UGAIN NETWERKEVENT MET LEZING: HET SCHAAKBORD VAN DE ENERGIETRANSITIE MET DHR. PIETER VAN DE PERRE (VOLZET!)

Vond plaats op woensdag 18 mei 2022 - 19 u.

Op woensdag 18 mei organiseert UGain (UGent Academie voor Ingenieurs) een netwerkevent met lezing 'Het schaakbord van de energietransitie', gegeven door dhr. Pieter Van de Perre.

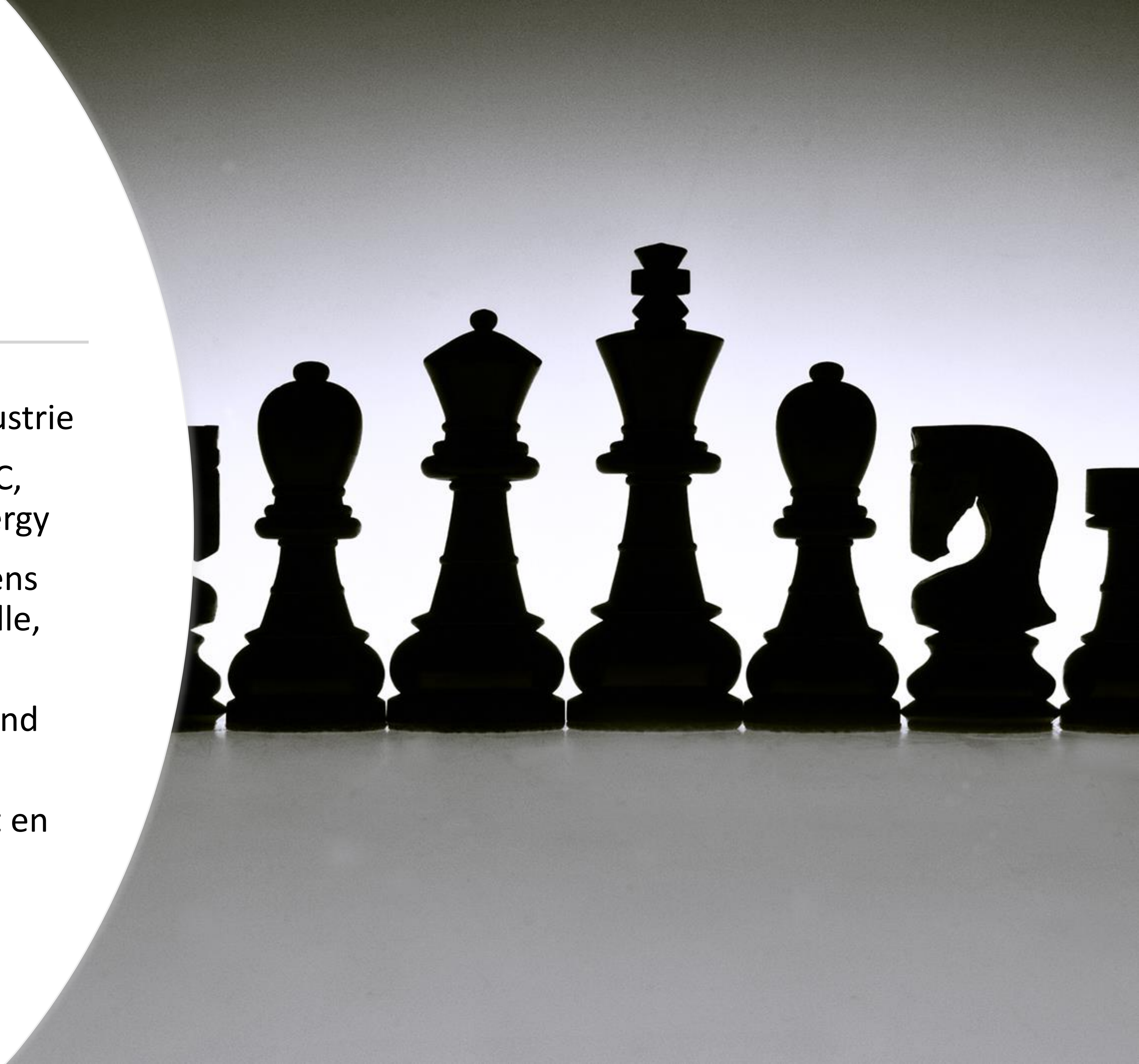
Dhr. Van de Perre heeft een uitgesproken interesse in het samenspel tussen ecologie, economie en technologie en denkt actief mee aan concepten die de maatschappij het volgend decennium kunnen mee bepalen zoals circulaire chemie, waterstofeconomie en carbon capture. Daarbij legt hij ook de link naar kernenergie en de toekomstige rol van SMR's (small modular nuclear reactors).

Race to zero

1. IPCC & beleid
2. Technologie
3. Economie
4. Schaakmat of Remise?

Uitgangspunten

- Persoonlijke visie als werknemer in de industrie
- Internationale Referentierapporten oa IPCC, IEA, IRENA, Nature, Ember, Bloomberg Energy
- Macro-analyse voor België op basis gegevens oa Elia (netbeheerder 30-380kV), Energyville, Deloitte
- Industriële projectachtergrond: schaal/ stand technologie
- Energiekost en efficiëntie bepaalt welvaart en competitiviteit – ‘race to zero’



climate change versus ‘race to zero’

ecosystems

(geo)politics

Minerals

Hydrogen

Renewables

Nuclear

Carbon capture

Storage

Bio-engineering

Efficiency

Energie vs vermogen – denkfout!

- **Energie** wordt aangeduid als de mogelijkheid om arbeid te verrichten. Er zijn verschillende vormen zoals elektrische energie, kinetische energie (wind), potentiële energie (waterkracht), lichtenergie, chemische energie (brandstoffen), thermische energie of kernenergie.
- In een elektriciteitscentrale wordt mechanische, chemische of kernenergie omgezet in elektriciteit, met een zeker verlies van energie.

(bron EOS 2019)

- **Eenheid energie J of Wh (kWh-MWh-GWh-TWh)**
- **Vermogen** is de hoeveelheid energie die per tijdseenheid gebruikt of opgewekt wordt
- **Eenheid vermogen J/s of W (kW-MW-GW). 1 W = A*V**

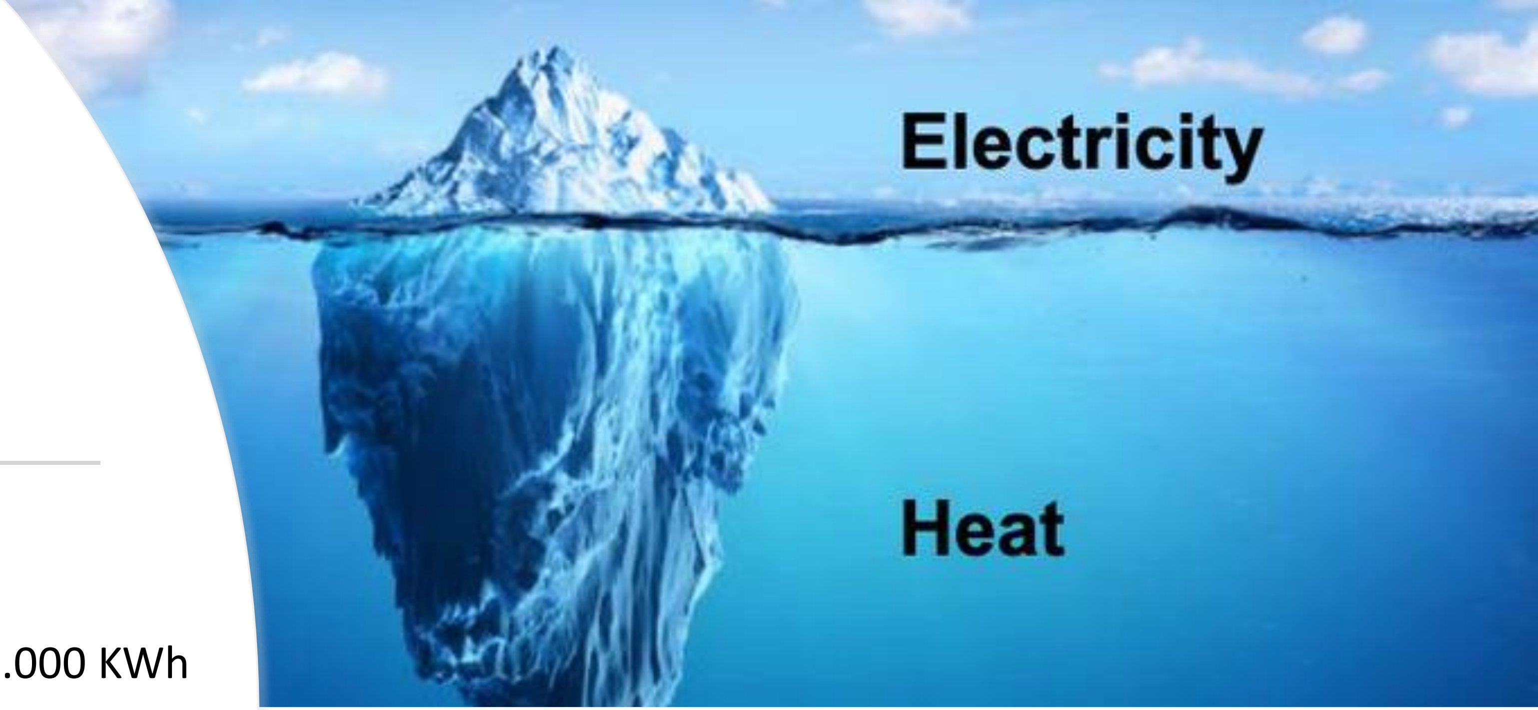
Geïnstalleerd vermogen

Energievraag

- Verbruik gezin typisch 3.500 KWh Elek en 15.000 KWh gas
- Primair energieverbruik België 725 TWh (terra = 10^12) en <u>finaal energieverbruik </u>België 460 TWh
- Elektriciteitsproductie 80 TWh waarvan 40-50 TWh nucleair en 18 TWh HE

Geïnstalleerd elektrisch vermogen eind 2020 (24 GW)

- Gas en fossiel 6.8-7.1 GW (Elia)
- Kernenergie 6 GW (Elia)
- Zon 4,80 GWp (Elia), wind 4.67 GW (Elia) waarvan 2.26 GW off-shore
- Waterkracht en biomassa: 2.5 GW



IPCC & Fitfor55

1. IPCC & Fitfor55
2. Technologie
3. Economie
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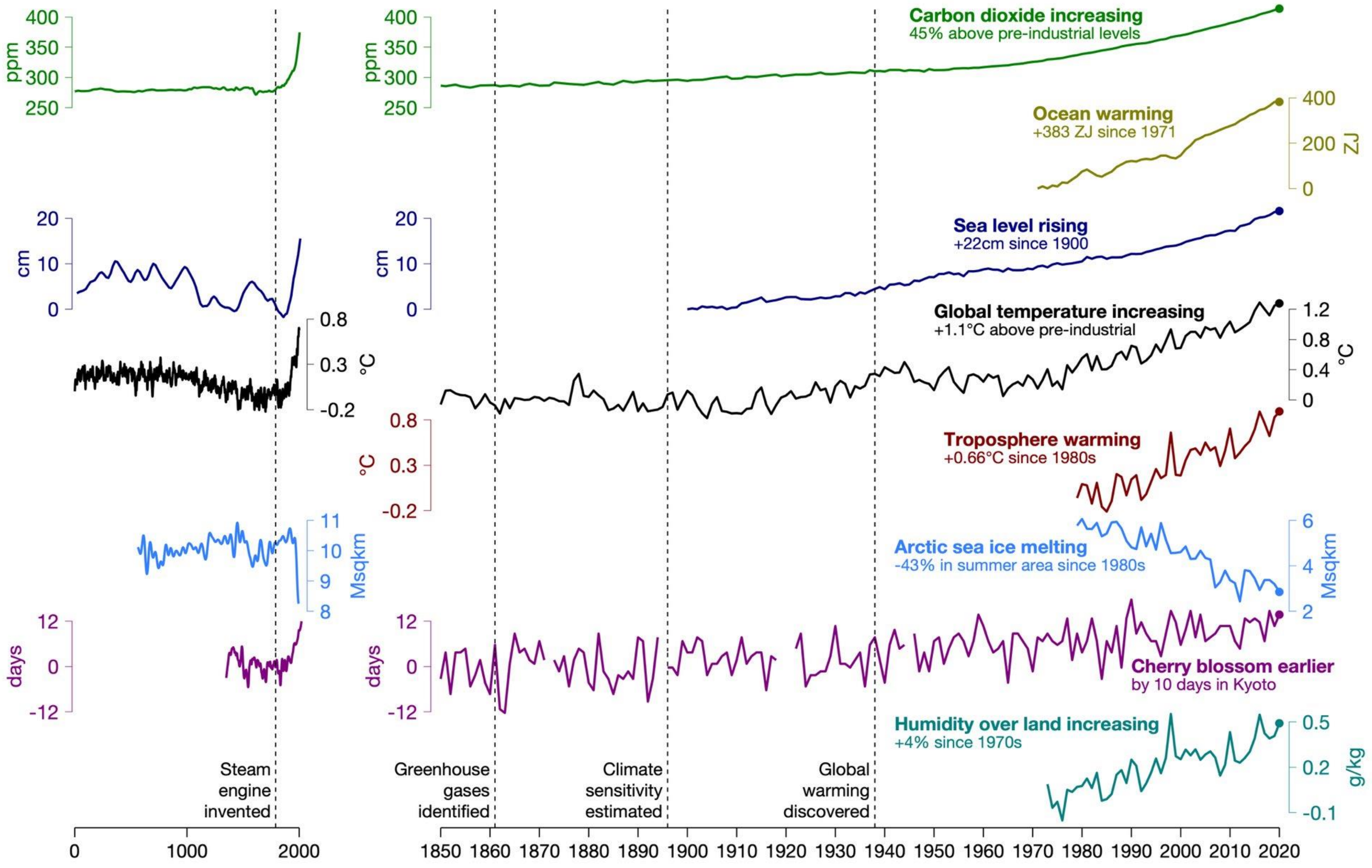
IPCC 6th assessment report 2022

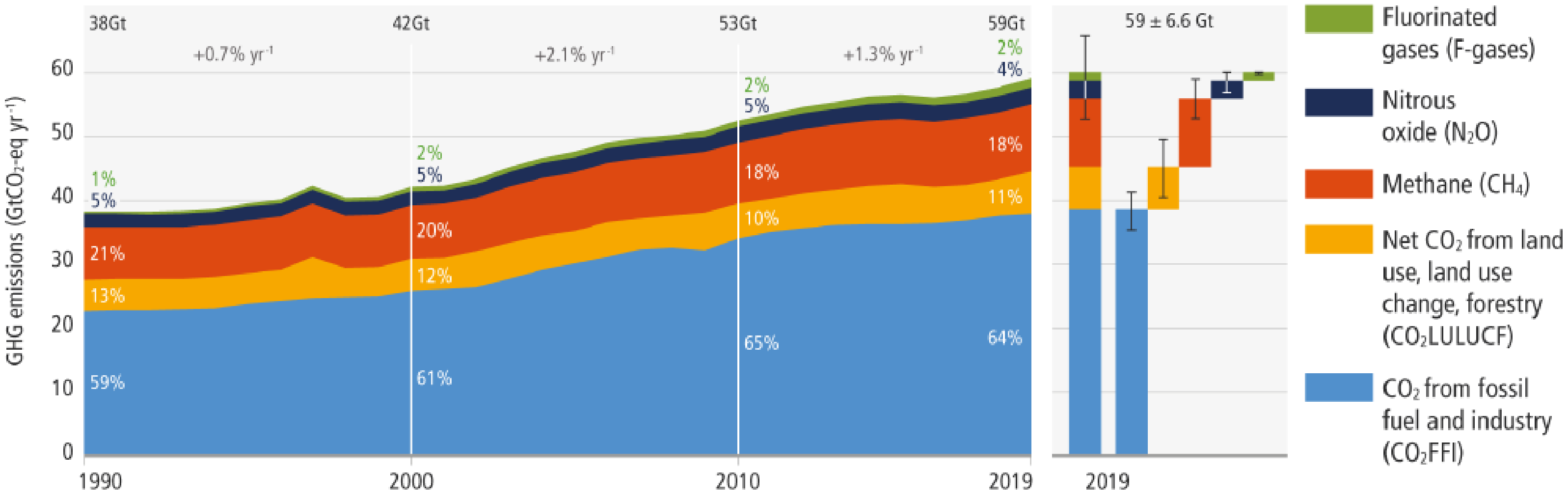
- 1ste rapport 1990
- 1.1°C opwarming tov pre-industrieel tijdperk
- 1.5°C opwarming kan enkel bij werldwijde daling CO2 uitstoot dit decennium! (*Parijs, pursue efforts*)
- 2.0° C opwarming kan indien alle beloftes (*pledges*) worden nagekomen (*Nature*)
- Verregaande ommekeer nodig tov huidige politiek, bv steenkool

Changes emerging across the climate system

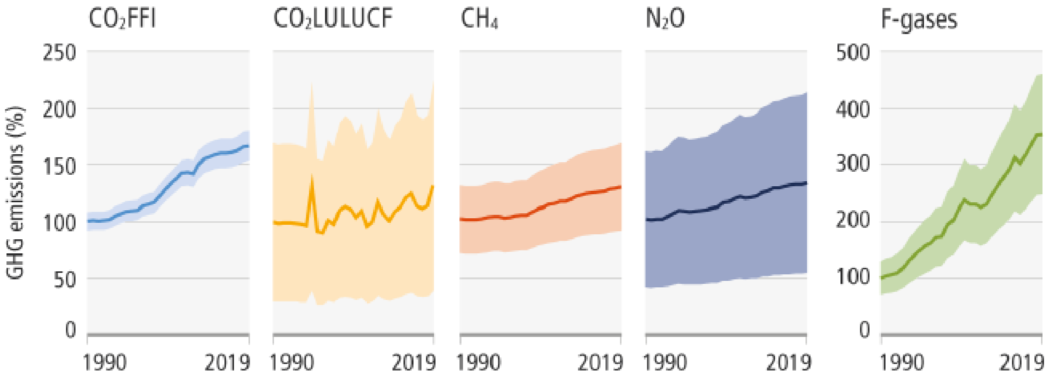


Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.

a. Global net anthropogenic GHG emissions 1990–2019 [6]



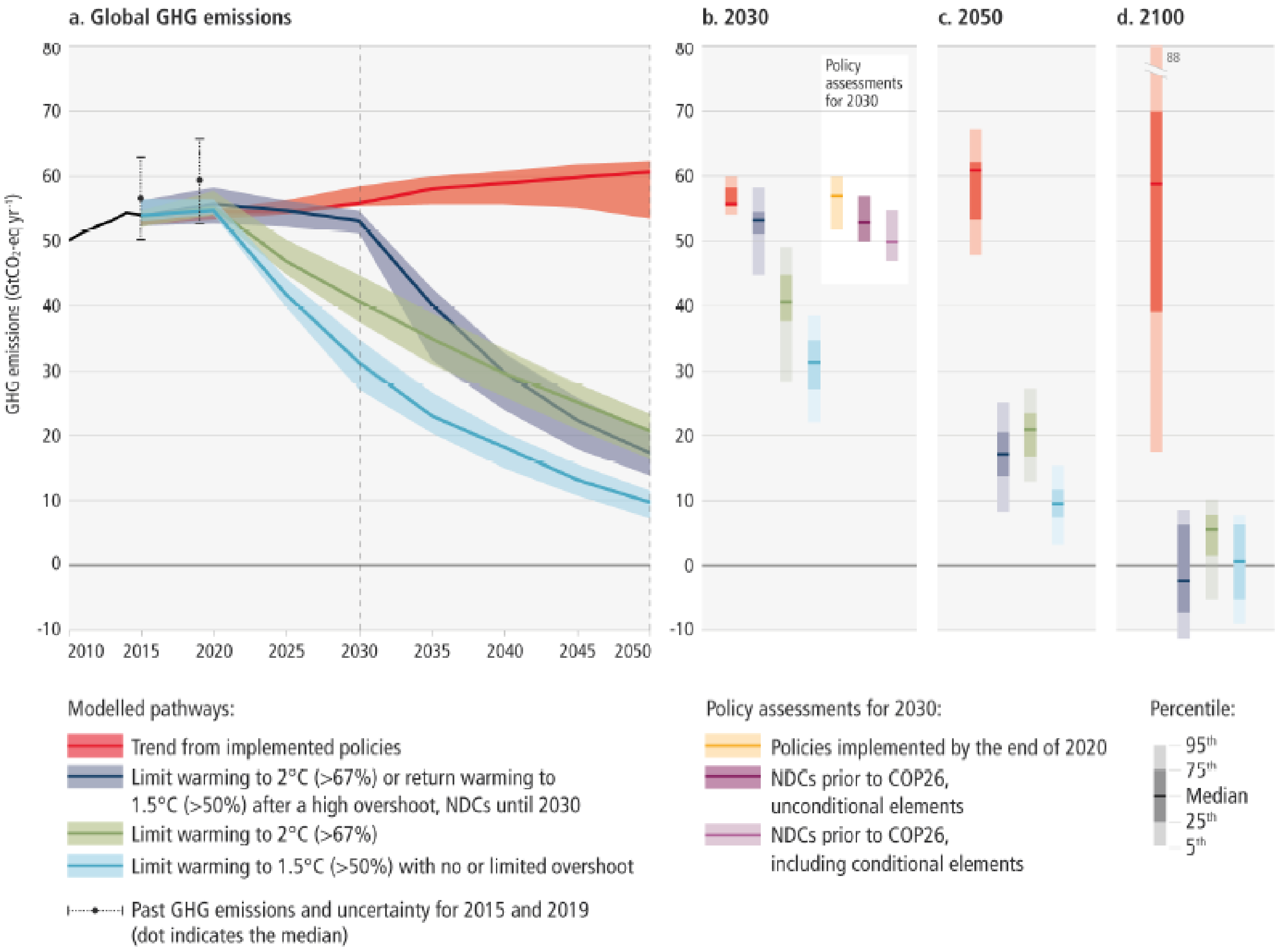
b. Global anthropogenic GHG emissions and uncertainties by gas – relative to 1990



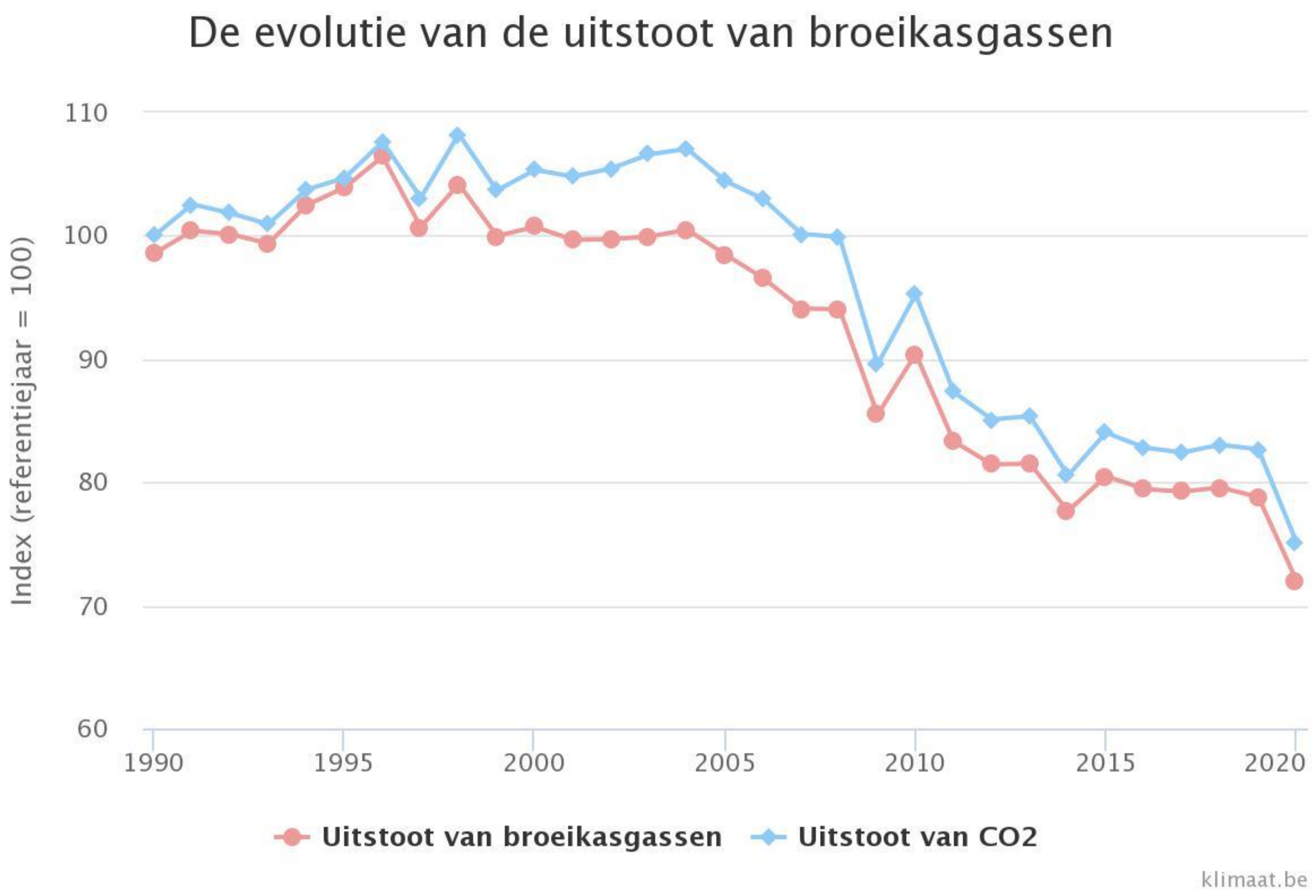
	2019 emissions ($GtCO_2$-eq)	1990–2019 increase ($GtCO_2$-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

The solid line indicates central estimate of emissions trends. The shaded area indicates the uncertainty range.

Projected global GHG emissions from NDCs announced prior to COP26 would make it likely that warming will exceed 1.5°C and also make it harder after 2030 to limit warming to below 2°C.



CO2 uitstoot BEL 106,4 Mton in 2020



Home > Press corner > EU economy and society to meet climate ambitions

Available languages: English

Press release | 14 July 2021 | Brussels

European Green Deal: Commission proposes transformation of EU economy and society to meet climate ambitions

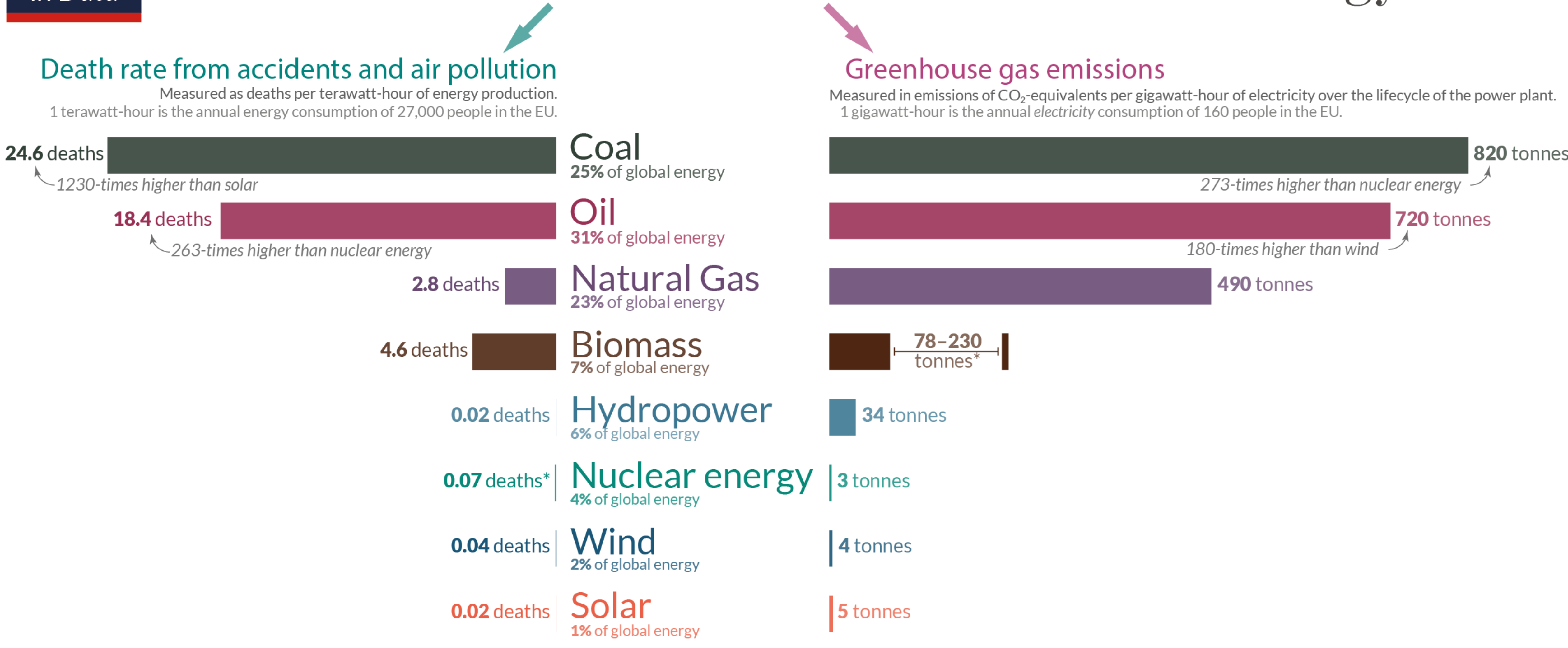
Fitfor55 deel Green Deal/ European Climate Law – EU klimaatneutraal in 2050

Tussentijdse doelstelling 55% reductie GHC in 2030

‘Proposal package’ ingediend in July 2021 bij Europese Raad

‘maintains and strengthens innovation and competitiveness of EU industry while ensuring a level playing field vis-à-vis third country economic operators’

What are the safest and cleanest sources of energy?



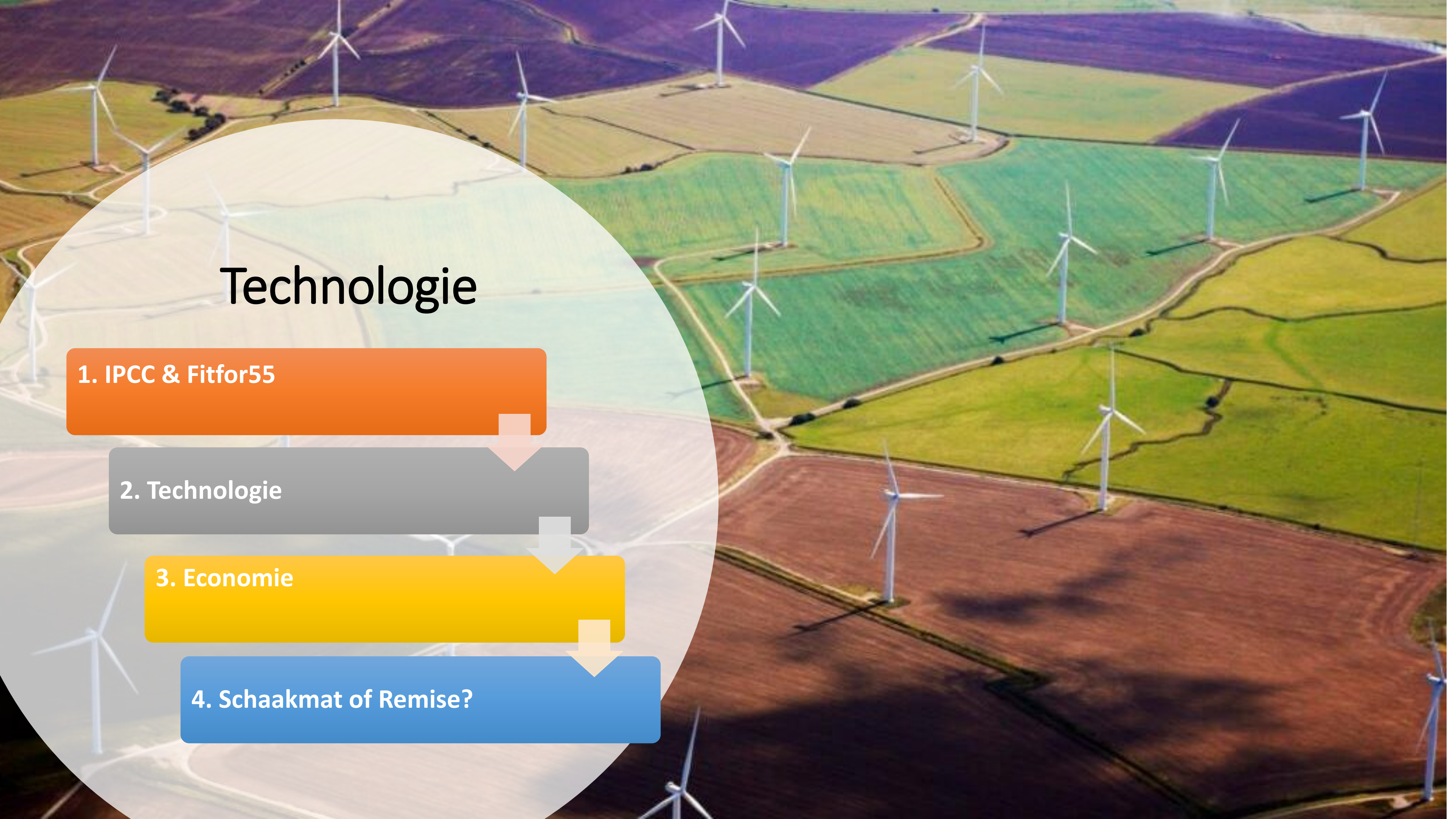
*Life-cycle emissions from biomass vary significantly depending on fuel (e.g. crop resides vs. forestry) and the treatment of biogenic sources.

*The death rate for nuclear energy includes deaths from the Fukushima and Chernobyl disasters as well as the deaths from occupational accidents (largely mining and milling).

Energy shares refer to 2019 and are shown in primary energy substitution equivalents to correct for inefficiencies of fossil fuel combustion. Traditional biomass is taken into account.

Data sources: Death rates from Markandya & Wilkinson (2007) in *The Lancet*, and Sovacool et al. (2016) in *Journal of Cleaner Production*; Greenhouse gas emission factors from IPCC AR5 (2014) and Pehl et al. (2017) in *Nature*; Energy shares from BP (2019) and Smil (2017).

OurWorldinData.org – Research and data to make progress against the world's largest problems.

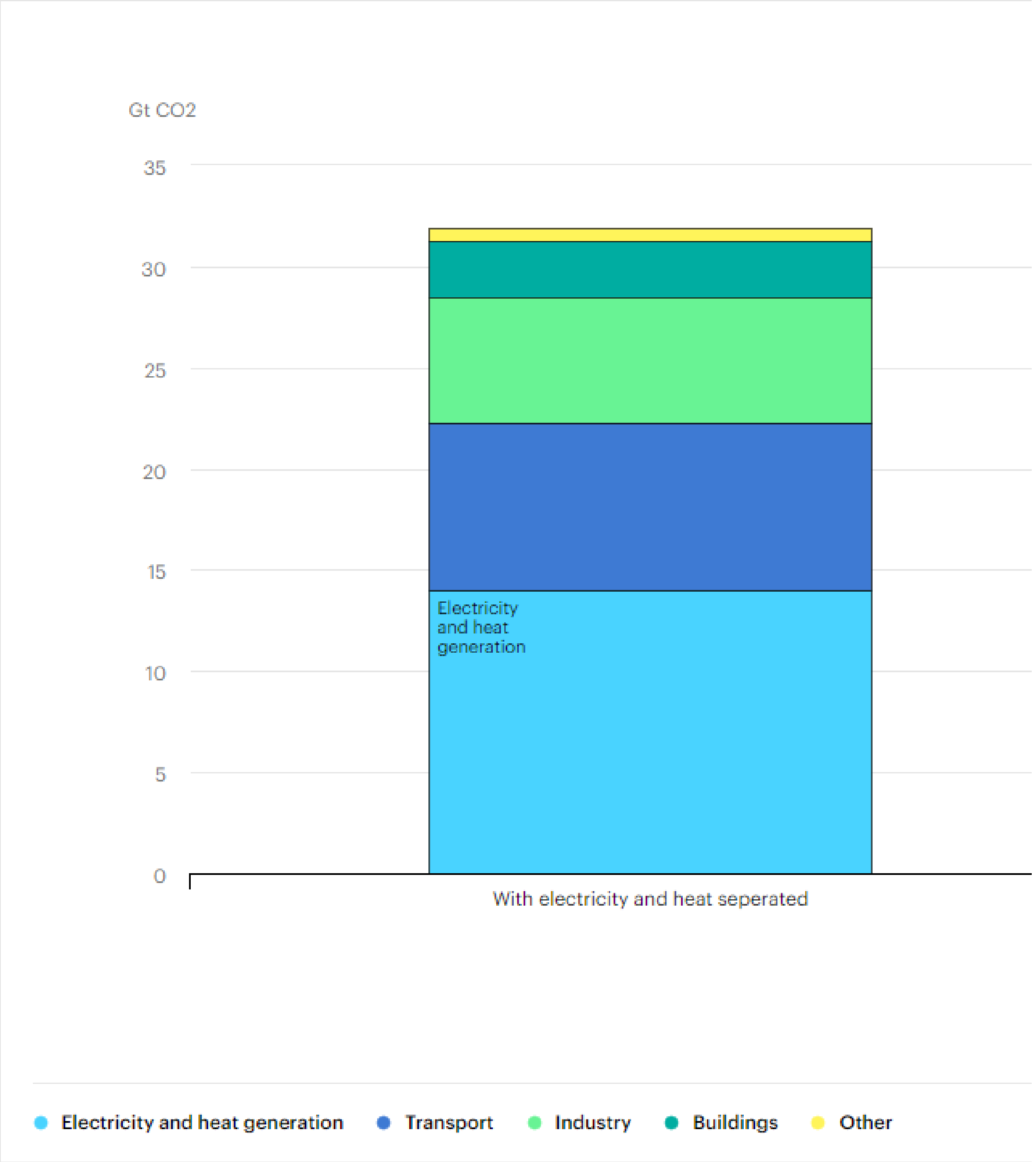


Technologie

1. IPCC & Fitfor55
2. Technologie
3. Economie
4. Schaakmat of Remise?

Key sectors transitie (IEA)

1. Groen staal → constructie/ REN
2. Chemie/ fertilizers
3. *Power sector*
4. Transport
5. Residentieel



Innovaties & tegelijk constraints

1. Waterstof
2. Critical materials
3. Small Modular Reactors

Staal

- Essentieel voor de transitie: bouw en infrastructuur, renewables, hydrogen pipelines
- 9.5% wereldwijde CO2
- IEA net zero 2050: 35 M tons H2 for steel making
- *Why both Hydrogen and Carbon are key for Carbon neutral steel making,* 29/06/2021 - Carl De Mare
- Cement and Steel – *9 steps to net zero, 23/03/2022* - Nature

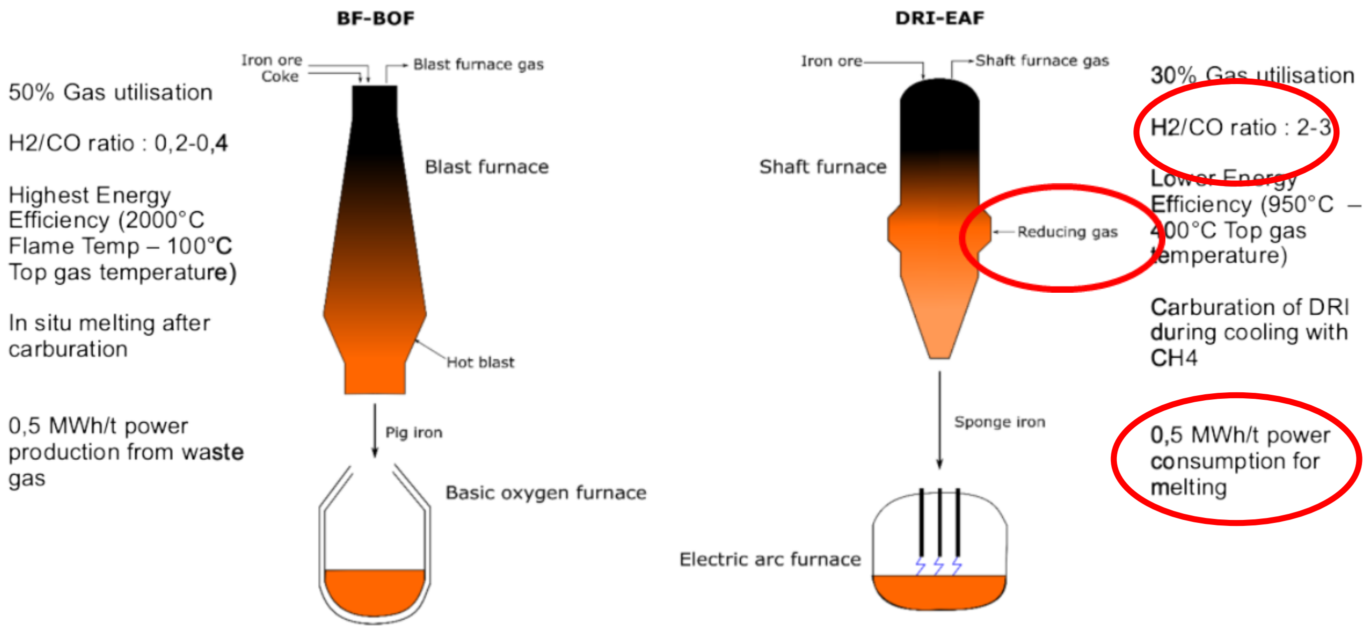


Fig. 4 Major KPI's for the 2 main production pathways to produce iron and steel.

$$Fe_2O_3 + 6\,CO = 2\,Fe + 3\,CO + 3\,CO_2 + 26{,}6\text{ kJ} \quad \text{(Eq. 1)}$$

$$Fe_2O_3 + 6\,H_2 = 2\,Fe + 3\,H_2 + 2\,H_2O - 99{,}5\text{kJ} \quad \text{(Eq. 2)}$$

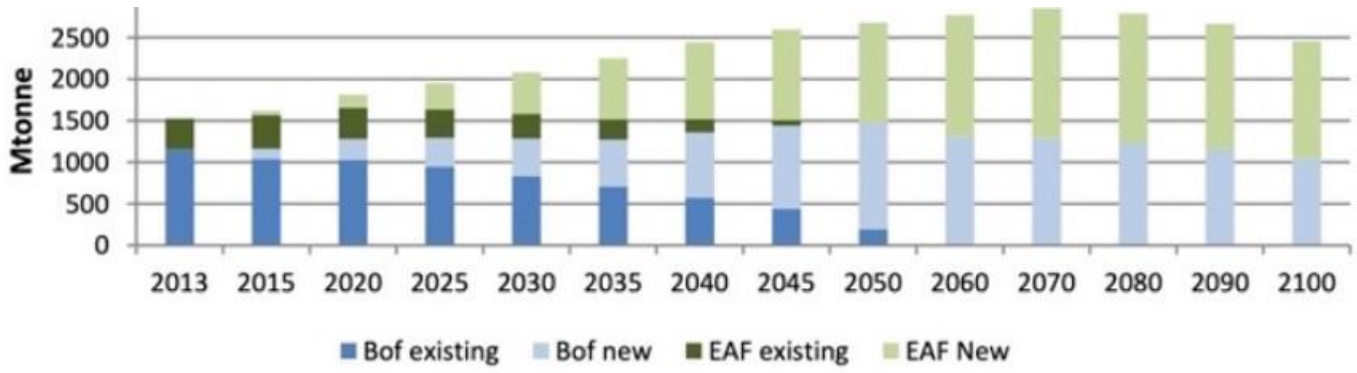


Fig. 3 Expected evolution of primary (BOF) and secondary (EAF) steelmaking in the 21th century [36]

28 September 2021 10:15 CET

ArcelorMittal signs letter of intent with the governments of Belgium and Flanders, supporting €1.1 billion investment in decarbonisation technologies at its flagship Gent plant

ArcelorMittal Belgium will reduce CO_2 emissions by 3.9 million tonnes per year by 2030, by building a 2.5 million-tonne direct reduced iron (DRI) plant and two electric furnaces at its Gent site, to operate alongside its state-of-the-art blast furnace that is ready to take waste wood and plastics as a substitute for fossil carbon.

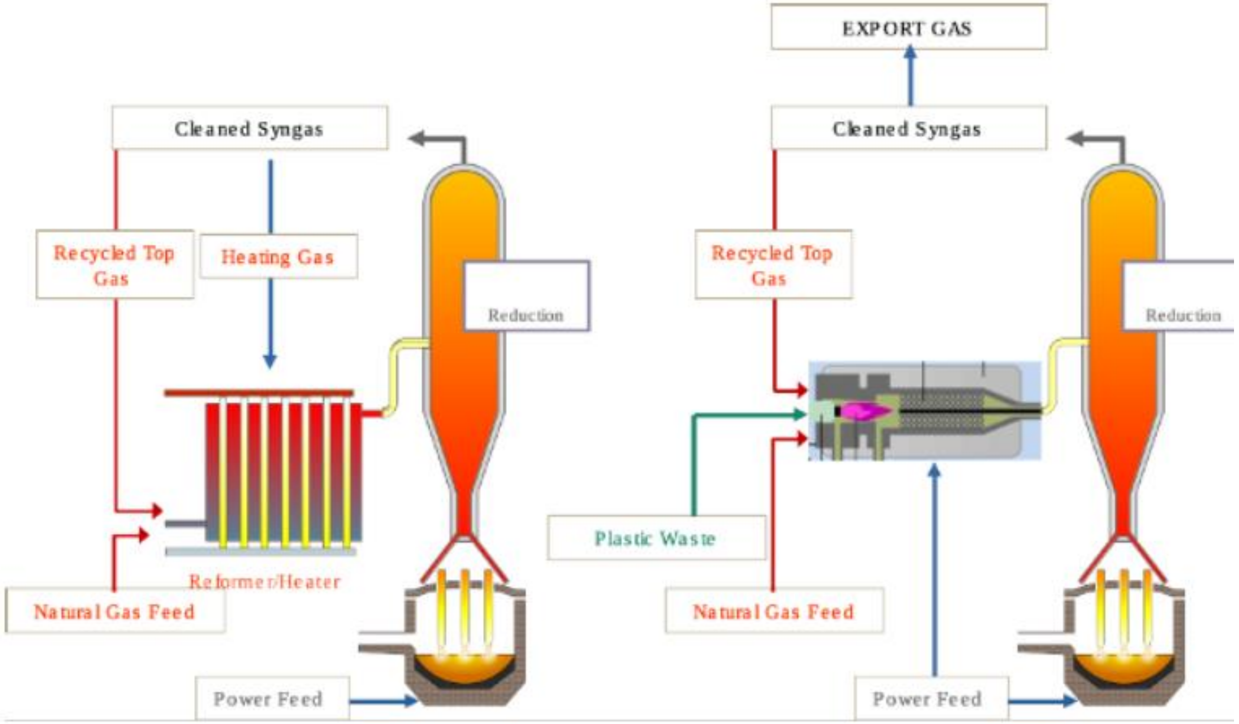


Fig. 23: Traditional process scheme (left) and scheme after electrification (right) of DRI /EAF plant.

- The renewable power allows to electrify the high temperature heat generation
- Renewable power is converted into 25kg Green hydrogen for injection in BF and DRI plants
- The cellulosic biowaste is converted into biocoal for the BF and the EAF
- The recycled polymers are gasified in order to reform with CO2 into a syngas for injection in DRI and BF shaft
- The waste gas of the DRI and BF plant is converted into high value molecules with biological gasfermentation
- The remaining fossil CO2 is captured, liquified and exported at low cost and imported again as green methanol produced with low cost renewable power

Syngas CO conversion/ Carbon capture

Fig. 25: Construction of the Steelanol plant at ArcelorMittal Gent[26]

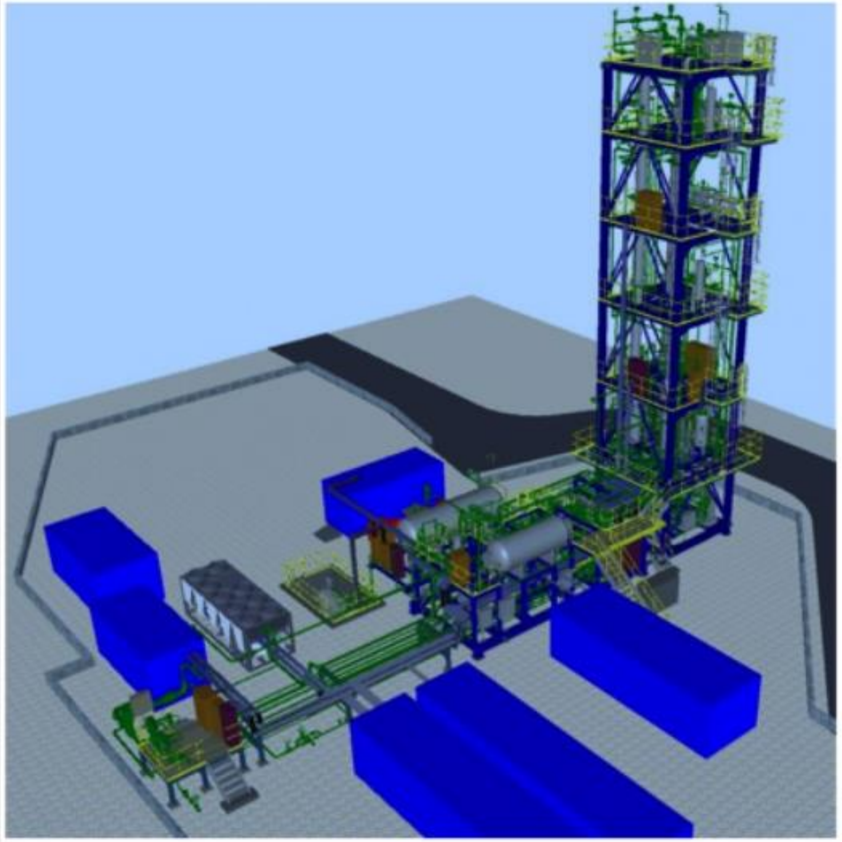


Fig. 27: CO2 capture unit under construction at the Blast Furnace of AM Dunkerque[32]

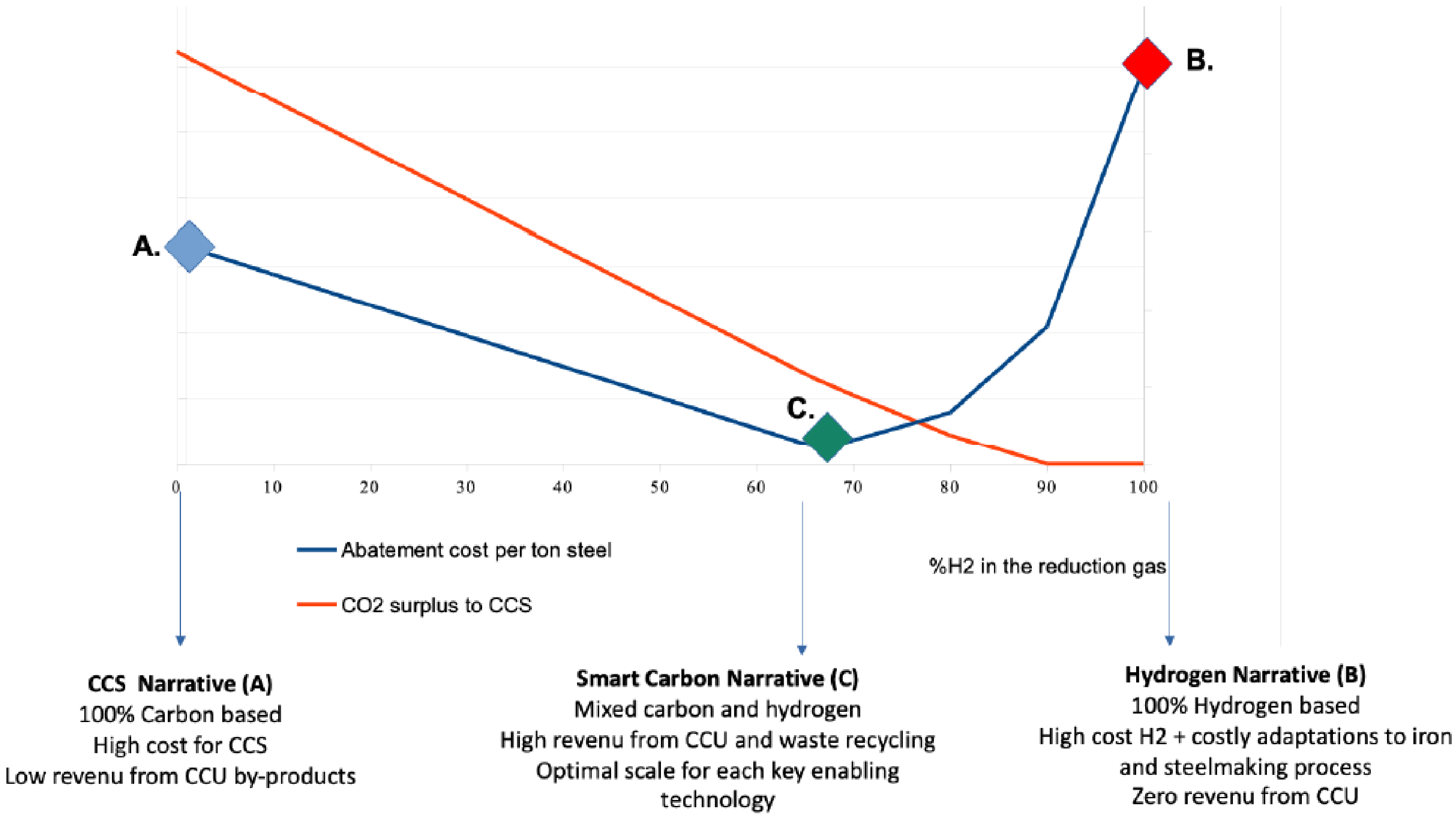


Fig. 31: The traditional CCS (point A) and Hydrogen (point B) narratives result in high cost and low flexibility (thus risks). The novel Smart carbon narrative is flexible and combines 5 strategies at their lowest cost point

Groen staal - conclusies

- Energievraag equivalent 3 GW site ACM Gent
- HV power/ waterstof vervangen methaan en steenkool
- Deel van circulaire economie (ethanol, CO_2, waste)
- ‘Smart carbon’ vs 100% H_2
- DRI en BOF naast elkaar
- ACM Gent 3.9 M ton/j CO_2 reductie tegen 2030

US steel giant invests in NuScale

06 April 2022

Share

Nucor Corporation has committed to a USD15 million private investment in public equity (PIPE) in small modular reactor (SMR) developer NuScale Power. The investment increases total committed PIPE investment to USD236 million.

The Nucor Steel Berkeley mill in Huger, South Carolina (Image: Nucor)

Nucor said it has entered into an agreement to fund NuScale via a private placement in the special purpose acquisition company, Spring Valley Acquisition Corporation, which intends to merge with NuScale.

Chemie en Raffinage

[Deloitte - Naar een koolstofcirculaire en CO2-arme Vlaamse industrie | Agentschap Innoveren en Ondernemen (vlaio.be)]

Hydrogen – Essenscia's vision, 6 juli 2021

BIOMASSA
Het gebruik van biomassa(afval) als feedstock of als energiebron.

CIRCULARITEIT
Via mechanische en chemische recyclage kunststoffen hergebruiken en langer in omloop laten.

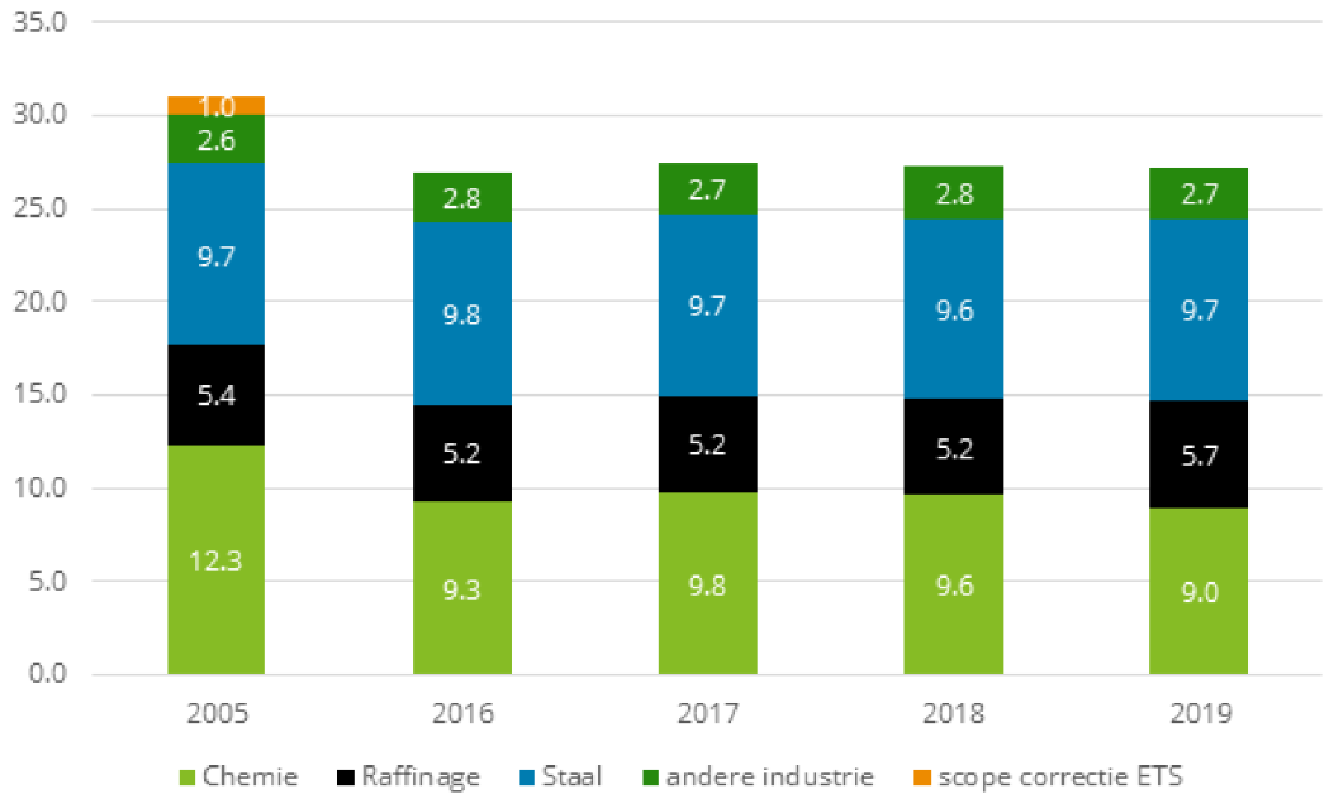
ELEKTRIFICATIE & H_2
Transformaties van processen via elektrificatie en het direct gebruik van H_2.

CARBON CAPTUR
Afvangen en het (her)gebruik van CC

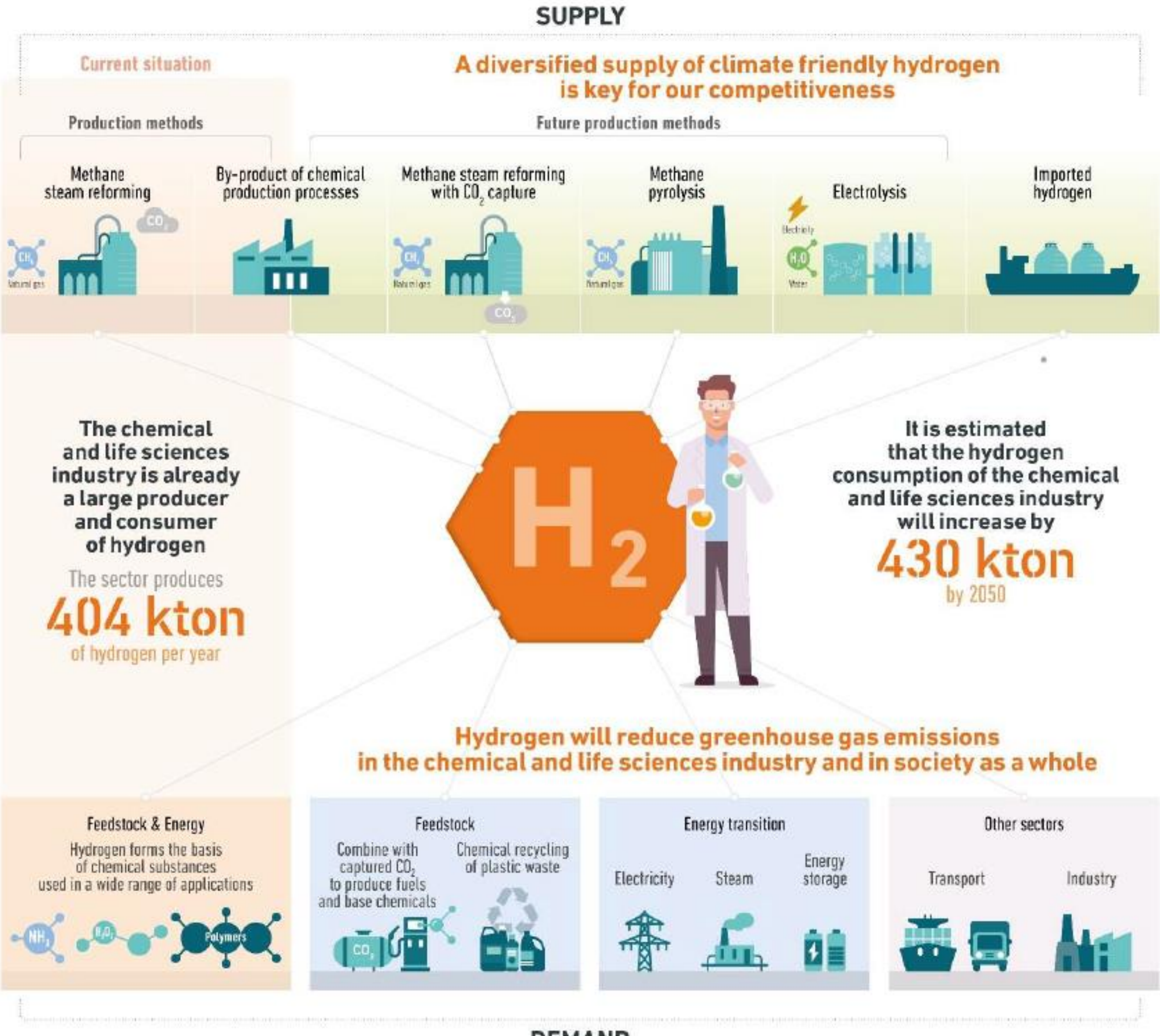
Deloitte Roadmapstudie (2020)

- Basisindustrie – 350.000 directe + indirecte jobs of 12% (Vl)
- Ongeveer 1/3 Vlaamse CO2 uitstoot
- Chemische sector >25% daling sinds 2005 door efficiëntie
- Radicale omslag nodig voor verdere reductie
- Ngl scenario stijging e-vraag industrie +50 to +300% naar 2050.

Evolutie van de uitstoot van broeikasgassen
BKG in miljoen ton



Figuur 3. Historische uitstoot broeikasgassen door sectoren staal, chemie en raffinage en andere industrie
Bron: Vlaamse Overheid


SUPPLY
Current situation
A diversified supply of climate friendly hydrogen is key for our competitiveness
Production methods
Future production methods
Methane steam reforming
By-product of chemical production processes
Methane steam reforming with CO_2 capture
Methane pyrolysis
Electrolysis
Imported hydrogen
CO_2
CO_2
H_2
The chemical and life sciences industry is already a large producer and consumer of hydrogen
The sector produces
404 kton
of hydrogen per year
It is estimated that the hydrogen consumption of the chemical and life sciences industry will increase by
430 kton
by 2050
Hydrogen will reduce greenhouse gas emissions in the chemical and life sciences industry and in society as a whole
Feedstock & Energy
Hydrogen forms the basis of chemical substances used in a wide range of applications
Polymers
Feedstock
Combine with captured CO_2 to produce fuels and base chemicals
Chemical recycling of plastic waste
Energy transition
Electricity
Steam
Energy storage
Other sectors
Transport
Industry
DEMAND

Hydrogen Essenscia’s vision 2021

- > 400 kton H2 productie /j als bijproduct (15%) en via steam methane reforming (85%)
- Verdere stijging vraag verwacht
- Equivalent 18 TWh of bijna 3 GW elektrolyser capaciteit (high Technology Readiness Level)
- 4 M ton/j potentieel CO2 winst (eigen berekening)
- Alternatief methaan pyrolyse (TLL 2-3) en carbon capture
- Infrastuctuur:
    - 2030 - 6800 km pipelines
    - 2040 - 23000 km pipelines (27-64 miljard €)

Figure 2: H2 and other gas infrastructure – source Air Liquide

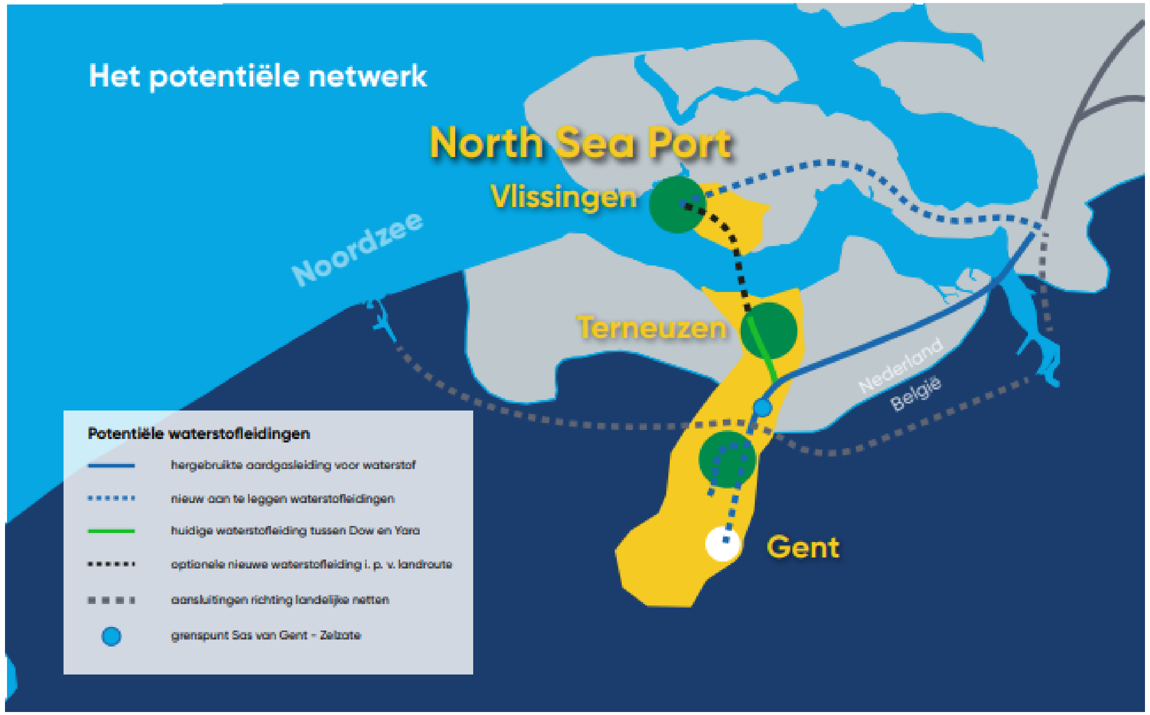
De eerste aardgasleiding die in de Benelux is hergebruikt voor transport van waterstof, is de verbinding tussen Dow en Yara. Waterstof van Dow wordt door Yara ingezet als grondstof, met een netto CO_2-reductie als gevolg. Door toenemende vraag en aanbod wordt dit netwerk verder uitgebreid.

In 2026 realiseren het Nederlandse Gasunie en het Belgische Fluxys, met steun van industrie en overheden, een volledig grensoverschrijdend pijpleidingennetwerk in het havengebied van North Sea Port (zie figuur 2). Hierdoor worden vraag en aanbod verbonden.

Voor dit netwerk worden waar mogelijk bestaande leidingen hergebruikt en waar nodig nieuwe leidingen aangelegd. De open toegankelijke waterstofinfrastructuur in North Sea Port wordt kort na de realisatie onderdeel van de nationale backbones van Gasunie en Fluxys.

Door haar unieke ligging groeit North Sea Port uit tot een waterstofknooppunt op belangrijke verbindingen in België (Zeebrugge-Antwerpen) en Nederland (Rotterdam-Chemelot). De beoogde pijpleidinginfrastructuur ontsluit een groot achterland in binnen- en buitenland.

Figuur 2. Het potentiële grensoverschrijdend waterstofnetwerk in en om North Sea Port



OUR CONCEPT

The Power to Methanol project in Antwerp will produce methanol from captured CO2 combined with hydrogen that has been sustainably generated from renewable electricity.

Currently, methanol is largely produced using fossil-based raw materials, which emits carbon dioxide from the process. With this innovative project, for each tonne of methanol produced at least one tonne of CO2 emissions would be avoided.

The 7 strong consortium comprises leading industrial and business partners: ENGIE, Fluxys, Indaver, INOVYN, Oiltanking, Participate maatshappij Vlaanderen (PMV) and Port of Antwerp.

Future development could see increased volumes of sustainable methanol produced for wider industry use, including as a sustainable fuel for marine and road transport.

OUR STORY

Power to methanol - Antwerp

Technology		Mechanisms	Pros	Cons
Absorption	Chemical absorption (e.g., MEA and NaOH)	chemical reaction between a solvent and CO_2	✓High capacity at low CO_2 pressure ✓Mature technology	• Energy-intensive regeneration • Low absorption–desorption rate • Corrosion • Absorbent degradation • High operating cost
	Physical absorption (e.g.,methanol, Selexol, and Rectisol)	The solubility of CO_2 in a solvent	✓High capacity at low temperature and high pressure ✓Cheaper solvent ✓Mature technology	• Low selectivity • High energy consumption • Low capacity at high temperature and low pressure • Absorbent loss
Adsorption	Physical adsorbents (e.g., AC, zeolites, and MOF)	Molecular sieve confinement effect of solid materials, normally with micropores	✓High capacity at low temperature and high pressure ✓Low waste generation	• Low CO_2 selectivity • Capacity decreases with temperature • Normally require high pressure • Moisture degrades the adsorbent performance
	Chemical adsorbents (e.g., CaO and Na_2SiO_3) —	Through the formation of carbonates or bicarbonates —	✓Work at high temperature ✓High capacity ✓Low waste generation	• Require high temperature for CO_2 sorption and adsorbent regeneration • High energy consumption • Performance loss with cycles
	Solid amine sorbents (e.g., PEI/SiO_2)	Chemical reaction between amine groups and CO_2	✓High capacity at low CO_2 pressure ✓High selectivity ✓Fast kinetics ✓Mild conditions ✓Positive effect of moisture ✓Lower energy consumption ✓Less corrosion ✓Low waste generation	• Thermal and oxidative degradation • Degradation due to contaminants (e.g., SO_x and NO_x)
Membrane		Different gas permeability	✓Relatively low operation cost ✓Easy handling and Operation	• High manufacturing cost • Relatively low separation selectivity • Permeability still low • Negative effect of moisture
Biological absorption/utilization		Captured and utilized through photosynthesis in plants	✓No hazards of chemicals ✓Coproduction of food, biofuels, and value-added products	• Long time requirement • Large area requirement • May affect biological diversity • Sensitive to other flue gas contaminants (e.g., SO_x and NO_x) and culture conditions (pH, temperature, and salinity)
Cryogenic separation		Different condensation temperature	✓High capture efficiency (up to 99.9%)	• High energy requirement • Low efficiency • Moisture pre-removal is required • Solidified CO_2 may be accumulated on the surface of heat exchanger

Direct Air Carbon Capture

Table 1 | Most important parameters for e-fuel cost estimation and sensitivity analysis

	2020–2025	2030	2050
Annual average electricity price (€ MWh^{-1})	50 ± 10	50 ± 10	30 ± 10
Electrolysis CAPEX (€ kW^{-1}, median of AEC/PEMEC literature review)	1,100 ± 389	625 ± 258	334 ± 189
DAC (€ per tCO_2 captured)	460 ± 90	150 + 150/− 50	50 + 50/− 10

For the full table and references, see Supplementary Information S2.

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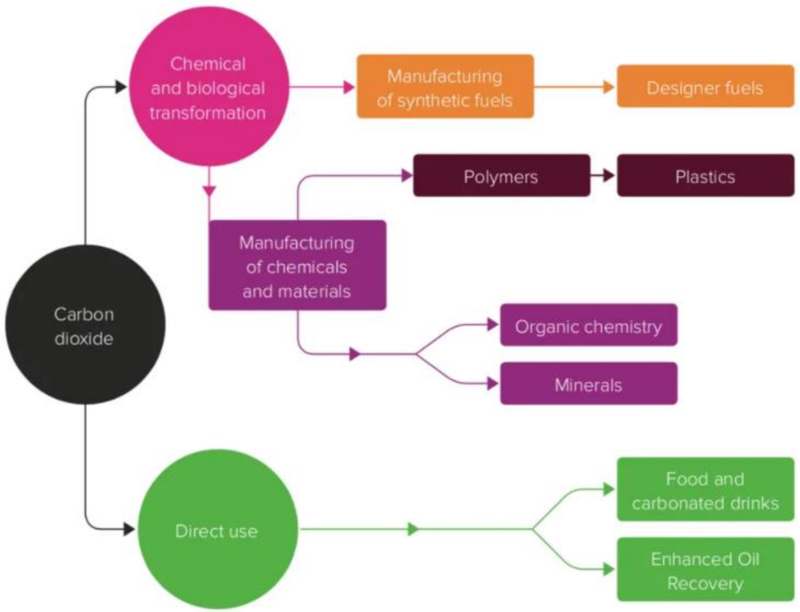
'The amount of energy required by direct air carbon capture proves it is an exercise in futility'

Removing CO2 directly from the air requires almost as many joules as those produced by burning the fossil fuel in the first place, writes Leigh Collins

Bron:Potential and risks of hydrogen-based e-fuels in climate change mitigation (Nature)

Uses of carbon dioxide



Two basic types of technology

- **Pressure Swing Adsorption** or PSA (A<u>d</u>sorbent Based)
- **Wash System** (A<u>b</u>sorbent Based)
  - "PCC" based for low pressure/low CO_2 concentrations
  - Traditional aMDEA type (with higher CO_2 levels and no O_2 in stream)

Technology choice depends on:

- CO_2 product specification (mainly purity) / CO_2 recovery target
- Feed gas quality (pressure, CO_2 content)
- Economic Basis (power cost, energy cost, etc.)

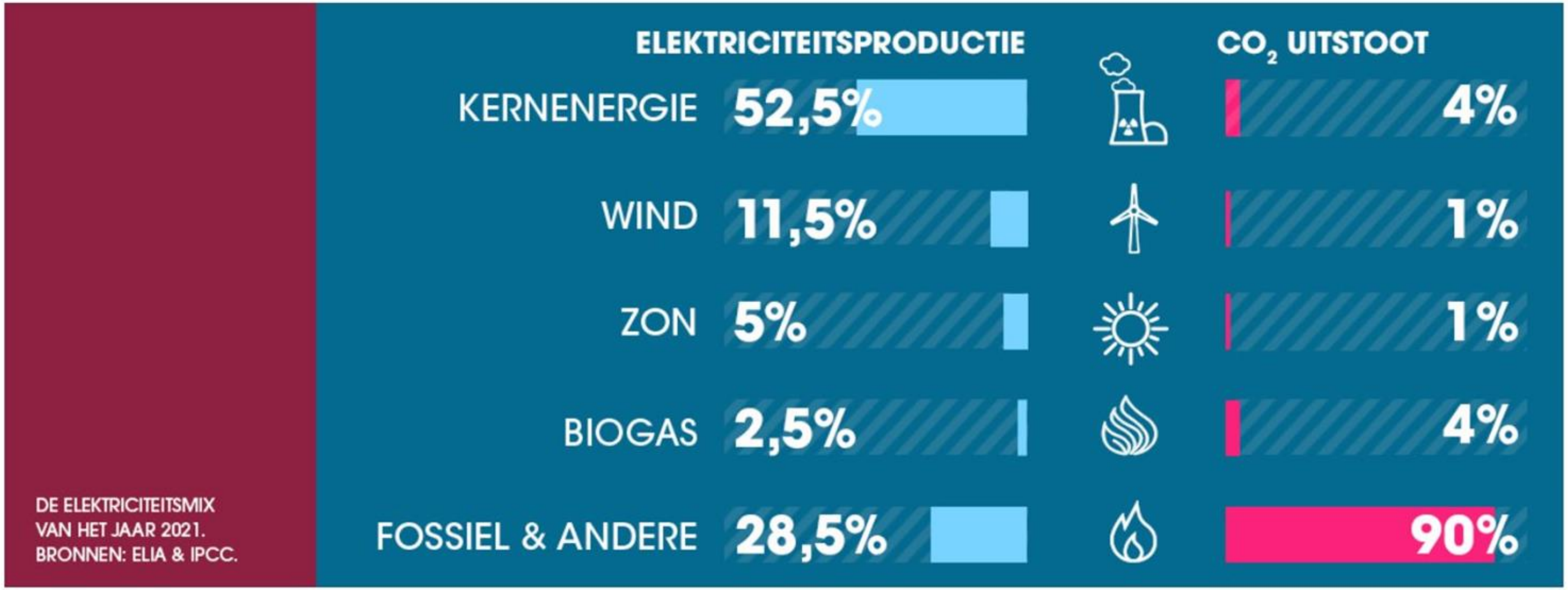
Chemie - conclusies

- Energievraag equivalent 18 TWh (3 GW) voor waterstof
- Waterstof ‘in line process’ → blauwe H_2?
- Combinatie clean hydrogen/ carbon capture/ elektrificatie/ procesinnovatie vb bioplastics
- Uitdaging: scale-up CO_2 afvang!
- Kost gerelateerd aan impurities, concentratie CO_2
- Valorisatie CO_2 technisch/ economisch belangrijk en voordeel Port of Antwerp
- Fit for 55 – versnelde vraag naar meer H_2/ elektriciteit
- Grote infrastuctuurwerken voor pipelines

Power sector

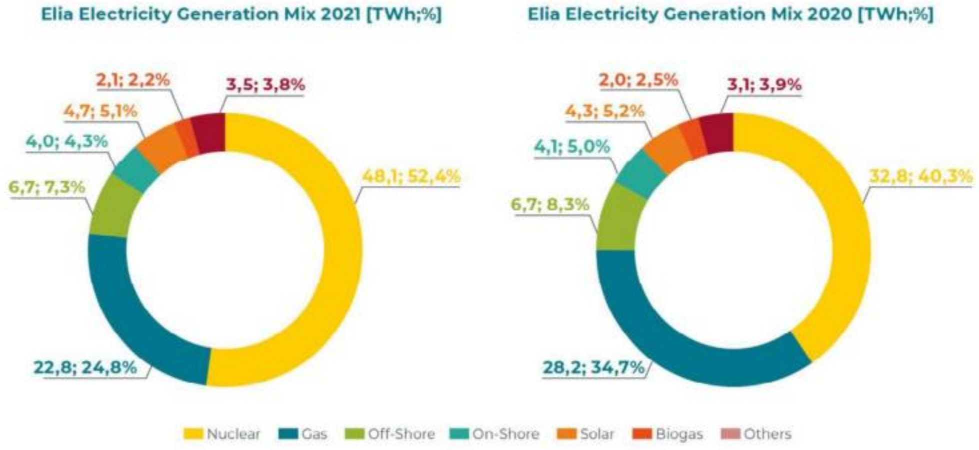
https://www.elia.be/en/news/press-releases/2021/06/20210625_elia-publishes-its-adequacy-and-flexibility-study-for-the-period-2022-2032

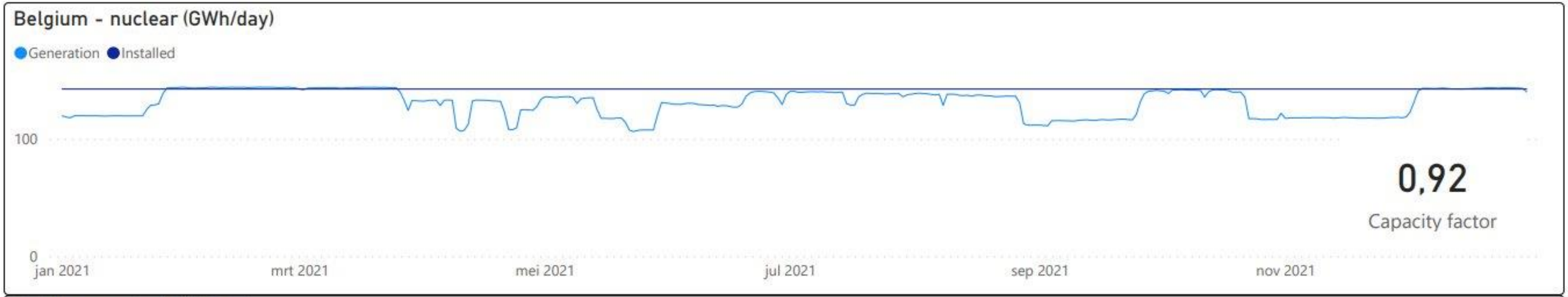
https://www.energyville.be/pers/energyville-lanceert-aanvullende-systeemscenarios-voor-elektriciteitsvoorziening-belgie-2030

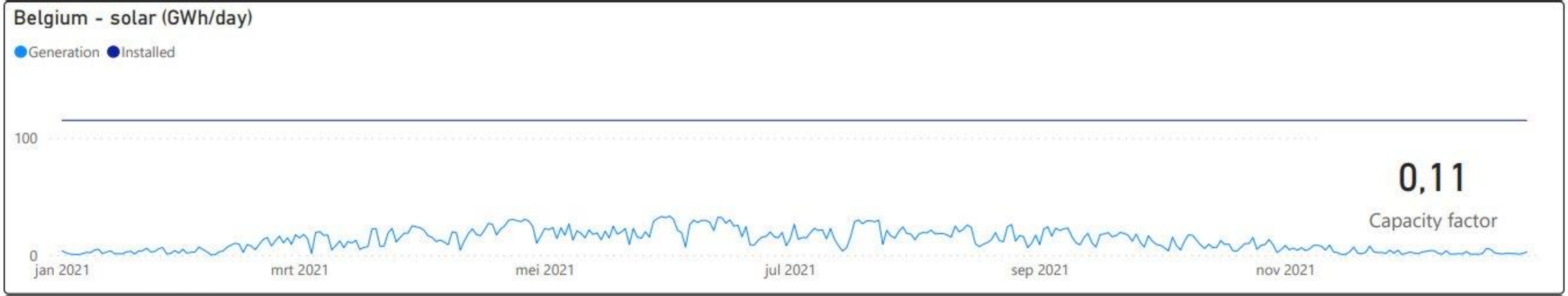


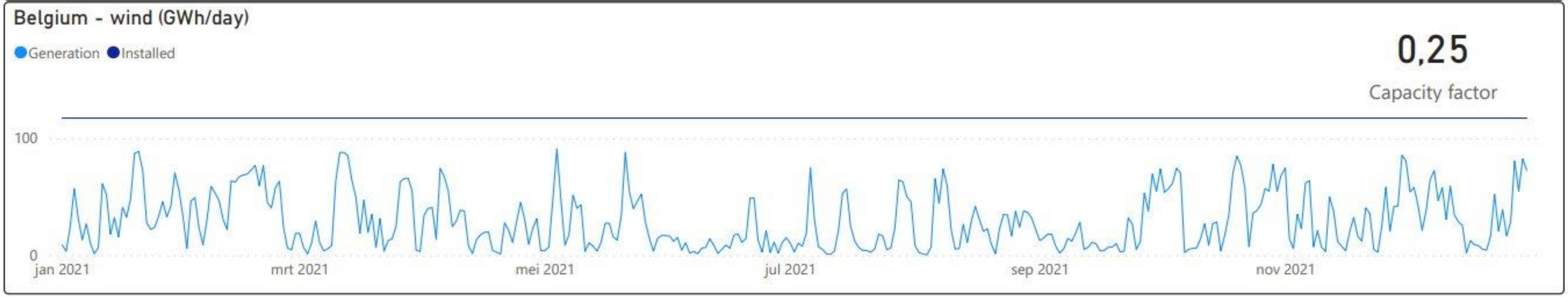
De Belgische elektriciteitsmix - jaarcijfers 2021 (bronnen: ELIA & IPCC)

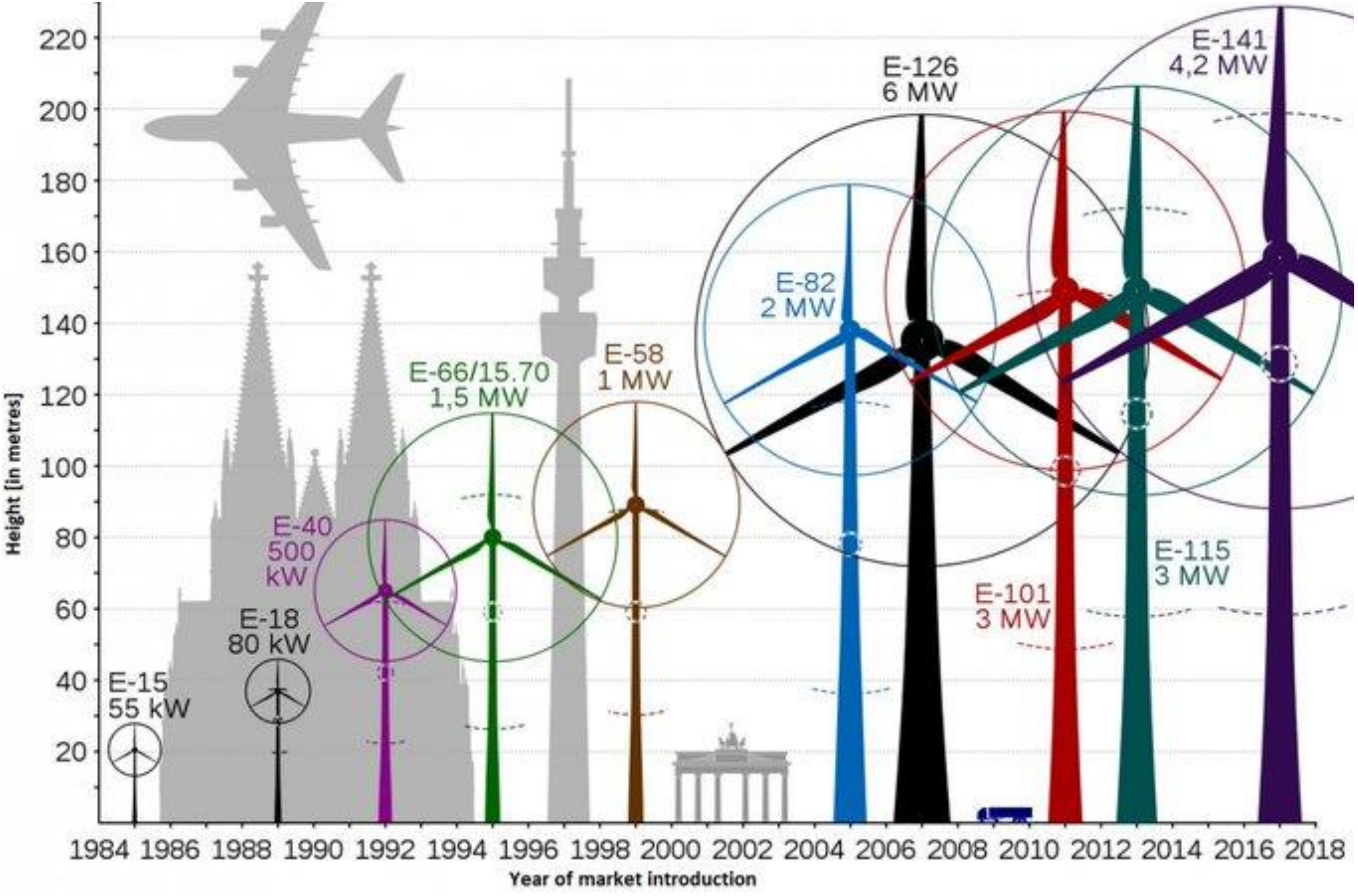
Electricity mix for 2021 and 2020




Belgium - nuclear (GWh/day)
Generation
Installed
100
0
jan 2021
mrt 2021
mei 2021
jul 2021
sep 2021
nov 2021
0,92
Capacity factor


Belgium - solar (GWh/day)
Generation
Installed
100
0
jan 2021
mrt 2021
mei 2021
jul 2021
sep 2021
nov 2021
0,11
Capacity factor


Belgium - wind (GWh/day)
Generation
Installed
0,25
Capacity factor
100
0
jan 2021
mrt 2021
mei 2021
jul 2021
sep 2021
nov 2021

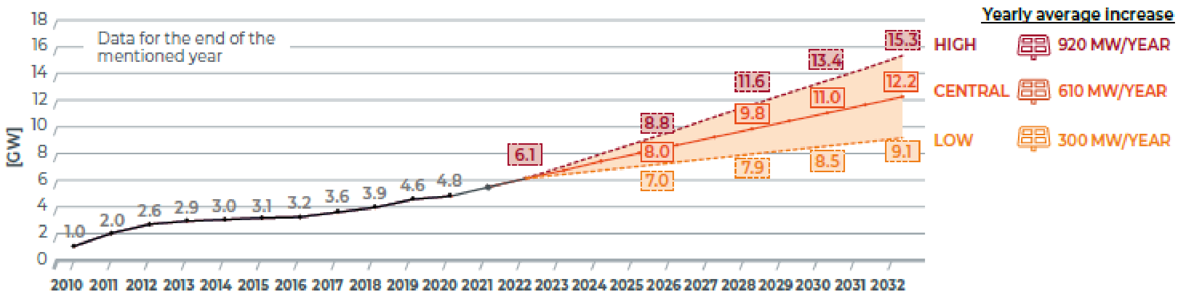


Bron: Jan Rosenow, Director @RegAssistProj, Board member @eceee_org @Euenergysavings, Twitter 16/05/2022

Elia Adequacy and Flexibility 2021

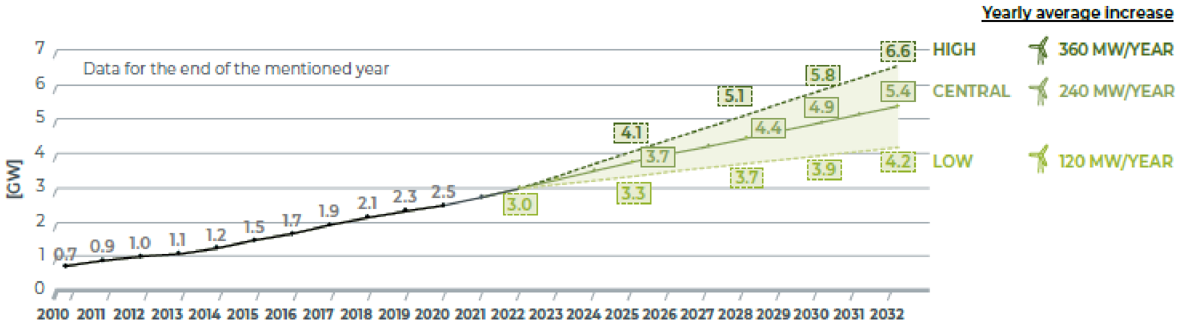
- Outlook 2022-2032 binnen gekende randvoorwaarden, simulatie 28 landen
- Uitbouw interconnectiviteit, hernieuwbaar, EV's, storage en warmtepomp
- 3.6 GW vervangcapaciteit in 2025 en 4.6 GW in 2032

[FIGURE 3-19] — EVOLUTION OF INSTALLED SOLAR CAPACITY PER SCENARIO IN BELGIUM

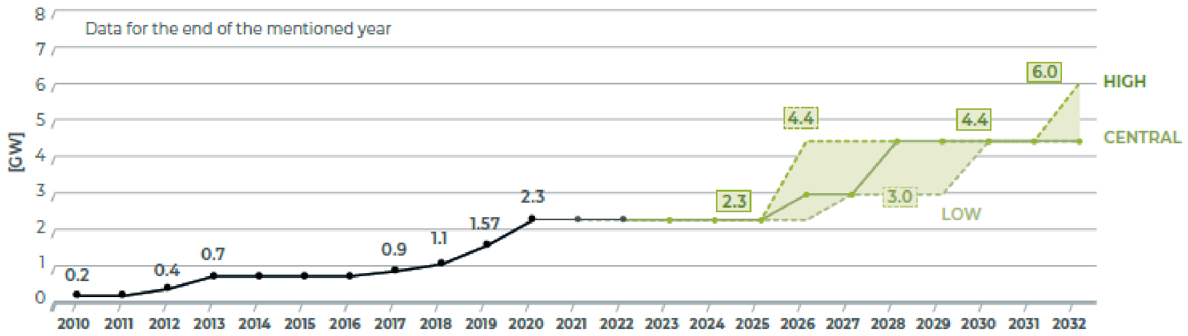


[FIGURE 3-20] — GEOGRAPHICAL DISTRIBUTION OF THE BELGIAN PHOTOVOLTAIC INSTALLED CAPACITY (SITUATION BEGINNING OF 2021)

[FIGURE 3-21] — EVOLUTION OF INSTALLED ONSHORE CAPACITY PER SCENARIO IN BELGIUM



[FIGURE 3-24] — EVOLUTION OF INSTALLED OFFSHORE WIND CAPACITY PER SCENARIO IN BELGIUM



[FIGURE 3-34] — SUMMARY OF ASSUMPTIONS FOR BELGIUM IN THE 'CENTRAL' SCENARIO

Key assumptions for Belgium

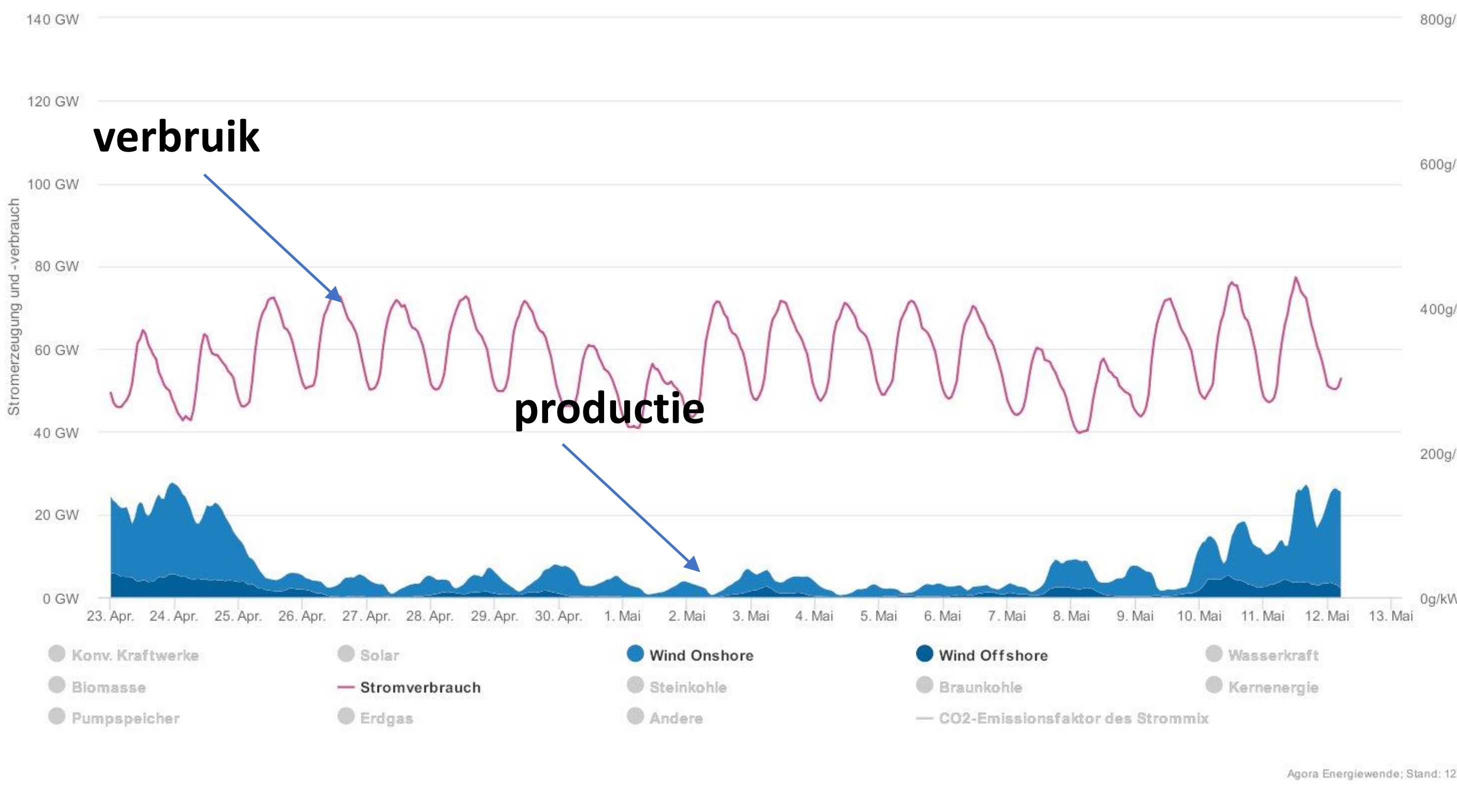
Data for the end of the mentioned year			2022	2025	2028	2030	2032
Demand and electrification		Energy efficiency Economic growth	Growth rates based on economic projections from the Federal Planning Bureau and additional electrification based on NECP				
		Amount of electric vehicles	0.1Mio	0.2Mio	1.0Mio	1.4Mio	1.8Mio
		Heat Pump penetration	1.0%	1.4%	2.7%	3.6%	4.5%
		Total Demand (incl. electrification) [TWh]	86.8	88.9	92.8	95.3	96.5
		Electrolysers [GW]	0	0.21	0.39	0.51	0.57
Demand Side Response		Shedding* [GW]	1.7	1.9	2.2	2.4	2.4
		Shifting [GWh/day]	0.2	0.5	1.1	1.5	1.5
Storage		Pumped storage [GW]	1.2	1.2	1.2	1.2	1.2
		Small, large and V2G batteries [GW]	0.2	0.6	1.1	1.6	1.6
RES	[GW]	Solar	6.1	8.0	9.8	11.0	12.2
		Onshore wind	3.0	3.7	4.4	4.9	5.4
		Offshore wind	2.3	2.3	4.4	4.4	4.4
		Hydro RoR	0.12	0.14	0.14	0.15	0.16
		Biomass + Waste	1.1	0.9	0.9	0.9	0.9
Thermal generation	[GW]	Nuclear	4.9	0			
		CHP	2.2		Possibility to extend lifetime of existing units if viable (economic viability assessment)		
		Existing CCGT/OCGT	4.4	4.1			
		Existing CCGT-CHP**	0.5	0.5			
		Turbojets	0.16	0.16			
New capacity		New capacity (DSM, Turbojets, CCGT, OCGT, Storage,...)	Possibility to invest in any new capacity if viable (EVA)				

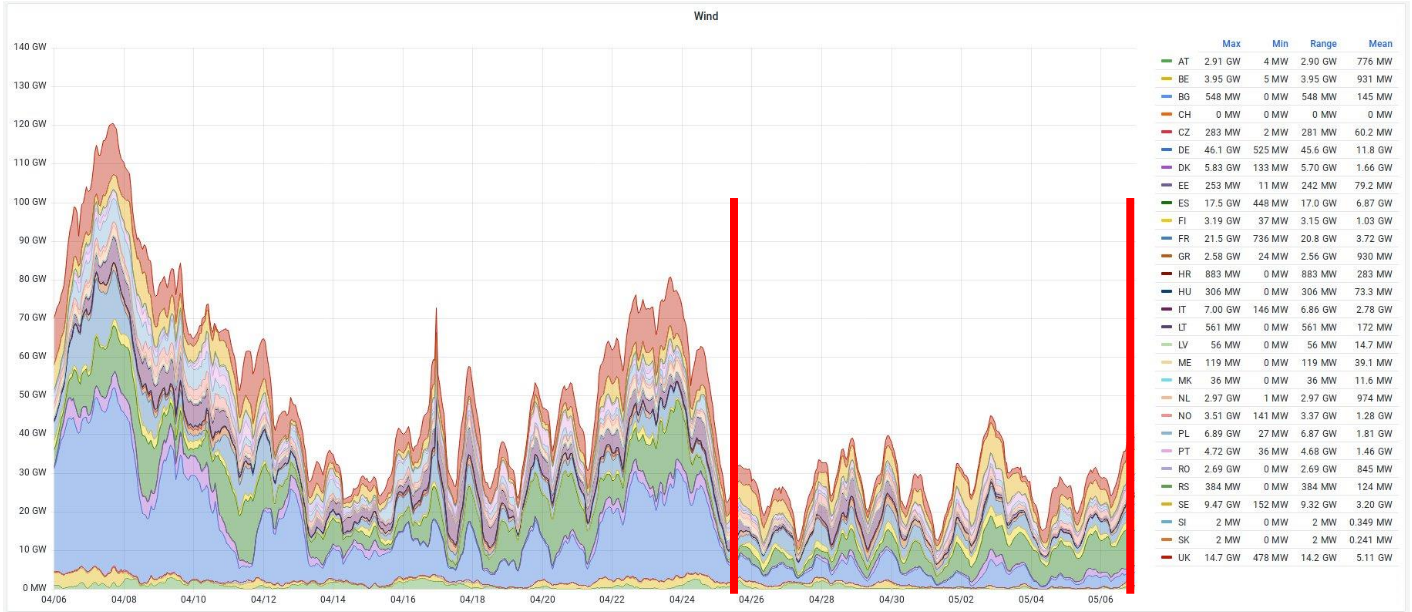
* including ancillary services volume

** Zandvliet and Inesco are categorised in CCGT-CHP to reflect their ability to operate in CHP mode

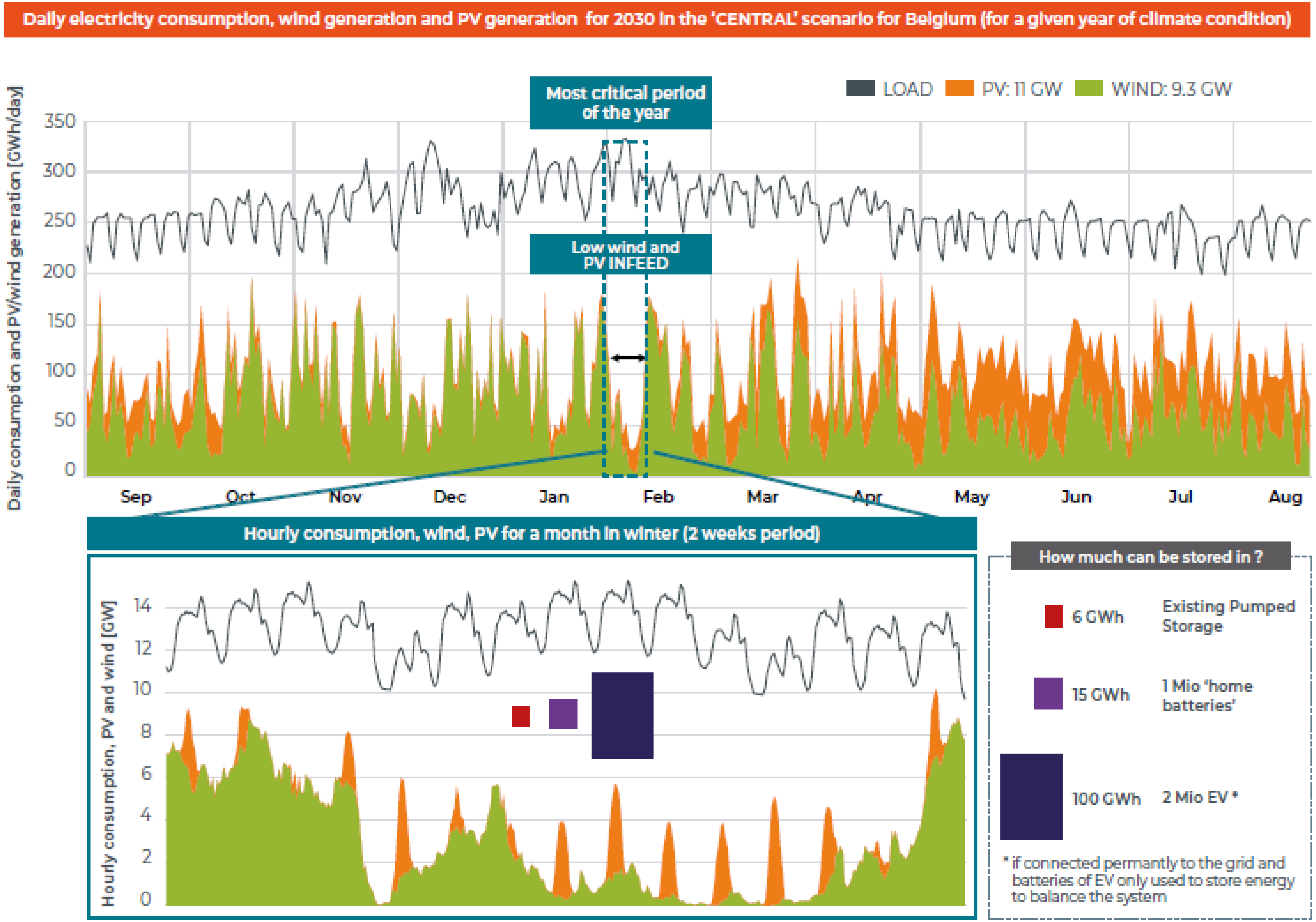
Back-up capaciteit?

- 26/04 – 09/05/2022 tussen 0-4 GW op 64 GW windenergie in Duitsland
- Zelfde patroon rest of EU/ VK in zelfde periode – tot 12 GW

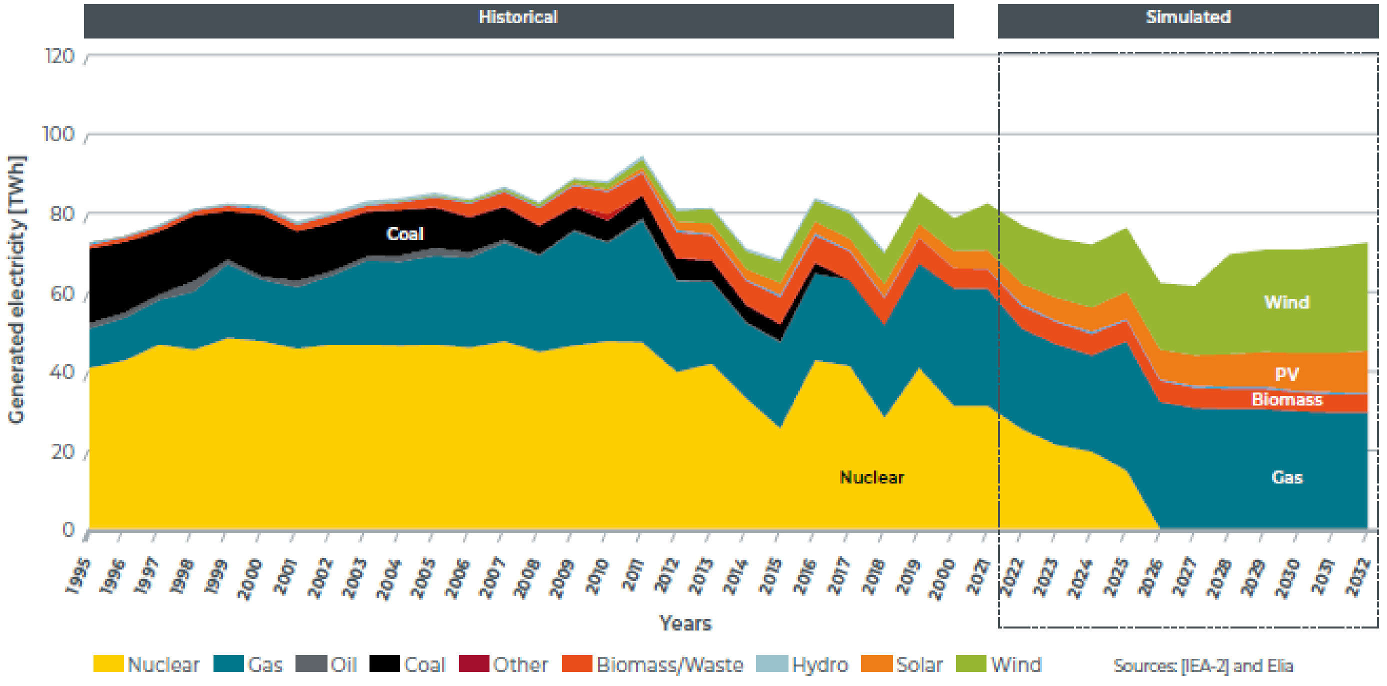




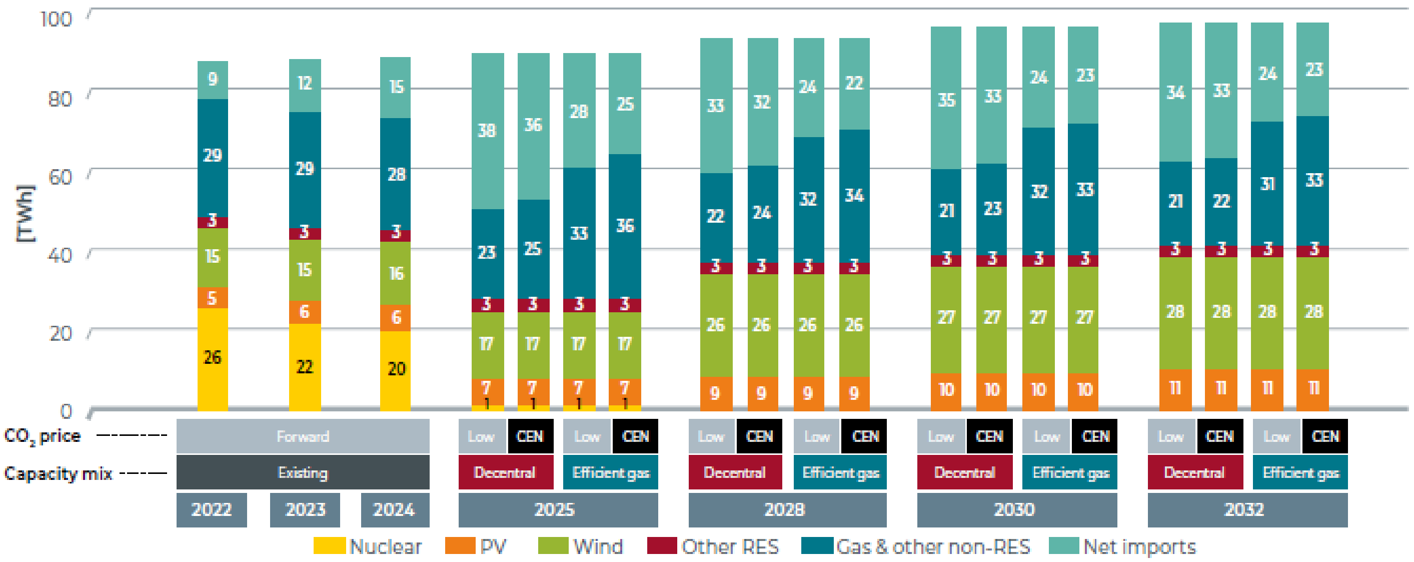
[FIGURE 5-30] — 'DUNKELFLAUTE' - LOW WIND AND PV INFEED DURING HIGH CONSUMPTION PERIODS

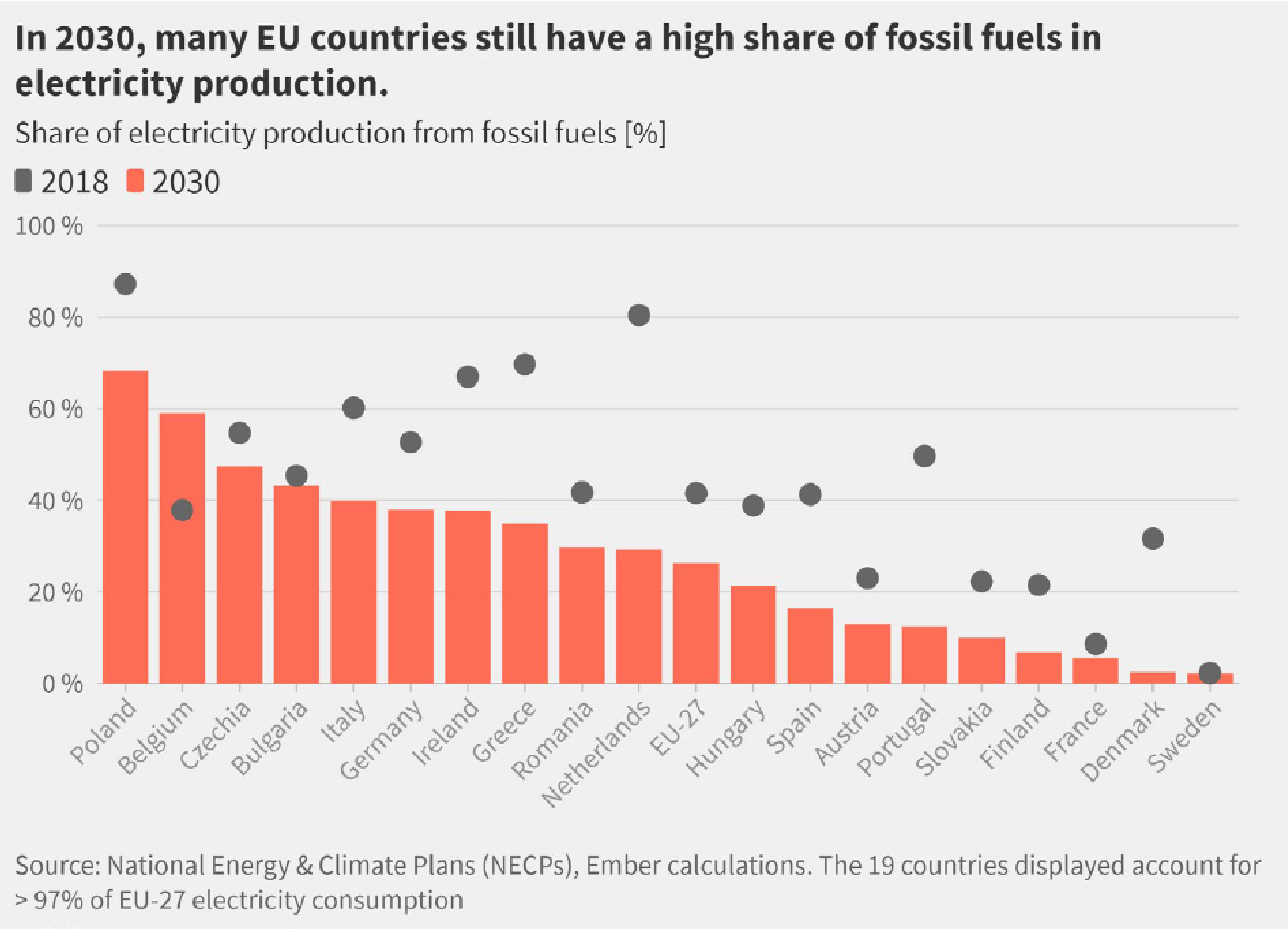


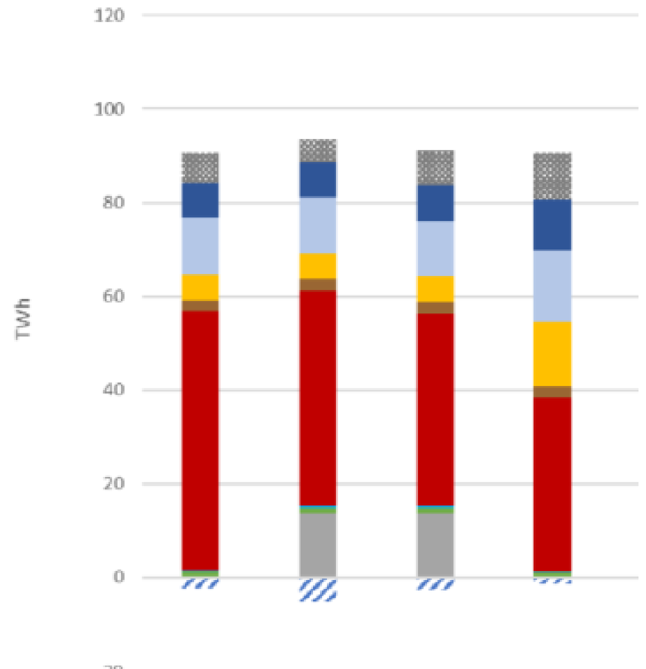
[FIGURE 5-65] — HISTORICAL AND FUTURE ELECTRICITY MIX IN BELGIUM IN THE EFFICIENT GAS SCENARIO



[FIGURE 5-66] — IMPACT OF CAPACITY MIX AND CO_2 PRICES ON THE FUTURE ELECTRICITY GENERATION MIX IN BELGIUM





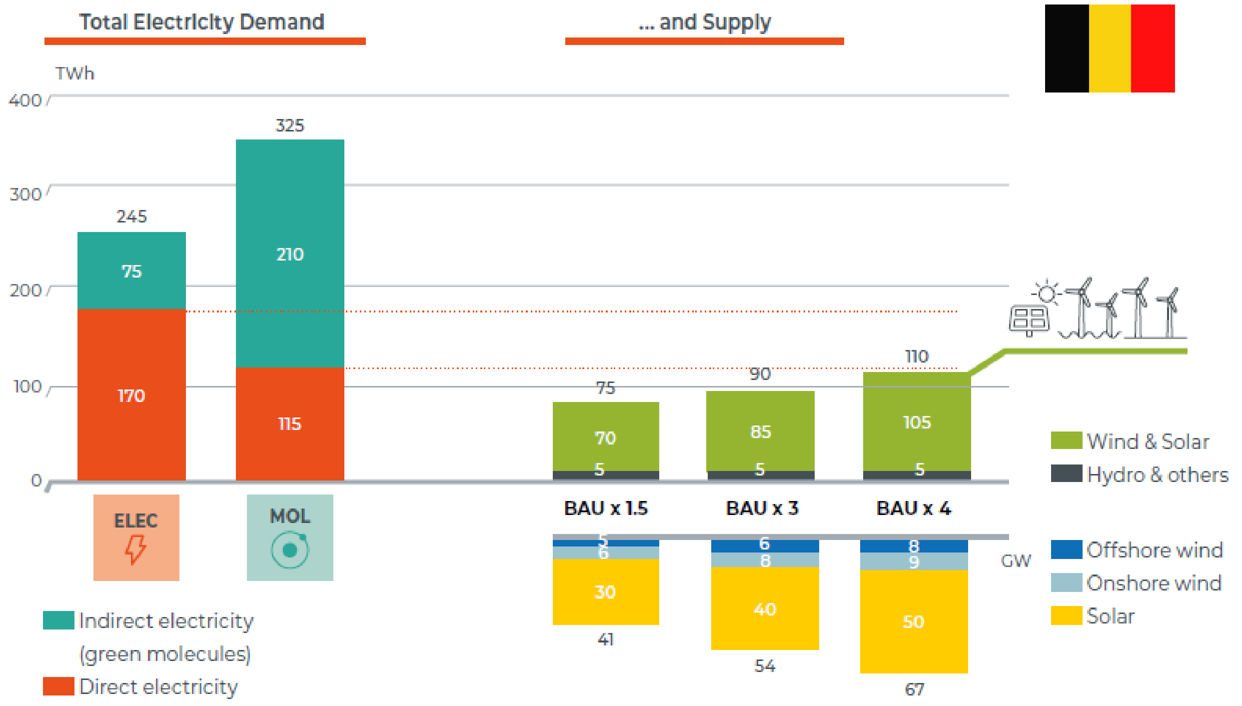


	Central Scenario	NUC10	NUC20	Central Scenario
		2026		
Exports	-2,31	-5,21	-2,71	-1,33
Imports	6,49	4,93	7,43	10,17
Wind Onshore	7,58	7,58	7,58	10,75
Wind Offshore	12,05	12,05	12,05	15,12
Solar PV	5,40	5,40	5,40	14,04
Other Fossil	2,41	2,41	2,41	2,29
Natural Gas	55,18	46,03	41,04	36,91
Hydro	0,38	0,38	0,38	0,38
Biomass & Other Ren.	1,25	1,25	1,25	1,01
Nuclear		13,63	13,63	

Energyville 2020

Elia – 'Roadmap to net zero' (2050)

FIGURE 10: COMPARISON BETWEEN THE TOTAL ELECTRICITY DEMAND AND THE ELECTRICITY SUPPLY FOR BOTH TRANSFORMATION PATHWAYS AND ALL THREE SUPPLY SCENARIOS FOR BELGIUM IN 2050

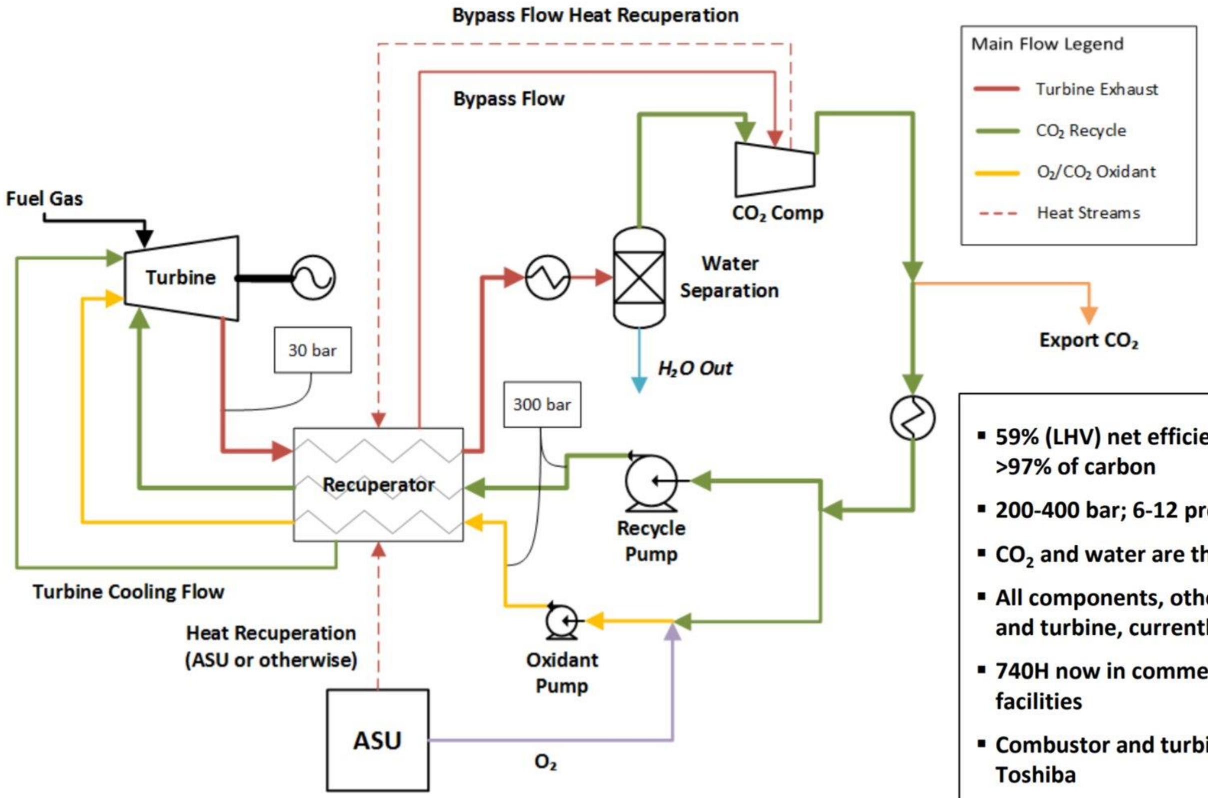


Dispatchable capacities are needed to cover sustained periods of low RES infeed.

In order to assess the need for additional dispatchable back-up capacities, a detailed adequacy analysis considering several climate years is performed within the market simulations (ELEC / BAUx3). The need for dispatchable capacities is driven both by developments on the demand side and on the supply side. On the supply side (as discussed above), the weather dependency of wind and solar power results in periods of sustained RES shortage that may last for several days up to several weeks. On the demand side, a strong increase of the annual electricity demand leads to higher peak electricity demand. Situations of low RES generation and high direct electricity demand define the need for additional back-up capacity.

The market simulations show that significant amounts of such dispatchable back-up capacity will be needed to ensure sufficient electricity supply at all times. Figure 28 depicts the dispatchable back-up capacity need on European level for ELEC/BAUx3. The stated ranges are related to the amount of available short-term flexibility and the level of European interconnection (see Annex A.3 for more information). The need is especially high in countries, such as Belgium and Germany that are short on large-scale hydro storage or other climate-neutral dispatchable generation technologies. As a result, the required back-up capacity for Belgium and Germany amounts to about 7.5 -15 GW and 40-70 GW respectively, depending on the level of flexibility and grid interconnection in the system. It is important to stress the level of uncertainty in these simulations. Hence, close monitoring of the need for dispatchable capacities on the road to net zero is required.

Flow Diagram of the Natural Gas Allam Cycle



- 59% (LHV) net efficiency, with capture of >97% of carbon
- 200-400 bar; 6-12 pressure ratio
- CO_2 and water are the only byproducts
- All components, other than combustor and turbine, currently available
- 740H now in commercial use at two facilities
- Combustor and turbine developed by Toshiba

3 RIVERS NETPOWER

Gas

UK's First Gas-Fired Allam Cycle Power Plant Taking Shape

The inventor of the Allam-Fetvedt Cycle, a novel power cycle that uses supercritical carbon dioxide (sCO_2), is collaborating with a subsidiary of Singapore-based Sembcorp Industries to potentially develop the UK's first 300-MW natural gas–fired NET Power station at an existing site at Teesside, northeastern England.

Rolls-Royce

Rolls-Royce expects UK approval for small nuclear reactors by mid-2024

Boss says he hopes to be providing power to the national grid by 2029

Jasper Jolly

@jjpjolly

Tue 19 Apr 2022 11.20 BST

A digital mock-up of a Rolls-Royce small modular reactor. Photograph: Rolls Royce/Studio Archetype

Rolls-Royce is to start building parts for its small modular nuclear reactors in anticipation of receiving regulatory approval from the British government by 2024, one of its directors has said.

Paul Stein, the chairman of Rolls-Royce SMR, a subsidiary of the FTSE 100 engineering company, said he hoped to be providing power to the UK's national grid by 2029.

- **Flexible power generation** ('Gas to Power'): Low carbon hydrogen can play an important role in providing flexible power generation such as such as through rapid operating 'peaker' plants and larger scale but less flexible Combined Cycle Gas Turbines (CCGTs), helping to meet short- and longer-term peaks in demand. This hydrogen could be used either as a blend or at 100 per cent and would be supplied by pipeline or through access to storage. Our analysis[47] indicates that by 2030, we could see a small but important role for low carbon hydrogen to generate power, with demand for hydrogen in power ranging from 0-10TWh. We expect to see further ramp up beyond 2030: hydrogen demand could increase to 10-30TWh in 2035, and 25-40TWh by 2050. Using hydrogen in this way could also play a role in establishing secure offtake for hydrogen production projects in the near term.

October 4, 2021
12:26 PM CEST
Last Updated 5 hours ago

Energy

All Britain's electricity to be green by 2035 - The Times

1 minute read

Reuters

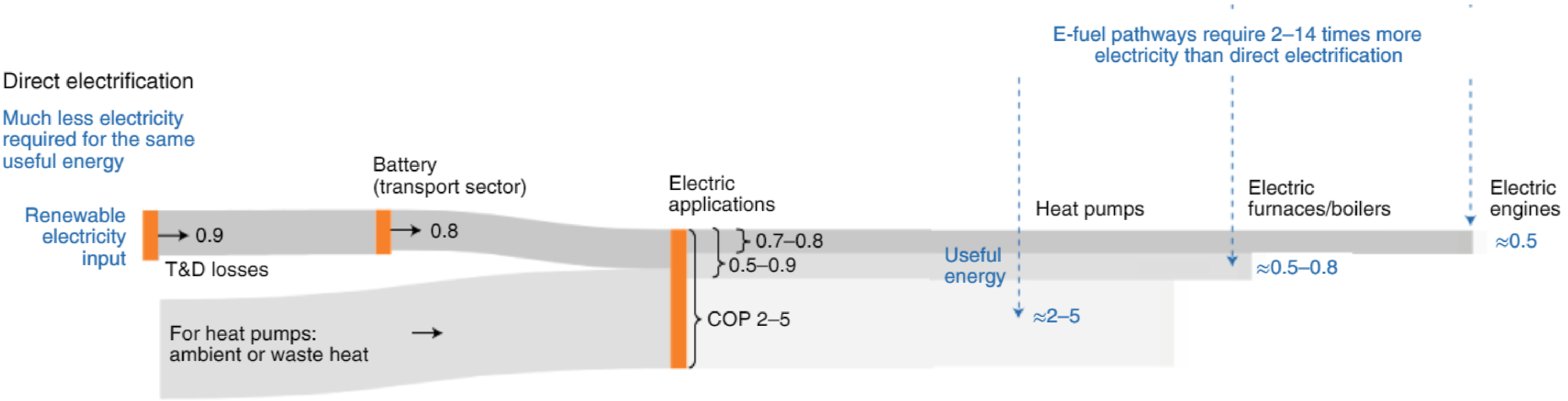
Power sector - conclusies

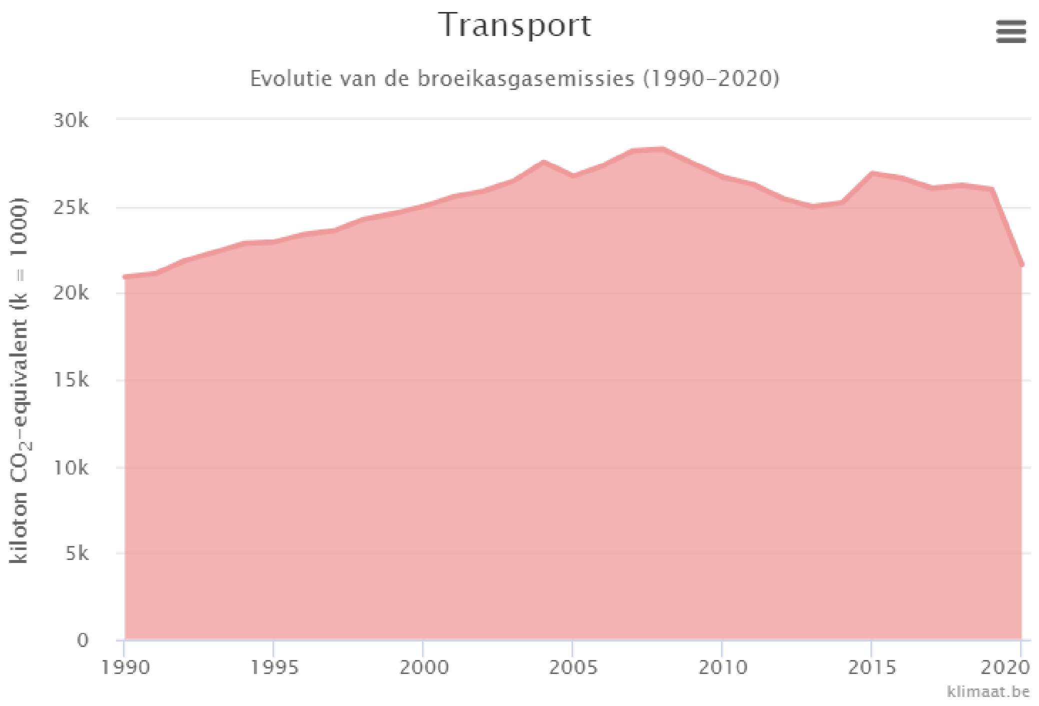
- België niet op weg voor zero carbon 2035. https://ember-climate.org/app/uploads/2022/02/Vision-or-division.pdf
- Belangrijke groei hernieuwbare energie
- Mogelijk extra e-vraag door ‘fit for 55’, waterstof en carbon capture
- Interconnectiviteit / vraagsturing/ import
- Waterstofcentrales/ power to gas enkel voor piekvraag
- Nucleair (base load) en hernieuwbaar complementair
- Innovaties Allam cycle, SMR’s, oxyfuels & carbon capture

Transport en gebouwen

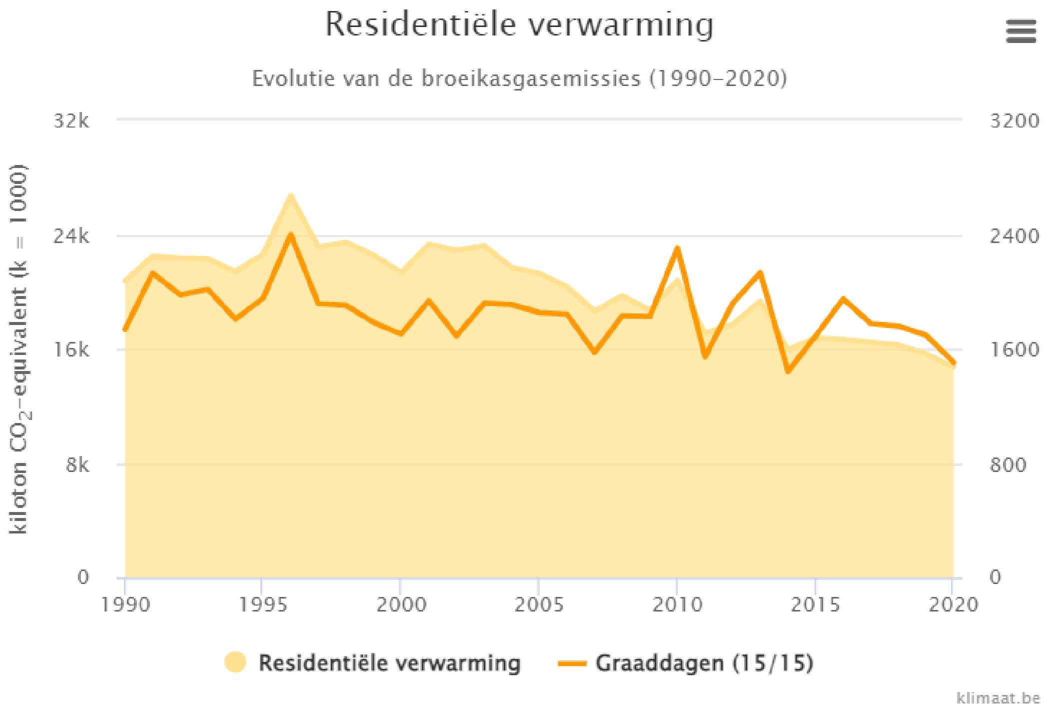
Potential and risks of hydrogen-based e-fuels in climate change mitigation (Nature)

https://klimaat.be/in-belgie/klimaat-en-uitstoot/klimaat





Transport
Evolutie van de broeikasgasemissies (1990-2020)
kiloton CO2-equivalent (k = 1000)
30k
25k
20k
15k
10k
5k
0
1990
1995
2000
2005
2010
2015
2020
klimaat.be



Residentiële verwarming
Evolutie van de broeikasgasemissies (1990-2020)
kiloton CO2-equivalent (k = 1000)
32k
24k
16k
8k
0
3200
2400
1600
800
0
1990
1995
2000
2005
2010
2015
2020
Residentiële verwarming
Graaddagen (15/15)
klimaat.be

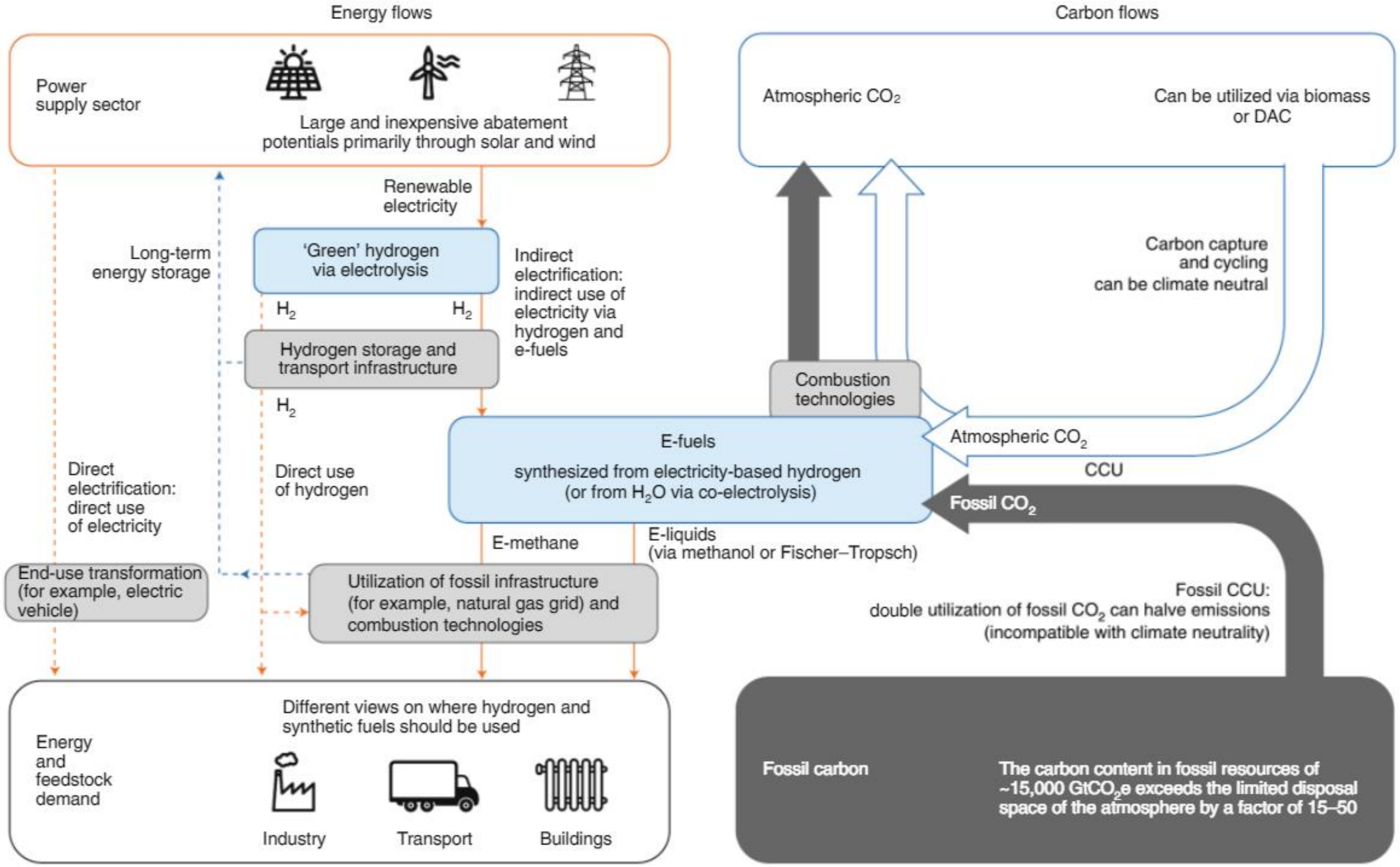
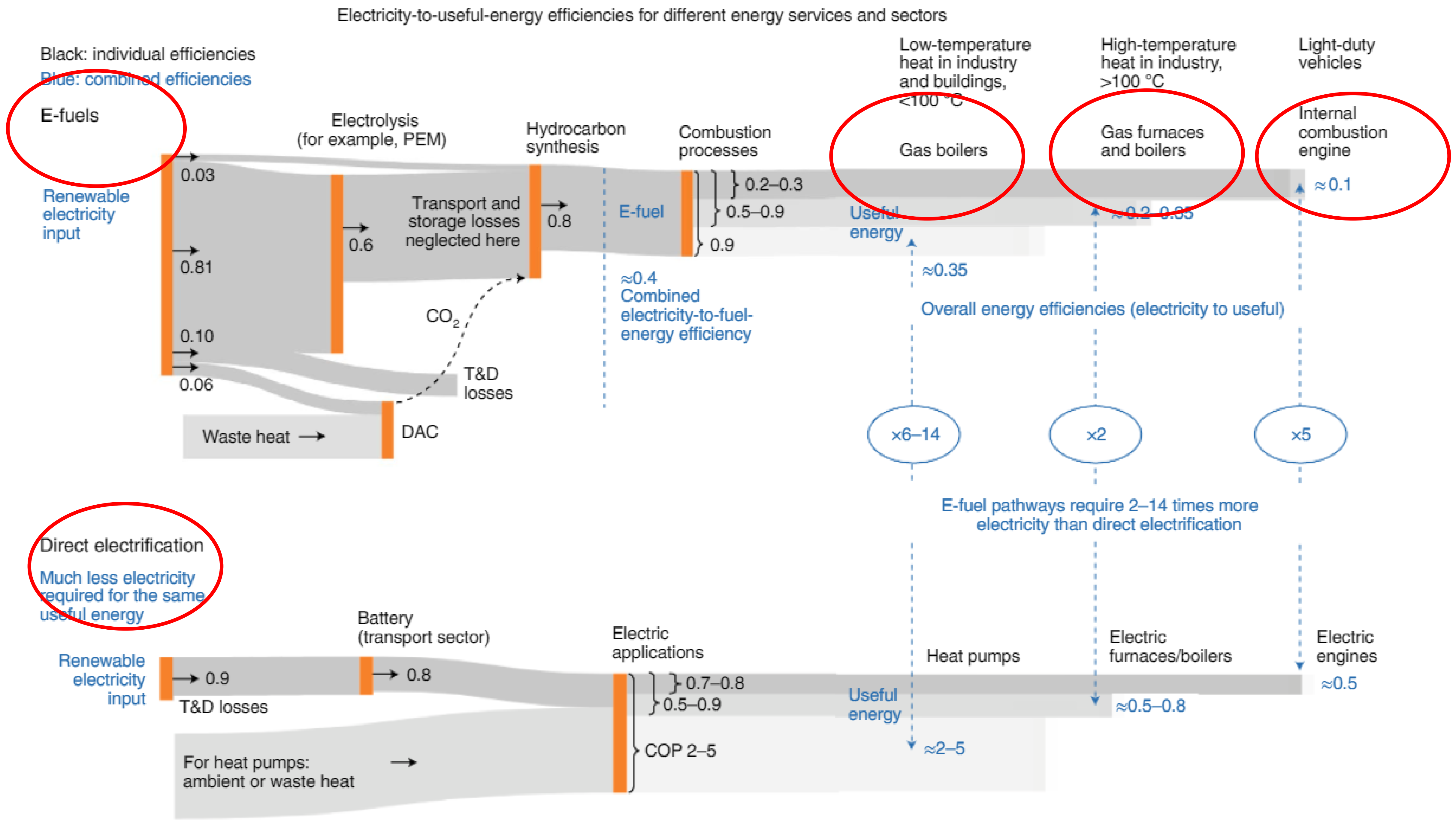
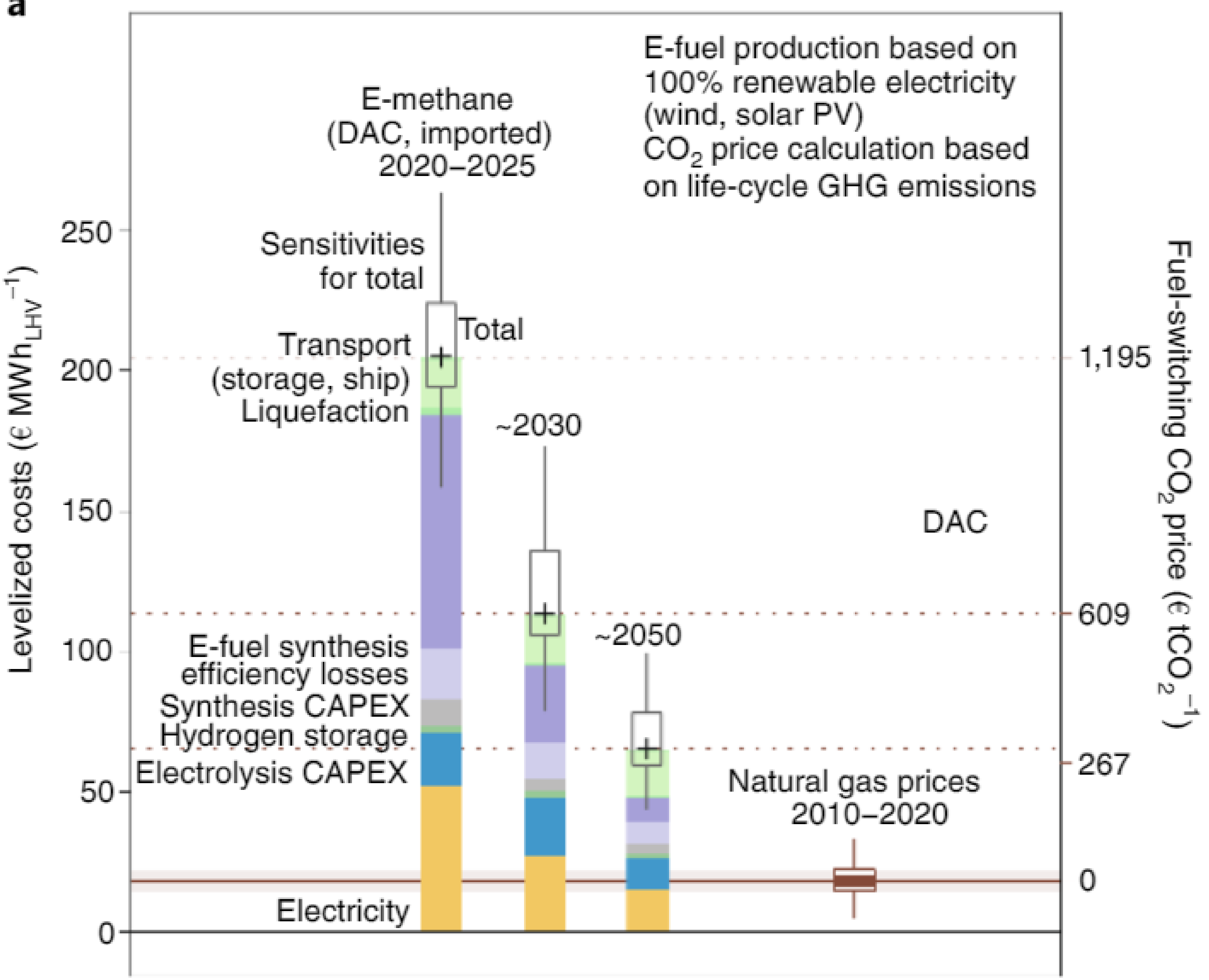


Fig. 1 | Basic principle of e-fuels in an energy system. Left: energy flows. E-fuels and hydrogen are forms of indirect electrification in which (renewable) electricity can be used via electrolysis and e-fuel synthesis to meet energy demands that rely on gaseous and liquid fuels. A competing option is direct electrification, which requires an end-use transformation to electric applications. Right: carbon flows associated with e-fuels when using CO_2 from atmospheric or fossil sources. Only utilizing atmospheric CO_2 (through biomass or DAC) creates a carbon cycle that is compatible with carbon neutrality.



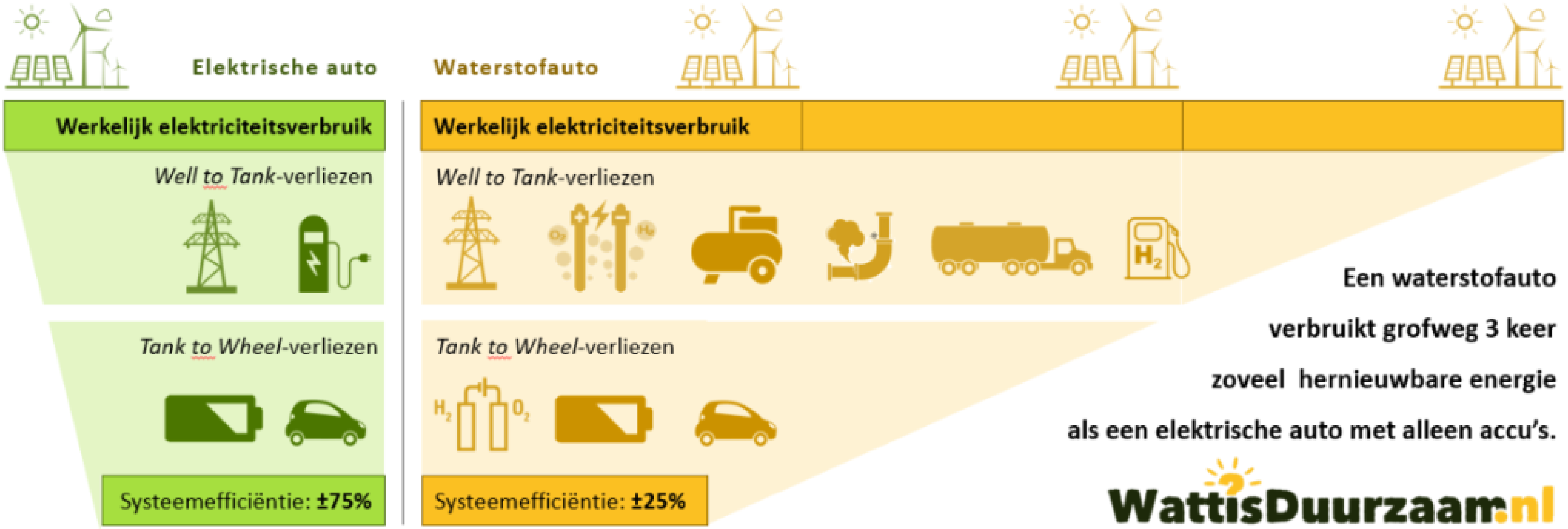
Electricity-to-useful-energy efficiencies for different energy services and sectors
Black: individual efficiencies
Blue: combined efficiencies
E-fuels
Renewable electricity input
0.03
0.81
0.10
0.06
Electrolysis (for example, PEM)
0.6
Transport and storage losses neglected here
Hydrocarbon synthesis
0.8
CO2
T&D losses
Waste heat
DAC
E-fuel
≈0.4 Combined electricity-to-fuel-energy efficiency
Combustion processes
0.2–0.3
0.5–0.9
0.9
Low-temperature heat in industry and buildings, <100 °C
Gas boilers
High-temperature heat in industry, >100 °C
Gas furnaces and boilers
Light-duty vehicles
Internal combustion engine
Useful energy
≈0.35
≈0.2–0.35
≈0.1
Overall energy efficiencies (electricity to useful)
×6–14
×2
×5
E-fuel pathways require 2–14 times more electricity than direct electrification
Direct electrification
Much less electricity required for the same useful energy
Renewable electricity input
0.9
T&D losses
Battery (transport sector)
0.8
For heat pumps: ambient or waste heat
Electric applications
0.7–0.8
0.5–0.9
COP 2–5
Useful energy
Heat pumps
≈2–5
Electric furnaces/boilers
≈0.5–0.8
Electric engines
≈0.5



a
E-fuel production based on
100% renewable electricity
(wind, solar PV)
CO_2 price calculation based
on life-cycle GHG emissions
E-methane
(DAC, imported)
2020–2025
Sensitivities
for total
Total
Transport
(storage, ship)
Liquefaction
~2030
~2050
DAC
E-fuel synthesis
efficiency losses
Synthesis CAPEX
Hydrogen storage
Electrolysis CAPEX
Electricity
Natural gas prices
2010–2020
Levelized costs (€ MWh_{LHV}^{-1})
Fuel-switching CO_2 price (€ tCO_2^{-1})
0
50
100
150
200
250
1,195
609
267
0

Waterstof voor transport?

- Waterstof is een belangrijke energiedrager voor de toekomst, maar niet voor auto's.



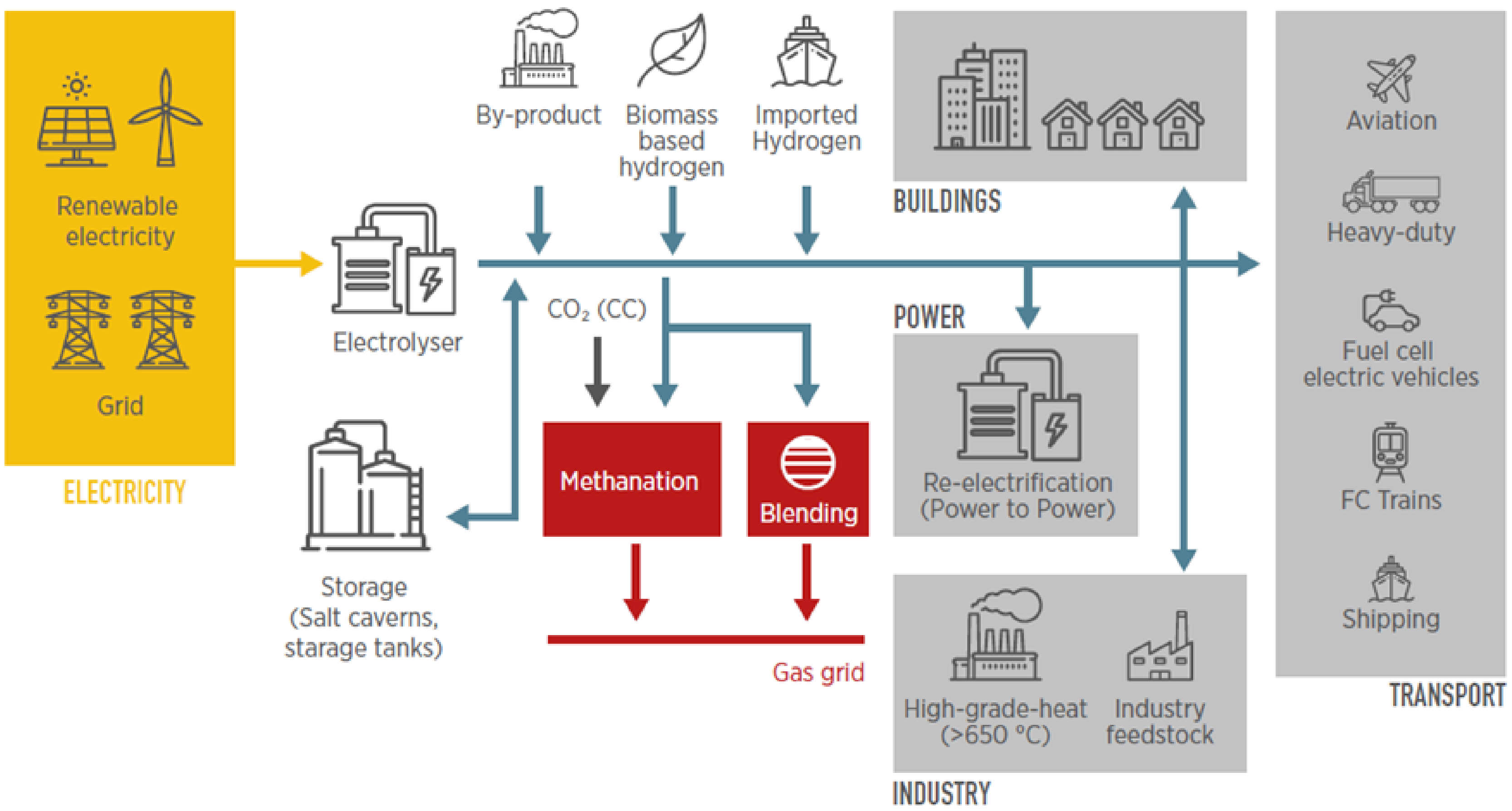
Transport en gebouwen - conclusies

- Pad via elektrificatie, warmtenetwerken steden
- E-fuels voor 'hard/ impossible to electrify': lucht- en scheepvaart
- E-gas voor verwarming niet efficiënt tov elektrificatie (1/8)
- Zwaar wegtransport – balans e-fuels/ waterstof en elektrificatie
- Rol NH3 voor vliegtuigmotoren?
- Meer deelgebruik transport
- Slechts zeer geleidelijke daling uitstoot

Key technologies

1. Waterstof/ carbon capture (niet DAC)
2. Hernieuwbare energie
3. Storage en interconnectiviteit
4. *Minerals - scarcity*
5. Elektrificatie en efficiëntie
6. Nucleair

Hydrogen, the most abundant chemical element in the universe, is an energy carrier that emits only water vapour and heat when burned with pure oxygen.



The colour of hydrogen

Not all hydrogen is created equal when it comes to its green credentials. True green hydrogen is produced through electrolysis, which separates water into hydrogen and oxygen using electricity from renewable sources such as wind or solar power. Yet, according to the IEA, this accounts for only 0.1% of global hydrogen production. Professor Nilay Shah from the Department of Chemical Engineering at Imperial College London and a member of the UK government's Hydrogen Advisory Council, explains: "The bulk of hydrogen currently in use is grey and probably most of the low-carbon hydrogen in the near future will be blue."

Grey hydrogen is produced by steam reformation of natural gas, which creates emissions. Blue hydrogen is produced in the same way, but the CO2 emissions are then captured and permanently stored, making it a greener

Bron: International Energy Agency

Waterstofplannen…

- Commercieel 5-20 MW (alkaline) elektrolysers
- Evolutie 100 MW PEM (proton exchange membrane) – variable load!
- TNO studie in NL
  - 400-450 TWh elektriciteit
  - 100 GW windtubines off shore
  - 1.5 miljoen ton/j vandaag naar 18 miljoen ton/j
  - Kost 3 * grijze H2
- Vandaag 2.5 GW wind NL off shore, plannen naar 11 GW

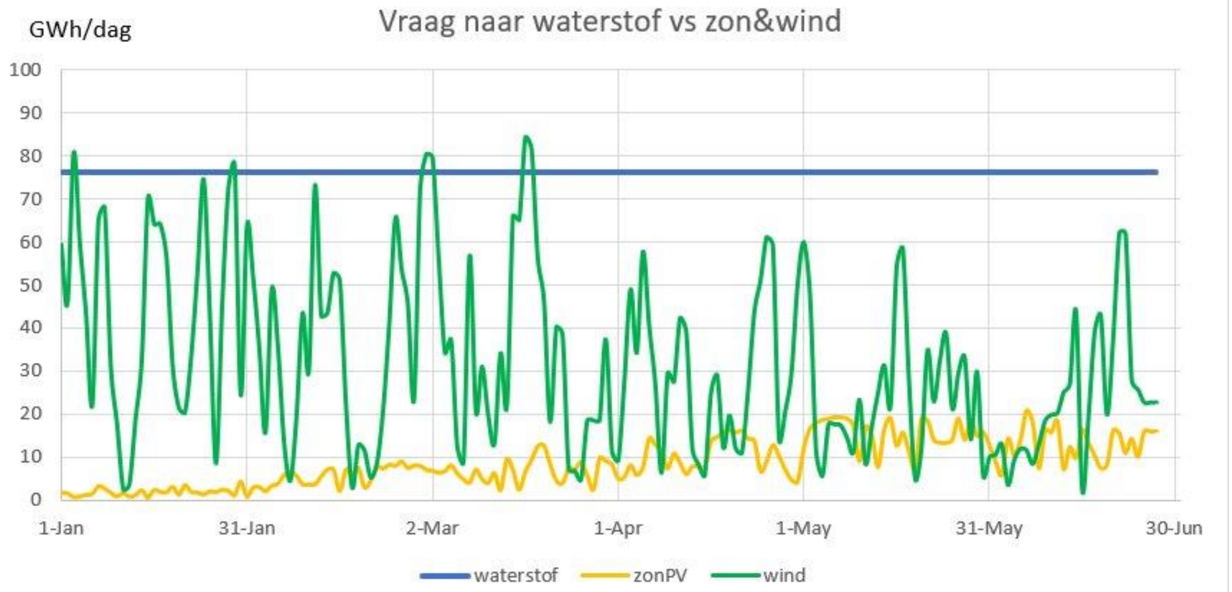

fd. Mijn nieuws Net binnen Beurs Krant

ENERGIE

Waterstofplannen vragen vier keer zoveel stroom als totale verbruik in Nederland nu

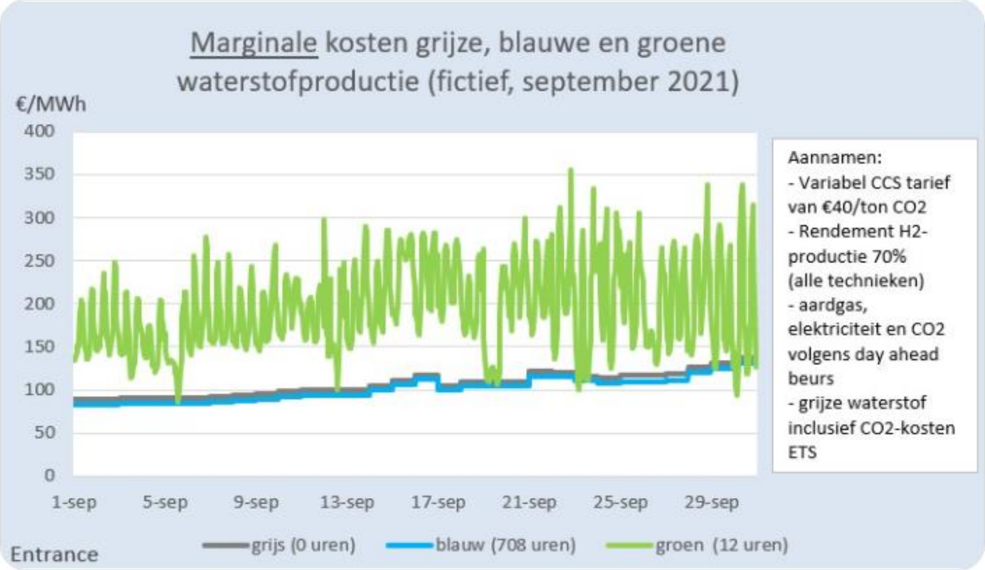
Bert van Dijk 20 sept 16:30

Voor de Nederlandse waterstofplannen in 2050 zou straks 100 gigawatt aan windenergie op zee nodig zijn. Op dit moment staat er in de Nederlandse kustwateren 2,5 gigawatt. Foto: Nicolas Economou/ANP



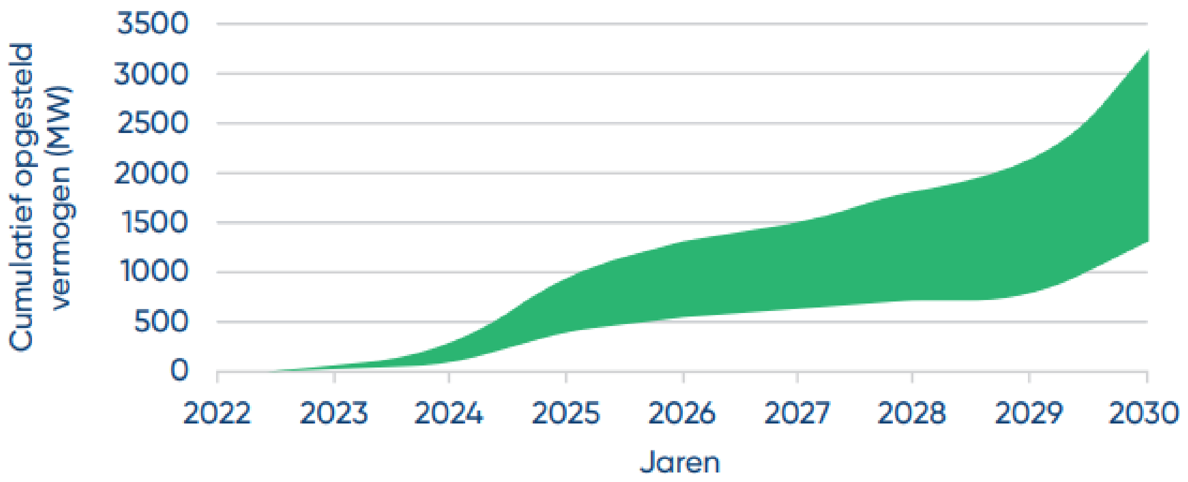
Martien Visser
@BM_Visser

Nauwelijks wind in september. Dan ga je dus in een (fictieve) waterstofeconomie geen groene waterstof maken. En dat klopt. Op slechts 12 uurtjes was de elektriciteitsprijs zo laag, dat de productie van groene waterstof lonend zou zijn geweest.
#grafiekvandedag



7:39 p.m. · 7 okt. 2021 · Twitter Web App

Figuur 1. Projectenportfolio voor **groene** waterstofproductie in North Sea Port (inclusief onzekerheidsmarge)

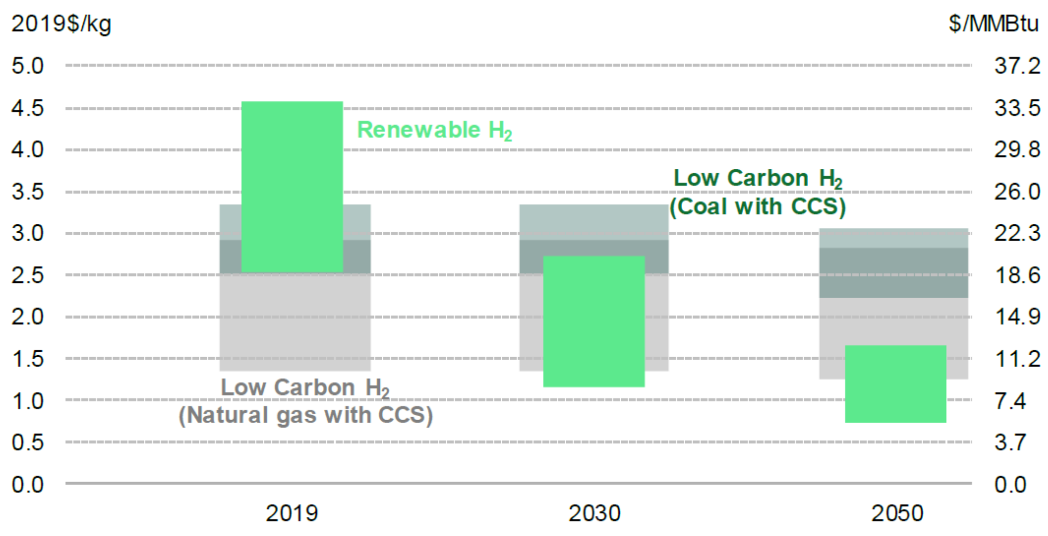


2 Bij Autothermal Reforming (ATR) kan de vrijkomende CO_2 bijna geheel worden afgevangen, waar dat bij SMR's voor grofweg ruim de helft van de vrijkomende CO_2 mogelijk is

3 Cijfers op basis van huidige projectontwikkeling binnen North Sea Port

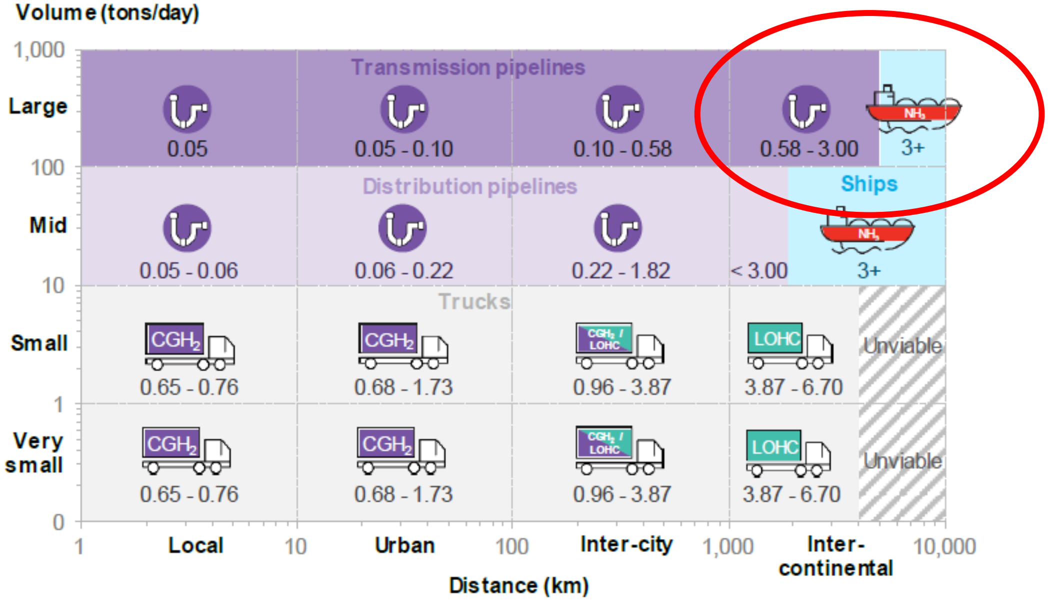
Hydrogen economy – Bloomberg 2020

Figure 3: Forecast global range of levelized cost of hydrogen production from large projects



Source: BloombergNEF. Note renewable hydrogen costs based on large projects with optimistic projections for capex. Natural gas prices range from $1.1-10.3/MMBtu, coal from $30-116/t.

Figure 4: H_2 transport costs based on distance and volume, $/kg, 2019



Legend: Compressed H_2 Liquid H_2 Ammonia Liquid Organic Hydrogen Carriers

Source: BloombergNEF. Note: figures include the cost of movement, compression and associated storage (20% assumed for pipelines in a salt cavern). Ammonia assumed unsuitable at small scale due to its toxicity. While LOHC is cheaper than LH_2 for long distance trucking, it is less likely to be used than the more commercially developed LH_2.

Hydrogen Economy Outlook– Bloomberg 2020

Table 1: Hydrogen storage options

	Gaseous state				Liquid state			Solid state
	Salt caverns	Depleted gas fields	Rock caverns	Pressurized containers	Liquid hydrogen	Ammonia	LOHCs	Metal hydrides
Main usage (volume and cycling)	Large volumes, months-weeks	Large volumes, seasonal	Medium volumes, months-weeks	Small volumes, daily	Small - medium volumes, days-weeks	Large volumes, months-weeks	Large volumes, months-weeks	Small volumes, days-weeks
Benchmark LCOS ($/kg)[1]	$0.23	$1.90	$0.71	$0.19	$4.57	$2.83	$4.50	Not evaluated
Possible future LCOS[1]	$0.11	$1.07	$0.23	$0.17	$0.95	$0.87	$1.86	Not evaluated
Geographical availability	Limited	Limited	Limited	Not limited	Not limited	Not limited	Not limited	Not limited

Source: BloombergNEF. Note: [1] Benchmark levelized cost of storage (LCOS) at the highest reasonable cycling rate (see detailed research for details). LOHC – liquid organic hydrogen carrier.

LNG to H2 – Bloomberg 05/2022

A rendering of the TES clean energy hub in Wilhelmshaven, Germany *Photographer: Source: TES*

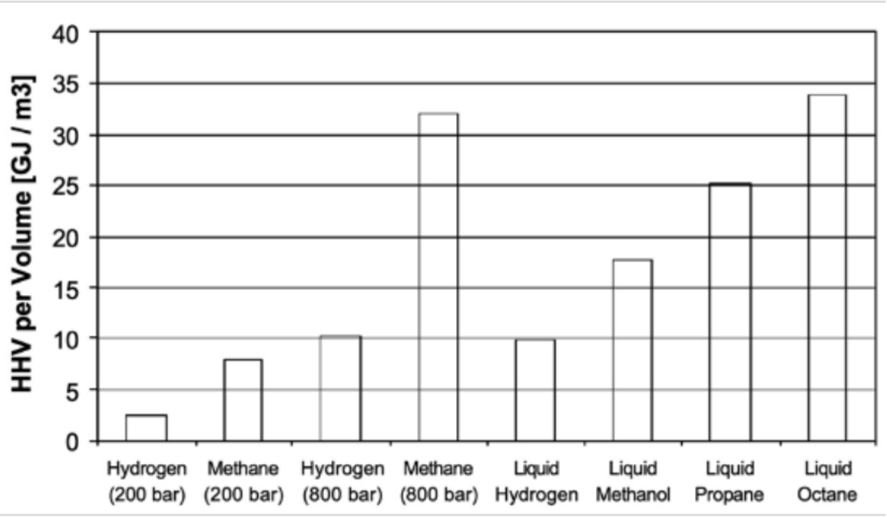
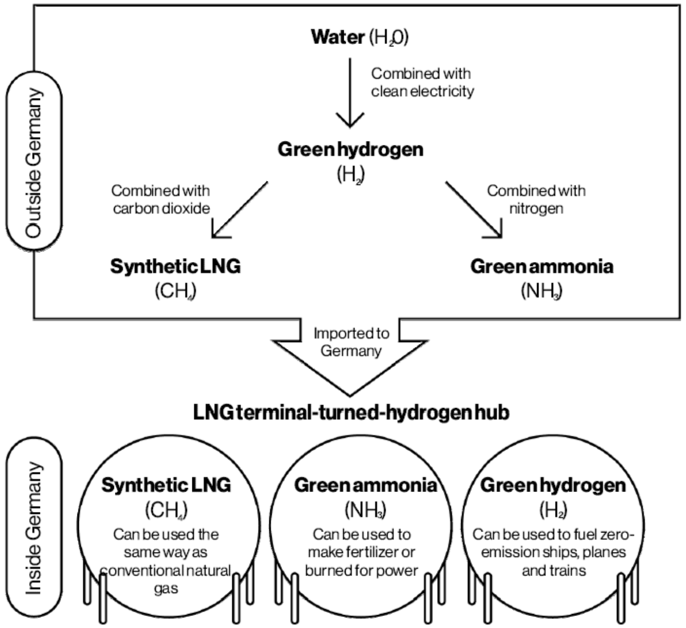


Fig. 15: Energy density of gasous and liquid fuels [17]

What Goes In and Comes Out of a Hydrogen Hub



LNG to H2 – Bloomberg

- 2.5 billions investment in LNG Wilhemshaven
- LNG -160°C vs H2 -252°C and NH3 -33°C
- Complete different vessels and pipelines for H2
- NH3 pumps/ HN3 cracking energy intensive
- E-methane as 4th option → crack to H2 and ship the CO2

Green

Clean Energy, Faster

How Germany's LNG Terminals Will Morph Into Green Hydrogen Hubs

Germany is building more LNG terminals to make up for the loss of Russian gas. In a few years, some of that infrastructure could be used to handle green fuels that power grids and heat homes.

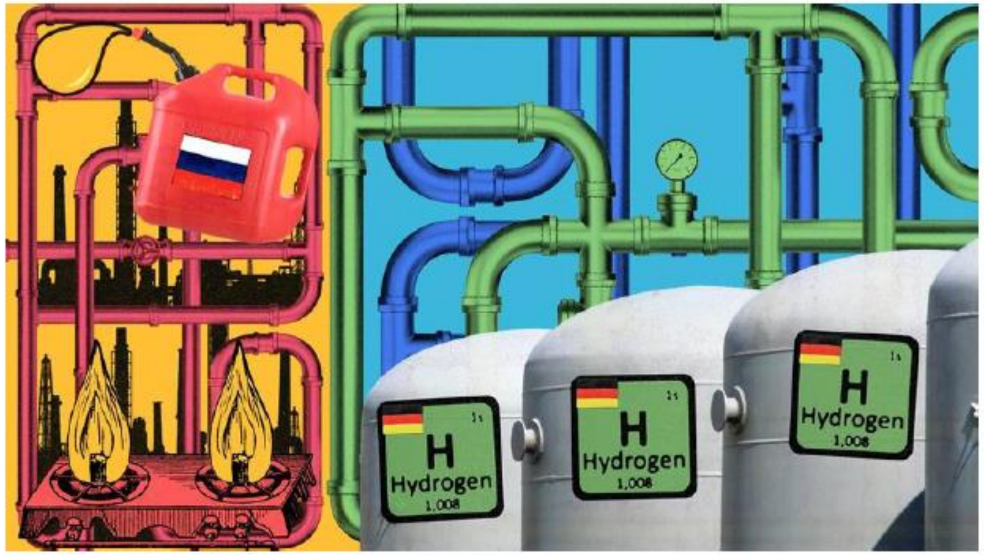
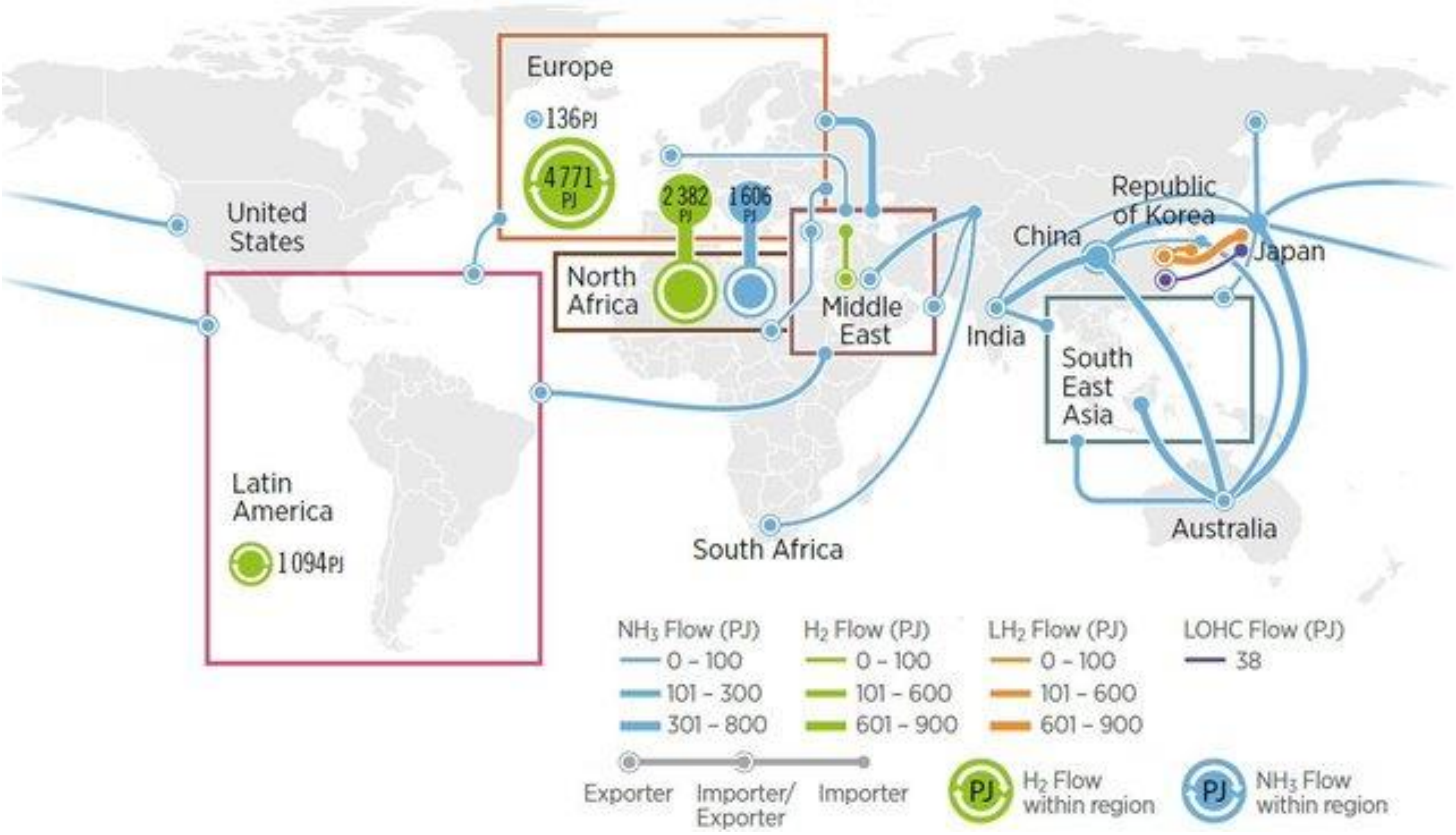


Photo illustration: Stephanie Davidson; Photos: Getty (6)

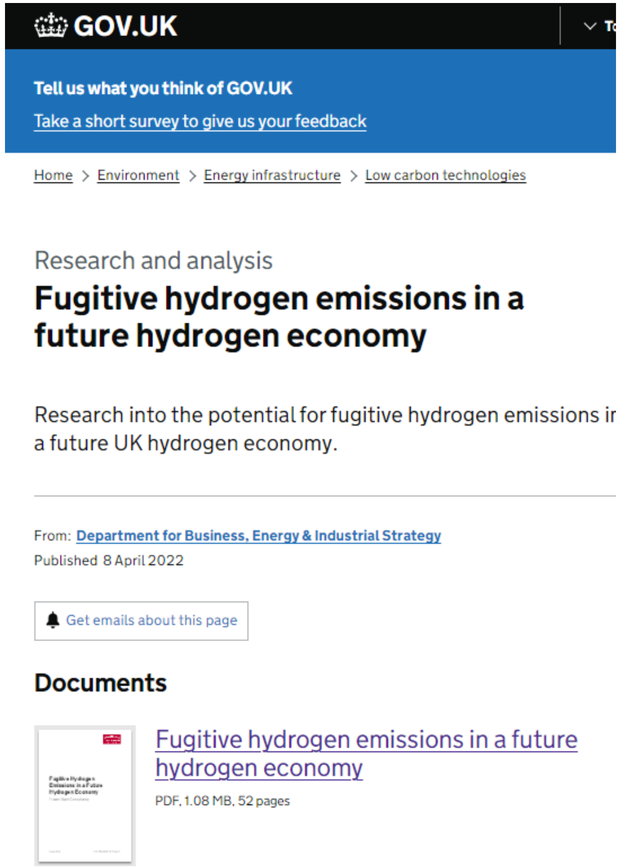
By Anna Shiryaevskaya

May 12, 2022, 7:00 AM GMT+2

FIGURE 5.11 Global hydrogen trade map in 2050 under optimistic technology assumptions



Fugitive emisisons 1-1.5%/j – GOV.UK


GOV.UK

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Home > Environment > Energy infrastructure > Low carbon technologies

Research and analysis

Fugitive hydrogen emissions in a future hydrogen economy

Research into the potential for fugitive hydrogen emissions ir a future UK hydrogen economy.

From: Department for Business, Energy & Industrial Strategy

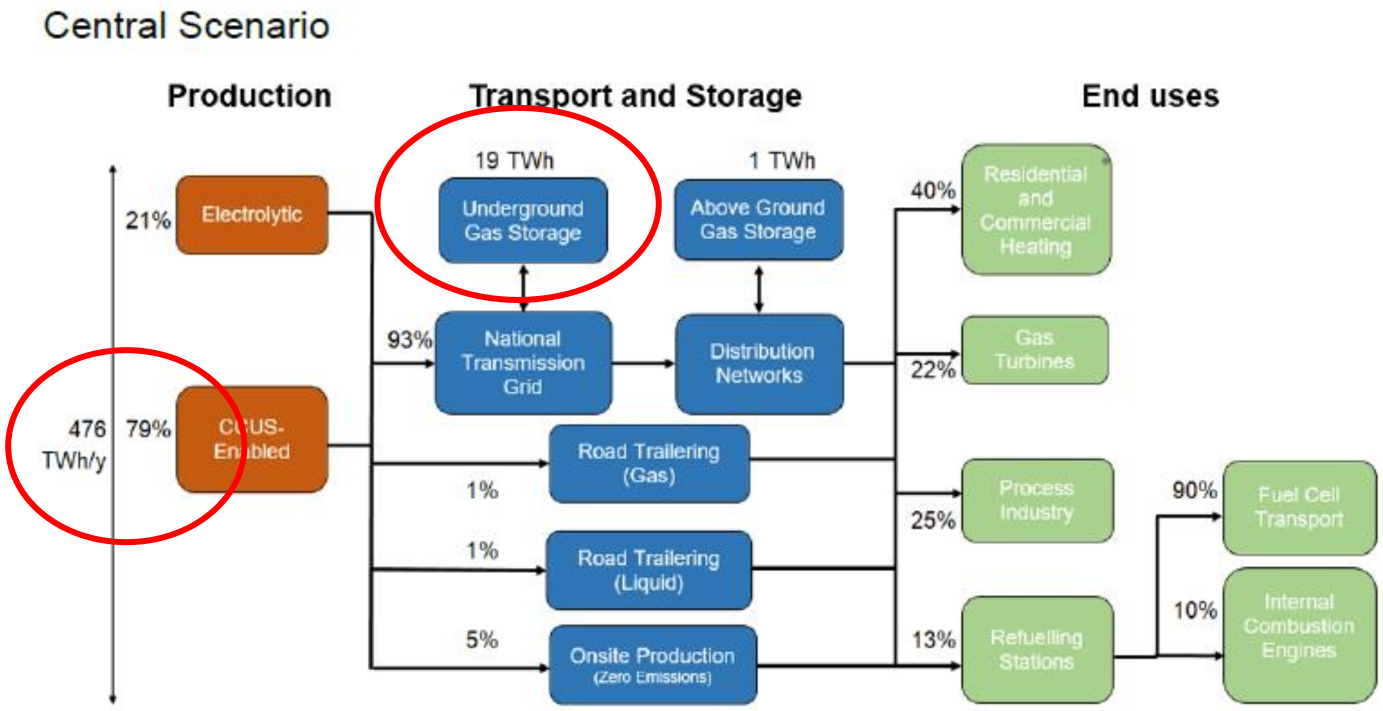
Published 8 April 2022

Get emails about this page

Documents

Fugitive hydrogen emissions in a future hydrogen economy

PDF, 1.08 MB, 52 pages



2050 hydrogen economy

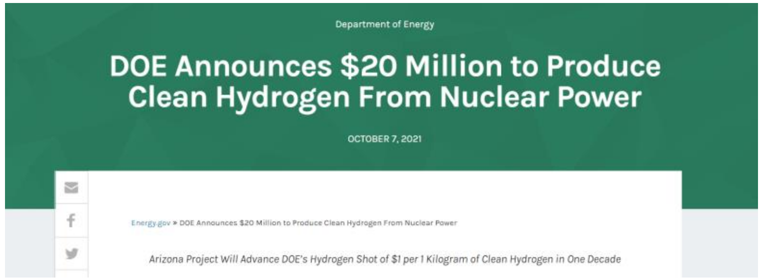
Daar is paarse waterstof…

- steam elektrolyse > 800°
- Sulfur-Iodine cycle (hoge temperatuur)
- Aankondiging US naar ontwikkeling hydrogen from nuclear @ 1USD/kg!
- Idem Japan, FR, VK, China


Accueil > Entreprises et marchés

Les actions de l'hydrogène cartonnent en Bourse, dopées par France 2030 : le conseil du jour

HYDROGÈNE SUIVRE CE SUJET

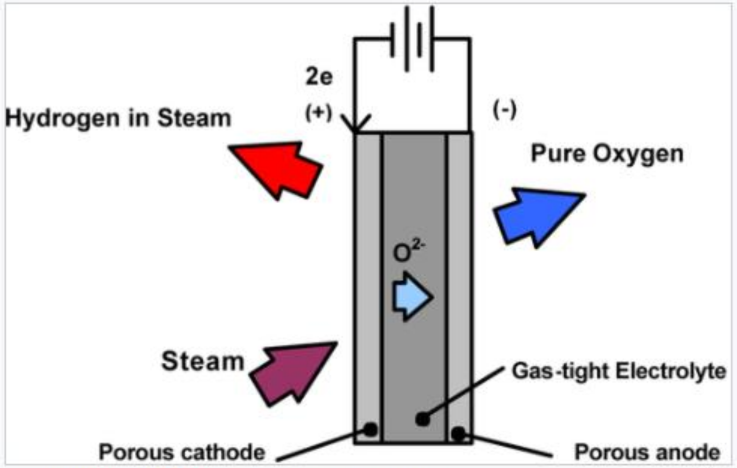

Department of Energy

DOE Announces $20 Million to Produce Clean Hydrogen From Nuclear Power

OCTOBER 7, 2021

Energy.gov » DOE Announces $20 Million to Produce Clean Hydrogen From Nuclear Power

Arizona Project Will Advance DOE's Hydrogen Shot of $1 per 1 Kilogram of Clean Hydrogen in One Decade



High-temperature electrolysis schema.


UK hydrogen strategy: a role for nuclear?

15 September 2021

Hydrogen is attracting growing interest worldwide, not least in the UK, where an H2 strategy has recently been launched. The nuclear industry sees significant opportunities

Heysham nuclear power plant (photo: EDF Energy)

Does nuclear have a role in UK hydrogen production?

In common with many other countries, the UK now has a hydrogen

Waterstof - conclusies

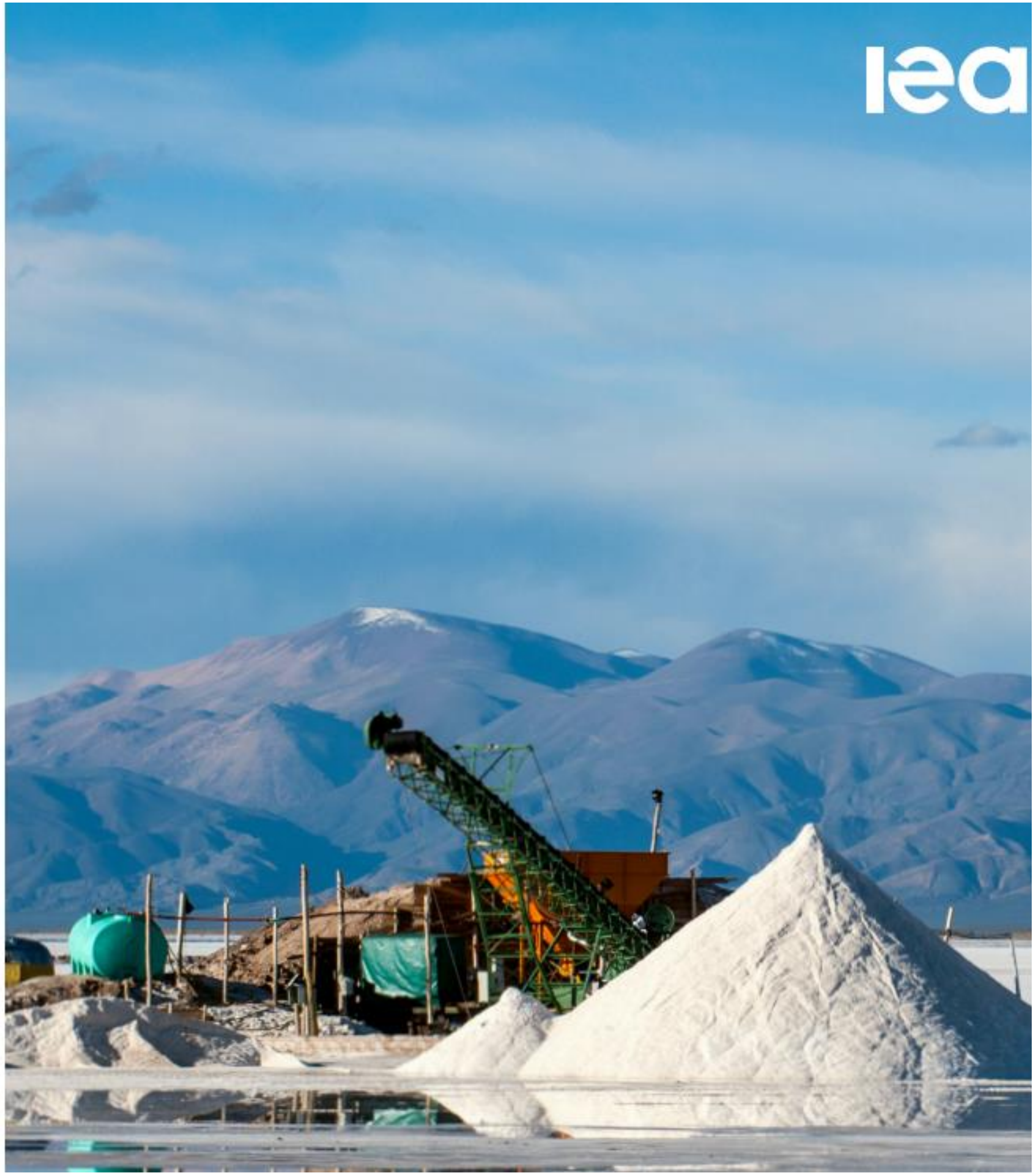
- Lokale groene H2 – business case?
- Energiedichtheid – liquid!
- Driver voor chemie/ staal/ e-fuels
- Transport pipelines/ ammoniak of LOCH
- Opslag: volume en kost
- Fugitive emissions → korte keten

→ ammoniak cracking?

- Lokale productie uit SMR’s

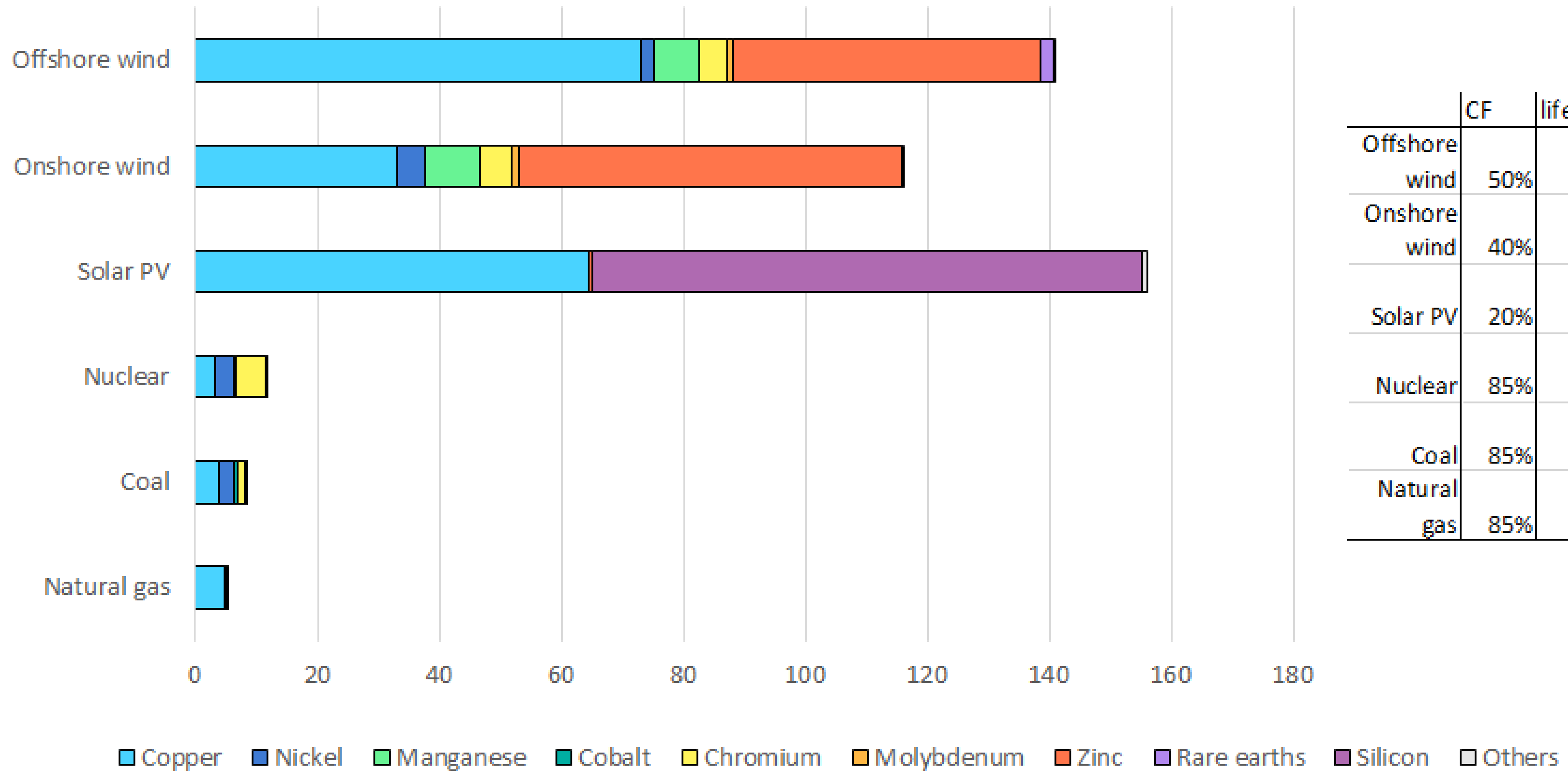
→ potentieel!

The Role of Critical Minerals in Clean Energy Transitions

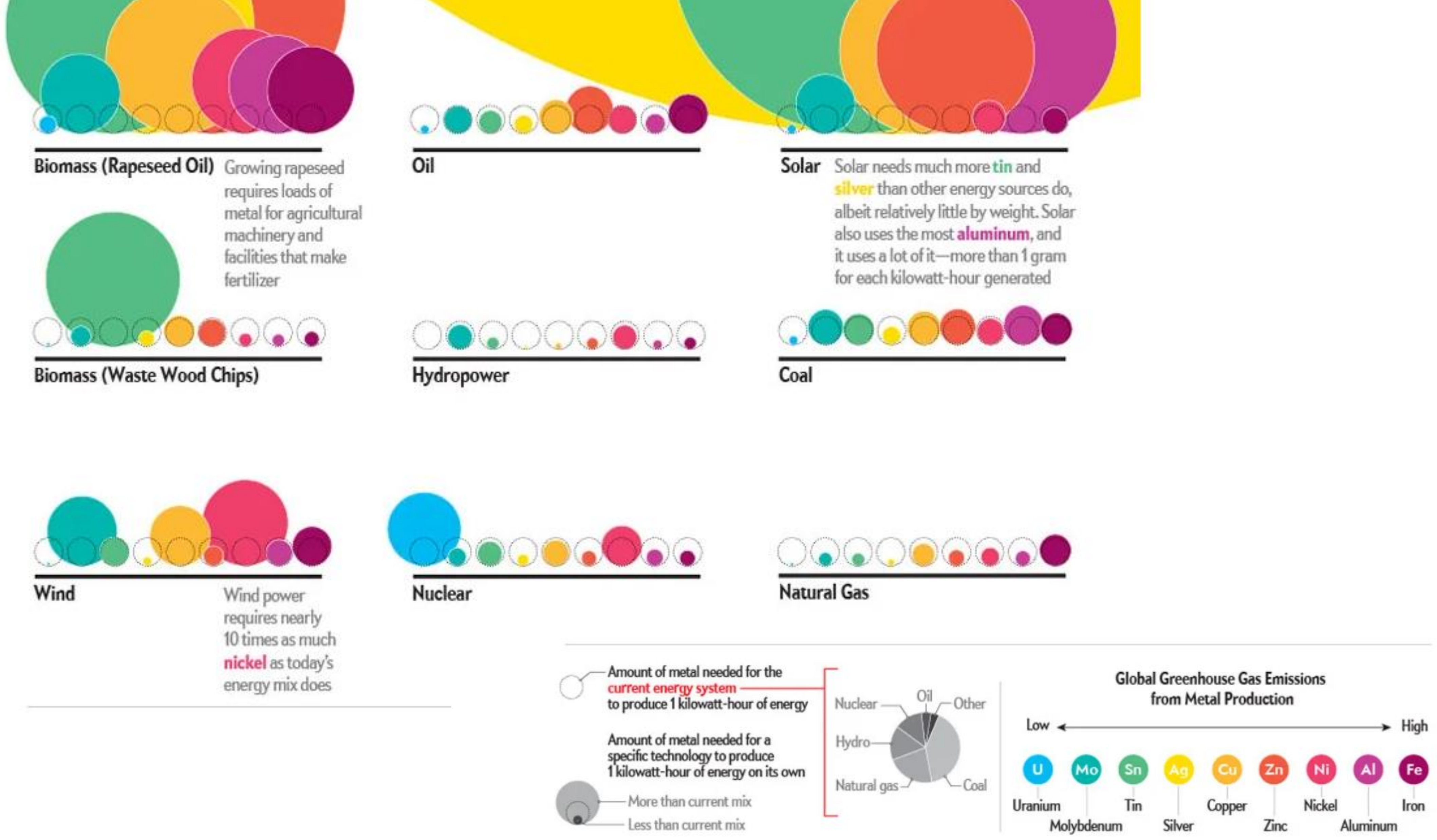


vergelijking critical minerals per MWh

Critical minerals used in clean energy technologies compared to other power generation sources g/MWh (based on IEA 2021 + capacity factors and operating lives)



	CF	life
Offshore wind	50%	25
Onshore wind	40%	25
Solar PV	20%	25
Nuclear	85%	60
Coal	85%	40
Natural gas	85%	30



Graphic by Arno Gehlfi, for SCIENTIFIC AMERICAN

SOURCES: "METAL REQUIREMENTS OF LOW-CARBON POWER GENERATION," BY RENÉ KLEIJN ET AL., IN ENERGY, VOL. 36, NO. 9; SEPTEMBER 2011 (*colored circles*); "ENVIRONMENTAL RISKS AND CHALLENGES OF ANTHROPOGENIC METALS FLOWS AND CYCLES: A REPORT ON THE WORKING GROUP ON THE GLOBAL METAL FLOWS TO THE INTERNATIONAL RESOURCE PANEL," BY E. VAN DER VOET ET AL. UNEP, 2013 (*greenhouse emissions by metal*)

3. Supply-demand market conclusions

- The 2020-2030 decade is the most challenging for global metals supply to keep up with demand. Serious supply risks are identified for copper, lithium, nickel, cobalt, and rare earth elements.
- The demand pull is expected to soften beyond 2030 and then again after 2040 as the deployment of clean energy technologies slows down, and more metals become available from secondary supply.
- Europe will be impacted by global supply constraints due to its import reliance for several ores and metals. Europe has the potential to change this picture through recycling, but only after 2040.
- European primary metal requirements are expected to peak around 2040, after which secondary supply will grow significantly. By 2050, secondary supply can deliver 45-65% of Europe's demand for most analysed metals, and over 75% for lithium and rare earth elements.
- Metals supply bottlenecks in the next 15 years would complicate the energy transition and encourage further reactions. Potential impacts include commodity price fly ups, innovation & substitution, consumption changes and a delay of technology uptake.

SDS: Sustainable Development Scenario, as developed by the International Energy Agency (IEA). This charts a pathway that meets in full the world's goals to tackle climate change in line with the Paris Agreement while meeting universal energy access and significantly reducing air pollution. In this scenario, all current net zero pledges are achieved in full and there are extensive efforts to realise near-term emissions reductions; advanced economies reach net zero emissions by 2050, China around 2060, and all other countries by 2070 at the latest.

Global total demand

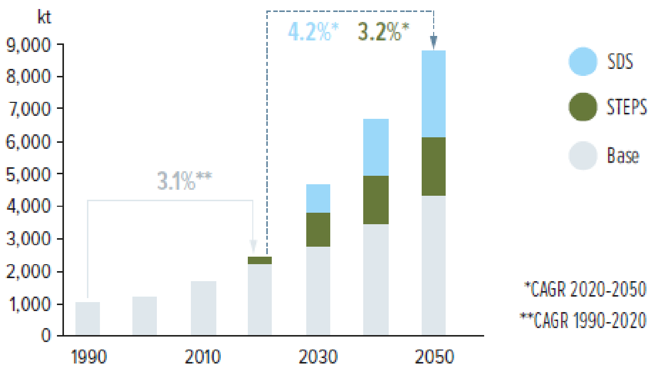


Figure 29. Nickel global total demand by scenario (STEPS and SDS)

Global total demand

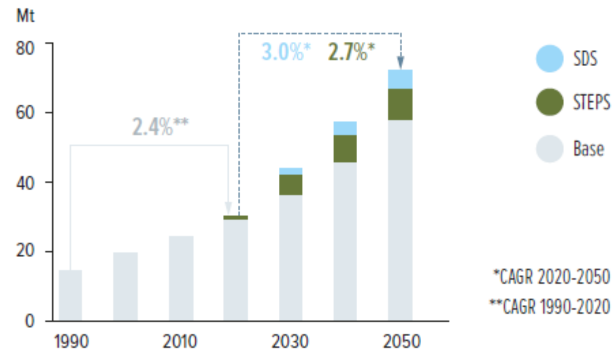


Figure 13. Copper global total demand by scenario (STEPS and SDS)

Global total demand

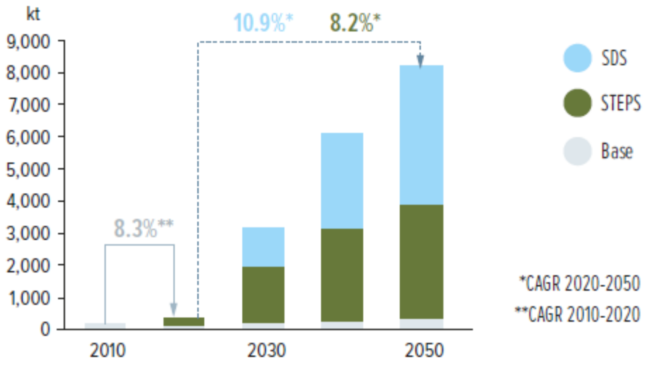


Figure 25. Lithium global total demand by scenario (STEPS and SDS)

Global total demand

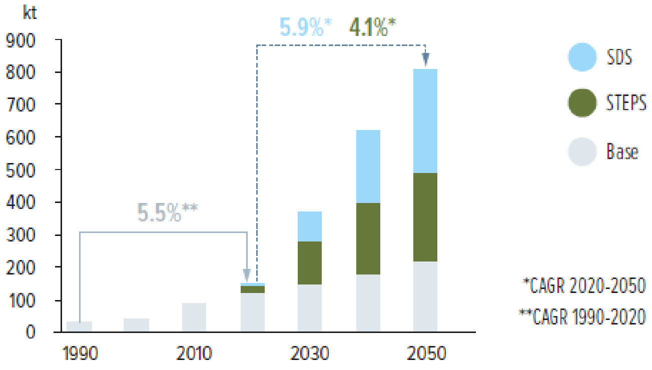


Figure 33. Cobalt global total demand by scenario (STEPS and SDS)

Rare earth metals

Global total demand

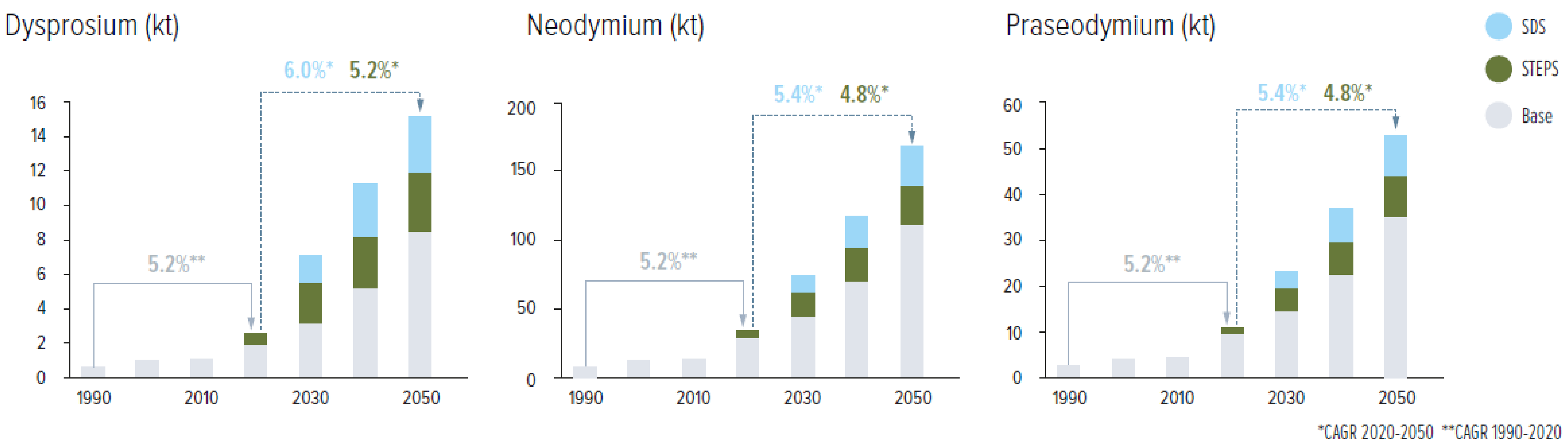


Figure 37. REE (dysprosium, neodymium, praseodymium) global total demand by scenario (STEPS and SDS)

Lithium

Global supply-demand results 2020-2030

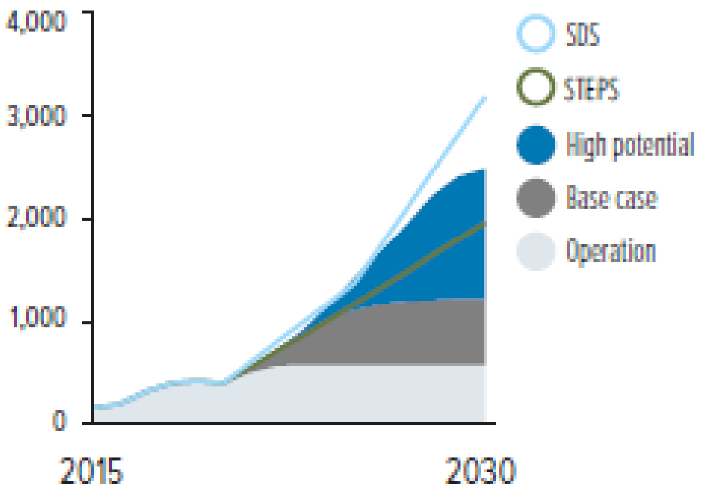


Figure 142. Global lithium mine supply-demand outlook (kt)

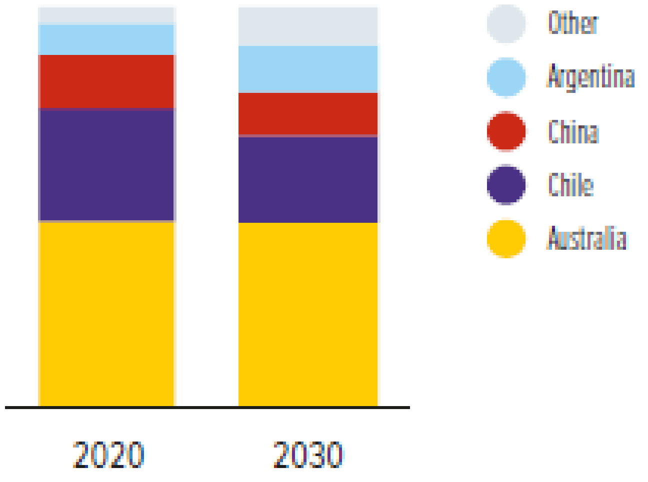


Figure 143. Global lithium mine supply by geography (% split)

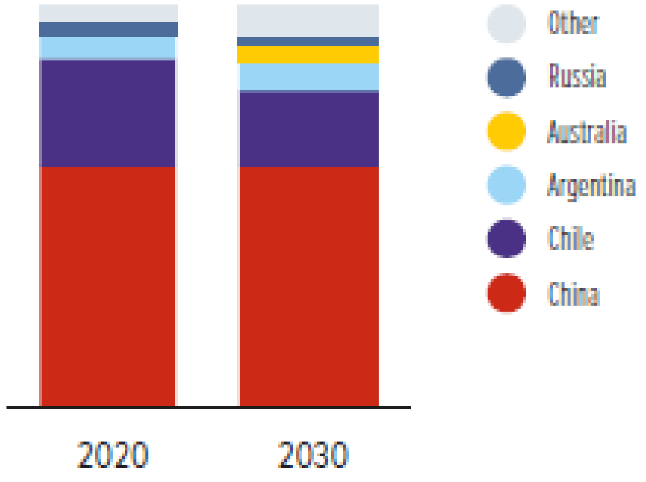


Figure 144. Global refined lithium supply by geography (% split)

Lithium demand is expected to keep growing very strongly for the production of EV batteries. However, the large project pipeline that is being developed will not be sufficient to meet demand in an SDS scenario (as currently announced).

Strong incentives are required to develop the more unlikely potential projects, and even more project announcements will be required to bring new capacity online. The typical lead times of 7+ years to develop greenfield projects will prove to be a challenge.

Zelfde patroon voor kobalt & koper

Estimates of the exact amount of rare earth minerals in wind turbines vary, but in any case the numbers are staggering. According to the Bulletin of Atomic Sciences, a 2 megawatt (MW) wind turbine contains about 800 pounds of neodymium and 130 pounds of dysprosium. The MIT study cited above estimates that a 2 MW wind turbine contains about 752 pounds of rare earth minerals.

To quantify this in terms of environmental damages, consider that mining one ton of rare earth minerals produces about one ton of radioactive waste, according to the Institute for the Analysis of Global Security. In 2012, the U.S. added a record 13,131 MW of wind

Bron: US - Institute of Energy Research

Métaux rares : « La dépendance à la Chine est beaucoup plus grave que notre dépendance au pétrole russe »

Réunis dans le cadre de la conférence interparlementaire sur l'autonomie stratégique européenne, les représentants des parlements nationaux de l'Union européenne débattaient au Sénat ce 14 mars d'autonomie stratégique et économique de l'Union européenne. Le journaliste Guillaume Pitron a décrit l'enjeu des métaux rares dans la transition écologique à venir.

Figure 162. Global REE (dysprosium, neodymium and praseodymium) mine supply-demand outlook (kt)

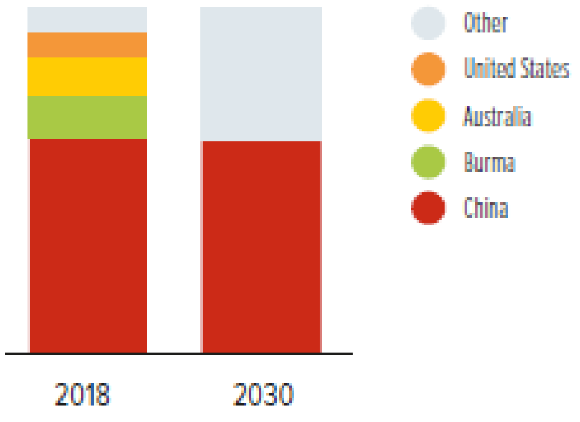


Figure 163. Global REO mine supply by geography (% split)

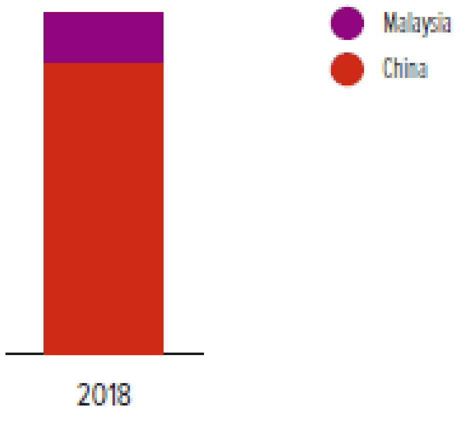
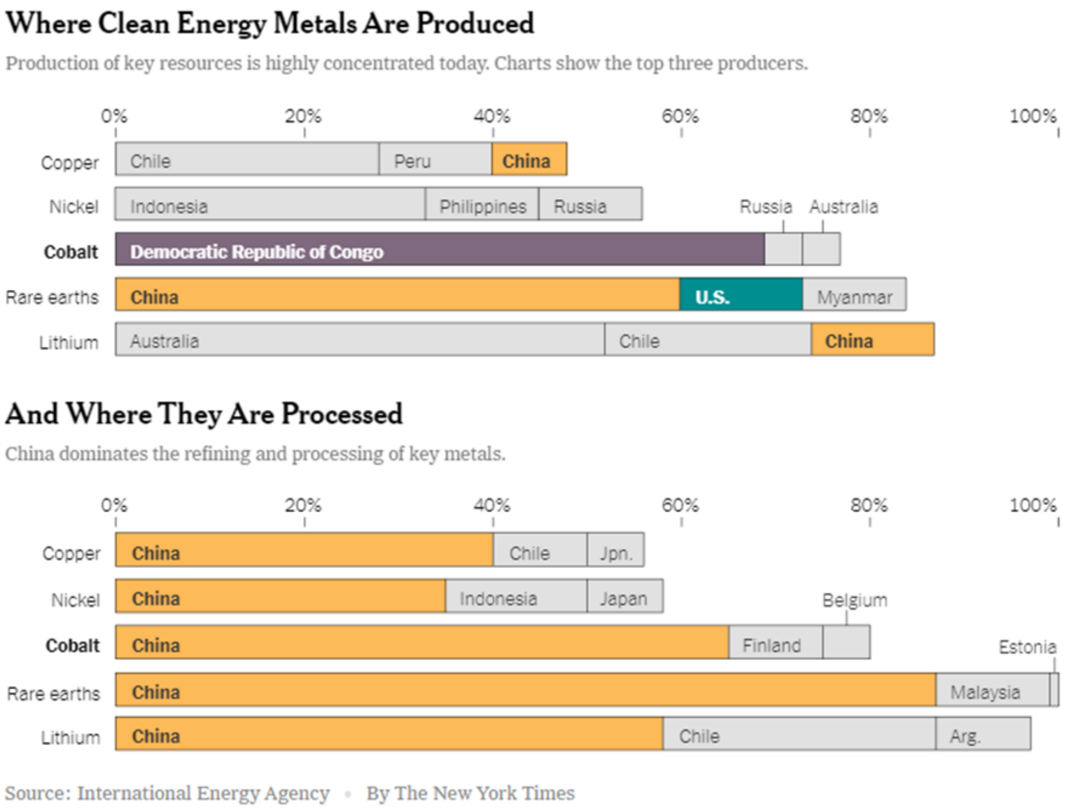


Figure 164. Global refined REO supply by geography (% split)

Extraction & Processing



China's Share	Extraction	Processing
Copper	8%	40%
Nickel	5%	35%
Cobalt	1.5%	65%
Rare Earths	60%	87%
Lithium	13%	58%

Bron: politico.eu

Lithium
Cobalt
Koper
Nikkel
…

Los Angeles Times

United States of California | Reshaping America's boardrooms | How companies keep polluting | Hydrogen fuel struggles | Environmental toll of e-cars

POLITICS

California's electric car revolution, designed to save the planet, also unleashes a toll on it

A mining permit pushed through in the last week of the Trump administration allows the Canadian company Lithium Americas Corp. to produce enough lithium carbonate annually to supply nearly a million electric car batteries. The mine pit alone would disrupt more than 1,100 acres, and the whole operation — on land leased from the federal government — would cover roughly six times that. Up to 5,800 tons of sulfuric acid would be used daily to leach lithium from the earth dug out of a 300-foot deep mine pit.

Tribal members and some ranchers are fighting the plans, alarmed by details in the environmental impact assessment: The operation would generate hundreds of millions of cubic yards of mining waste and lower the water table in this high desert region by churning through 3,200 gallons per minute. Arsenic contamination of the water under the mine pit could endure 300 years.

"This is our homeland," says Daranda Hinkey, a Paiute-Shoshone tribal member and an organizer with People of Red Mountain, a group of Indigenous people fighting the Thacker Pass mine. (Carolyn Cole / Los Angeles Times)

Energie en Geo-politiek (J. Holslag Tijd Sept 2021)

"Wat ik ook beschamend vind, is de energiedimensie. Je kan stellen dat nieuwe gasimport een overgangsmaatregel is in de strijd tegen klimaatverandering, maar het feit dat we Vladimir Poetin, de Qatari en de rest de komende decennia honderden miljarden gaan toestoppen omdat wij onze kerncentrales sluiten en geen andere vorm van elektriciteit hebben, vind ik een van de grootste strategische blunders die we kunnen maken. Wat ik vooral erg vind, is dat de voorstanders van de *Energiewende* weigeren om deze strategische gevolgen uit te leggen. Ik hoor alleen maar dat het 'een transitiefase' is, maar die duurt wel tien jaar. Tegen dan zitten we in een andere wereld. Hoe we ons als Europa nu aan een infuus van autocratische regimes leggen, kan ik niet rijmen met duurzaamheid of met waarden en idealen. Ik heb het daar heel moeilijk mee. Niets is zo schadelijk als doen alsof je de veiligheid waarborgt terwijl je beleid de tegenovergestelde richting uitgaat."

Afghanistan + Add to myFT

China to 'respect choices of Afghan people' following Taliban takeover

Beijing offers support to militant group while state media scorns 'unreliability' of Washington's commitments to allies

Save

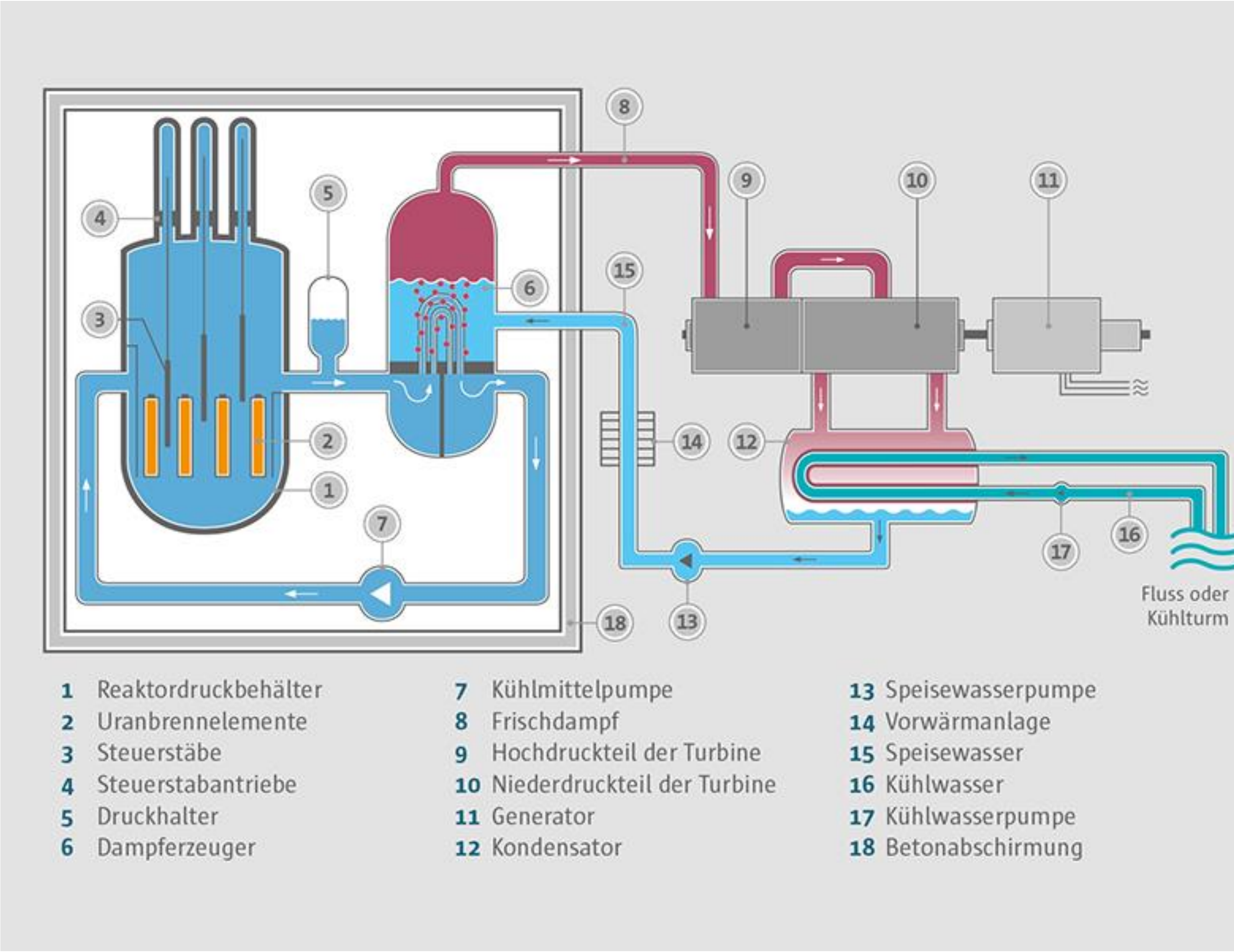
Taliban co-founder Mullah Abdul Ghani Baradar travelled to Tianjin last month for talks with Chinese foreign minister Wang Yi ahead of the militant group's rapid advance in Afghanistan © AP

Minerals - conclusies

- Basismetalen lithium (het witte goud), koper, kobalt, nikkel potentieel probleem voor bevoorrading dit decennium
- Idem voor zeldzame aardmetalen
- Ecologische aspect bij mijnbouw, ook Uranium!
- Reputatie China in DOC (kobalt!)
- Geopolitiek staat EU zeer zwak in mining en processing
- Kernenergie verbruikt veruit minste mineralen (g/MWh)

Reactor types

- Pressurized water reactor -70%
- Boiling water reactor -15%
- Pressurized heavy water reactor -11%
- Reactorstaven energie voor 4.5 j!



Hickley Point UK (EDF)
3.2 GW

Five years on, 22,000 workers in Britain are at work on Hinkley Point C

Five years after getting the go-ahead, the number of people across Britain working on the Hinkley Point C power station has reached 22,000. The growing number includes 6,300 on site, compared to just 1,500 at the height of the pandemic last year.

Key facts and figures

850,000 hours

of engineering studies were part of the rigorous four-year design approval process

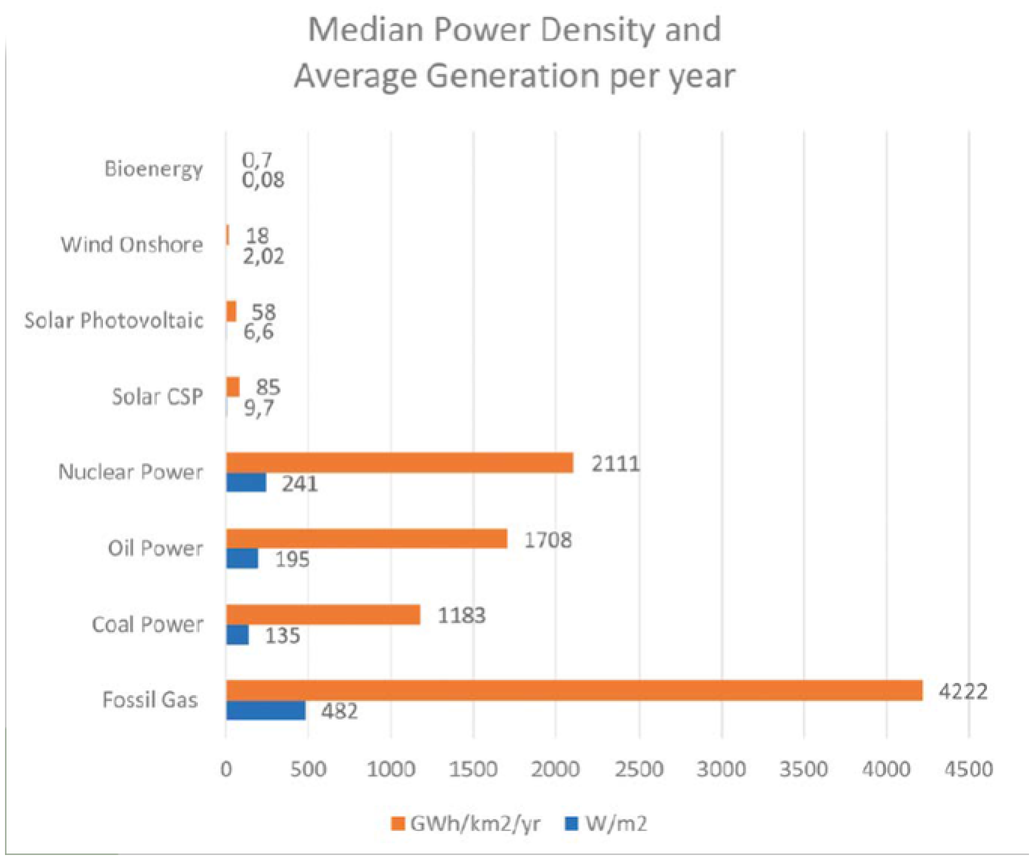
17% less

The EPR's large core means it uses 17% less uranium than older technology

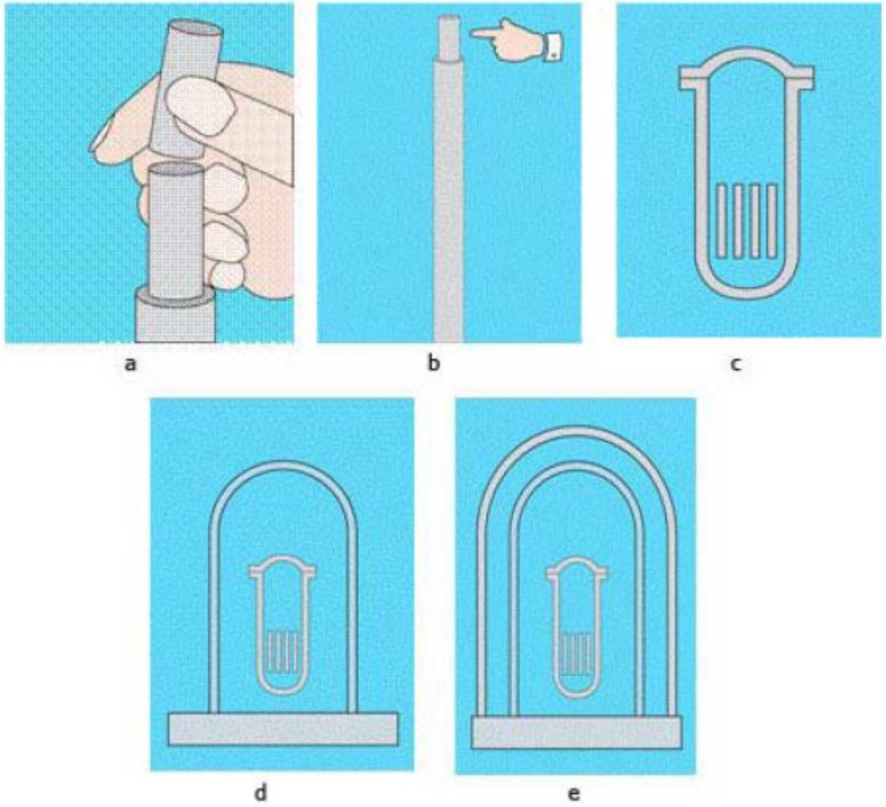
4

separate safety systems in the EPR protect against all hazards, including earthquakes and flooding

Figure 7: Median power densities and average energy generation for various energy sources according to Zalk et al. 2018.



Vijf barrieres om te voorkomen dat radioactiviteit ontsnapt uit Pressurized Water Reactors (PWR)



a uranium is geperst in kleine cylinders;

b deze cylinders zitten in **Z**r buizen (weerstaat zeer hoge temperaturen)

c de brandstofstaven zitten in een 20 cm dik, stalen reactorvat;

d, e het reactorvat is omgeven door twee metersdikke koepels van met staal versteviigd beton.

- eerste omhulsel:
  zorgt er voor dat geen radioactiviteit uit het reactorgebouw kan ontsnappen; bestand tegen hoge druk van binnen uit.

- tweede omhulsel :
  beschermt de kernreactor tegen gevaren van buitenaf (bv. vliegtuigcrash)

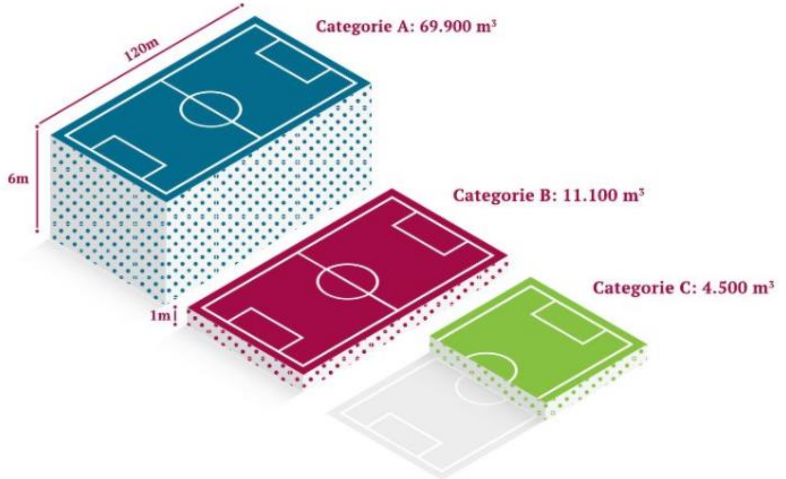
<u>ook</u>: - batterijen + dieselgeneratoren (op +10 m)

- voor alle cruciale componenten zijn steeds minstens twee vervangstukken beschikbaar
- om de 10 jaar een volledige veiligheidsrevisie
- eigen veiligheidsdienst + Feder. Agentsch voor Nucl. Controle (FANC) superviseren

Kernafval - volumes

1. Cat A. 70.000 m3 laag actief afval (korte levensduur en zwakke tot gemiddelde radioactiviteit) of ca. 82%: beschermingsmateriaal, injectienaalden, verpakkingen, afval van de ontmanteling van kerncentrales, afval van onderzoekscentra en universiteiten…
2. Cat B. 11.000 m3 middel actief kernafval (lange levensduur en een zwakke tot gemiddelde radioactiviteit) of ca. 13%: fragmenten van ontmantelde kerncentrales, afval van nucleaire brandstof, afval van onderzoekscentra en universiteiten…
3. Cat C. 4.500 m3 hoogactief radioactief afval of ca. 5% van alle kernafval: gebruikte nucleaire brandstof.
   Wie 100 jaar oud wordt, produceert op zijn hele leven zo'n 3 blikjes hoogactief nucleair afval.

https://fanc.fgov.be/nl/classificatie-van-afval-belgie



De volumes radioactief afval over een periode van 100 jaar. (bron: NIRAS)

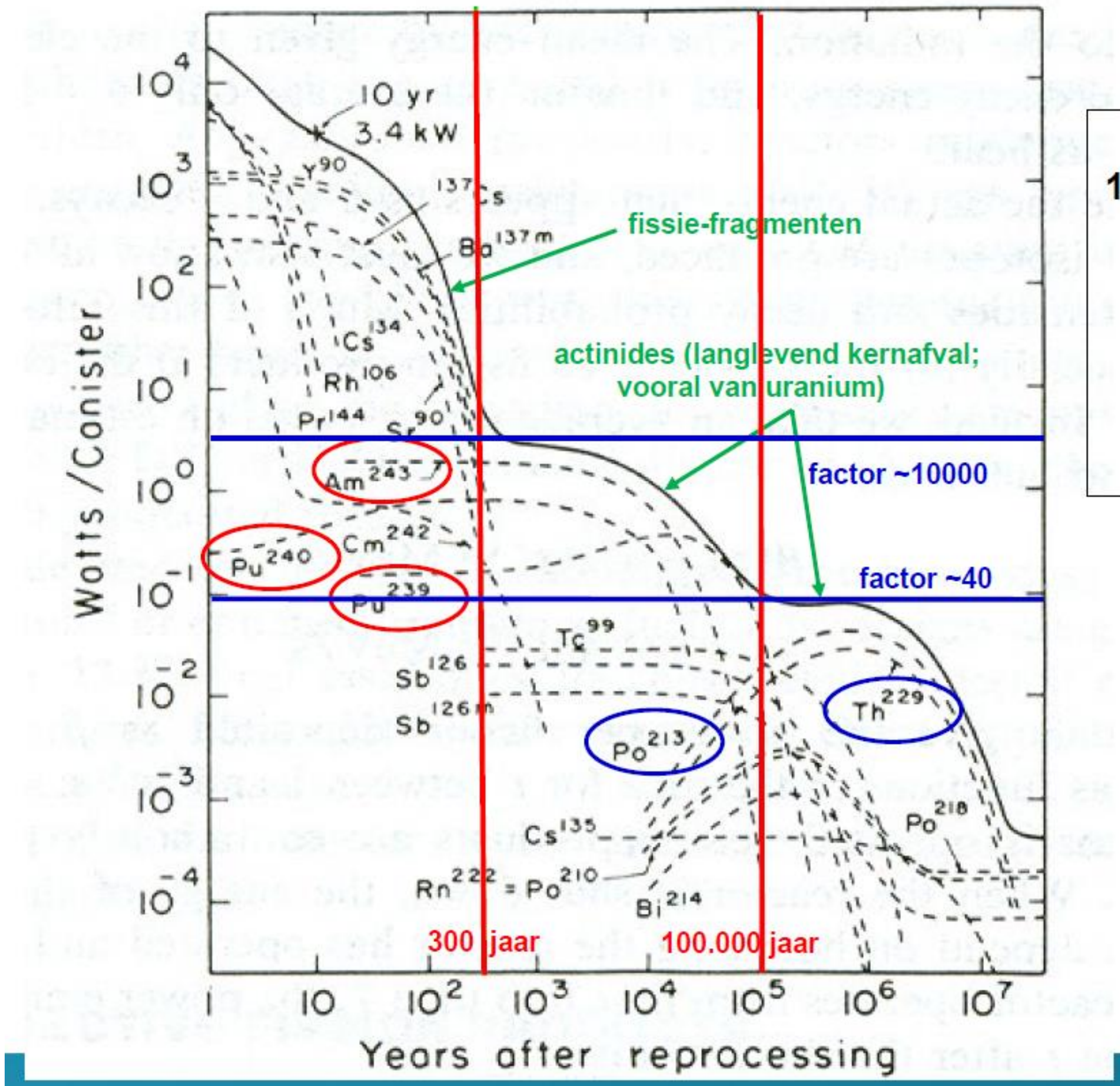

Beeld: Het opslaggebouw voor laagactief geconditioneerd afval op de site van Belgoprocess (bron: Belgoprocess)

Kernafval - verwerking

1. Volume-verkleining. BelgoProcess plasma-oven (5000°C) reductie factor 80. Eerste gebouwd in Bulgarije.
2. Verlaging duurtijd radio-activiteit: Myrrha – factor 1000
3. Advanced nuclear/ MSR’s – hergebruik kernafval
4. Conditionering en opslag in vaten BelgoProcess bovengronds
5. Onderzoek ondergrondse opslag

<u>Nota</u>: moratorium opwerking nucleaire brandstof (1-3)!

Energie die vrijkomt uit gebruikte kernbrandstof:

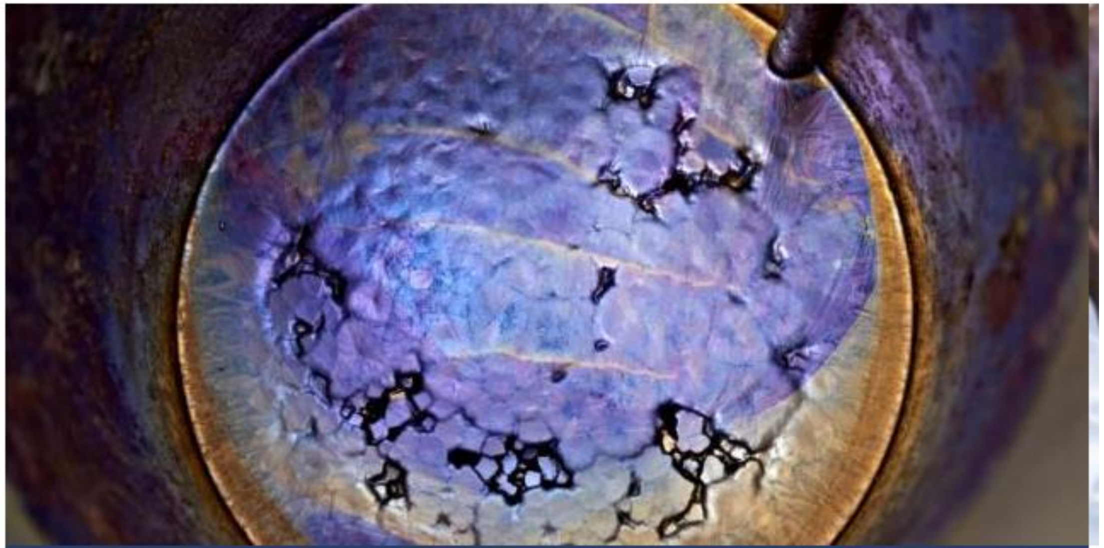


1. langlevend afval opnieuw splijten in nieuwe reactoren

   heeft 'snelle' neutronen nodig !!

Myrrha (SCK Mol)

- Reductie stockage kernafval naar 300 j (factor 1000)
- Onderzoeksreactor materialen SMR
- Accelerator Driven System: koppelt sub-kritische kern (dwz die van zichzelf niet voldoende neutronen genereert om fissie in stand te houden) aan een neutronen bron. Bij MYRRHA is de neutronenbron het vloeibaar metaal dat ook als koelmiddel dient. Door dit te beschieten met een hoge stroom (mA) aan hoge energie protonen (600 MeV) worden voldoende neutronen gegenereerd voor de fissie-reactie. Dit concept is dan ook inherent veilig: als de accelerator afgaat gaat ook de reactor af.

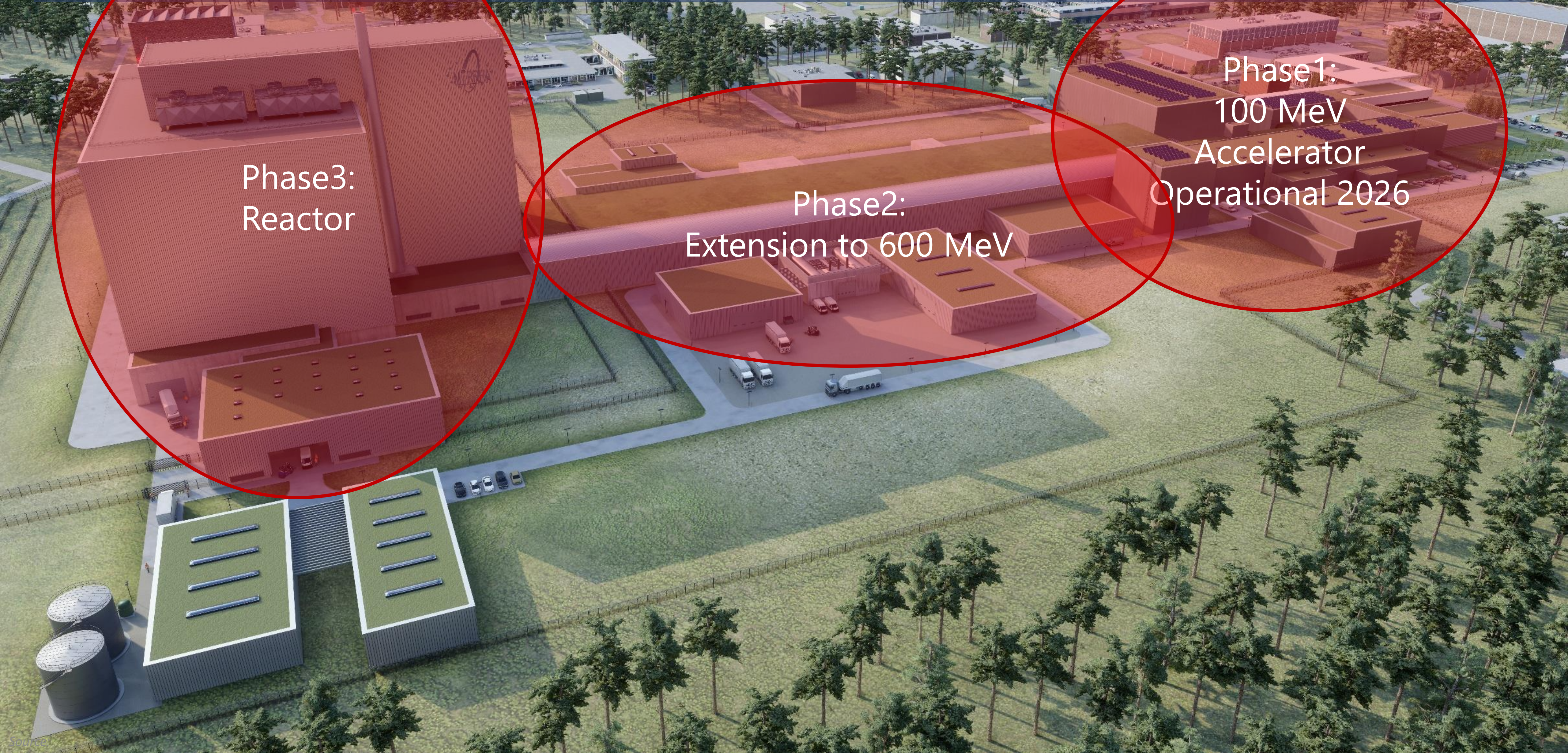


Nuclear waste treatment

SCK CEN works actively on the design and construction of a new multi-purpose research plant: MYRRHA, which stands for *Multi-purpose HYbrid Research Reactor for High-tech Applications*. MYRRHA is a versatile research infrastructure but above all unique. It is the world's first research reactor driven by a particle accelerator.

MYRRHA Reactor: implementation in 2036

Objectives = transmutation + radioisotopes + fusion material r&d + Fission technology platform



Gen III reactors (World Nuclear Association)

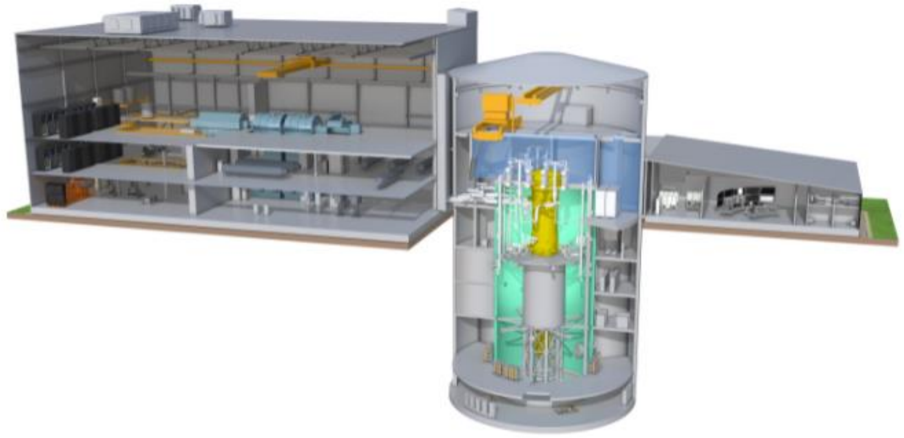
So-called third-generation reactors have:

- A more standardised design for each type to expedite licensing, reduce capital cost and reduce construction time.
- A simpler and more rugged design, making them easier to operate and less vulnerable to operational upsets.
- Higher availability and longer operating life – typically 60 years.
- Further reduced possibility of core melt accidents.*
- Substantial grace period, so that following shutdown the plant requires no active intervention for (typically) 72 hours.
- Stronger reinforcement against aircraft impact than earlier designs, to resist radiological release.
- Higher burn-up to use fuel more fully and efficiently, and reduce the amount of waste.
- Greater use of burnable absorbers ('poisons') to extend fuel life.

SMR = small modular reactor. Kan Gen III of Gen IV zijn.

SMR
GE/ Hitachi

THE BWRX-300 SMALL MODULAR REACTOR



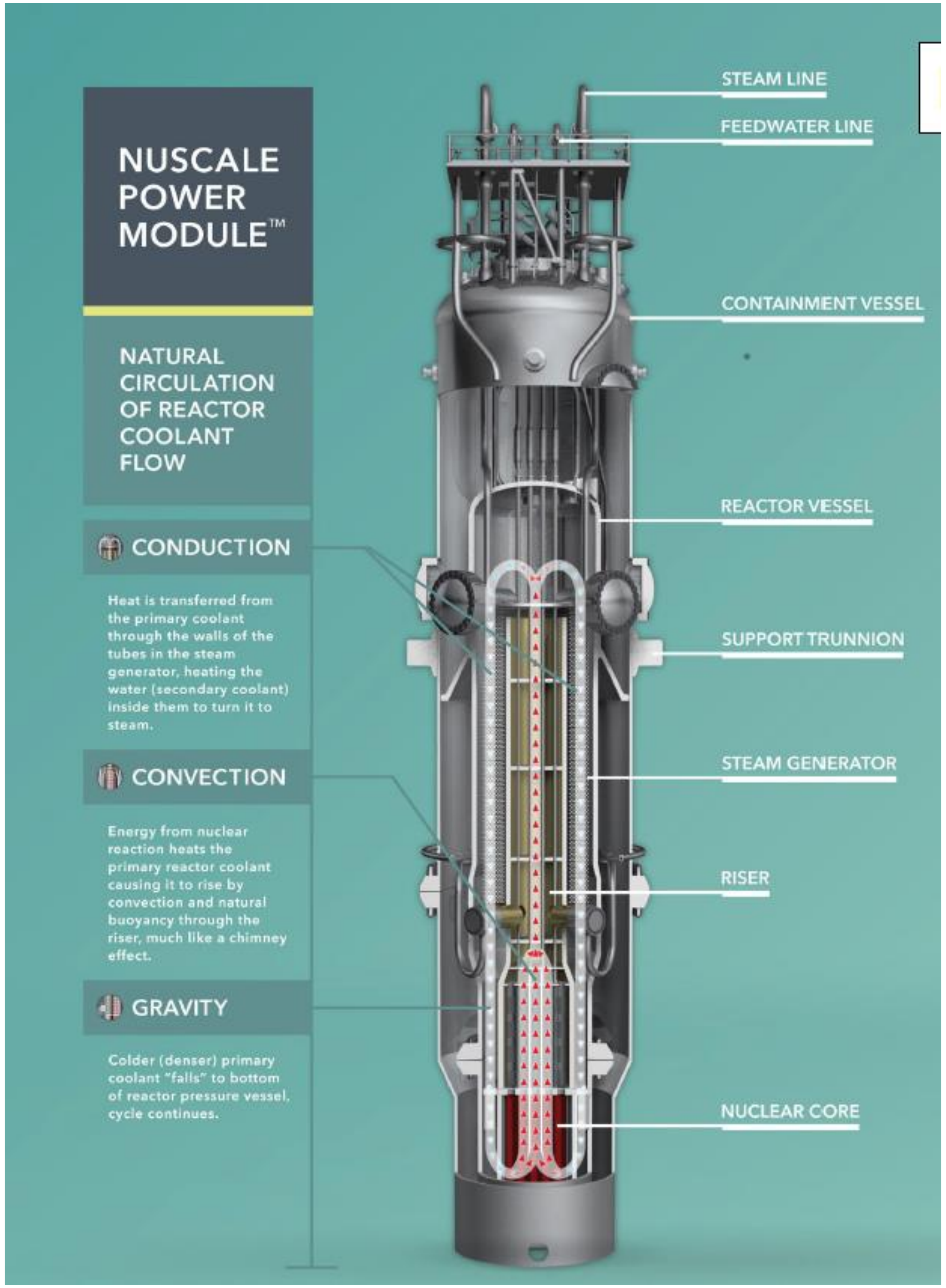
COMPETITIVE, WORLD-CLASS SAFETY, PASSIVE COOLING

The BWRX-300 is a ~300 MWe water-cooled, natural circulation Small Modular Reactor (SMR) with passive safety systems. As the tenth evolution of the Boiling Water Reactor (BWR), the BWRX-300 represents the simplest, yet most innovative BWR design since GE began developing nuclear reactors in 1955.

BENEFITS AND FEATURES

- World class safety: mitigates loss-of-coolant accidents (LOCA) enabling simpler passive safety
- Cost competitive: projected to have up to 60% less capital cost per MW when compared with typical water-cooled SMR
- Passive cooling: steam condensation and gravity allow BWRX-300 to cool itself for a minimum of seven days without power or operator action
- Quick Deployment: Deployable as early as 2028 thanks to proven know-how and construction techniques

SMR
Nuscale (60 MWe module)



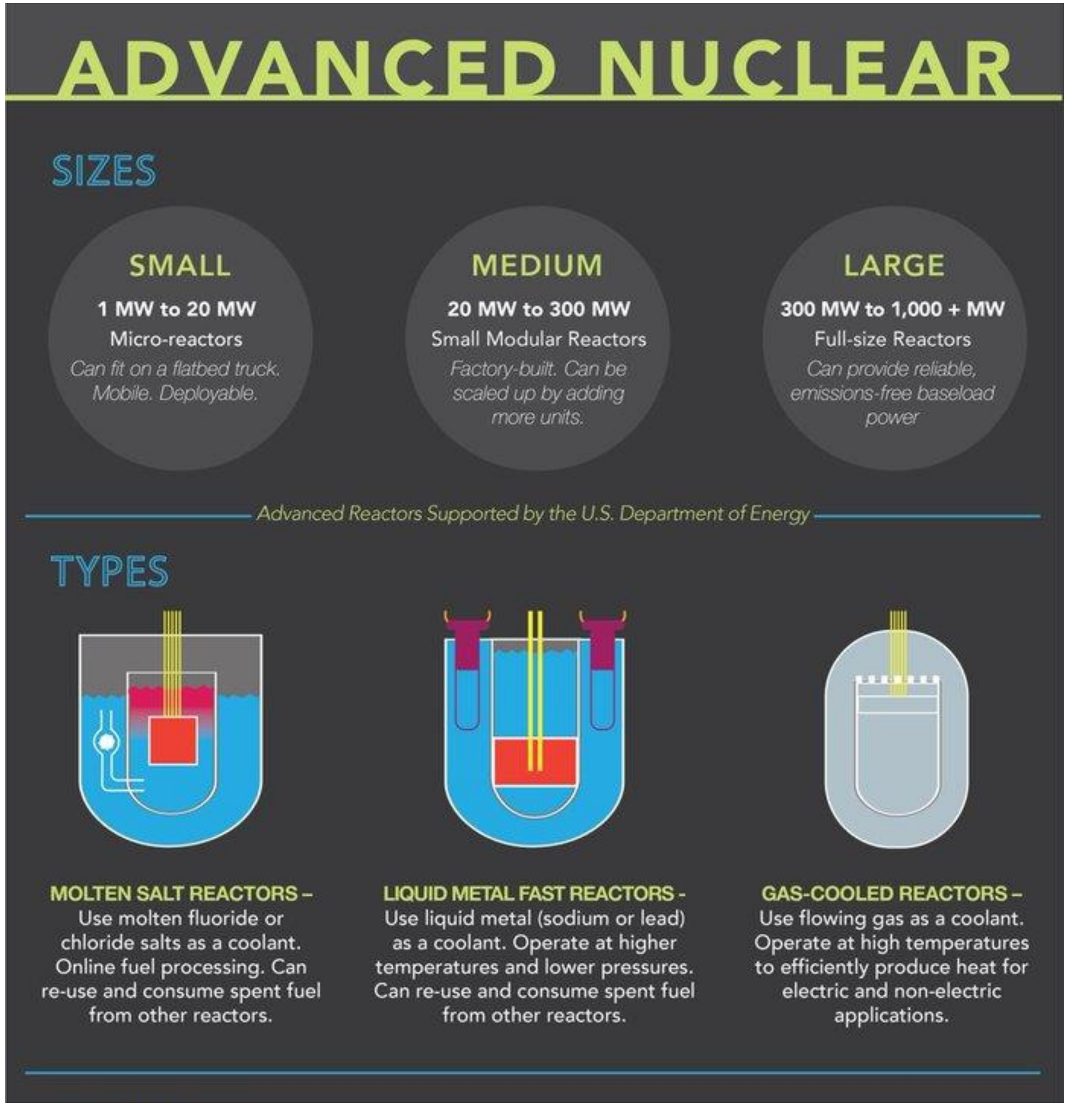
Gen IV reactors (World Nuclear Association)

(Updated December 2020)

- An international task force is sharing R&D to develop six Generation IV nuclear reactor technologies. Four are fast neutron reactors.
- All of these operate at higher temperatures than today's reactors. In particular, four are designated for hydrogen production.
- All six systems represent advances in sustainability, economics, safety, reliability and proliferation-resistance.
- Europe is pushing ahead with three of the fast reactor designs.
- A separate programme set up by regulators aims to develop multinational regulatory standards for Generation IV reactors.

‘Advanced Nuclear’

- Intrinsiek veilig
- Bij liquid metal/ MSR kernafval nog 300 j actief, minimaal deel hoog radio-actief
- Molten salt en Liquid metal kunnen bestaand kernafval verwerken
- Corrosie – research reactormaterialen
- SMR <> advanced nuclear



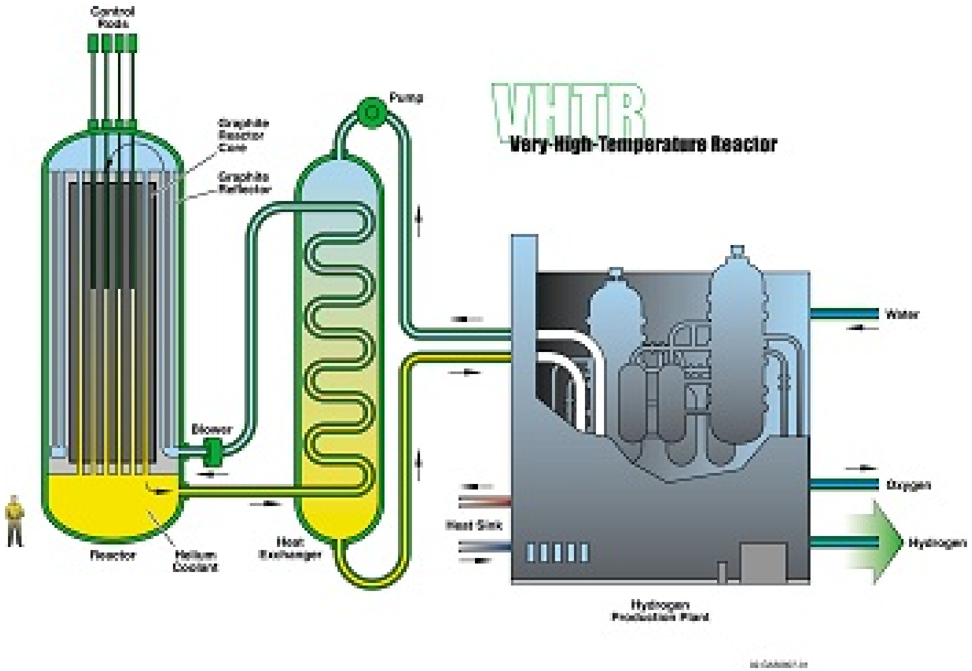
	Neutron spectrum (fast/thermal)	Coolant	Temperature (°C)	Pressure*	Fuel	Fuel cycle	Size (MWe)	Use
Gas-cooled fast reactors	fast	helium	850	high	U-238 +	closed, on site	1200	electricity & hydrogen
Lead-cooled fast reactors	fast	lead or Pb-Bi	480-570	low	U-238 +	closed, regional	20-180** 300-1200 600-1000	electricity & hydrogen
Molten salt fast reactors	fast	fluoride salts	700-800	low	UF in salt	closed	1000	electricity & hydrogen
Molten salt reactor - **advanced high-temperature reactors**	thermal	fluoride salts	750-1000		UO_2 particles in prism	open	1000-1500	hydrogen
Sodium-cooled fast reactors	fast	sodium	500-550	low	U-238 & MOX	closed	50-150 600-1500	electricity
Supercritical water-cooled reactors	thermal or fast	water	510-625	very high	UO_2	open (thermal) closed (fast)	300-700 1000-1500	electricity
Very high temperature gas reactors	thermal	helium	900-1000	high	UO_2 prism or pebbles	open	250-300	hydrogen & electricity

* high = 7-15 MPa

+ = with some U-235 or Pu-239

** 'battery' model with long cassette core life (15-20 yr) or replaceable reactor module.

VHTR



The VHTR is a next step in the evolutionary development of high-temperature gas-cooled reactors. It is a graphite-moderated, helium-cooled reactor with thermal neutron spectrum. It can supply nuclear heat and electricity over a range of core outlet temperatures between 700 and 950°C, or more than 1 000°C in future. The reactor core type of the VHTR can be a prismatic block core such as the Japanese HTTR, or a pebble-bed core such as the Chinese HTR-10. For electricity generation, a helium gas turbine system can be directly set in the primary coolant loop, which is called a direct cycle or at the lower end of the outlet temperature range, a steam generator can be used with a conventional rankine cycle. For nuclear heat applications such as process heat for refineries, petrochemistry, metallurgy, and hydrogen production, the heat application process is generally coupled with the reactor through an intermediate heat exchanger (IHX), the so-called indirect cycle. The VHTR

Advanced Reactor Technologies (ART) is a national program funded by the U.S. Department of Energy (DOE). Here at INL, work is focused specifically on developing a High Temperature Gas-cooled Reactor (HTGR), which will offer enhancements in safety and efficiency. This HTGR has a modularized design, which enables plants with larger power demands to simply build more than one module. Modularization requires no extra design work and increases safety and efficiency by allowing a singular module to run or be stopped at any given time in the event of an incident or a changing need for power. HTGRs also produce process heat during operation, making them ideal for location near other industrial plants that could put this process heat to use in their own production and thus reduce the need for non-renewable energy sources upon which these plants currently rely.

https://x-energy.com/video/technology-explainer

This reactor concept can also be designed to incorporate passive cooling through natural conduction, thermal radiation and convection in the case of a loss of helium coolant—meaning it doesn't have to rely on large local water sources, pumps, or safety systems to prevent fuel damage.


X-energy

Other benefits:

- Ability to load follow (from 100% to 40% power within 20 minutes), making the plant complementary to maintaining a stable load on a grid that includes renewables
- Continuous fueling and on-site fuel storage, delivering high availability (93-95%) while ensuring plant resiliency
- Reduced construction time (2.5 – 4 years for a 300 MWe plant)
- Factory-produced major components, enabling improved quality control while reducing per unit costs.

What's Next?

X-energy was awarded **$80 million in initial funding** to demonstrate a four-unit, 320 MWe plant within the next seven years through the U.S. Department of Energy's **Advanced Reactor Demonstration Program**.

The company is on target to have its basic design completed by 2021 and has successfully fabricated its first fuel pebbles using natural uranium at a pilot scale fuel facility, on-site at the **Oak Ridge National Laboratory**.

Our Reactor

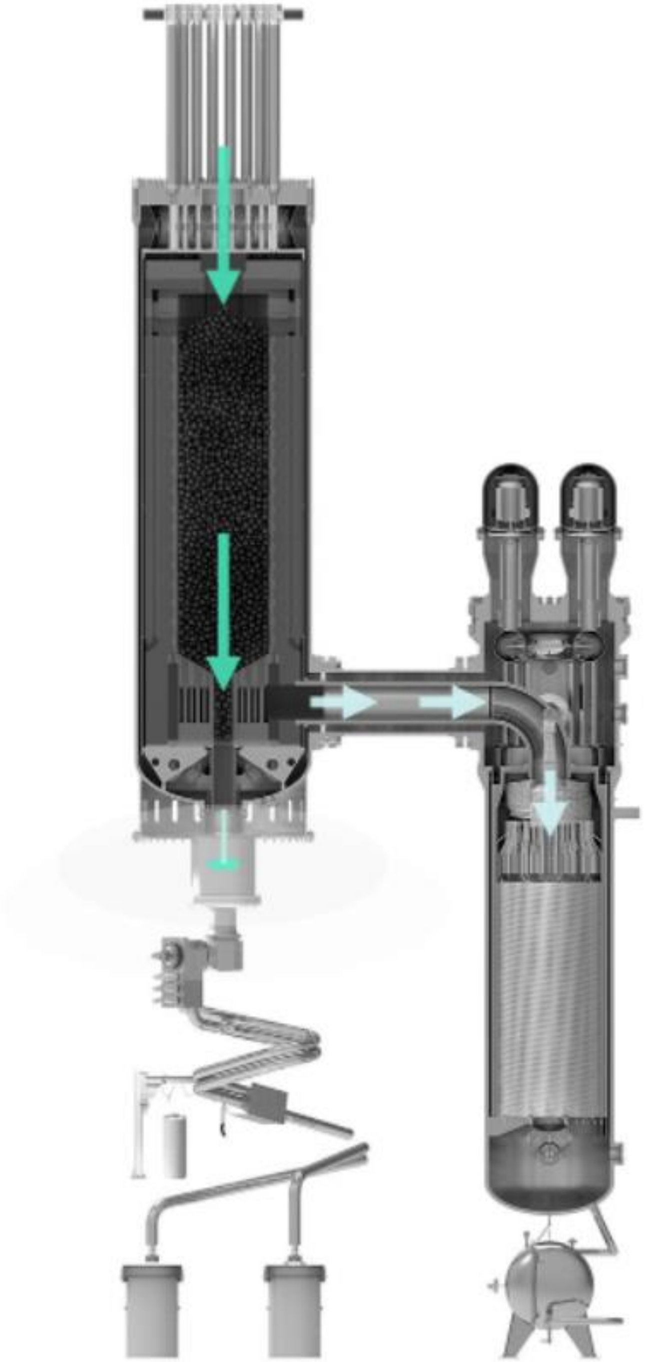
X-energy's reactor designs are based on HTGR technology — a Generation-IV reactor technology with a proven operational pedigree.

Xe-100

- 220,000 Graphite Pebbles with TRISO Particle fuel
- High temperature tolerant graphite core structure
- ASME compliant reactor vessel, core barrel & steam generator
- Designed for a 60-year operational life
- Flexible application – electricity and/or process heat
- Base load or load following
- Online refueling (95% plant availability)
- High burn-up fuel cycle (160 GWd/tHM)

200 MW ...Thermal Output
80 MW ...Electric Output
750°C ...Helium Temperature
6 MPa ...Helium Pressure
565°C ...Steam Temperature
16.5 MPa ...Steam Pressure

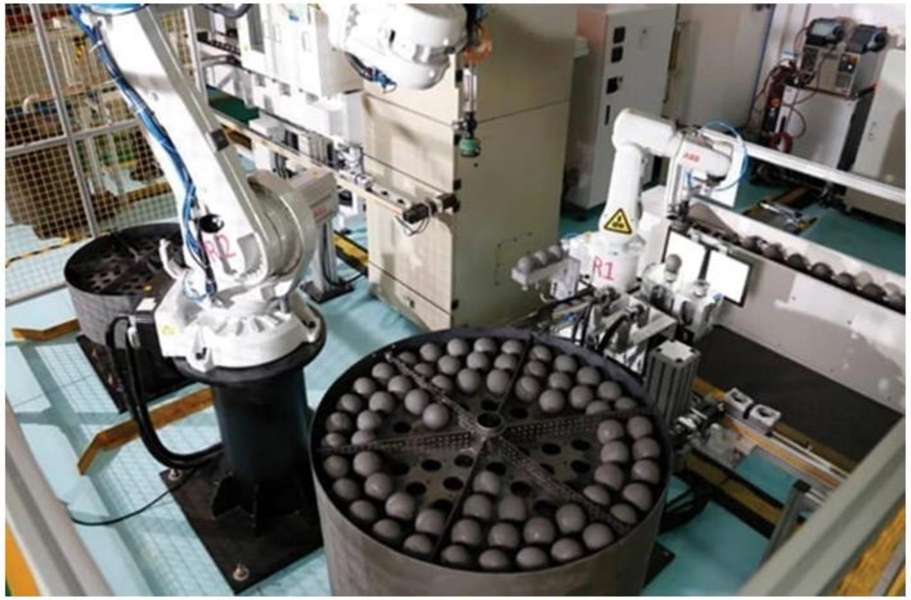
Watch Video



China Starts Up First Fourth-Generation Nuclear Reactor

The first of two units at China's much-watched high-temperature gas-cooled modular pebble bed (HTR-PM) demonstration project was successfully connected to the grid on Dec. 20. The achievement marks a major milestone for fourth-generation advanced nuclear technology.

The demonstration high-temperature gas-cooled reactor pebble-bed module (HTI
site in Shandong Province of China was connected to the grid in December 2021.
Energy Association

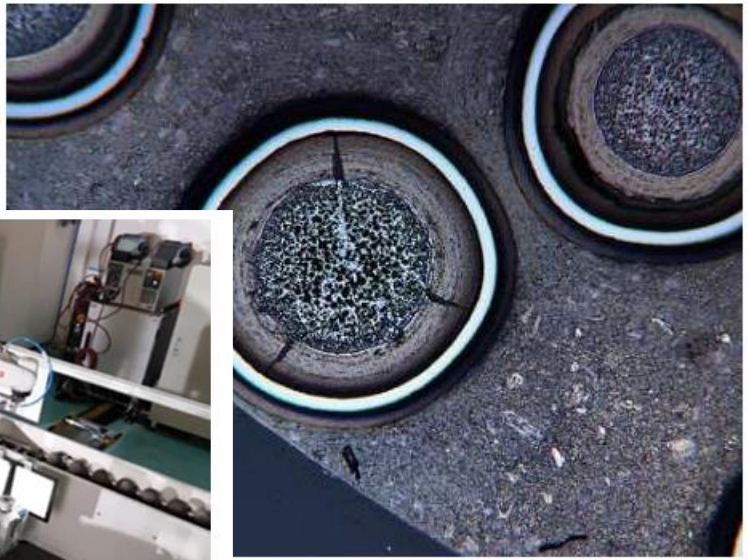


Fuel loading at the Shidaowan high-temperature gas-cooled reactor pebble-bed module (HTR-PM) in China began in the spring of 2021. It involved putting 870,000 spherical TRISO fuel elements into the two small reactors that will drive a single 210-MWe turbine. Courtesy: China National Nuclear Corp. (CNNC)

Safe nuclear fuel

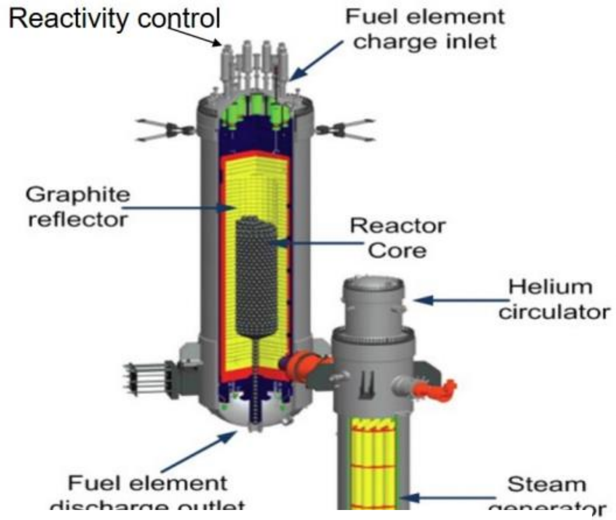
The main concern regarding any nuclear reactor is a potential meltdown. But the main advantage of TRISO is that it just can't undergo a meltdown.

Each TRISO capsule consists of a kernel made up of uranium, carbon, and oxygen. This particle, about the size of a poppy seed, is surrounded by three small three layers of carbon- and ceramic-based materials. The resulting structure not only prevents the release of radioactive fission products but is also resistant to neutron irradiation, corrosion, oxidation and high temperatures — the most common sources of risk in a nuclear reactor.

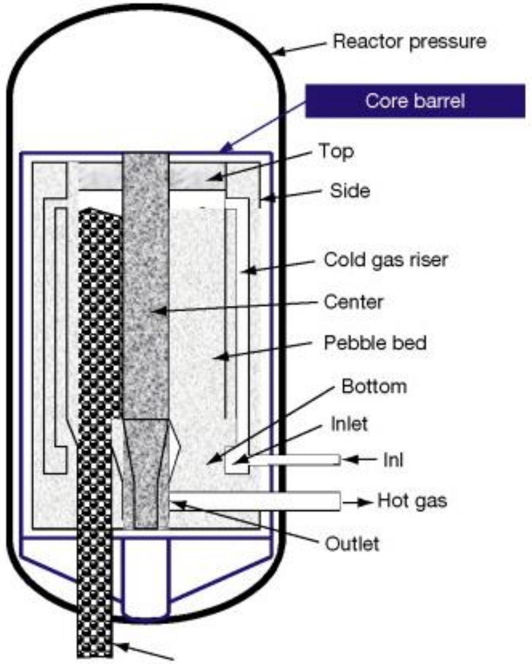


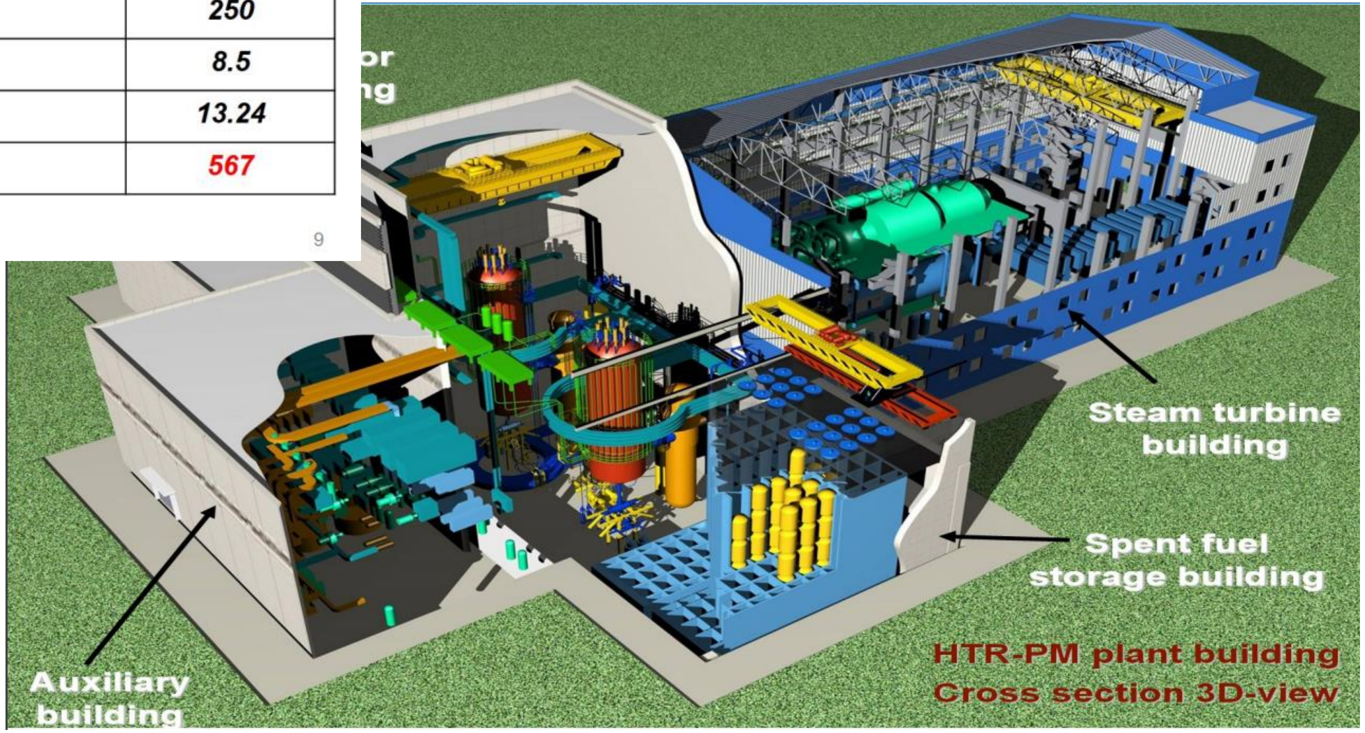
les cannot melt in a reactor and can withstand extreme
temperatures. Image credits: Department of Energy.

Overview of Design



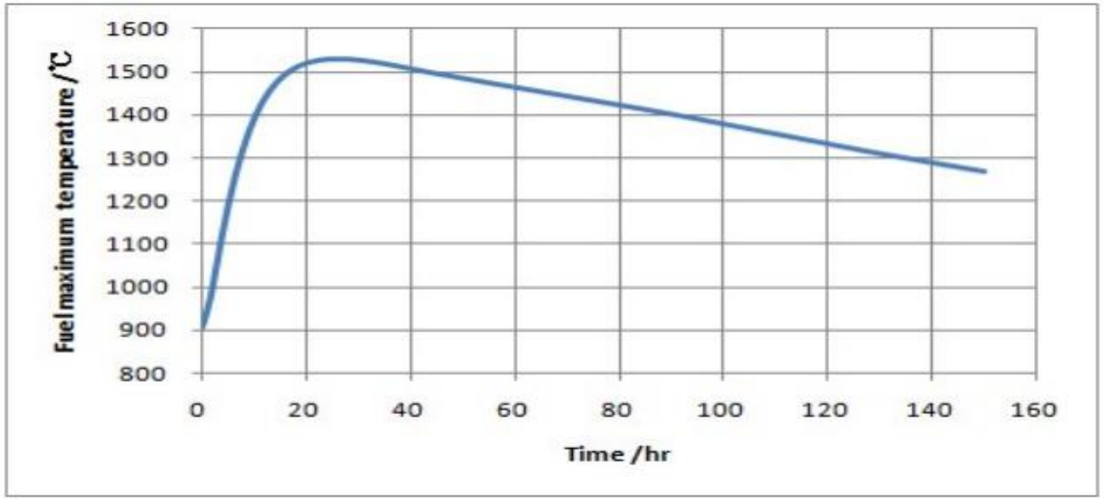
Plant electrical power, MWe	211
Core thermal power, MW	250
Number of NSSS Modules	2
Core diameter, m	3
Core height, m	11
Primary helium pressure, MPa	7
Core outlet temperature, ℃	750
Core inlet temperature, ℃	250
Fuel enrichment, %	8.5
Steam pressure, MPa	13.24
Steam temperature, ℃	567

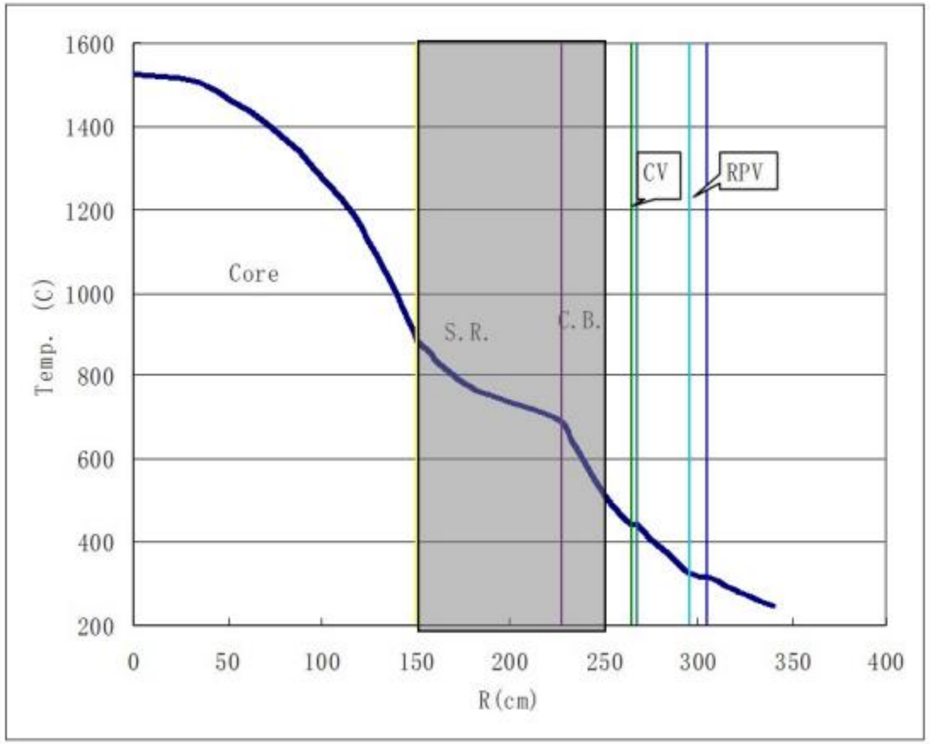




Removal of Decay Heat

Max. fuel temperature is lower than the limit temperature of materials during loss of coolant





RESEARCH & DEVELOPMENT

Japan / JAEA And MHI Join Global Race To Generate Green Hydrogen From Nuclear

By David Dalton
26 April 2022

Achievement could produce large quantities of low-carbon energy for industry, transport and home heating.

MOST POPULAR

NUCLEAR POLITI
Europe / 10-N

Japan's *Basic Energy Plan* - approved by the government in October 2021 - states that high-temperature gas reactors will be used in the production of hydrogen. In addition, the *Green Growth Strategy for 2050 Carbon Neutral* (released in June 2021) says it will be necessary to utilise the HTTR to produce large quantities and inexpensive carbon-free hydrogen by 2030.

Researched and written by World Nuclear News

World Nuclear News @W_Nuclear_News · 12 mei

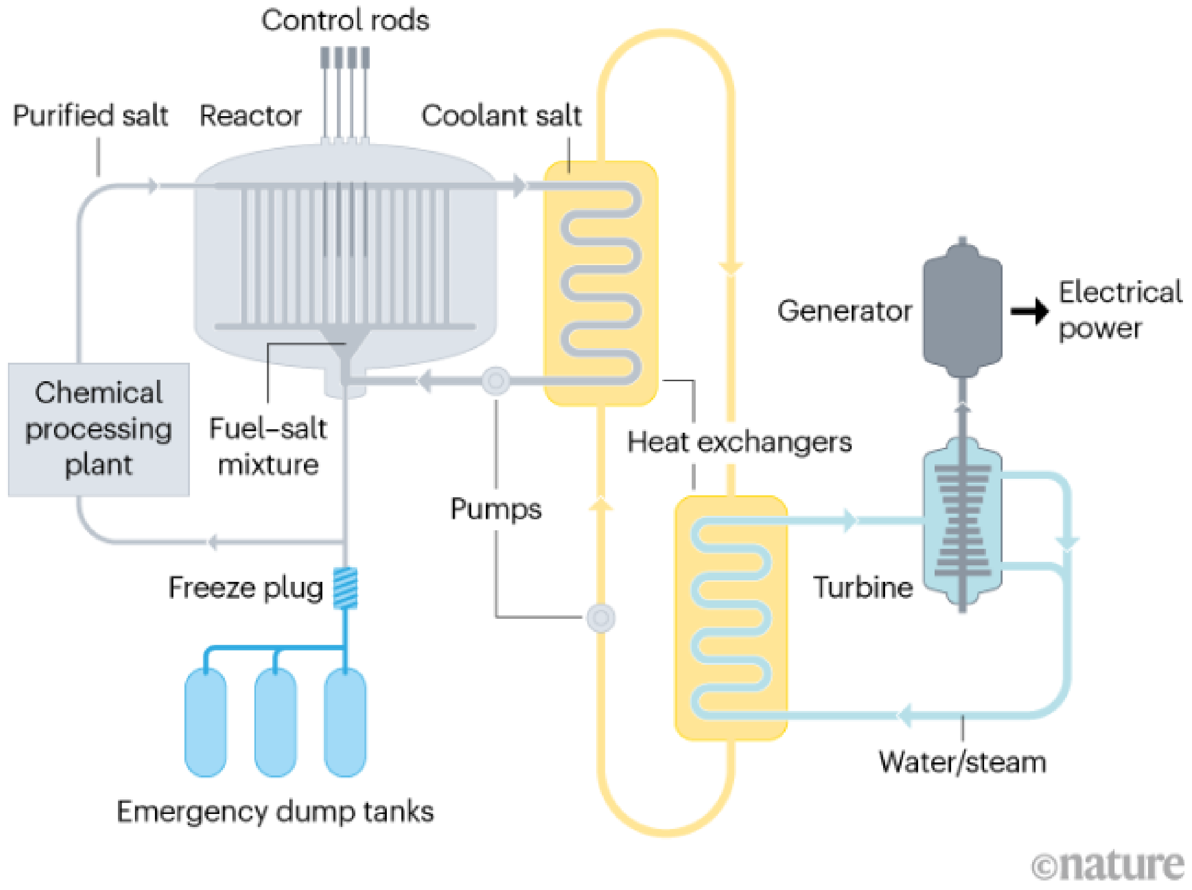
Britain's Cavendish #Nuclear has signed an MoU with @xenergynuclear of the USA to act as its deployment partner for High Temperature Gas-Cooled Reactors in the UK tinyurl.com/4fn42rrj

7 21

Challenge = leak tightness HP He

MOLTEN-SALT REACTOR

In a molten-salt nuclear reactor the fissile material is dissolved in liquid salt in the reactor core. Liquid salt also acts as a coolant in place of water. Fission occurs in the reactor core, generating heat, which is transmitted by the coolant salt and heat exchangers to water, producing steam. This drives a turbine to generate electricity. A frozen plug of salt melts if the reactor core overheats, allowing the fuel-salt mixture to drain into emergency dump tanks.

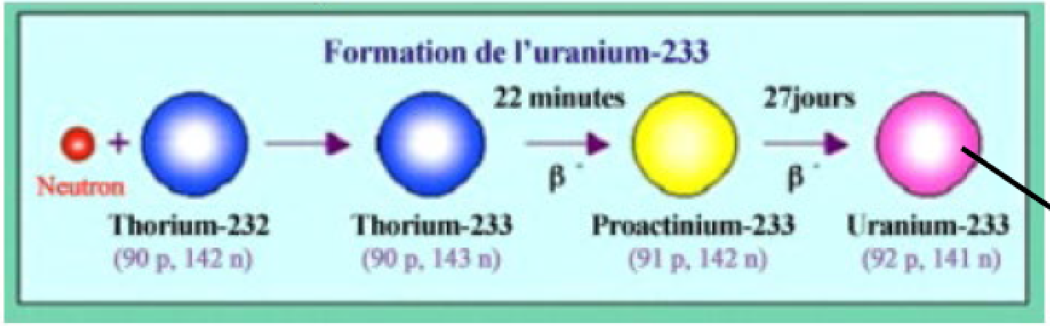


Source: US Department of Energy/International Atomic Energy Agency

Thorium pellets at the Bhabha Atomic Research Centre in Mumbai, India. Credit: Pallava Bagla/Corbis/Getty

Challenge = Materials (corrosion)

6. Thorium als brandstof: de ^{232}Th - ^{233}U cyclus



splijtbaar isotoop

Thoriumreserves (WNA, 2009):

Australia	489 000	metric tonnes
USA	400 000	
Turkey	344 000	
India	319 000	
Brazil	302 000	
Venezuela	300 000	
…		

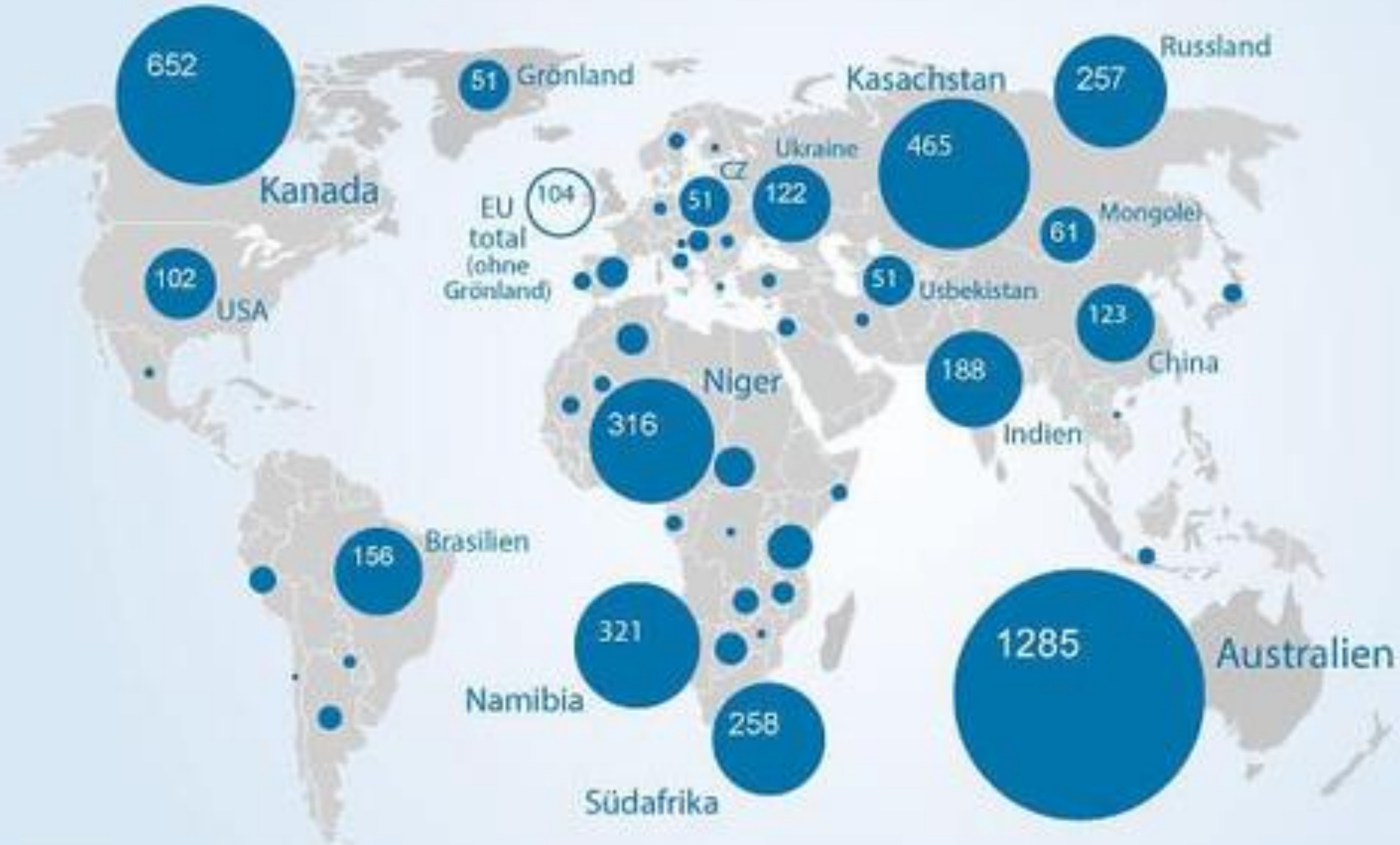
(de gekende thoriumvoorraad is 4x groter dan de uraniumvoorraad; thorium kan ook volledig gebruikt worden (abundantie is 100% vs. maar 3-5% (na aanrijking) voor uranium; dit levert een extra factor 20 tot 30) → 1kg thorium / jr / 1000 MW
→ de huidige wereldproductie van kernenergie (ong. 430 reactoren) kan zeker 10.000 jaar worden voortgezet als we alle reactoren volledig op thorium zouden omschakelen.

- splijting van ^{233}U levert ong. 200x minder actiniden (het langlevend kernafval) dan de ^{235}U - ^{239}Pu cyclus

- beperkte hoeveelheid (~10%) ^{235}U of ^{239}Pu is nodig om via splijting de neutronen te leveren om de reactor te kunnen starten

KU LEUVEN

Weltweite Uranreserven 2019 (in 1000 Tonnen Uran)



Angegeben sind die
RAR (Reasonably
Assured Resources)
bei einem Uranpreis
bis 260 Dollar pro kg

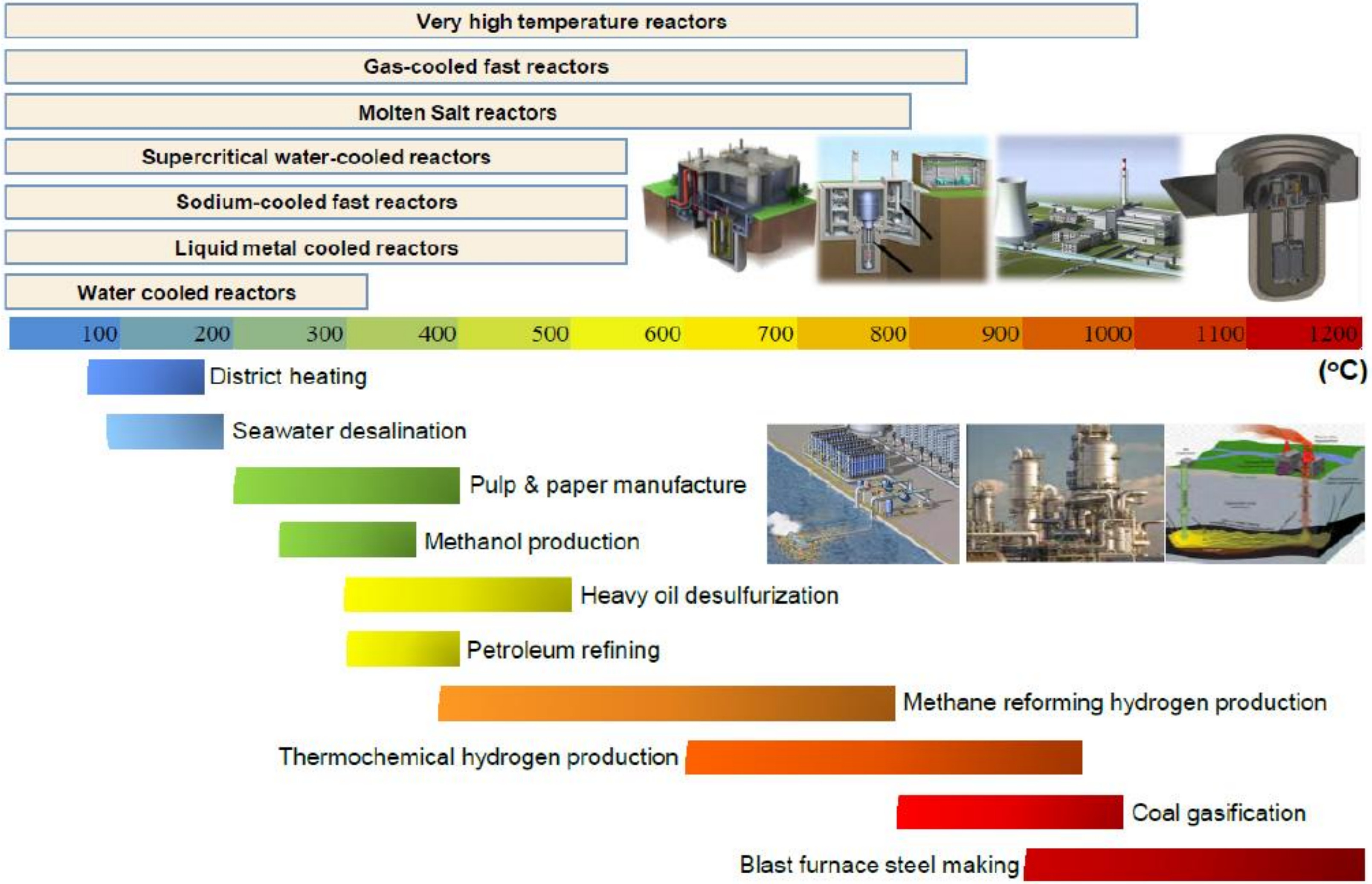
Stichtag: 1.1.2019

Quelle: NEA / IAEO
«Red Book» 2020

SMR's vandaag

- Mobiele PWR reactor Rusland 2*35 MW
- Thorium molten salt reactor China 2 MWt
- ACP100 aanbouw China 125 MW
- VHT reactor China 210 MW (HTR-PM)
- VHT door X-Energy – 2027/ samenwerking VK
- Terrapower MSR US - start constructie 2024
- Licence application BWRX-300 VS 2023/24
- VHT reactor kan ingebouwd in coal fired plant!

Exit Temperature of SMR Designs and their Corresponding Non-Electric Applications



Advances in Small Modular Reactor Technology Developments, 2020 Edition, IAEA

Voordelen nucleaire techologie

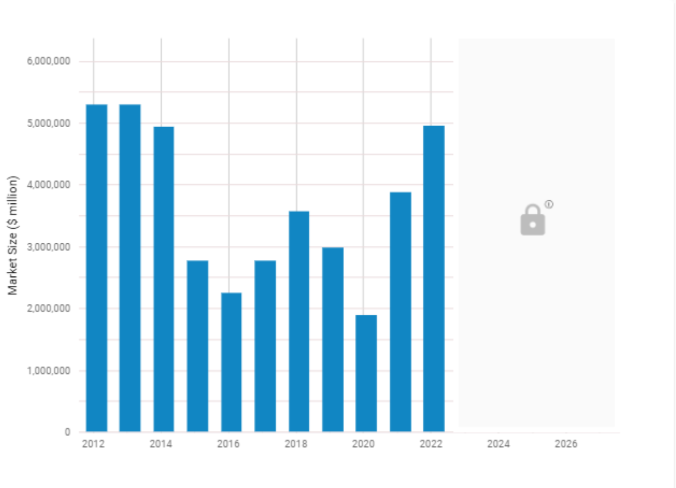
- Ruimte – 2.5 km² voor 6 GW
- Gebruik grondstoffen/ diversity of supply
- Diverse technologieën/ proceswarmte
- Kenniscentrum België met SCK, Tractebel, Engie
- Systeemkost
- Geopolitiek
- Klimaat
- Stuurbaar vermogen - SMR

Market value Nuclear vs. Oil & Gas (US)

INDUSTRY STATISTICS - GLOBAL

Global Oil & Gas Exploration & Production - Market Size 2005–2028

Updated: March 31, 2022



$5.0tr Global Oil & Gas Exploration & Production Market Size in 2022

27.5% Global Oil & Gas Exploration & Production Market Size Growth in 2022

12.3% Global Oil & Gas Exploration & Production Annualized Market Size Growth 2017–2022

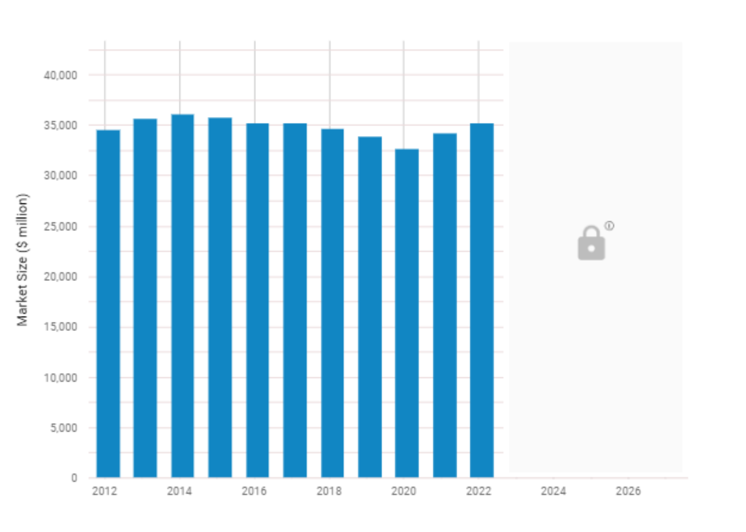
Global Oil & Gas Exploration & Production Market Size Growth 2022–2028

Curious about **what drives these trends**? IBISWorld's **Global Oil & Gas Exploration & Production Industry Report** has got you covered.

VIEW INDUSTRY ANALYSIS

Nuclear Power in the US - Market Size 2001–2027

Updated: September 30, 2021



$35.2bn Nuclear Power in the US Market Size in 2022

3% Nuclear Power in the US Market Size Growth in 2022

0% Nuclear Power in the US Annualized Market Size Growth 2017–2022

Nuclear Power in the US Market Size Growth 2022–2027

Curious about **what drives these trends**? IBISWorld's **Nuclear Power in the US Industry Report** has got you covered.

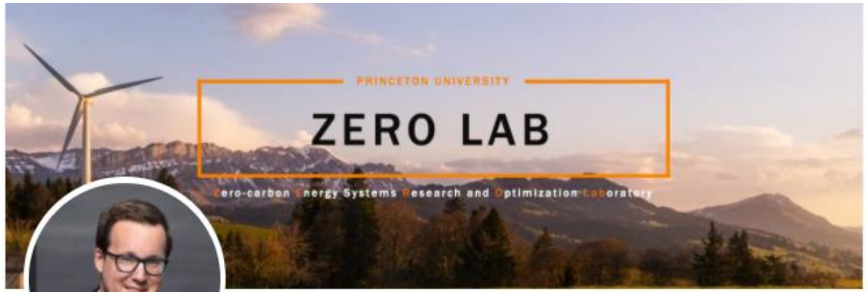
VIEW INDUSTRY ANALYSIS

Nuclear - conclusies

- Niet blind zijn voor belangrijke problemen
  - Nuclear fleet EDF in FR ‘dreadful performance’
  - Design and build GEN III in VS en EU: cost and time overrun >>
  - Elke installatie is opnieuw grote uitdaging
- Enorm potentieel nucleaire technologie voor elektriciteit en proceswarmte
- SMR: modulair/ kortere bouwtijd
- Schaalvergroting industrie
- Weg voorbereiden voor een aantal SMR types in België

Opslag energie vandaag?

- Grootste project Europa liquid air battery (aanbouw) UK 250 MWh – 90 M€.
  18 nodig voor 30’ gemiddelde e-vraag België.
- Tesla 750 MWh in aanbouw California. 6 nodig voor 30’ gemiddelde e-vraag België.
- Bastogne battery park 20 MWh/ Nyrstar 100 MWh
- Buiten waterkracht, andere technologieën eerder voor KT compensatie
- Zelfde tendens thuisbatterij (5-10 kWh)



JesseJenkins
@JesseJenkins

Macro-energy systems engineering, optimization, and policy w/a focus on electricity. Prof @EPrinceton (MAE) & @AndlingerCenter. PI of ZERO Lab. Personal account

linkedin.com/in/jessedjenki... Lid geworden in oktober 2008

10,8K Volgend **46,2K** Volgers

JesseJenkins @JesseJenkins · 9 sep.

H2 & SNG: w/large underground storage (saline or depleted gas fields), costs could be <$1/kWh! Round trip (esp. discharge) efficiency low, which negates some of that advantage. Metal tanks cost $10-15/kWh. Electrolysis & fuel cell costs need to fall a lot.
LDES Verdict: ✅

1 kg H2 = 33 KWh

1 12 47

JesseJenkins
@JesseJenkins

There are 4 main types of energy storage devices:

1. Mechanical (e.g., compressed air or pumped hydro),
2. Electrochemical (e.g., flow batteries or metal air batteries),
3. Thermal (e.g. ceramic bricks),
4. Chemical storage technologies (e.g., hydrogen).

Which work for LDES?

Tweet vertalen

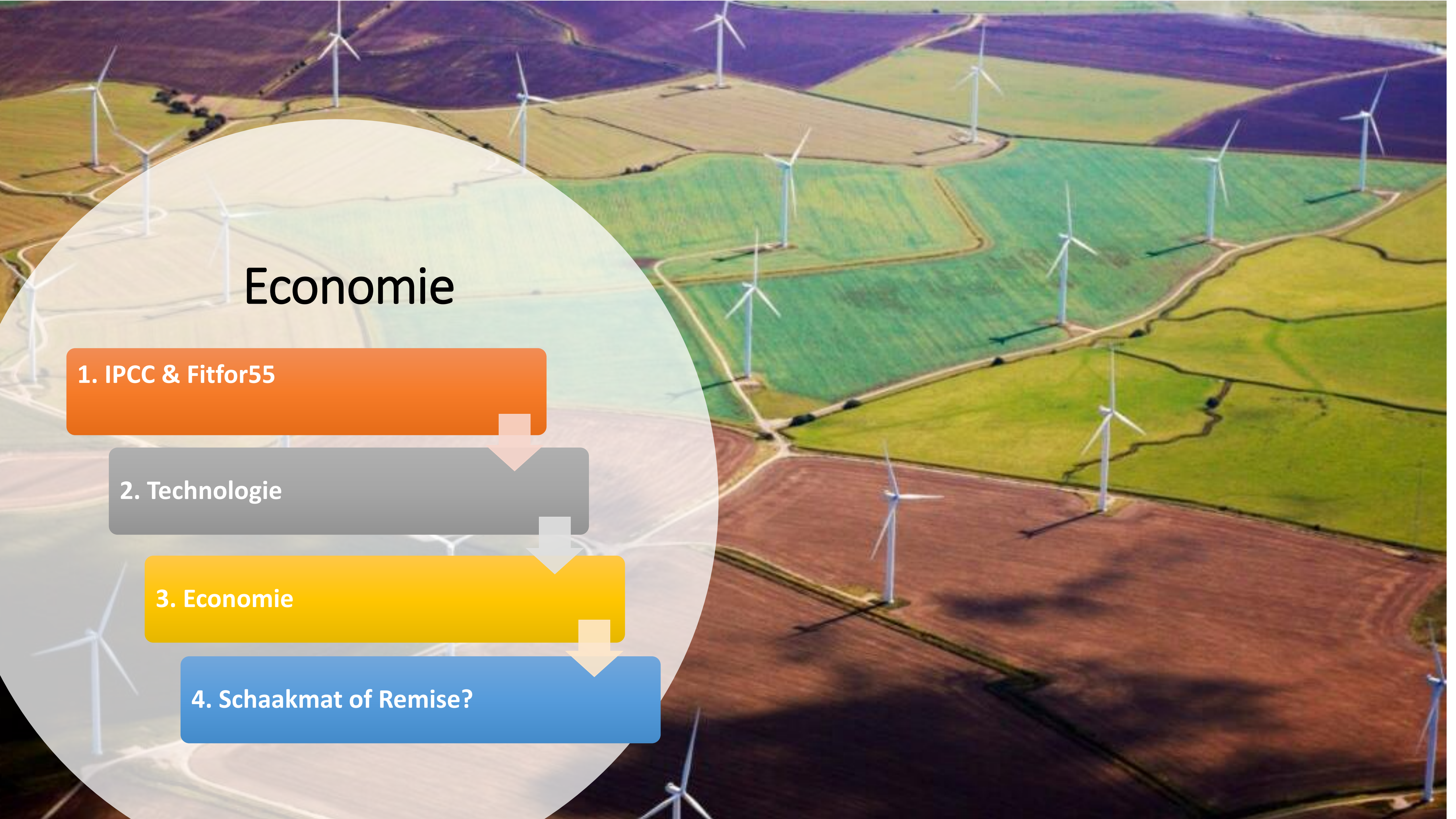
5:50 p.m. · 9 sep. 2021 · Twitter Web App

JesseJenkins
@JesseJenkins

4b. Development of competitive LDES techs remains uncertain + our research indicates complete substitution of LDES for firm power generation is unlikely even if cost targets reached. Betting narrowly on LDES is too risky. Best outcome is wind/solar + Li-ion + LDES + clean firm.

Tweet vertalen

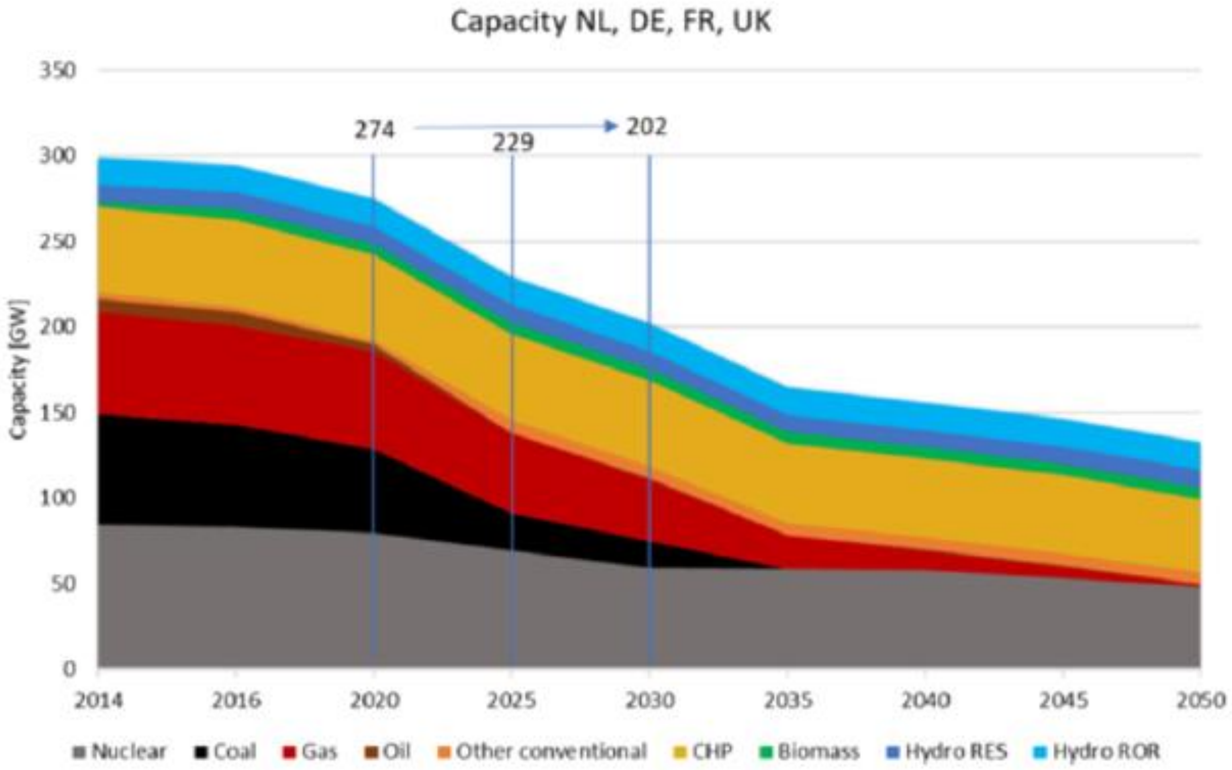
6:31 p.m. · 9 sep. 2021 · Twitter Web App



Economie

1. IPCC & Fitfor55
2. Technologie
3. Economie
4. Schaakmat of Remise?

Afbouw stuurbaar vermogen



Figuur 3 – afbouw thermische capaciteit in de buurlanden, Energyville 2020

Explosie prijs lithium, uranium, nikkel, gas, staal, fertilizers…

World of Statistics
@stats_feed

🔋 Lithium price ($/tonne):

2022: $78,032
2021: $17,000
2020: $6,800
2019: $11,310
2018: $14,660
2017: $12,070
2016: $8,840
2015: $5,110
2014: $4,680
2013: $4,750
2012: $4,450

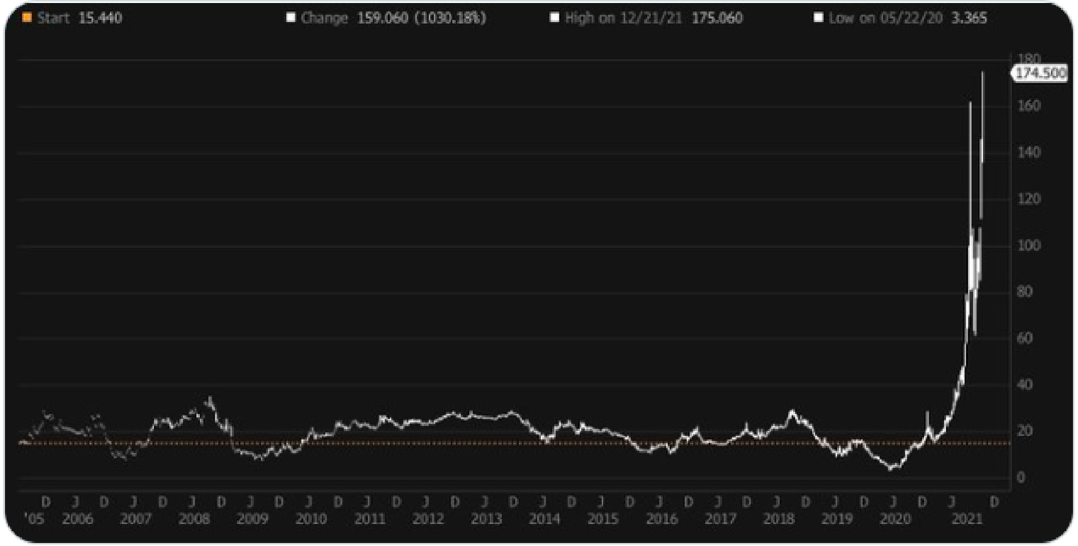
Tweet vertalen

5:00 p.m. · 8 apr. 2022 · Twitter for iPhone

4.656 Retweets **775** Geciteerde Tweets **30K** Vind-ik-leuks

Javier Blas @JavierBlas · 21 dec. 2021

EUROPEAN ENERGY CRISIS (1): Natural gas **benchmark** prices in Europe **jump** to an intraday all-time high, above the peak set in October. Dutch TTF has risen above €175 per MWh (that's almost $60 per mBtu or ~$330 per barrel of oil equivalent). UK NBP jumped to 441 pence per therm



5 140 275

Javier Blas @JavierBlas · 18 mrt.

CHART OF THE DAY: **Fertilizer** prices climb to a fresh record, as sales from Russia (one of the world's top producers) are disrupted, and super-expensive natural gas in Europe curtails output. The chart below is New Orleans urea price from 1977 to date | #OATT 🌽🚜👩‍🌾🌾⚗️

59 1.061 1.777

Javier Blas @JavierBlas · 20 mrt.

CHART OF THE DAY: Steel prices in Europe have surged to a fresh all-time high, with bechmark hot rolled coil trading above **€1,400** per tonne. Alongside the surge in fertiliser prices, this is another corner of the commodity market few are paying enough attention, but will bite

117 1.426 3.143

Bloomberg Energy
@BloombergNRG

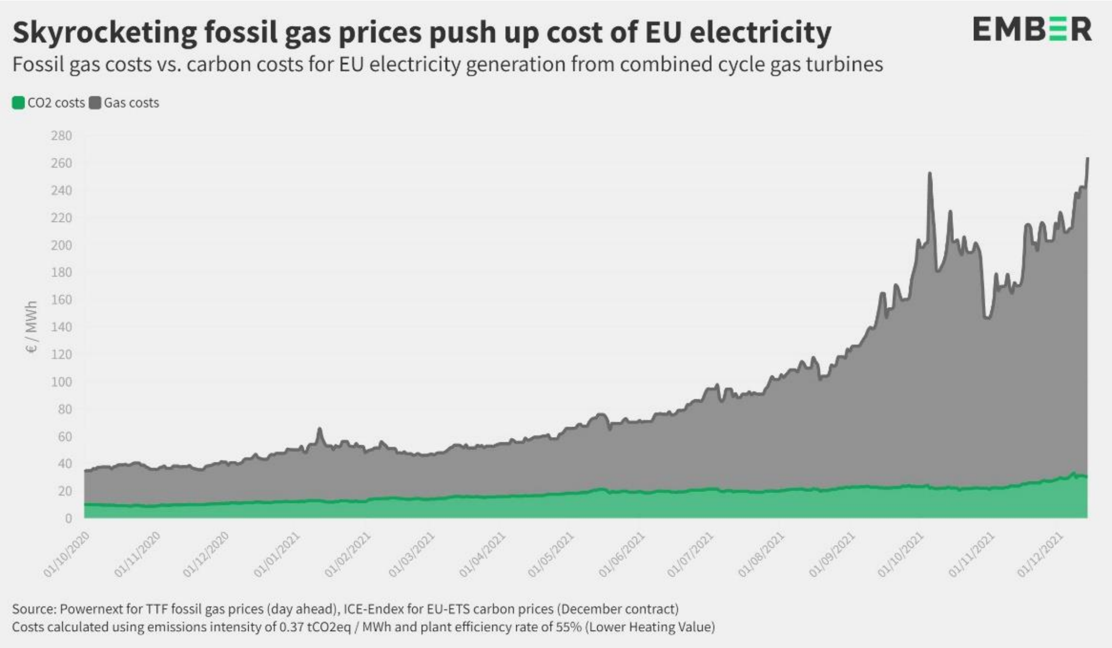
Benchmark German power for next year rises above 200 euros a megawatt-hour, the highest since December, as natural gas costs climb

Tweet vertalen

bloomberg.com

German Power Climbs Above 200 Euros on Higher Gas Costs

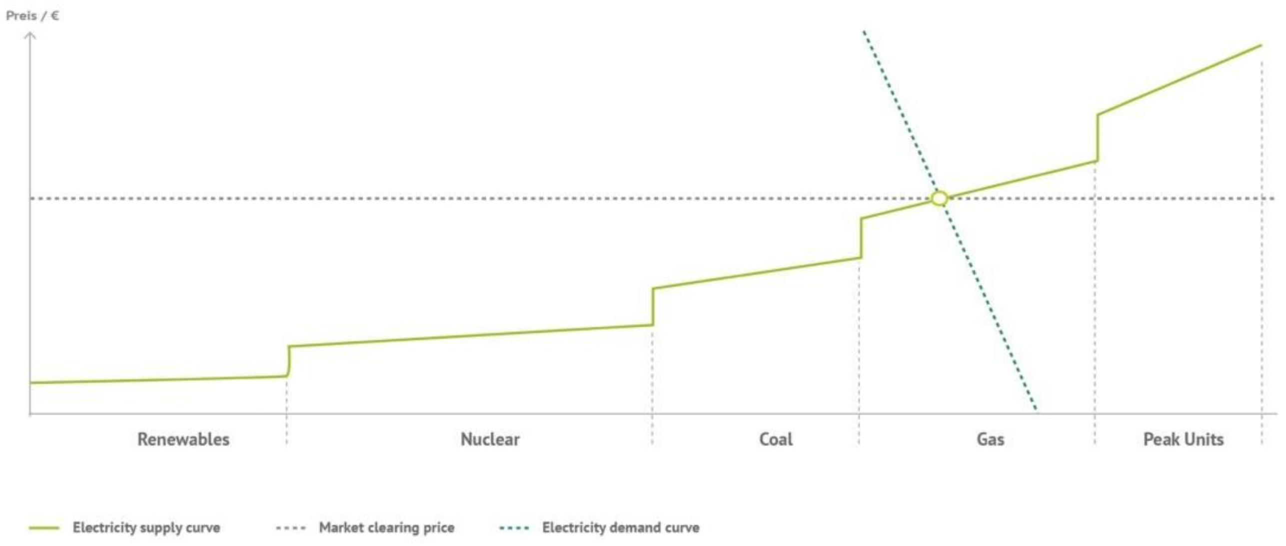
Benchmark German power for next year rose above 200 euros a megawatt-hour, the highest since December, as natural gas costs climbed.



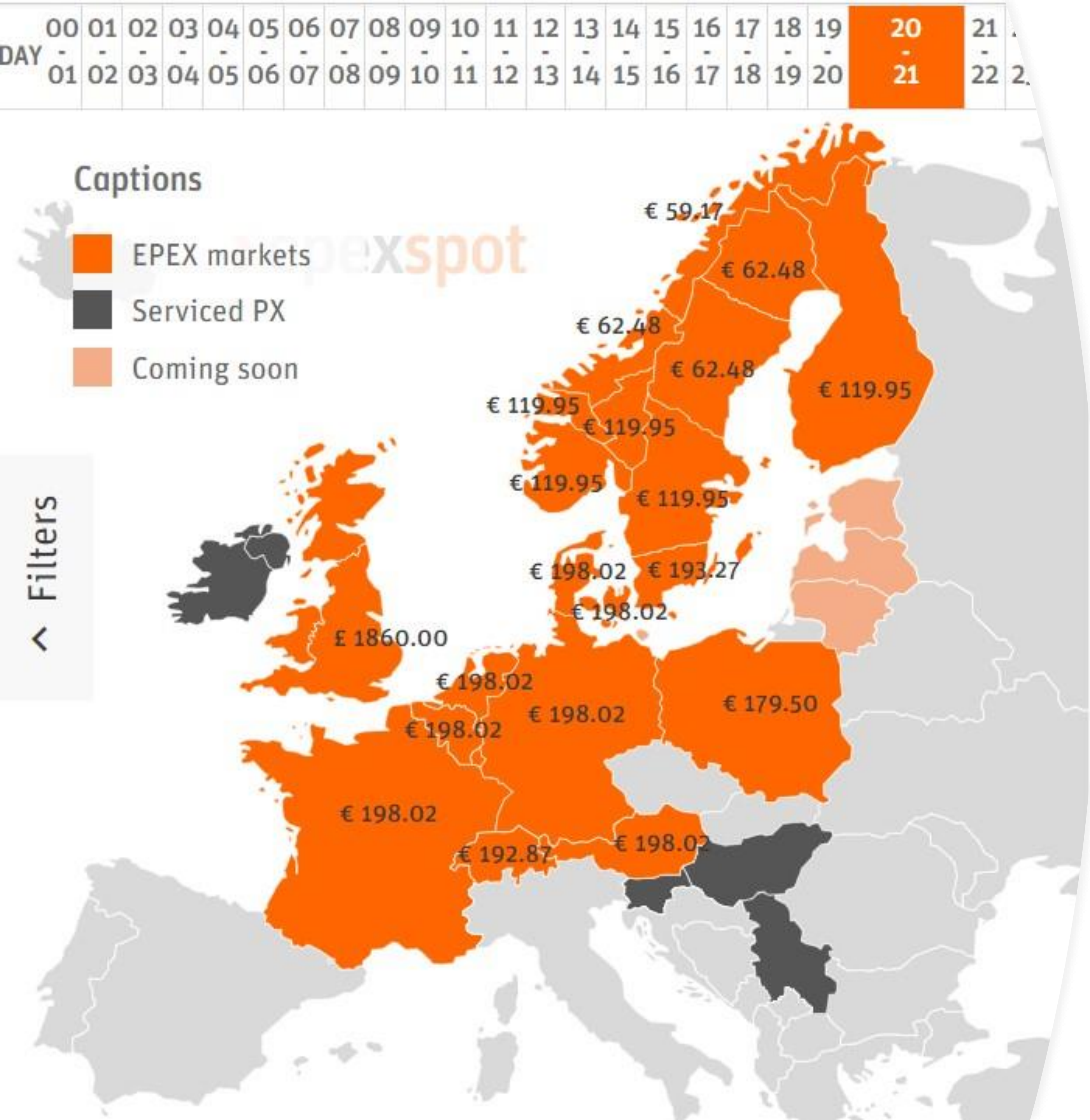
Marginal pricing

- marginale productiekost van het productiesysteem dat op het snijpunt ligt van vraag en aanbod
- Spot en LT markt (futures)
- OTC en energiemarkt: beide convergeren maar gasprijs bepaalt marktprijs voor 98%
- Kernenergie bij OTC valt weg
- ‘Windfall tax’
- Geïnterconnecteerde markten

Merit-order-curve



The market operator will also **aggregate the demand bids to form the demand curve**. The **intersection of the demand and the supply curve** determines the clearing price and the clearing volume. All generation market participants will **receive this clearing price for the electricity they inject in the grid**. Equally, the market participants who take off electricity will all pay that same price, being the clearing price.



Explosieve situatie

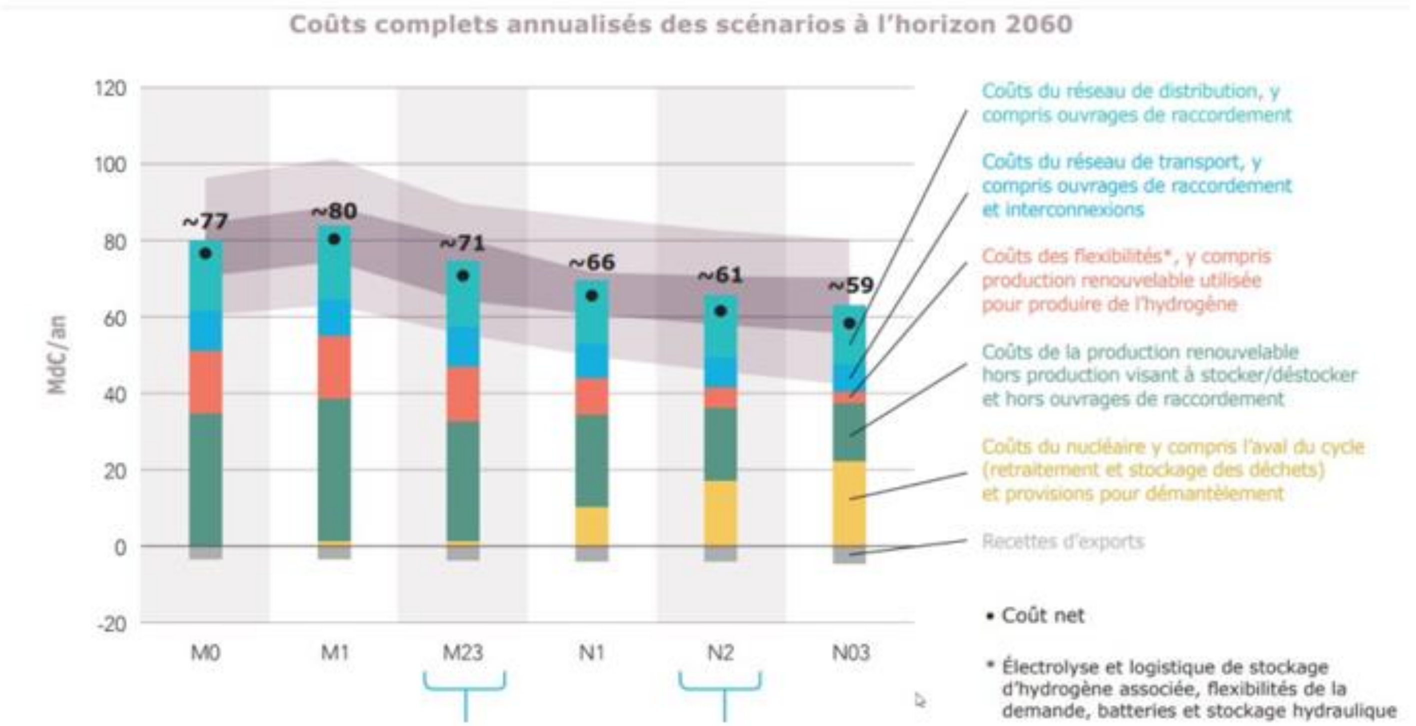
- Gasprijs onvoorspelbaar, van 20 naar 175 €/MWh
- Extremenen op spot markt: negatief tot 2000 €/MWh
- Switch naar LNG vraagtekens bij ecologie (fracking), bevoorrading (LNG tankers), kost
- 1/1 impact op alle energie-intensieve processen en elektriciteit
- Schaarste aanbod
- Recessie, begrotingstekort, voedselcrisis, concurrentiekracht

Prijs versus kost!

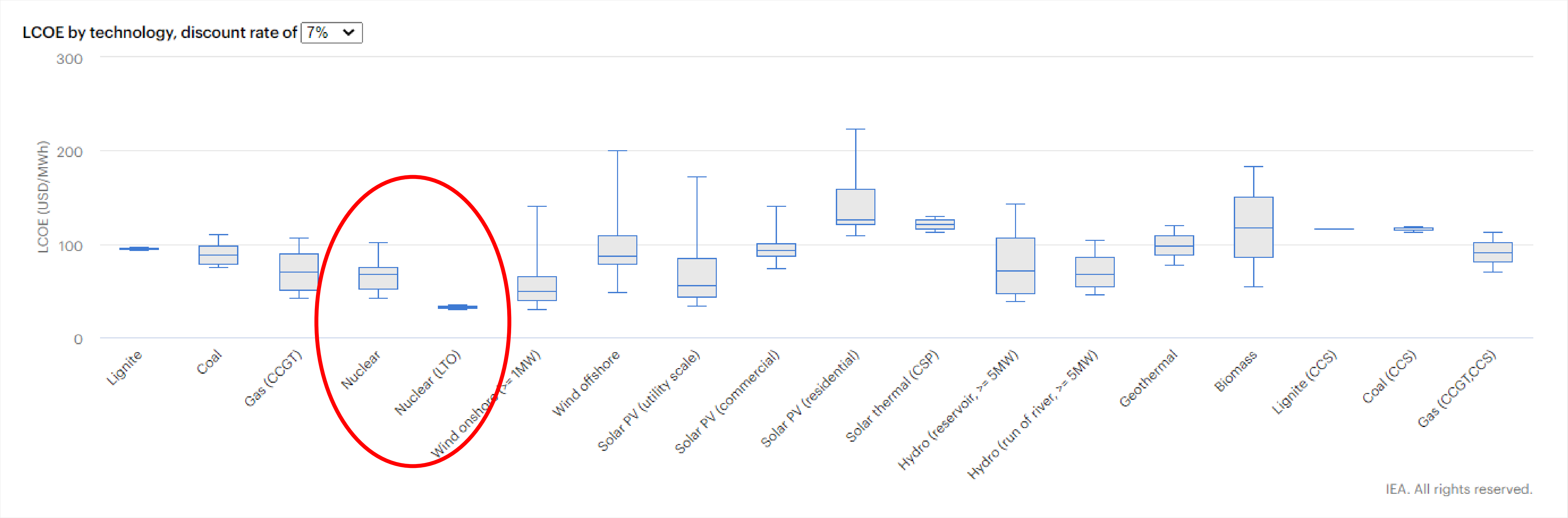
- ETS cost (import)
- trade cost (handelsbalans)
- Fuel cost (Ur versus NG)

→ 'Societal cost' (Energyville)

- System cost
- LCOE = levelized cost of energy



Figuur 11: RTE Frankrijk, doorlichting totale kost voor verschillende scenario's


LCOE by technology, discount rate of 7%
300
200
100
0
LCOE (USD/MWh)
Lignite
Coal
Gas (CCGT)
Nuclear
Nuclear (LTO)
Wind onshore (>= 1MW)
Wind offshore
Solar PV (utility scale)
Solar PV (commercial)
Solar PV (residential)
Solar thermal (CSP)
Hydro (reservoir, >= 5MW)
Hydro (run of river, >= 5MW)
Geothermal
Biomass
Lignite (CCS)
Coal (CCS)
Gas (CCGT,CCS)
IEA. All rights reserved.

SMR	Overnight capital cost Per kW net of installed capacity	Description	Australian owner's costs and contingency Per kW of installed capacity (generic estimate, 25% of OCC)
NuScale Power Module (NuScale Power)	$5100 NOAK	Conforms to AACE International Class 4 cost estimate with over 14,000 line items (equipment, material, etc) priced using Fluor's current proprietary cost data or actual vendor quotes	$1257
BWRX- 300 (GE Hitachi)	$3200 NOAK	Publicised target cost	$800
Integral Molten Salt Reactor (Terrestrial Energy)	$4100 FOAK	Disclosed target of US$3000/kW	$1025

Note: FOAK = First of a kind; NOAK= Nth of a kind

TABLE 4

Estimated levelised cost of electricity (net) for SMRs from three vendors

A$, 2020

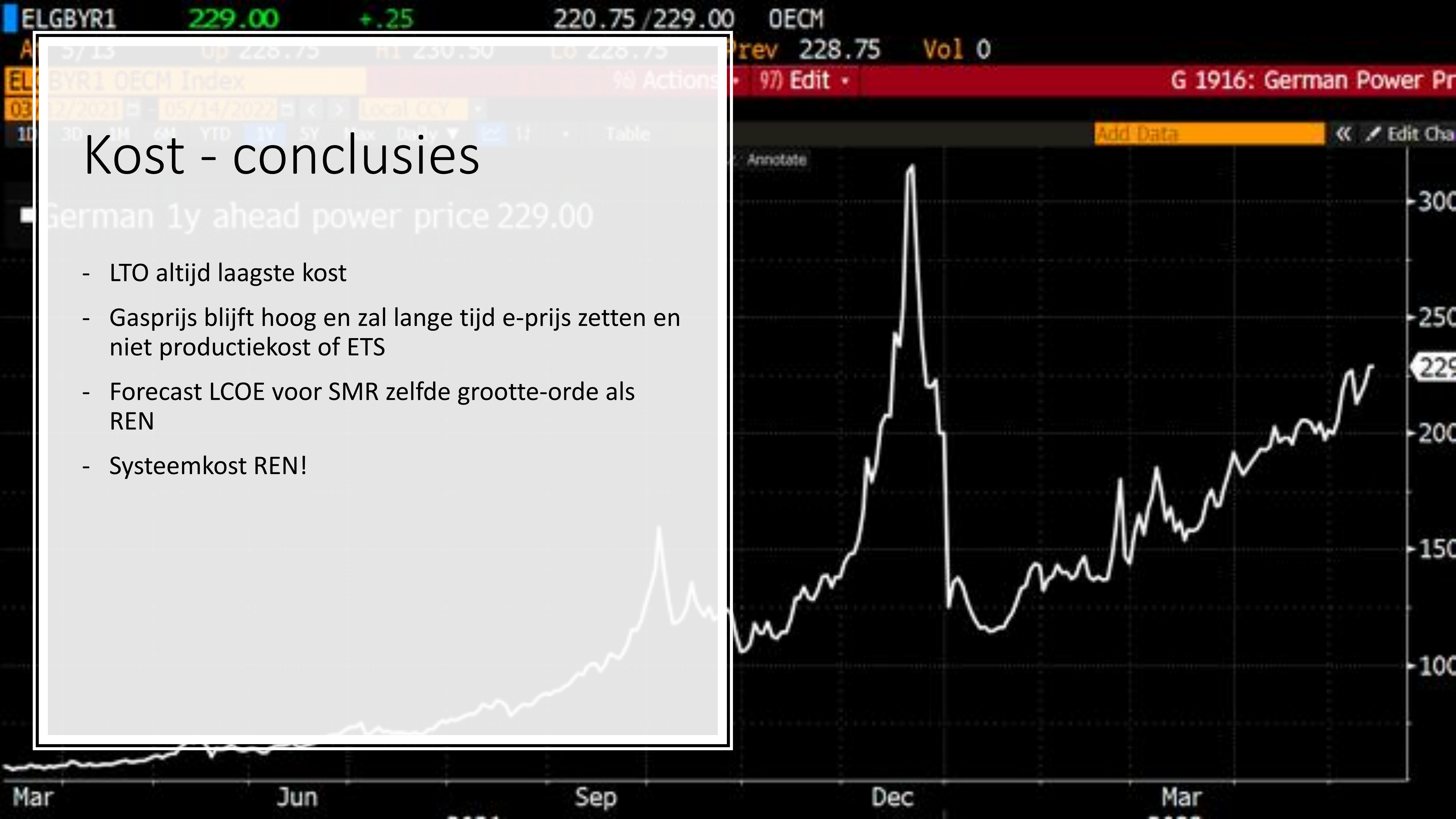
Product	Capacity MWe	Total overnight cost $/kW installed	Total overnight cost Total, million	Asset life Years	Capacity factor %	Fixed O&M $ per kW	Variable O&M $ per MWh	Fuel $ per GJ HHV	Thermal efficiency %	Build time Years	Output p. a. GWh	LCOE 5.9%
NuScale Module	884	$6750	$5636	40	90%	$80	$1	0.6	33%	3	6969	$77
BWRX-300	280	$4000	$1120	40	90%	$158	$2	0.6	33%	3	2365	$64
IMSR	390 (2 x 195)	$5125	$1999	40	90%	$158	$2	0.6	45%	3	3074	$72

Note: Total overnight cost = overnight capital cost plus 25% owners cost and contingency

SMR's in the Australian context, 2021

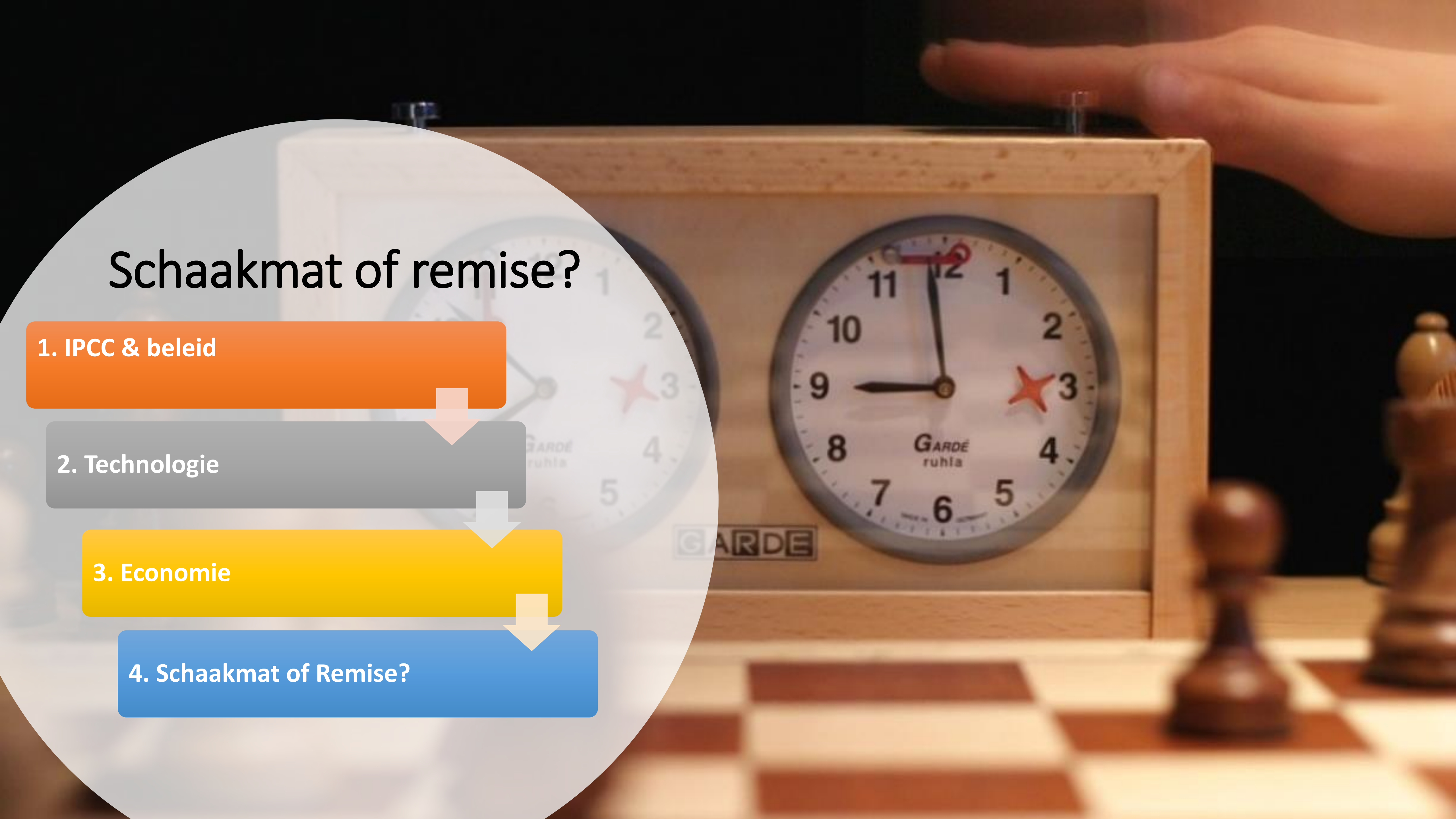
Kost - conclusies

- LTO altijd laagste kost
- Gasprijs blijft hoog en zal lange tijd e-prijs zetten en niet productiekost of ETS
- Forecast LCOE voor SMR zelfde grootte-orde als REN
- Systeemkost REN!



Schaakmat of remise?

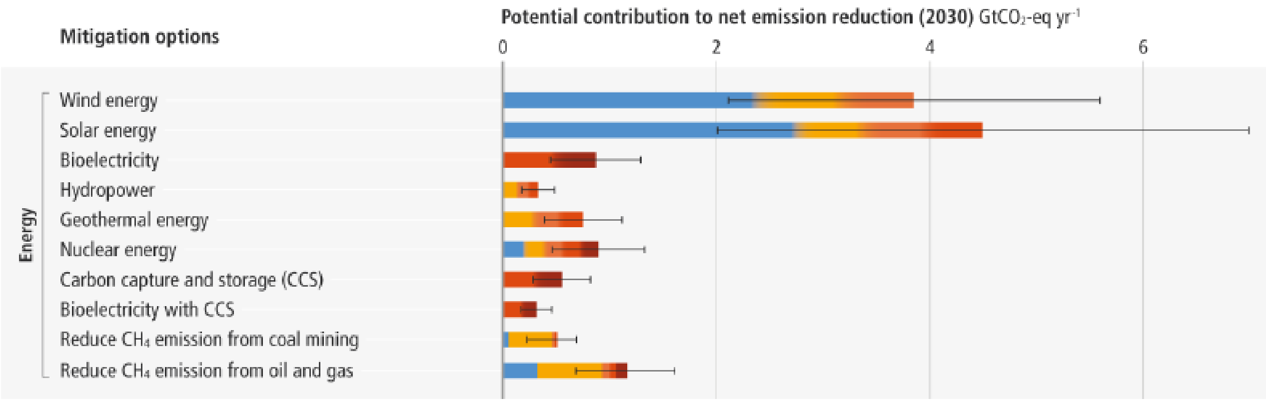
1. IPCC & beleid
2. Technologie
3. Economie
4. Schaakmat of Remise?



If we can put a man on the moon

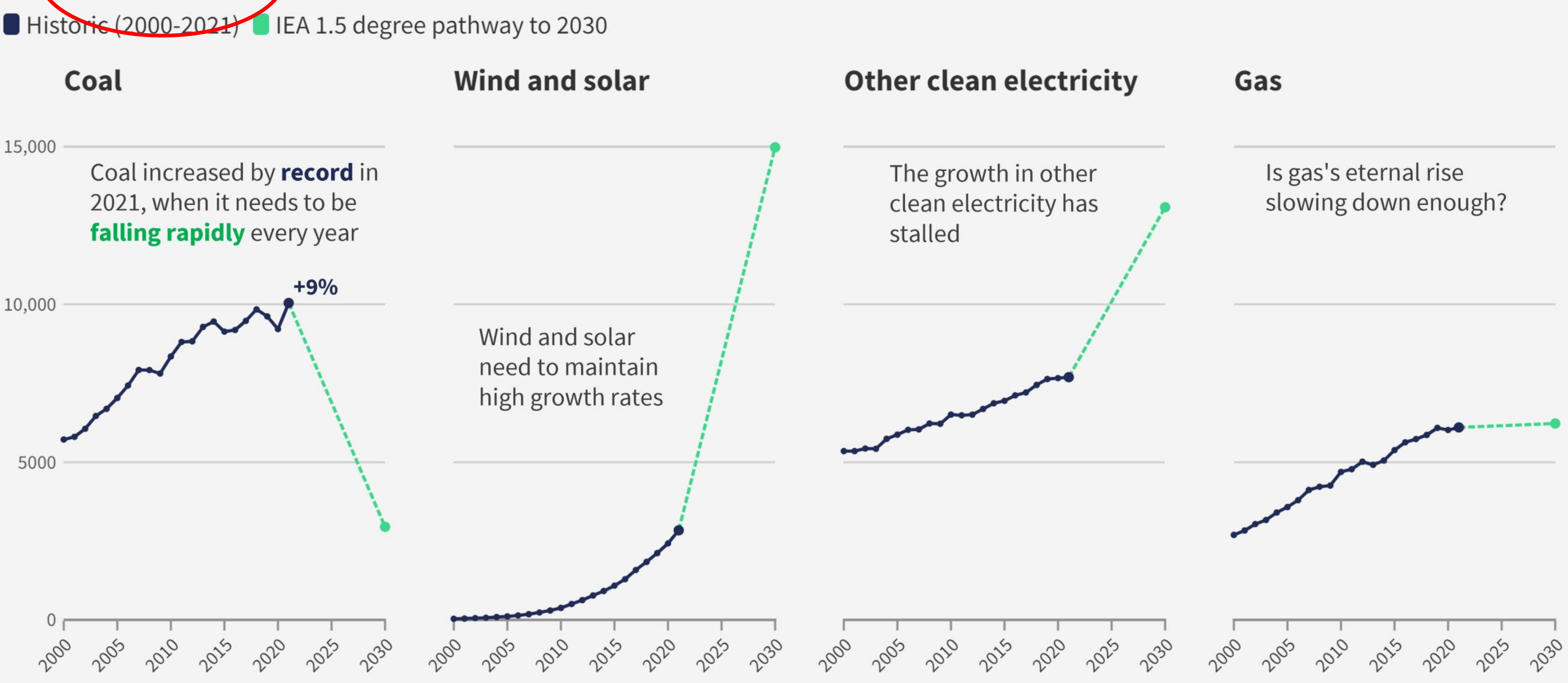
- IEA 10 2022 points plan for EU
    - Openhouden nucleaire installaties
    - HE/ warmtepompen
- IPCC aanbevelingen 2022-32
- Carbon trade (ETS/ Fitfor55)
- Innovations
    - Mining
    - Industrie: staal, circulaire CO2,…
    - Hydrogen
    - Nuclear
    - Storage, HVDC,…
- Energy savings!

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.



What needs to happen for 1.5 degrees?

Global electricity generation, in terawatt hours



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report.

Other clean electricity includes: Nuclear, hydro, bioenergy, other renewables, hydrogen and fossil CCS

Green Industrial Revolution for 250,000 jobs

Prime Minister Boris Johnson outlines his Ten Point Plan for a Green Industrial Revolution for 250,000 jobs.

From: Prime Minister's Office, 10 Downing Street and The Rt Hon Boris Johnson MP
Published 18 November 2020

trust

Blog Post - 19 November 2021

Ten Point Plan: what progress has been made in the first year?

Policy

	– Launching £240 million to Net Zero Hydrogen Fund and later in April – Developed indicative Heads of Terms for hydrogen business model contract
Delivering new and advanced nuclear power	– Committed to provide up to £1.7 billion of direct government funding to enable one nuclear project to FID this Parliament – Investing £100 million into Sizewell C to help develop this project – Investing £210 million to develop Small Modular Reactors with Rolls Royce – Announced a £120 million Future Nuclear Enabling Fund to progress new nuclear
Accelerating the shift	– £4 billion of investment has flowed into the UK zero emission

	year
Protecting our natural environment	– Additional £124 million provided at Spending Review 2021 to the Nature for Climate Fund to support tree planting and peat restoration, going beyond 2019 manifesto commitment of £640 million – 13,290 hectares of trees planted across the UK in 2020 to 2021 – Launched 3 new Community Forests in Cumbria, Devon and the North-East – £5.2 billion invested in a 6 year programme of flood defences

Persoonlijke visie

- REN + nucleair beide nodig voor stabiele bevoorrading en klimaatbeleid/ ‘EU Green Deal to include nuclear technology’
- Evaluatie veiligheid en LTO bestaande reactoren. Parallelle piste voor eigen waterstof uit overcapaciteit nucleair (4 GW!), vandaag < 1 GW worldwide
- Infrastructuurwerken pipelines/ HV
- Dreigend materialentekort (Al, Fe, Cu, Co, Li, REM, Ur,…)
- Stimuleer innovatie en R&D/ kennis SCK/ bereid weg voor SMR’s → wet 2003!
- Culpabiliseren individu werkt niet
- Interessante evolutie CERN (kernfusie)
- Energiecrisis als opportuniteit → gerichte investeringen!

Masterpiece

- Creativiteit
- Innovatie
- Durf
- Doorzetting
- Positivisme

Bio

- Qualifications
  - Master of Science in Chemical Engineering, KUL
  - Post University Degree in Environmental Technology, UG
  - Post University Degree in Business Economics, KUL evening course
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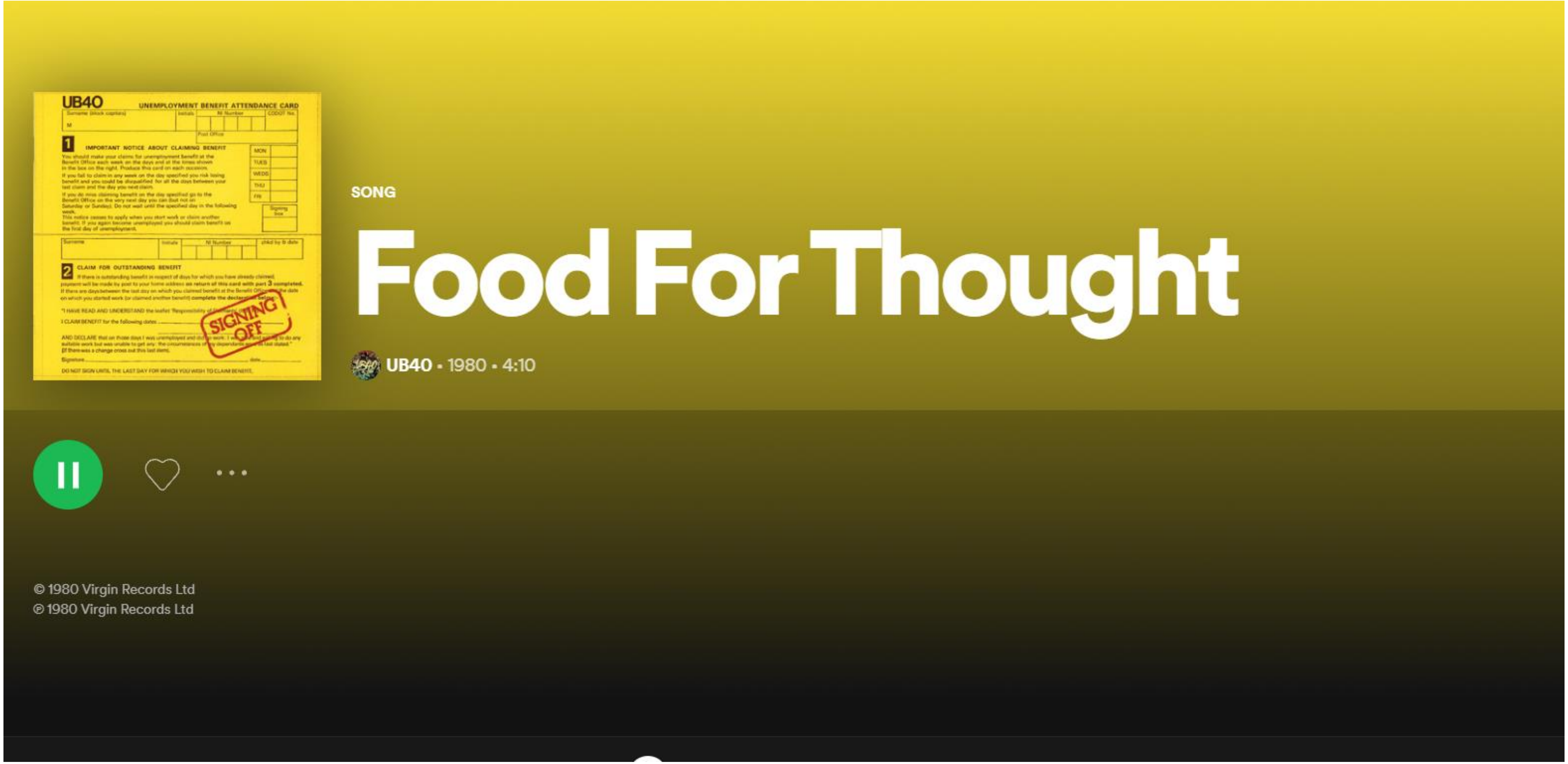
- On line:
  - https://www.ecomodernisme.be/post/kernenergie-onmisbare-bouwsteen-in-de-energietransitie
  - https://www.keepthelightson.be/ Perspectieven ‘sociaaleconomische aspecten’ en ‘bevoorradingszekerheid’



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