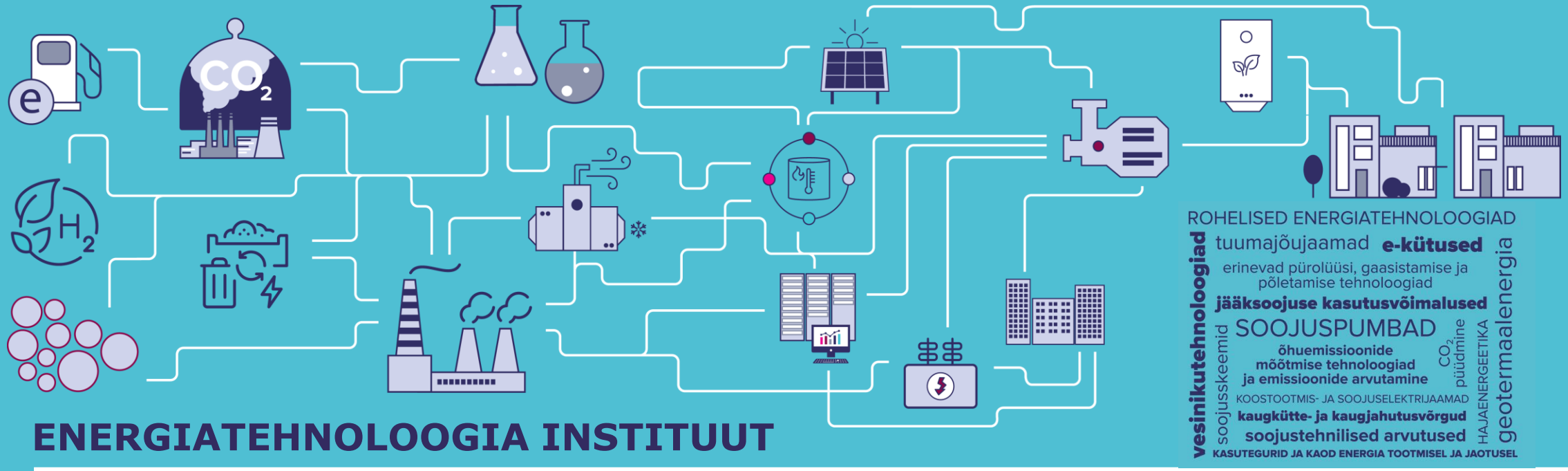


PÕLEVKIVI ENERGEETIKA TULEVIK: JÄTKUSUUTLIKKUS JA ROHEPÖÖRDE VÄLJAKUTSED

Mäekonverents 2025
„Maavarade kestlik kaevandamine ja materjalide teisene kasutamine“

Prof. Alar Konist
Energiatehnoloogia instituudi direktor

27.05.2025

TALLINNA TEHNIKAÜLIKOOL

ÜLDISED TRENDID ENERGIASEKTORIS

Tarbijate käitumisharjumused ja -loogika on pandeemiast, sõdadest ning energiahindade kõikumistest tulenevalt muutunud

Poliitiline tahe kliimamuutustega võitlemise osas on Euroopa Liidus tugevalt väljendatud. Majandus näitab jahenemise märke. Muu maailma lähenemine kliimaküsimustele on teistsugune

Riikidevahelised jõujooned energeetikas on oluliselt muutumas (Hiina ja Venemaa vs Euroopa Liit ja USA vs Aafrika ja Ladina-Ameerika vs Lähis-Ida naftariigid)

Muutused Ameerika poliitikas – 47. Ameerika president on öelnud: „Drill Baby Drill" ja lähtub MAGA liikumisest

Trump signs executive orders to boost US coal as power demand rises – Coal power 20%, versus 50% in 2000

Projektide finantseerimine on intressitõusude tõttu muutumas järjest keerulisemaks, mitmetel suurtel taastuvenergia seadmete tootjatel on finantsraskused

Energiavaesus ja sotsiaalprobleemid on järjest enam tõusmas poliitiliseks väljakutseks

Suur elektrikatkestus Hispaanias ja Portugalis 28.04.2025

TAL TECH

https://www.reuters.com/business/energy/trump-sign-executive-orders-boost-coal-industry-sources-say-2025-04-08/

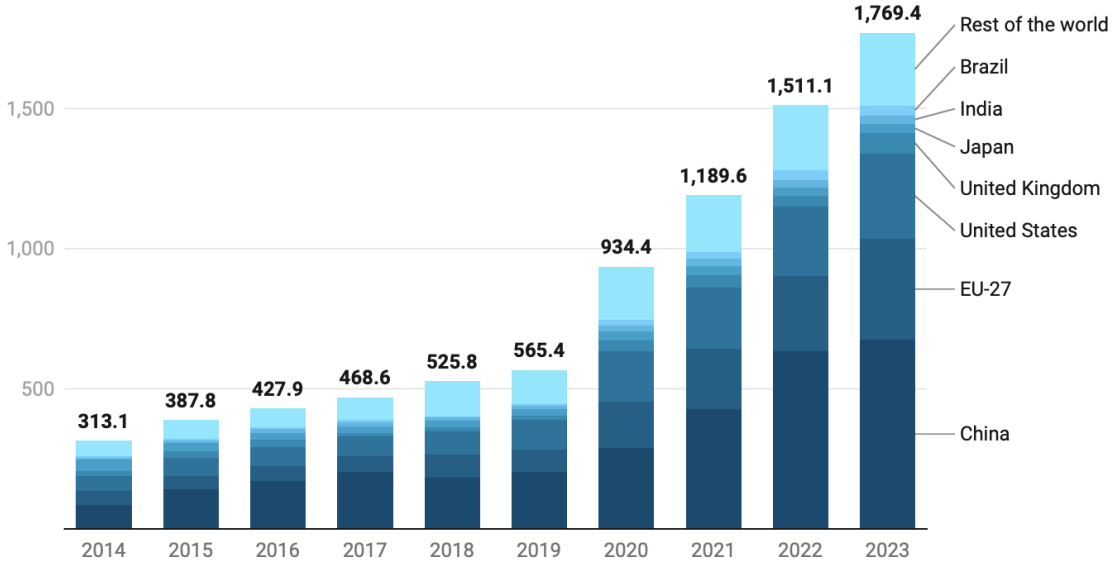
ÜLDISED TRENDID ENERGIASEKTORIS

SEARCH

Investment in the energy transition ($ billion), by region

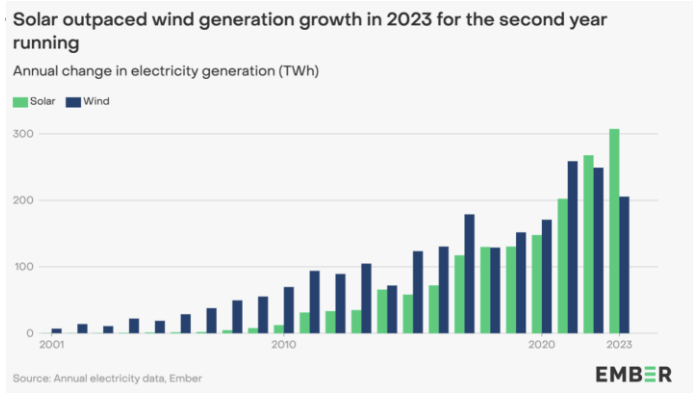
European Investment Bank

Investment in the energy transition ($ billion), by region



Note: Data collection started at different times for different sectors, but all sectors were accounted for by 2020. The steep rise in 2020 is by the decision to add power grid investments.

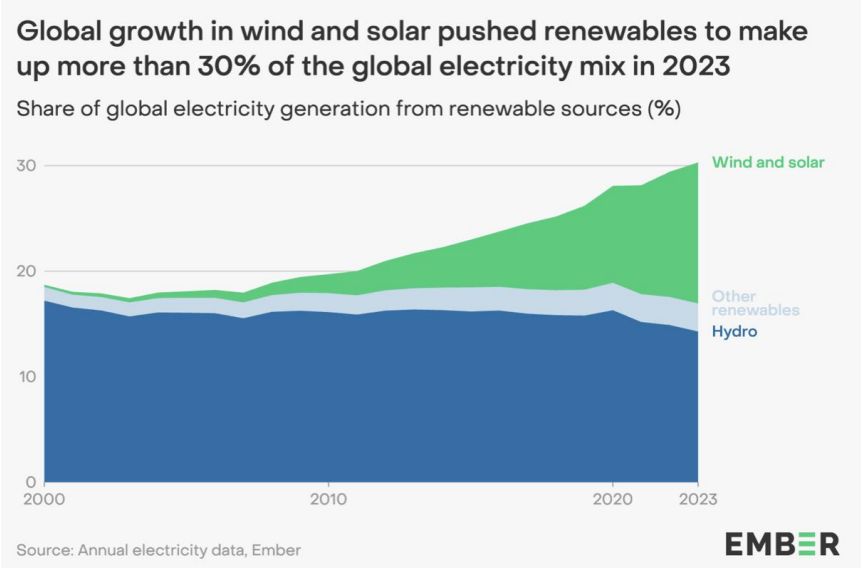
Source: BloombergNEF • Get the data

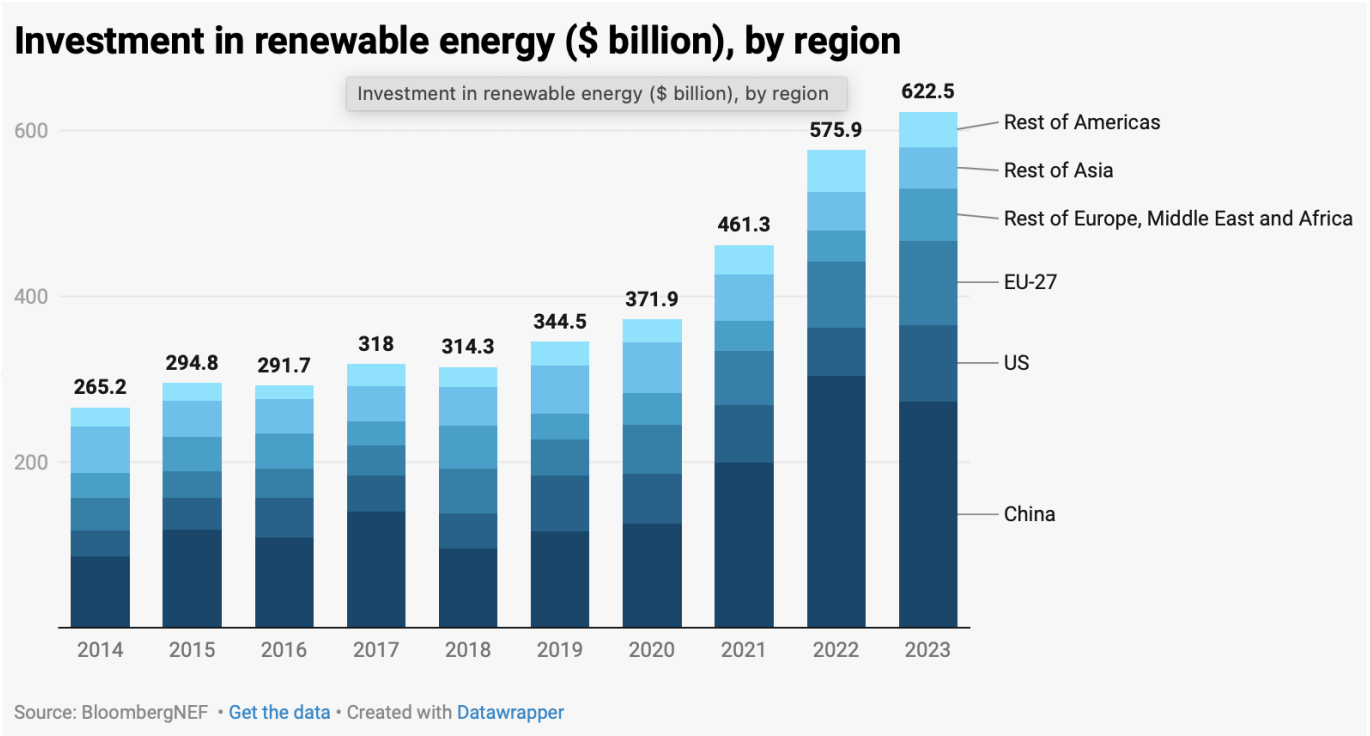


TAL TECH

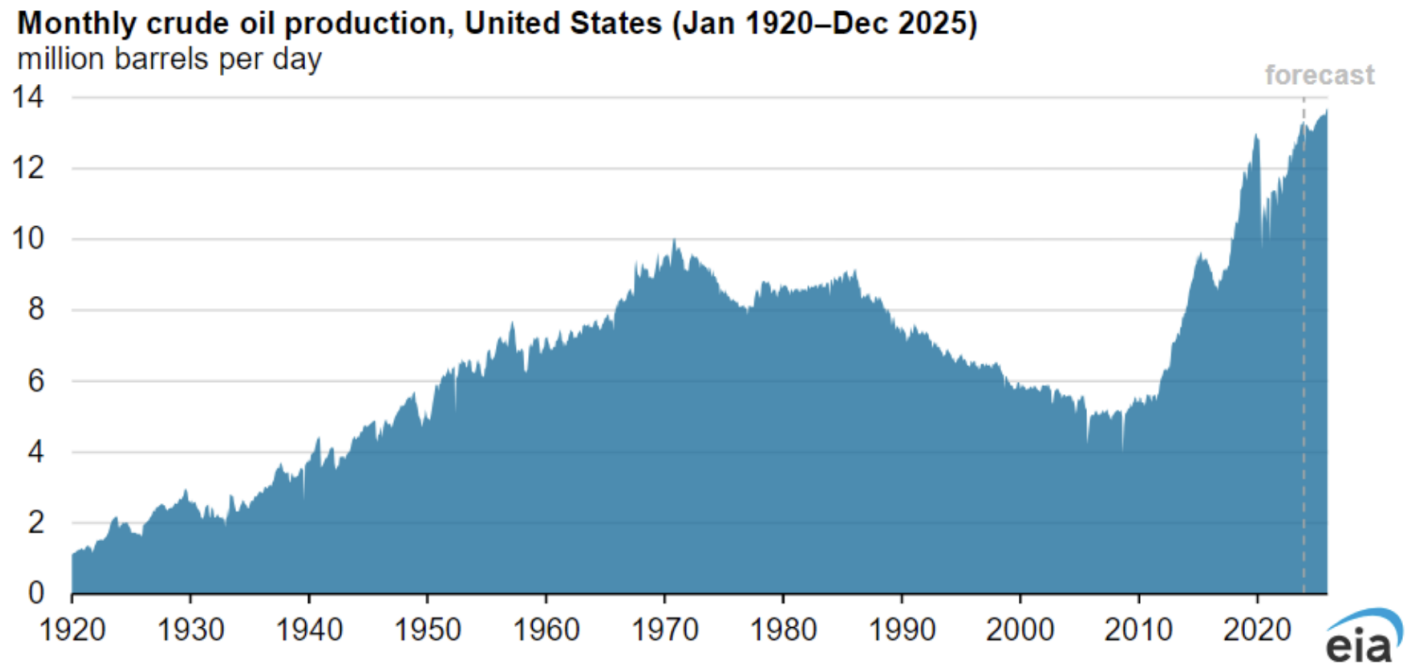
https://www.eib.org/en/essays/europe-energy-transition-renewable

https://ember-energy.org/app/uploads/2024/05/Report-Global-Electricity-Review-2024.pdf

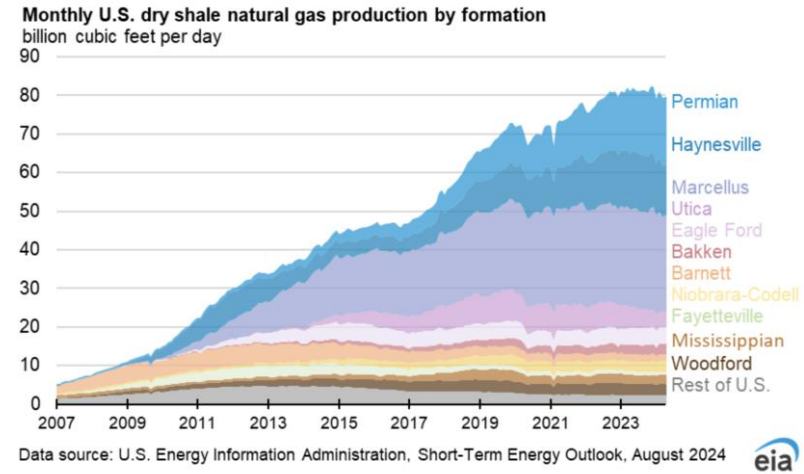


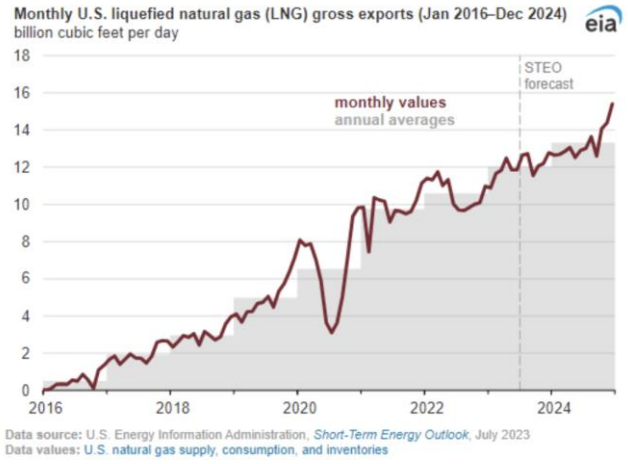


ÜLDISED TRENDID ENERGIASEKTORIS

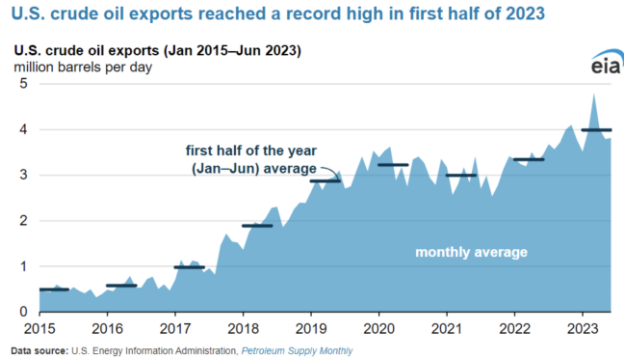


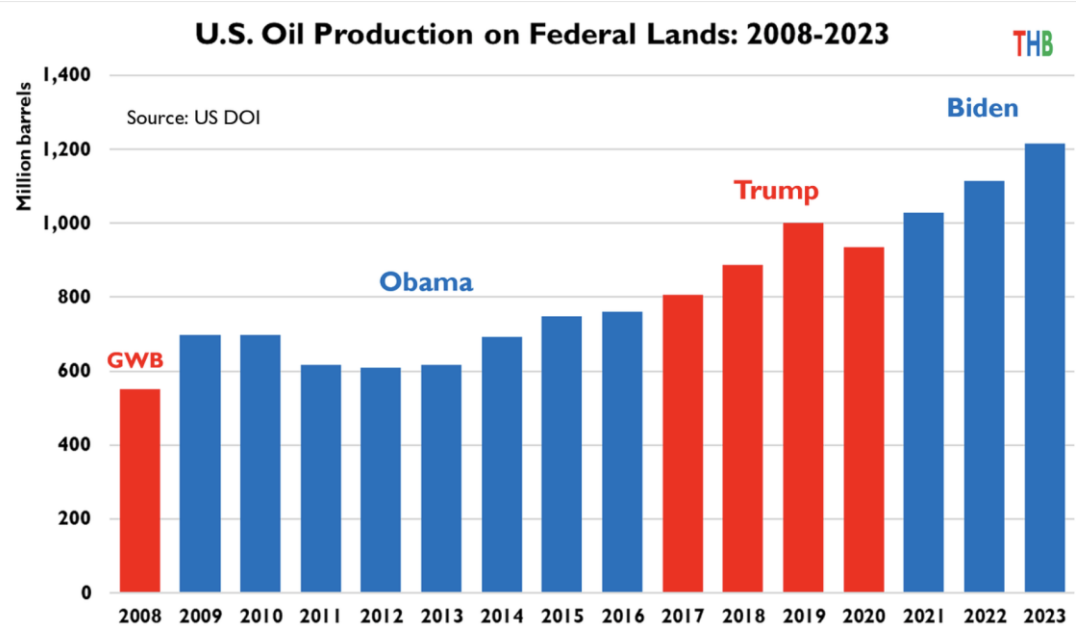
Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, February 2024

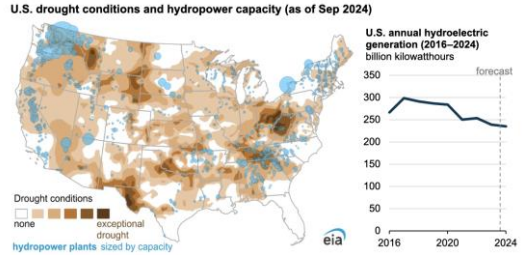




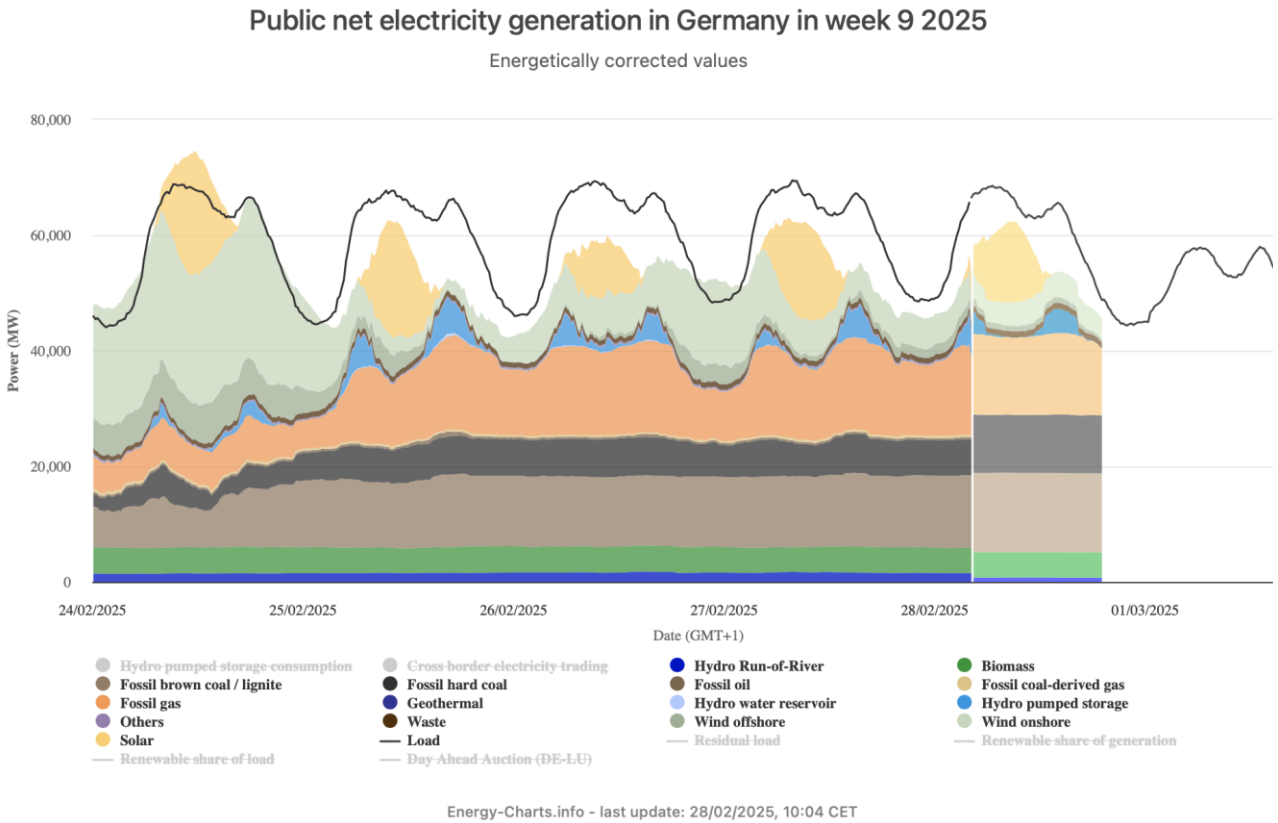
https://www.aei.org/articles/joe-biden-is-the-drill-baby-drill-president/
https://www.eia.gov

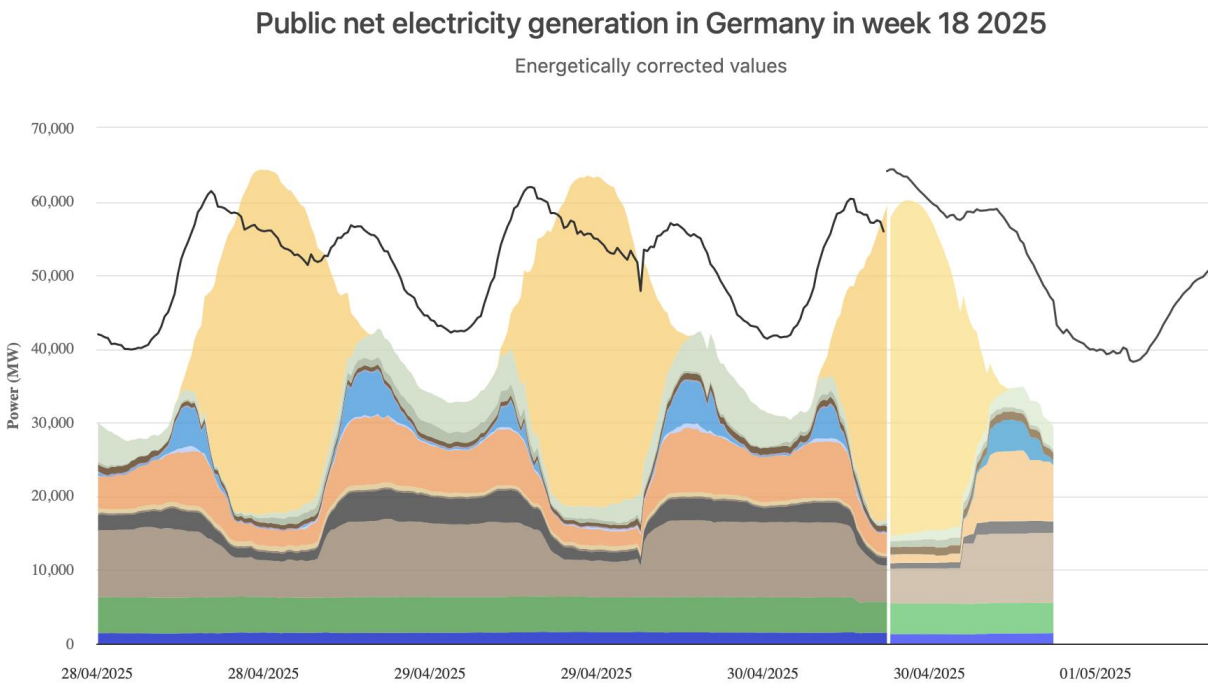


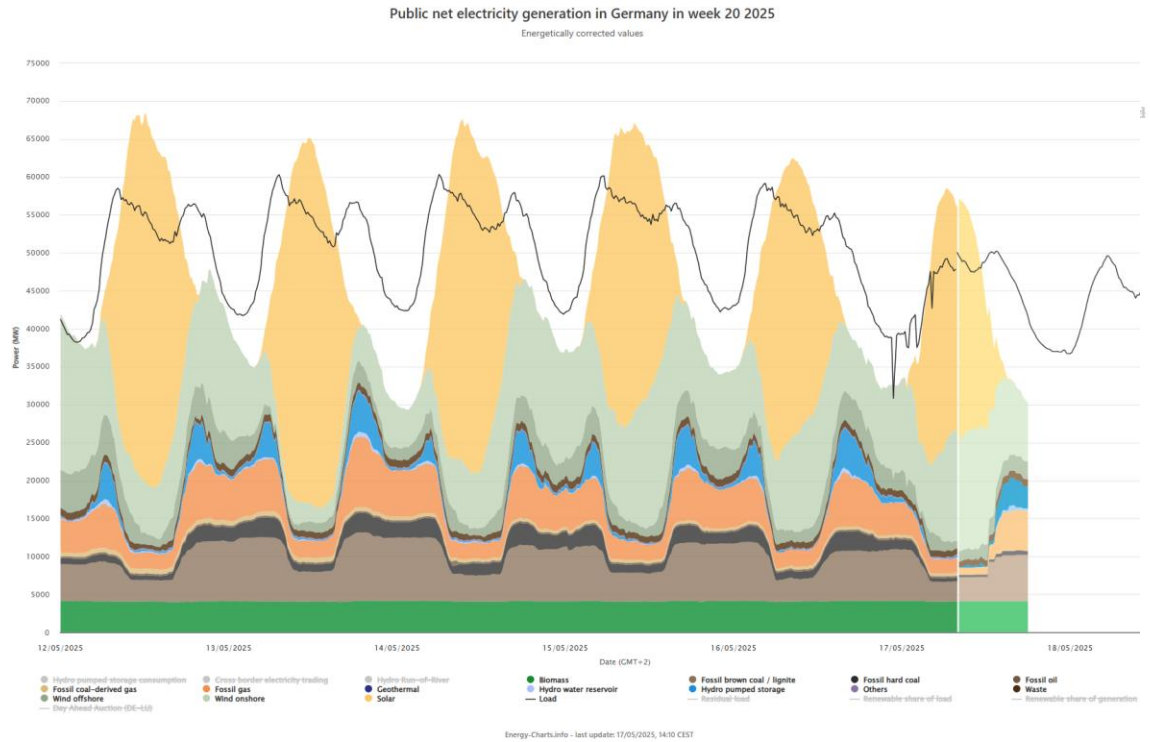




ÜLDISED TRENDID ENERGIASEKTORI







TAL TECH | TALLINNA TEHNIKAÜLIKOOL

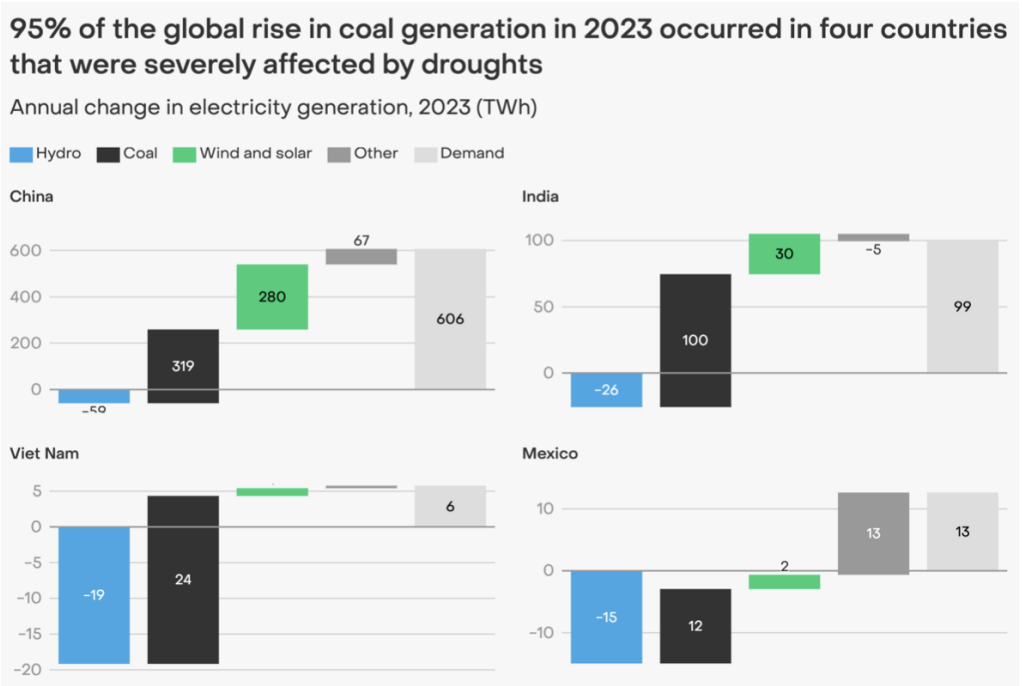
https://www.energy-charts.info/charts/power/chart.htm?c=DE

ÜLDISED TRENDID ENERGIASEKTORIS

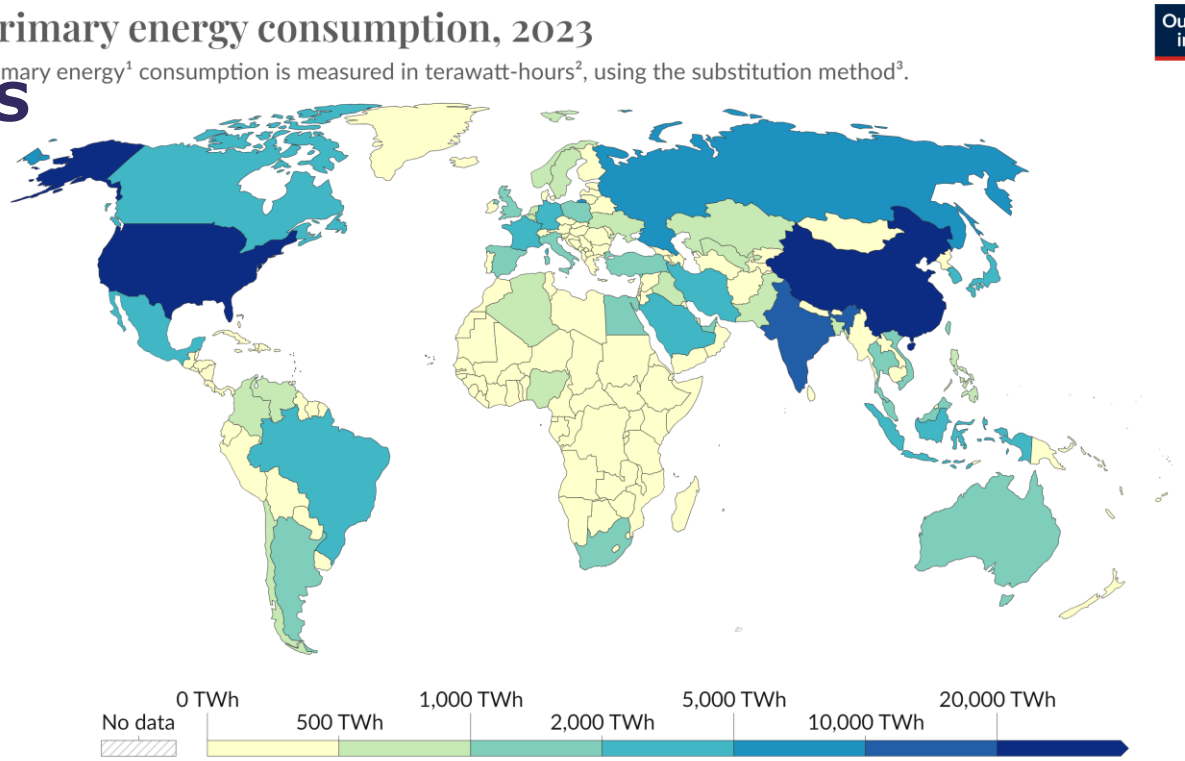
Global energy consumption growth accelerated in 2023 (+2.2%), much faster than its average 2010-2019 growth rate (+1.5%/year).

The total primary energy consumption, in 2023 across the world, is leading by China (47,428 TWh), the United States (26,189 TWh), and India (10,838 TWh).

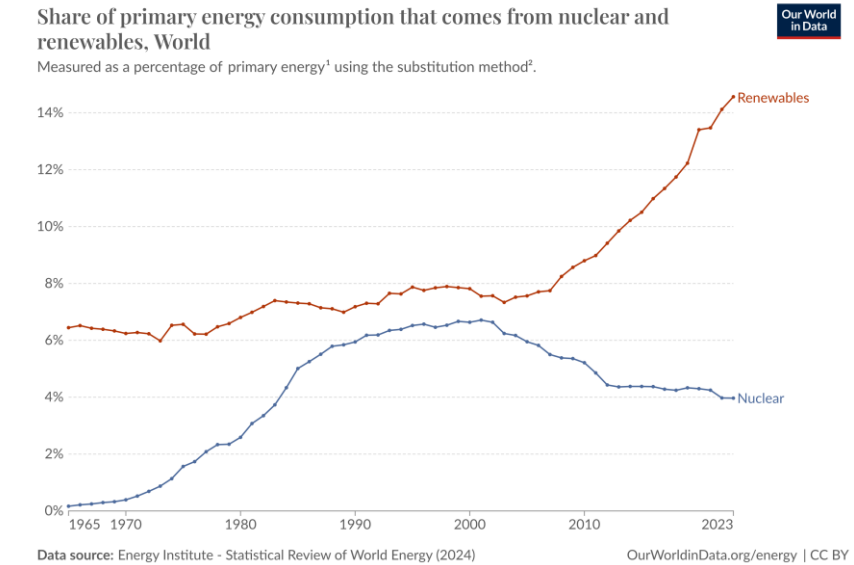
The consumption for Estonia is 56 TWh.



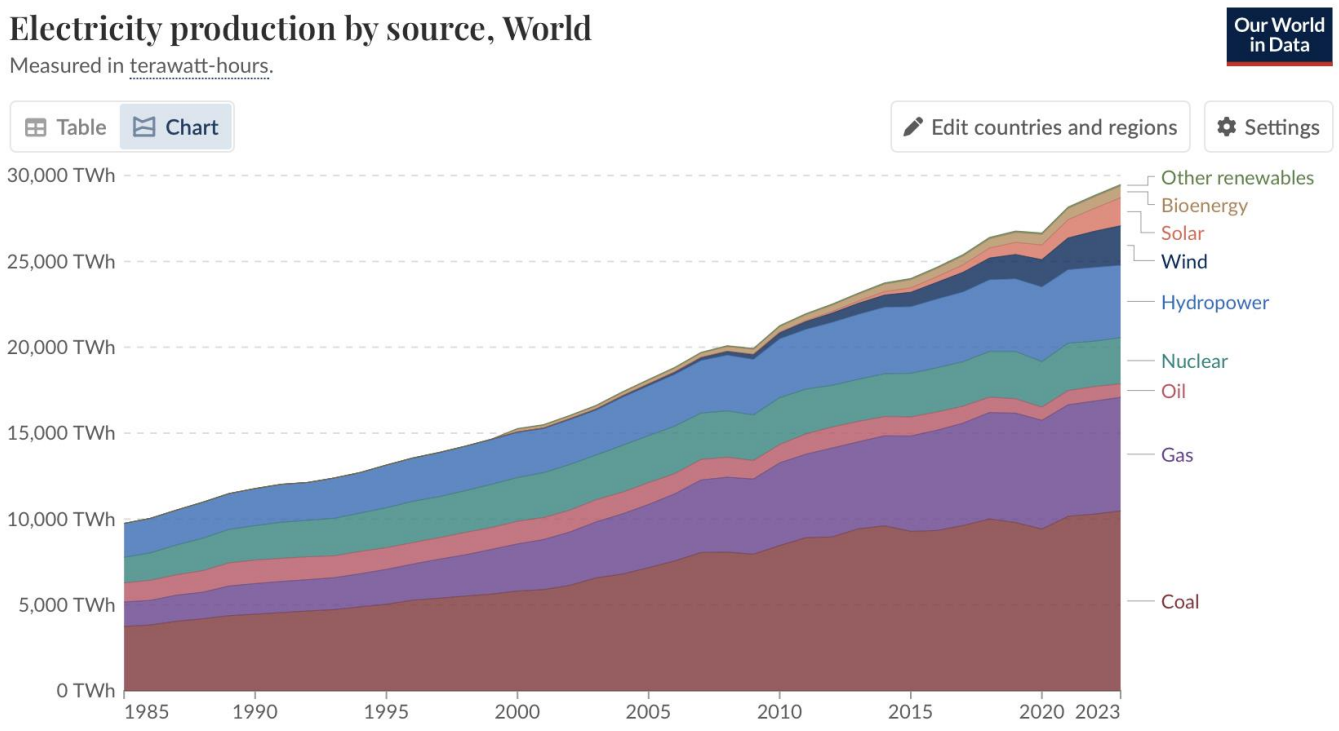
https://ember-energy.org/app/uploads/2024/05/Report-Global-Electricity-Review-2024.pdf https://ourworldindata.org

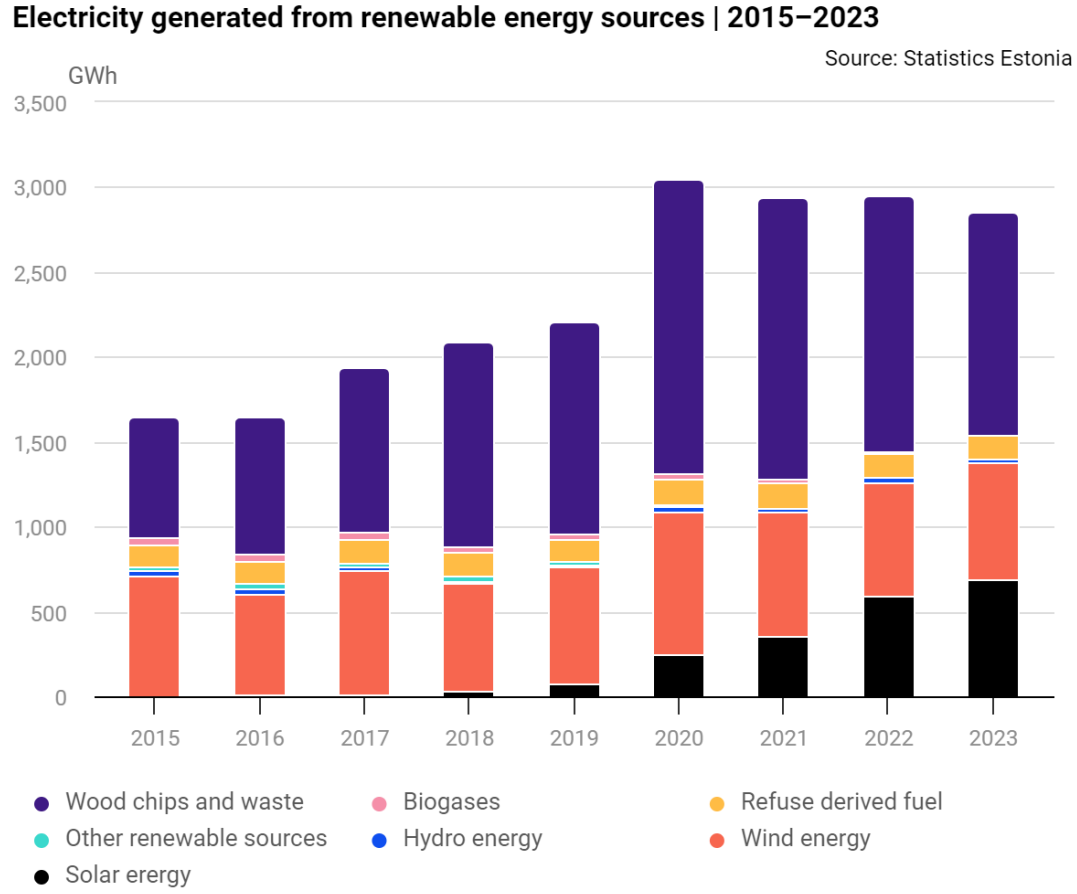


Data source: U.S. Energy Information Administration (2023); Energy Institute - Statistical Review of World Energy (2024)
Note: Data includes only commercially-traded fuels (coal, oil, gas), nuclear and modern renewables. It does not include traditional biomass.
OurWorldInData.org/energy | CC BY



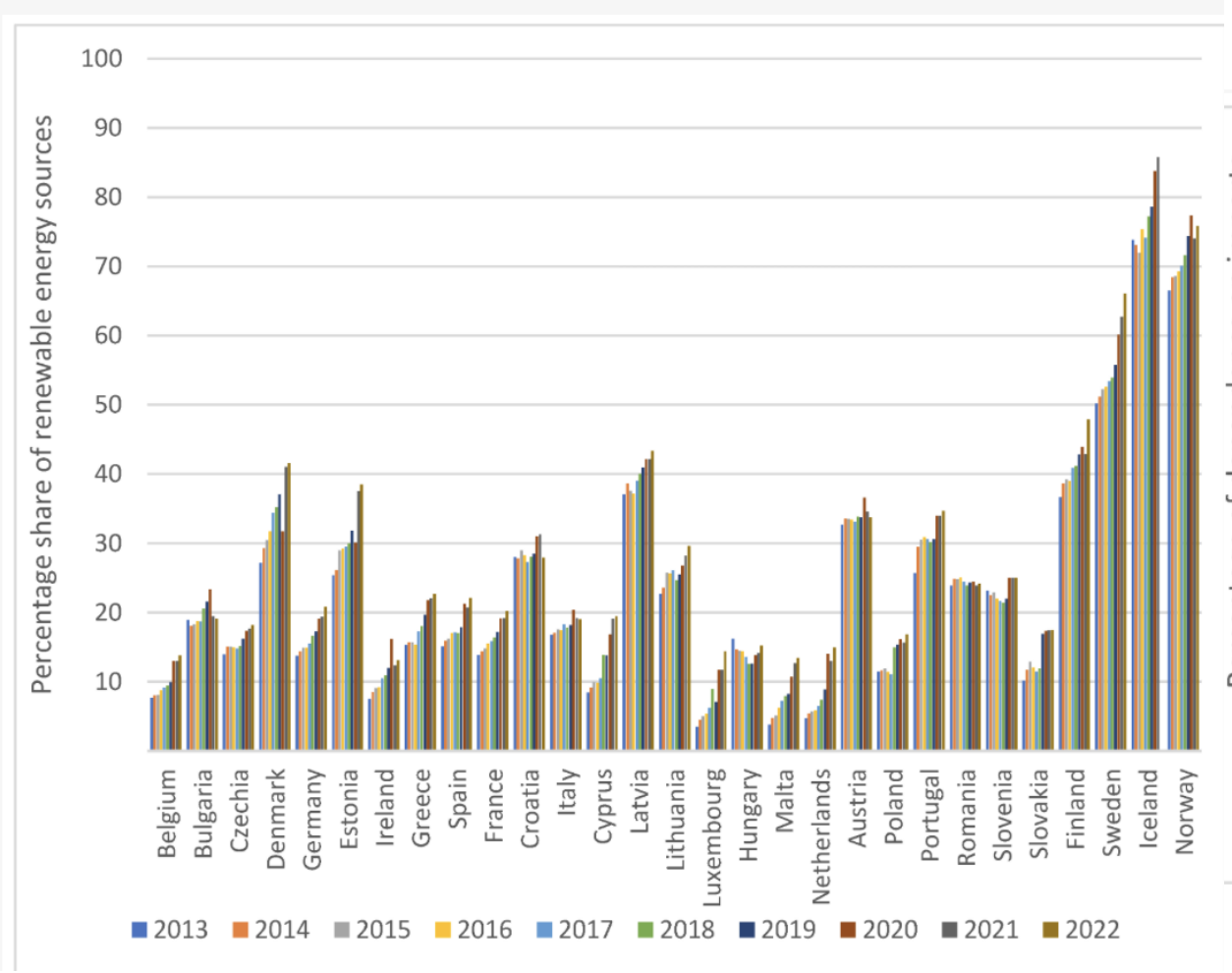
ELEKTRITOOTMINE
EESTIS



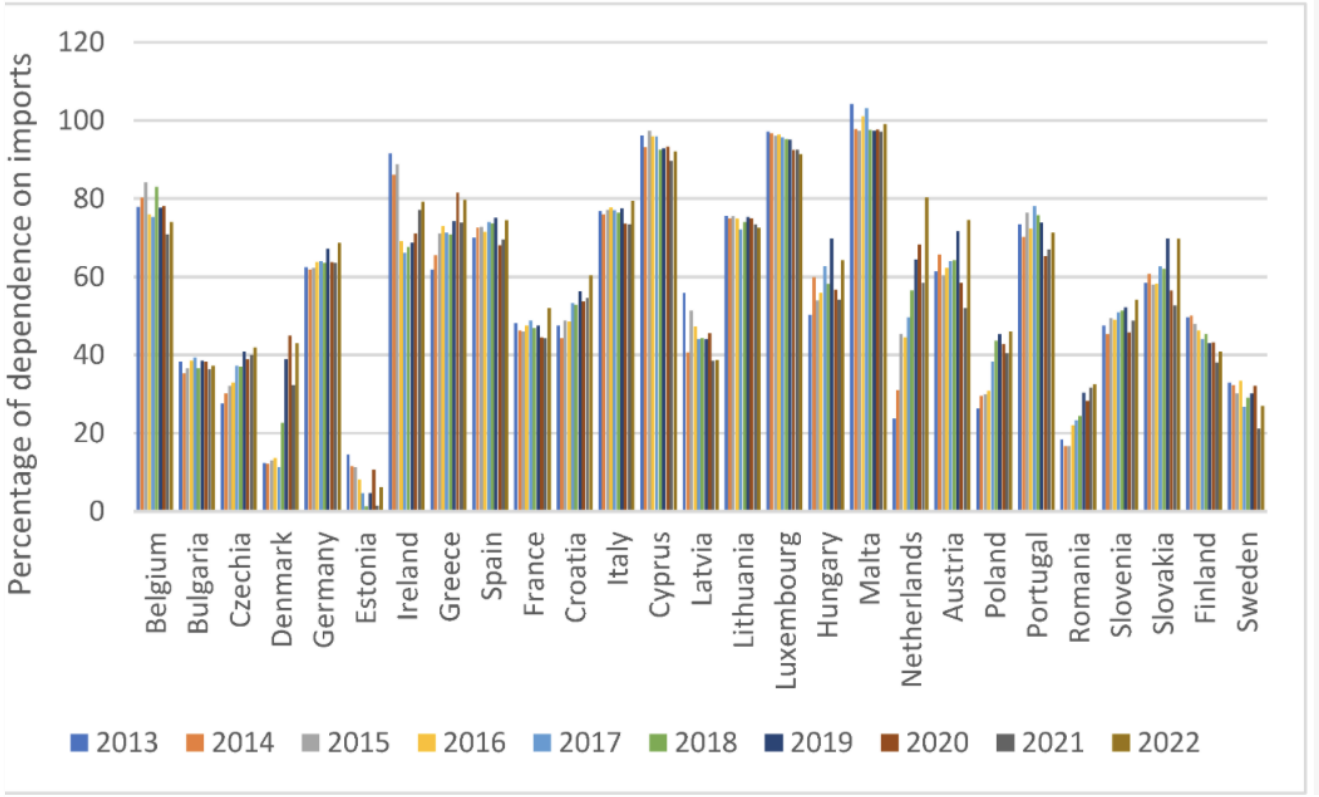


TAL TECH | TALLINNA TEHNIKAÜLIKOOL

ENERGEETIKA EESTIS JA MUJAL MAAILMAS



Taastuvenergia osakaalud riigiti

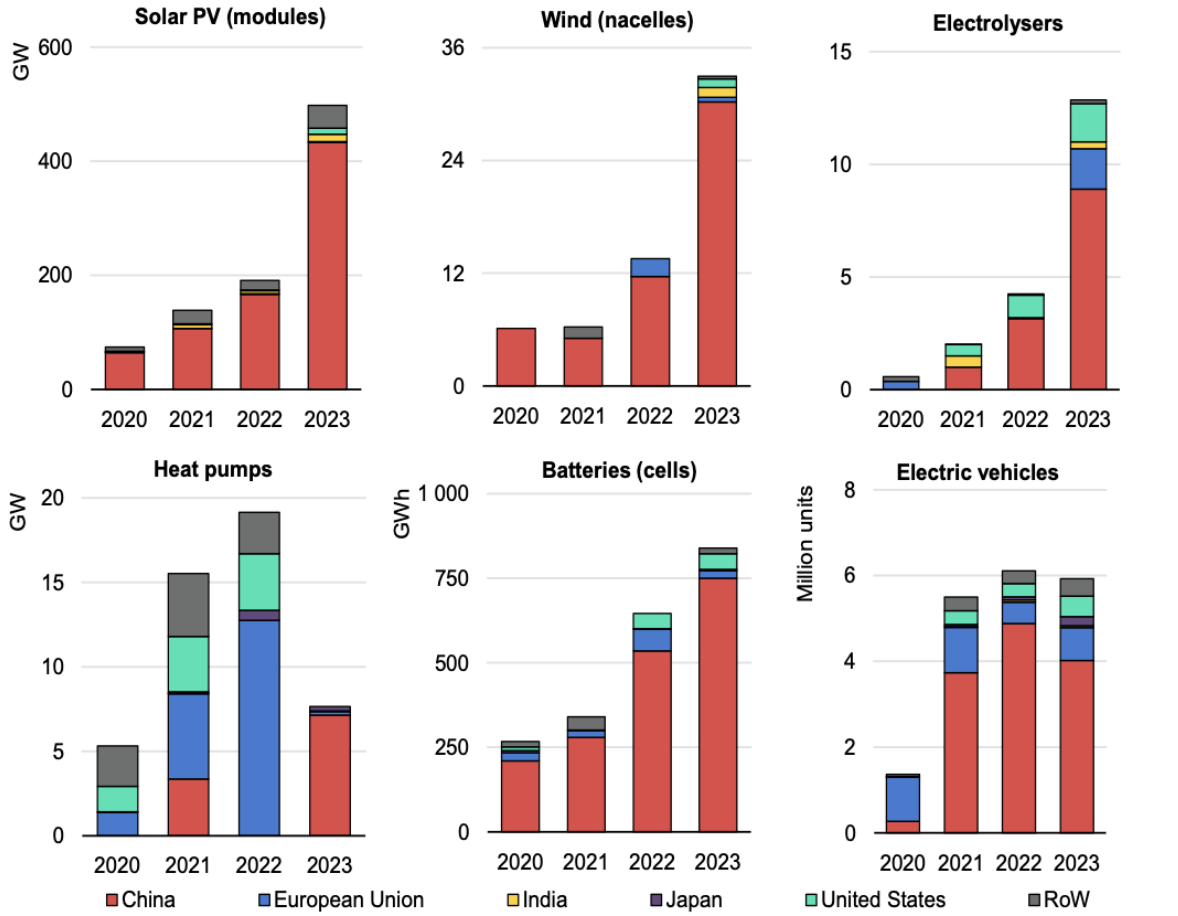


Energiaimport riikide lõikes

https://www.mdpi.com/1996-1073/17/7/1778

ENERGEETIKA EESTIS JA MUJAL MAAILMAS

Valitud puhaste energiatehnoloogiate tootmisvõimsuse netolisandused riikide/piirkondade kaupa, 2020-2023



Note: RoW = Rest of World.

Sources: IEA analysis based on S&P Global (2024); WindEurope (2023); BNEF (2024a); GWEC (2023); Wood Mackenzie (2024); InfoLink (2024); SPV Market Research (2024); BMI (2024); EV Volumes (2024), BNEF (2024b); BNEF (2024c); Oxford Economics Limited (2024b); CEPII (2024); as well as announcements by manufacturers and personal communications, gathered by the IEA.

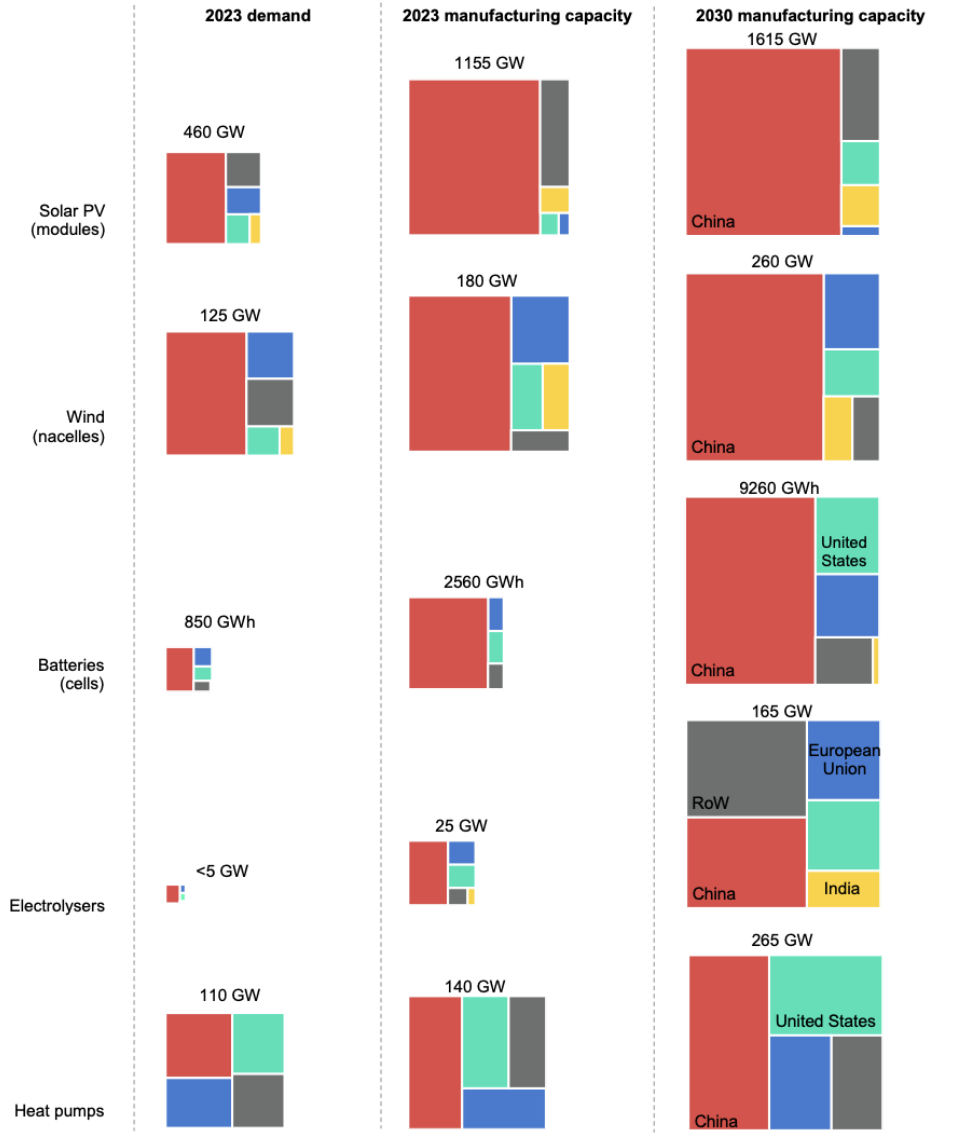
Clean technology manufacturing capacity surged in 2023, with only heat pumps and electric vehicles seeing smaller capacity additions than in 2022.

TALLINNA TEHNIKAÜLIKOOL

https://iea.blob.core.windows.net/assets/34511d5d-8dc8-42a2-8faf-b83606cffced/EnergyTechnologyPerspectives2024.pdf

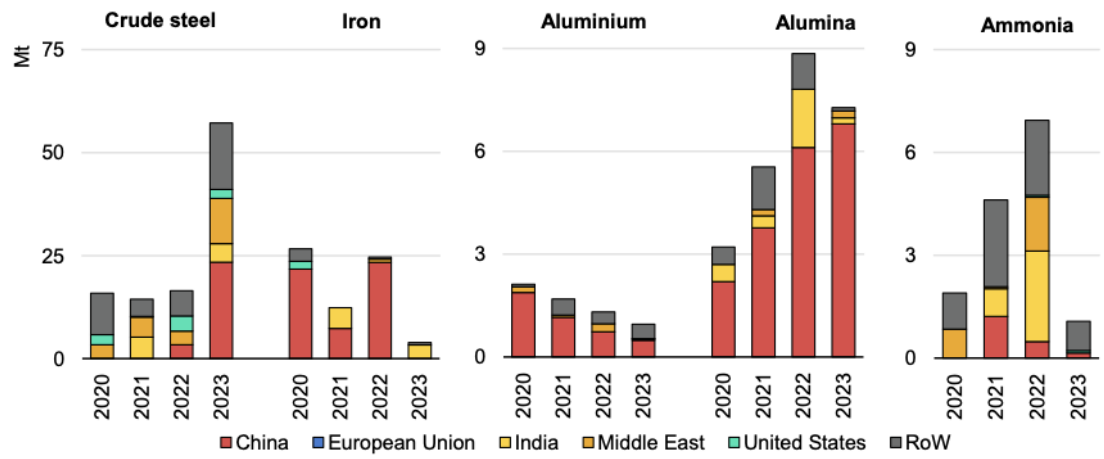
ENERGEETIKA EESTIS JA MUJAL MAAILMAS

Ülemaailmne nõudlus ja tootmisvõimsus riikide/piirkondade kaupa valitud puhaste energiatehnoloogiate järele väljakuulutatud projektide alusel, 2023-2030



IEA. CC BY 4.0.

Valitud materjalide tootmisvõimsuse ülemaailmne netolisandamine, 2020-2023



IEA. CC BY 4.0.

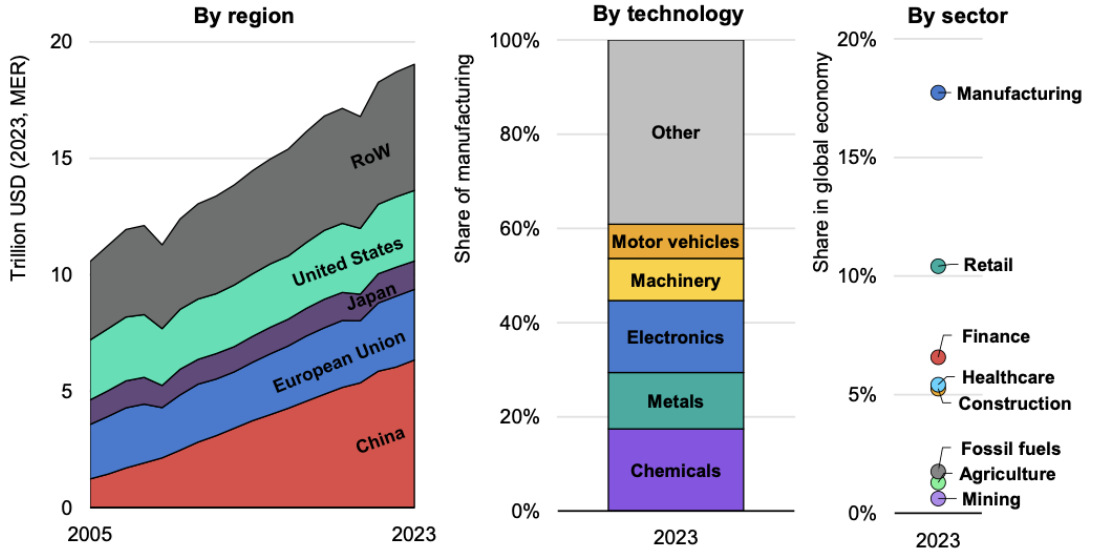
Notes: RoW = Rest of World. Capacity additions exclude regions where capacity has fallen. Aluminium refers to primary production capacity only.

Sources: IEA analysis based on IFA (2024); IEA (2024c); OECD (2024b); GEM (2024); and CRU (2024).

China, India and the Middle East have together accounted for more than half of global net capacity additions for key materials and their intermediates since 2020.

https://iea.blob.core.windows.net/assets/34511d5d-8dc8-42a2-8faf-b83606cffced/EnergyTechnologyPerspectives2024.pdf

Ülemaailmne majanduslik lisandväärtus töötlevas tööstuses



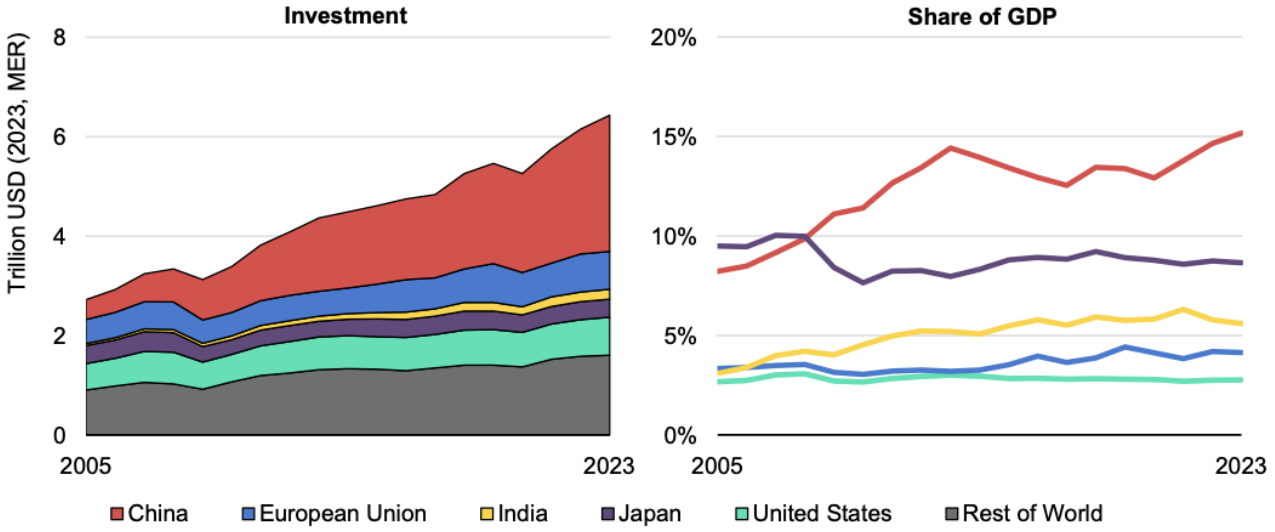
IEA. CC BY 4.0.

Notes: RoW = Rest of World. The middle chart refers to the share of each technology area within the value added of manufacturing. The right-hand side chart refers to the share of each sector's value added in the value added of the whole economy. Data for retail, finance and agriculture are the result of a weighted average over 2019-2021 in major advanced economies. Fossil fuels refer to fossil fuel extraction.

Source: IEA analysis based on IEA (2024a); OECD (2024a); and Oxford Economics Limited (2024a).

Manufacturing accounts for nearly one-fifth of global GDP, with China the leading producer, followed by the United States and the European Union.

Töötleva tööstuse investeeringud riikide/piirkondade kaupa, 2005-2023



IEA. CC BY 4.0.

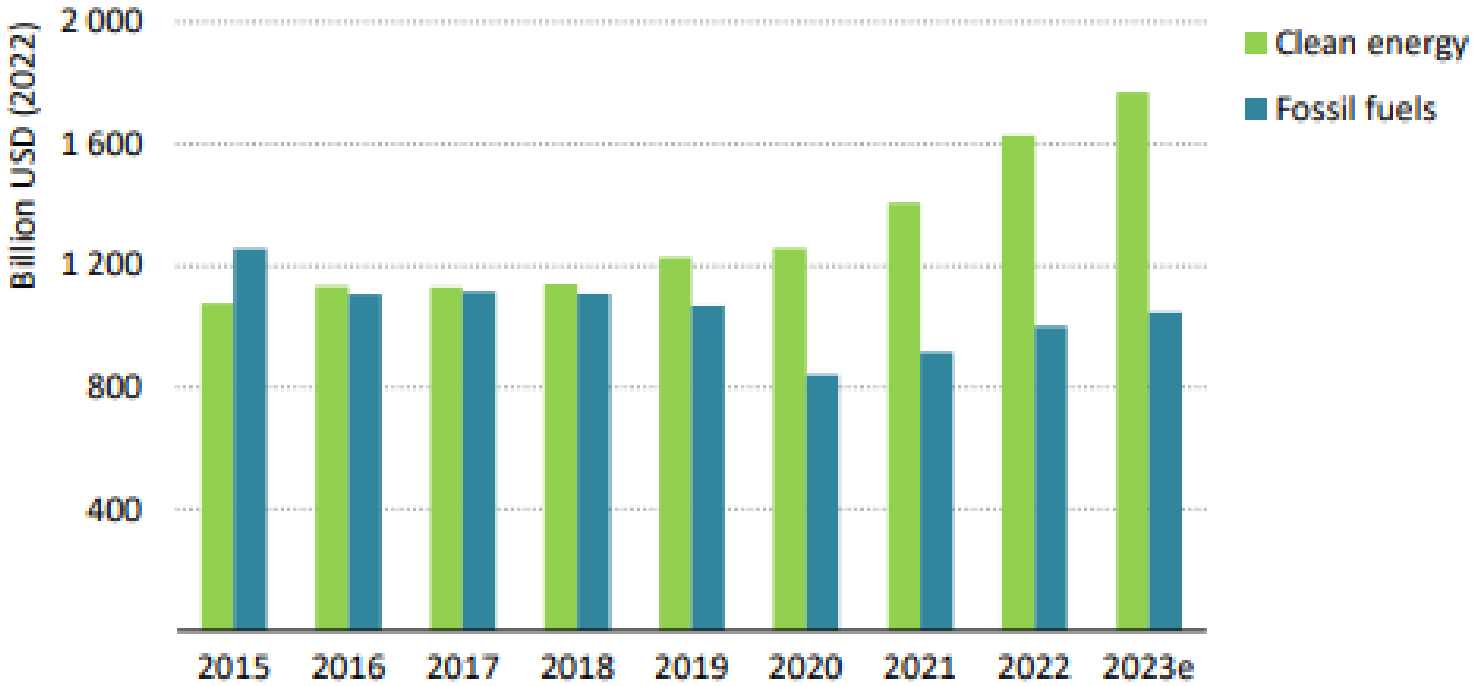
Sources: IEA analysis based on Oxford Economics Limited (2024a).

Manufacturing investment has risen most rapidly in China over the past two decades, while the share of investment in GDP has stagnated in major advanced economies.

https://iea.blob.core.windows.net/assets/34511d5d-8dc8-42a2-8faf-b83606cffced/EnergyTechnologyPerspectives2024.pdf

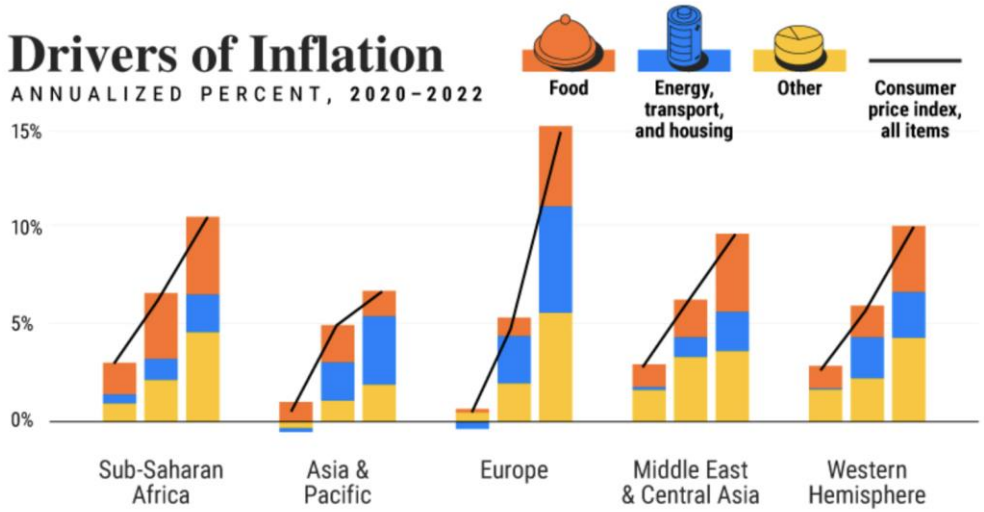
Üldised trendid energiasektoris

Figure 2.3 ▷ Global energy investment in clean energy and fossil fuels



IEA. CC BY 4.0.

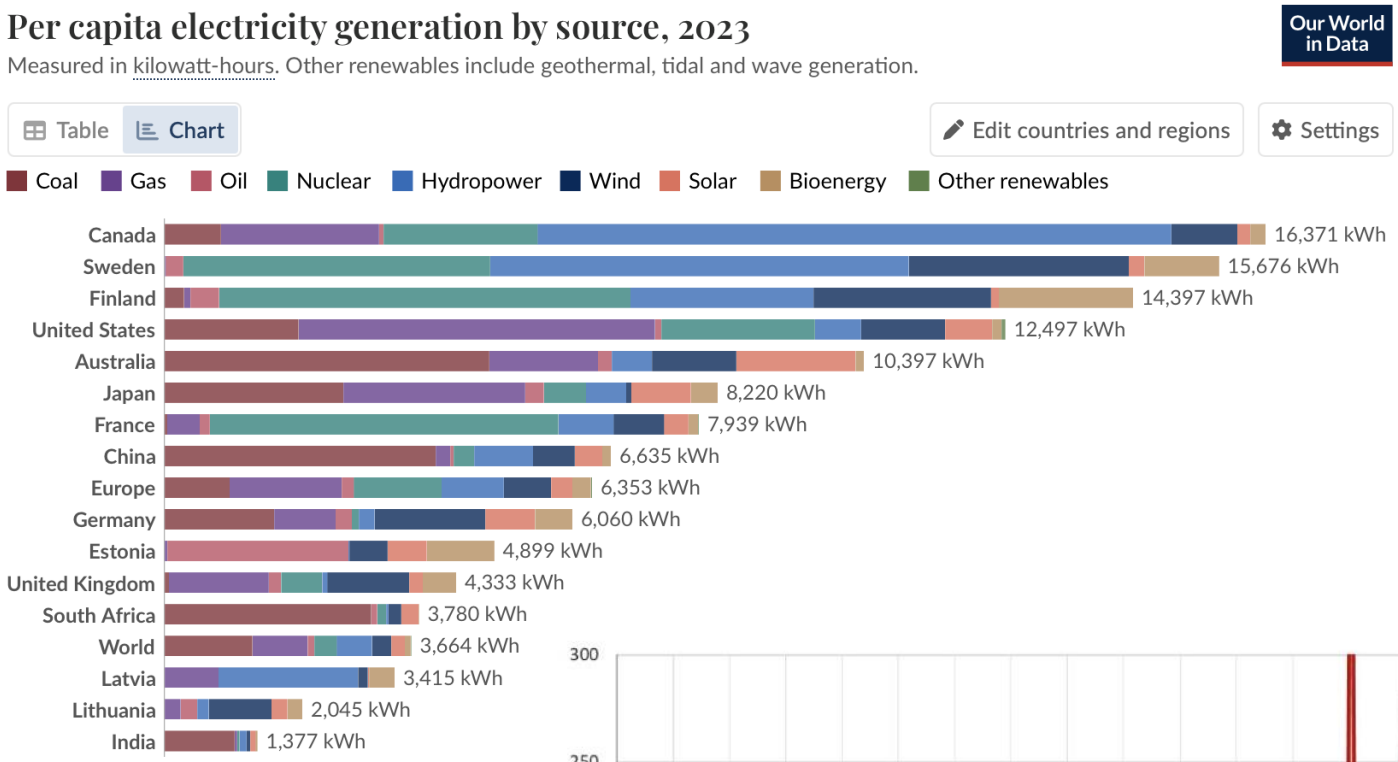
For every USD 1 spent on fossil fuels, USD 1.8 is now being spent on clean energy: five years ago this ratio was 1:1

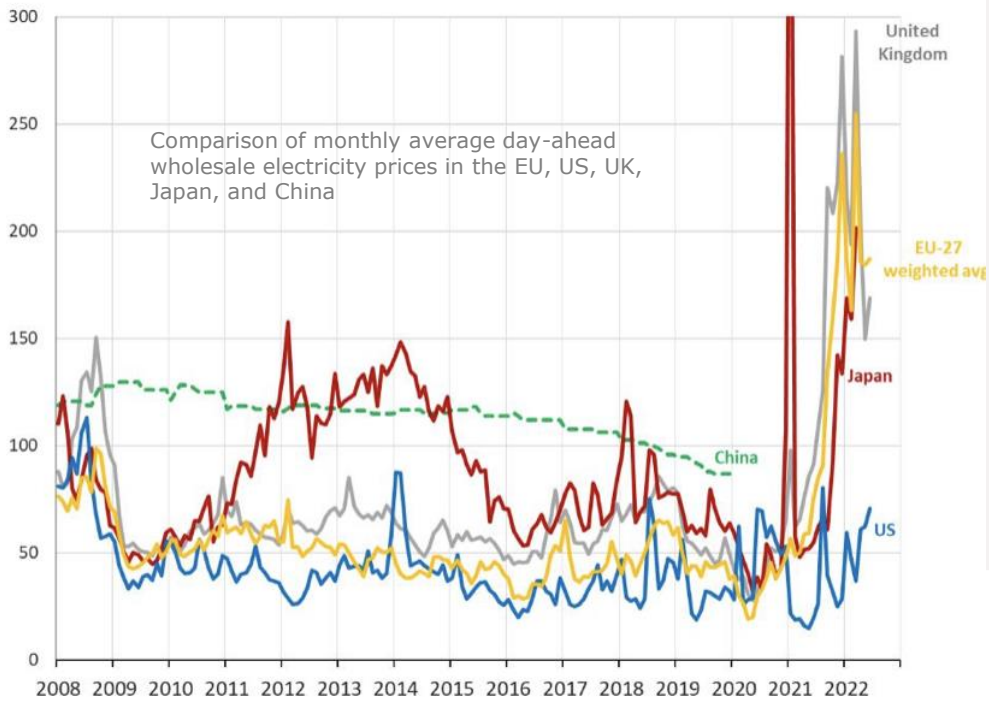


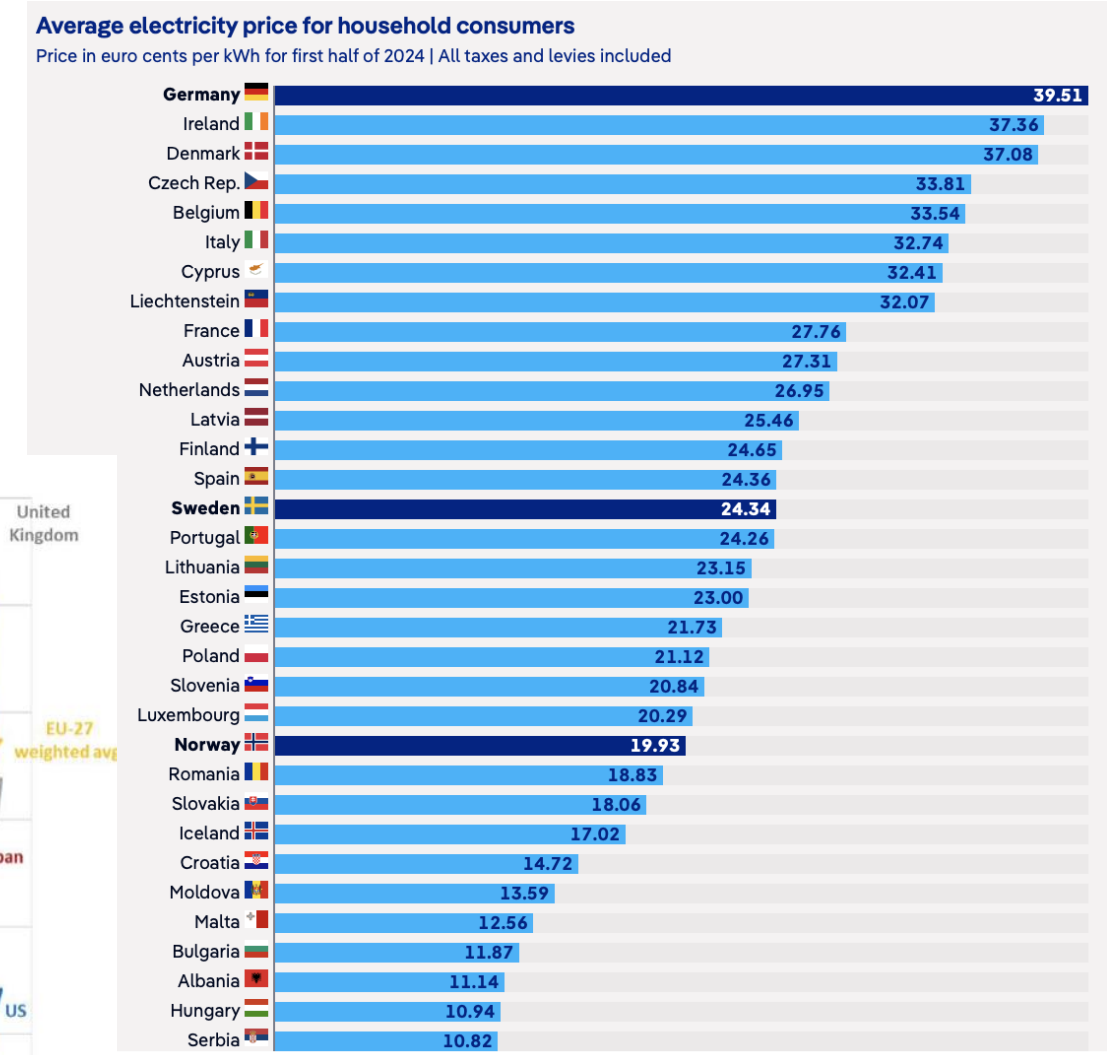
Source: International Monetary Fund World Economic Outlook, October 2022

IEA (2023), World Energy Outlook 2023, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2023, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)

ENERGEETIKA EESTIS JA MUJAL MAAILMAS



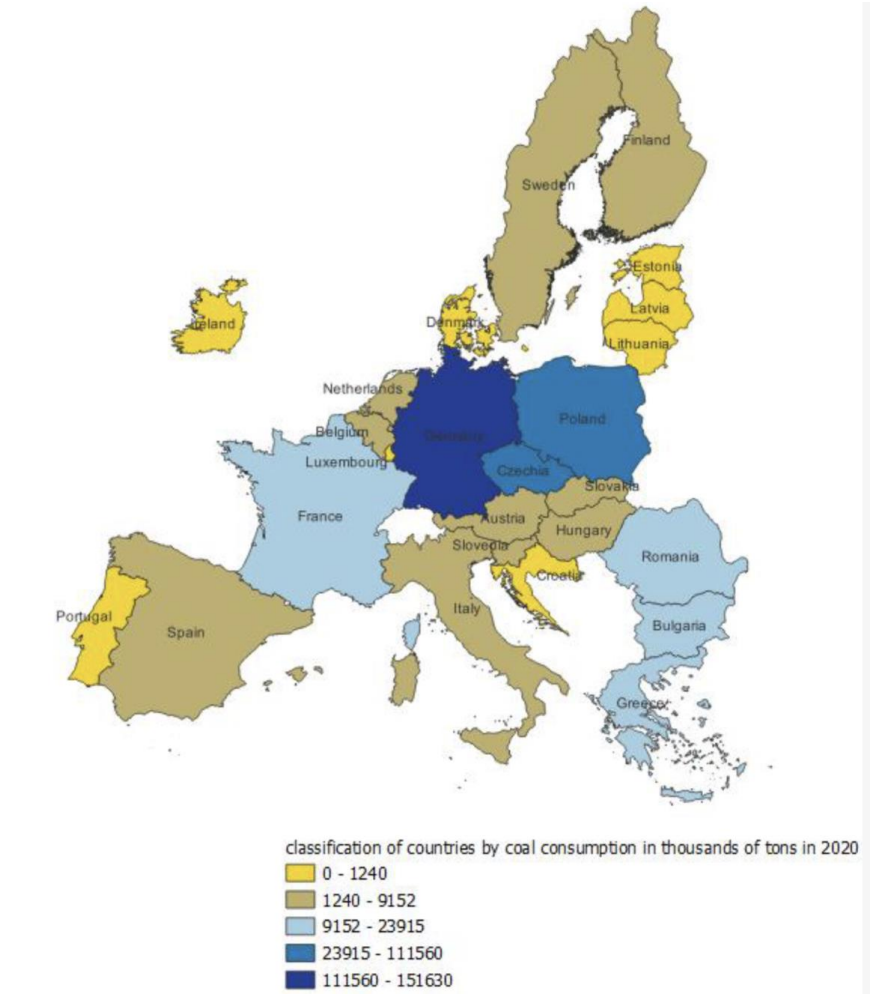




TAL TECH | TALLINNA TEHNIKAÜL

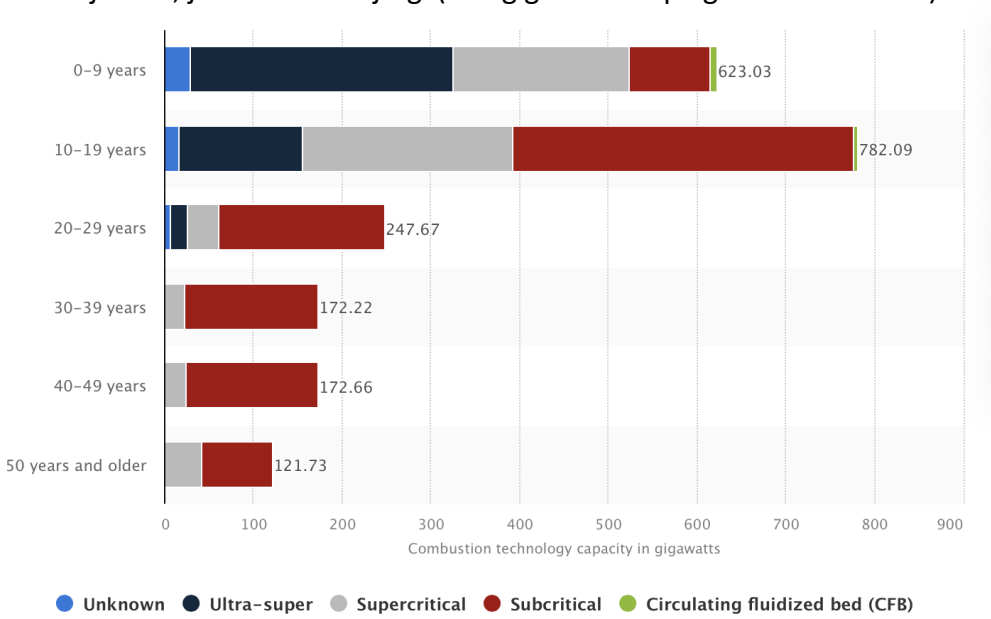
https://ourworldindata.org/electricity-mix
https://www.dw.com/en/combating-high-energy-prices-in-the-eu-though-more-coordination/a-71094111

ENERGEETIKA EESTIS JA MUJAL MAAILMAS

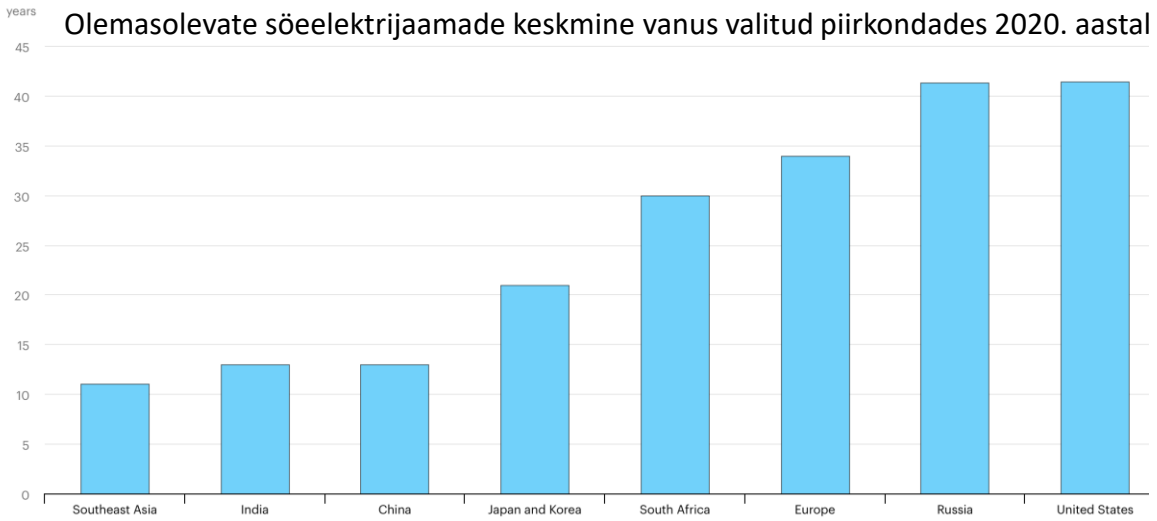


Classification of countries according to coal consumption in 2020

Enim paigaldatud põletustehnoloogiat kasutavate kivisöeelektrijaamade arv maailmas 2024. aasta juuliks, jaama vanuse järgi (GW gigavattides paigaldatud võimsus)

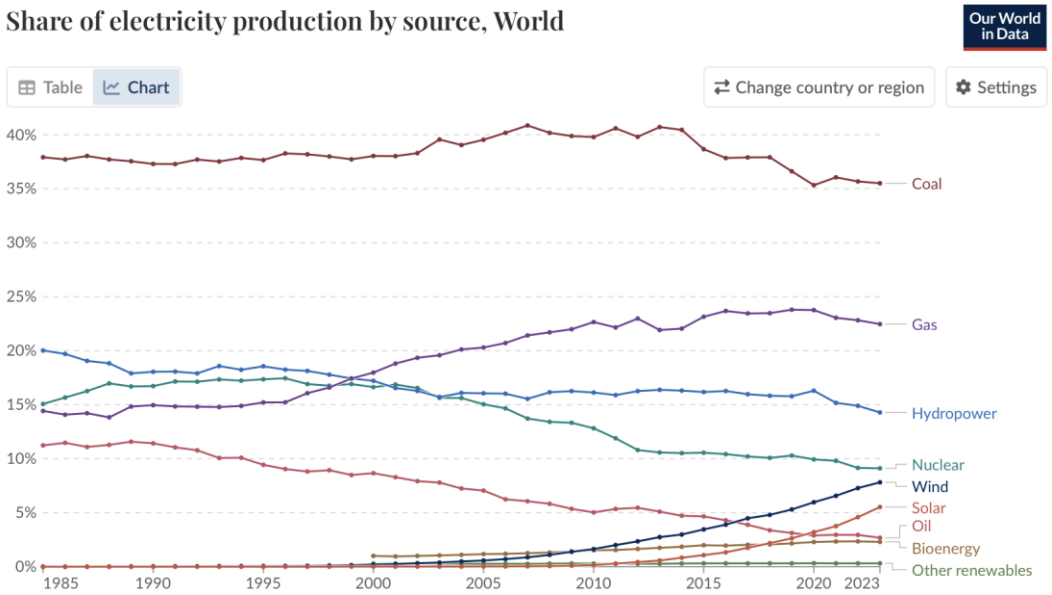


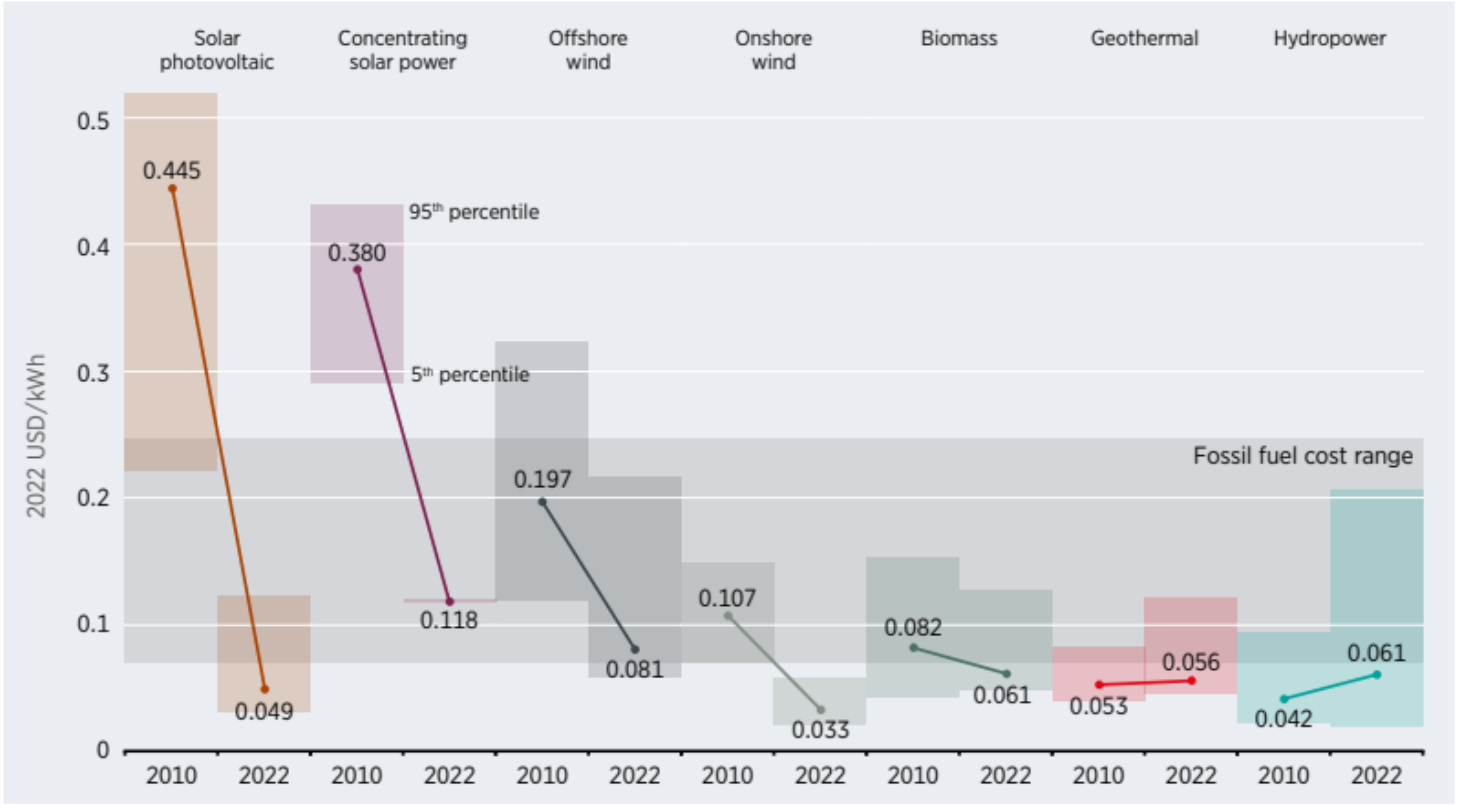
Olemasolevate söeelektrijaamade keskmine vanus valitud piirkondades 2020. aastal



https://www.mdpi.com/1996-1073/17/7/1778 - Towards Energy Transformation: A Case Study of EU Countries
https://www.statista.com/statistics/859116/global-coal-plants-combustion-types-by-age/
https://www.iea.org/data-and-statistics/charts/average-age-of-existing-coal-power-plants-in-selected-regions-in-2020

ELEKTRITOOTMINE JA HINNAD



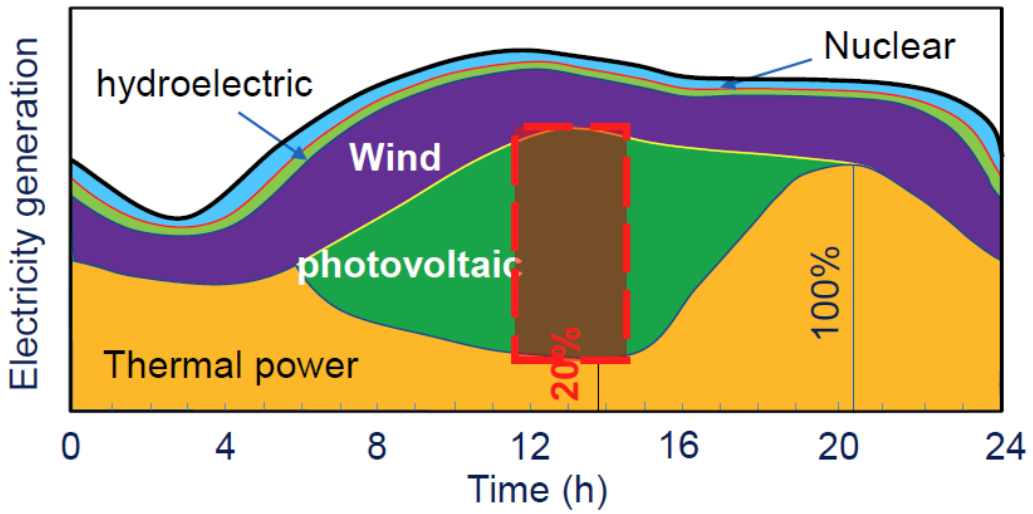


Note: These data are for the year of commissioning. The thick lines are the global weighted average LCOE value derived from the individual plants commissioned in each year. The LCOE is calculated with project-specific installed costs and capacity factors, while the other assumptions, including weighted average cost of capital (WACC), are detailed in Annex I. The grey band represents the fossil fuel-fired power generation cost in 2022, assuming that 2021 fossil gas prices were the correct lifetime benchmark rather than the crisis prices of 2022. While the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

IRENA (2023), Renewable power generation costs in 2022, International Renewable Energy Agency, Abu Dhabi.

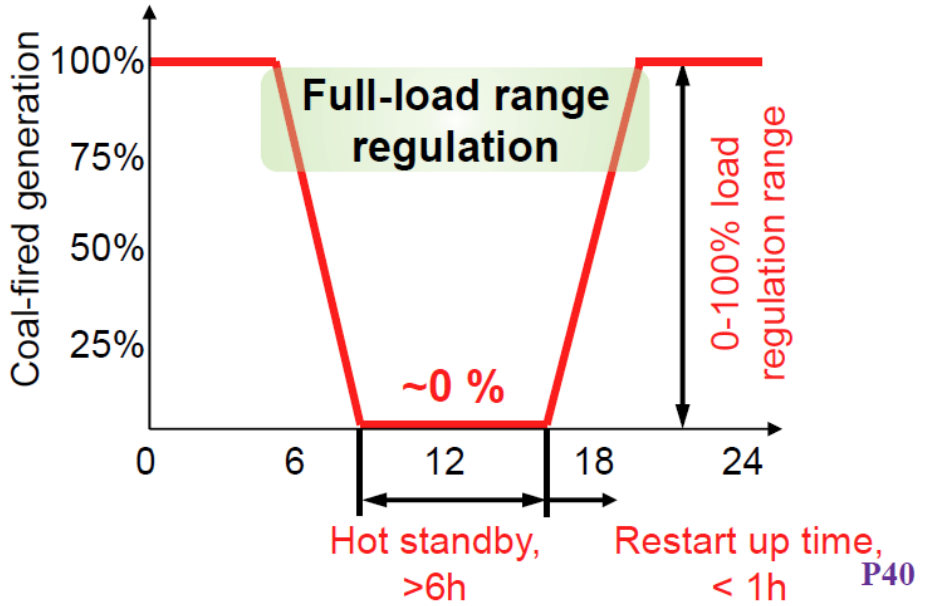
3.1 Background: Flexible coal-fired power unit

- Carbon neutrality requires to establish a new power system dominated by renewable energy, this means the capacity of wind & photovoltaic power will further increase. However, the renewable power needs flexible power to balance its inherent shortcoming of intermittency, instability, and randomness.
- For example, one of a province power grid, the renewable power capacity shares about half of the total. During noon, since the photovoltaic power output peaks, the thermal power output has to decrease below 20% of the rated one. This is the minimum output of coal fired power plant by stable combustion limit.
- In China, coal-fired power is the only choice. Obviously, with the increasing of the renewable energy capacity, the coal fired power must be flexible with long-term hot standby and fast load ramp rate abilities.



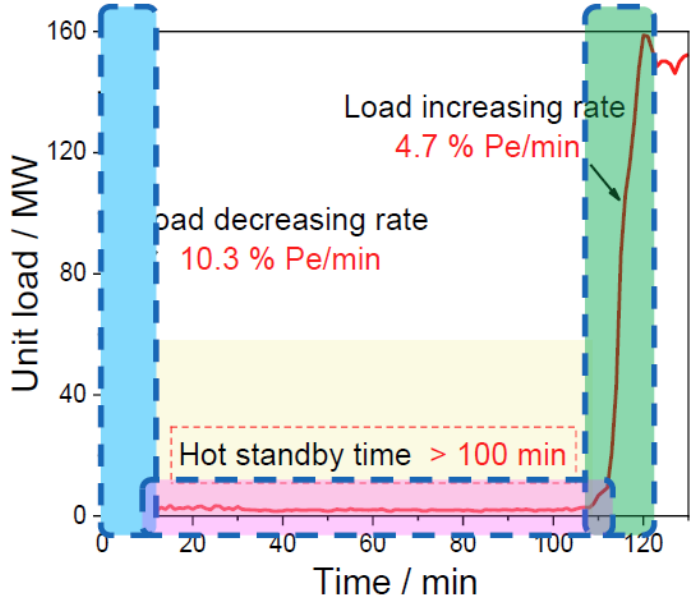
Typical curves for a grid with high proportion of renewable energy

Future



3.6 Practical verification

- After stopping coal and air supply, the unit load quickly dropped with load decreasing rate of 10.4% Pe/min).
- The heat stored in the bed material releases to generate extremely low steam flow rate to drive the steam turbine → maintained long-term near-zero load operation with stable performance of whole systems (~2 h)。
- Without oil assisting combustion, the rapid restart-up was successfully realized. and the rapid loading change rate was also achieved with ramp rate of 4.7% Pe/min. It spends only 15 minutes from the hot standby to 55% load.
- CFB coal-fired power units will play an important role in the new power system with a huge installed capacity of renewable energy sources.

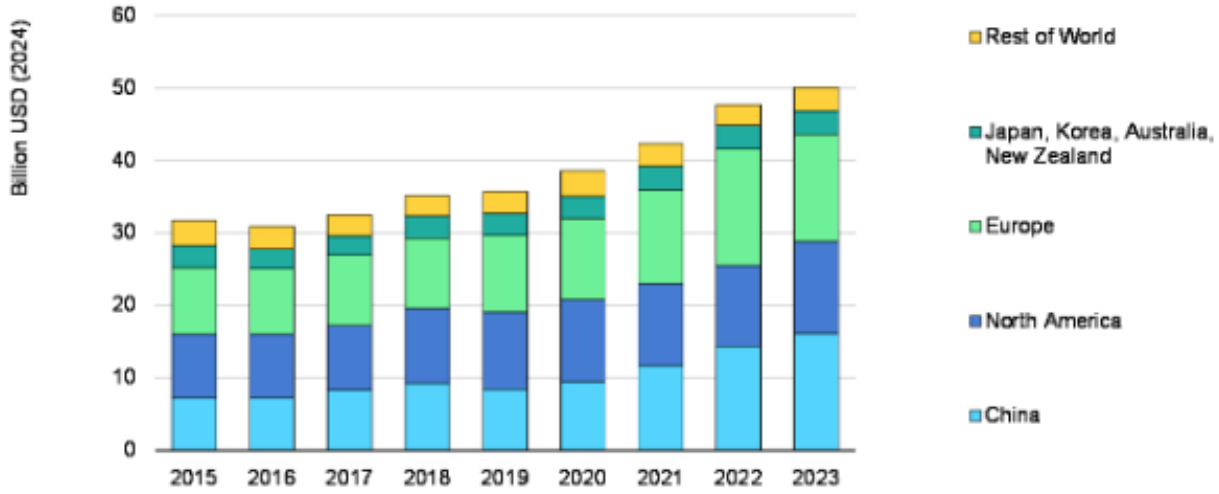


Shut down, hot standby, and restart-up of a 300MW CFB boiler

More detailed information on this topic will be presented in the reports at the parallel sessions

Üldised trendid energiasektoris

Government spending on energy R&D, 2015-2023

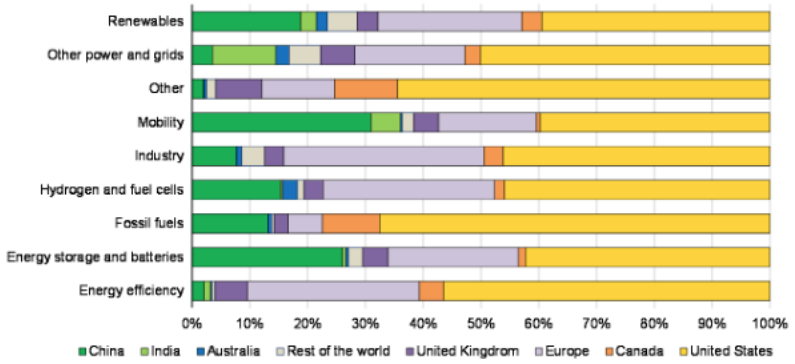


IEA. CC BY 4.0.

Notes: Includes spending on demonstration projects (i.e. RD&D) wherever reported by governments as defined in IEA documentation. State-owned enterprise funds comprise a significant share of the Chinese total. China's 2023 estimate is based on reported company spending where available. The IEA Secretariat has estimated US data from public sources.

Source: IEA Energy Technology RD&D Budgets

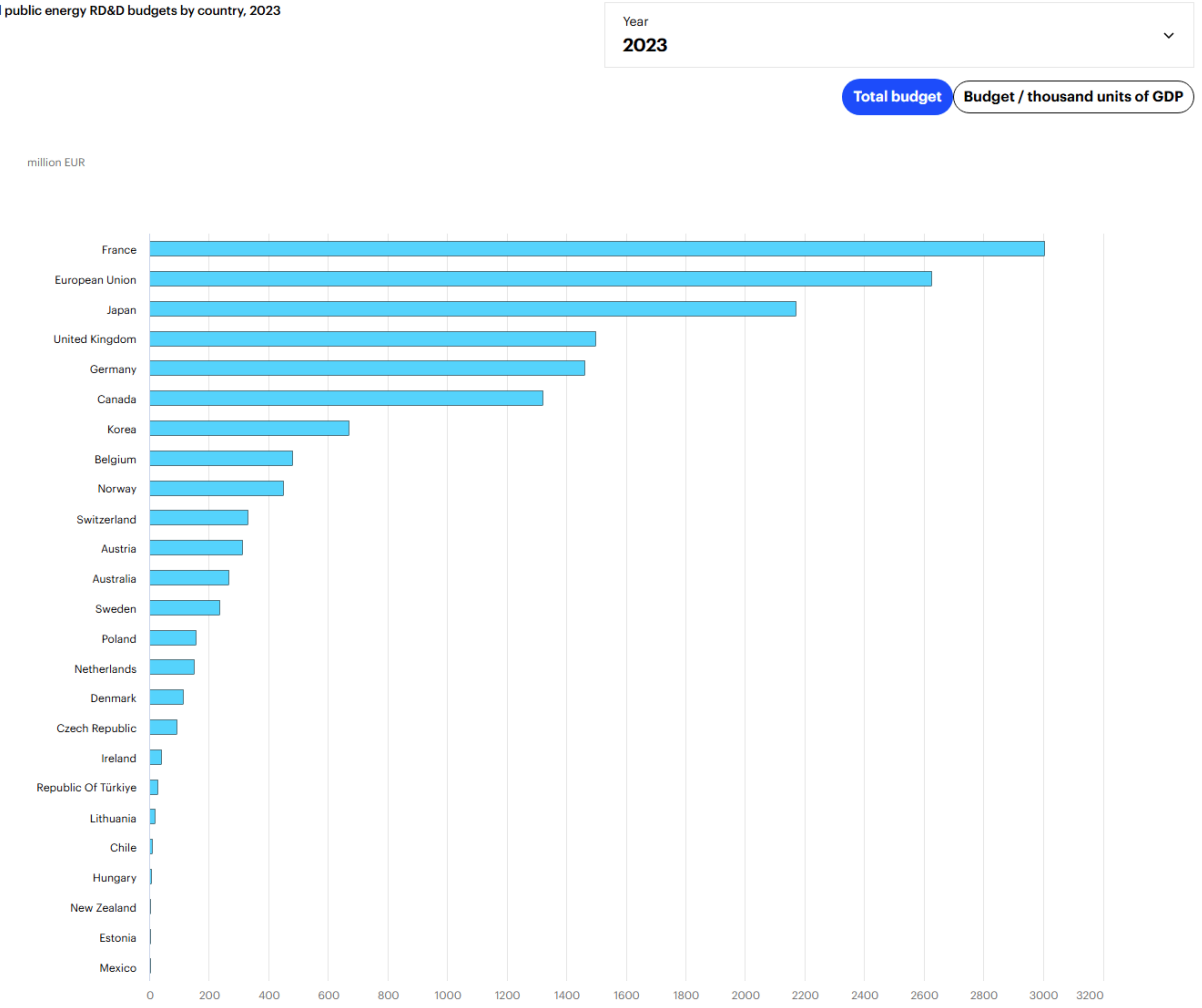
Early- and growth-stage investments in energy start-ups by region and technology area, 2020-2024.



IEA. CC BY 4.0.

Source: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

Total public energy RD&D budgets by country, 2023



Energy Technology RD&D Budgets Data Explorer – Data Tools - IEA

Põlevkivi energeetika tulevik: jätkusuutlikkus ja rohepöörde väljakutsed

CO_2 ERIHEITMED – VÄHENDAMISE VÕIMALUSED

Auvere: 305MW_{el}
Kasutegur: 40%

100% põlevkivi

CO_2 990 kg/MWh_{el}

CO_2 498 kg/MWh_{el}

50%* põlevkivi + 50% biomass

CO_2 505 kg/MWh_{el}

50%* põlevkivi + 50% NH3

CO_2 140 kg/ MWh_{el}

100% Põlevkivi **+CCS**

CO_2 -383 kg/MWh

50%/50% Põlevkivi/Bio **+CCS**

CO_2 -496 kg/MWh

50%/50% Põlevkivi/Bio 50% tuhast tsemendiks **+CCS**

CO_2 827 kg/ MWh_{el}

100% põlevkivi + 50% tuhast tsemendiks

CO_2 416 kg/ MWh_{el}

50%* põlevkivi + 50% biomass + 50% tuhast tsemendiks

* -Soojuse järgi

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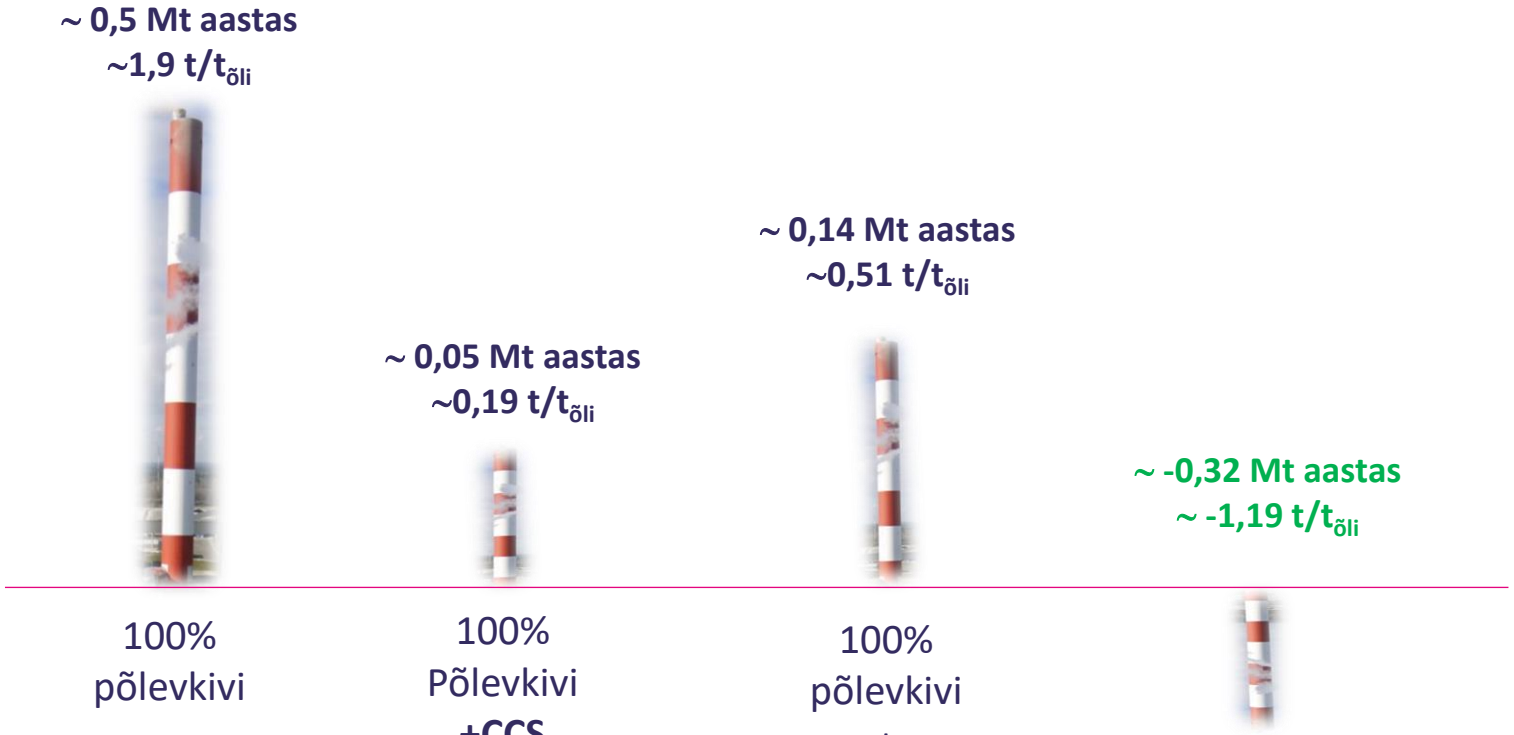
Põlevkivi energeetika tulevik: jätkusuutlikkus ja rohepöörde väljakutsed

CO_2 ERIHEITMED – VÄHENDAMISE VÕIMALUSED

Enefit 280:
Põlevkivi 280 t/h



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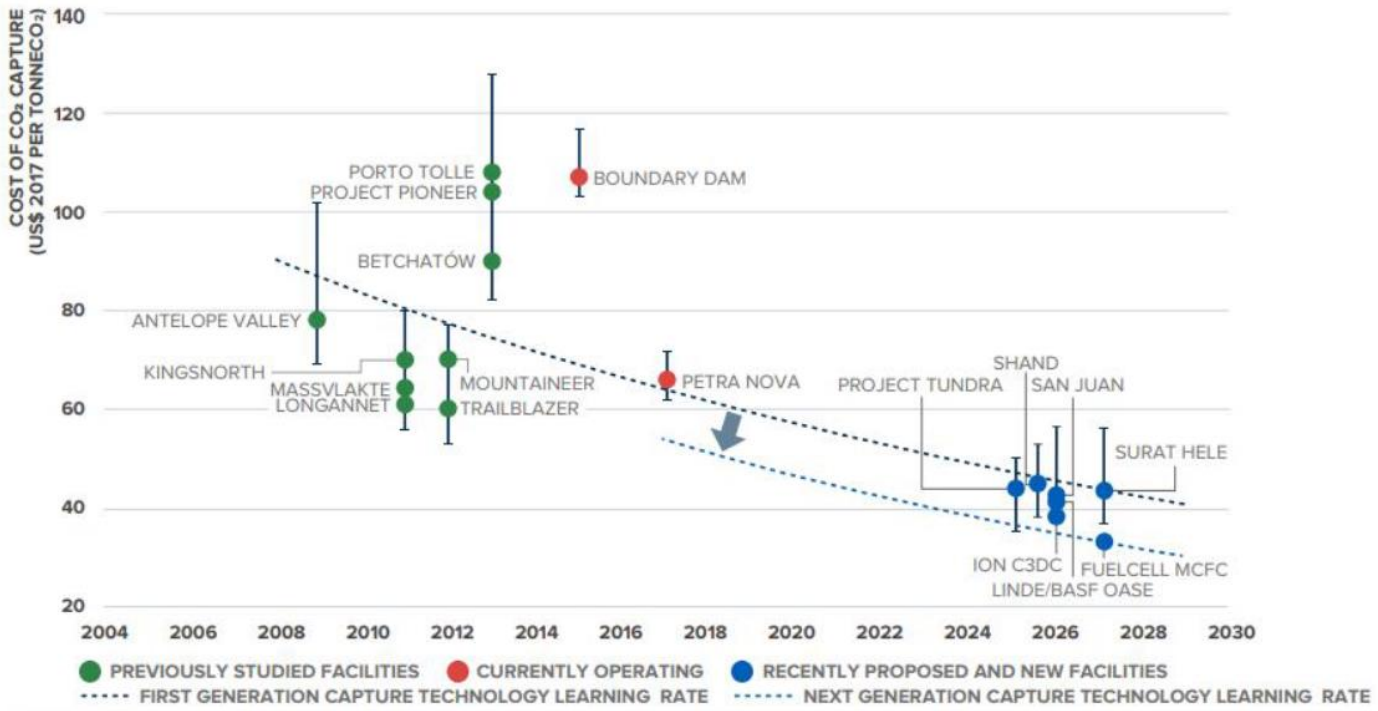
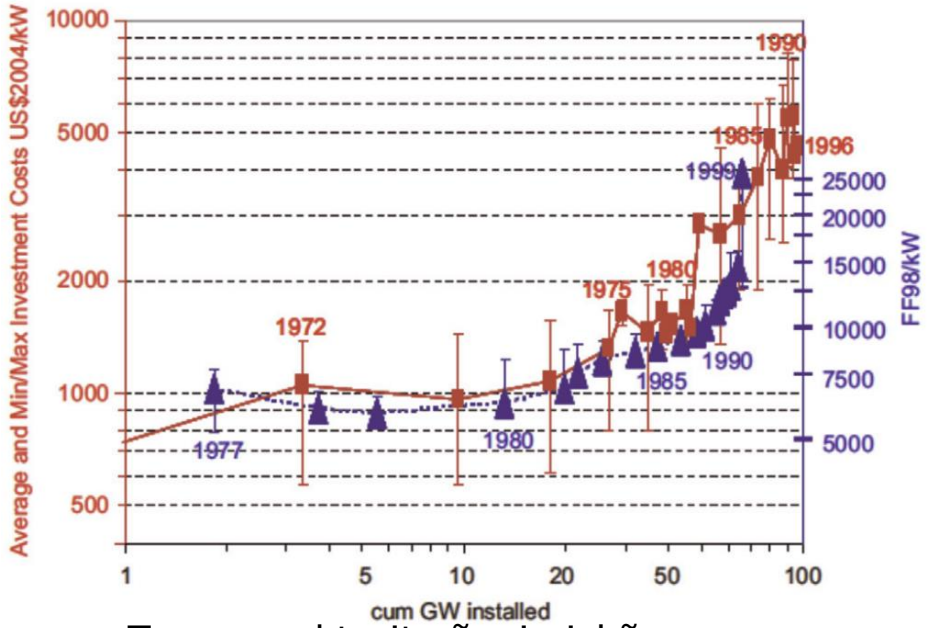
PÕLEVKIVI ENERGEETIKA TULEVIK: JÄTKUSUUTLIKKUS JA ROHEPÖÖRDE VÄLJAKUTSED

CO_2 PÜÜDMISE MAKSUMUS – KUIDAS SEE VÕIKS MUUTUDA?



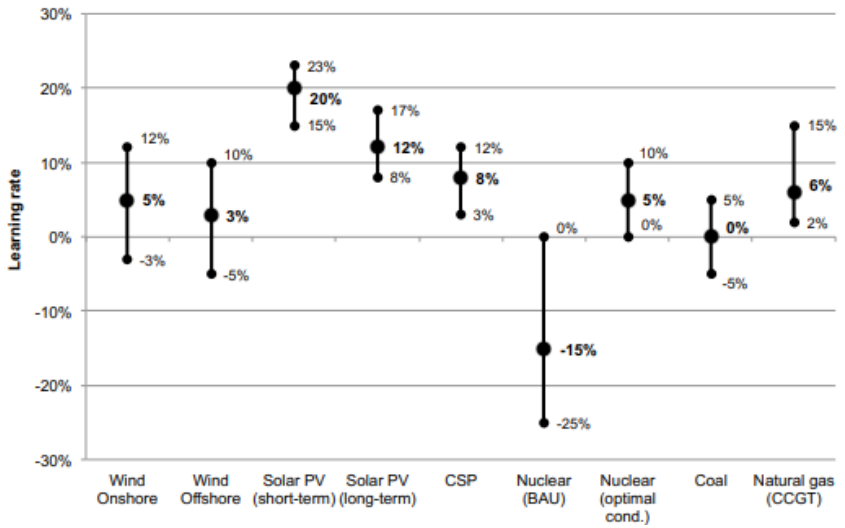
CO_2 püüdmise tehnoloogiate õppimiskõver

[WP3 Scale and Cost Reduction. Scottish Net Zero Roadmap]



Tuumareaktorite õppimiskõver

[DOI: 10.1016/j.enpol.2015.06.011]



Erinevate energia tootmisvõimsuste õppimiskiirus

[DOI: 10.1016/j.rser.2017.08.077]

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ENERGEETIKA EESTIS JA MUJAL MAAILMAS

Millised on tänased tähelepanekud

1.Puhta energia tootmine: Taastuvenergia tehnoloogiate ja nende rolli mõistmine nullilähedaste eesmärkide saavutamisel

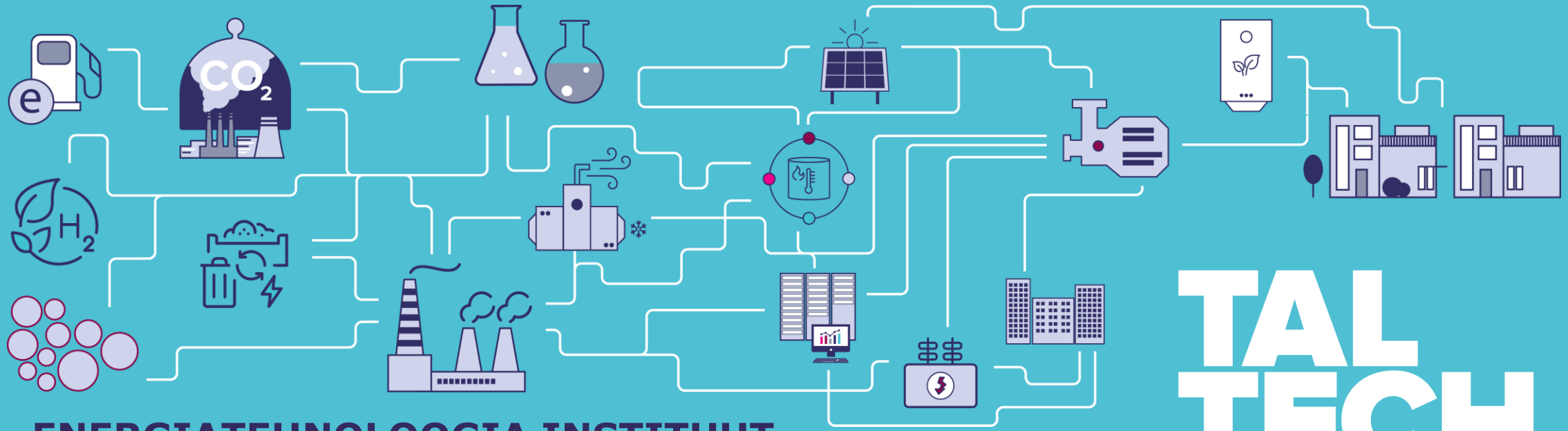
2.Elektritootmist ja elektrivõrku tuleb vaadata ühtse tervikuna

3.Elektritootmisel tuleb lähtuda kohalikest ressurssidest

4.Süsinikdioksiidi kogumine, kasutamine ja säilitamine (CCUS): Täiustatud meetodite uurimine süsinikdioksiidi heitkoguste vähendamiseks ja jätkusuutlikkuse edendamiseks

5.Sünteetilise kütuse tootmine: Uuritakse uuenduslikke lähenemisviise alternatiivsete kütuste tootmiseks, mis toetavad vähese süsinikdioksiidiheitega majandust

6.Liikuvuse dekarboniseerimine



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