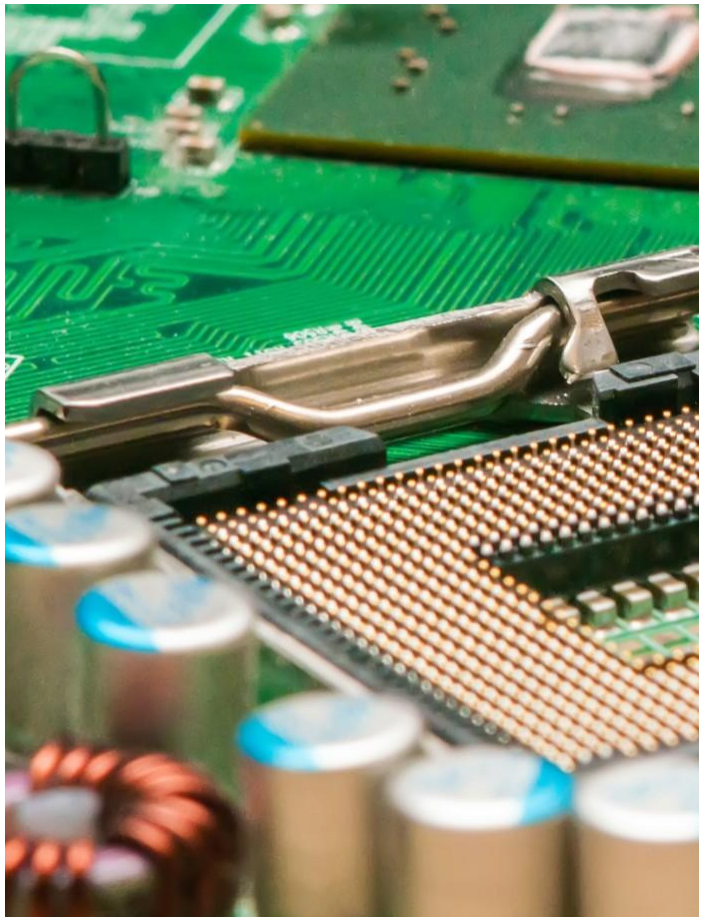
Fundamentals of Electrical & Electronic Engineering

Prof. John G. Breslin, Electrical & Electronic Engineering

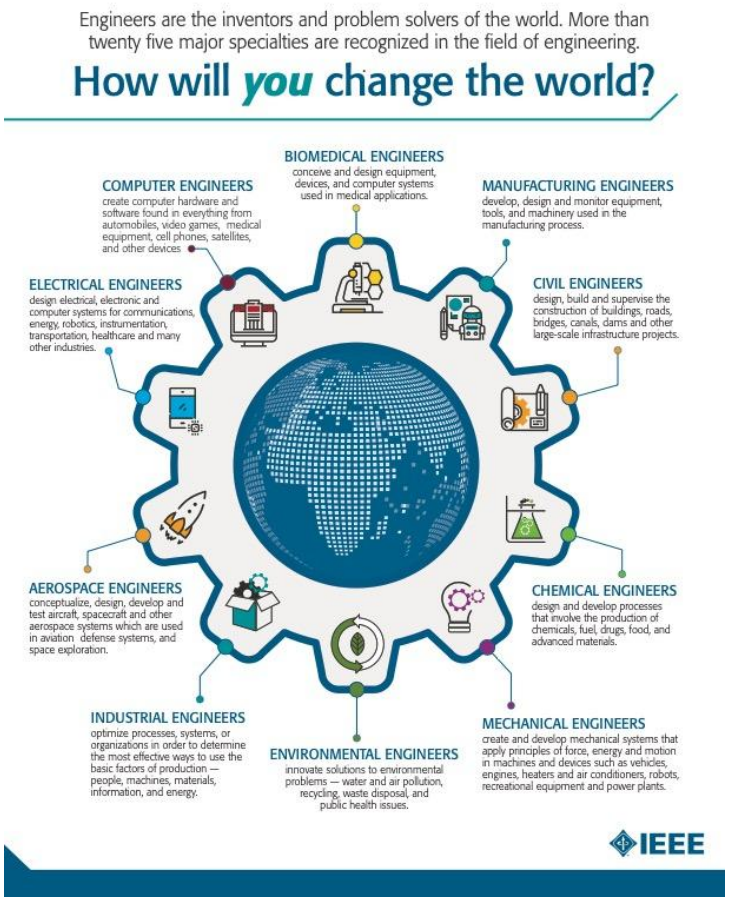


Lecture 0

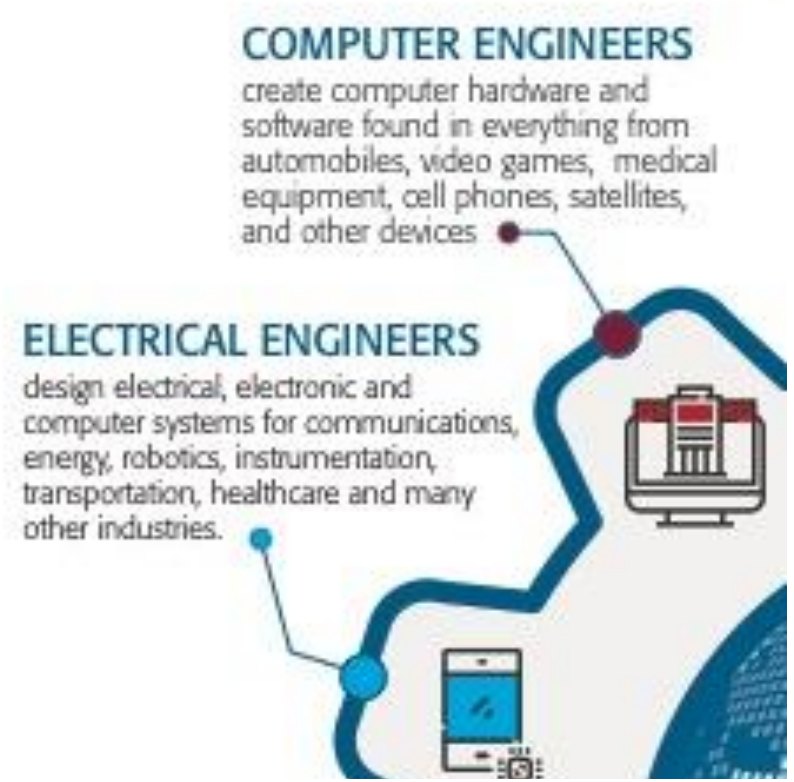
Why is this important?

Ollscoil na Gaillimhe
University of Galway

How will *you* change the world?



- Design, create, innovate



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What do you think were the greatest engineering achievements of the past 100 years?

Let's go…

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Greatest engineering achievements of the 20th century (NAE)

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration

1. Highways
2. Spacecraft
3. Internet
4. Imaging
5. Household Appliances
6. Health Technologies
7. Petroleum and Petrochemical Technologies
8. Laser and Fiber Optics
9. Nuclear Technologies
10. High-performance Materials

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Notice anything? ☺

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
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And the (14) engineering challenges for the future?

- Make solar energy affordable
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools for scientific discovery

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Why do you need to study EE?

- To pass the Fundamentals of Engineering examination here at the University of Galway but also any future exams as a registered professional (engineer), allowing you to perform engineering services for the public.
- To have a broad enough knowledge base so that you can lead design projects in your own field. Increasingly, EE is interwoven with nearly all scientific experiments and design projects in other fields of engineering. Industry has repeatedly called for engineers who can see the big picture and work effectively in teams. Engineers or scientists who narrow their focus strictly to their own field are destined to be directed by others.
  - EEs are somewhat fortunate in this respect because the basics of structures, mechanisms, and chemical processes are familiar from everyday life. On the other hand, EE concepts are somewhat more abstract and hidden from the casual observer.
- To be able to operate and maintain electrical systems, such as those found in control systems for manufacturing processes. The vast majority of electrical-circuit malfunctions can be readily solved by the application of basic EE principles. You will be a much more versatile and valuable engineer or scientist if you can apply electrical-engineering principles in practical situations.
- To be able to communicate with EE consultants. Very likely, you will often need to work closely with EEs in your career. We aim to give you the basic knowledge needed to communicate effectively.

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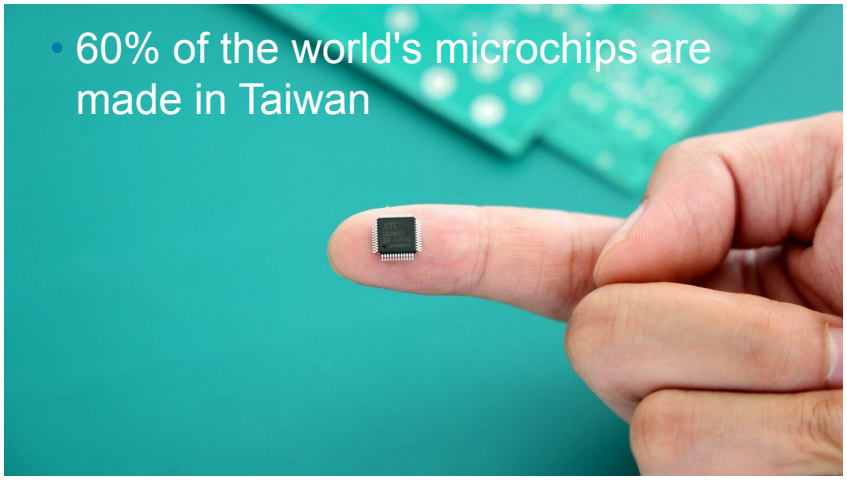
Skills shortage in the chips industry poses major problems, Silicon Republic, 26 May 2023

“To continue our leadership in semiconductors, we need a steady supply of electronic engineering graduates”

“Making a chip involves physics, chemistry, mechanical engineering, electronics, computer science and statistics. [Peter] Kennedy [professor of microelectronic engineering at University College Dublin] said when it comes to the design side of things, companies such as AMD, Analog Devices, Intel, Qualcomm and more are mainly in need of electronic engineers who are proficient in maths and computing.

“‘On the design side, AMD, Analog Devices, Bosch, Intel, Infineon, Qualcomm, and others mainly need electronic engineers who are creative, good with computers, and proficient in maths.’”

“Why Ireland is well positioned to capitalise on chip ‘gold rush’”, Silicon Republic, 23 August 2023



- “The explosive growth of the semiconductor industry also poses capacity challenges for Europe. While the EU recently adopted its long-awaited Chips Act, which aims to increase the region’s share of global chip production to at least 20pc by the end of the decade, the continent will need to rapidly increase capacity across construction, fit-out and operation of wafer fabs.
- “This is a highly specialised task, but one that Ireland has experience of, which could give it an advantage.” - Jenny Darmody

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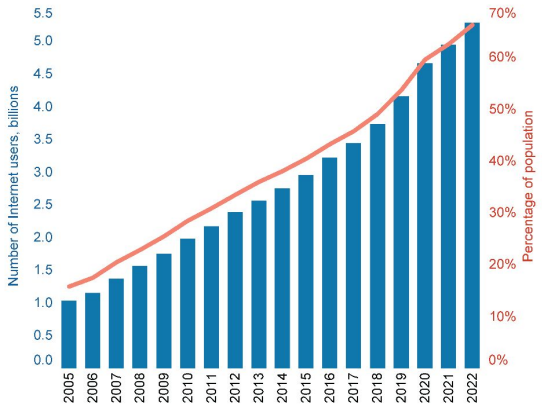
Growth of internet use and mobile uptake (itu.int)

offline

Individuals using the Internet



Source: ITU

Today, an estimated 5.3 billion people, or 66 per cent of the world's population, use the Internet. This represents a growth rate of 6.1 per cent over 2021, up from 5.1 per cent for 2020-2021, but pales in comparison with the 11 per cent for 2019-2020 seen at the beginning of the COVID-19 pandemic. That leaves 2.7 billion people offline, showing just how much remains to be done if the target of universal and meaningful connectivity that the world set itself for 2030 is to be reached.

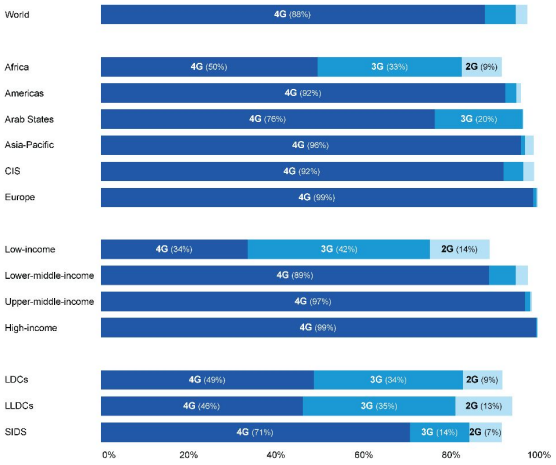
In the countries of Europe, the Commonwealth of Independent States (CIS) and the Americas, between 80 and 90 per cent of the population uses the Internet, approaching universal use (defined for practical purposes as an Internet penetration rate of at least 95 per cent). Approximately two-thirds of the population in the Arab States and Asia-Pacific countries (70 and 64 per cent respectively) use the Internet, in line with the global average, while the average for Africa is just 40 per cent of the population.

Universal connectivity also remains a distant prospect in the least developed countries (LDCs)

In many countries older-generation networks are being switched off in favour of networks that are more efficient and allow the development of a digital ecosystem compatible with 5G. This is particularly the case for 3G, which is often shut down so that the freed-up spectrum can be re-used for 5G, while keeping 2G for older legacy devices. This is the case for most European operators, who are planning to have their 3G networks switched off by December 2025, and for the Asia-Pacific region. However, in other regions of the world the path is less clear, mainly because 2G and 3G networks retain a significant presence. This is the case notably in lower-income countries, where both technologies are an important means of communication. In those countries, the main obstacles to 5G deployment include high infrastructure costs, device affordability, and regulatory and adoption barriers.

Preliminary data show that 19 per cent of the global population was covered by a 5G network in 2021. The highest roll-out was in Europe at 52 per cent, followed by the Americas (38 per cent) and the Asia-Pacific region (16 per cent).

Population coverage by type of mobile network, 2022



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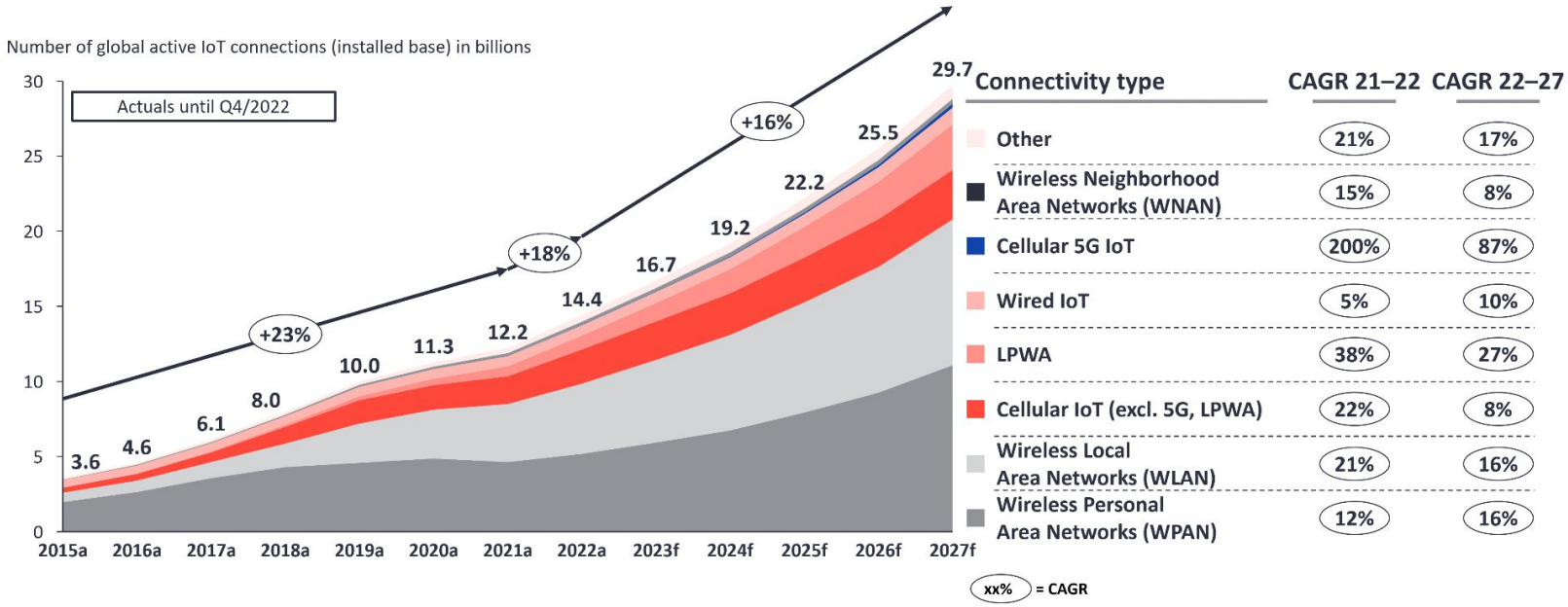
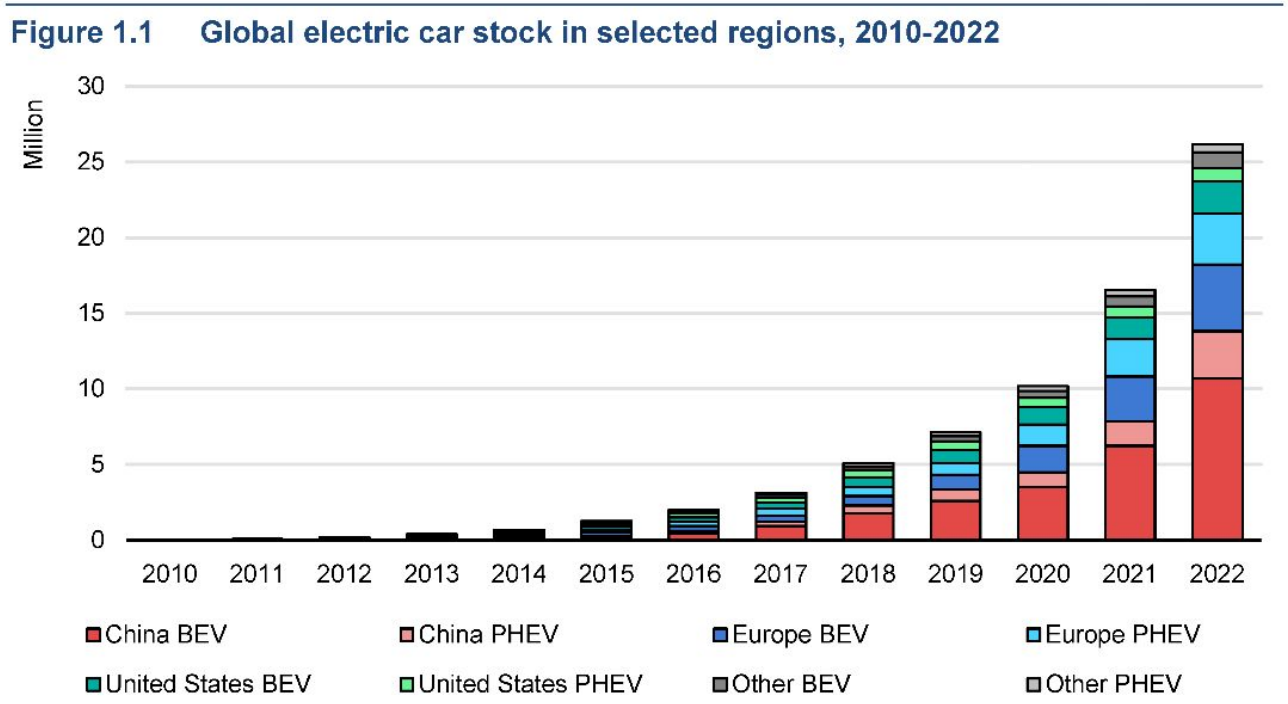
Growth of IoT (iot-analytics.com)



"According to our analysis, by 2027, there will likely be more than 29 billion IoT connections." From https://iot-analytics.com/number-connected-iot-devices/

Growth of electric cars (and self-driving cars to come) (iea.org)



"Over 26 million electric cars were on the road in 2022, up 60% relative to 2021 and more than 5 times the stock in 2018" From https://www.iea.org/reports/global-ev-outlook-2023

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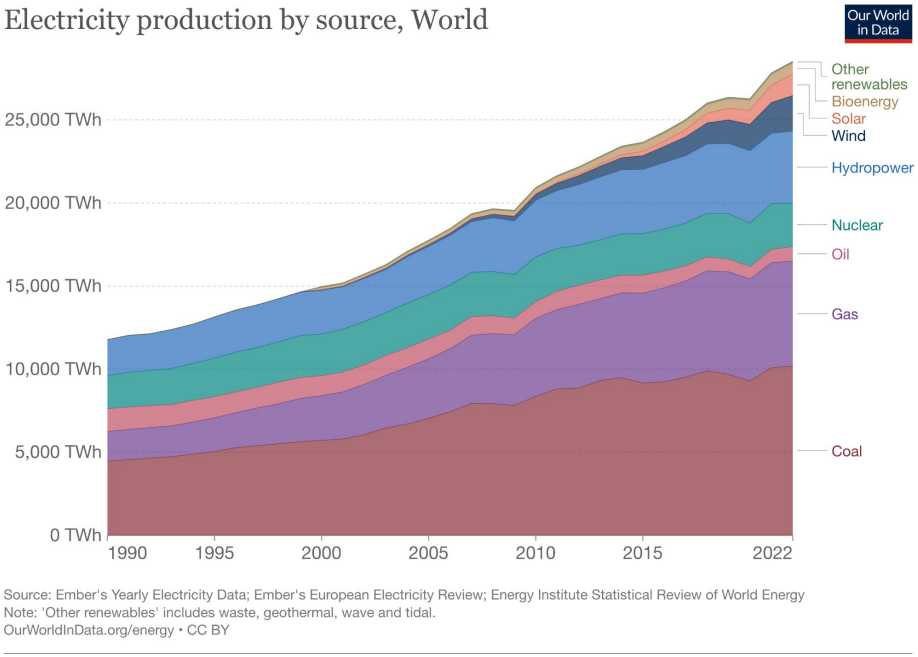
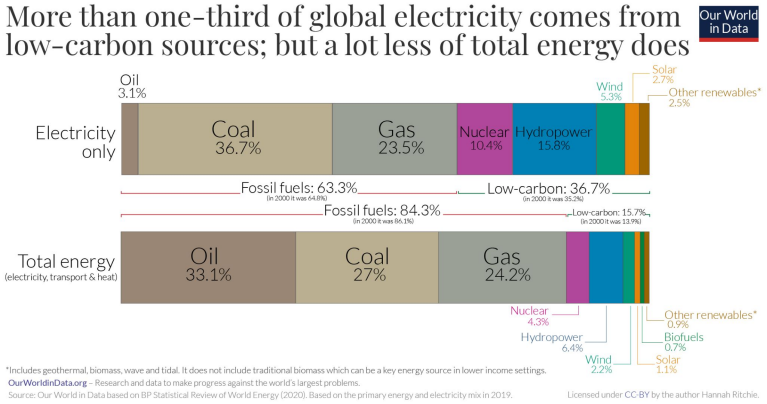
Growth of energy (ourworldindata.org)





- From https://ourworldindata.org/electricity-mix

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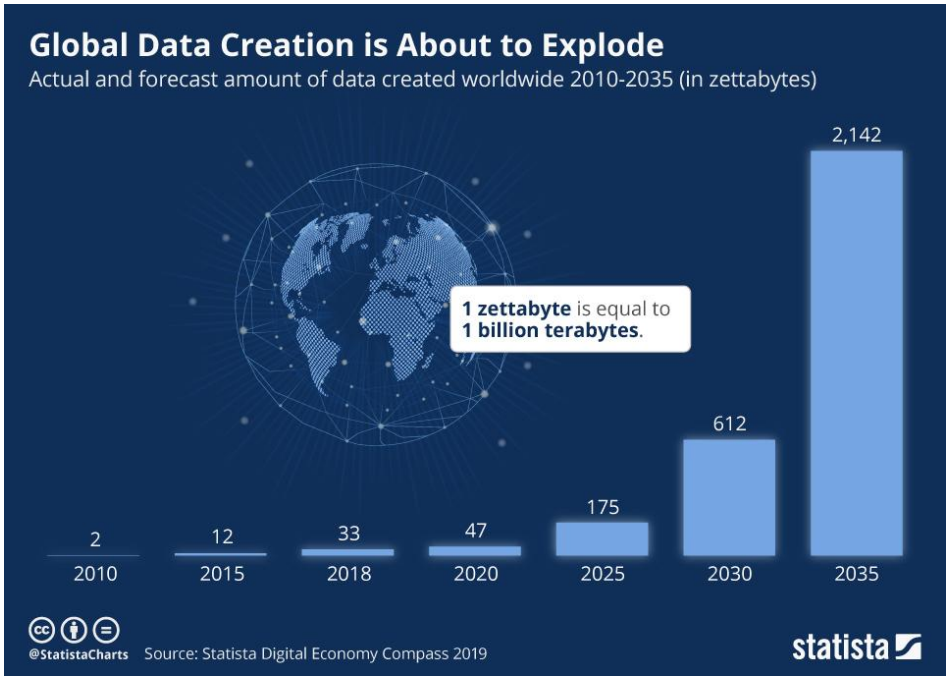
Growth of data (statista.com)
1 bit = 1 b and 1 byte = 1 B = 8 bits = 8 b



- By my calculations…
- 1 ZB = 1,000 billion (1 trillion) GB
- 50 GB = 1 Blu-Ray disc (1.2 mm thick)
- 175 ZB = 175,000 billion GB = 3,500,000,000,000 (3.5 trillion) Blu-Ray discs
- This equates to a stack of Blu-Ray discs 4.2 trillion millimetres or 4.2 million km high, which is about 11 times the distance from the earth to the moon

- From https://www.statista.com/chart/17727/global-data-creation-forecasts/