The Mystery of Energy Data Science

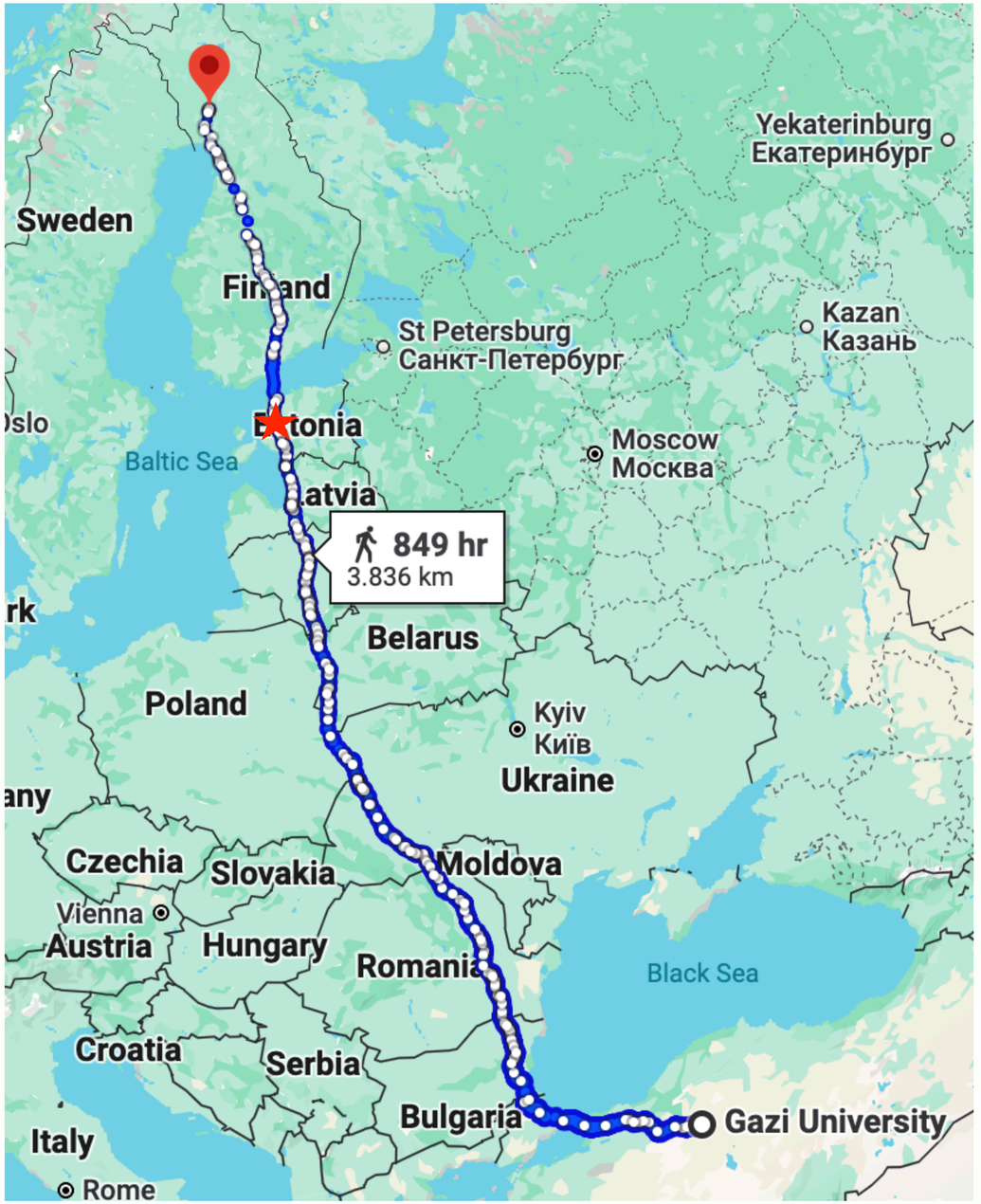
Prof. Juri Belikov

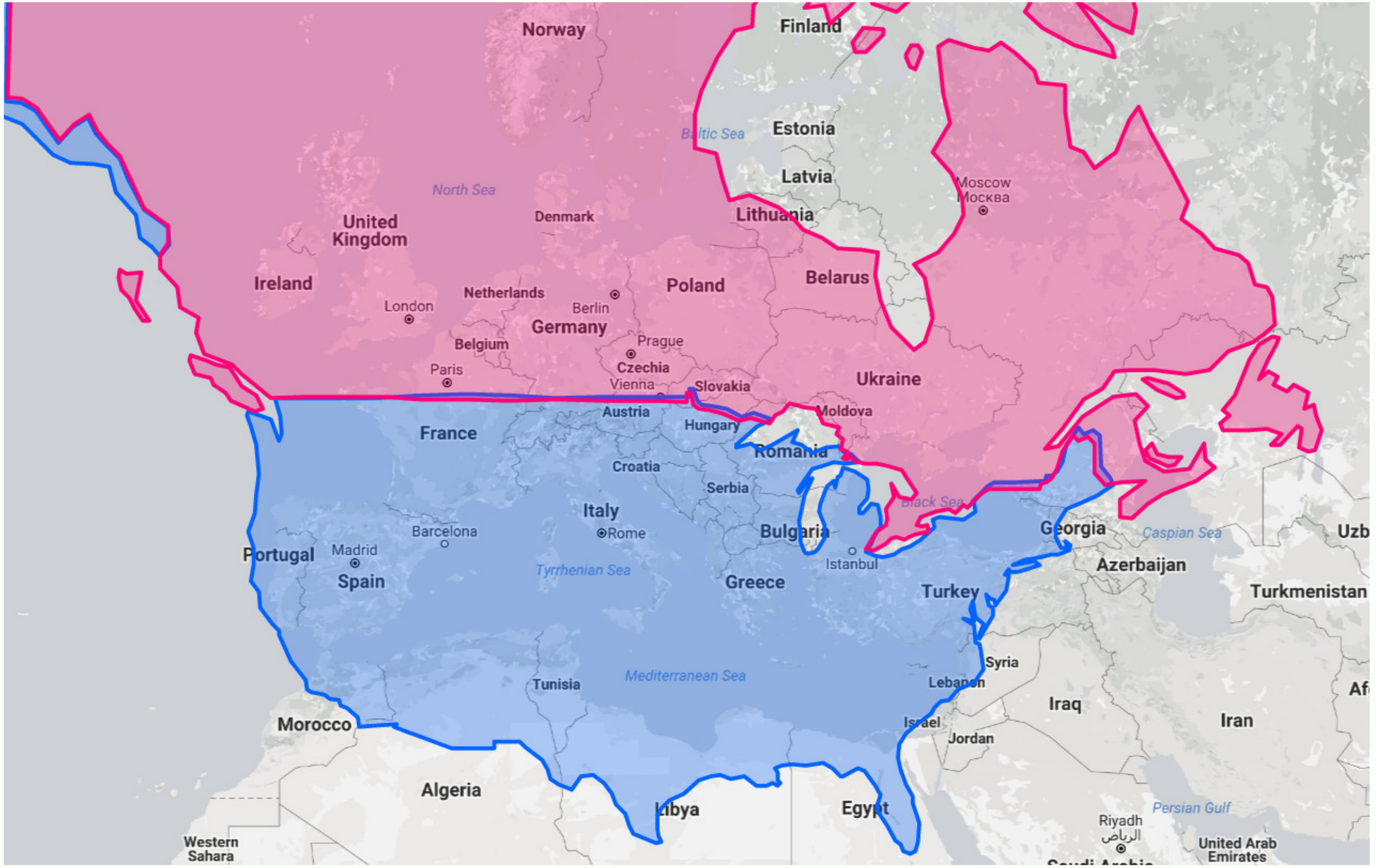
Department of Software Science
Tallinn University of Technology
juri.belikov@taltech.ee

Gazi University, Ankara, 13.05.2025

ESTONIA

- ✓ Area 45,227 km2
- ✓ Population ~1.3 mln
- ✓ Capital: Tallinn
- ✓ Currency: Euro
- ✓ Over 52% is covered with forest
- ✓ Highest point is 318m above the sea level
- ✓ 10 unicorns (eg Skype, Playtech, Wise, Bolt, etc.)





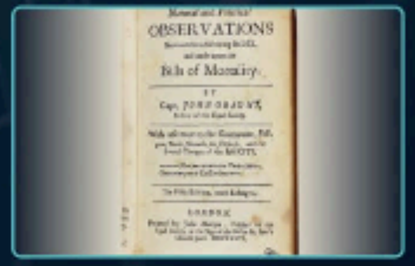
[Accessed February 27, 2025], https://www.reddit.com/r/MapPorn/comments/63m1fn/the_united_states_and_canada_at_the_same/

HISTORY OF DATA

19,000 BC

The Ishango bone holds the first evidence of data collection and storage.

1600s



John Graunt introduces the concept of data analysis in 1663.

1800s

Herman Hollerith designs a machine that helped complete the US census in 1890.

1900s

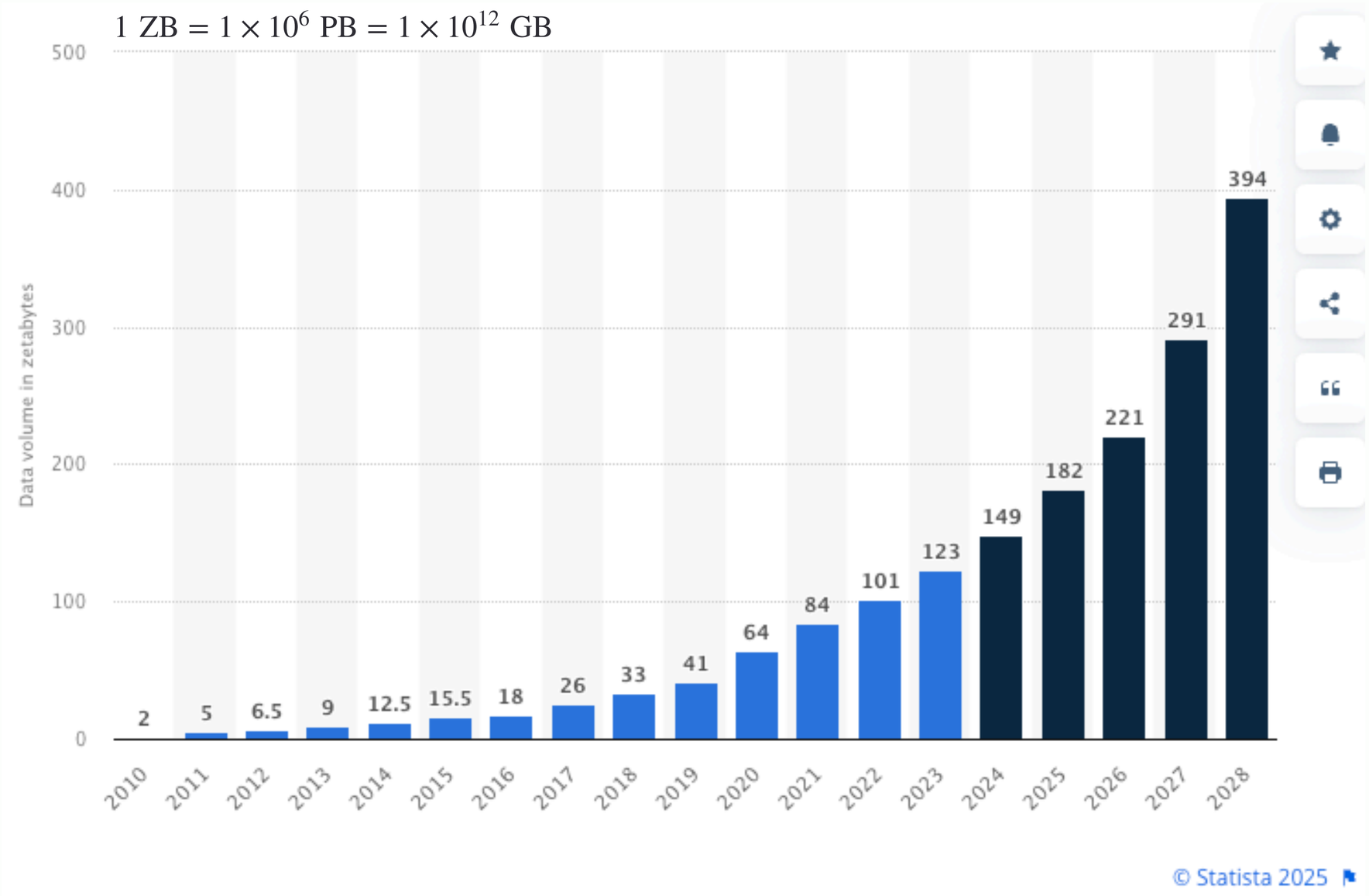
Fritz Pfleumer invents the magnetic tape which later inspired the invention of floppy disks and hard disk drives.

1990s

Sir Tim Berners Lee invents the World Wide Web.

[Accessed February 27, 2025], https://365datascience.com/trending/history-of-data/

WORLD DATA IN NUMBERS

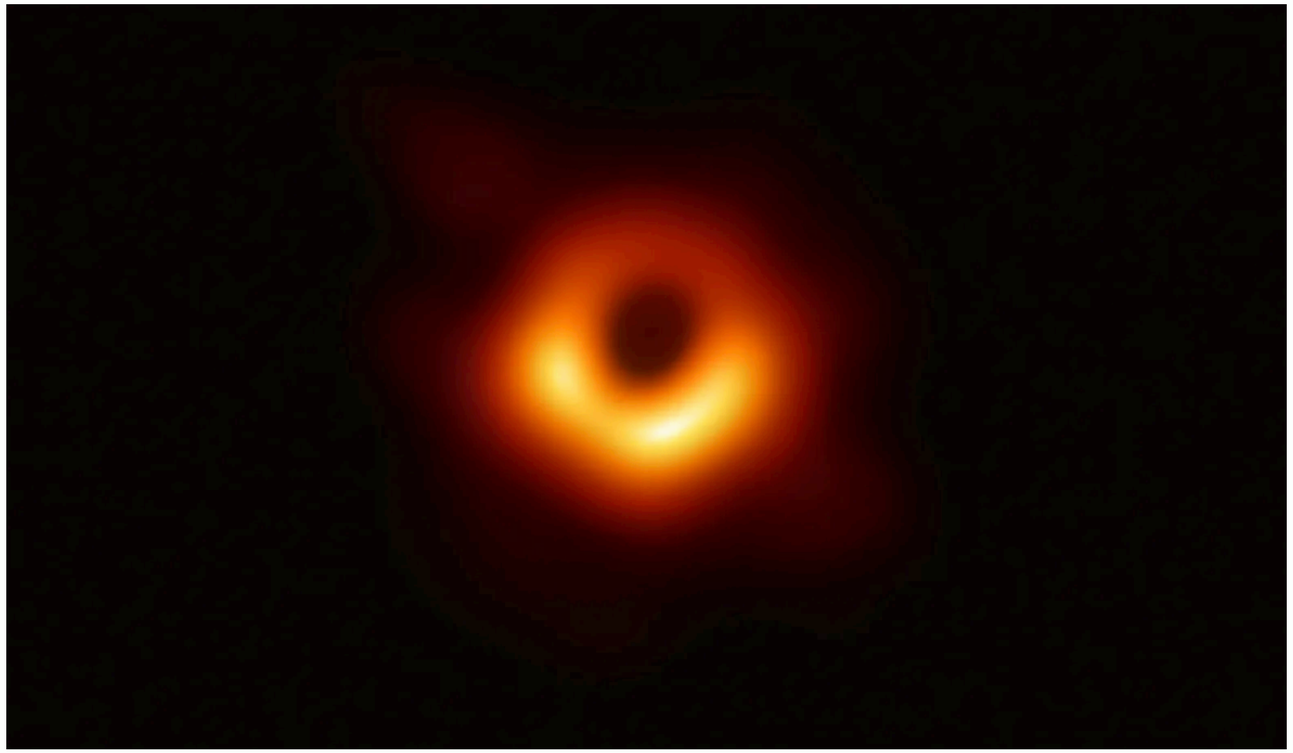


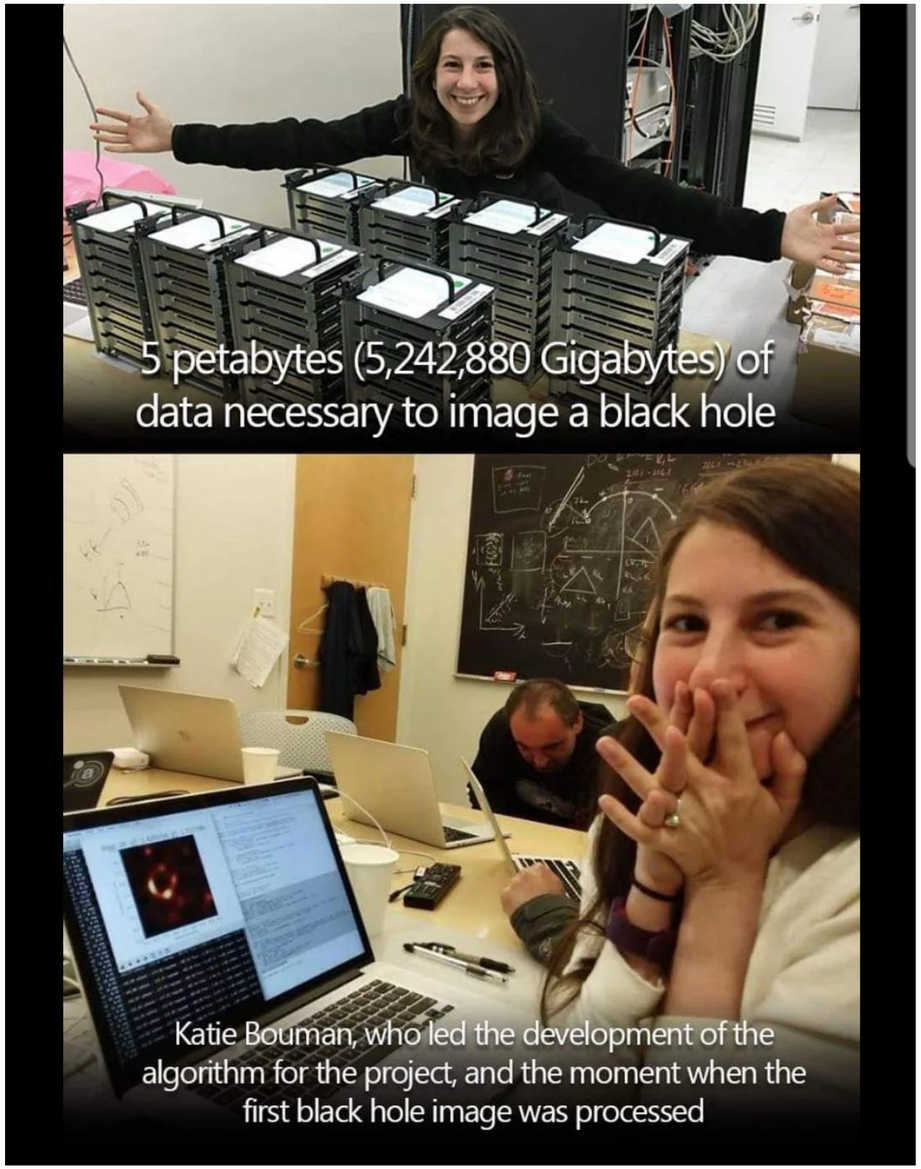
[Accessed February 27, 2025], https://www.statista.com/statistics/871513/worldwide-data-created/

WORLD DATA IN NUMBERS (2)

Home > Extreme

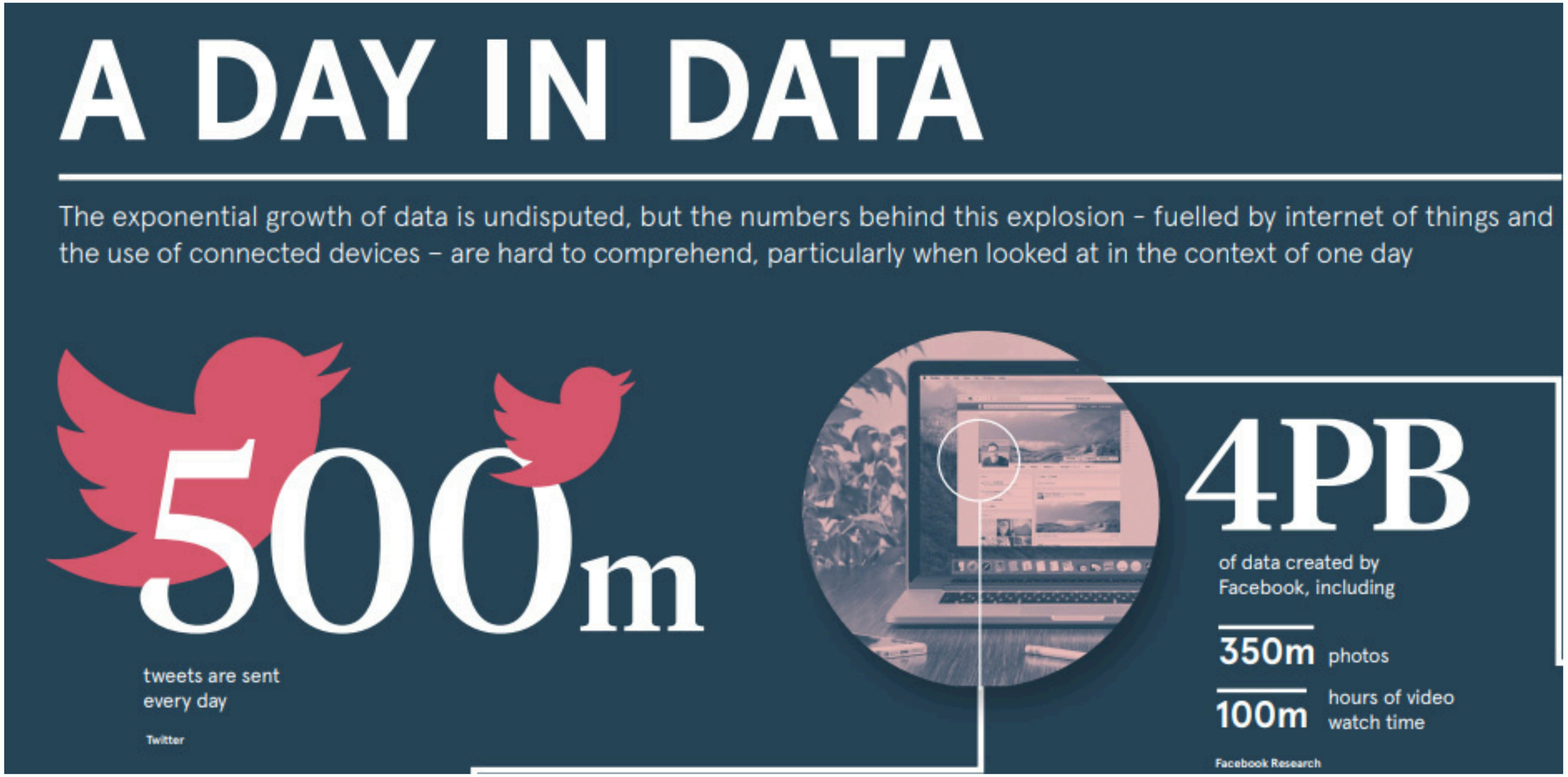
It Took Half a Ton of Hard Drives to Store the Black Hole Image Data





[Accessed February 27, 2025], https://www.extremetech.com/extreme/289423-it-took-half-a-ton-of-hard-drives-to-store-eht-black-hole-image-data
https://science.nasa.gov/resource/first-image-of-a-black-hole/

WORLD DATA IN NUMBERS (3)



[Accessed August 19, 2024], https://www.visualcapitalist.com/wp-content/uploads/2019/04/data-generated-each-day-wide.html

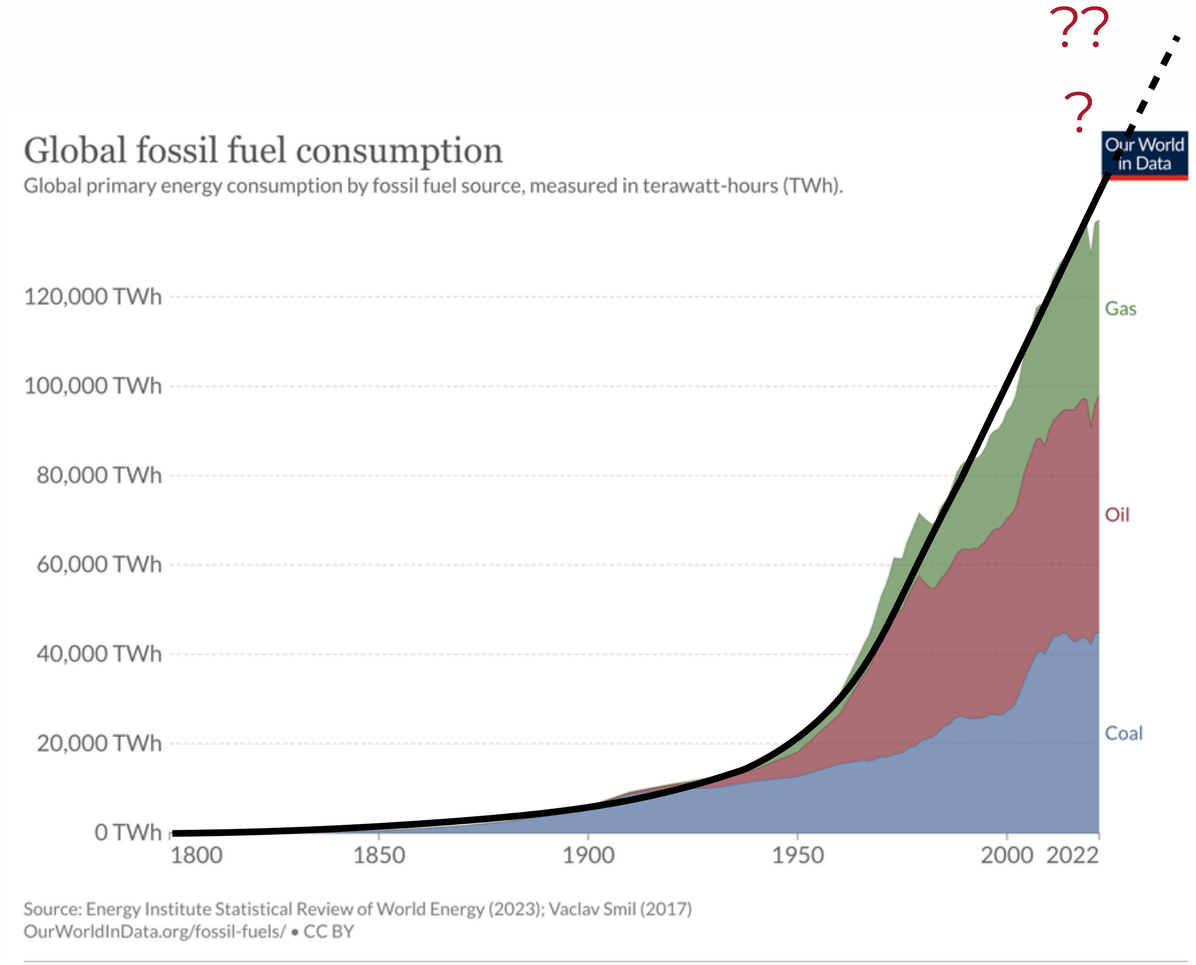
[Accessed February 27, 2025], https://dryield.com/using-predictive-data-analytics-in-manufacturing/

ENERGY & SCIENCE

Humans learn to use more energy ...

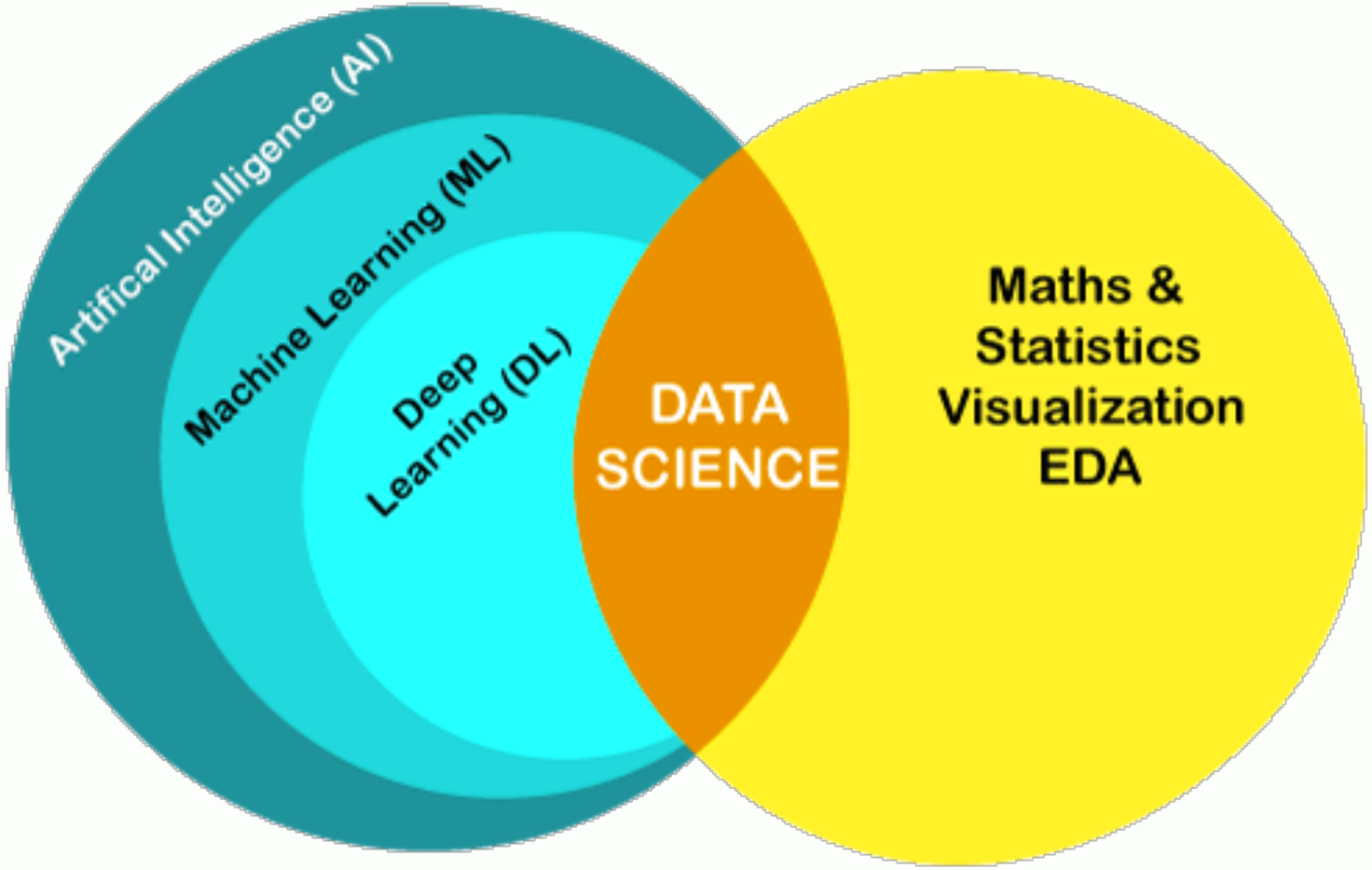
ENERGY LANDSCAPE: HOW LONG?

Such a growth is not *sustainable* and cannot last forever ...



https://ourworldindata.org/energy-mix

[Accessed February 27, 2025], https://www.linkedin.com/pulse/exploring-interdependency-data-governance-management-science-garg-6i85e/



[Accessed August 20, 2024], https://www.javatpoint.com/data-science-vs-machine-learning

WHAT IS A DATA SCIENCE?

Data science **combines** math and statistics, specialised programming, advanced analytics, artificial intelligence (AI), and machine learning with specific subject matter expertise to **uncover** actionable insights hidden in an organisation's data.

These insights can be used to guide decision making and strategic planning.

by IBM

https://www.ibm.com/topics/data-science
https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century
https://hbr.org/2022/07/is-data-scientist-still-the-sexiest-job-of-the-21st-century

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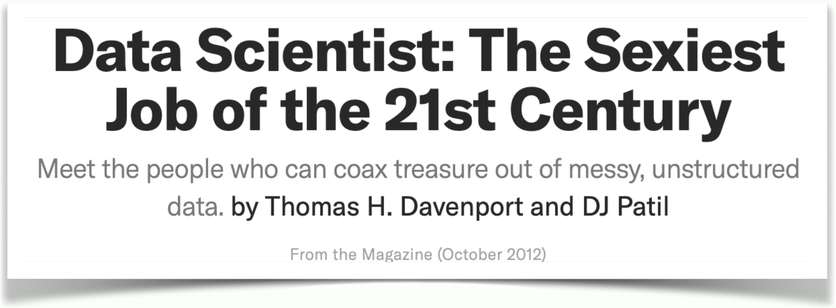

Data Scientist: The Sexiest Job of the 21st Century

Meet the people who can coax treasure out of messy, unstructured data. by Thomas H. Davenport and DJ Patil

From the Magazine (October 2012)

https://www.ibm.com/topics/data-science
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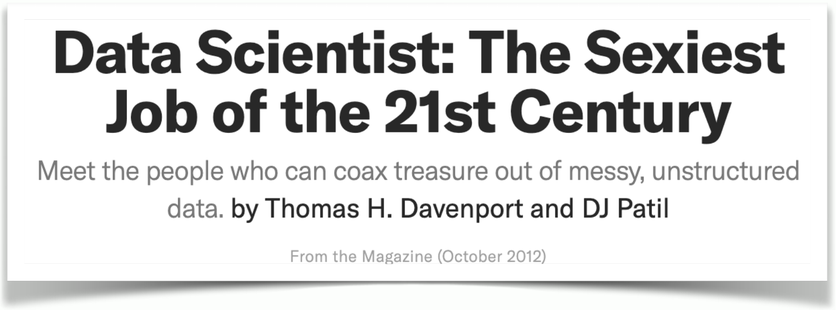

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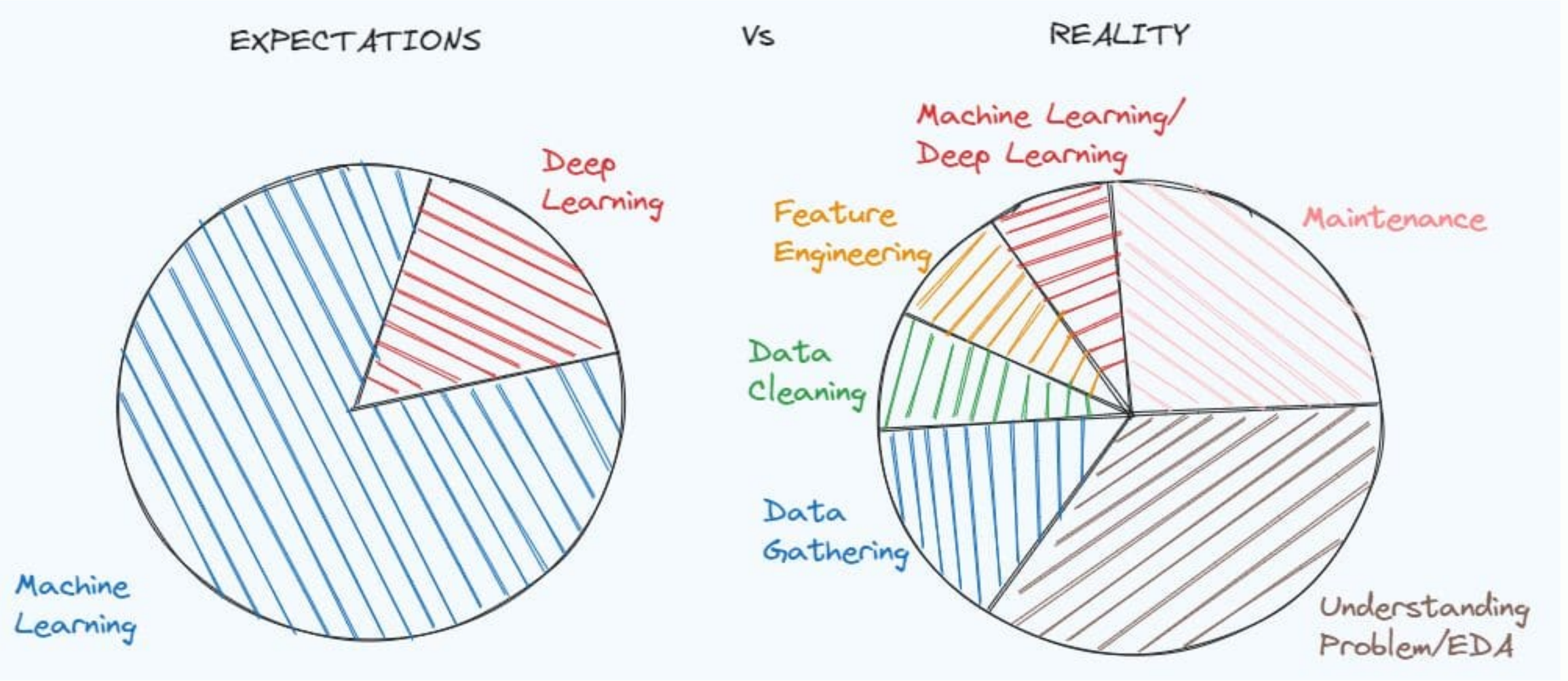
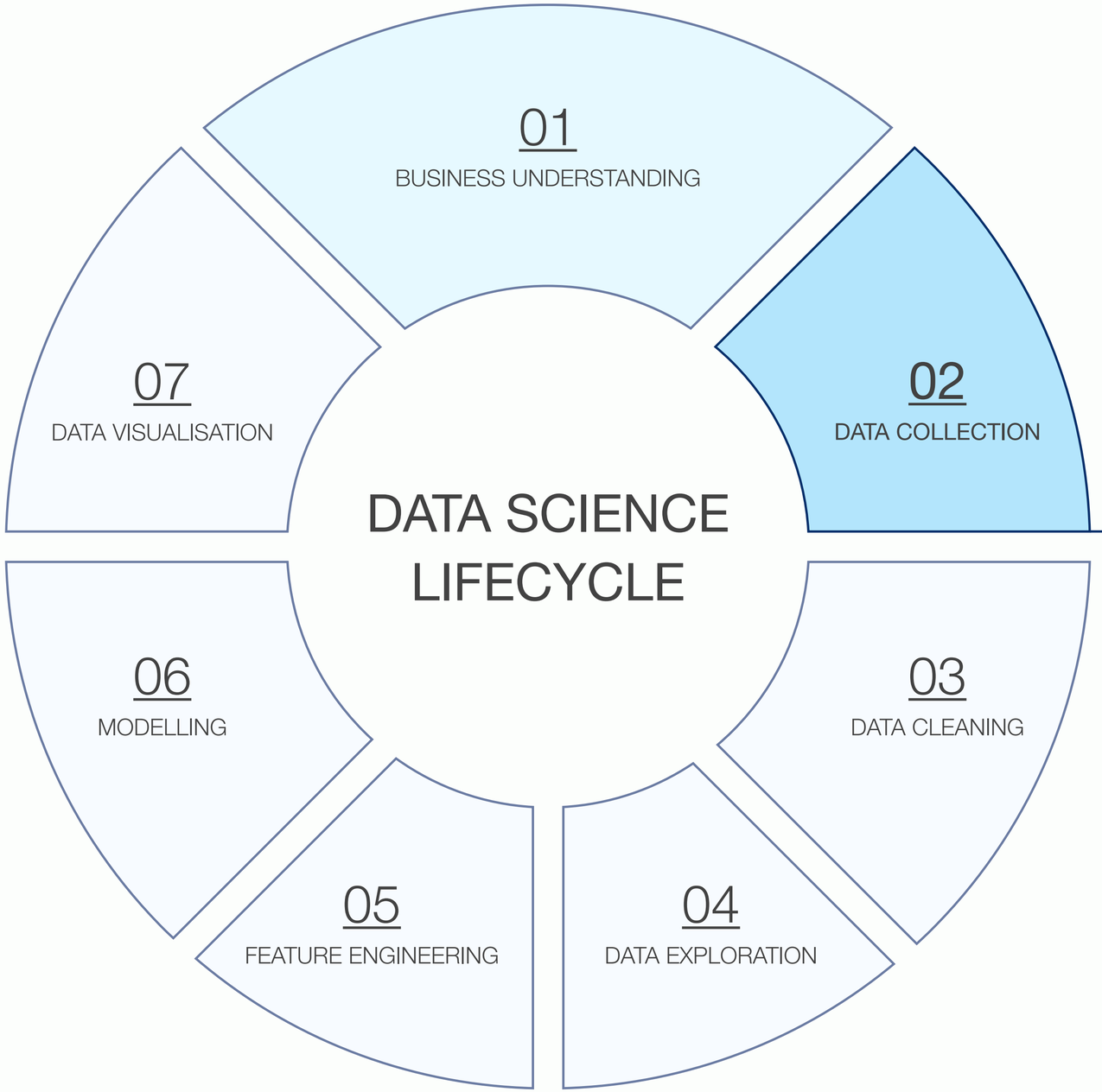

EXPECTATIONS
Vs
REALITY
Deep Learning
Machine Learning
Machine Learning/ Deep Learning
Feature Engineering
Maintenance
Data Cleaning
Data Gathering
Understanding Problem/EDA

Adopted from https://nearlearn.com/blog/machine-learning-data-science-life-cycle-whats-the-difference/

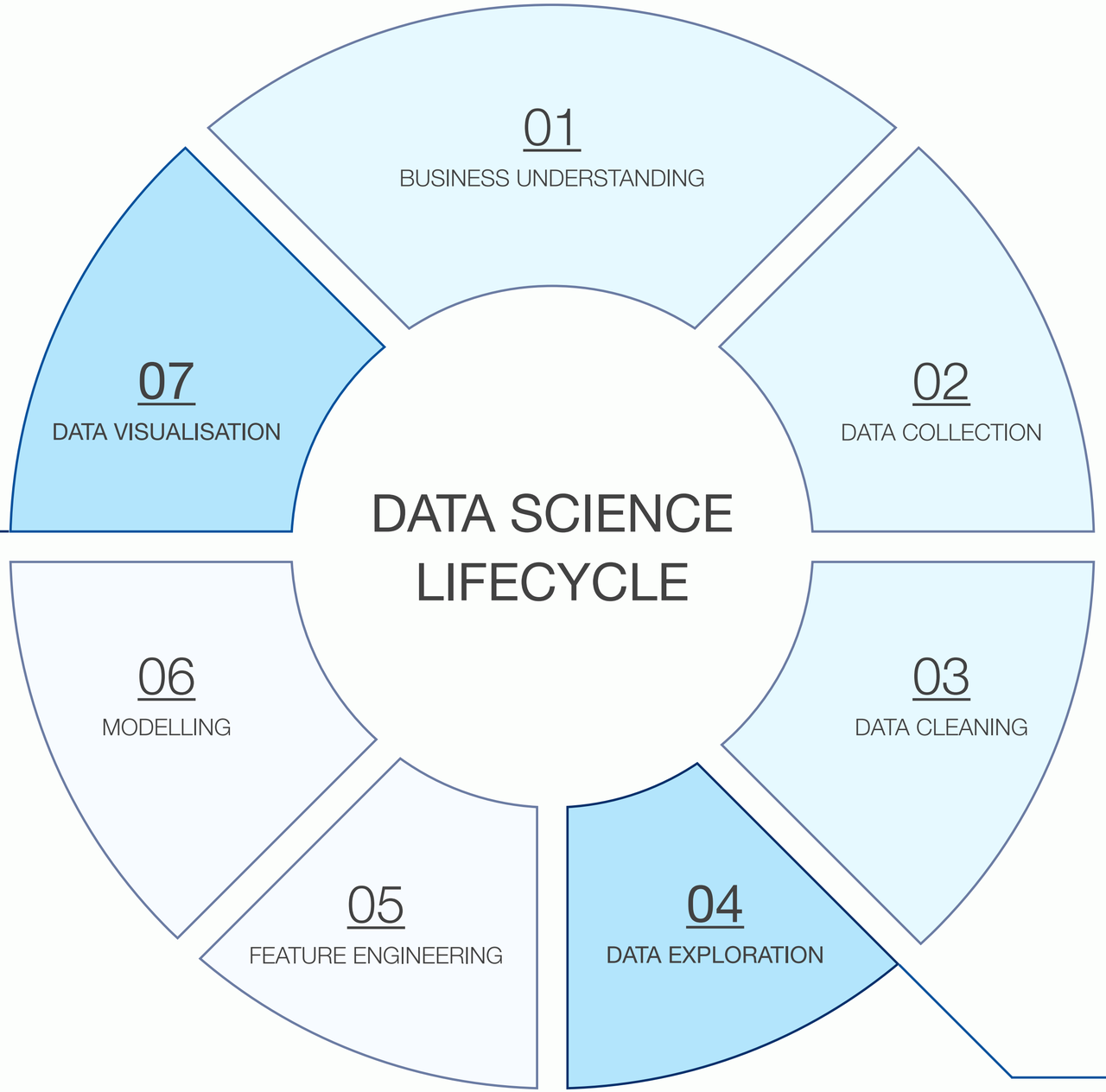
Understand the business use case and how it can be improved. Ask relevant questions and define objectives for the problem that needs to be solved.



Collect the data necessary for the project.

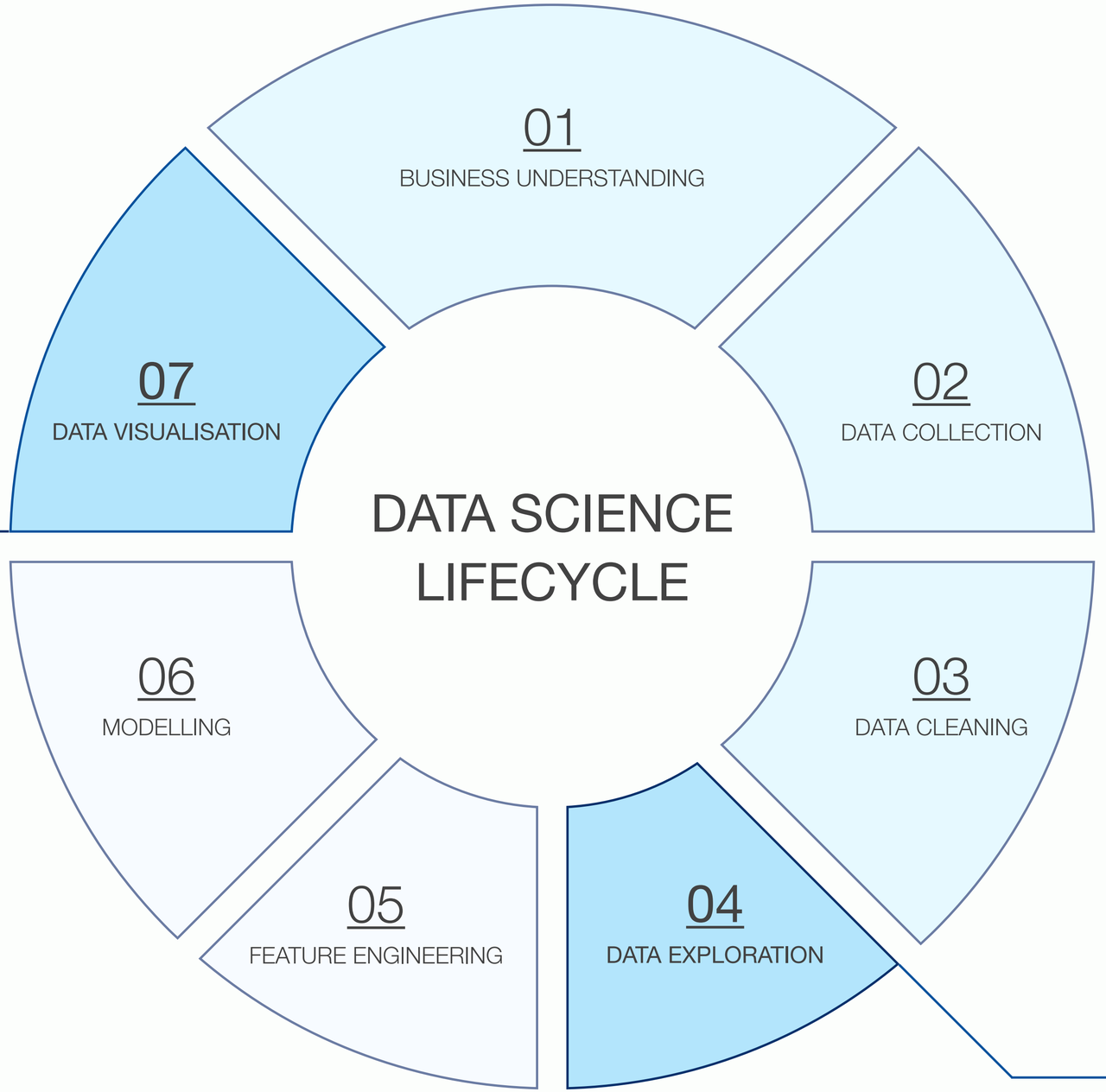
Remove data that does not belong in your dataset. Fix inconsistencies within the data and handle missing values.

DATA SCIENCE LIFECYCLE



Communicate the findings with key people using plots and interactive visualisations.

Explore and visualise data to uncover insights from the data and form hypotheses.

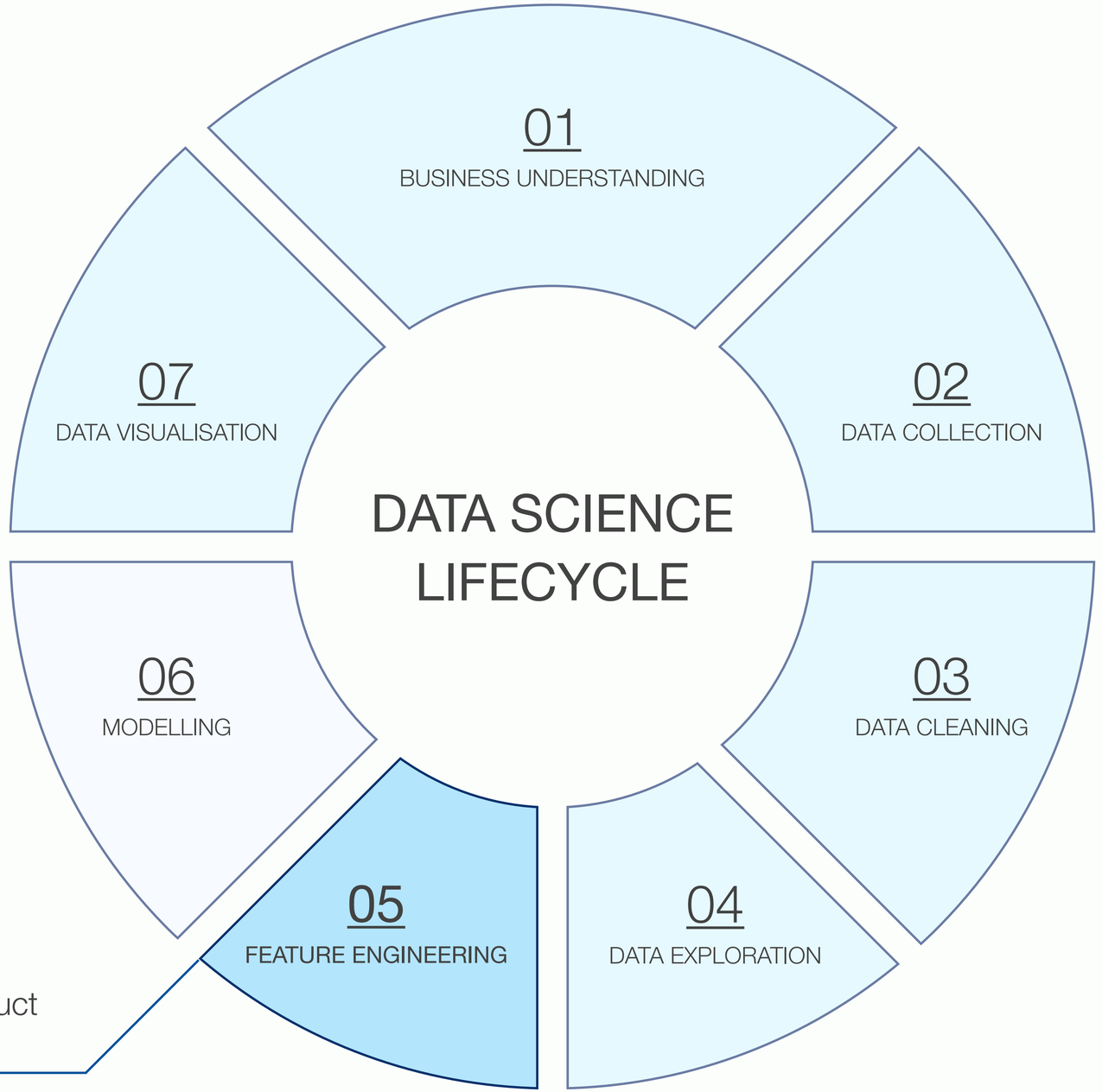


Communicate the findings with key people using plots and interactive visualisations.

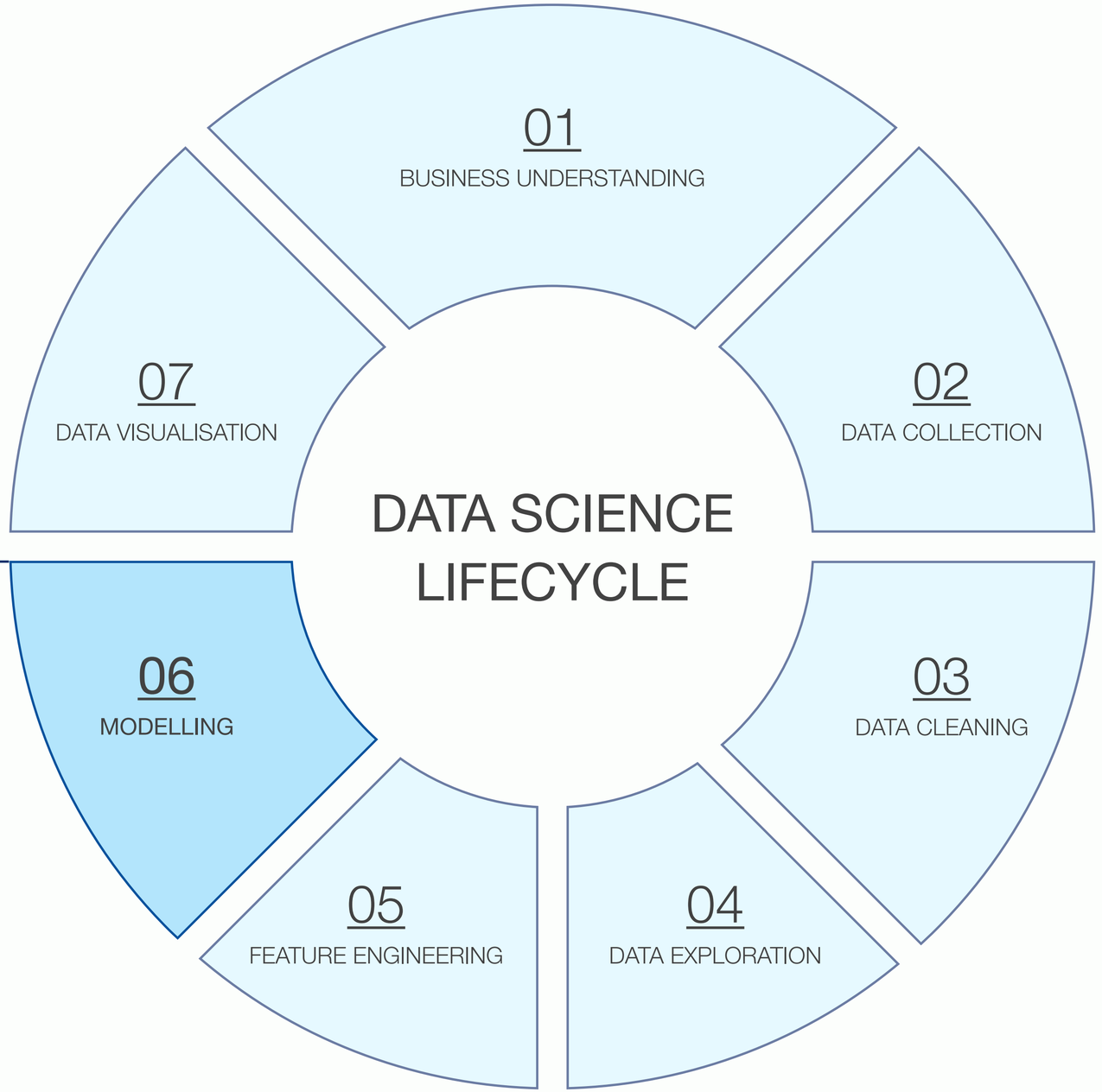
Convincing others it is true

Explore and visualise data to uncover insights from the data and form hypotheses.

Figuring out what is true

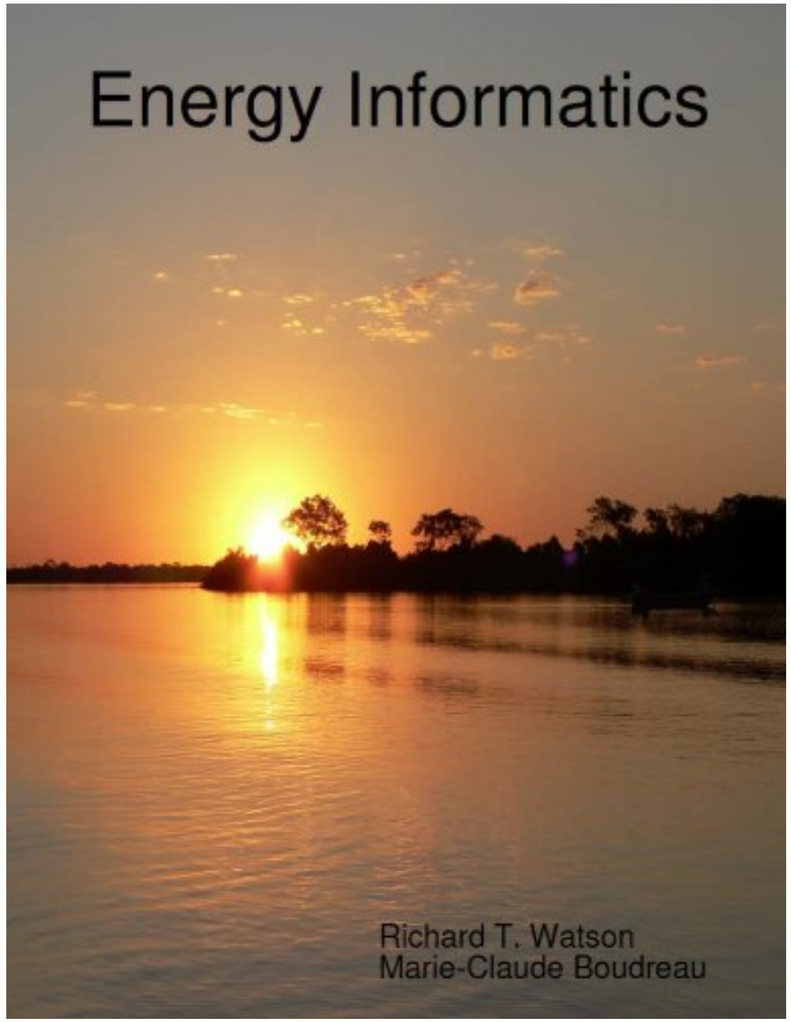


Select important features and construct more meaningful ones.



Train ML models, evaluate performance, and make predictions.

ENERGY INFORMATICS

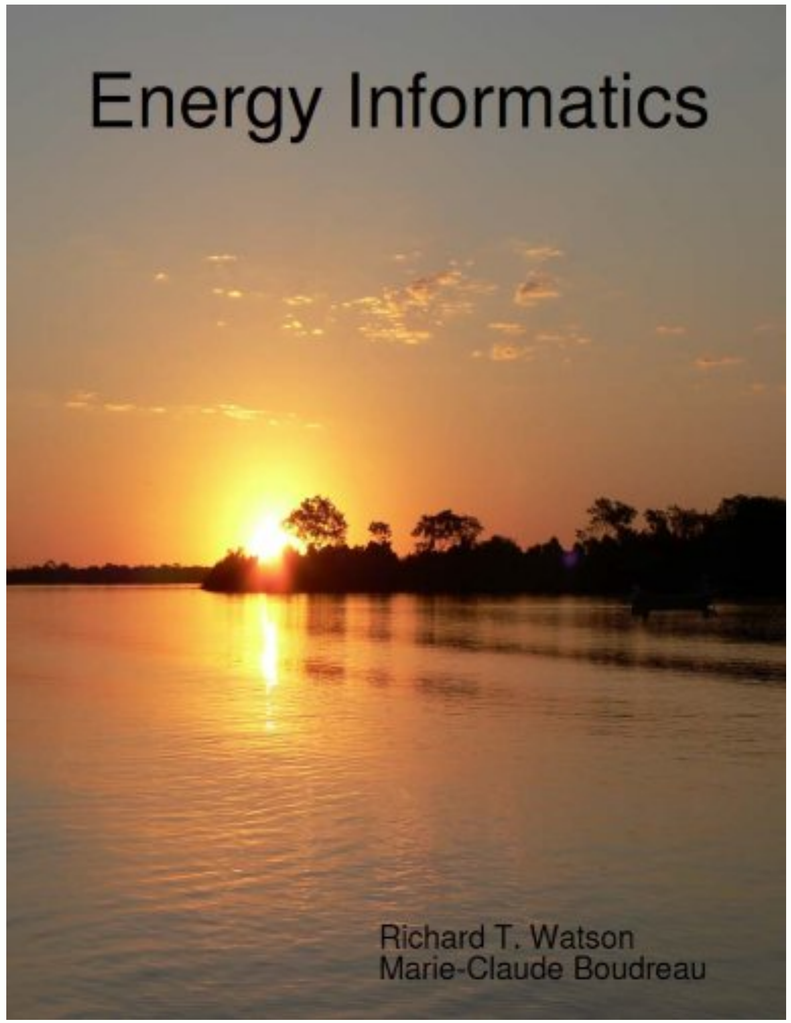


“Energy Informatics”

by R. Watson and M.-C. Boudreau, eGreen Press, kindle edition, 2011

“According to Darwin, fire (a form of energy) and language (an information system) are the two most important human inventions.”

ENERGY INFORMATICS



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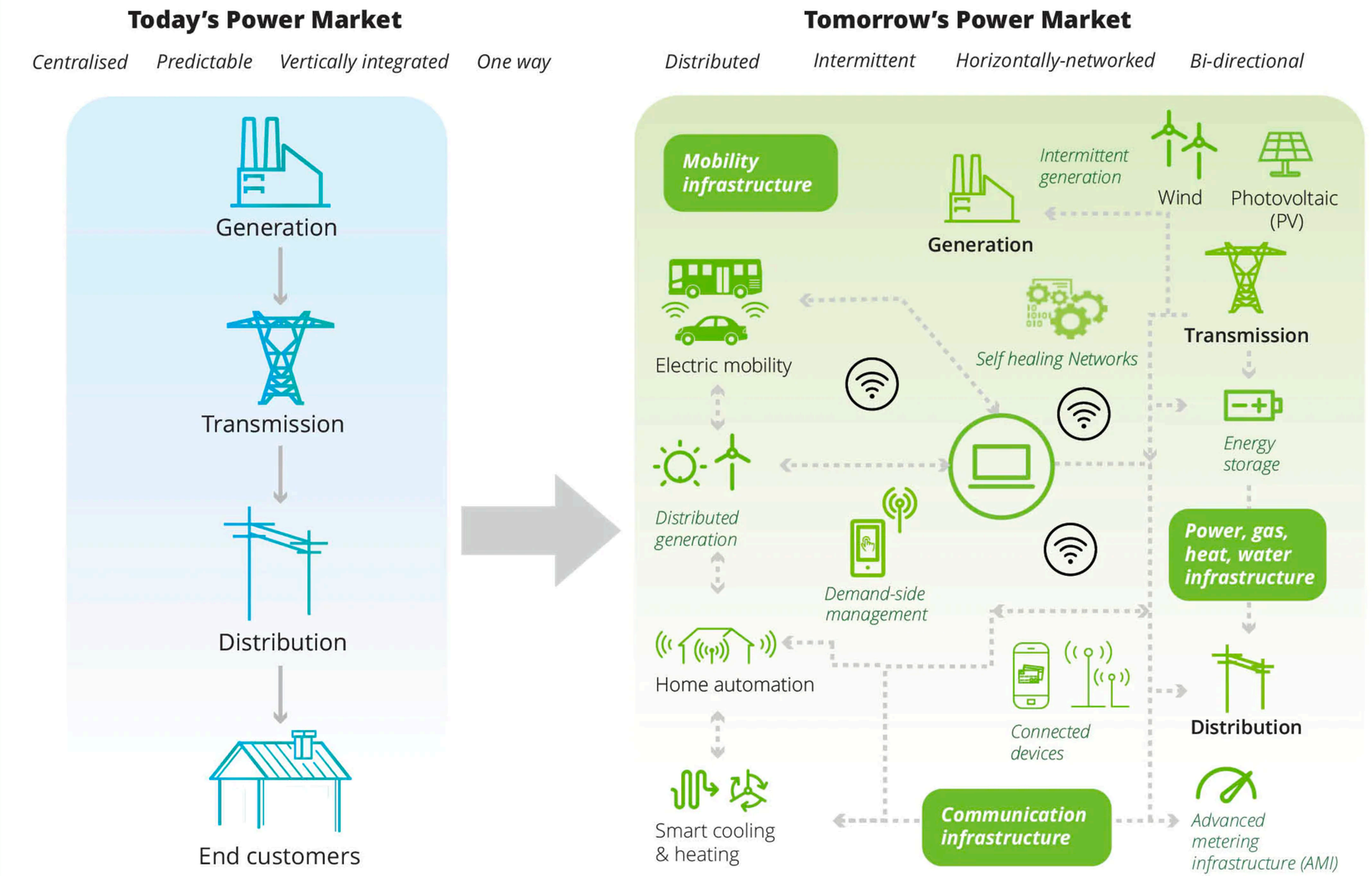
Fundamental principle:

Energy + Information < Energy

WHAT IS IN THE FUTURE?

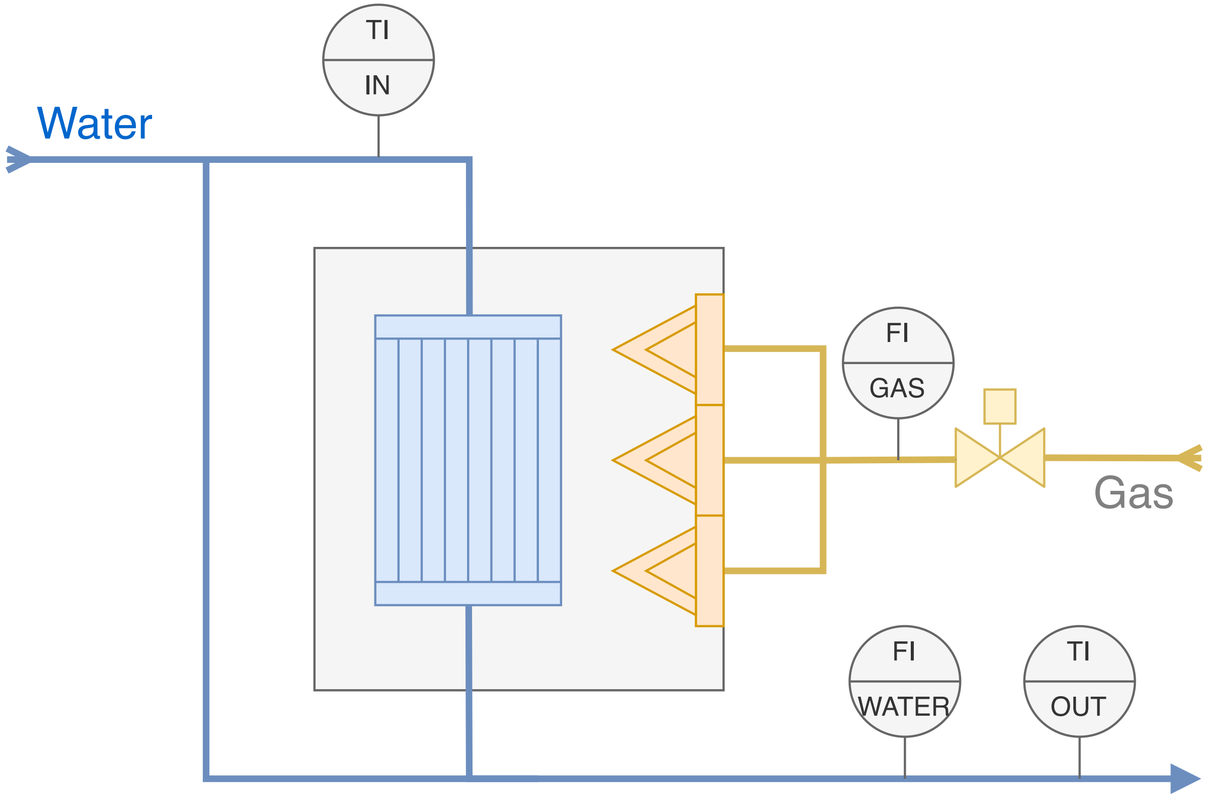


Energy-as-a-service

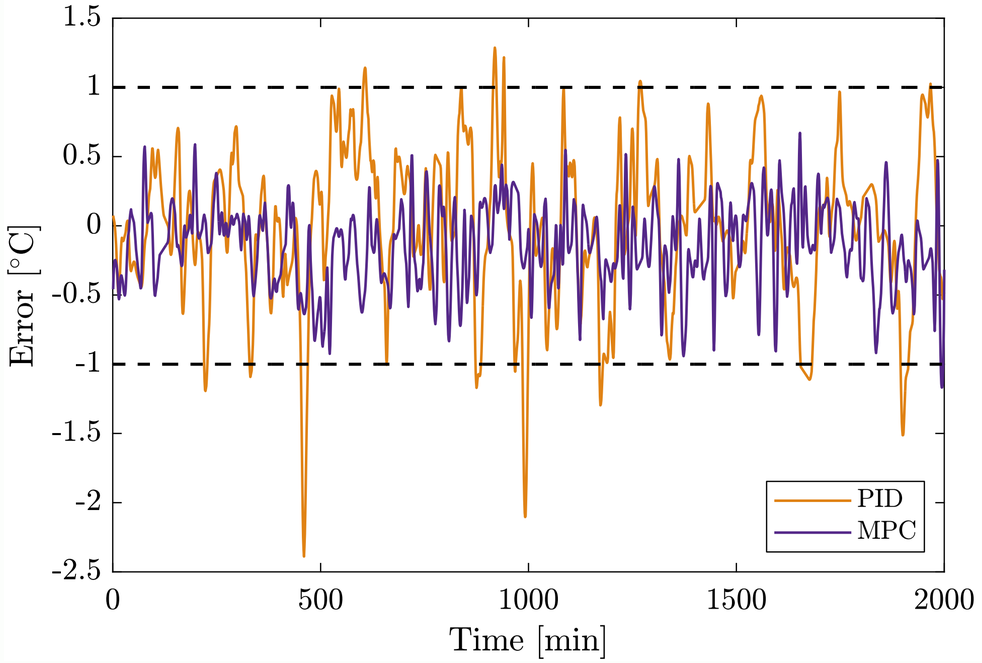
https://www2.deloitte.com/uk/en/pages/energy-and-resources/articles/energy-as-a-service.html

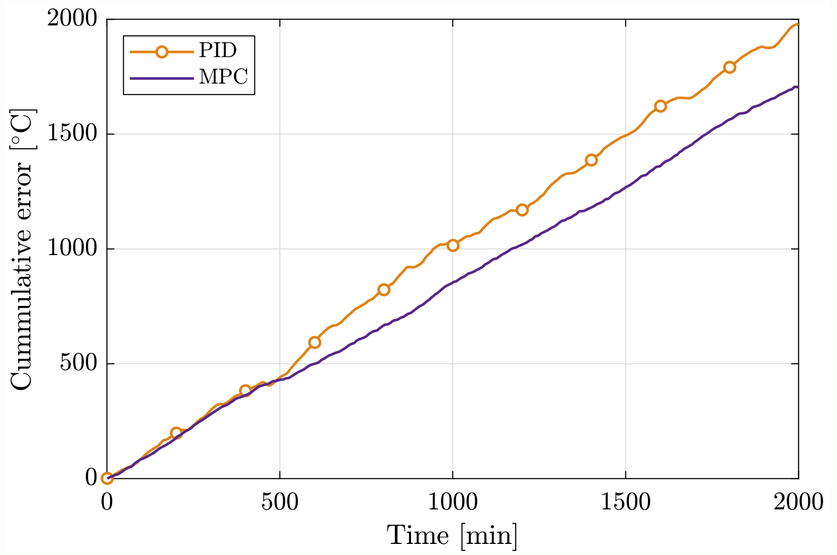
Practice-oriented Examples

DISTRICT HEATING PLANT



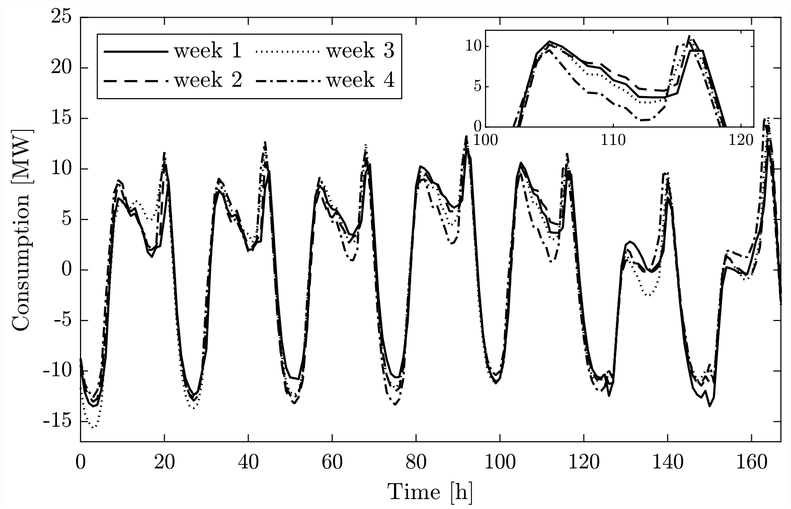
Reactive vs proactive

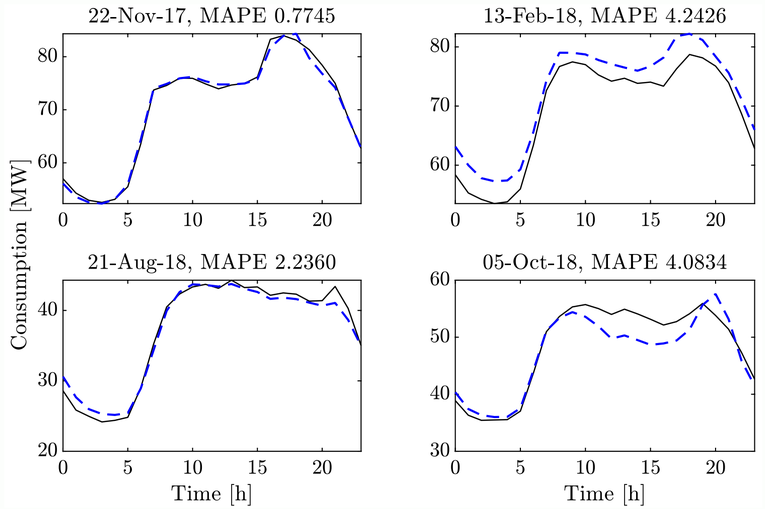


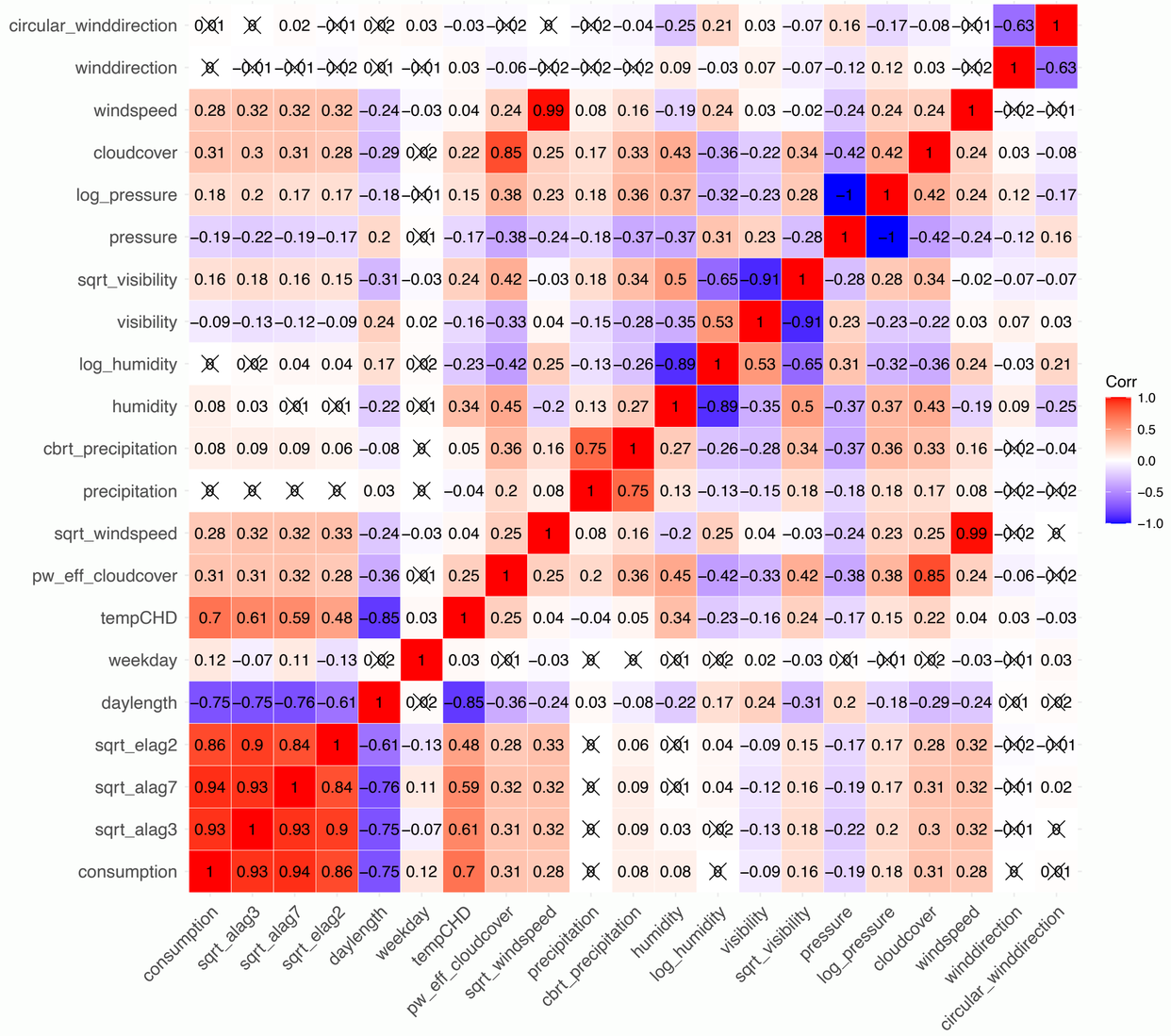


Vansovits, V.; Petlenkov, E.; Tepljakov, A.; Vassiljeva, K.; Belikov, J. Bridging the Gap in Technology Transfer for Advanced Process Control with Industrial Applications. *Sensors* 2022, *22*, 4149.

FORECASTING ELECTRICITY DEMAND

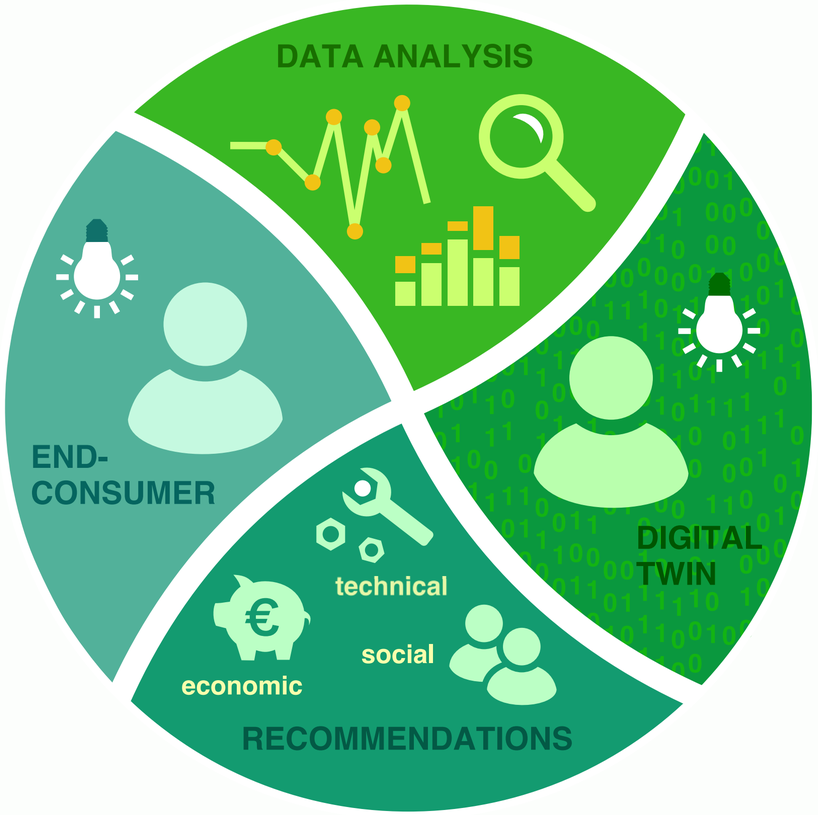


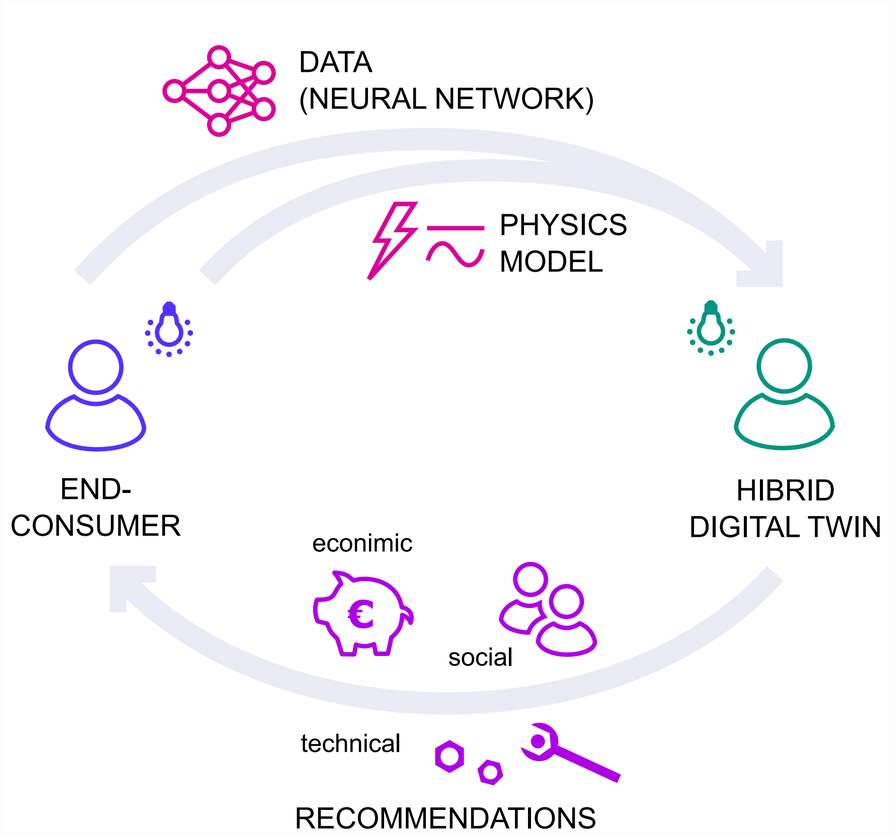




M. Sinimaa, M. Spichakova, J. Belikov, and E. Petlenkov. Feature engineering of weather data for short-term energy consumption forecast. *IEEE Madrid PowerTech*, June 28th - July 2nd, 2021, Madrid, Spain.

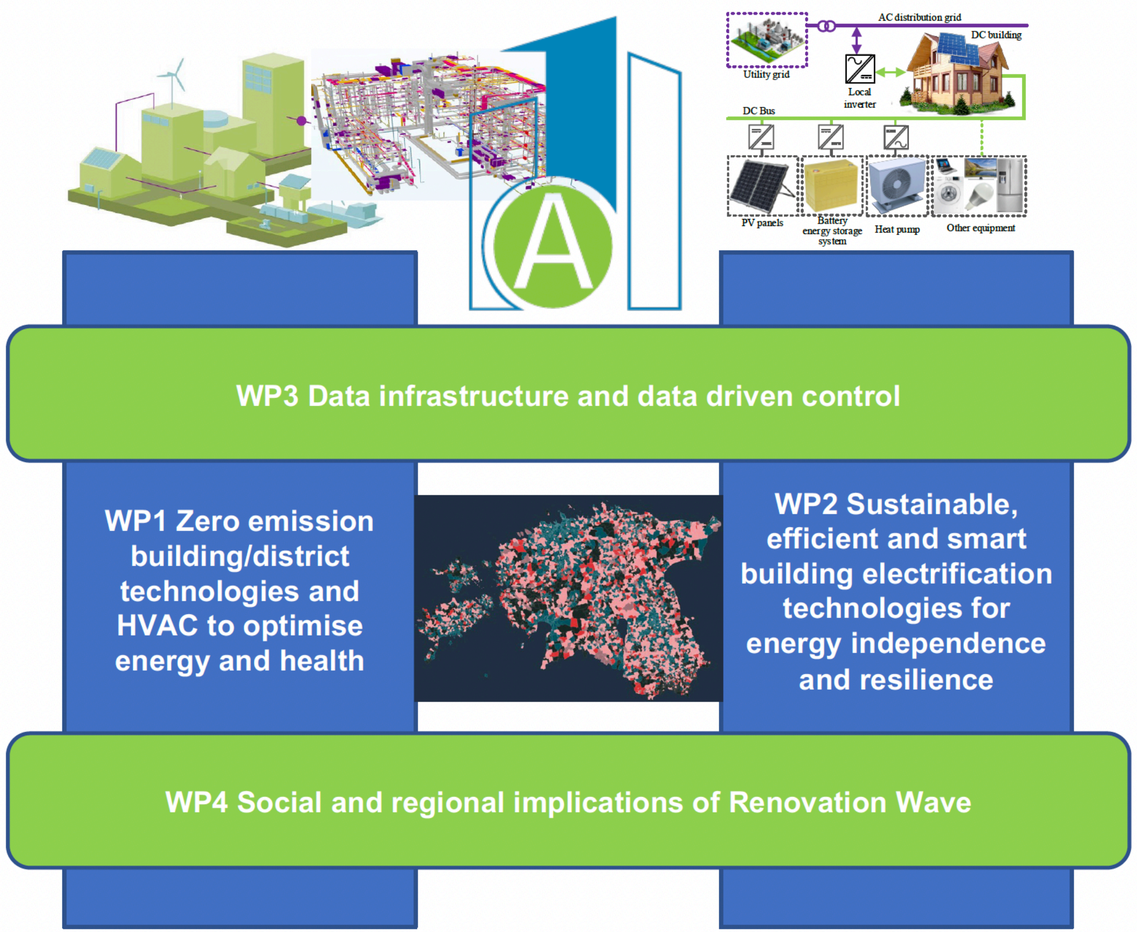
DT & INTELLIGENT ENERGY SERVICES





A. E. Onile, J. Belikov, Y. Levron, and E. Petlenkov
Energy efficient behavior modelling for demand side recommender system in solar microgrid applications using multi-agent reinforcement learning model.
Sustainable Cities and Society, 90, 104392. DOI: 10.1016/j.scs.2023.104392.

ENER



Data infrastructure, and data driven monitoring and control

- Development of data infrastructure
- Data driven modelling and control
- Intelligent energy services
- Trustworthy and reliable AI
- Occupant in the loop control

Centre of Excellence in Energy Efficiency

https://ener.ee/juhtimissusteemide-andmeteaduse-uurimisruhm/

SMART & COGNITIVE BUILDINGS

- Human-centric AI
- Demand side management
- Optimal control
- Demand/supply forecast
- Mixture of enabling technologies: AI, ML, data science, IoT, smart materials and electronics, etc.

Forbes

FORBES > SMALL BUSINESS

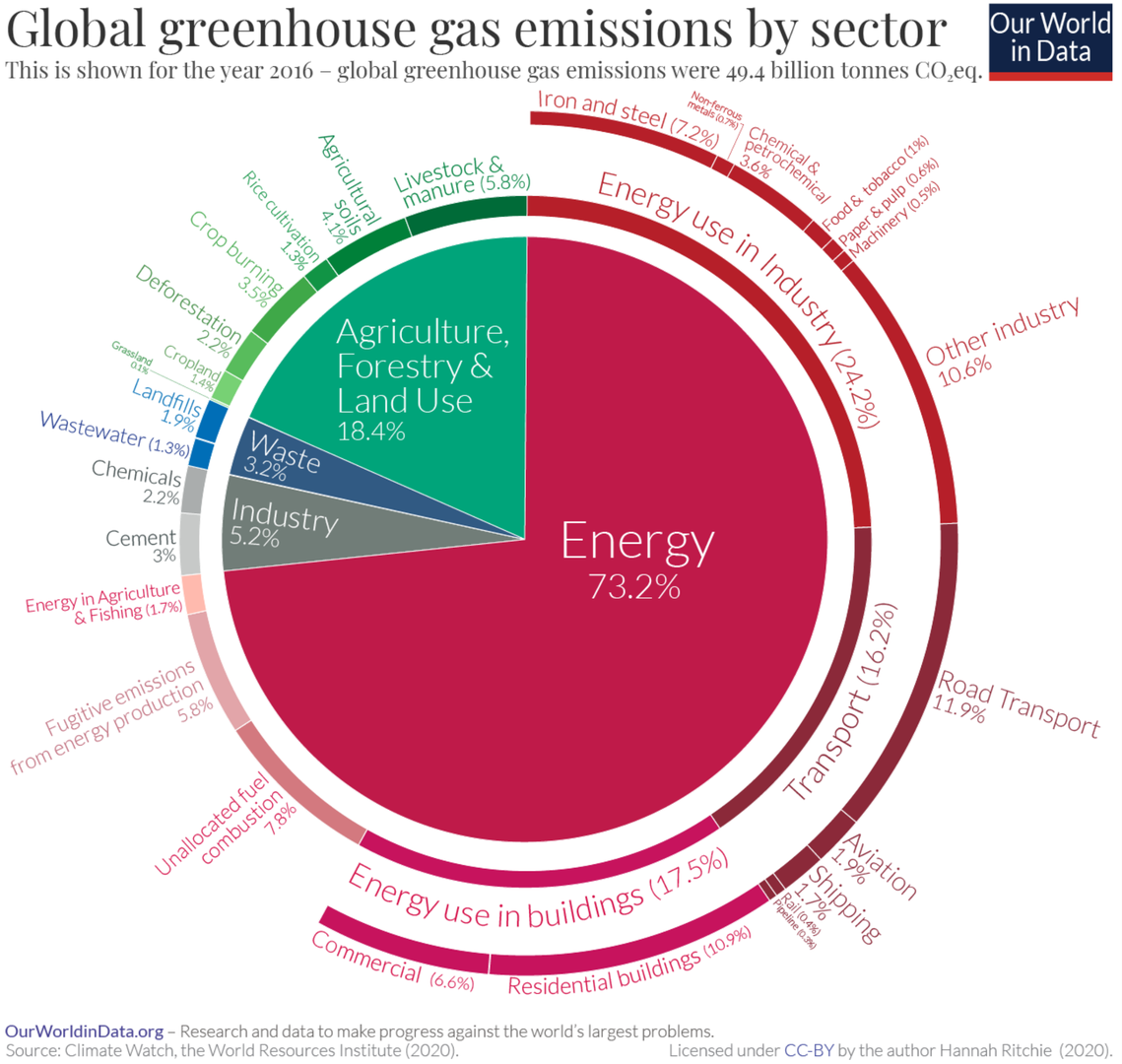
Confronting Commercial Real Estate's Biggest Challenges With Technology

Jeri Frank Former Forbes Councils Member
Forbes Business Council COUNCIL POST | Membership (Fee-Based)

Aug 4, 2022, 09:00am EDT

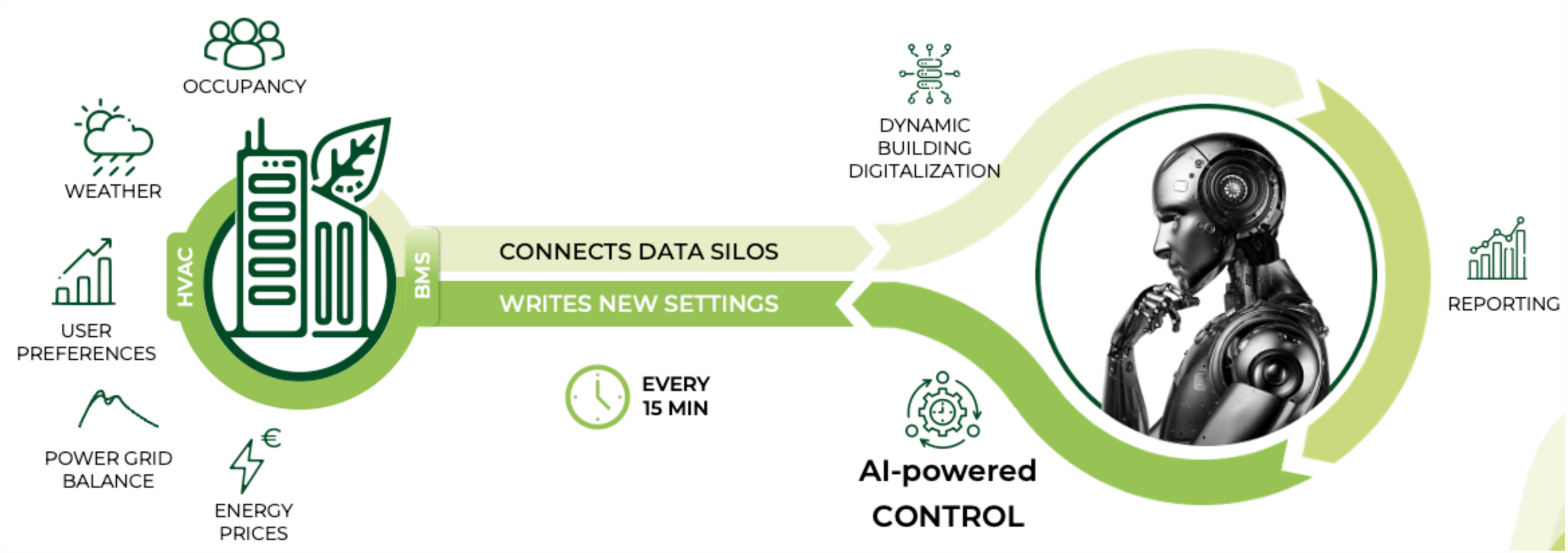
Climate Change And The Impact On Technology

First, let's talk about climate technology and how it is affecting the real estate industry. Nearly half of all greenhouse gas emissions are generated from real estate. Approximately 27% of annual CO2 emissions come from building operations and another 20% come from building materials, construction and other construction-related causes. Concrete, steel and aluminum for new construction are particularly large contributors to carbon emissions. Existing buildings are contributing to the climate crisis due to a lack of energy efficiency. Even though upgrades are available, many real estate developers and owners are slow to embrace sustainable solutions.

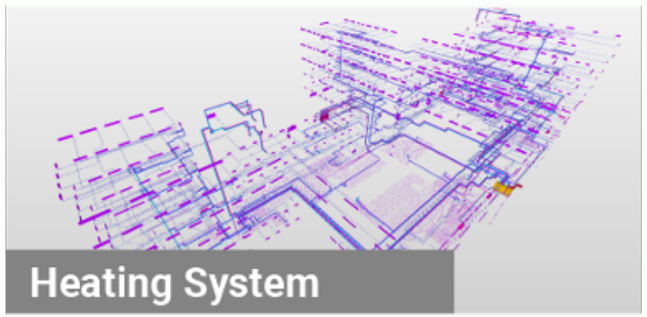


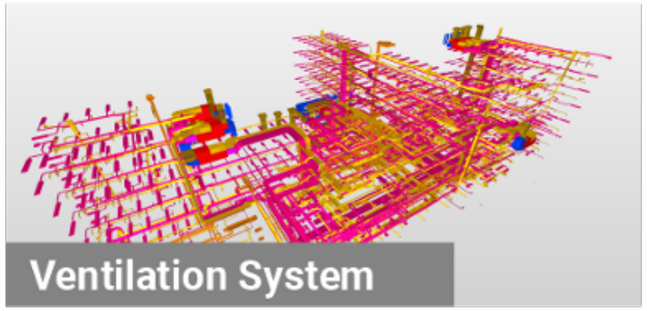
[Accessed February 27, 2025], https://www.forbes.com/sites/forbesbusinesscouncil/2022/08/04/confronting-commercial-real-estates-biggest-challenges-with-technology
https://ourworldindata.org/ghg-emissions-by-sector

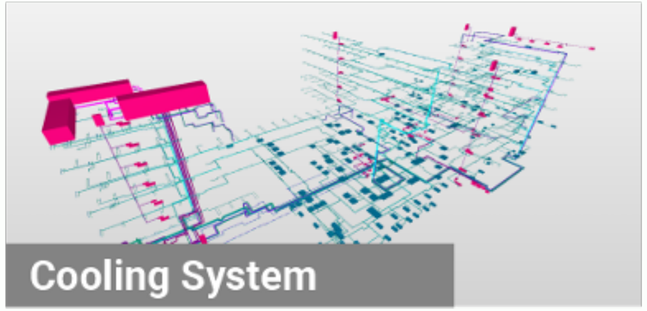
DIGITAL OPERATOR



SMART BUILDINGS







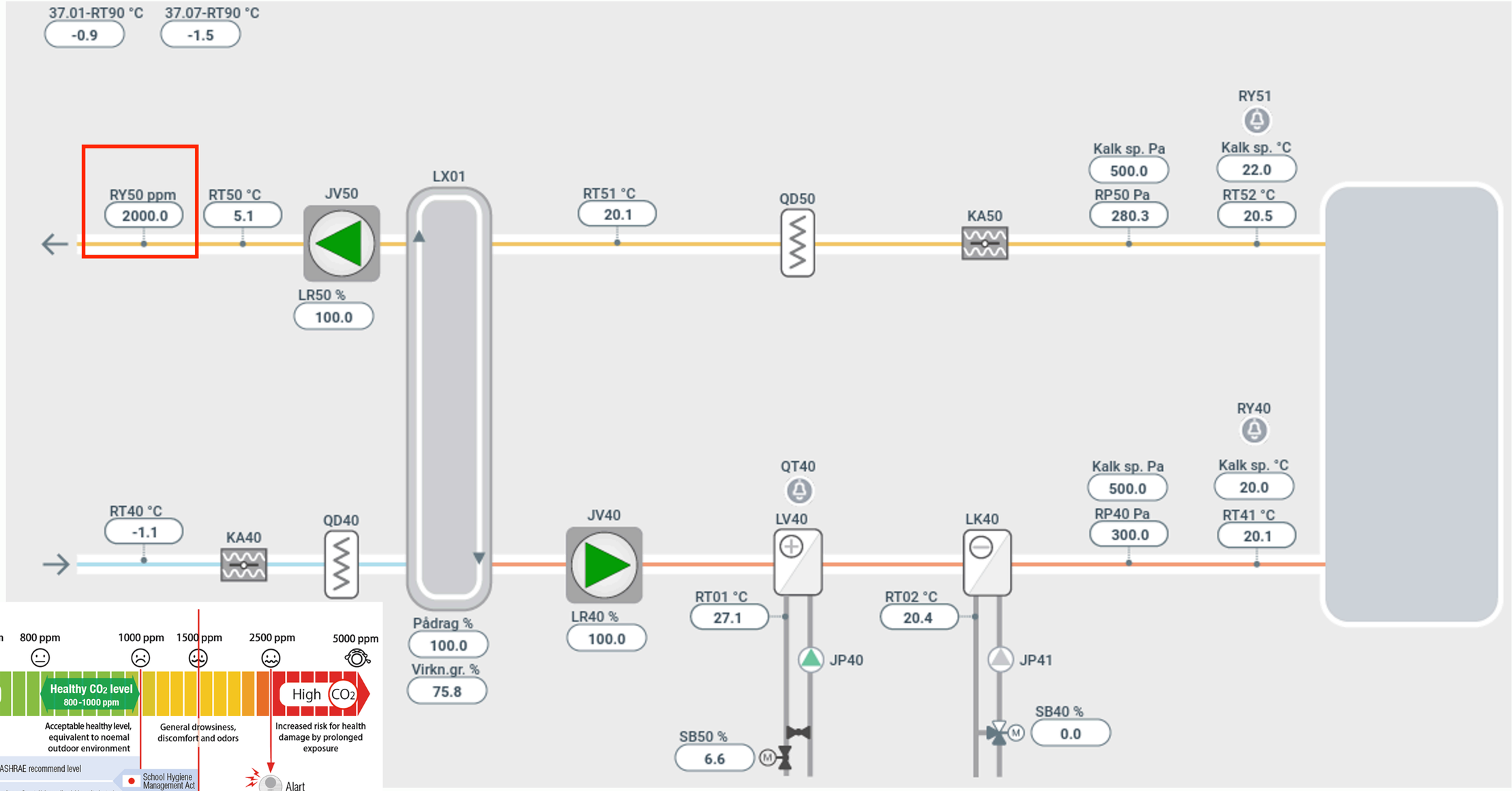
constructed 2018

25 304 m² office building

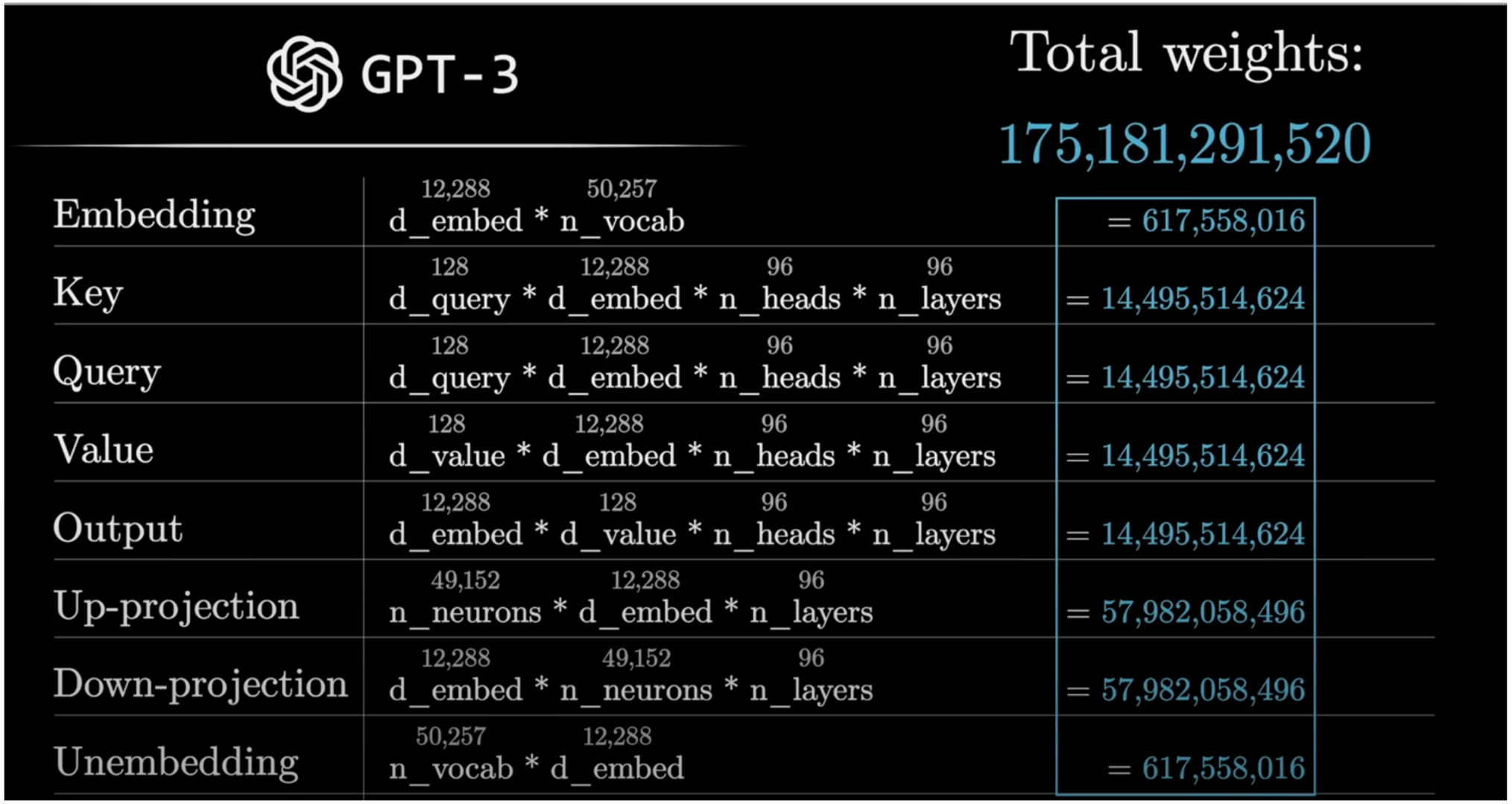
48 813 datapoints

2 898 controllable HVAC components

SHOWCASE (3): VENTILATION UNIT WORKS AT 100%; BROKEN CO2 SENSOR



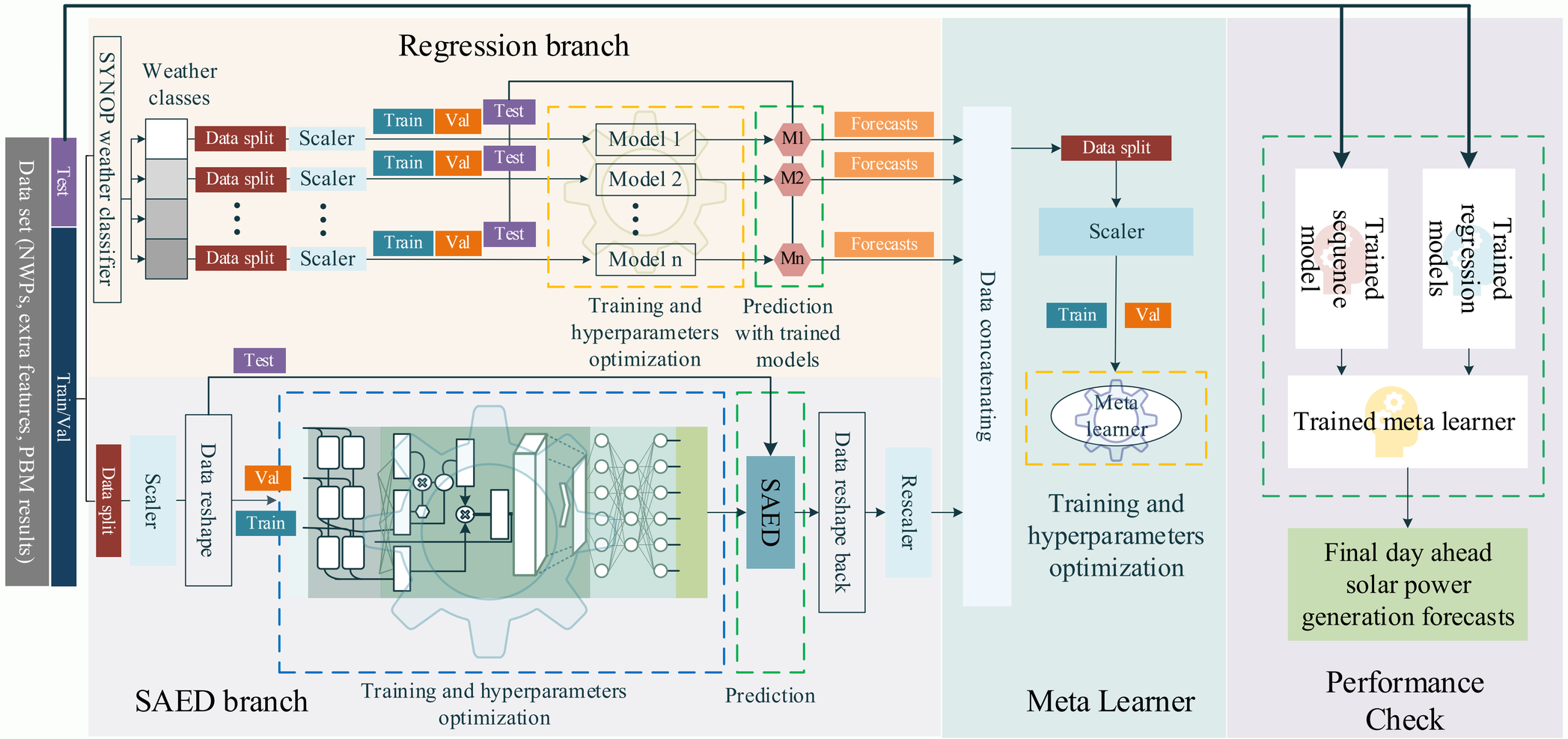
OUTRO



[Accessed April 3, 2024], https://www.youtube.com/watch?v=wjZofJX0v4M

OUTRO (2)

ML model pipeline for the problem of day-ahead solar power generation forecast

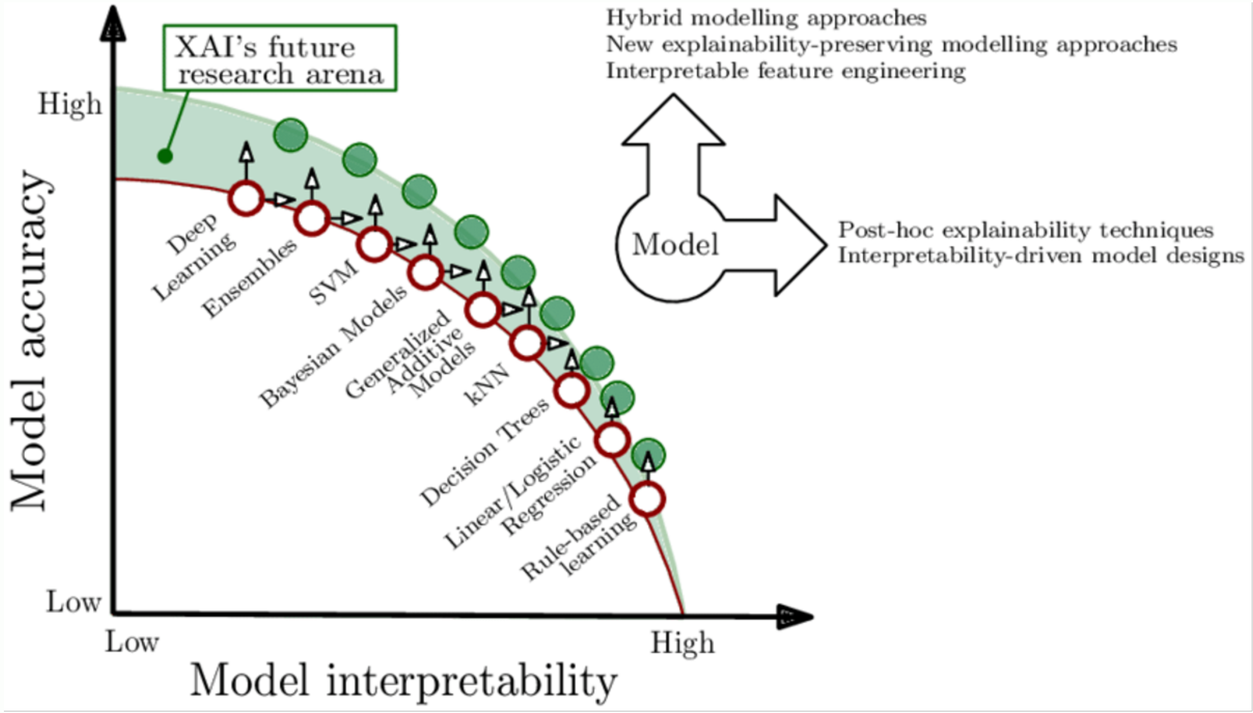


Problems:

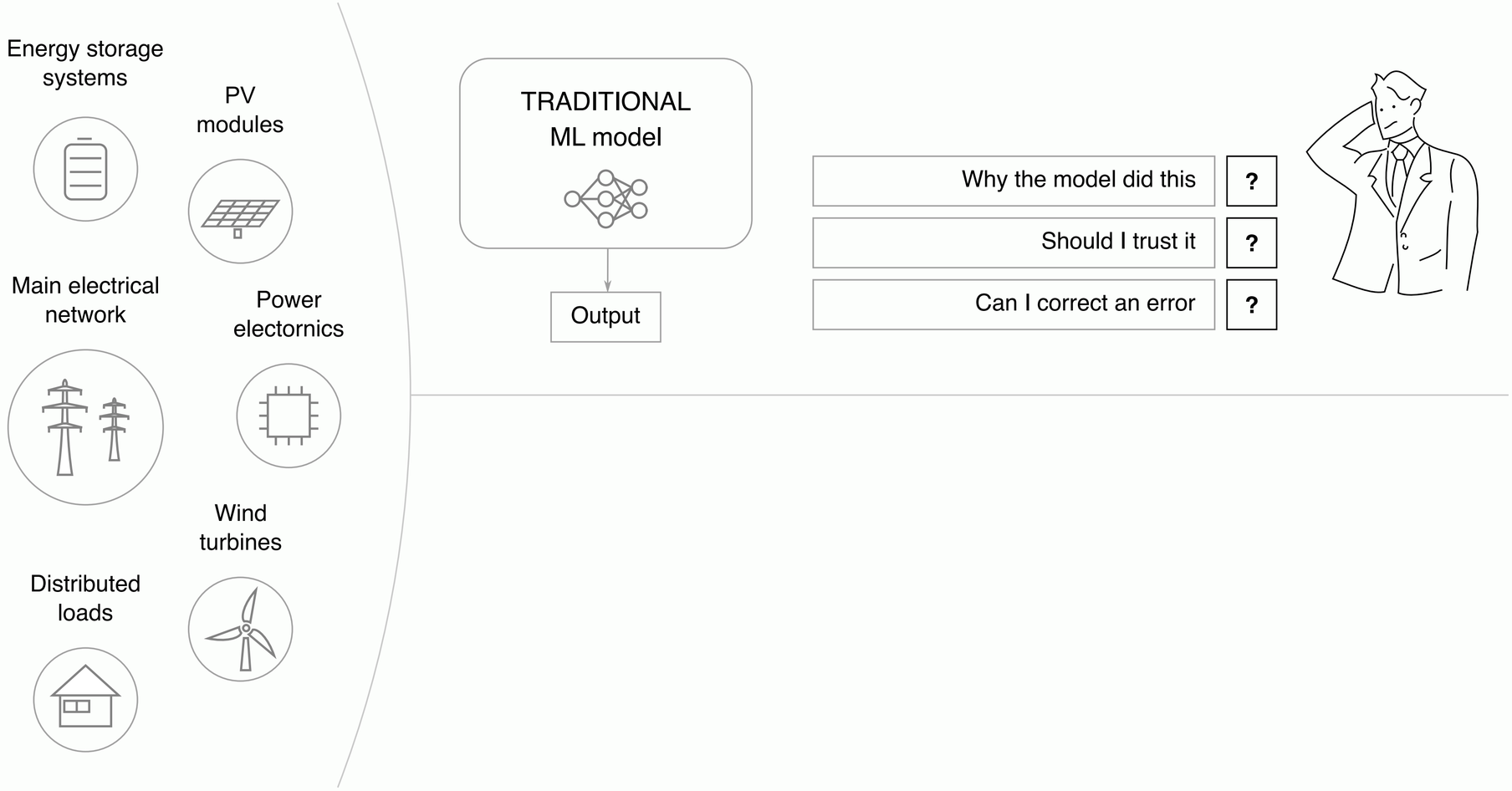
- Amount of data

Bilding type	Total # of points	Controlled points
Shopping mall 1	4657	890
Shopping mall 2	3082	709
Hotel	7556	1404
Office	17380	1636
Office	10498	2383

- Accuracy vs complexity vs transparency

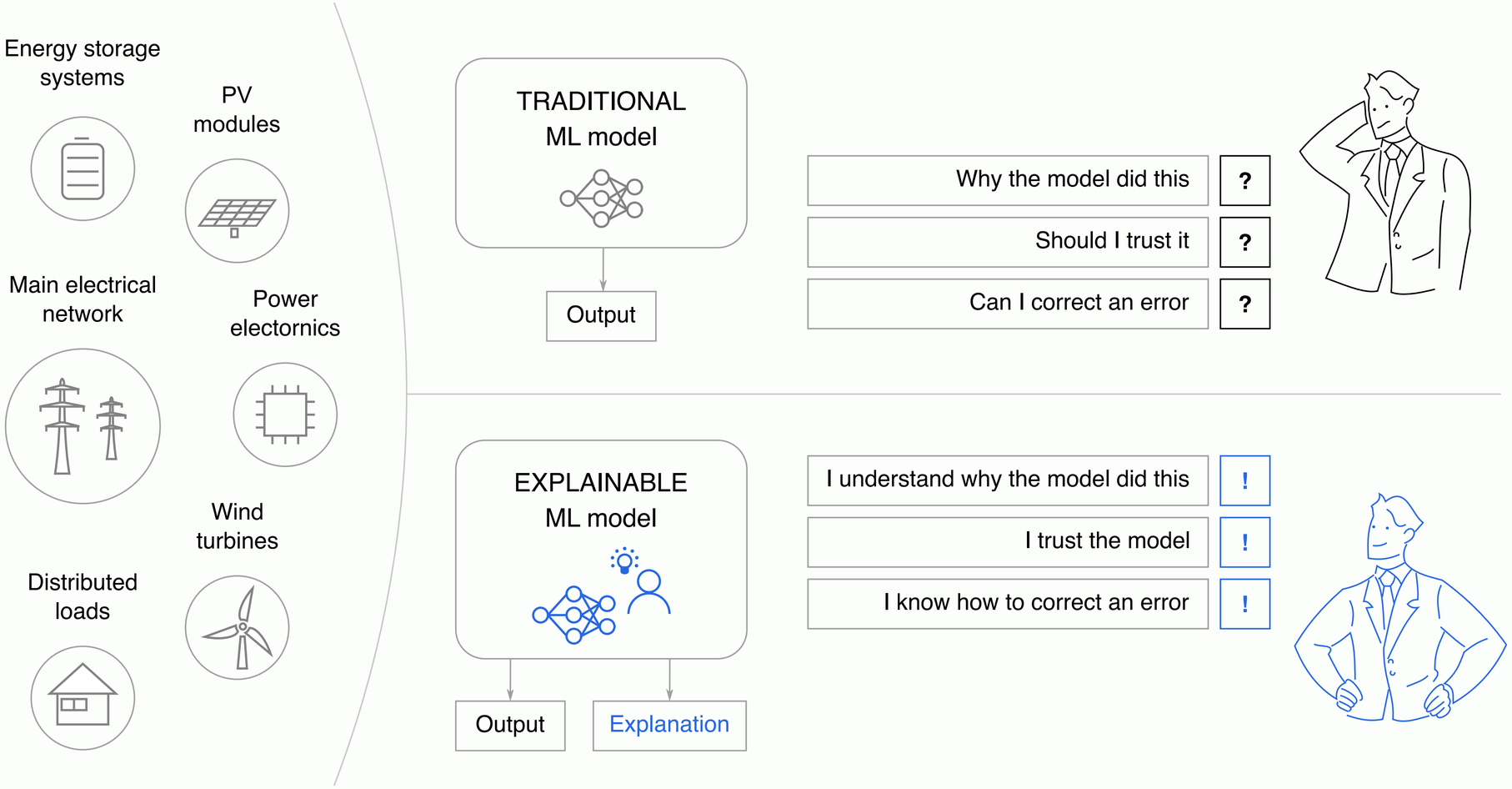


EXPLAINABLE AI



R. Machlev, L. Heistrene, M. Perl, K. Y. Levy, J. Belikov, S. Mannor, and Y. Levron. Explainable Artificial Intelligence (XAI) techniques for energy and power systems: Review, challenges and opportunities, *Energy and AI*, 9, pp. 100169, 2022.

EXPLAINABLE AI



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Thank you for your attention!