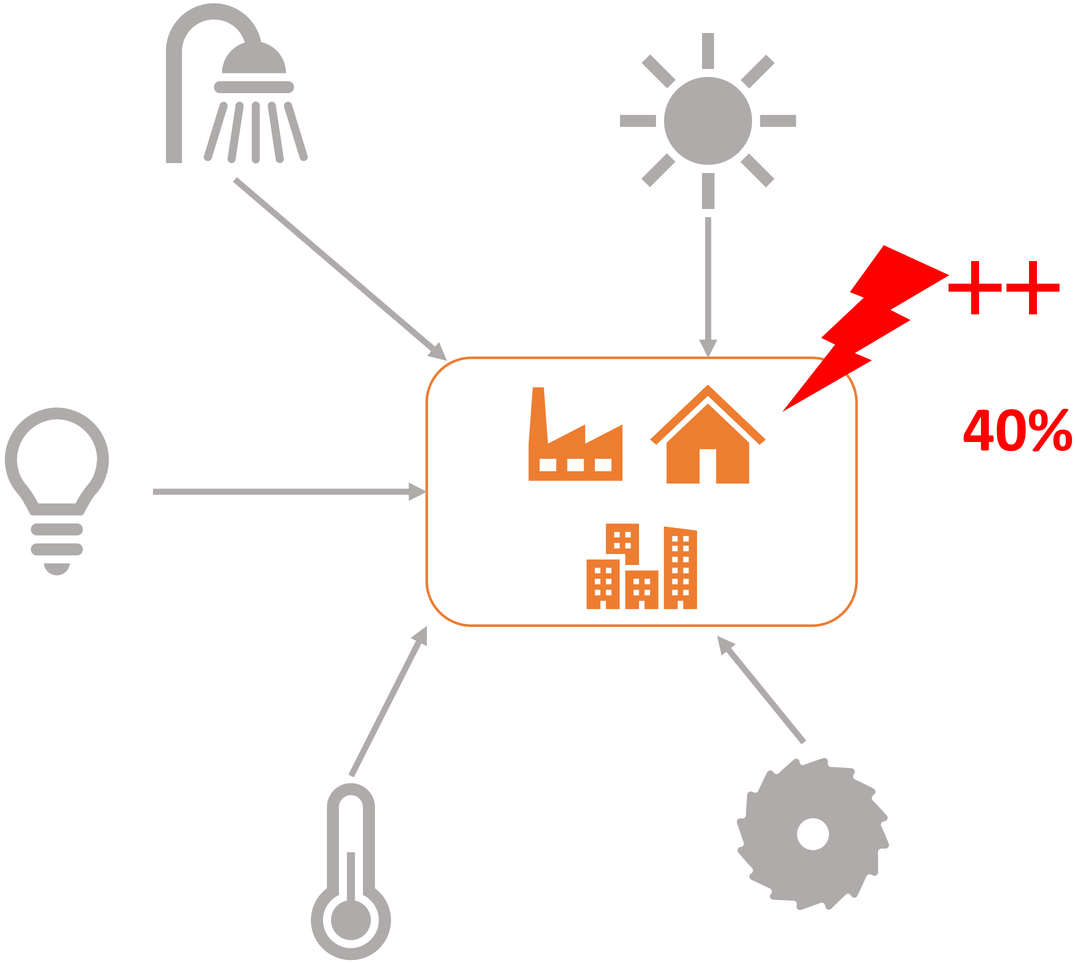
KAIZEN

Data science in energy industry

Data science in energy industry

40% of the mondial energy consumption

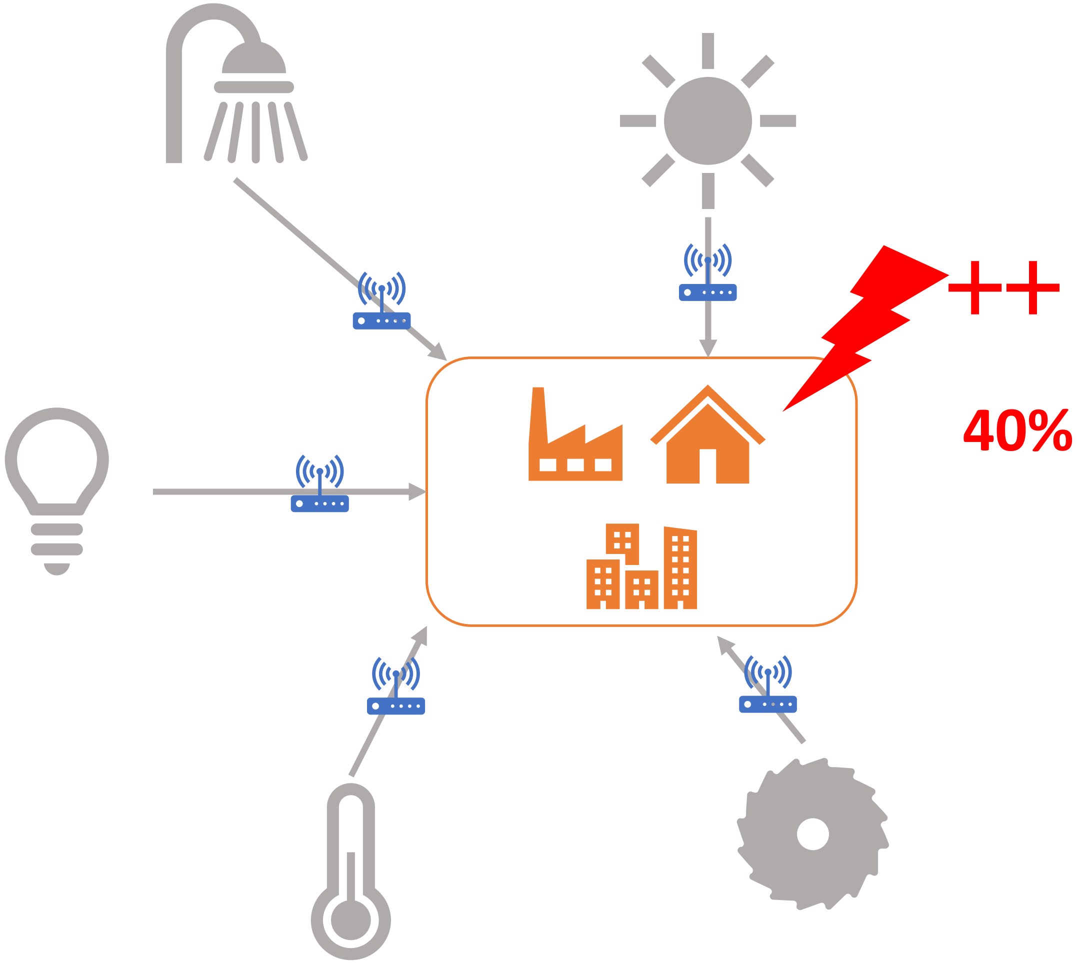
Data science in energy industry



40% of the mondial energy consumption

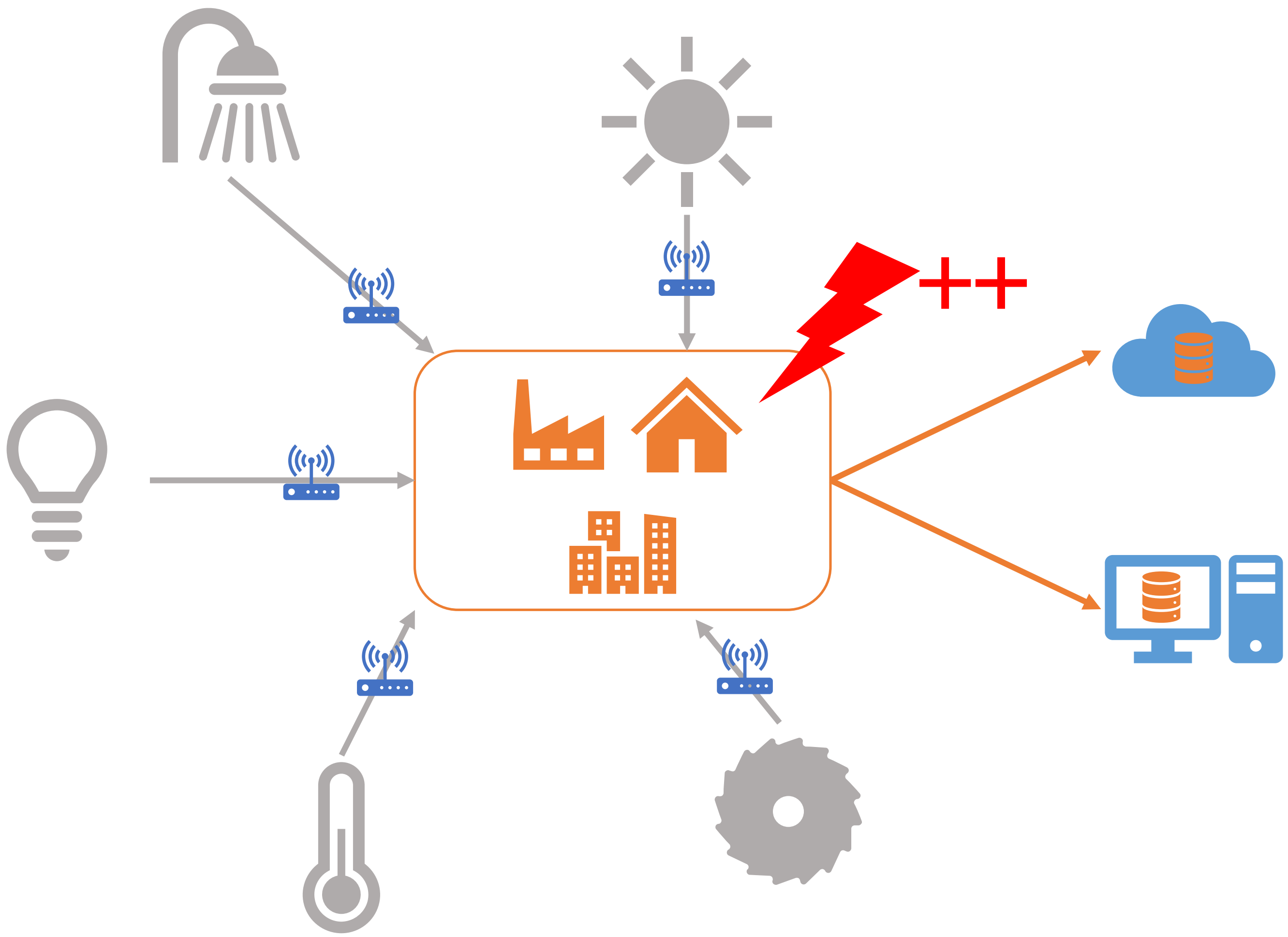
TECH WEEK
KAIZEN

Data science in energy industry

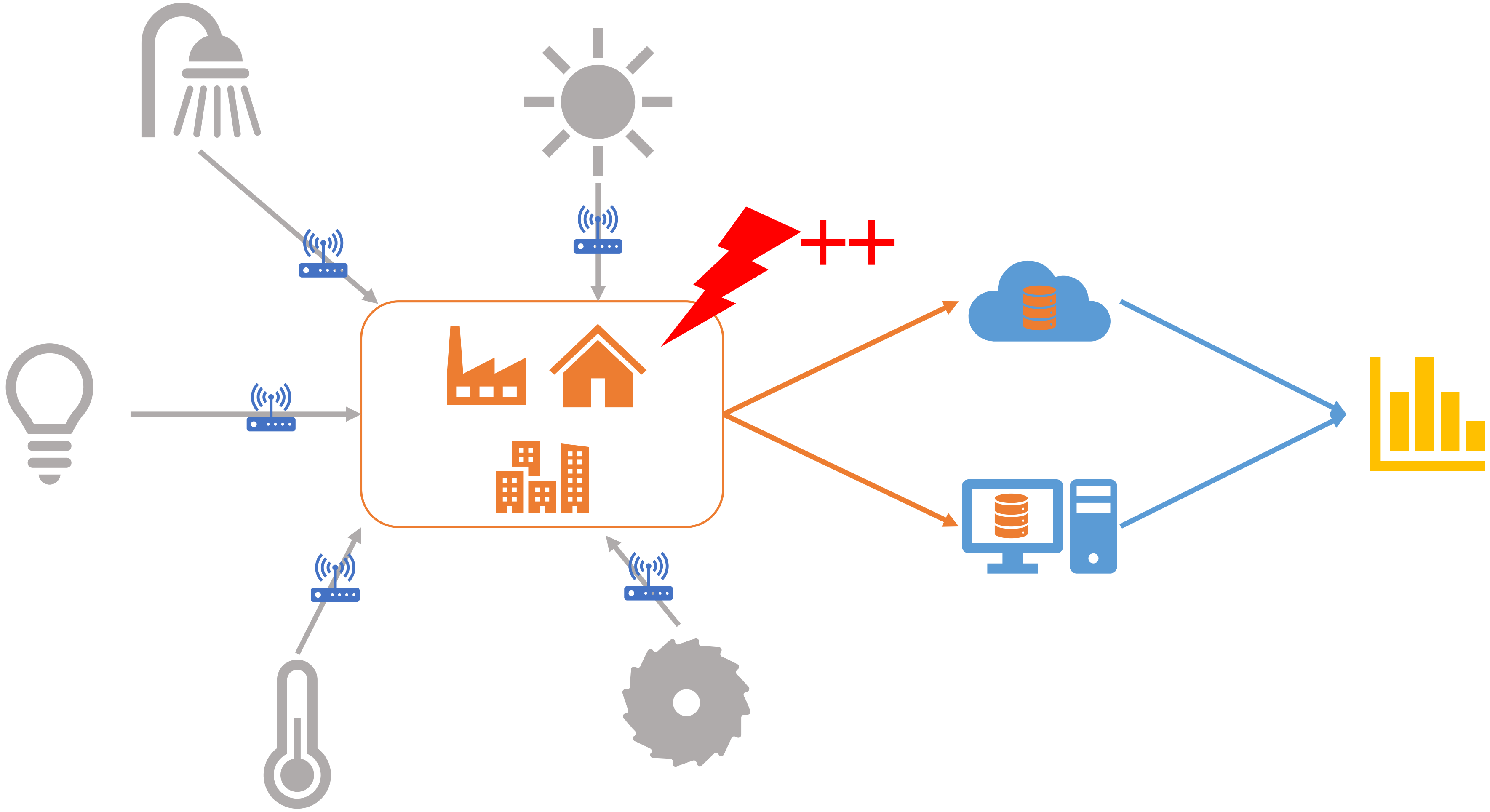


40% of the mondial energy consumption

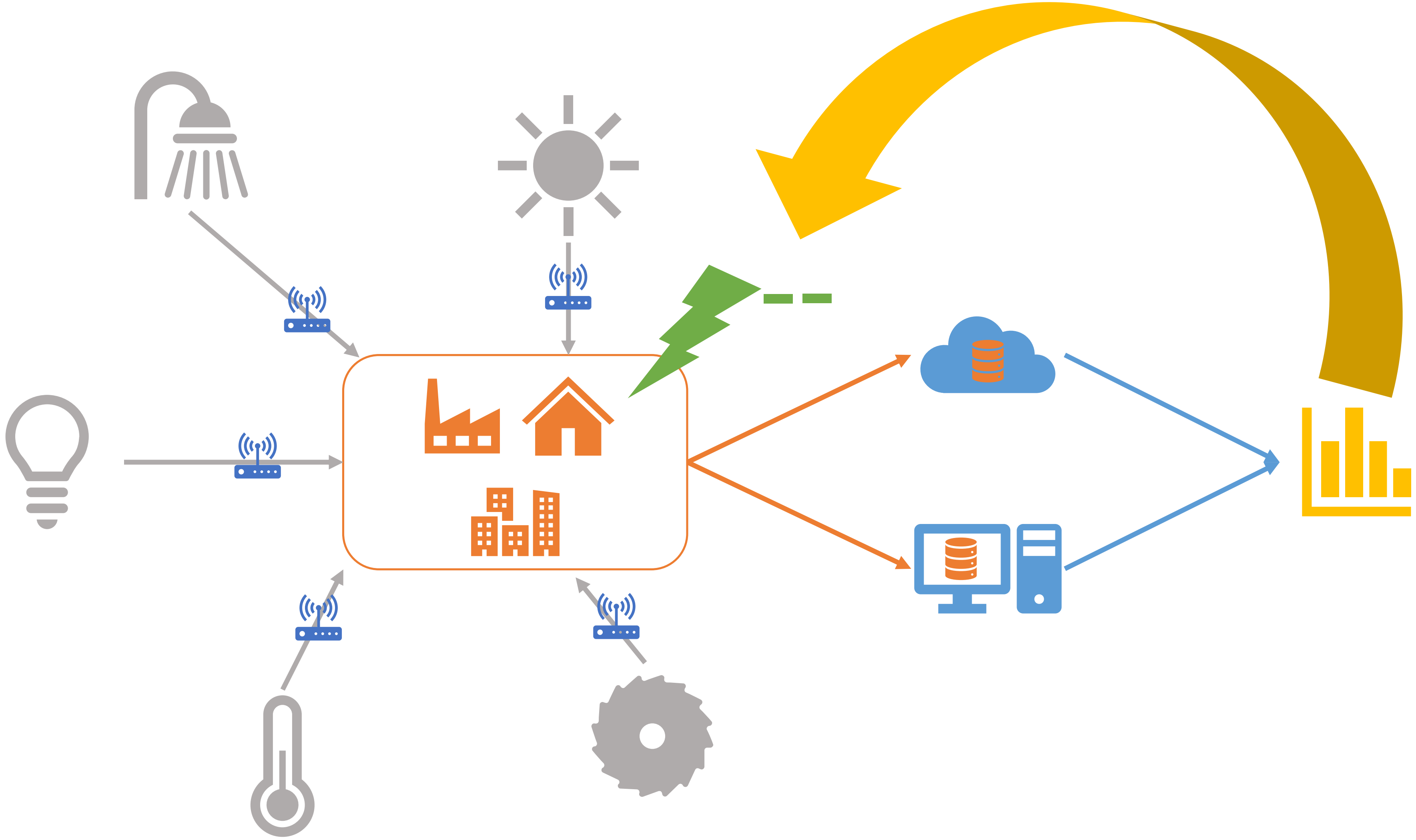
Data science in energy industry



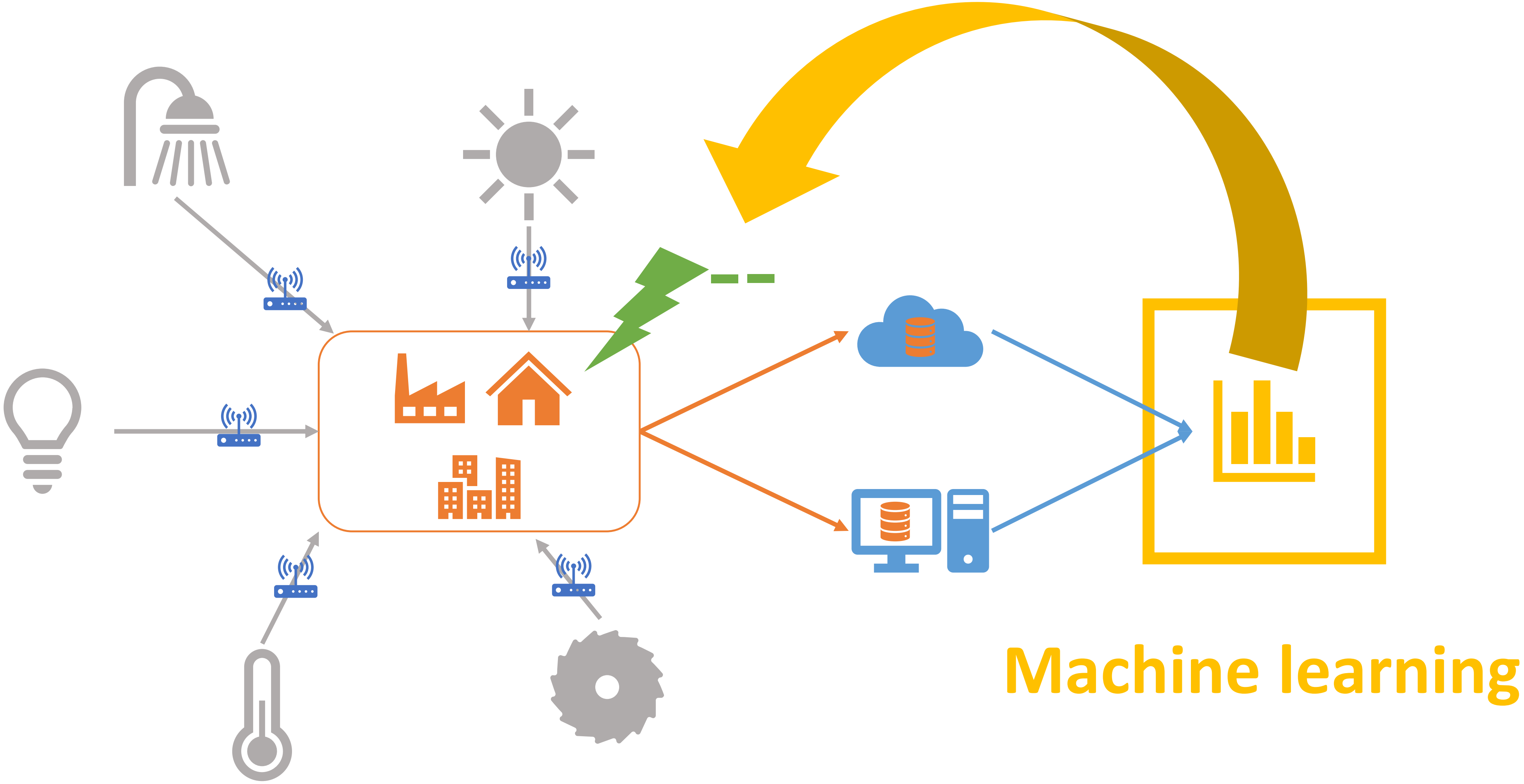
Data science in energy industry



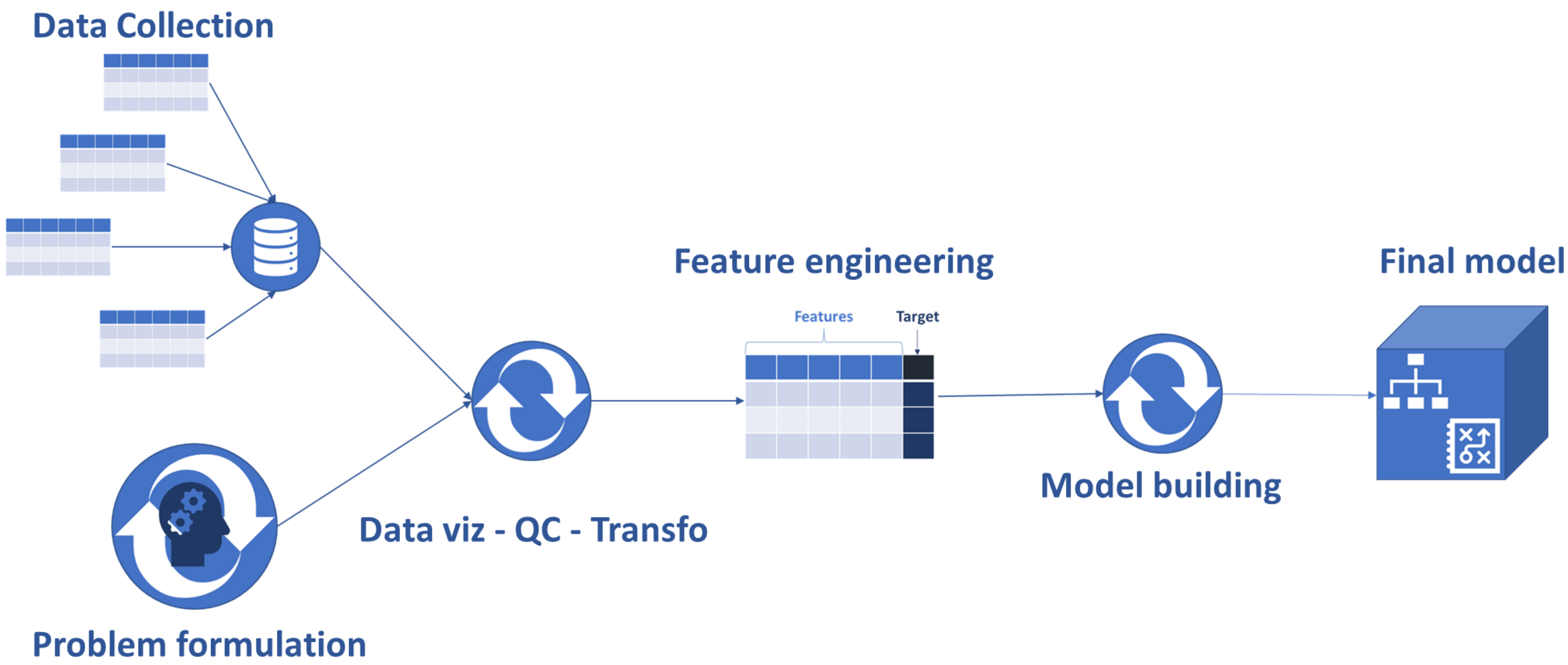
Data science in energy industry



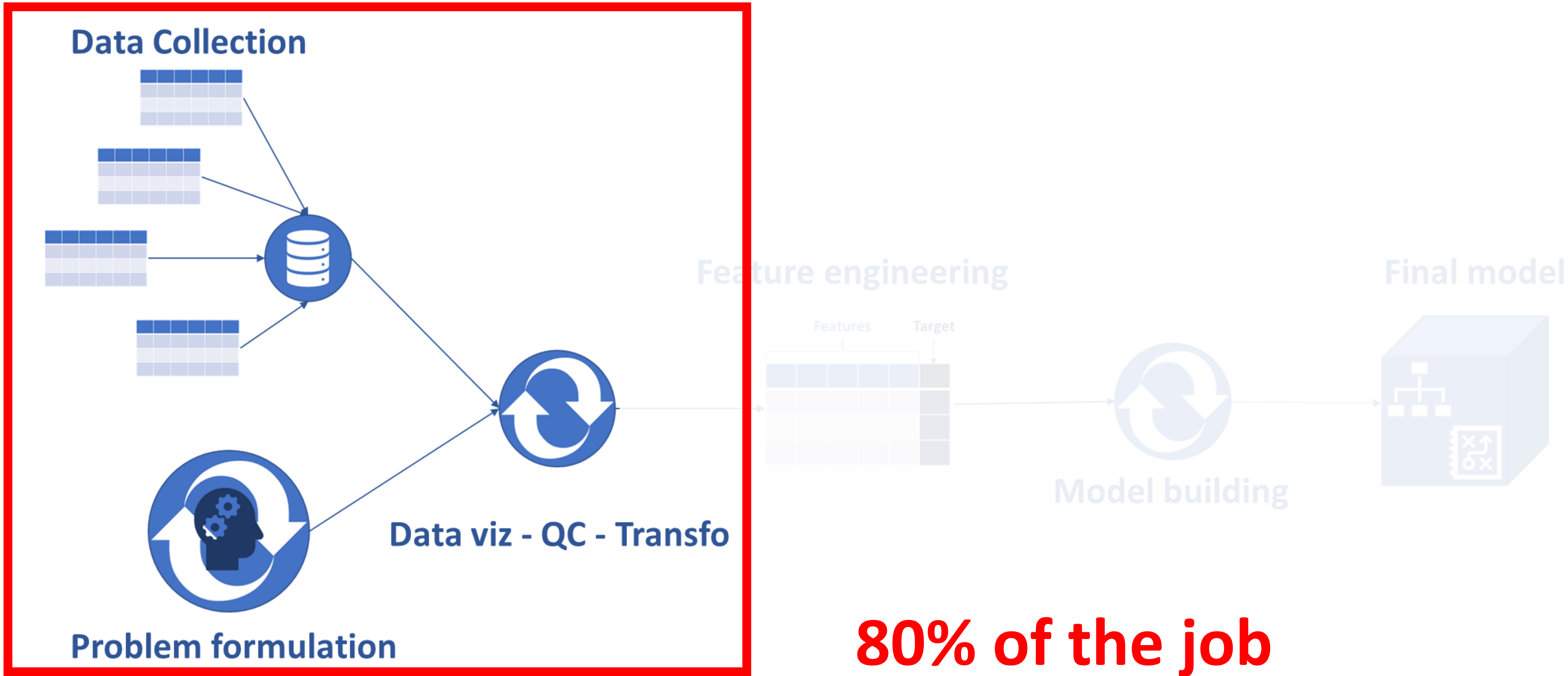
Data science in energy industry



Machine learning challenges

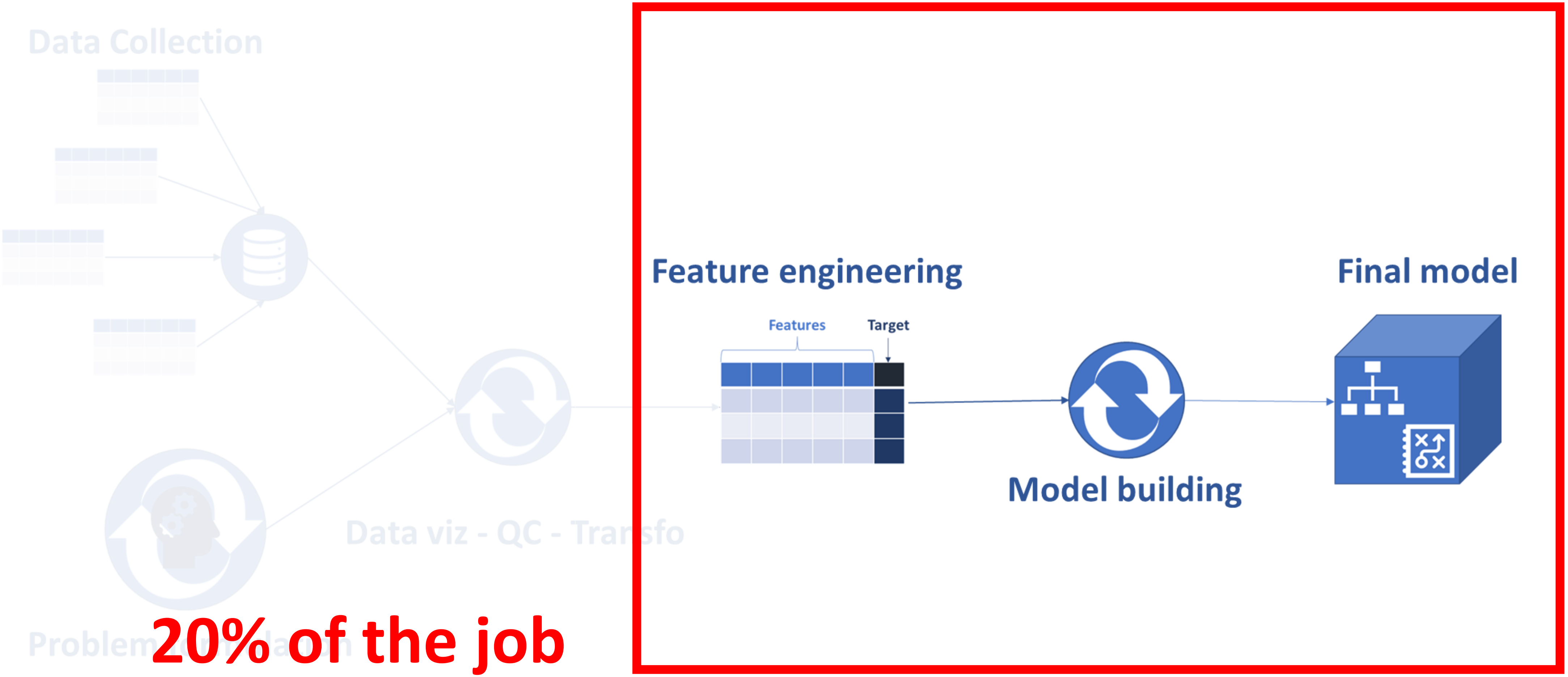


Machine learning challenges



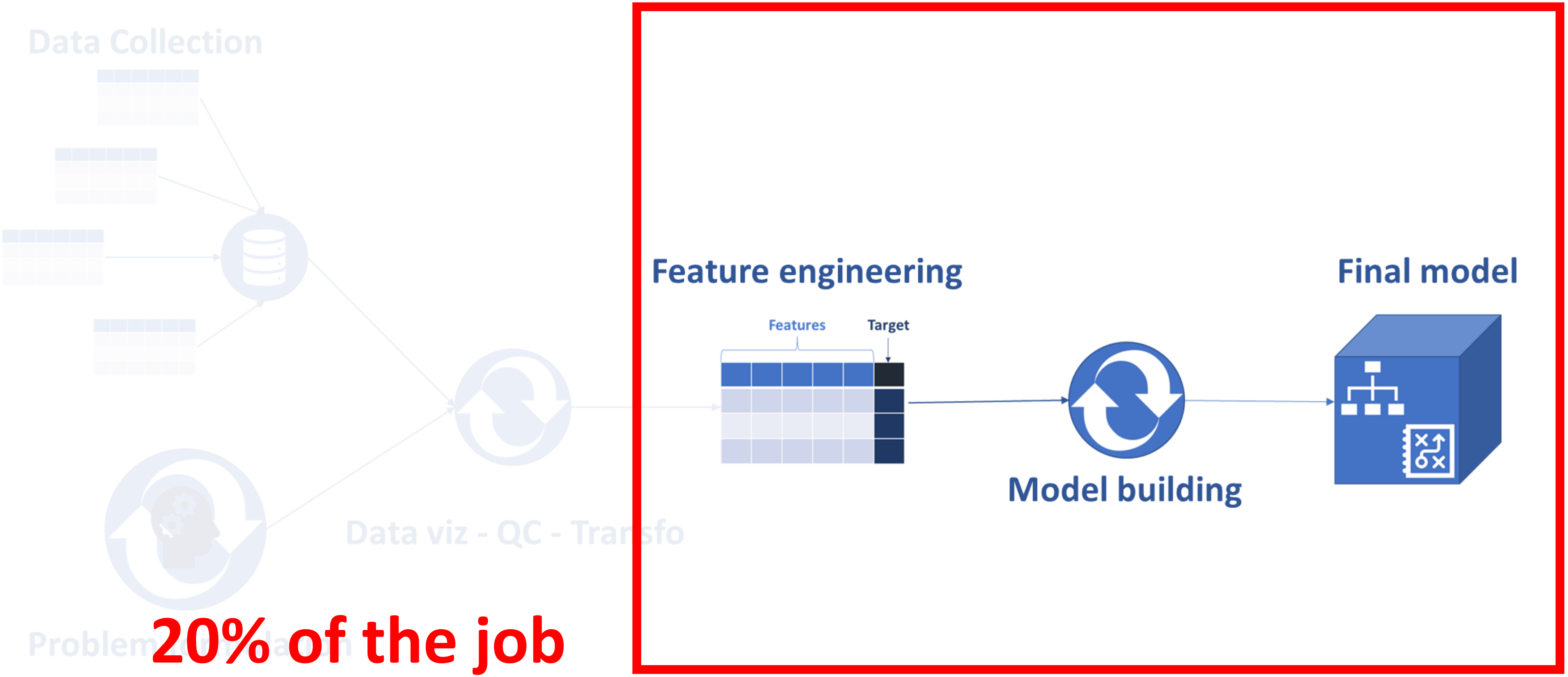
80% of the job

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

TECH WEEK
KAIZEN

Quick Facts

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

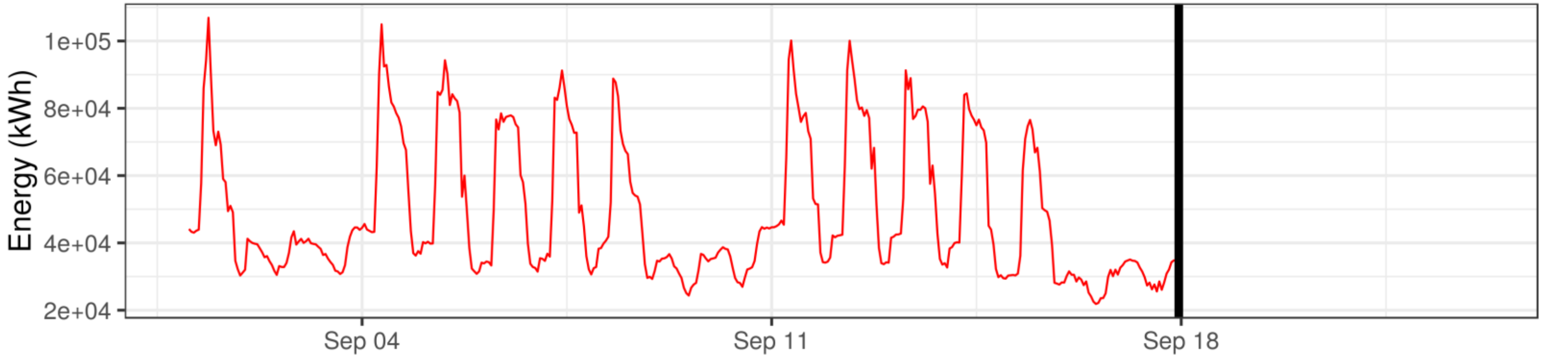
TECH WEEK
KAIZEN

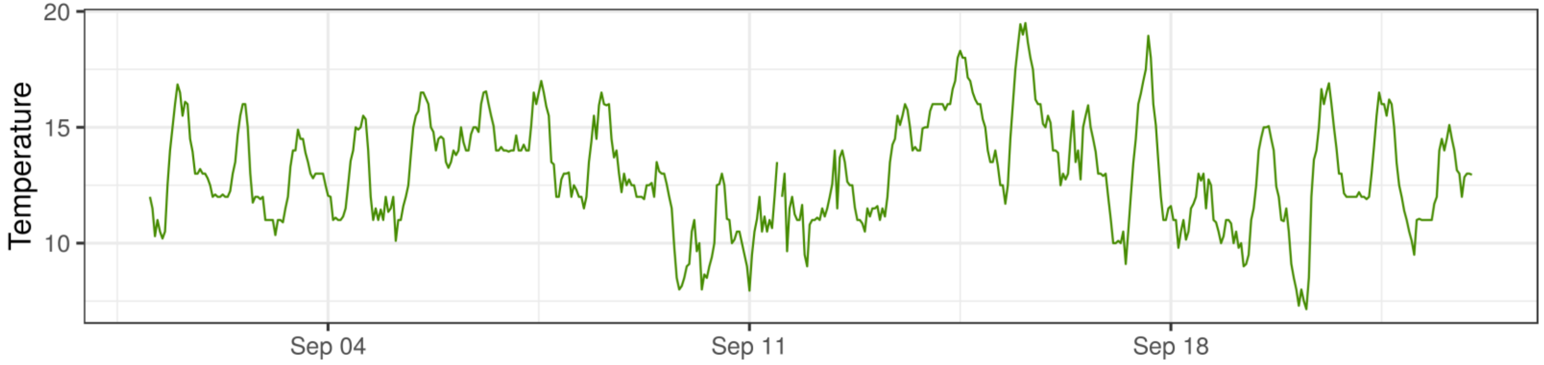
Why ?

- 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

Forecasting building energy consumption

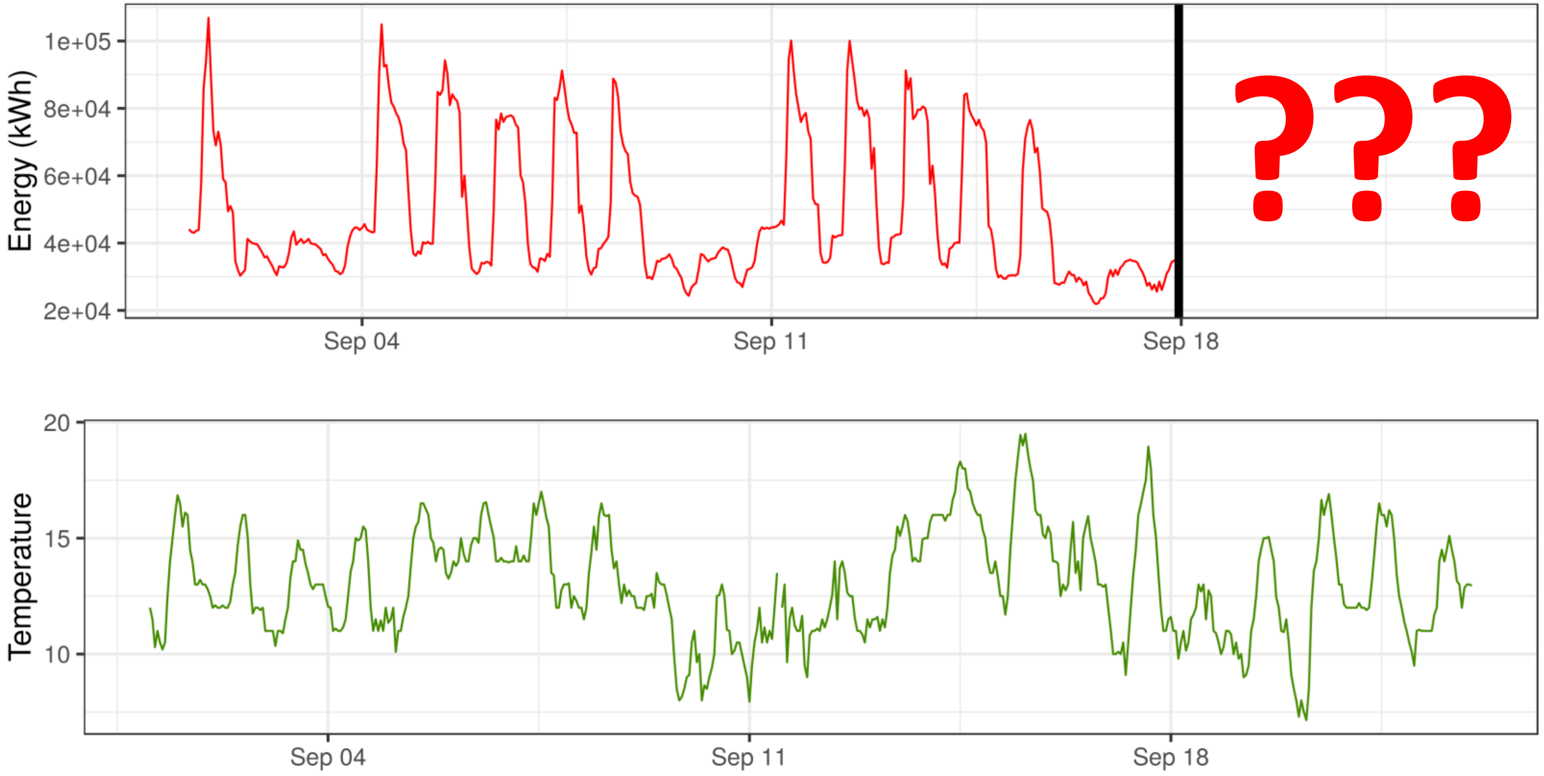




Competition Data

- Energy consumption historic for ~200 buildings
- Temperature

Forecasting building energy consumption



Competition Data

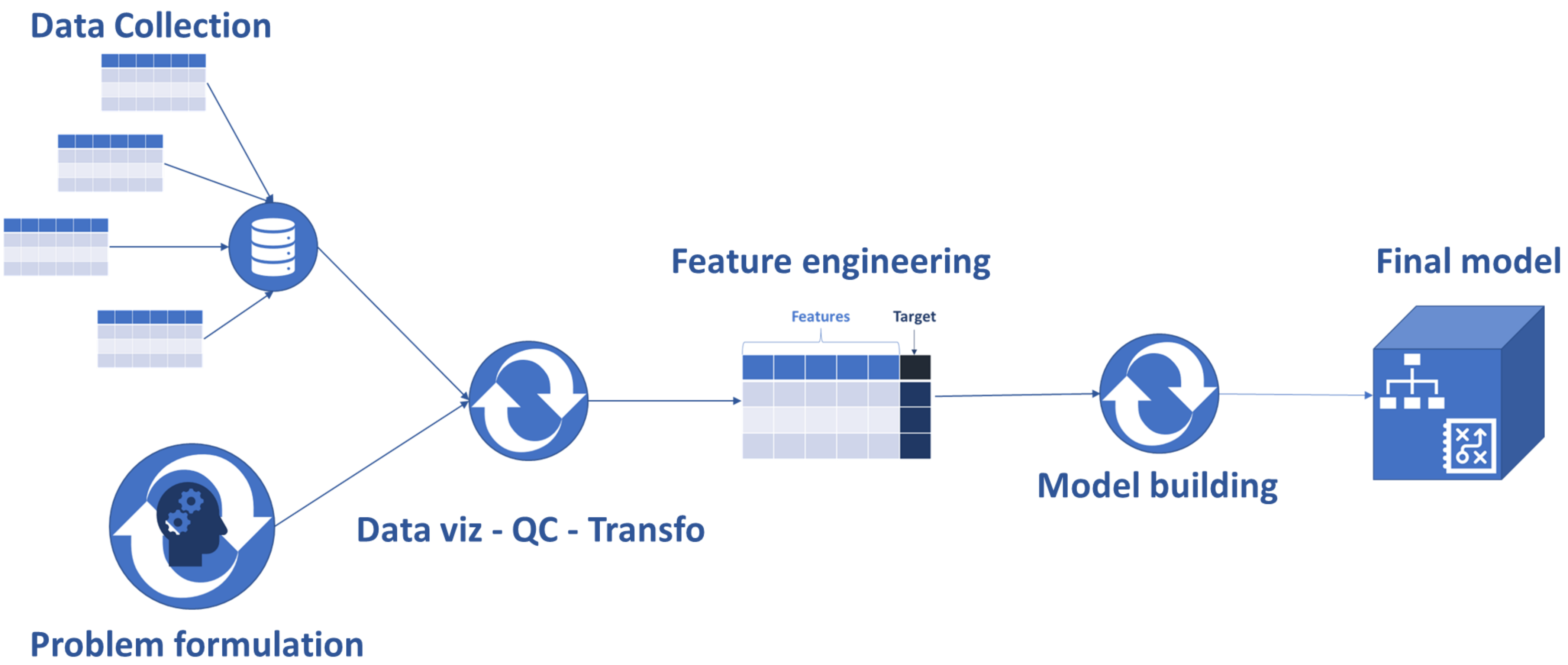
- Energy consumption historic for ~200 buildings
- Temperature

Competition Objective

- Forecast Energy consumtption through different horizons

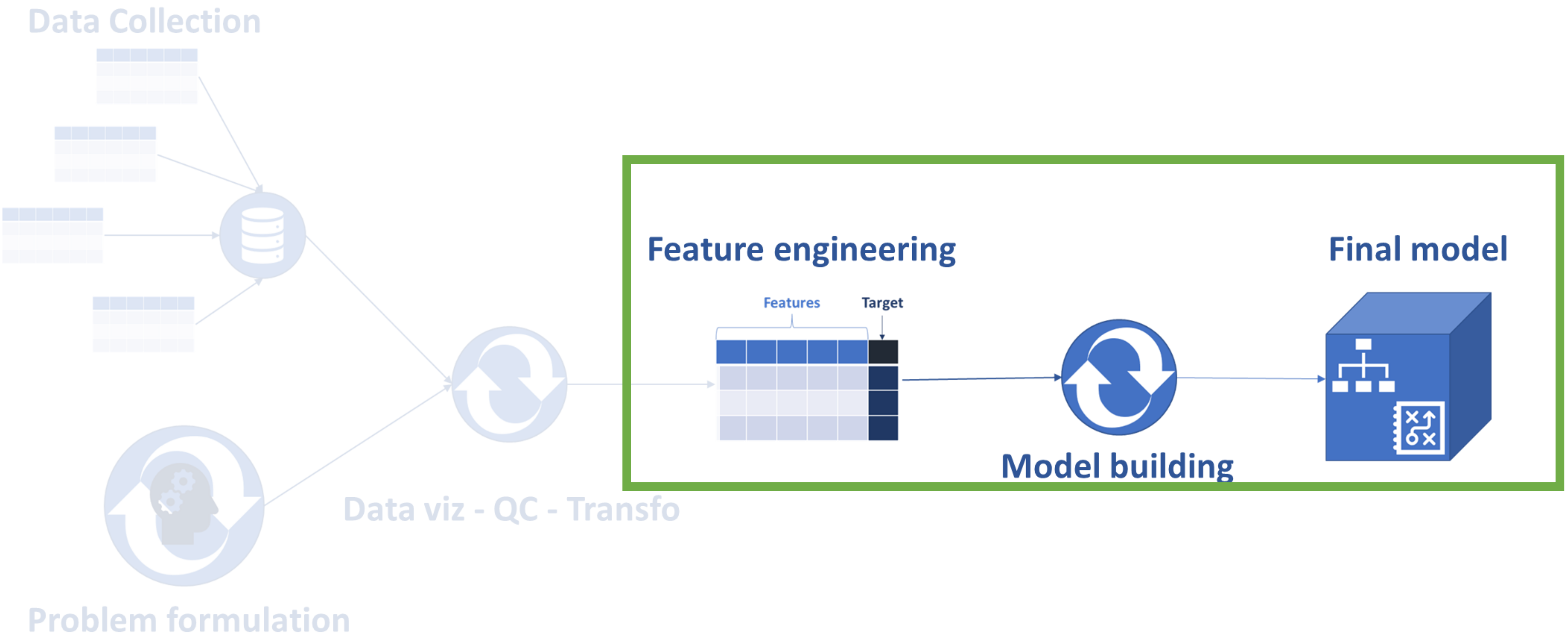
TECH WEEK
KAIZEN

Winner solution

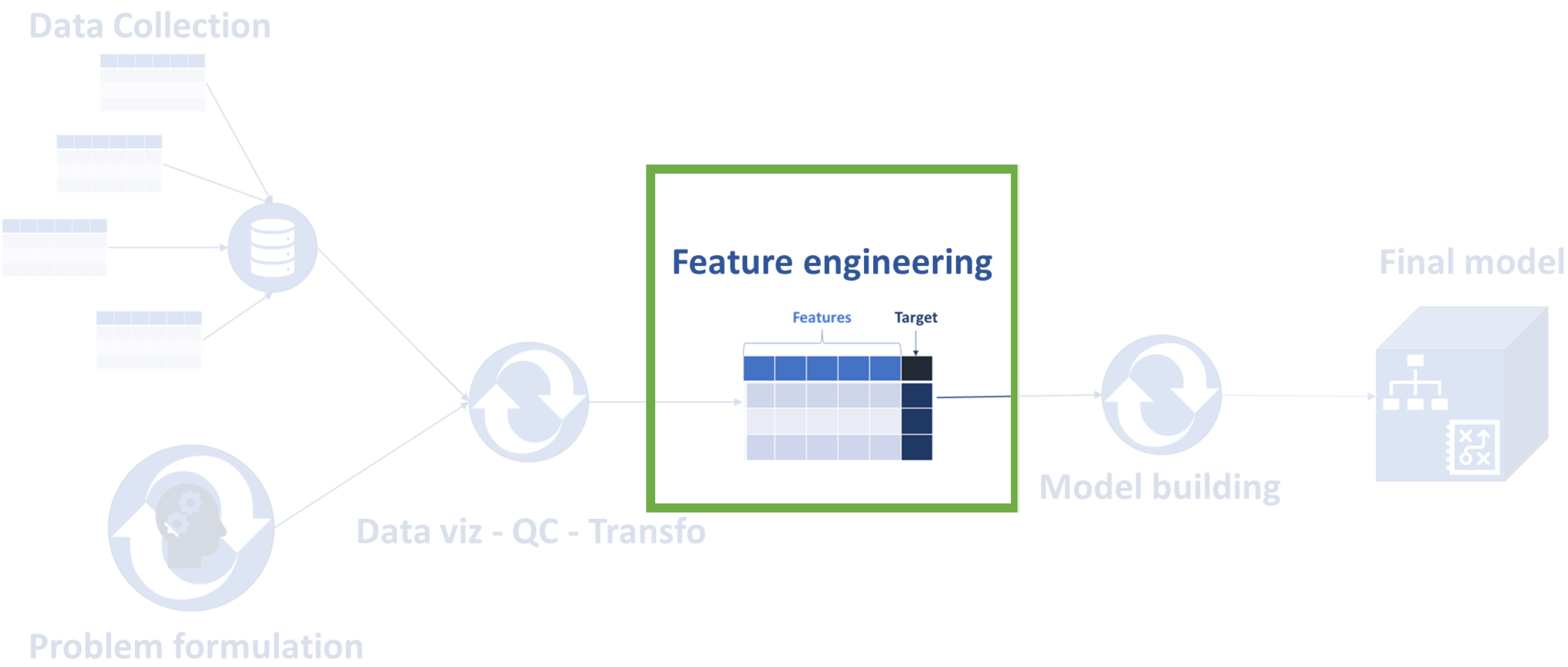


TECH WEEK
KAIZEN

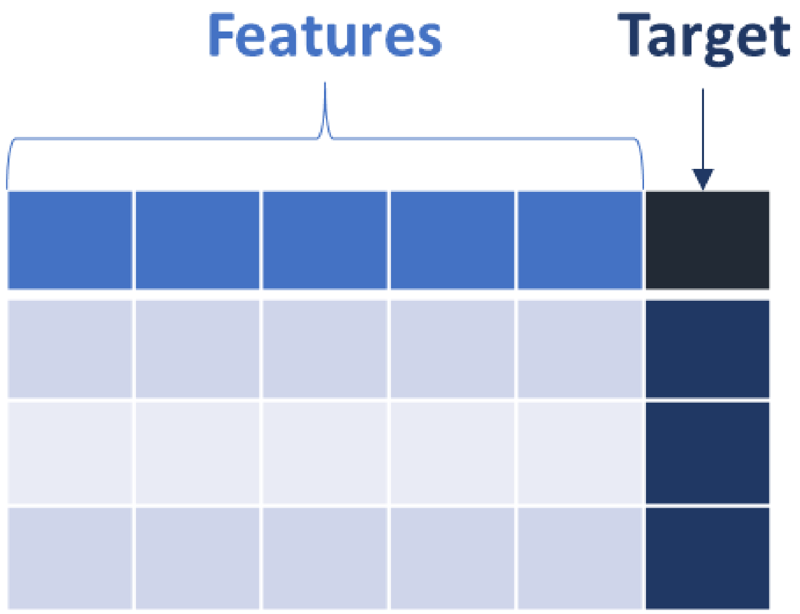
Winner solution



Winner solution

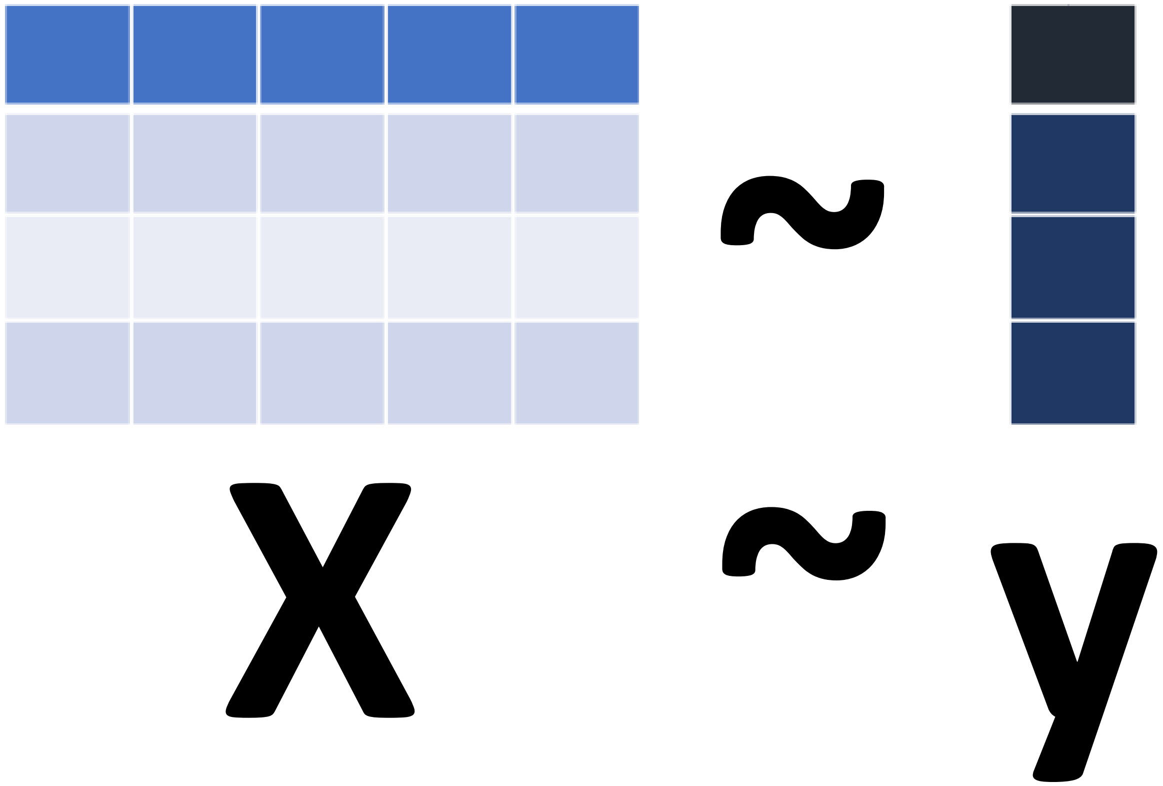


Feature engineering

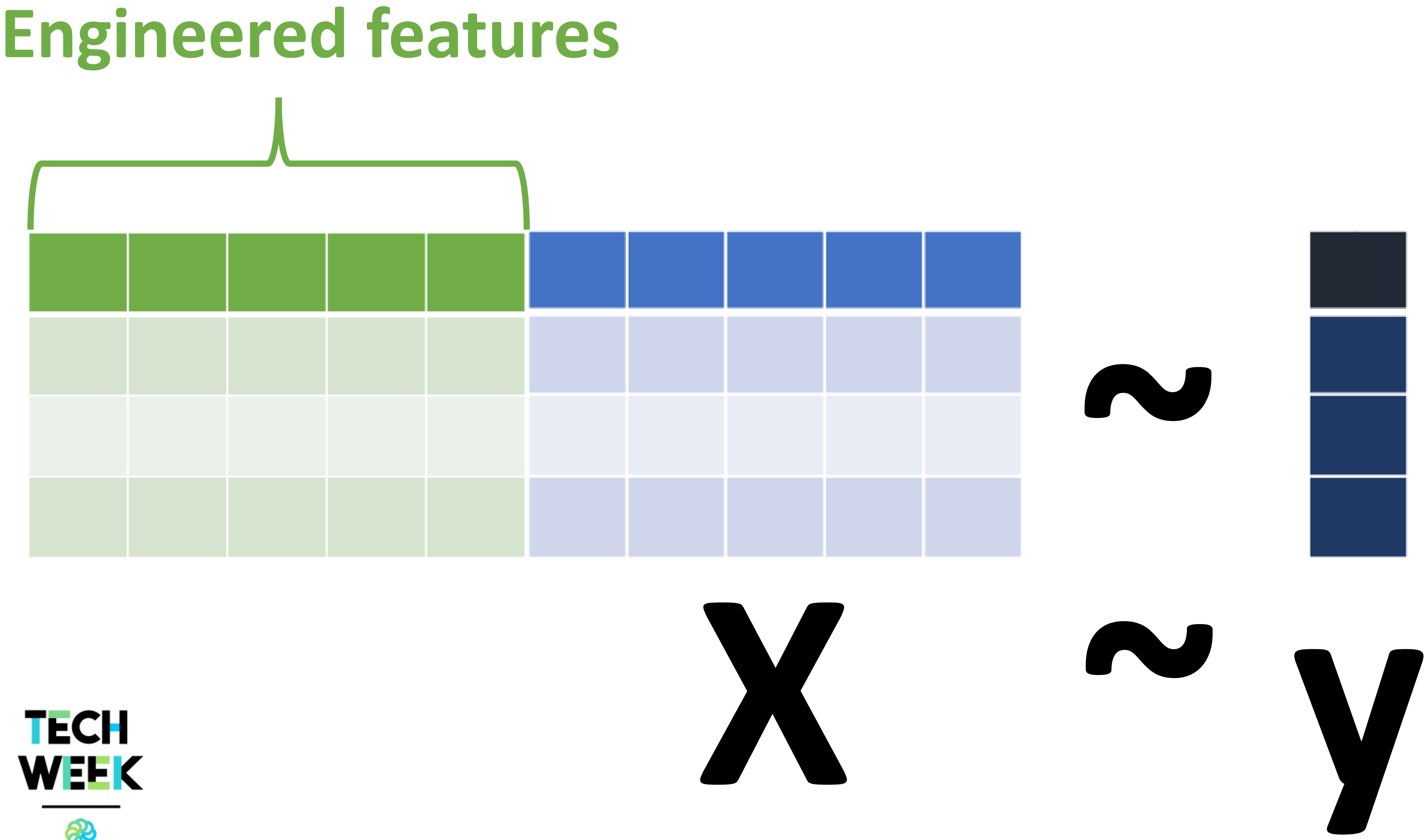


TECH WEEK
KAIZEN

Feature engineering

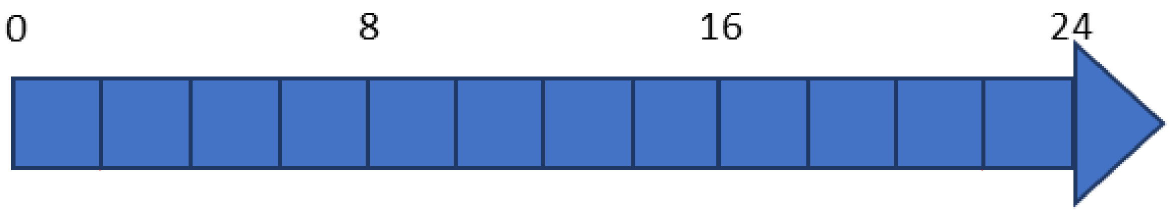


Feature engineering



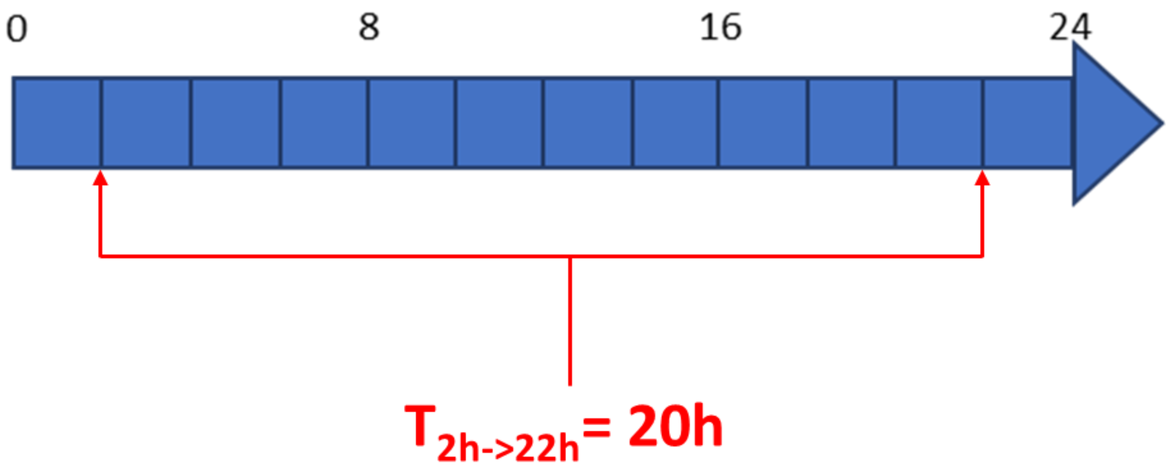
Feature engineering

Cyclical time encoding



Feature engineering

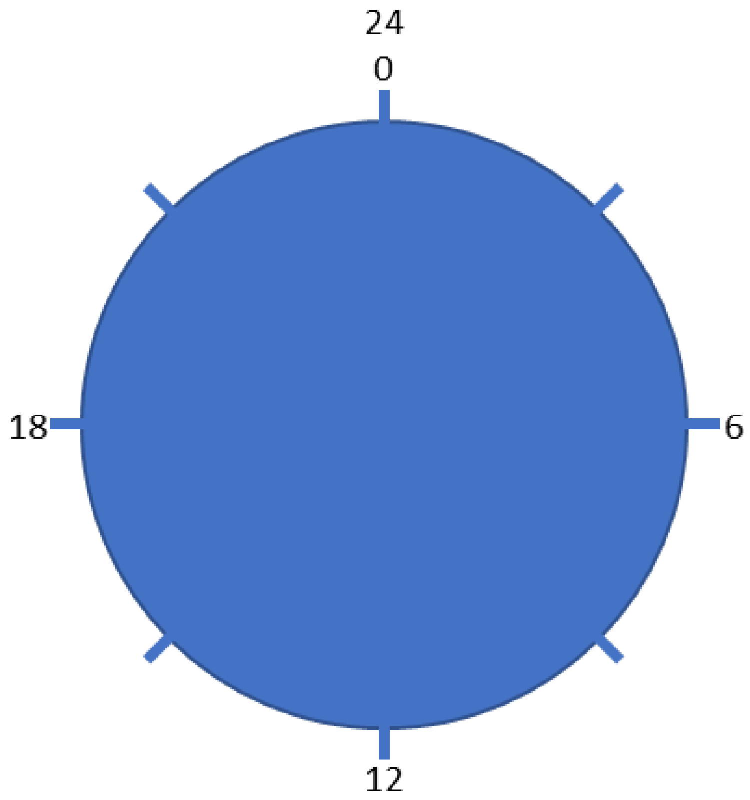
Cyclical time encoding



TECH WEEK KAIZEN

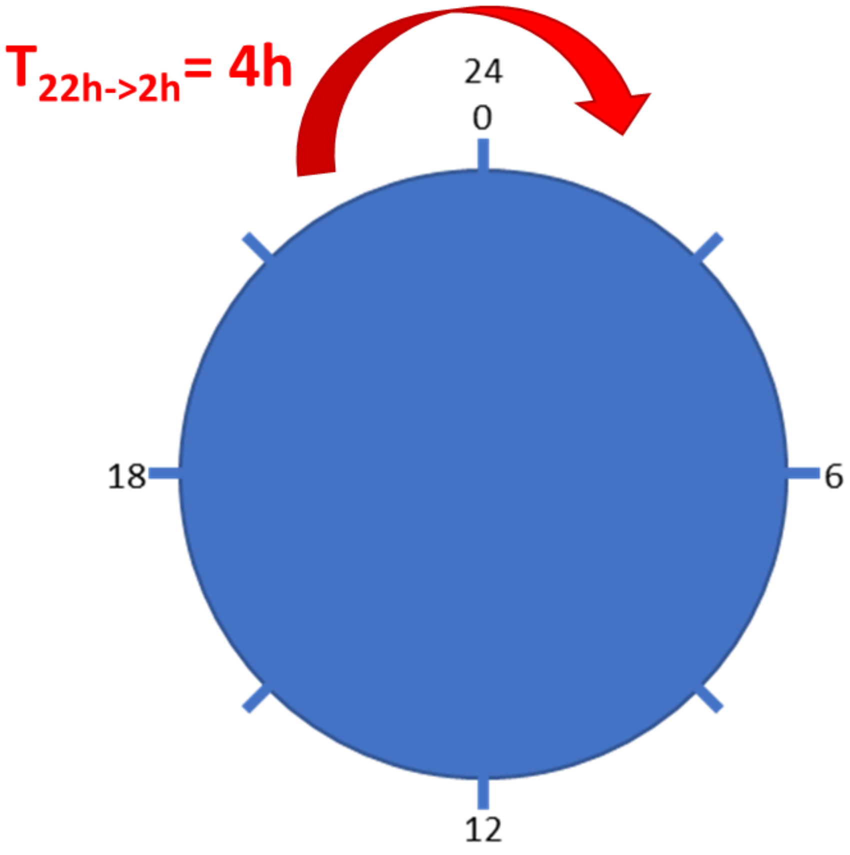
Feature engineering

Cyclical time encoding



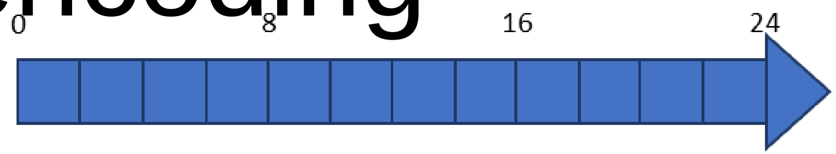
Feature engineering

Cyclical time encoding



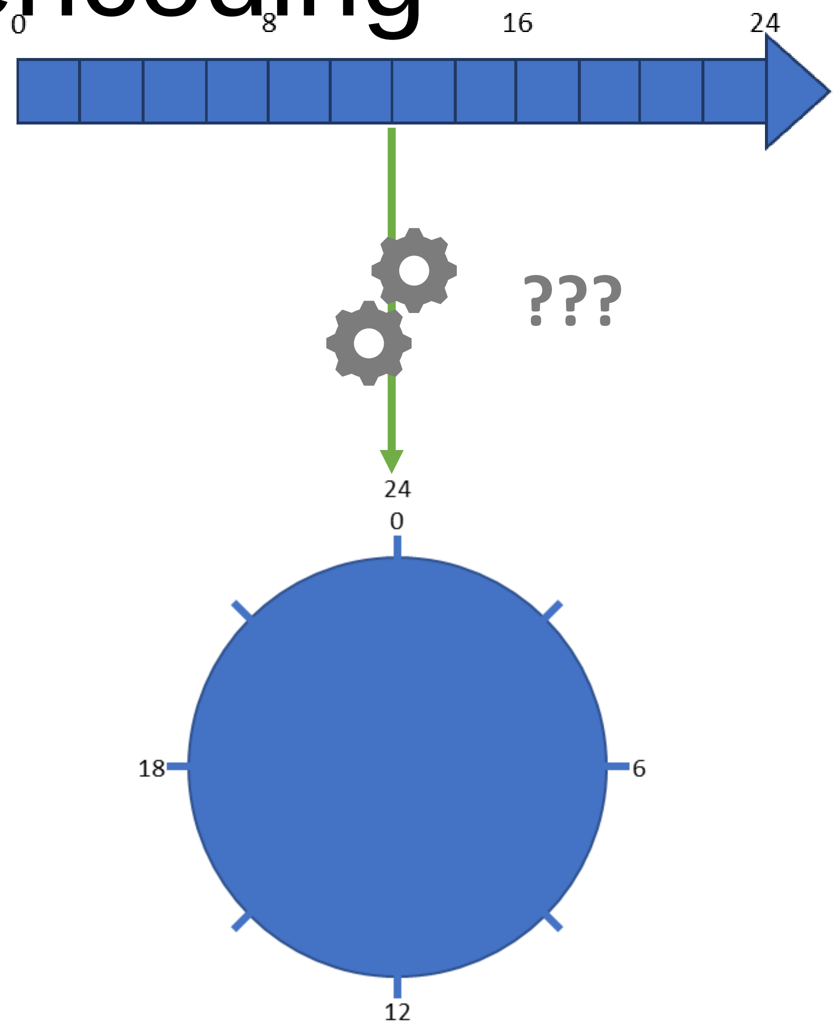
Feature engineering

Cyclical time encoding



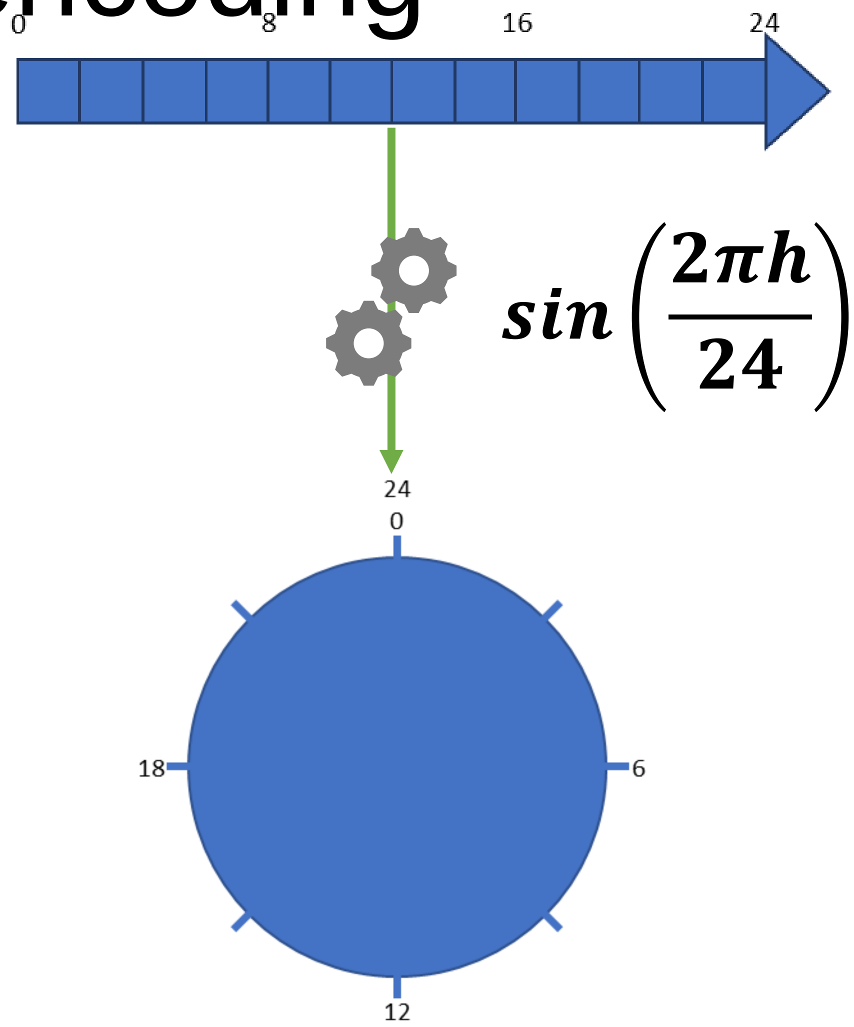
Feature engineering

Cyclical time encoding



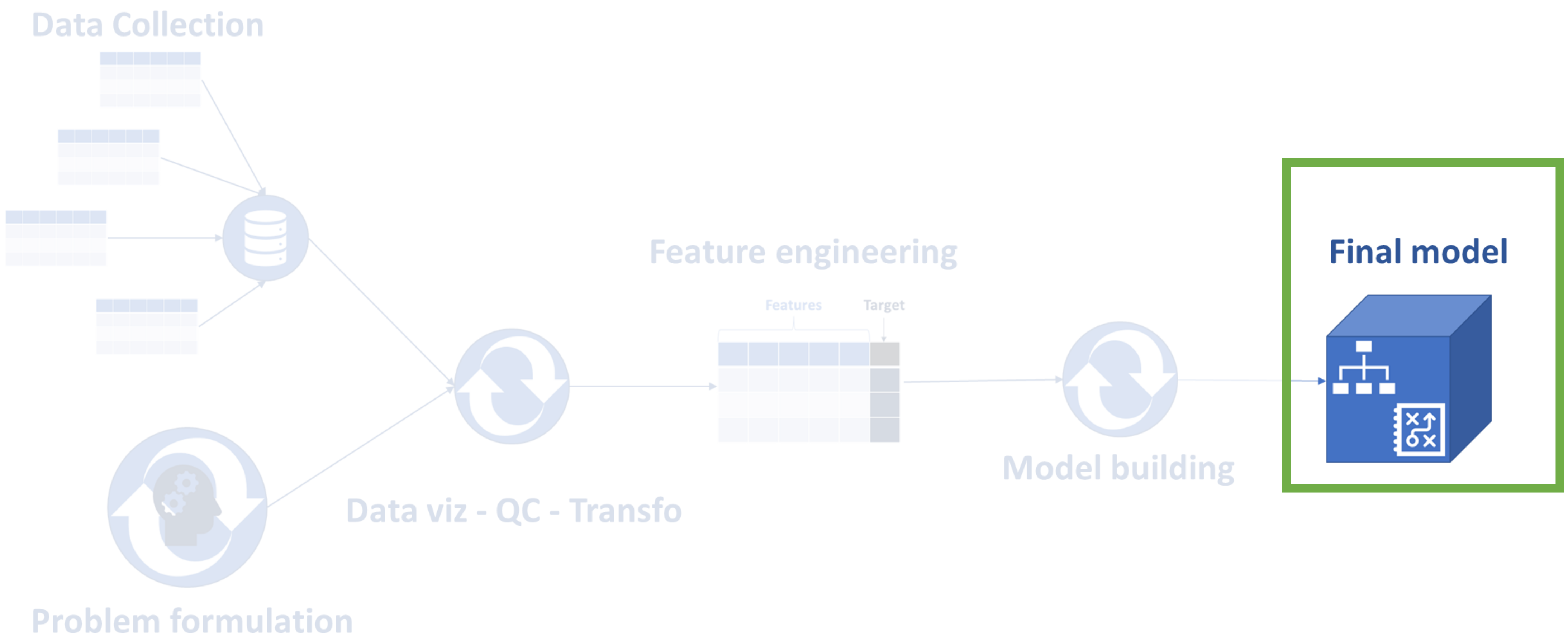
Feature engineering

Cyclical time encoding



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

Winner solution

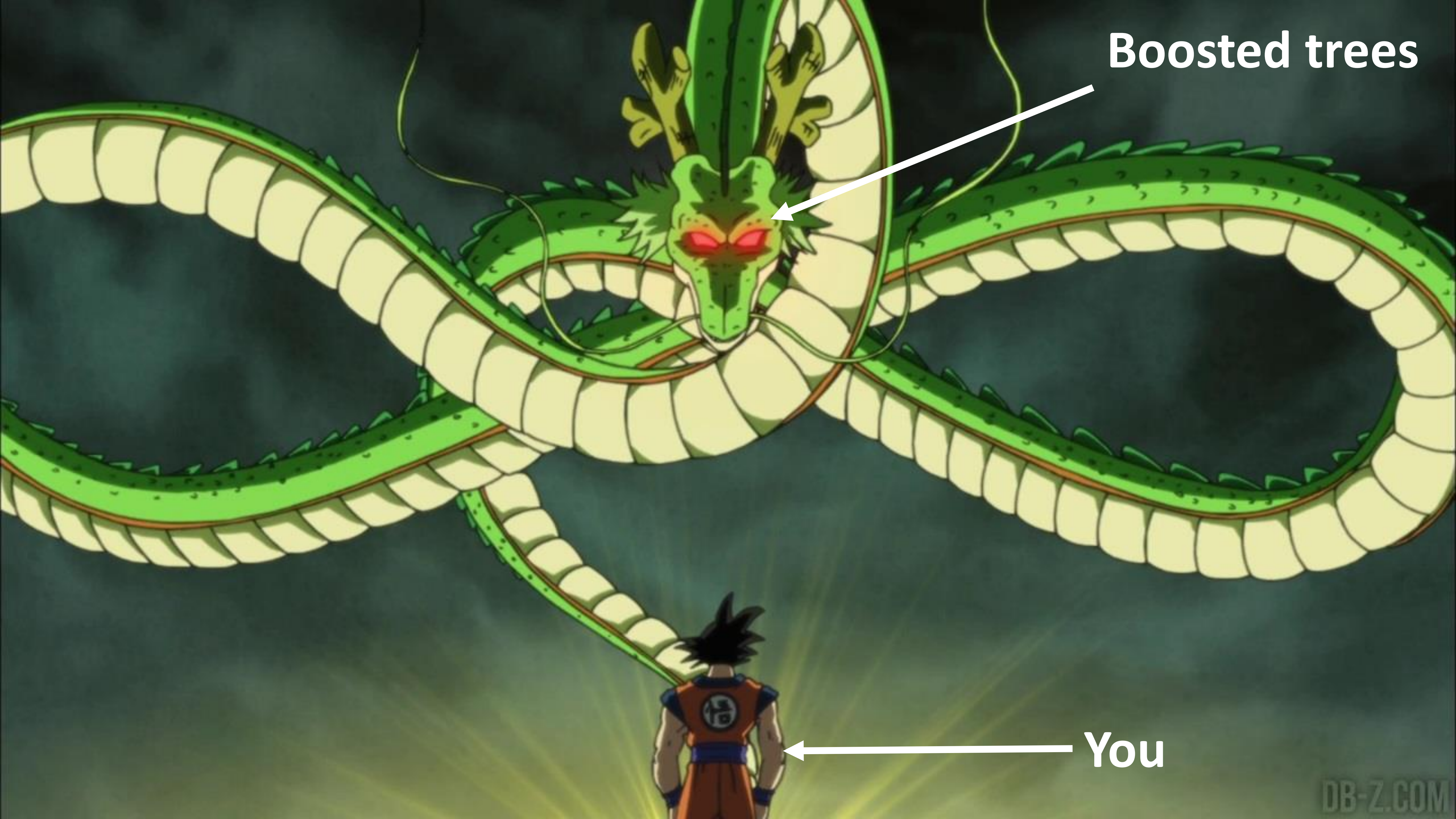


TECH WEEK
KAIZEN

Winner solution

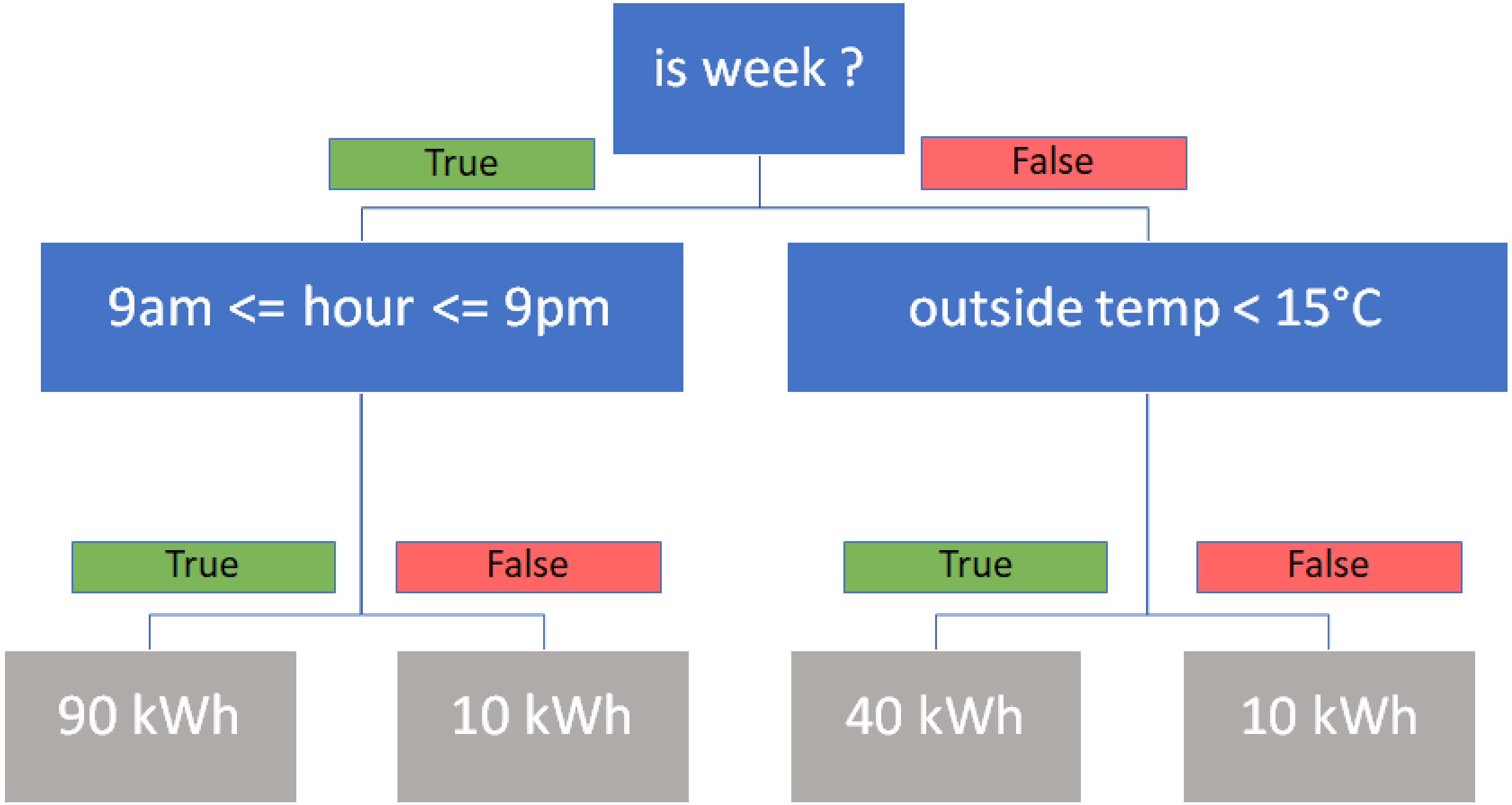
Final model

Boosted trees


Boosted trees
You
DB-Z.COM

Boosted trees

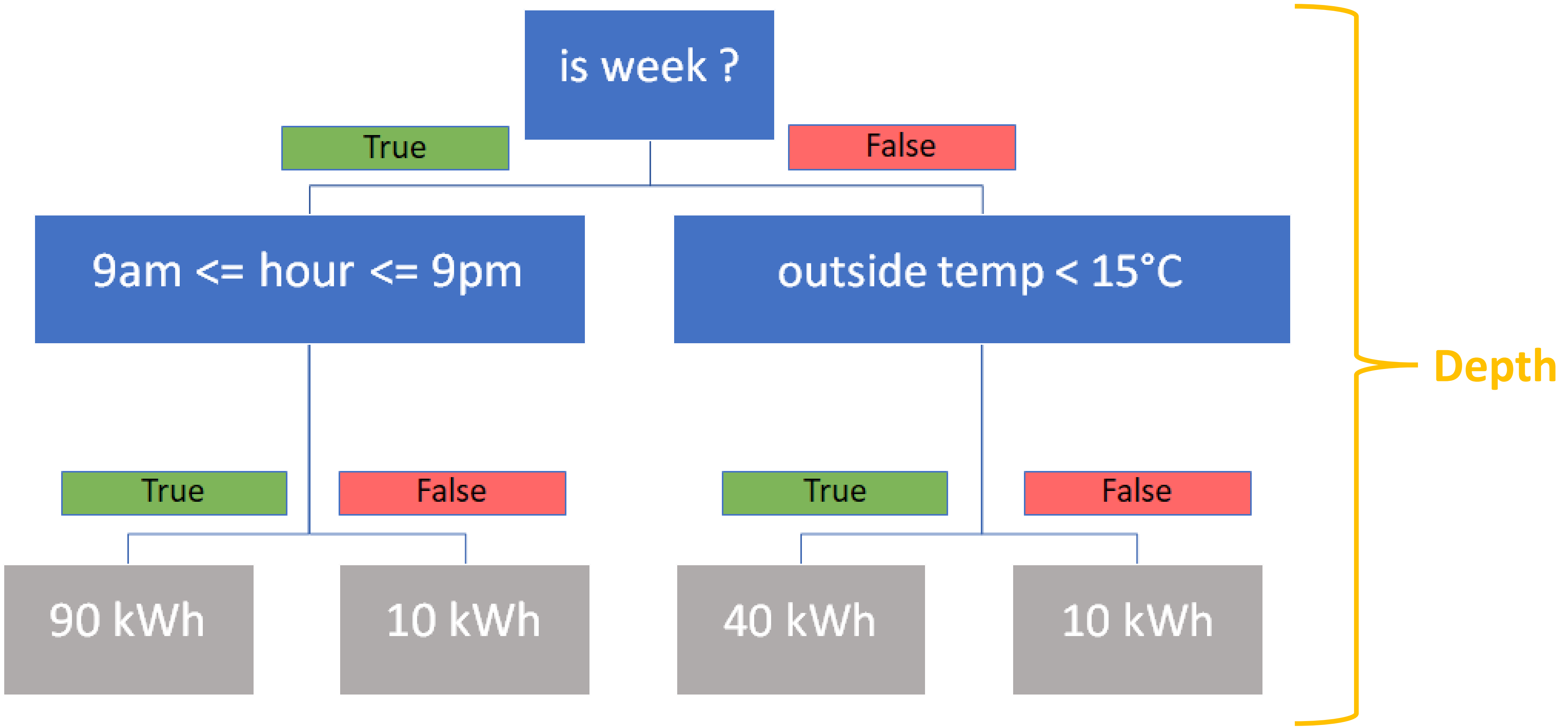
Decision trees



TECH WEEK
KAIZEN

Boosted trees

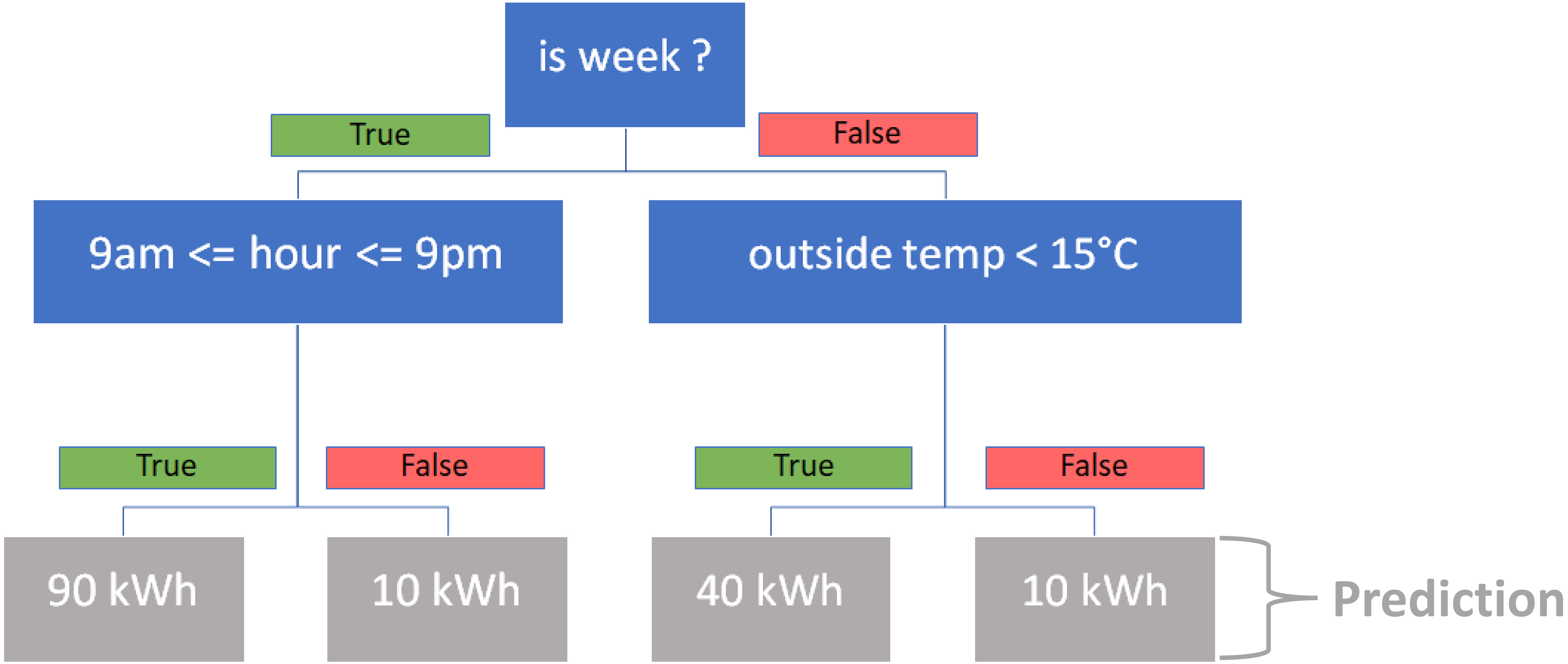
Decision trees



TECH WEEK
KAIZEN

Boosted trees

Decision trees



Boosted trees

Boosting

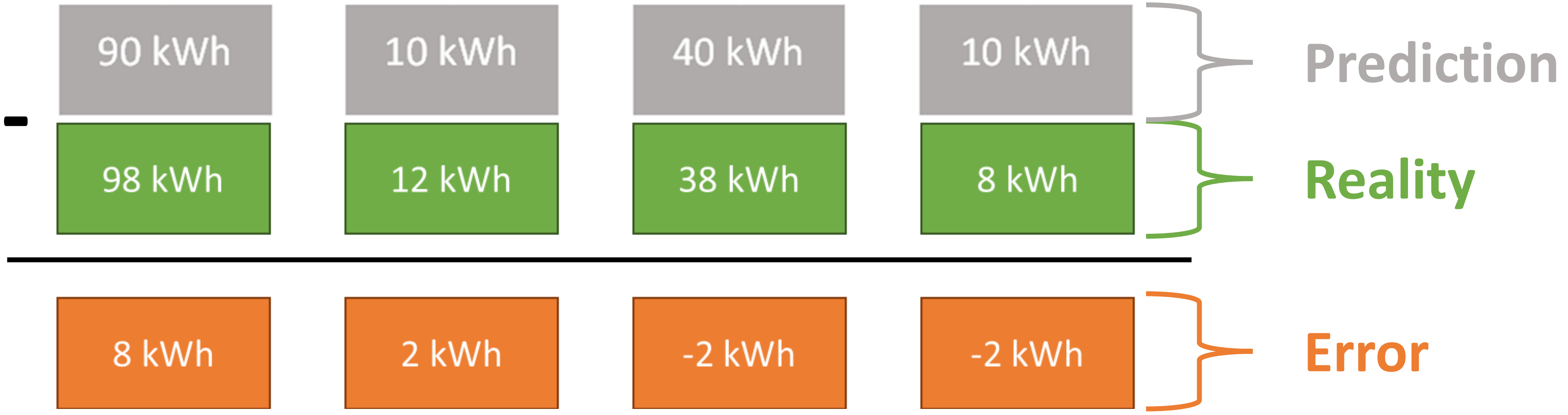
Boosted trees

Boosting

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

Boosted trees

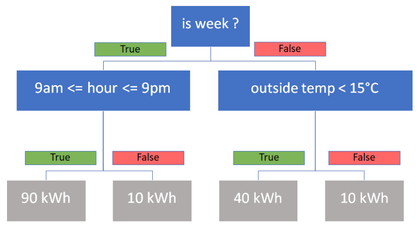
Boosting



Boosted trees

Boosting

90 kWh	10 kWh	40 kWh	10 kWh	Prediction
98 kWh	12 kWh	38 kWh	8 kWh	Reality
8 kWh	2 kWh	-2 kWh	-2 kWh	Error

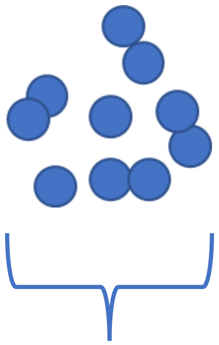


TECH WEEK

KAIZEN

Boosted trees

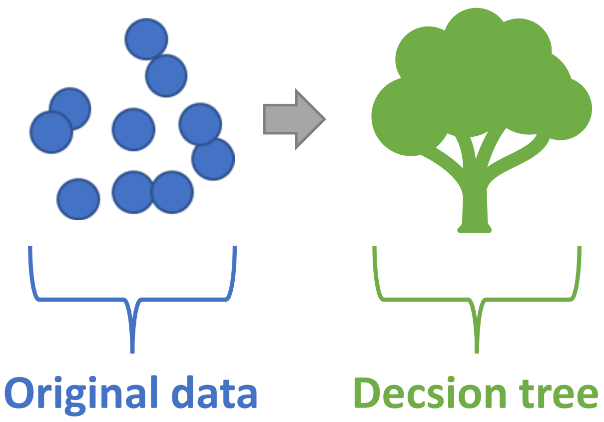
Boosting



Original data

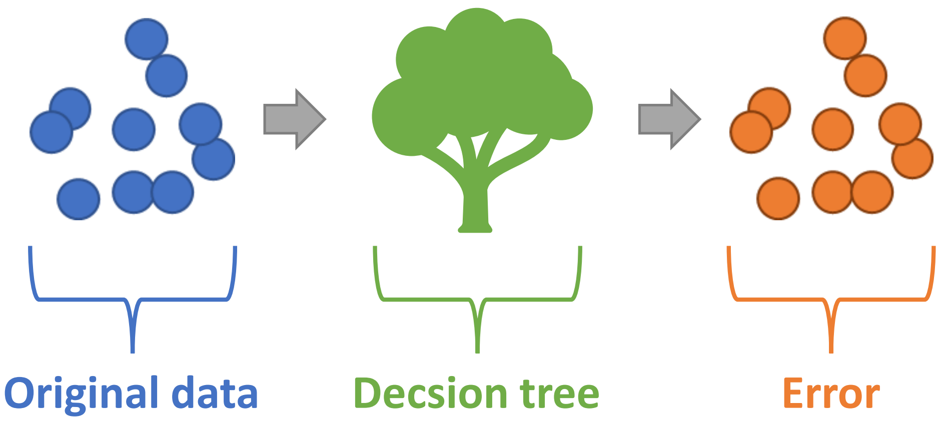
Boosted trees

Boosting



Boosted trees

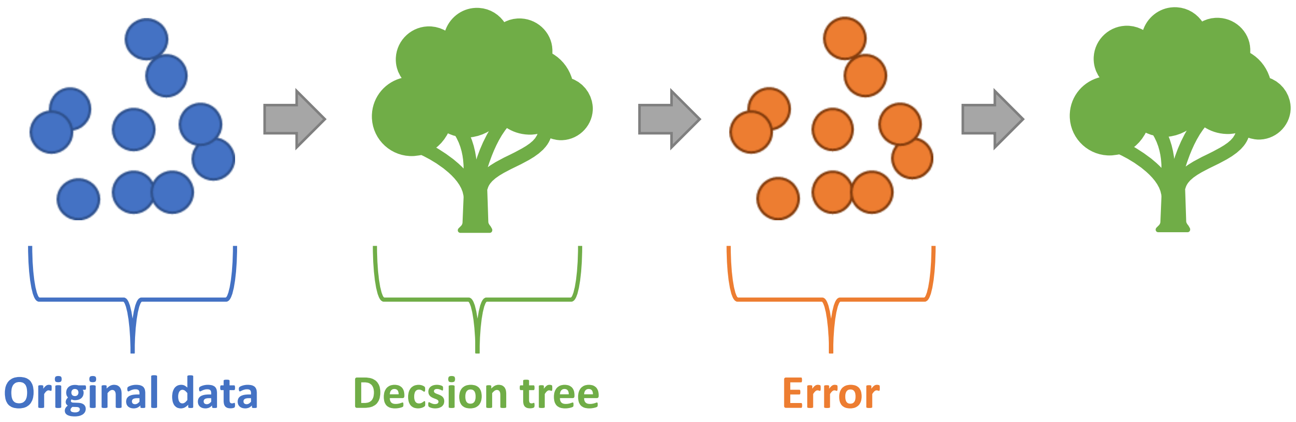
Boosting



TECH WEEK
KAIZEN

Boosted trees

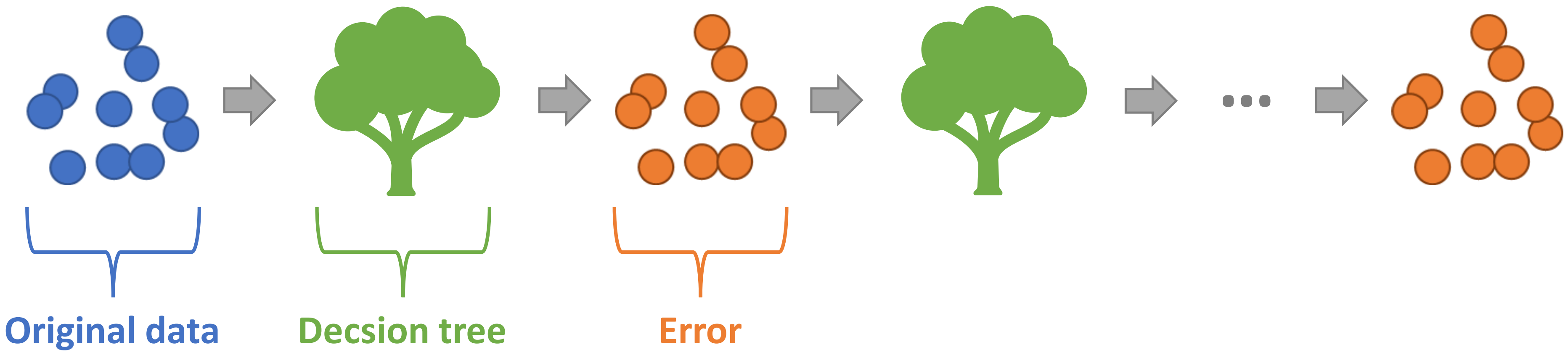
Boosting



TECH WEEK
KAIZEN

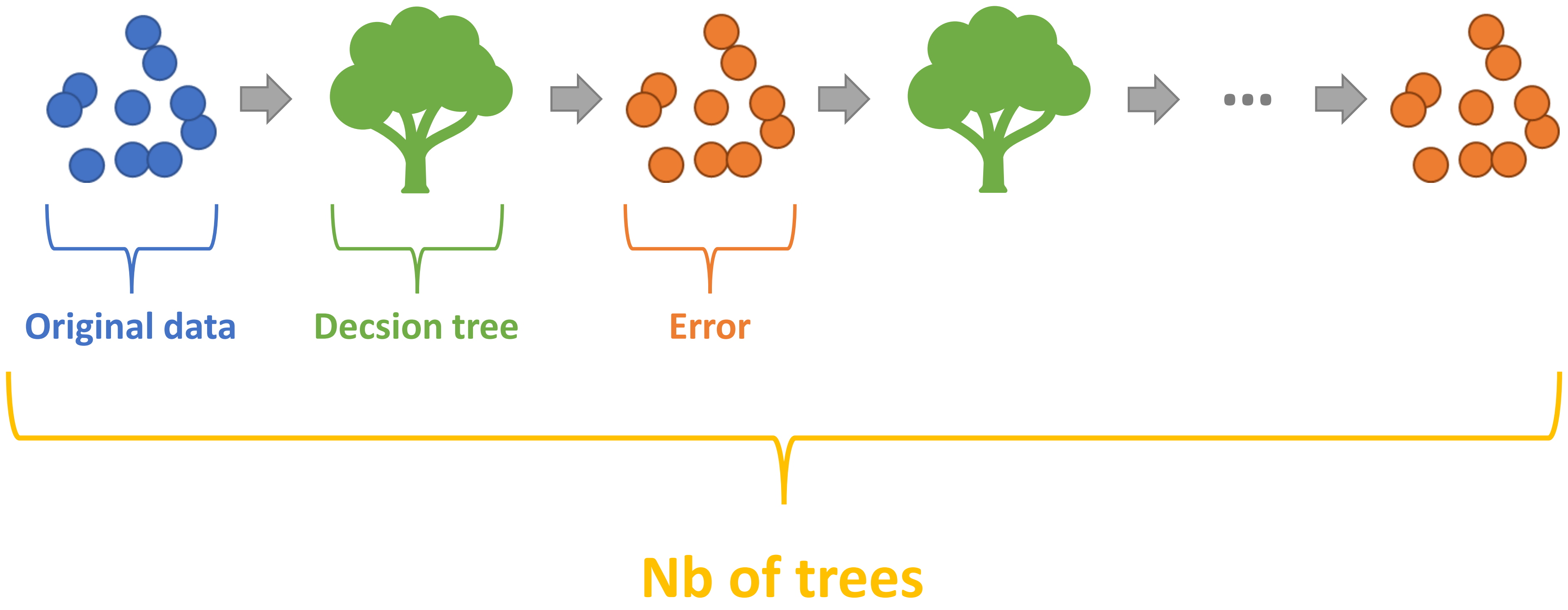
Boosted trees

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

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.

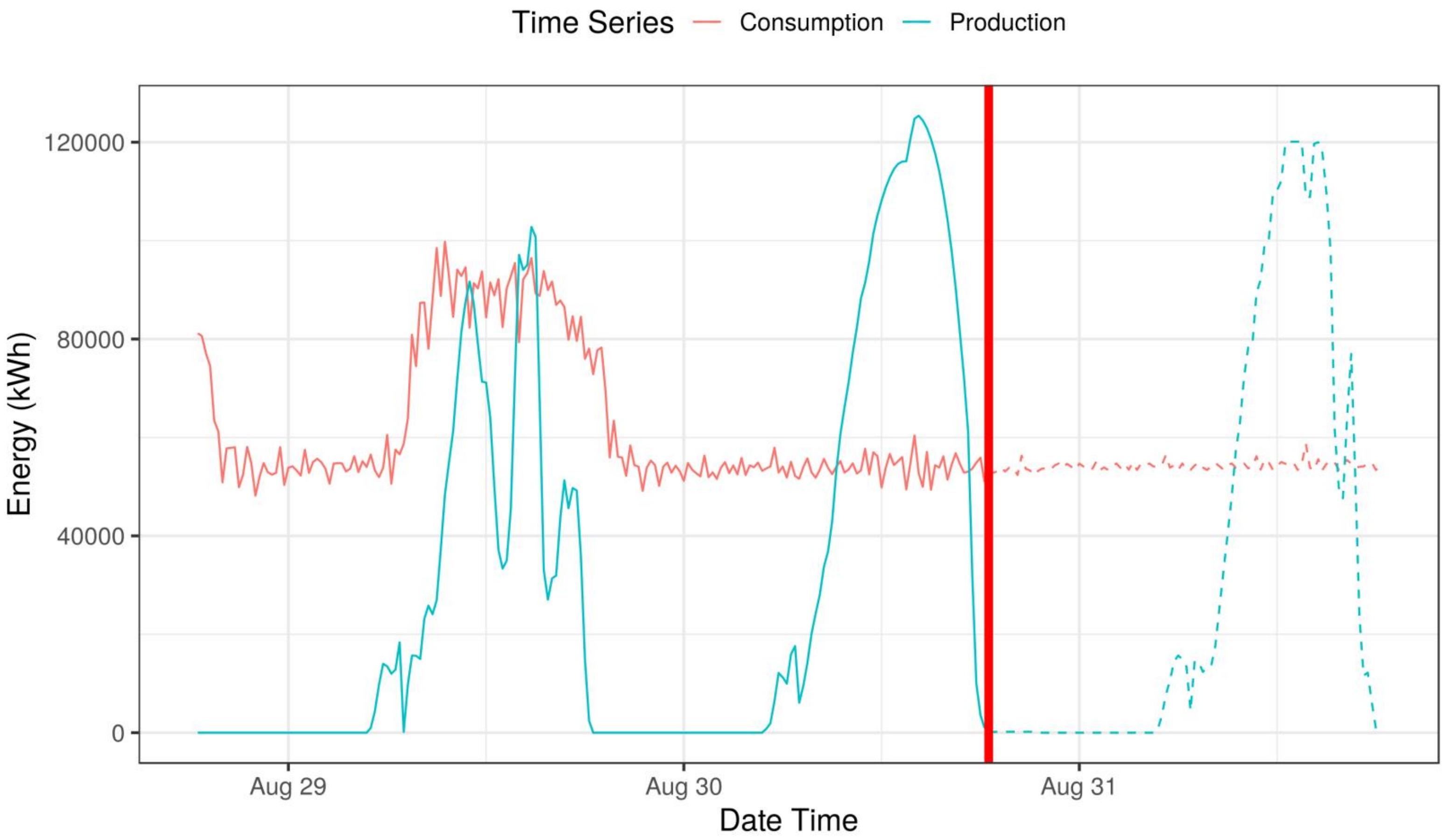
⇒ Algorithms can help battery charging systems to be as efficient as possible

Quick Facts

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

TECH WEEK
KAIZEN

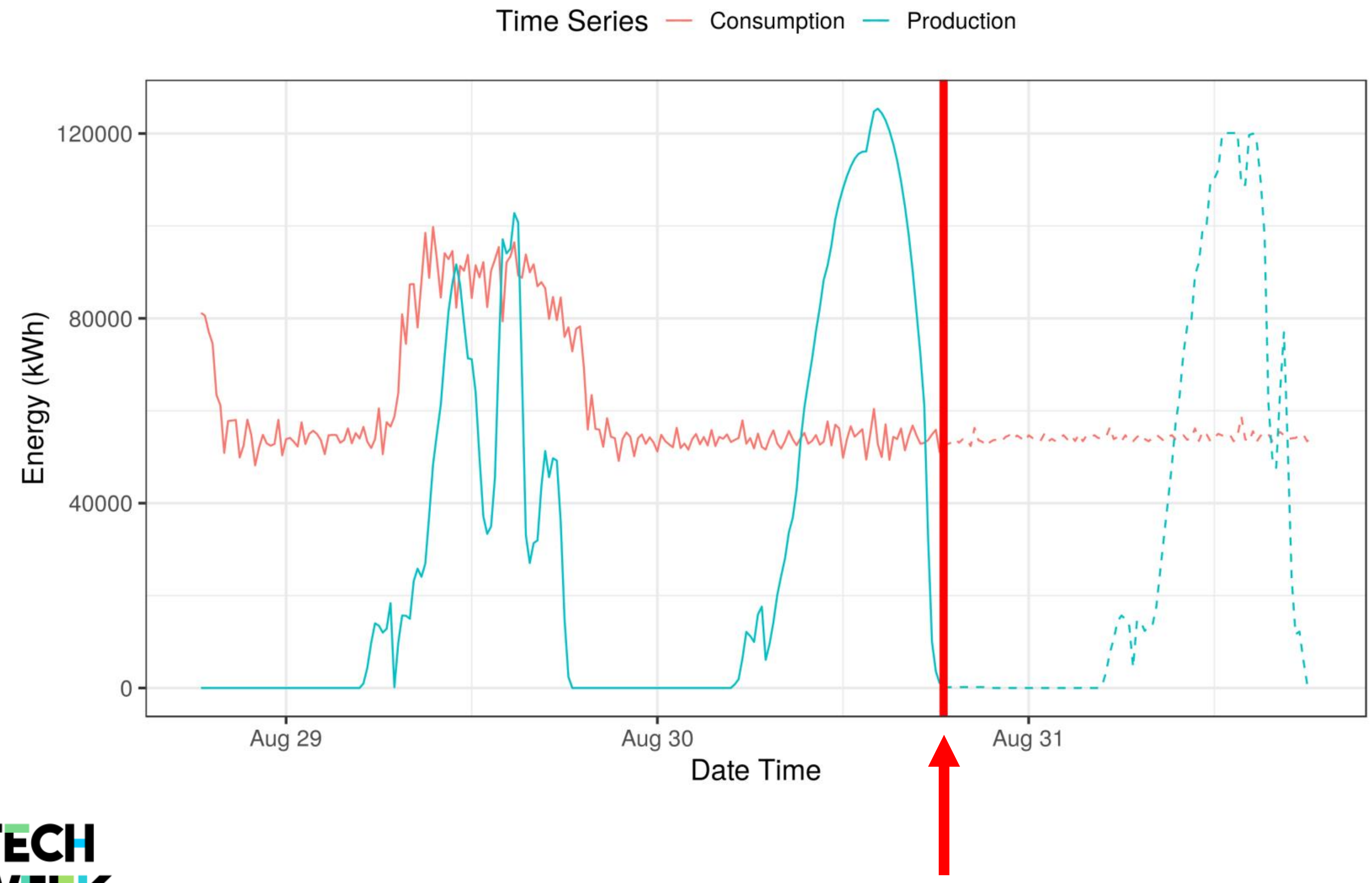
Competition Description



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

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

TECH WEEK
KAIZEN

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

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

TECH WEEK
KAIZEN

Linear Programming

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

Linear Programming

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

Linear Programming

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

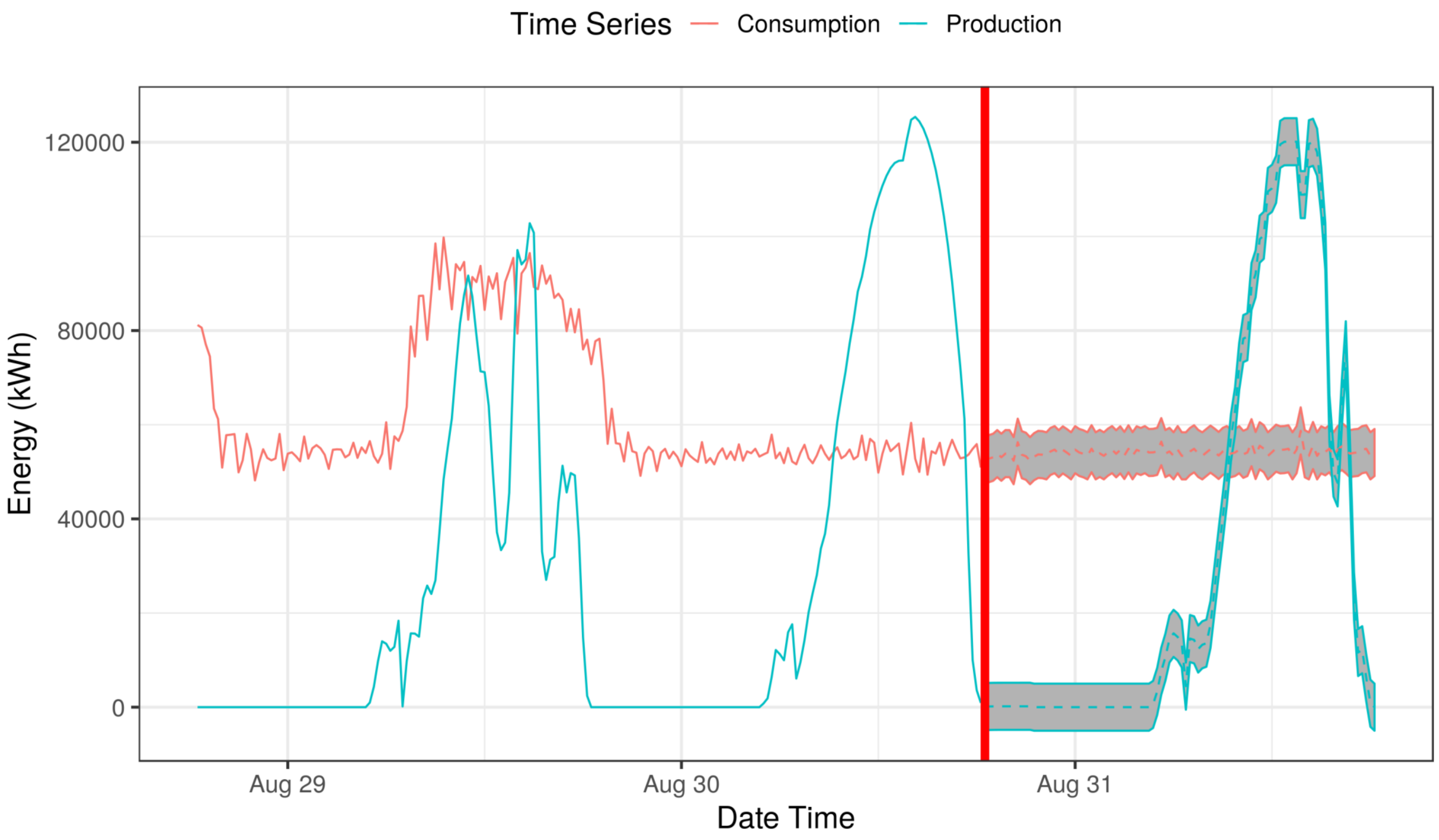
Linear Programming

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

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

TECH WEEK KAIZEN

Forecasting Error



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

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

TECH WEEK

KAIZEN

Scenario based stochastic programming

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

TECH WEEK

KAIZEN

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

TECH WEEK

KAIZEN

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

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

TECH WEEK
KAIZEN

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

Quick Facts

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

TECH WEEK
KAIZEN

Conclusion

Business needs

- Business context
- True dataset

Conclusion

Business needs

- Business context
- True dataset

Open Sources

- Understand Solutions
- Formation

Conclusion

Business needs

- Business context
- True dataset

Open Sources

- Understand Solutions
- Formation

Continuous Improvement

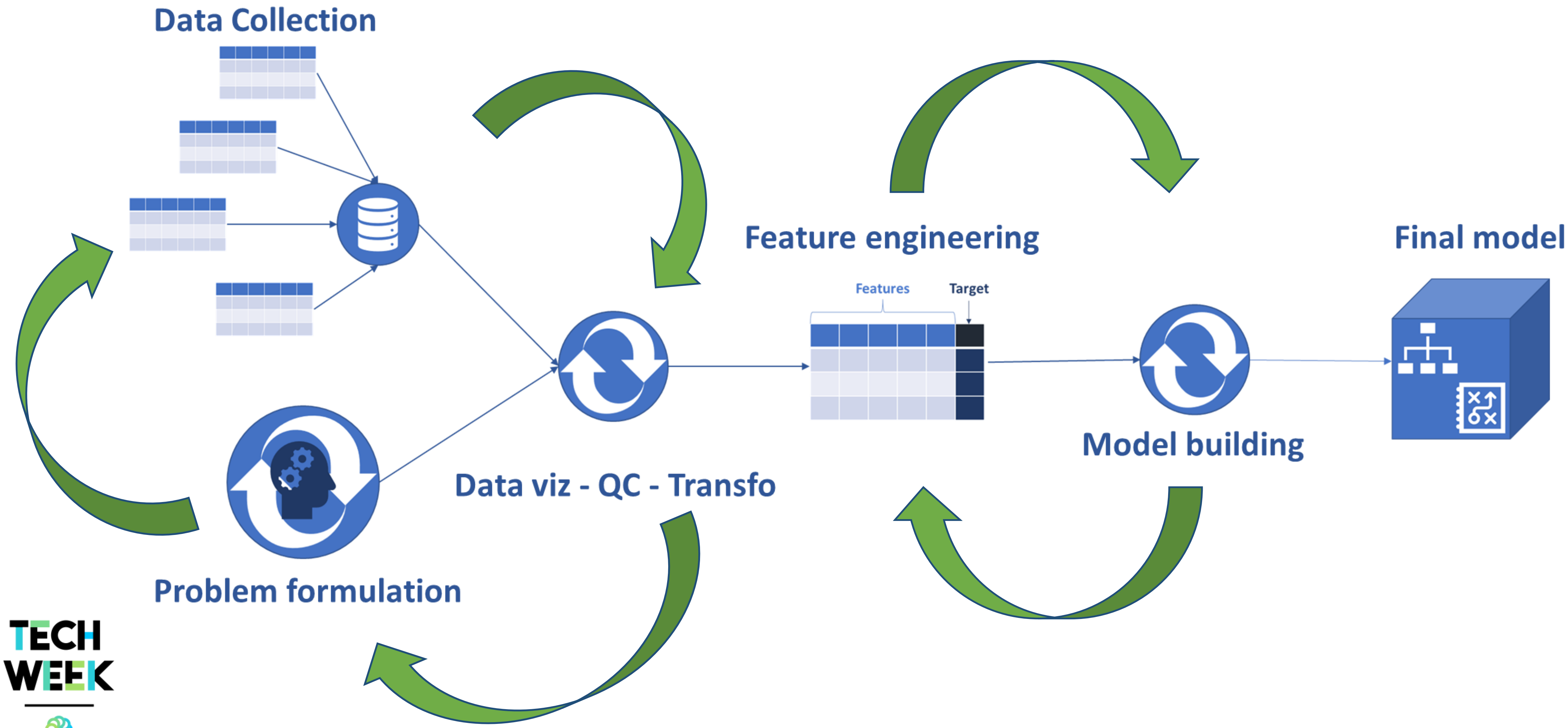
- Compare with existing
- Community

Any questions ?

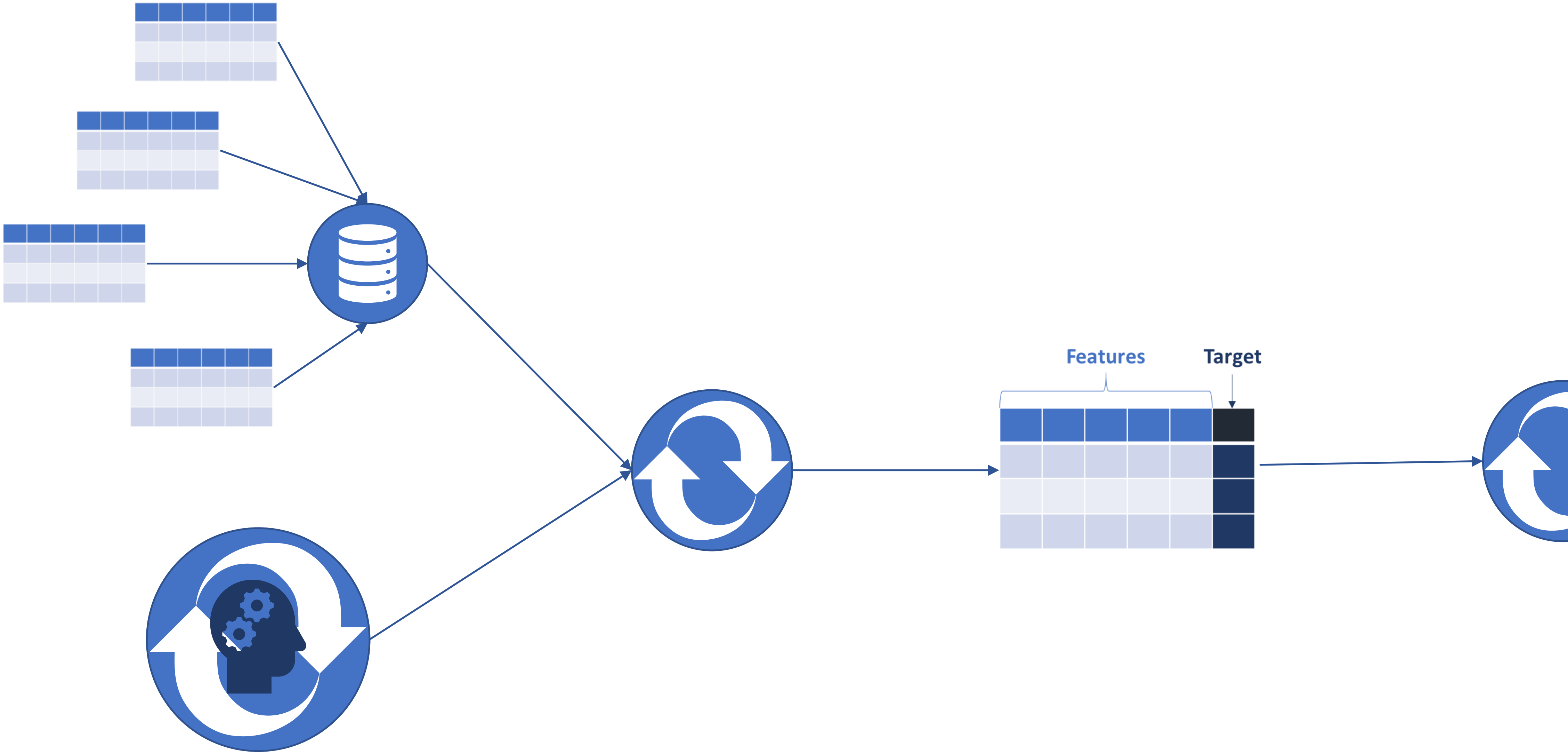
TECH WEEK

KAIZEN

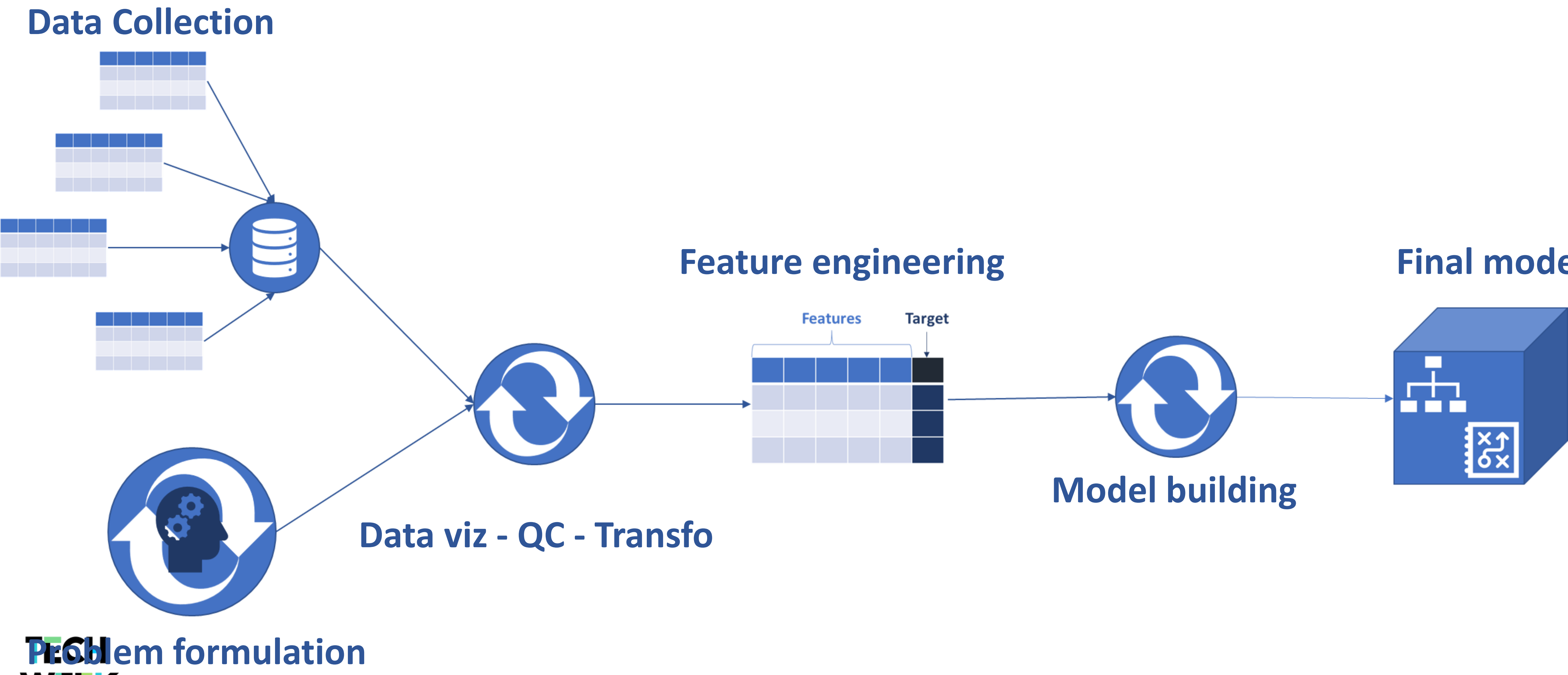
Winner solution



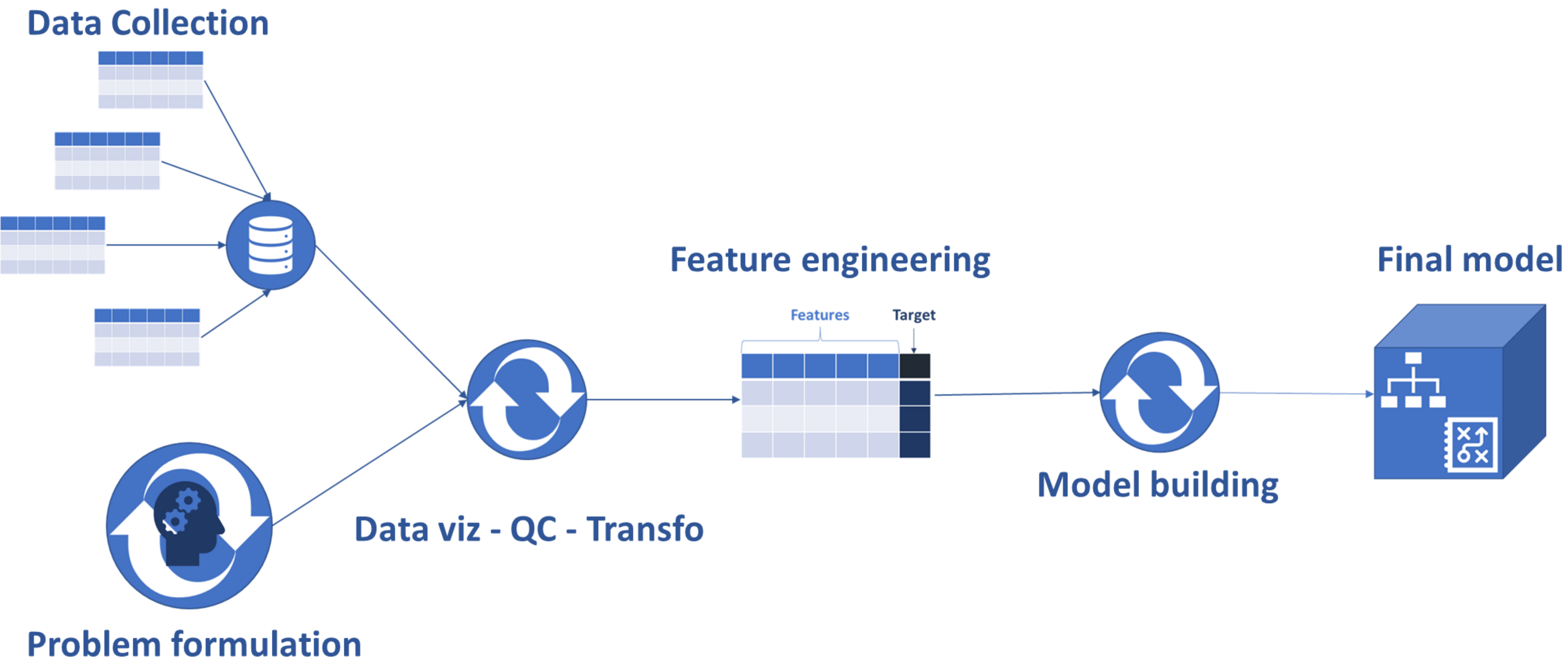
TECH WEEK
KAIZEN



TECH WEEK
KAIZEN



TECH WEEK
KAIZEN



TECH WEEK

KAIZEN