Andmeteadusest energeetikas

Juri Belikov, Kaasprofessor tenuuris, Tallinna Tehnikaülikool

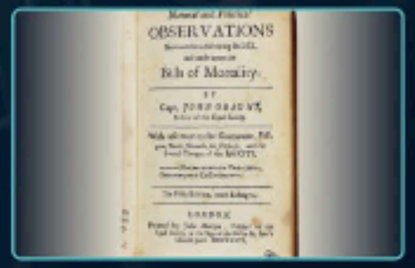
XIX Eesti Matemaatika Päevad, Pariisi puhkeküla, 22.08.2024

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

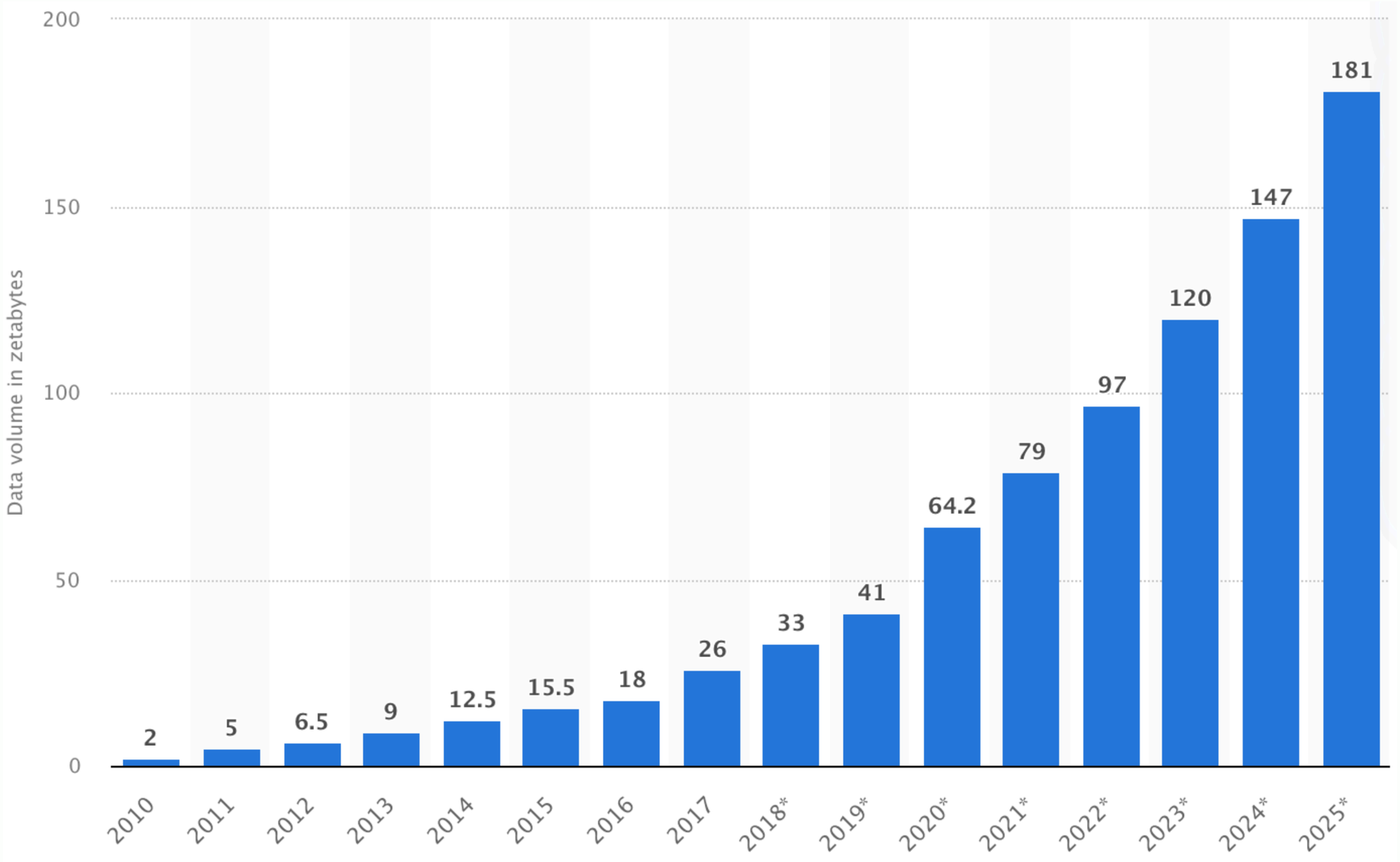
Fritz Pfleumer invents the magnetic tape which later inspired the invention of floppy disks and hard disk drives.

1990s

Sir Tim Berners Lee invents the World Wide Web.

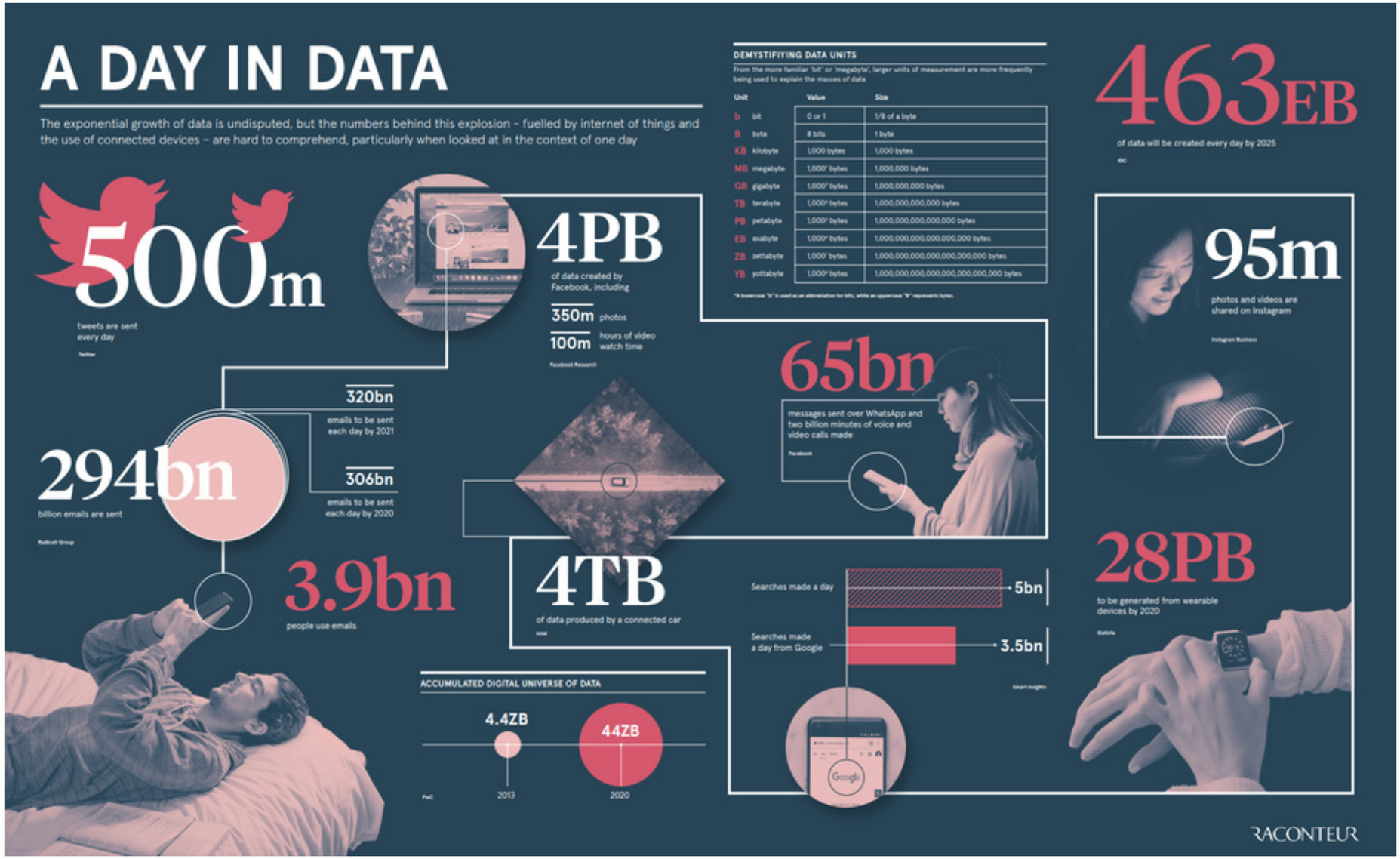
[Accessed August 19, 2024], https://365datascience.com/trending/history-of-data/

WORLD DATA IN NUMBERS



[Accessed August 19, 2024], https://www.statista.com/statistics/871513/worldwide-data-created/

WORLD DATA IN NUMBERS (2)

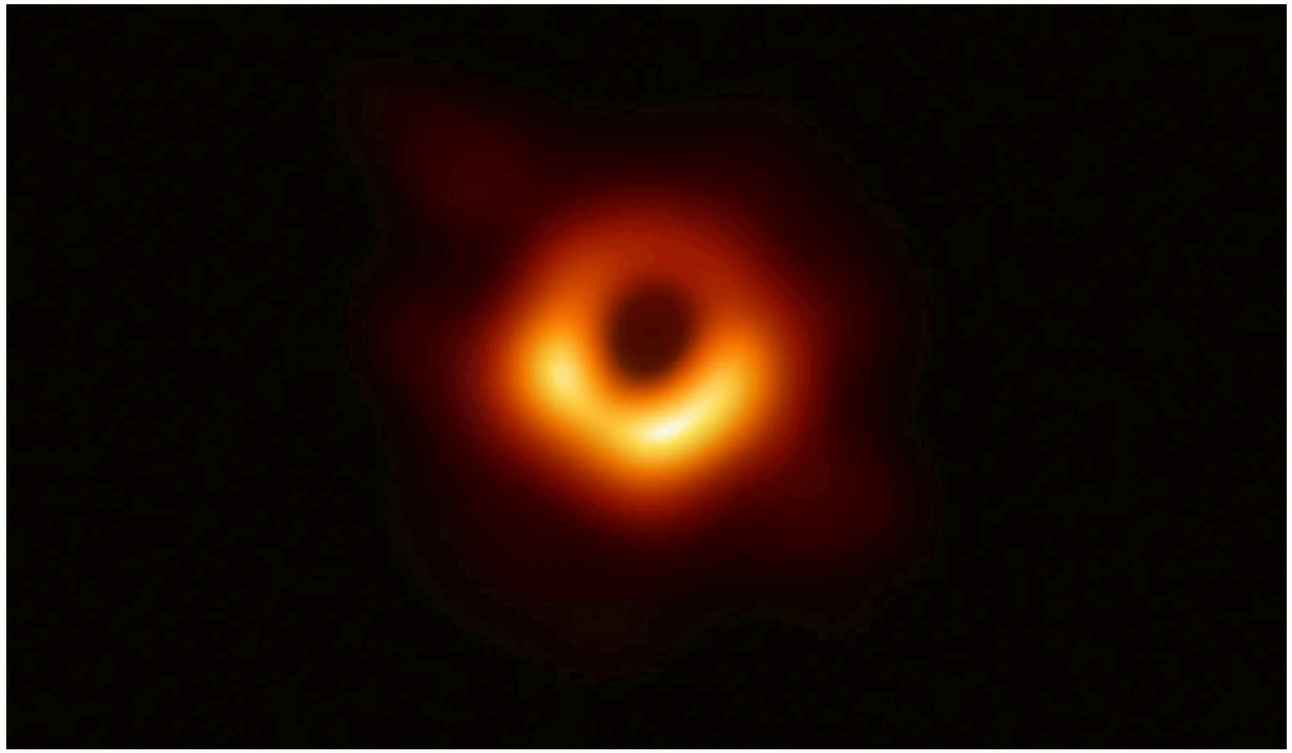


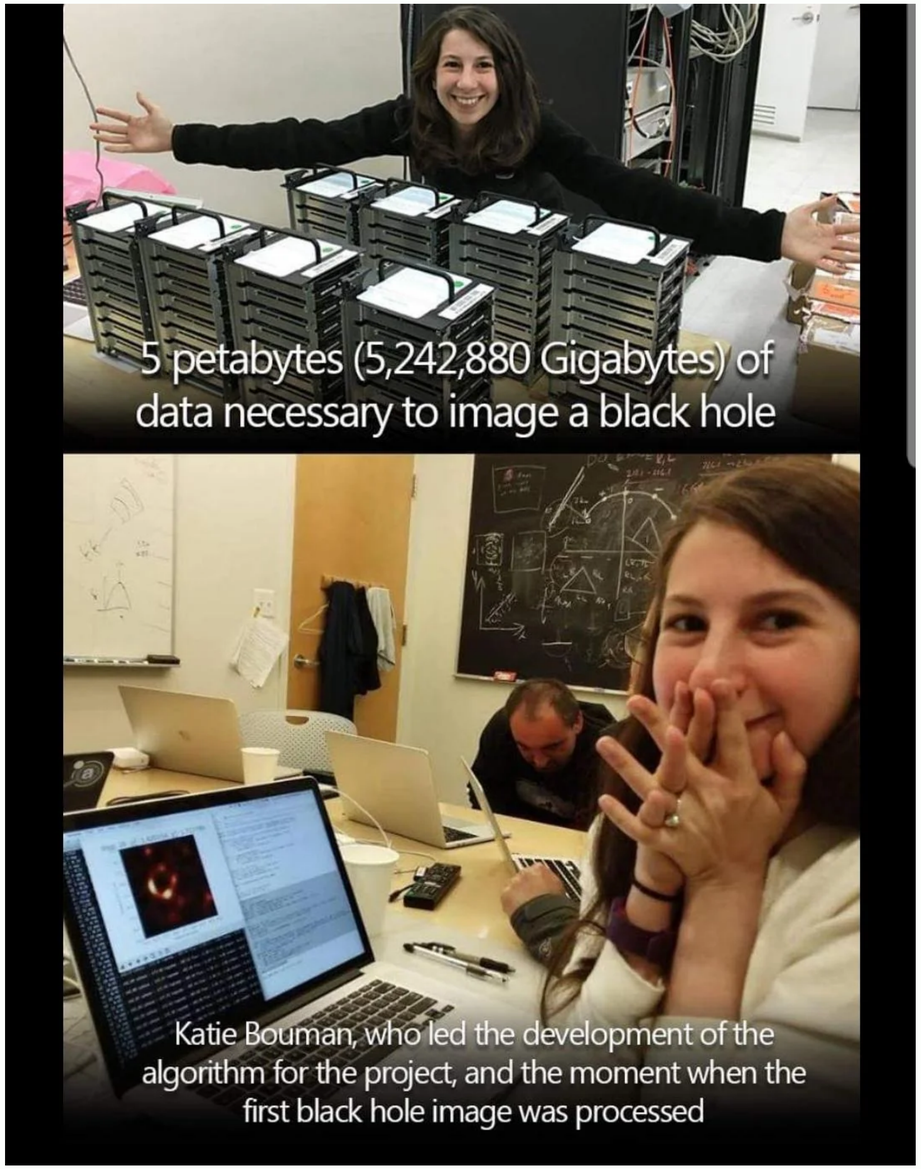
[Accessed August 19, 2024], https://www.visualcapitalist.com/wp-content/uploads/2019/04/data-generated-each-day-wide.html

WORLD DATA IN NUMBERS (3)

Home > Extreme

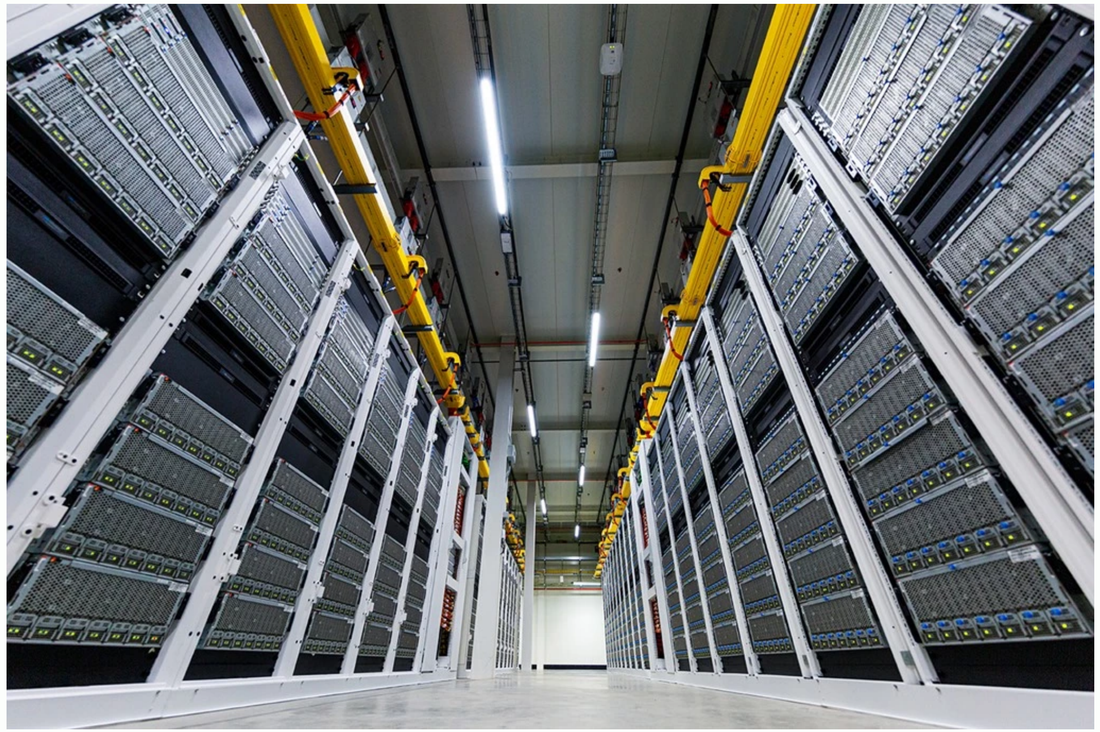
It Took Half a Ton of Hard Drives to Store the Black Hole Image Data





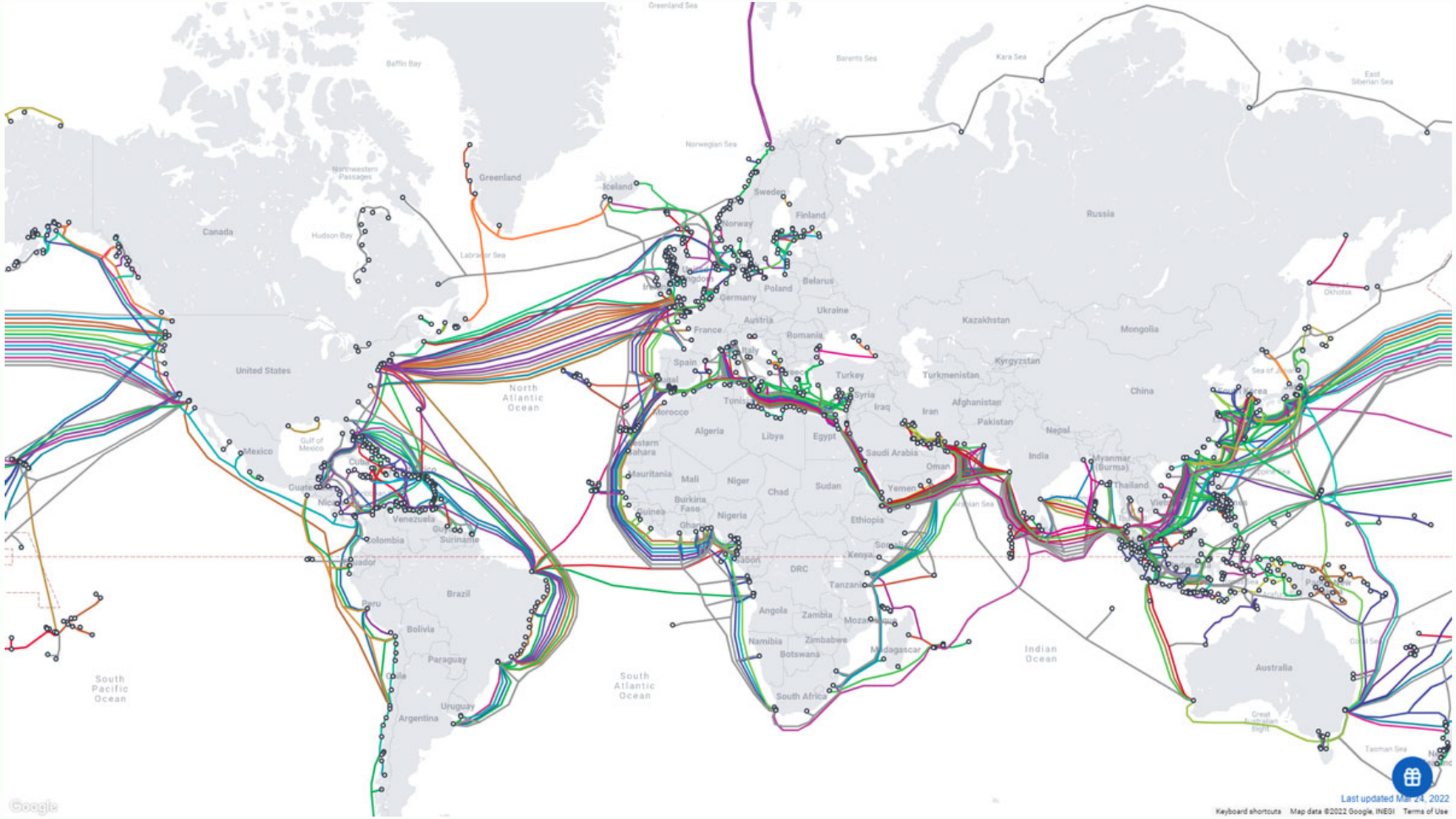
[Accessed August 19, 2024], https://www.extremetech.com/extreme/289423-it-took-half-a-ton-of-hard-drives-to-store-eht-black-hole-image-data
https://science.nasa.gov/resource/first-image-of-a-black-hole/

WORLD DATA IN NUMBERS (5)



[Accessed August 19, 2024], https://azure.microsoft.com/en-us/blog/the-anatomy-of-a-datacenter-how-microsofts-datacenter-hardware-powers-the-microsoft-cloud/
https://news.microsoft.com/europe/2021/11/16/microsoft-opens-its-sustainable-datacenter-region-in-sweden-creating-new-opportunities-for-a-cloud-first-sweden/

WORLD DATA IN NUMBERS (6)



[Accessed August 19, 2024], https://www.submarinecablemap.com/

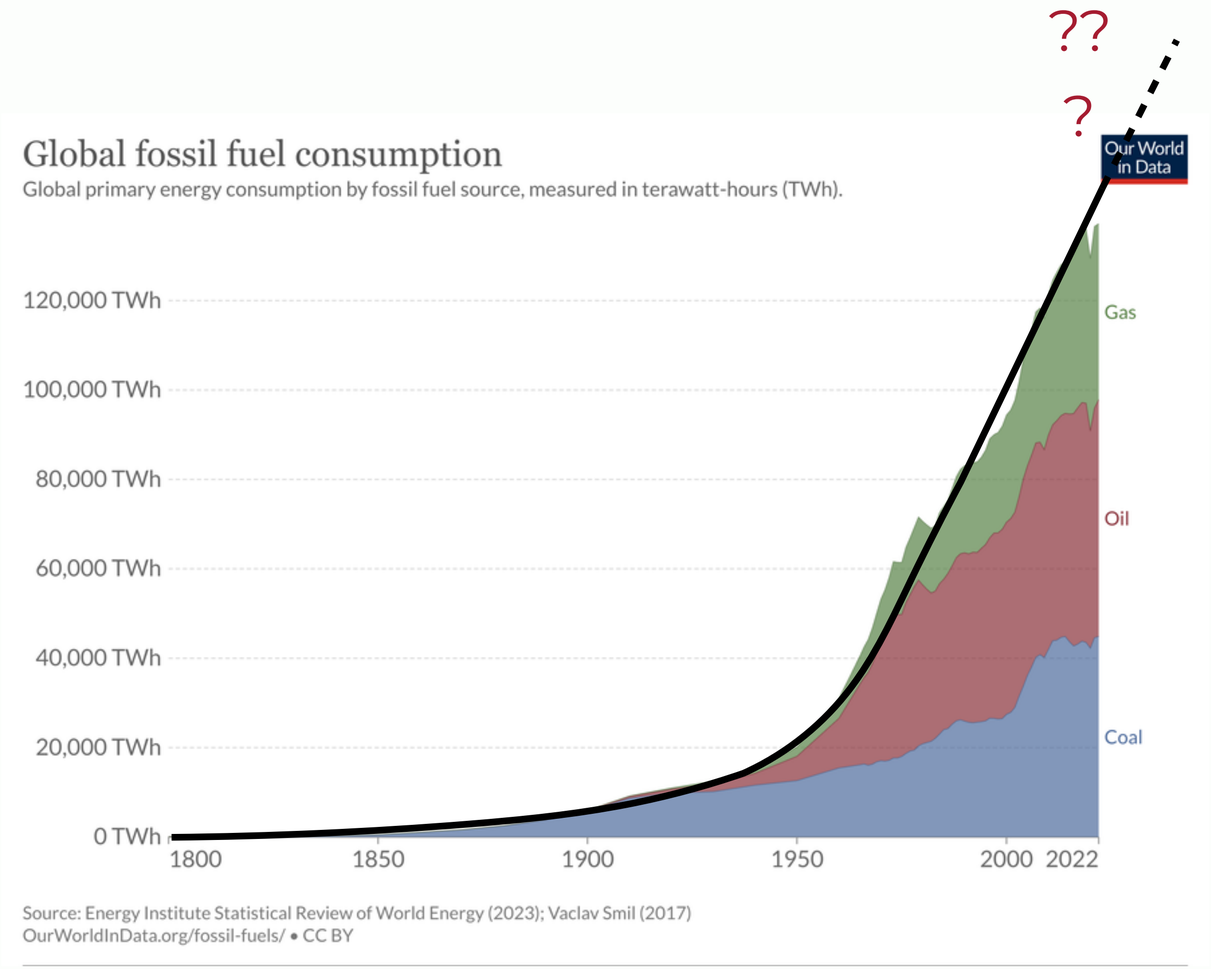
[Accessed August 19, 2024], https://dryield.com/using-predictive-data-analytics-in-manufacturing/

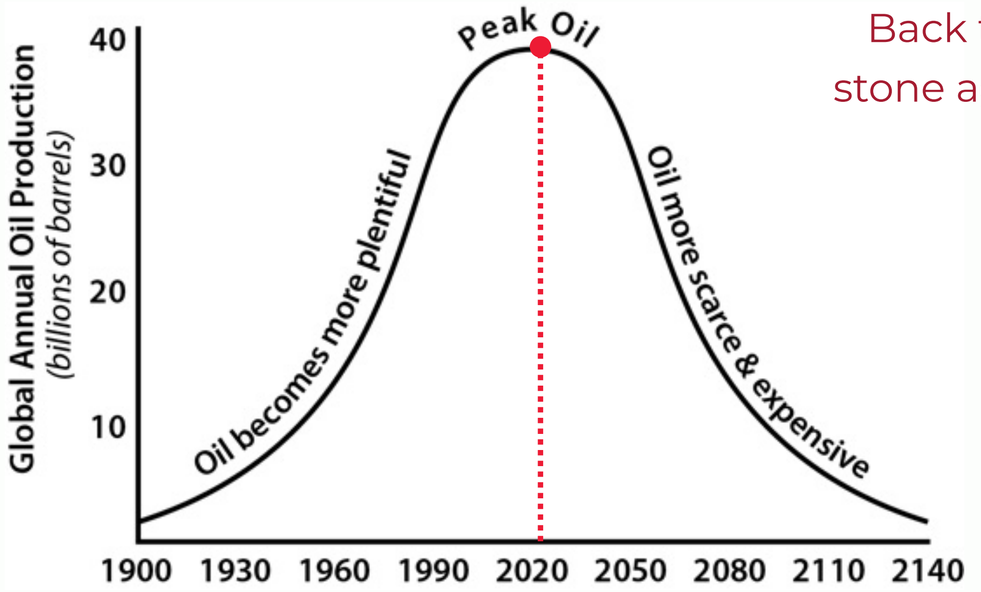
ENERGY & SCIENCE

Humans learn to use more energy ...

ENERGY LANDSCAPE: HOW LONG?

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

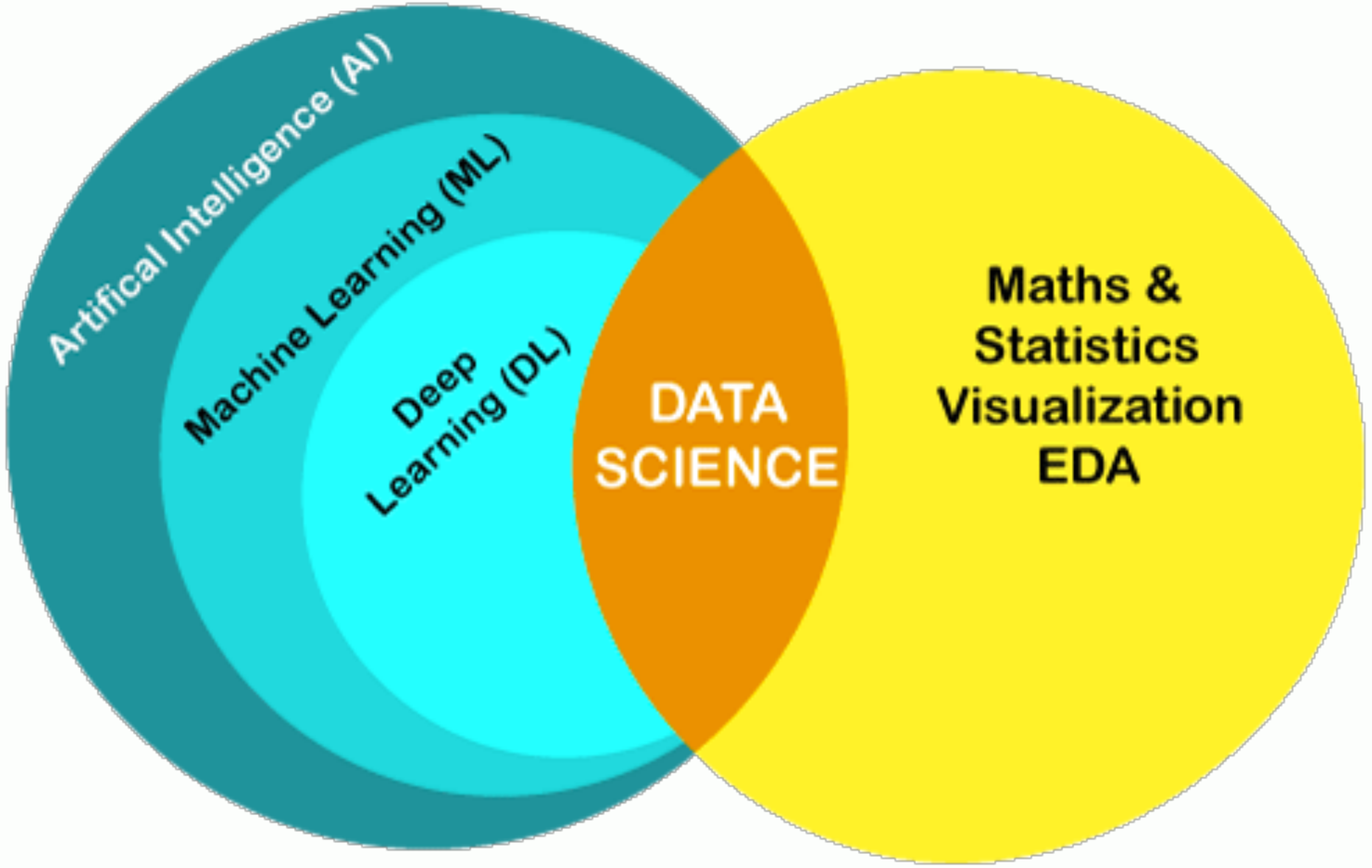




Back to stone age?

https://ourworldindata.org/energy-mix
https://www.explainingthefuture.com/peak_oil.html

[Accessed August 19, 2024], 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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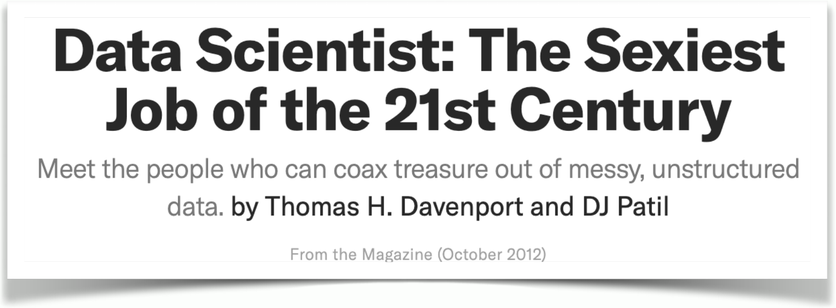

Data Scientist: The Sexiest Job of the 21st Century

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
https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century
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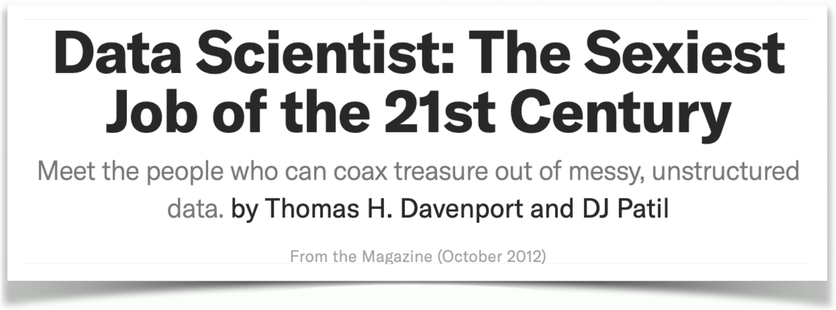

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https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century
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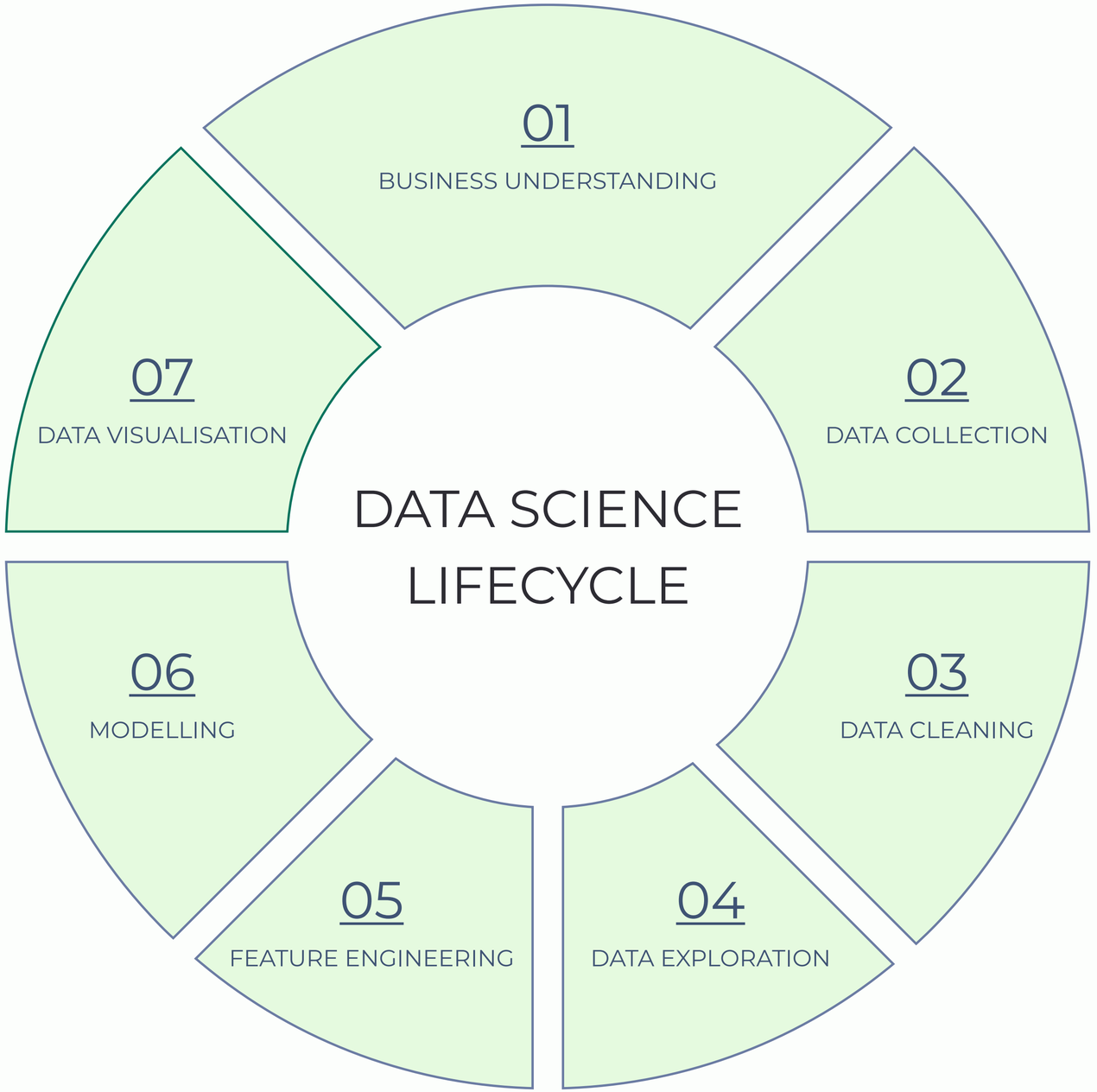
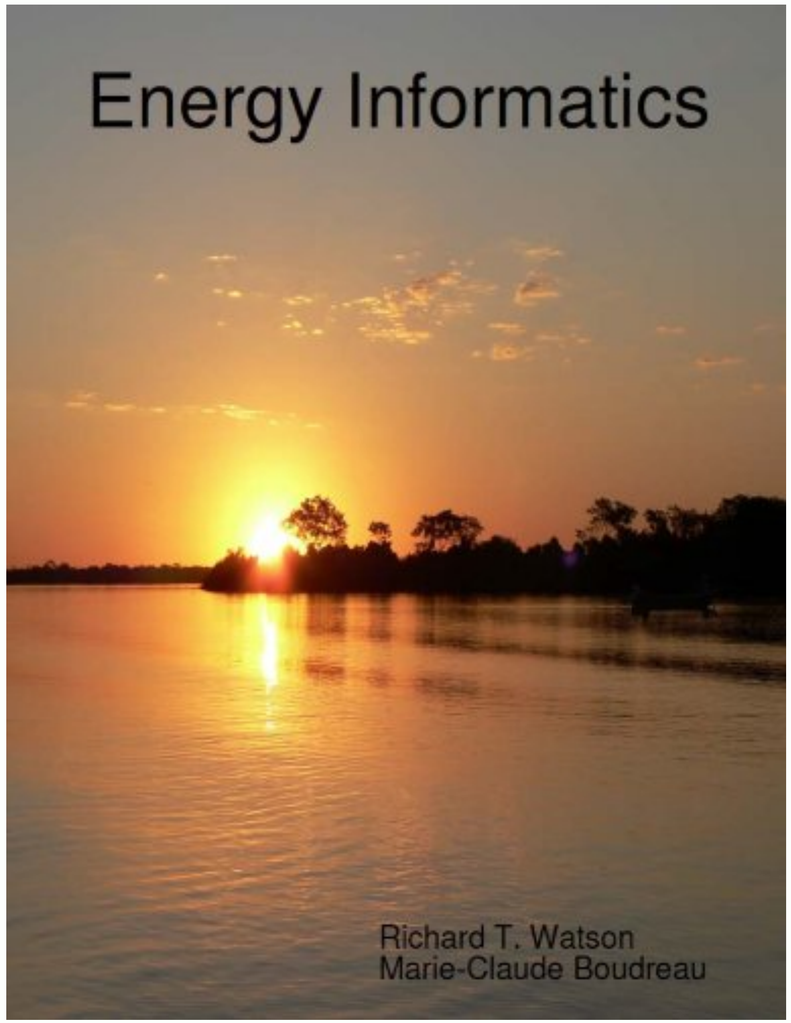


Adopted from https://nearlearn.com/blog/machine-learning-data-science-life-cycle-whats-the-difference/

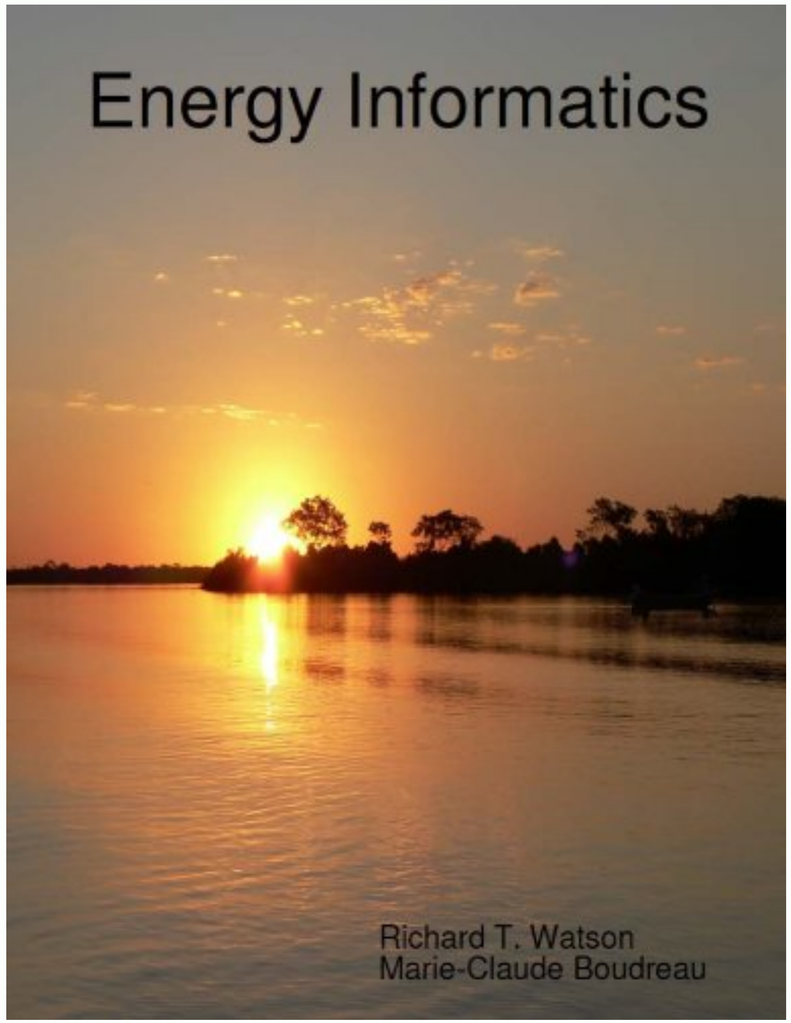
ENERGY INFORMATICS



“Energy Informatics”
by W. C. Booth, G. G. Colomb, J. M. Williams, J. Biz, W. T. Fitzgerald, University of Chicago Press, Fourth edition, October 18, 2016

“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

FUSION OF ENERGY AND IT

APPLICATION	GOAL	TECHNOLOGY

Energy (application areas):

- ✓ Buildings
- ✓ Cities
- ✓ Industries
- ✓ Grid
- ✓ Transportation
- ✓ Factories
- ✓ Agriculture

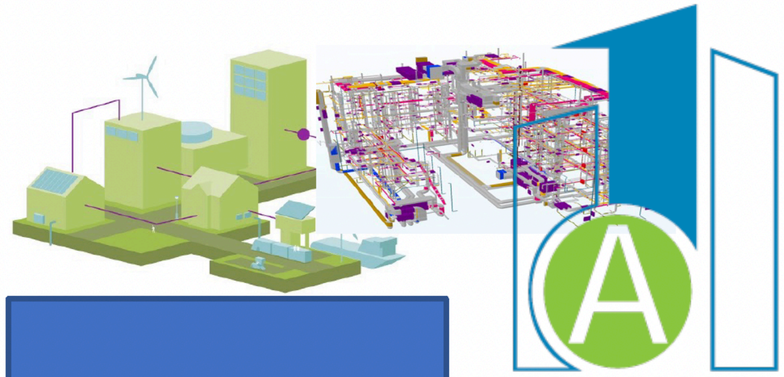
- Energy efficiency
- Predictive maintenance
- Renewable energy integration
- Environmental impact assessment
- Consumer engagement

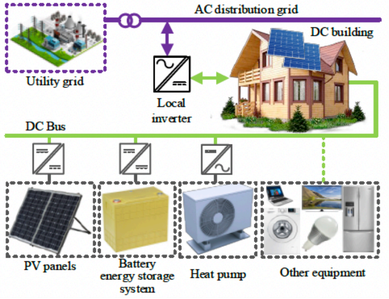
IT (enabling technologies):

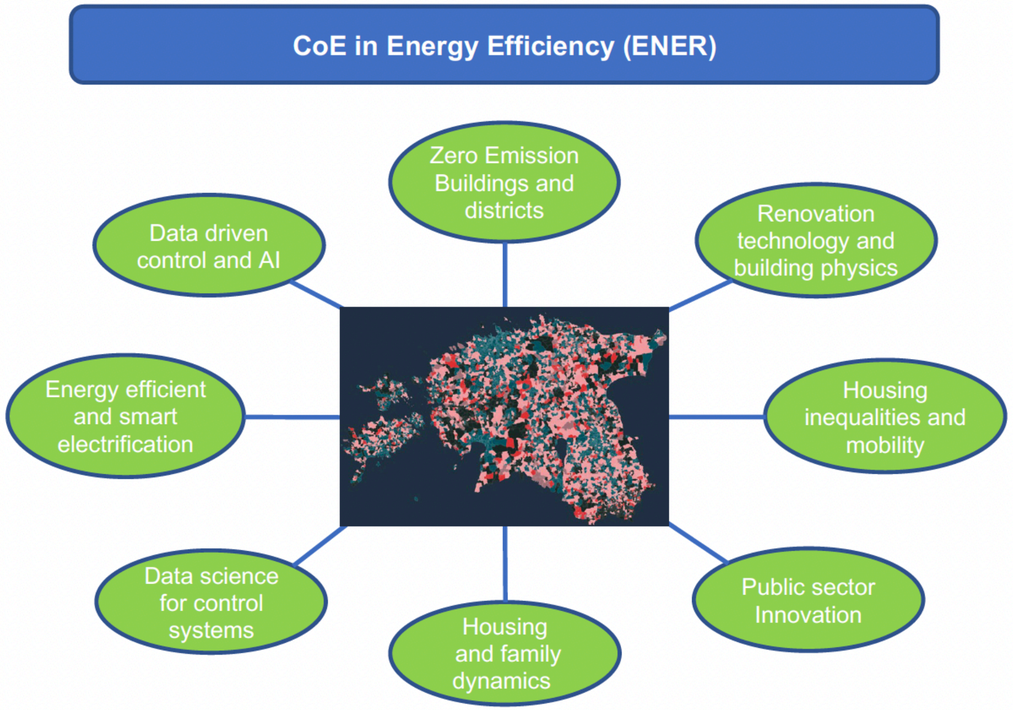
- ✓ Internet of Things
- ✓ Digitalisation
- ✓ Machine learning
- ✓ Artificial Intelligence
- ✓ Blockchain
- ✓ Cloud computing
- ✓ Big data
- ✓ Data analysis

DATA!

Centre of Excellence in Energy Efficiency







WP3 Data infrastructure and data driven control

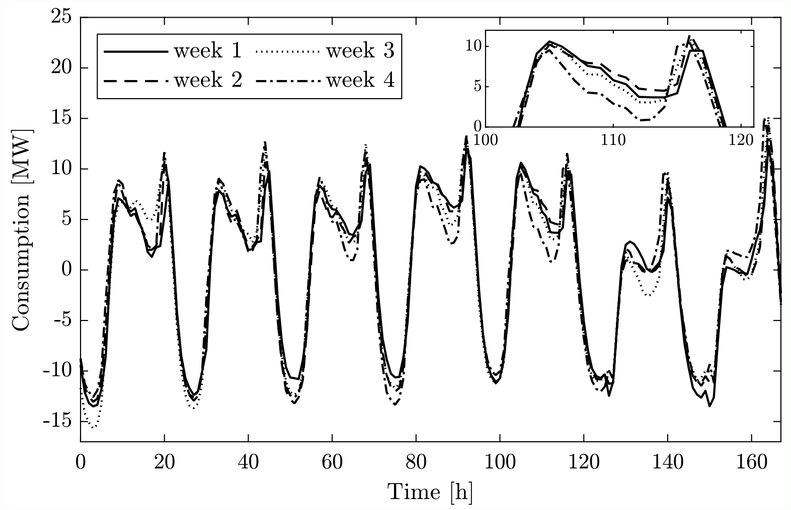
WP1 Zero emission building/district technologies and HVAC to optimise energy and health

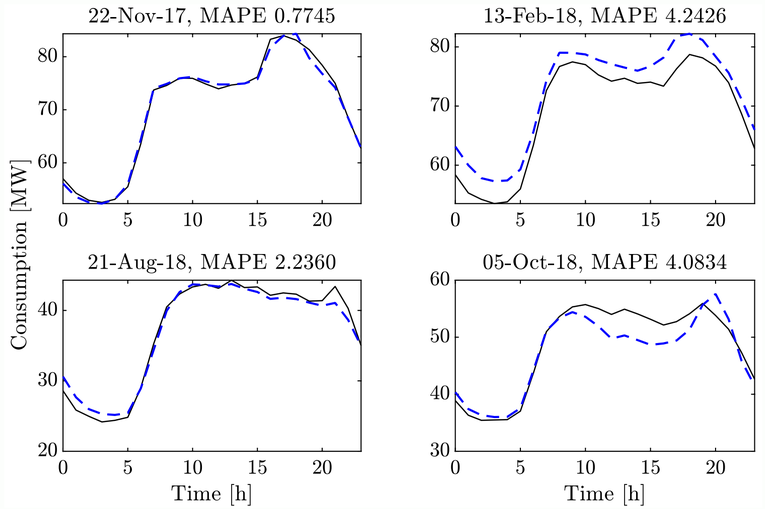
WP2 Sustainable, efficient and smart building electrification technologies for energy independence and resilience

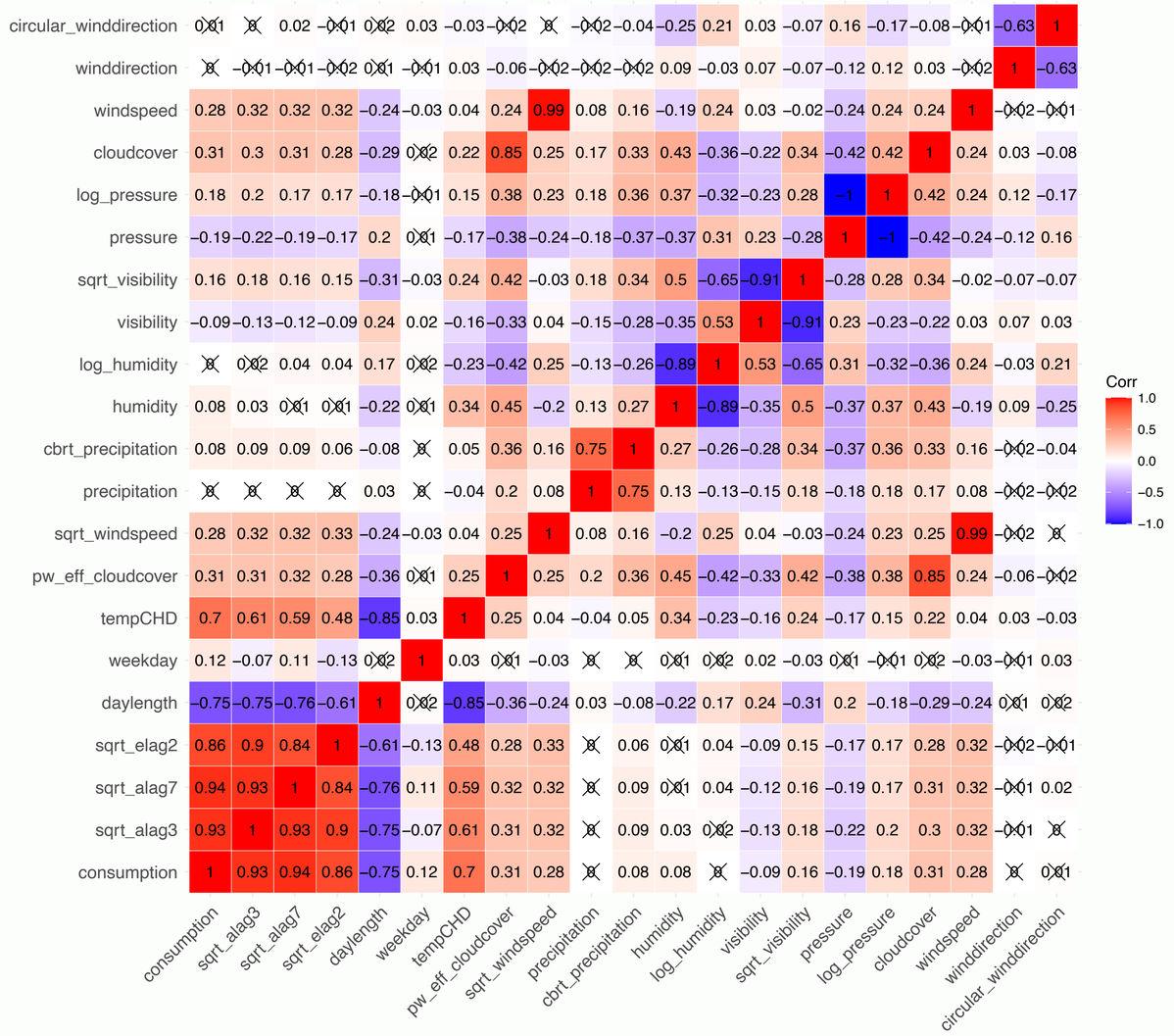
WP4 Social and regional implications of Renovation Wave

Practice-oriented Research

APPS: FORECASTING 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.

APPS (2): NONINTRUSIVE LOAD MONITORING

Non-Intrusive Load Monitoring (NILM) techniques estimate the consumption of individual appliances in a household, based on readings of a centralised meter.

Meter measure power (input)

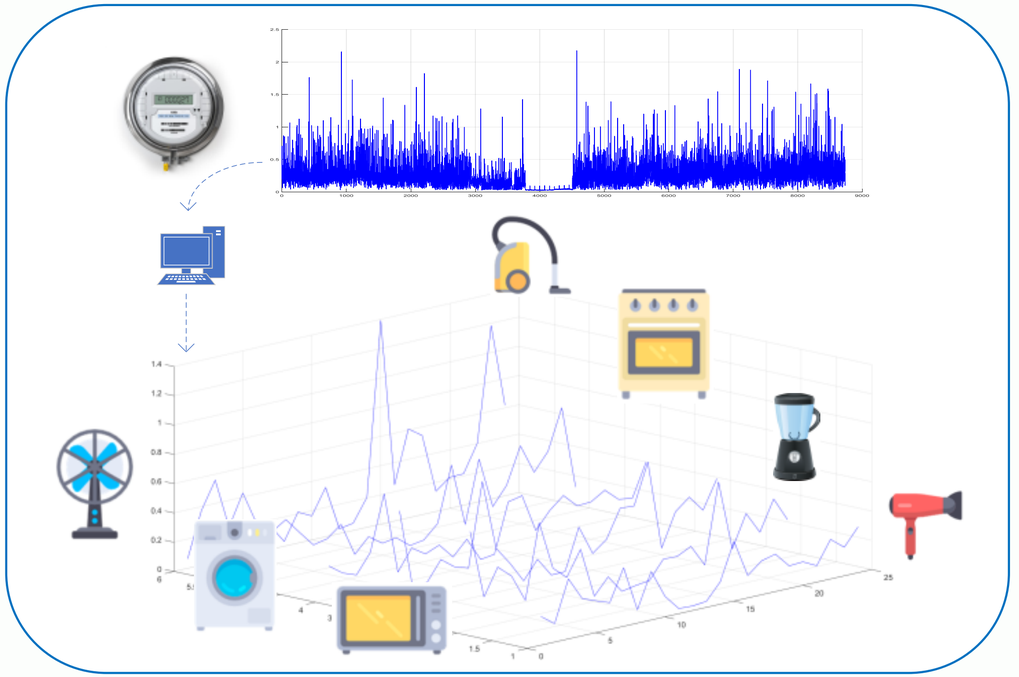
Number of appliances

Background noise

$$P[n] = \sum_{i=1}^{N} s_i[n] p_i + P_{noise}[n]$$

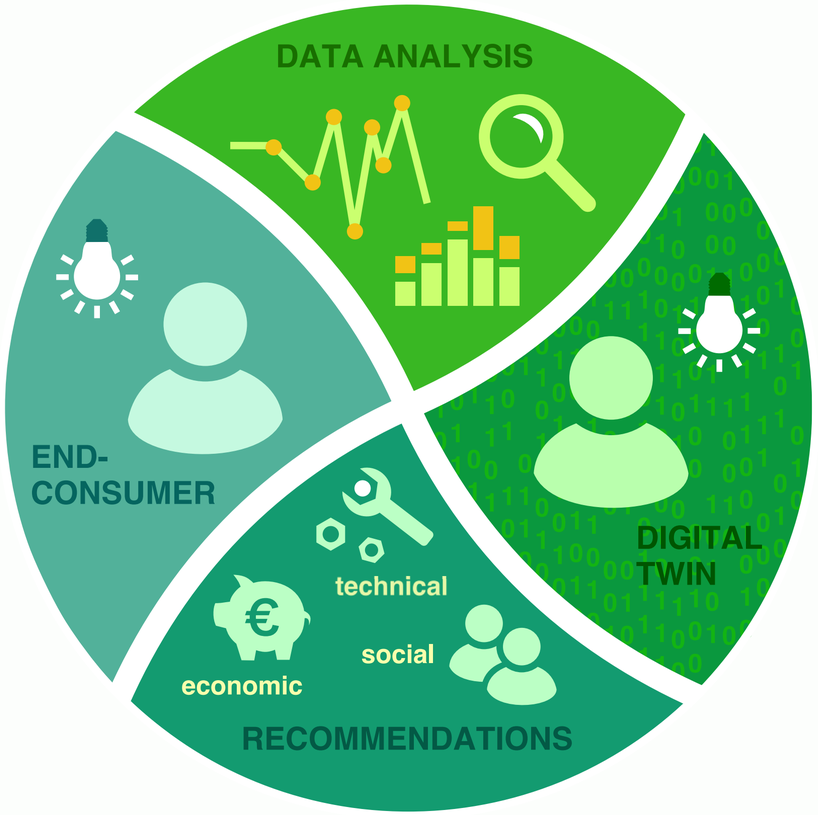
Off/On {0,1} of appliance *i*

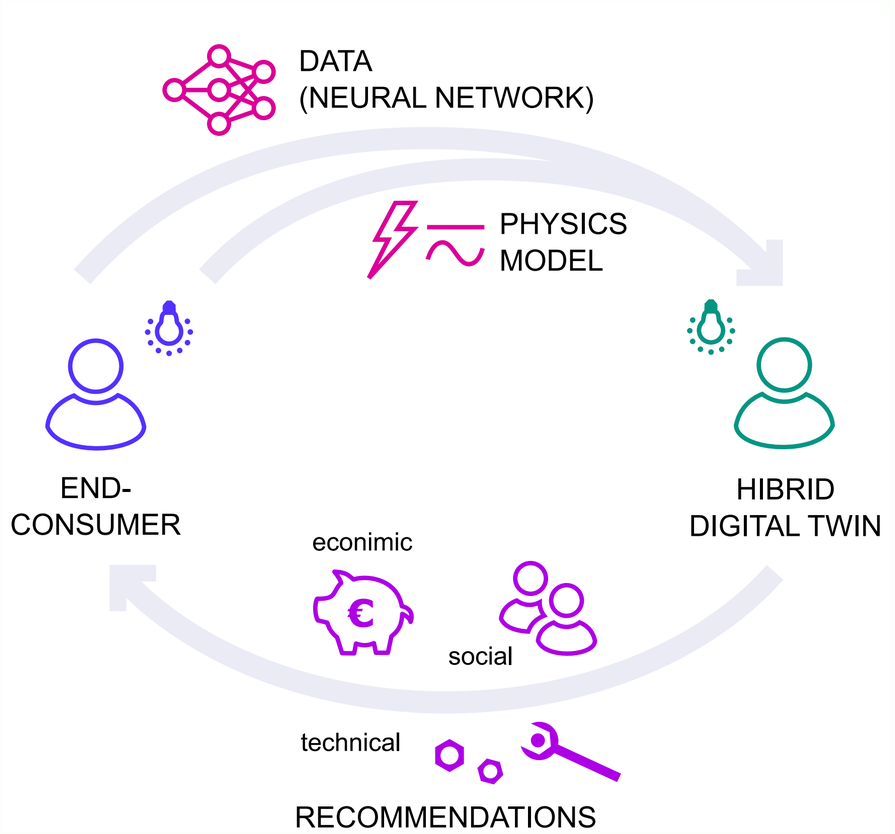
Power of device *i*



R. Machlev, J. Belikov, Y. Beck, Y. Levron. MO-NILM: A multi-objective evolutionary algorithm for NILM classification. *Energy and Buildings*, 199, 134–144, 2019.

APPS (3): 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.

Forbes

FORBES > SMALL BUSINESS

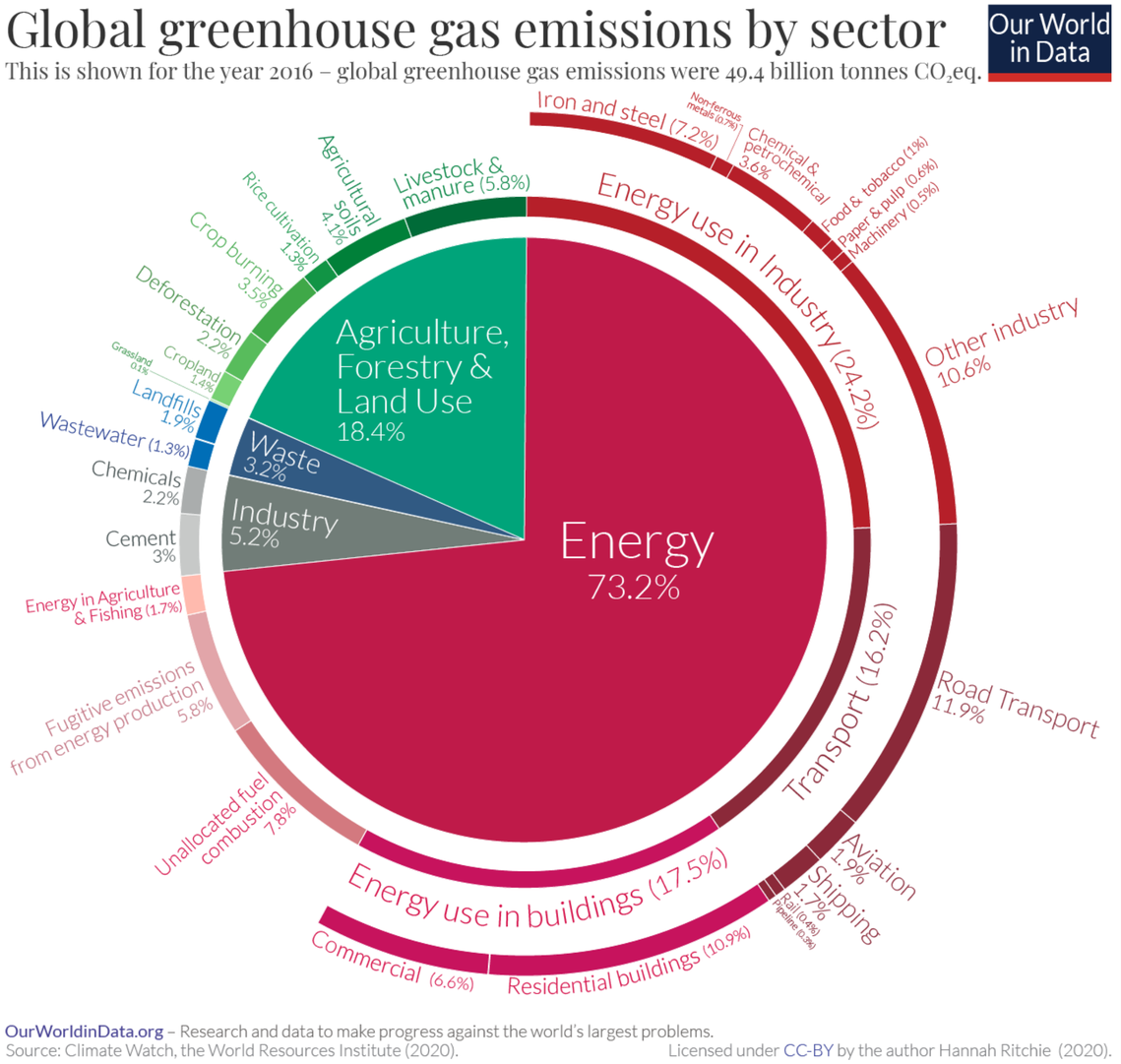
Confronting Commercial Real Estate's Biggest Challenges With Technology

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

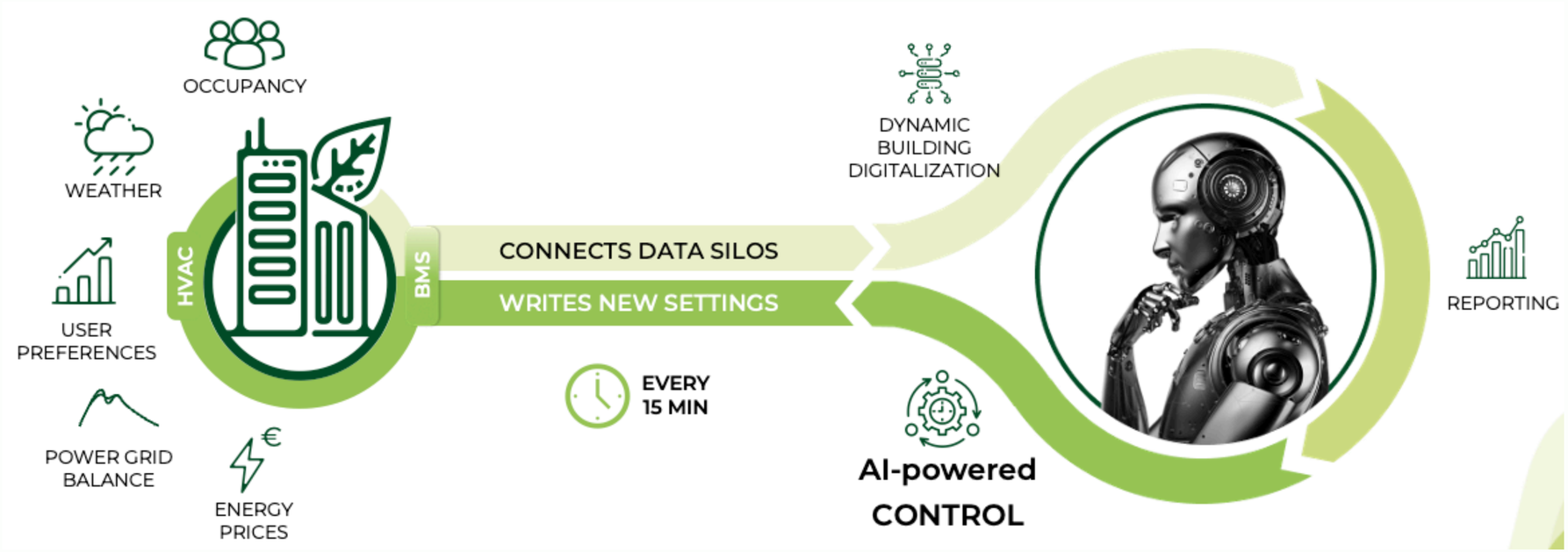
First, let's talk about climate technology and how it is affecting the real estate industry. Nearly half of all greenhouse gas emissions are generated from real estate. Approximately 27% of annual CO2 emissions come from building operations and another 20% come from building materials, construction and 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 March 28, 2024], https://www.forbes.com/sites/forbesbusinesscouncil/2022/08/04/confronting-commercial-real-estates-biggest-challenges-with-technology
https://ourworldindata.org/ghg-emissions-by-sector

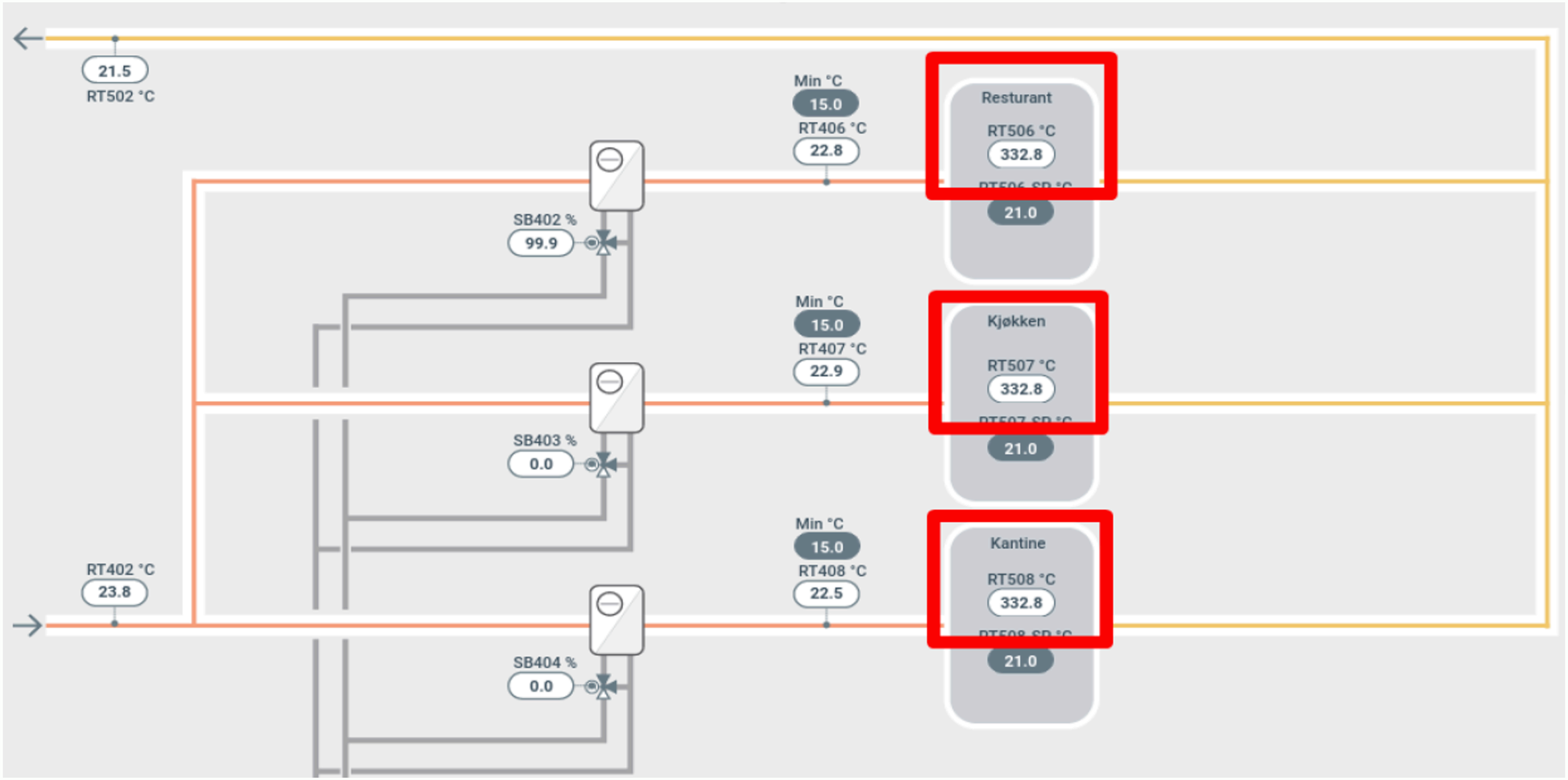
APPS (5): SMART BUILDINGS

- Knowledge transfer
- Contributing to decarbonisation of CRE and green transition
- Joint industrial MSc/PhD students
- Internship opportunities
- Industrial scholarship (TalTech arengufond)

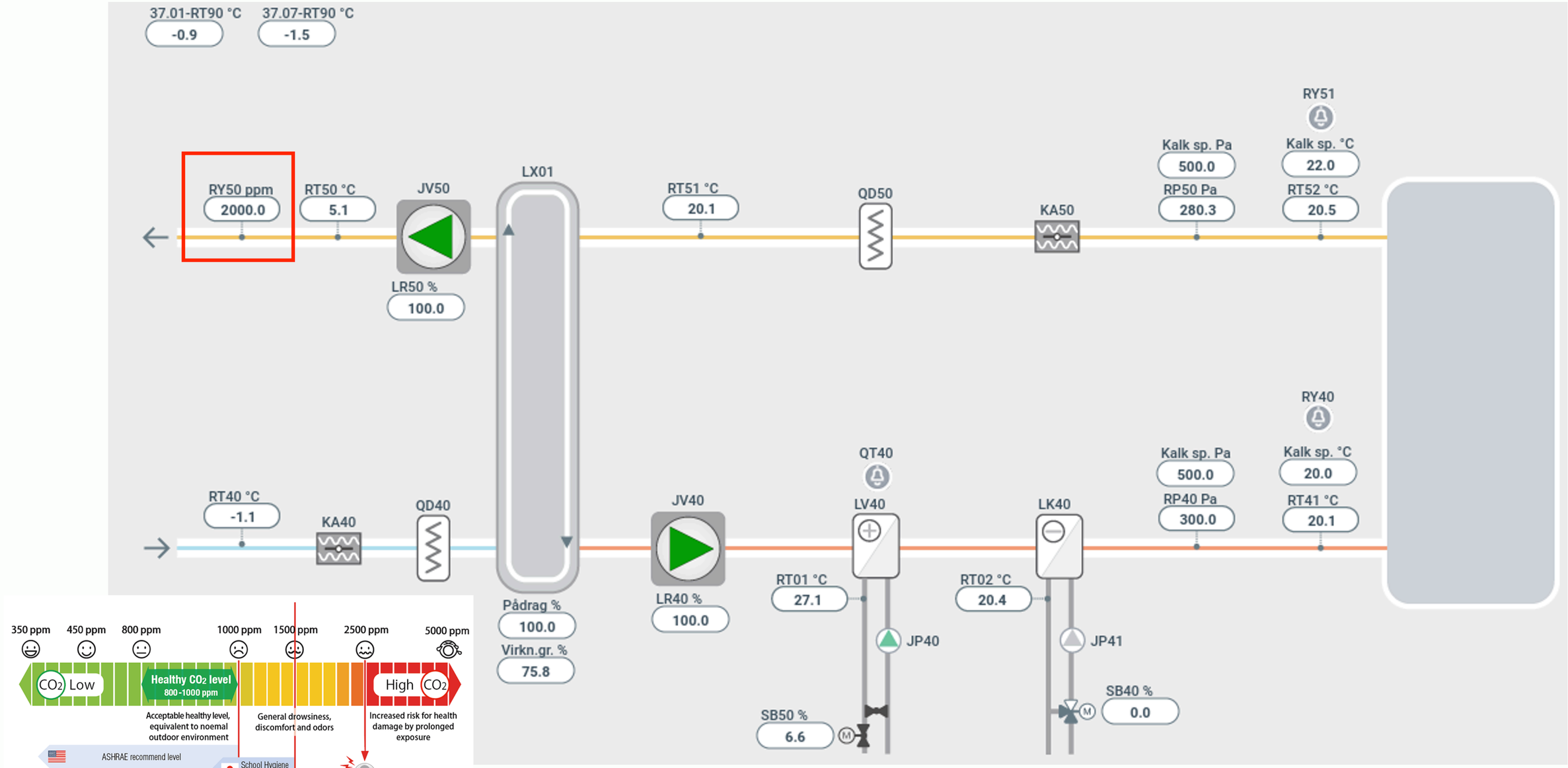


https://r8tech.io/
https://taltech.ee/arengufond/stipendiumid/2023-sugis#p2574788

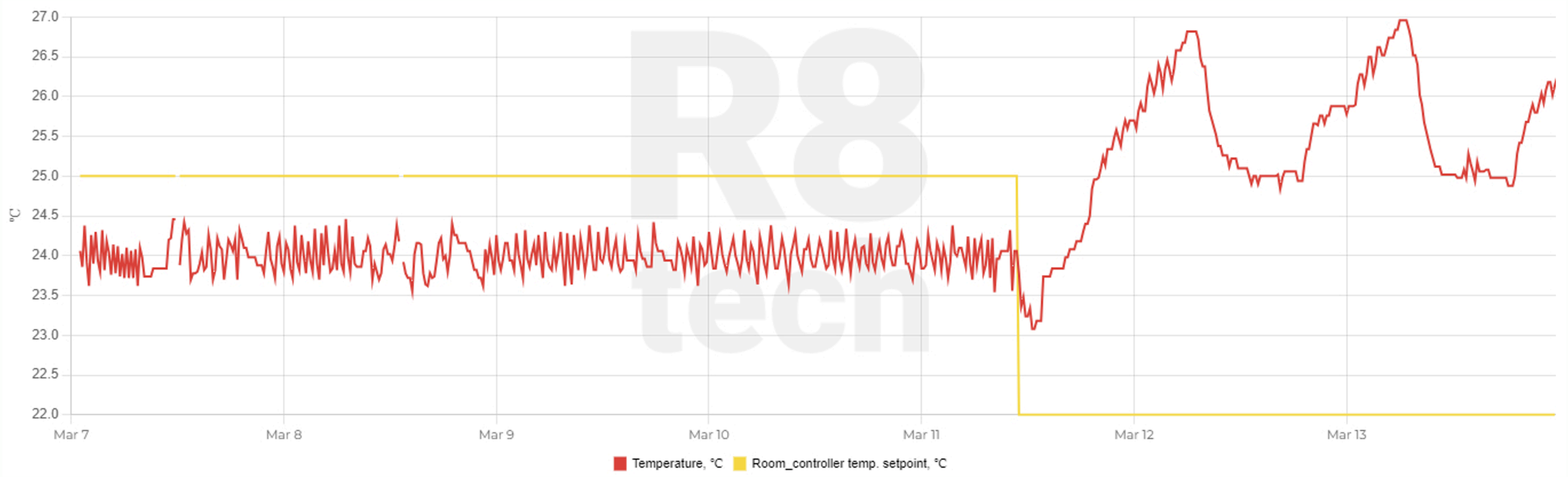
EX1: Room temperature sensors are static.



EX2: The ventilation unit always performs at high speed (100%) because of the broken CO2 sensor which shows too high values.



Rooms temperatures are not following setpoints.

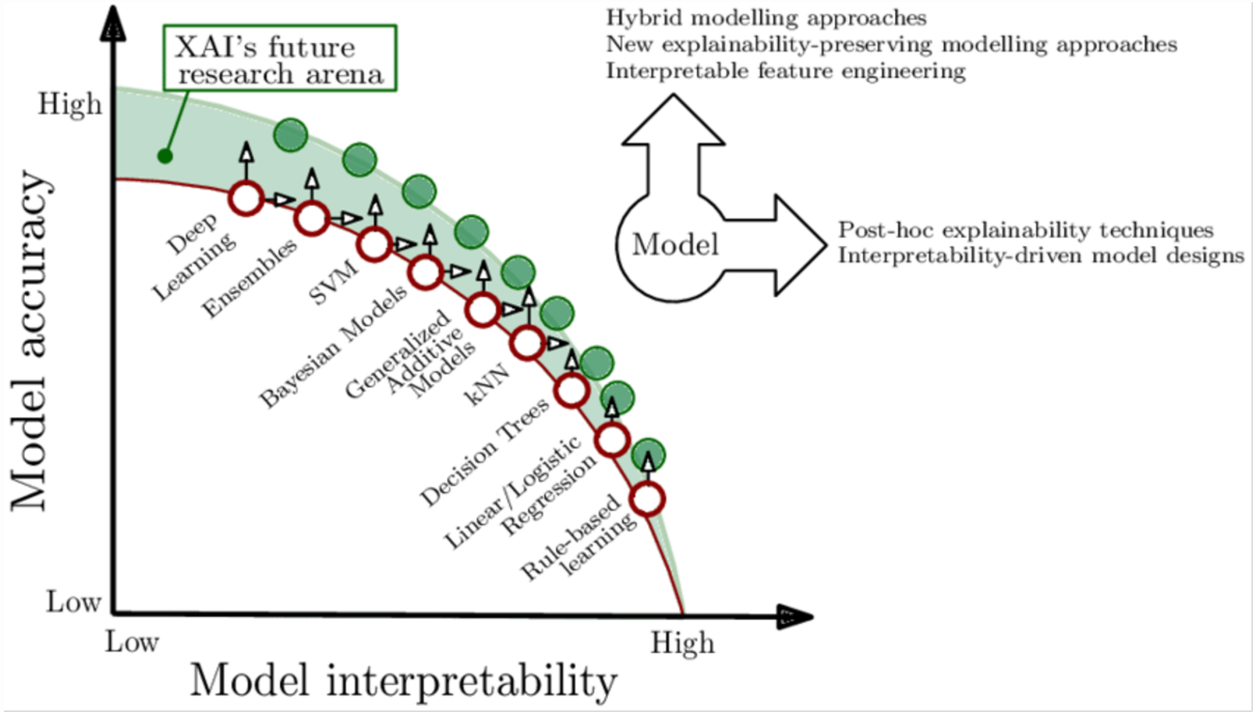


Problems:

- Amount of data

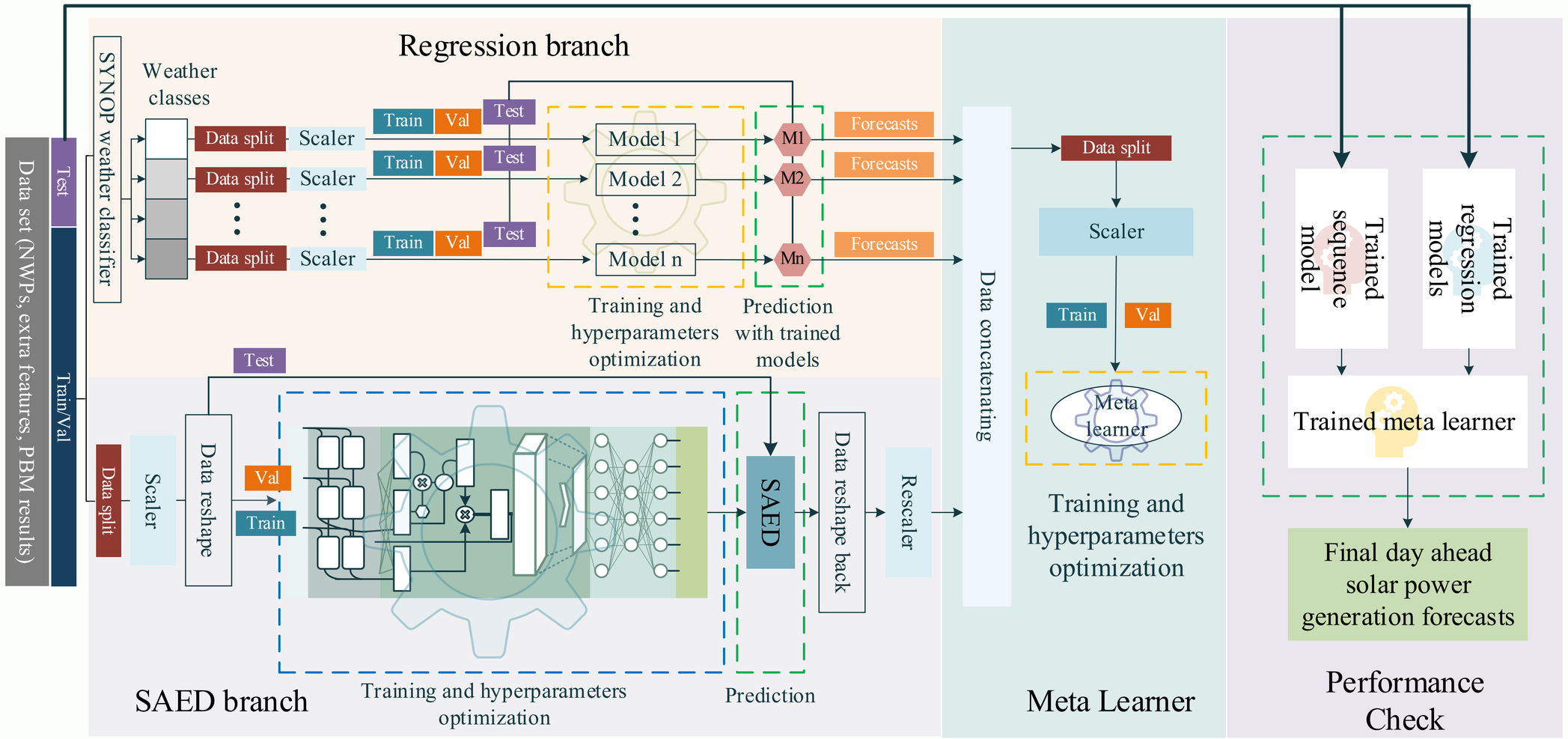
Bilding type	Total # of points	Controlled points
Shopping mall 1	4657	890
Shopping mall 2	3082	709
Hotel	7556	1404
Office	17380	1636
Office	10498	2383

- Accuracy vs complexity vs transparency



OUTRO

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



OUTRO

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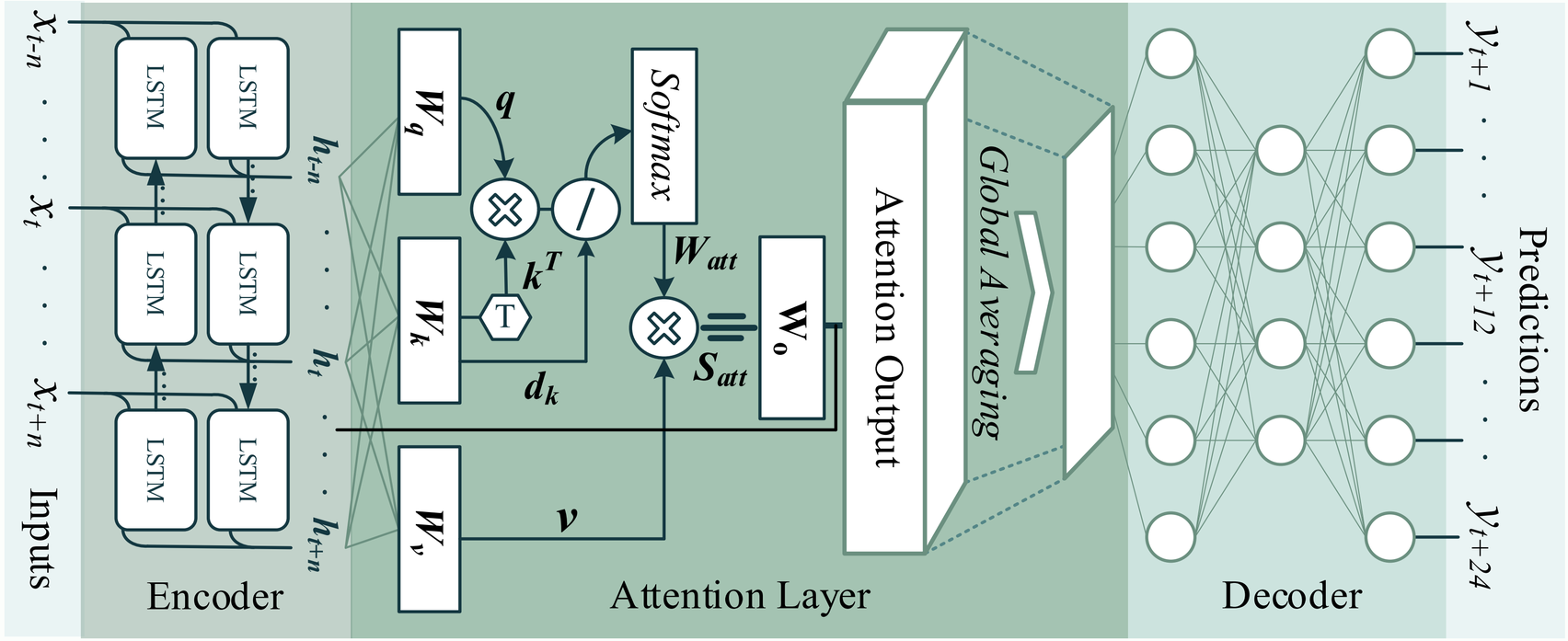
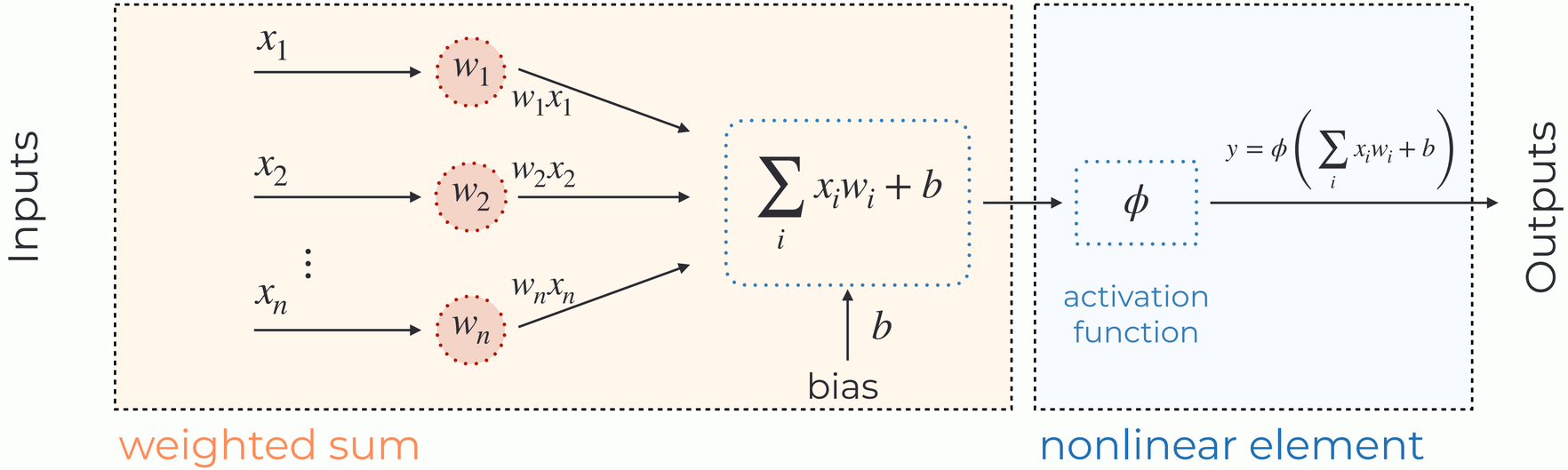


OUTRO (2): ANN



Matrix notation:

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$

$$W = [w_1, w_2, \ldots, w_n]$$

$$y = \phi\left(WX + b\right)$$

GPT-3

Total weights:

175,181,291,520

Embedding	^{12,288} d_embed * ^{50,257} n_vocab	= 617,558,016
Key	^{128} d_query * ^{12,288} d_embed * ^{96} n_heads * ^{96} n_layers	= 14,495,514,624
Query	^{128} d_query * ^{12,288} d_embed * ^{96} n_heads * ^{96} n_layers	= 14,495,514,624
Value	^{128} d_value * ^{12,288} d_embed * ^{96} n_heads * ^{96} n_layers	= 14,495,514,624
Output	^{12,288} d_embed * ^{128} d_value * ^{96} n_heads * ^{96} n_layers	= 14,495,514,624
Up-projection	^{49,152} n_neurons * ^{12,288} d_embed * ^{96} n_layers	= 57,982,058,496
Down-projection	^{12,288} d_embed * ^{49,152} n_neurons * ^{96} n_layers	= 57,982,058,496
Unembedding	^{50,257} n_vocab * ^{12,288} d_embed	= 617,558,016

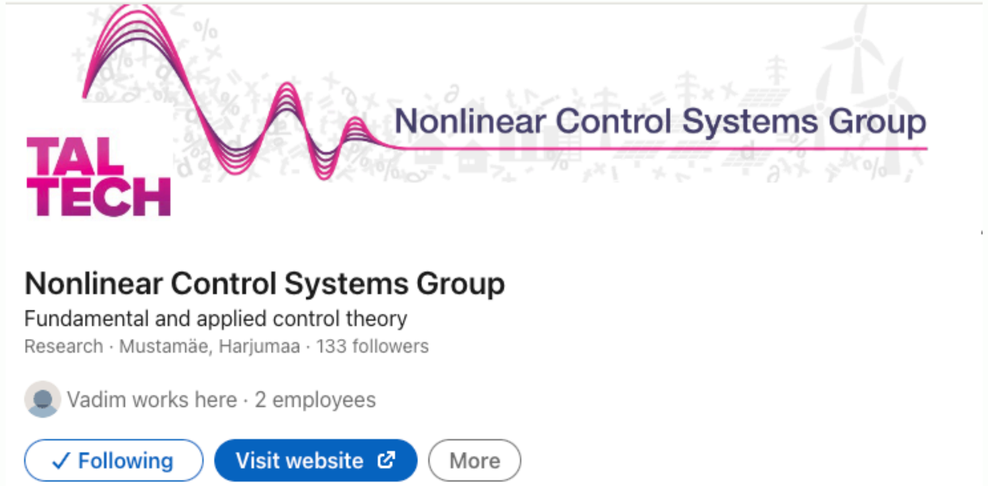
[Accessed April 3, 2024], https://www.youtube.com/watch?v=wjZofJX0v4M

RESEARCH GROUP

The **best** results would come from everyone in the group doing what's for himself and the group.

(c) „A beautiful mind“,
R. Crowe as J. Nash

Thank you for your attention!



https://www.linkedin.com/company/nonlinear-control-systems-group