Joachim Feuerborn, ECOBA, Europe
Craig Heidrich, ADAA, Australia
Thomas Adams, ACAA, USA
Jinder Jow, CCAPC, China

INTERNATIONAL PERSPECTIVES
- On the stretch from Suitability to Sustainability - report on behalf of the WWCCPN

World Wide Coal Combustion Products Network

ACAA
American Coal Ash Association

ADAA
Ash Development Association of Australia

Asian CAA
Asian Coal Ash Association

CCAPC
China Coal Ash Professional Committee

CAII
Coal Ash Institute of India

ECOBA
European Coal Combustion Products Association e.V.

IACEE MPEI - Russia
Informational & Analytical Center "Ecology of Power Engineering" of MPEI

JCOAL
Japan Coal Energy Center

NCAB
National Coal Ash Board

UPS
Polish Union UPS

SACAA
South African Coal Ash Association

UKQAA
UK Quality Ash Association

www.wwccpn.net

> 90% coal use in phased out by 2050

- COP 28 significant [200 countries] agreement reached on ‘first time’ net zero by 2050
- Kyoto Annex I countries
  - E.g. EU 15 by 2038, Australia by 2040
- Kyoto Annex II countries
  - E.g. China still expanding CFPS grow, by commitments beyond +2030

COP 28

https://unfccc.int/cop28

COP 28 – Signals end of fossil "fuels"

16:00 13 Dec, 2023 Show less

COP28 Agreement Signals "Beginning of the End" of the Fossil Fuel Era

COP28 closed today with an agreement that signals the "beginning of the end" of the fossil fuel era by laying the ground for a swift, just and equitable transition, underpinned by deep emissions cuts and scaled-up finance.

In a demonstration of global solidarity, negotiators from nearly 200 Parties came together in Dubai with a decision on the world's first 'global stocktake' to ratchet up climate action before the end of the decade – with the overarching aim to keep the global temperature limit of 1.5°C within reach.

"Whilst we didn't turn the page on the fossil fuel era in Dubai, this outcome is the beginning of the end," said UN Climate Change Executive Secretary Simon Stiell in his closing speech. "Now all governments and businesses need to turn these pledges into real-economy outcomes, without delay."

https://unfccc.int/cop28

COP 28 – Global tracking indicators

- 3 x **renewable power capacity** globally by **2030**
- 2 x global rate of **energy efficiency improvement** by **2030**
- Accelerate efforts globally towards **net zero emission by 2050**
- Accelerate **phase out coal power**: but in a **just**, **orderly** and **equitable** manner
- Accelerate **zero and low-emissions technologies**
- Substantially **reduce methane emission** by **2030**
- Accelerate the **reduction of emission from road transport** (electrification?)
- Phase out **fossil fuel subsidies**

G7 meeting of environmental ministers

G7 ITALIA 2024

MINISTERS' MEETING ON CLIMATE, ENERGY AND ENVIRONMENT

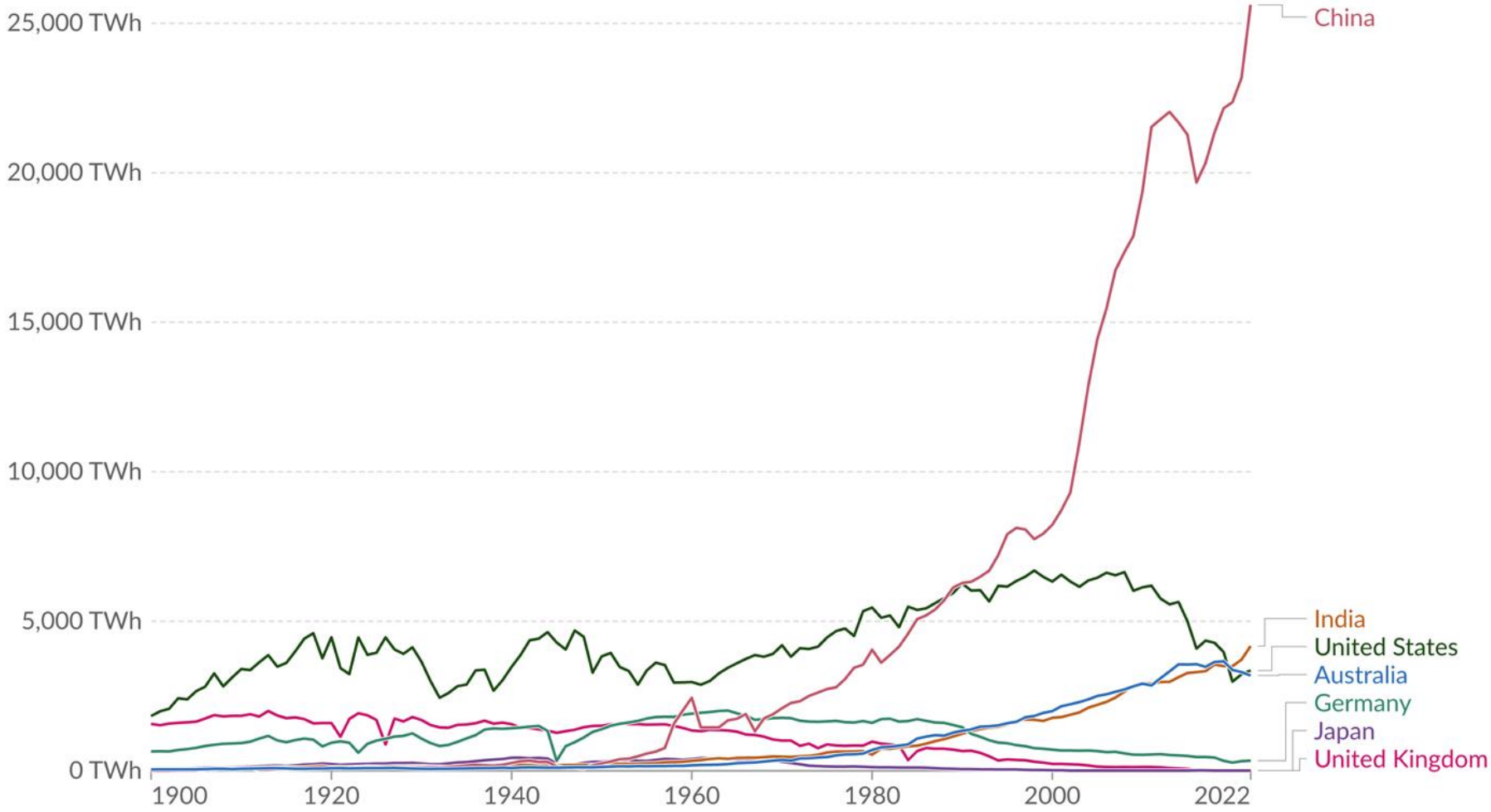
Torino, 28 - 29 - 30 April

G7- Enviroment Minister – outcome

- **Phase coal power first half of 2030s** or consistent with limit of 1.5°C temperature**. Track with countries' net-zero pathways**;
- Take concrete and timely steps as part of the policies that **inform and implement the next Nationally Determined Contributions**;
- Promote cooperation with countries and international partners including the financial sector towards the **end of the approval of new coal-fired power plants globally** as soon as possible;
- Engage **finance institutions** to continue working with governments to **enable the transitioning away from coal power**.

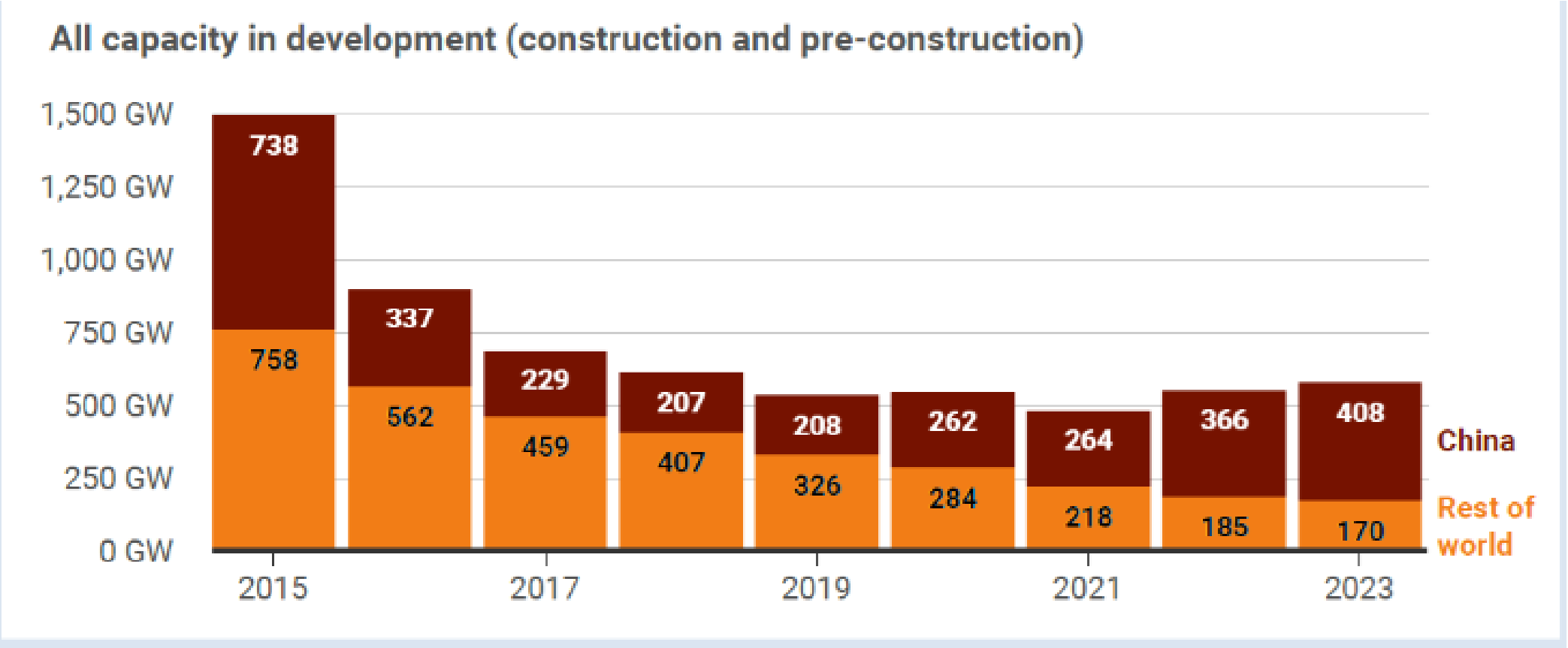
Coal production

Measured in terawatt-hours.



Data source: Energy Institute - Statistical Review of World Energy (2023); The Shift Data Portal (2019)
OurWorldInData.org/fossil-fuels | CC BY

Trends in new coal power



Source: Boom and Bust Coal 2024, Global Energy Monitor, April 2024

Top 25 Coal Power Countries

Ranking of countries by coal generation (TWh) in 2020

EMBER

Rank	2019-2020	Country	Coal generation (TWh)	Percentage of electricity production	Change 2015-2020 (TWh)
1		China	4631	61	
2		India	947	71	
3		United States	774	19	
4		Japan	274	29	
5		South Korea	192	36	
6		South Africa	191	86	
7	▲*	Indonesia*	168	60	
8		Russia	155	15	
9	▲	Vietnam	141	53	
10		Australia	135	54	
11	▼	Germany	134	24	
12	▲	Taiwan	117	44	
13	▼	Poland	110	70	
14		Turkey	99	34	
15		Kazakhstan	72	70	
16		Malaysia*	67	41	
17		Philippines	49	50	
18		Canada	45		
19		Ukraine	38	28	
20	▲	Thailand	35	20	
21	▼	Czechia	32	40	
22		Pakistan	29	20	
23	▲	Serbia	25	70	
24	▼	Brazil	22		
25		Israel*	22	33	

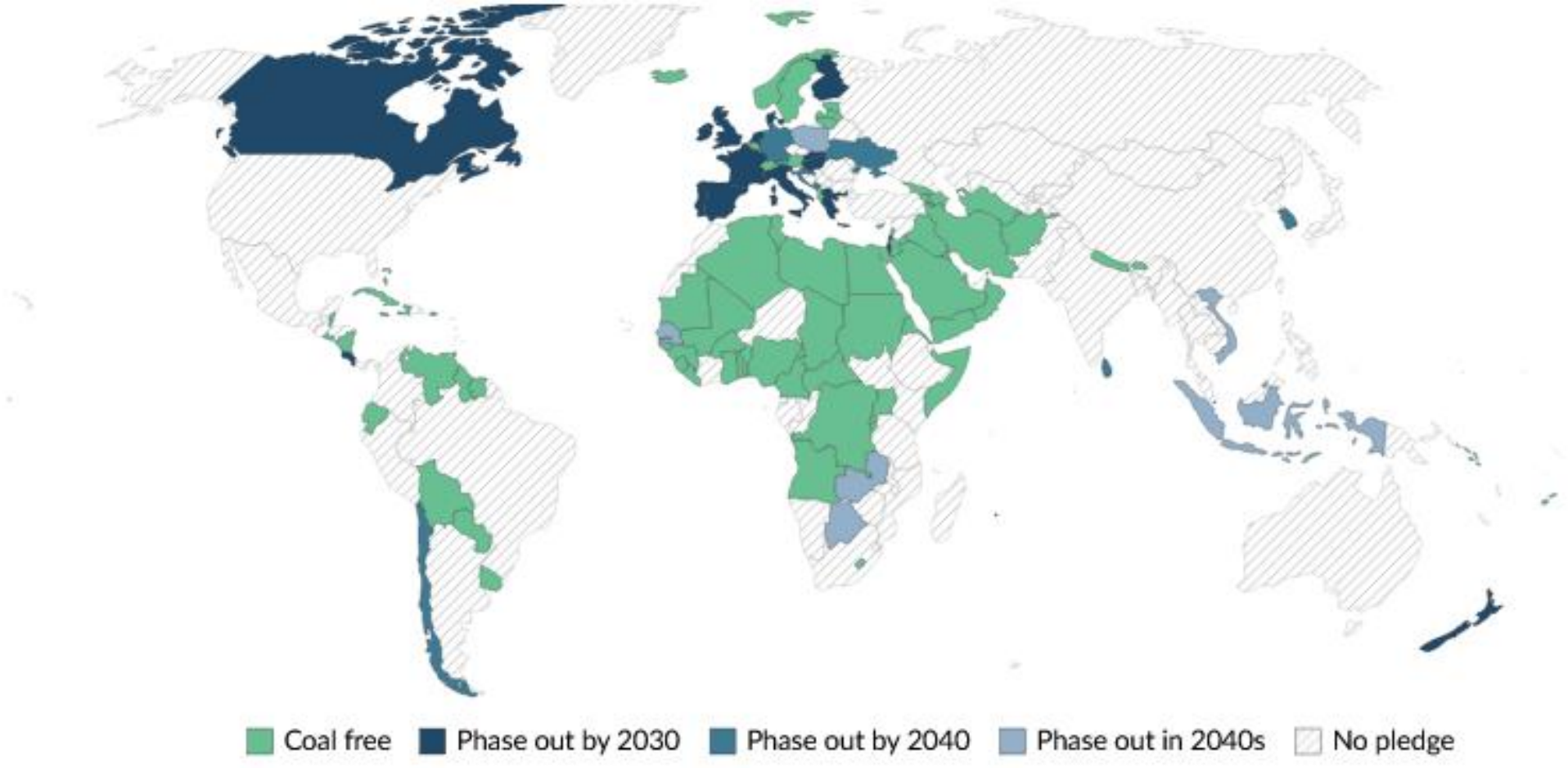
Source: Ember Global Electricity Review 2021 • *For Indonesia, Malaysia and Israel, 2019 is used as no 2020 data exists.

increase

more or less same level

decrease

Coal phase-out annoucements worldwide

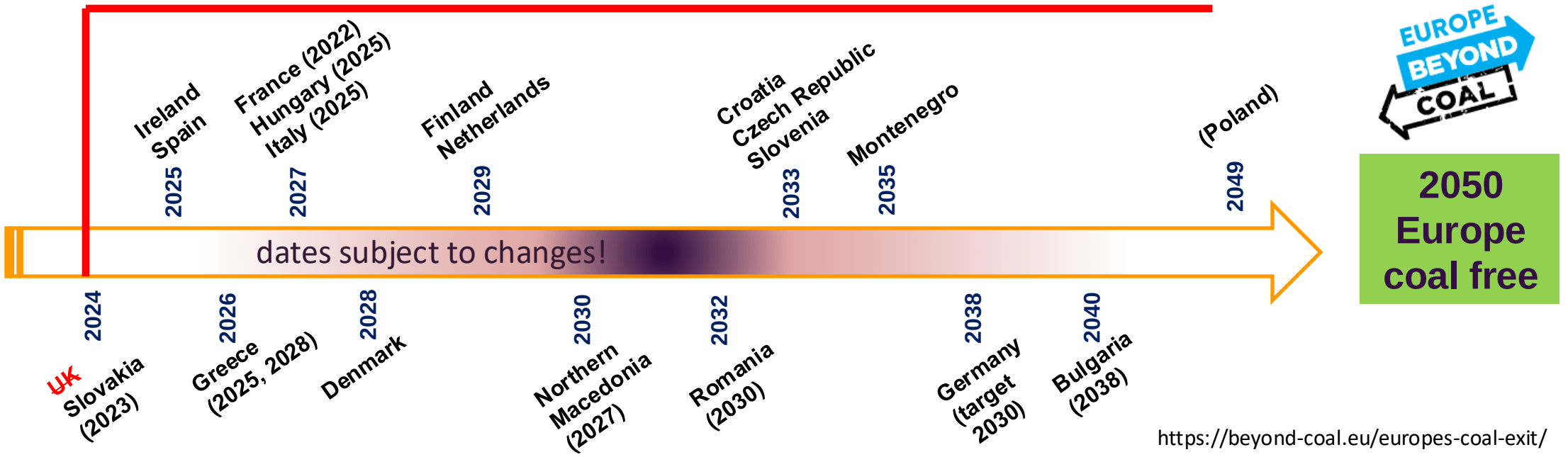


https://ourworldindata.org/coal-phase-out

Coal phase-out announcements in Europe

Coal phase-out in Europe - status / announcements

No coal in energy mix:	Albania, Cyprus, Estonia (oil shale), Iceland, Latvia, Lithuania, Luxembourg, Malta, Norway, Switzerland
No phase out under discussion:	Bosnia-Herzegowina, Kosovo, (Serbia, (Poland), (Turkey)
Phased out:	2016 Belgium; 2020 Austria, Sweden; 2021 Portugal; 2024 UK



https://beyond-coal.eu/europes-coal-exit/
status 08-2024; upd 10.2024

Coal phase-UK

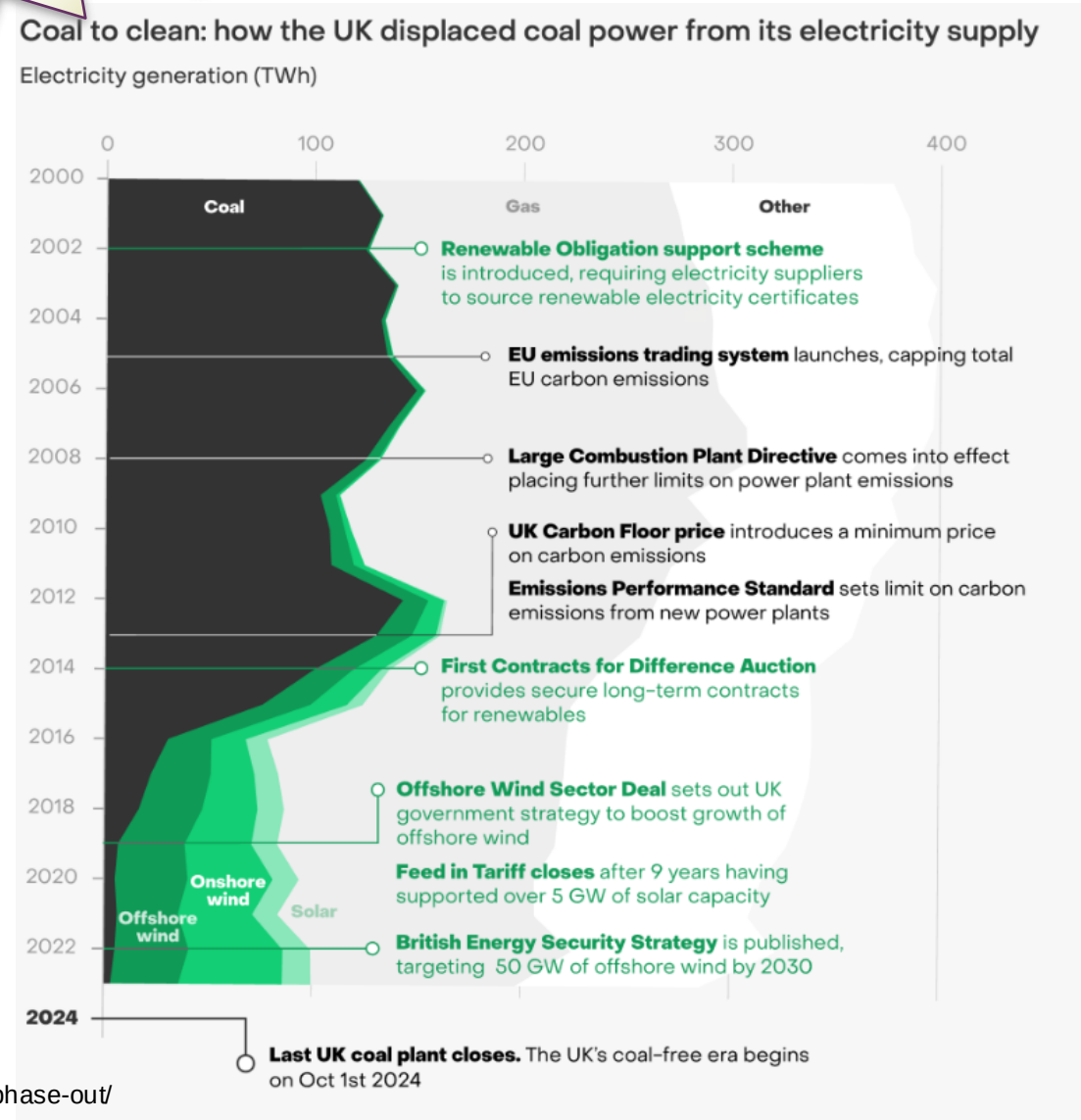
Executive summary

The UK's era of coal-free electricity begins

The closure of the final coal plant in the UK, Ratcliffe-on-Soar, at midnight on 30th September 2024, marks the beginning of a new era.

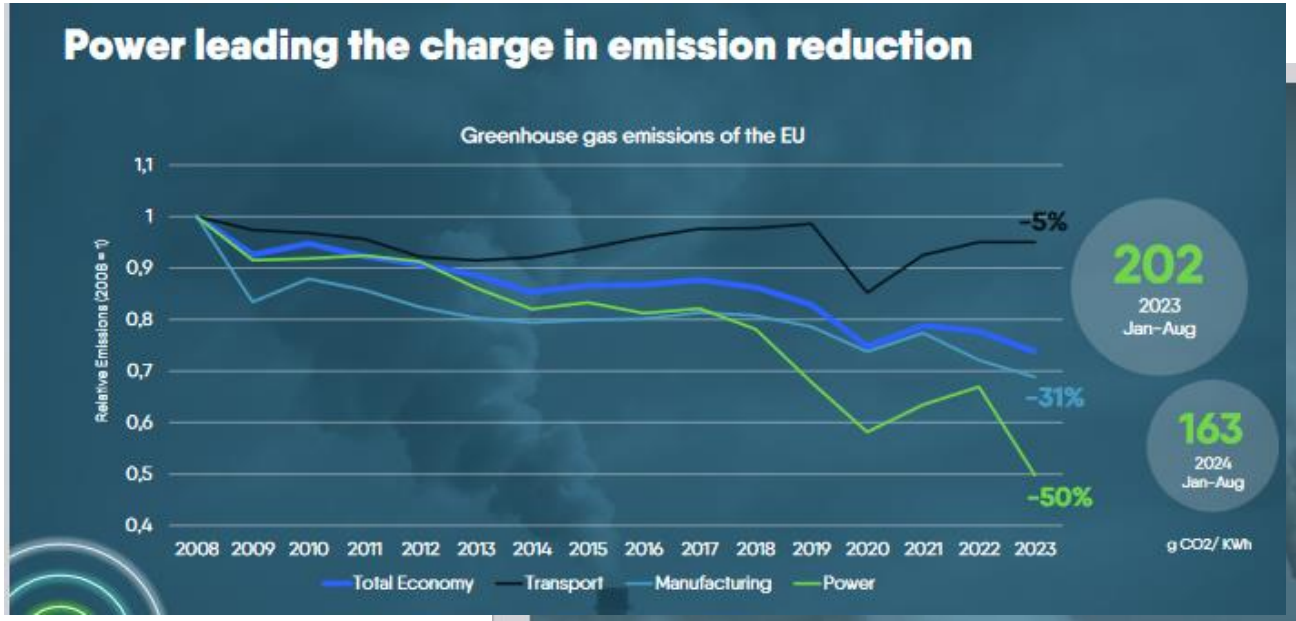
1st October 2024 marks a historic moment: the first day of the UK coal-free power era. Looking back at the last decade shows the astonishing pace at which the UK achieved this milestone. UK policies have incentivised the rapid deployment of renewable energy over the last decade, while simultaneously tightening restrictions on high polluting coal power plants. These policies have delivered a large drop in carbon emissions from electricity generation, from 160 million tonnes of carbon dioxide equivalent (MtCO2e) in 2012 to 41 MtCO2e in 2023.

As the UK now targets another ambitious decarbonisation goal — clean power by 2030 — keeping the lessons of coal phase-out in mind will be critical, as well as preparing for the unique challenges that will be faced as the UK targets economy-wide decarbonisation.



https://ember-climate.org/insights/research/the-uks-journey-to-a-coal-power-phase-out/

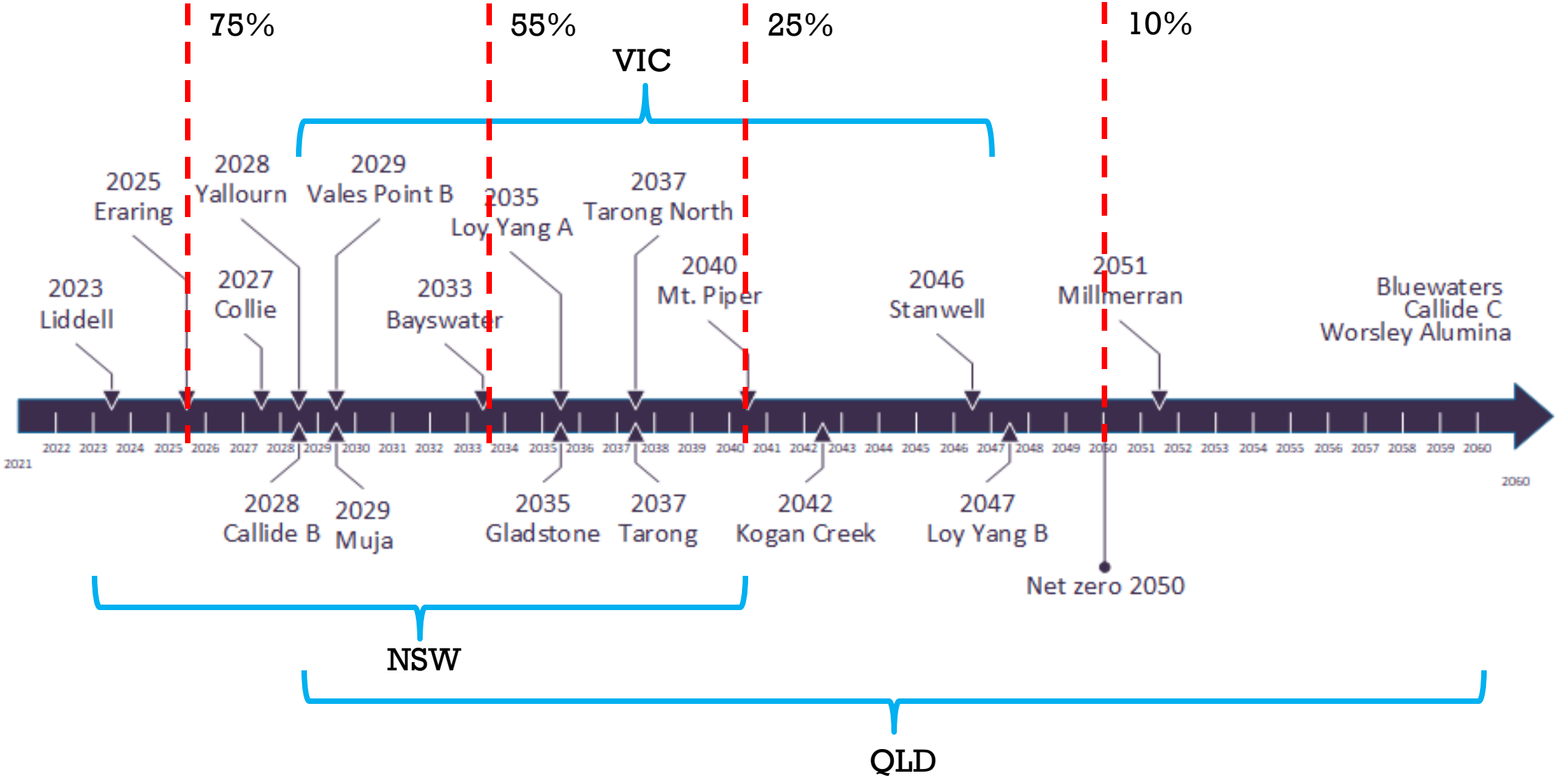
EU - Development in energy production



Source: Eurelectric Power Barometer 2024

Sources: Eurelectrics ELDA for 2024; Eurostat for 2015

Coal phase-out announcements in Australia



Global Production 2022

Table 3. Production and Utilisation Rates of CCPs by Country 2022

Country/Region	Production (Mt)	Utilisation (Mt)	Utilisation Rate %
Australia	10.6	6.6	62%
Asia	724.5		
- China	650.0	388.0	60%
- Korea	7.5	6.2	83%
- Other Asia	67.0		0%
Canada	3.4		0%
Europe	60.0		
- EU15	15.0	18.0	120%
India	282.8	282.7	100%
Japan	12.1	11.6	97%
Middle East & Africa	34.5	2.4	7%
Israel	0.5	0.5	100%
United States of America	45.5	29.3	64%
South America	8.6		0%
Russian Federation	17.4	5.0	29%
Total	1199.9	750.7	62%

Global definition for CCPs

Table 1. WWCPN global definitions for coal combustion products[i]

Term	Definition
Coal Combustion Products	Coal combustion products (CCPs) include fly ash, bottom ash, boiler slag, fluidized-bed combustion (FBC) ash, or flue gas desulfurization (FGD) material produced primarily from the combustion of coal or the cleaning of the stack gases of coal fired power stations. The term coal ash is used interchangeable for the different ash types.
Fly ash	The finer ash produced in a coal fired power station, which is collected using electro-static precipitators. This is also known as Pulverised Fuel Ash (PFA) in some countries. About 85+% of the ash produced is fly ash.
Furnace Bottom Ash (FBA)	The coarse ash that falls to the bottom of a furnace. The molten ash adheres to the boiler tubes, eventually falling to the base of the furnace. ….. Usually <15% of the ash produced is FBA
Cenospheres	Hollow ash particles that form in the furnace gas stream. They float on water and are usually collected from lagoons, where ash/water disposal systems are being used.
Conditioned ash	Where fly ash is mixed with a proportion of water (10 to 20% by dry mass typically) in order that it can be transported in normal tipping vehicles without problems with dust for sale or disposal.
Flue Gas De-sulfurisation	Where a source of calcium is injected into the furnace gas stream to remove sulfur compounds. The sulfur compounds convert the calcium carbonate to calcium sulfate, or gypsum, which is used in the wallboard industry for general construction
Harvested CCPs (new)	**The removal, or reclamation, of CCPs from an active or inactive storage area for the purpose of beneficial use.**

Green construction with CCPs

Global Cement and Concrete Association

INNOVANDI GCCRN LOGIN | MEMBERS AREA

ABOUT US | ABOUT CEMENT & CONCRETE | NET ZERO | INNOVATION | ESG | NEWS AND EVENTS | POLICIES

In 2020, member companies of the Global Cement and Concrete Association came together as leaders in the sector to commit to producing carbon neutral concrete by 2050, in line with global climate targets – accelerating the CO_2 reductions that we have already achieved. Our 2050 Net Zero Roadmap sets out in detail how collectively, in collaboration with built environment stakeholders and policymakers, we will fully decarbonise the cement and concrete industry and provide net zero concrete for the world.

Circular Economy

The industry utilises recycled/secondary aggregates and cementitious industrial by-products in concrete and alternative fuels/raw materials in cement kilns. Concrete buildings are long-lasting and can be re-used or adapted and re-purposed.

https://gccassociation.org/concretefuture/

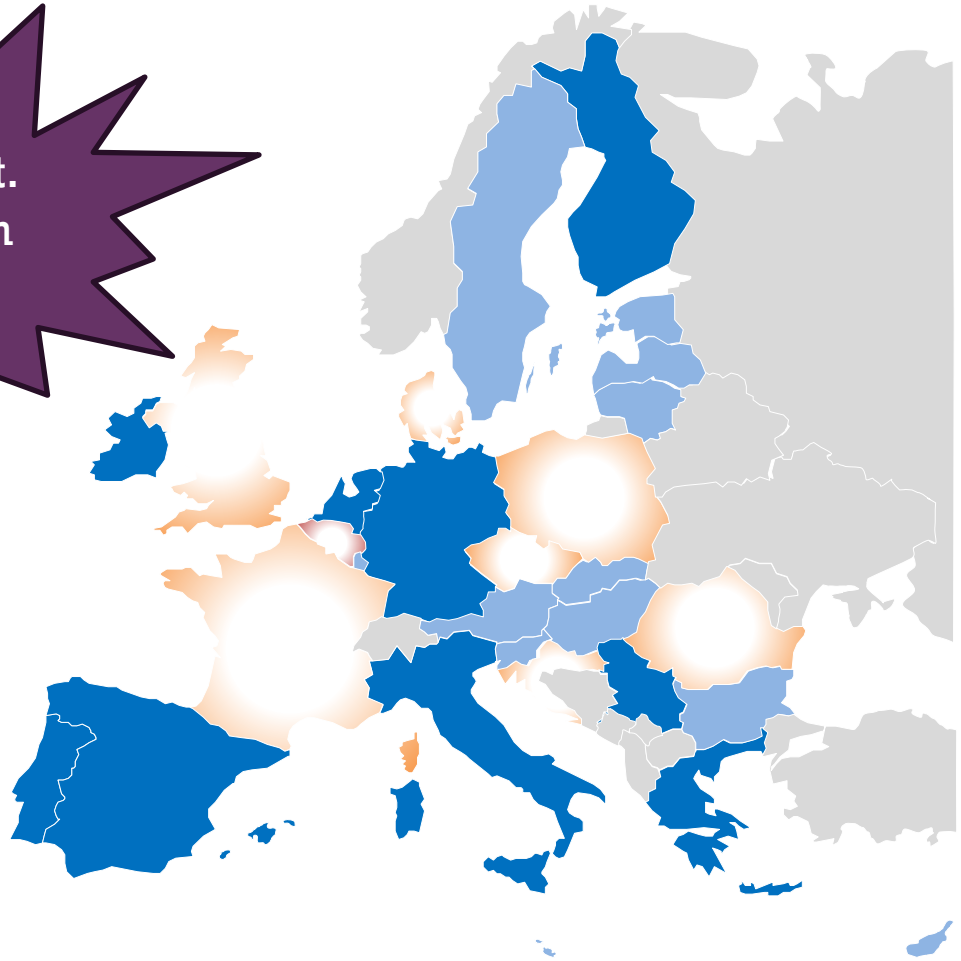
Resource harvesting & conservation opportunities with CCPs

- Mt Everest ~1,400 Billion M^3
- Global Construction Materials use, ~48 Billion M^3
- Mt Everest consumed every 30 years
- Harvestable CCPs today, ~100 Billion M^3
- ~ 100-150 years of resources if economic

Development EU: re-use from stock

Re-use from stock: ongoing and/or developing

>500 mill. t. of ashes on identified stocks



Ongoing re-use:
- Regular re-use in France
  - since more than 50 years as wet ash for different applications
  - since more than 30 years for cement and concrete industry after drying
- In other EU countries for cement and concrete and for road construction

Developing re-use:
- Identification of stocks
- Research work on properties of ash from stock
- Identification of markets and processing technologies
- Huge reserves on stock identified

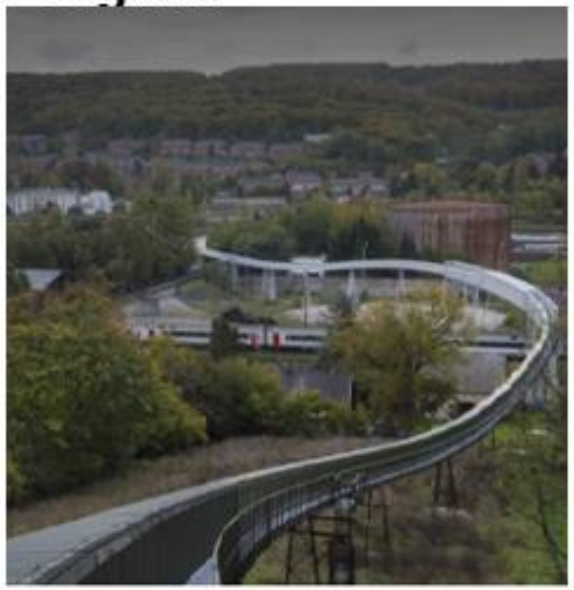
Development EU: re-use from stock

Availability of ash: re-use from stock

- Re-use from stock is practised for more than 50 years in Europe (30 year for also re-drying
- Data for re-use from stock and/or import are covered by the ECOBA statistics. The figures from 2010 to 2022 range from 0.4 to 2.2 Mt with increasing tendency.
- Projects ongoing or newly started in different EU-countries

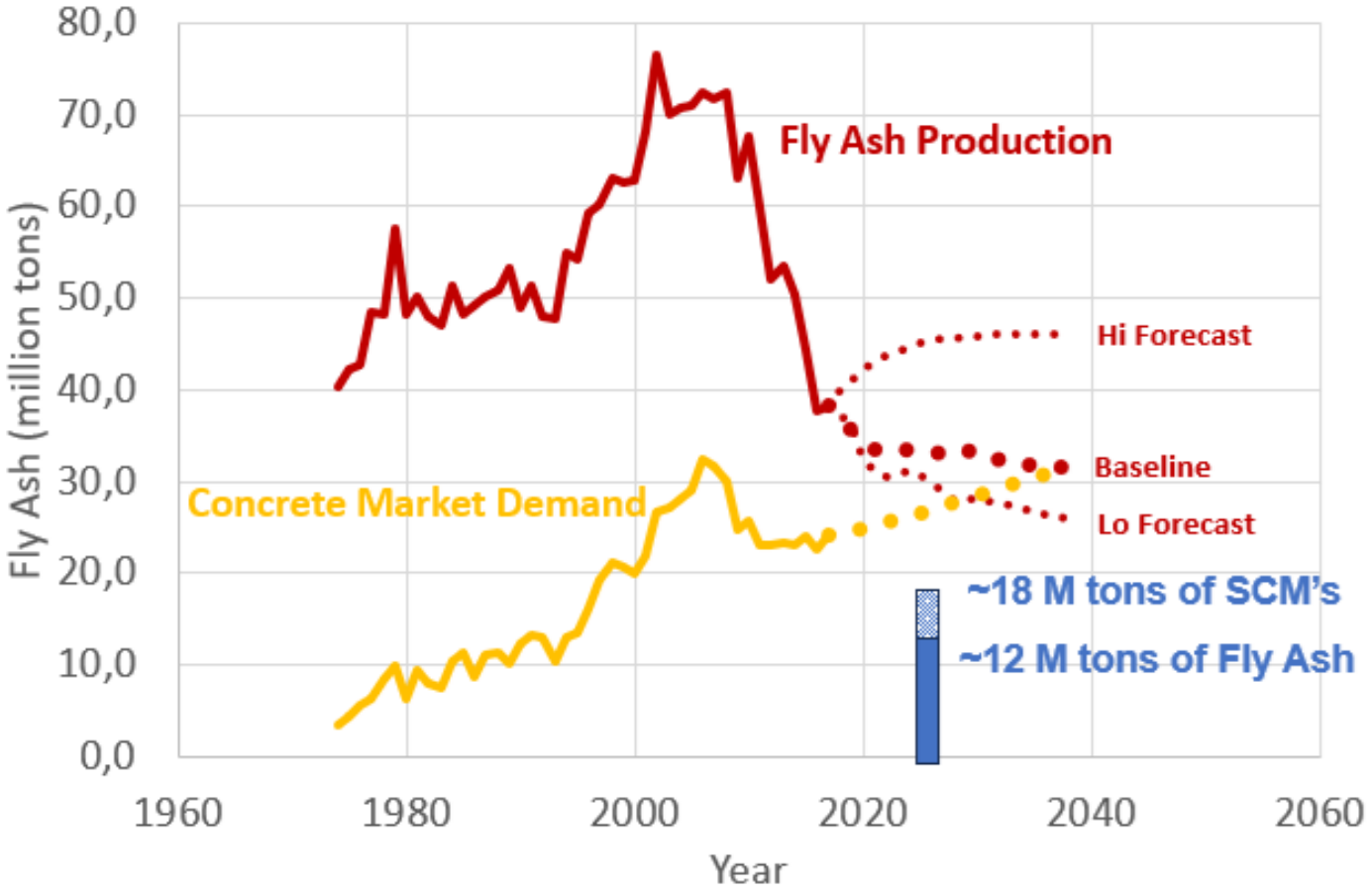
The Gale Common Extraction Project/UK

The HENA Project Belgium



50 years re-use wet
30 years re-use dry
France

Development US: production vs demand



The total production forecasts do not account for:

- material quality
- regional disparity
- seasonal disparity
- type disparity

There continues to be a significant gap between quality fly ash supply and demand to meet the concrete market.

R. MinkaraLegacy Ash for Beneficial Use in the US, **EUROCOAL**ASH 2023, Warsaw :

International Standards

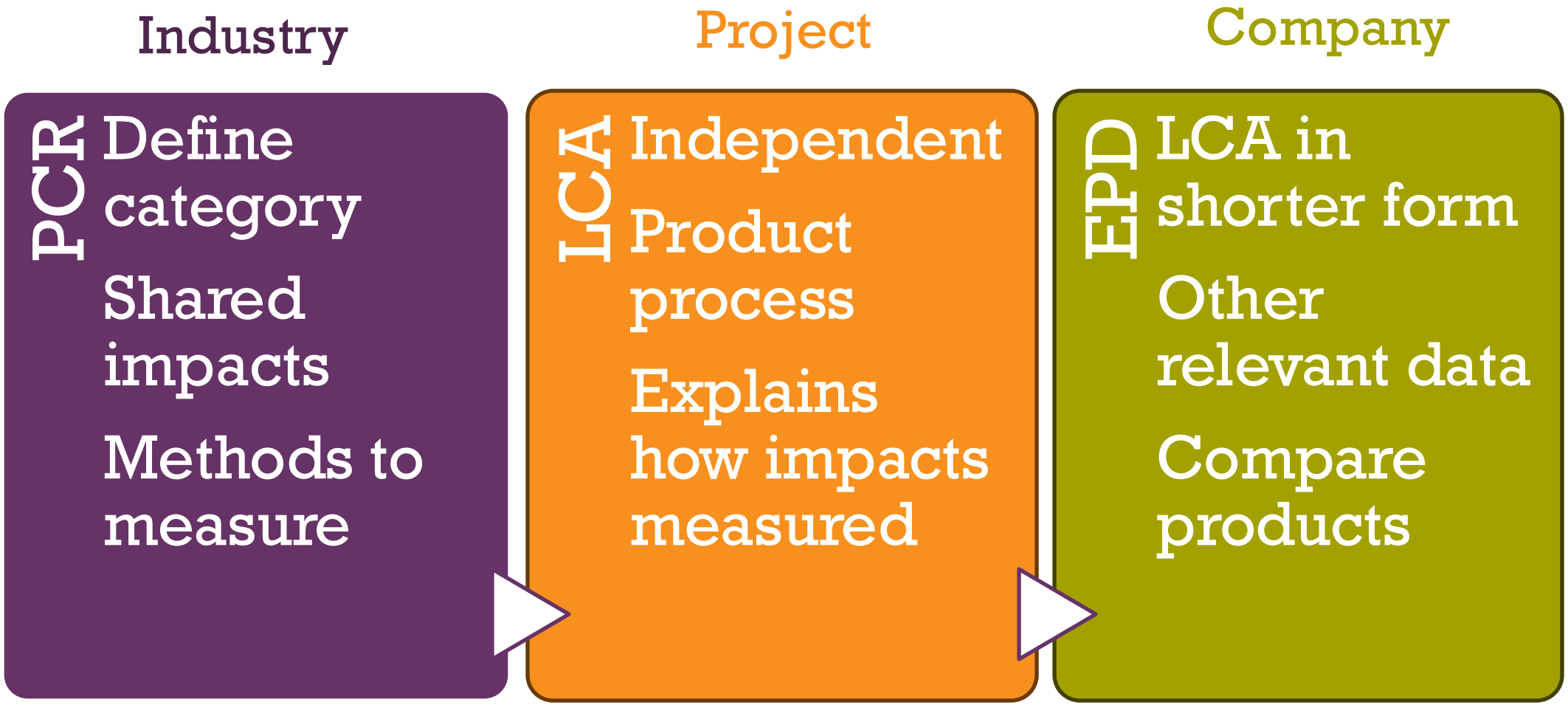
COUNTRY	Europe		USA		India		Australia			China		Russia		Japan			
Standard	EN 450-1		ASTM C 618		IS 3812-1		AS 3582.1			GB/T 1596		GOST 25818		JIS 6201			
Classification	Cat N	Cat S	Class F	ClassC	siliceous	calcareous	spec.grade fine	grade1 medium	grade2 coarse	Class F	ClassC	siliceous	calcareous	type I	type II	type III	type IV
Loss on ignition, max,%	<5; <7; <9 (cat A;B;C)		6.0 (12.0)	6	5.0 (7.0[2)])		3	4	6	≤5; ≤8[1)]; ≤10 (class I; II; III)		<10;<15 (type I;II)[1)]	<3;<5 (type I;II)	≤ 3	≤ 5	≤ 8	≤ 5
CaOfree, max,%	1.5 (>1.5)									≤ 1.0	≤ 4.0		<5 (type I;II)				
SO3, max,%	3.0		5.0		3.0 (5.0[2)])		3			≤ 3.0 (≤ 3.5[1)])		<3;<5 (type I;II)	<5 (type I;II)				
Cl, max, %	0.1				0.05												
CaO, %			≤ 18	> 18			<10 (AS) / < 25 (NZS)				2)						
Reactive CaO, max,%	10				< 10	> 10						< 10	> 10				
Reactive SiO2, min,%	25				20												
SiO2, min %					35	25								≥ 45			
SiO2 + Al2O3 + Fe2O3 min,%	70		70	50	70	50	70 (AS) / 60 (NZS)			≥ 70	≥ 50	≥ 70					
Na2O equ., max,%	5				1.5							< 3	< 1,5 (type I;II)				
MgO, max,%	4				5							< 5					
P2O5 sol., max, mg/kg	100																
P2O5 %	5																
Moisture %			3.0		2.0		0.5			≤ 1.0		≤ 1.0		≤ 1			
Amount retained on 45µm, max,%	40 (+/-10%)	12	34 (+/-5%)		34 (50[2)])		15	25	45	≤12; ≤30; ≤45 (class I; II; III)				≤ 10	≤ 40	≤ 40	≤ 70
Amount retained on 80µm, max,%												<20;<30 (type I;II)	<20 (type I;II)				
Amount retained on 150µm, max.%			10[1)]														
Fineness: specific surf. area cm²/g					min. 3200[1)] (2000[2)])							>2500/1500 (type I/II)	>2500/2000 (type I/II)	≥ 5000	≥ 2500	≥ 2500	≥ 1500
Particle density, kg/m3	+/- 2001)		5%[1)]							≤ 2.6							
Specific gravity, min														≥ 1.95			
Soundness, max	10 mm[2)]		0.8%[2)]		0.8%						≤ 5 mm						
Setting time, max minutes to ref.	120[3)]																
Strength (Activity) Index ß7d min,%			75[3)]														
Strength (Activity) Index ß28d min,%	75[4)]		75[3)]		80					≥ 70				≥ 90	≥ 80	≥ 80	≥ 60
Strength (Activity) Index ß90d min,%	85[4)]																
Strength (Activity) Index ß91d min,%														≥ 100	≥ 90	≥ 90	≥ 70
Relative Strength, Mpa min							105% (1)	75% (1)									
Lime reactivity Mpa					4.5												
Water requirement, max, % of control	95[5)]		105		105					≤95; ≤105; ≤115 (class I;II;III)				≥ 105	≥ 95	≥ 85	≥ 75

1) for coal ash that is harvested or containing bottom ash

International Standards -- Summary

Country/Region	standard	date	Title/scope
Europe	**EN 450-1**	**2012**	**Fly ash for concrete -** Part 1: Definitions, specification and conformity criteria
USA	**ASTM C 618**	**2023**	**Coal ~~Fly~~ Ash and Raw or Calcined Natural Pozzolan for Use in Concrete** for use in concrete, where cementitious or pozzolanic action, or both, is desired
Australia/New Zealand	**AZ/NZS 3582**	**2016**	**Supplementary cementituous materials** **Part 1: Fly ash** for use as a cementitious material in concrete, mortar and related application
Japan	**JIS a 6201**	**2015**	**Fly ash** to be used as the admixture in mortar or concrete standards contains also test procedures
Israel	**SI 1209**	**2016**	**Fly ash for concrete -** Part 1: Definitions, specification and conformity criteria Based on EN 450 with deviations on co-combustion (from coal only), and conformity criteria
South Africa	**SANS50450-1**	**2014**	**Fly ash for concrete -** Part 1: Definitions, specification and conformity criteria completely based on EN 450-1
India	**IS 3812-part 1** **IS 3812-part 2**	**2013** **2013**	Pulverized Fuel Ash - Specification Pulverized Fuel Ash - Specification (for mound ash and pond ash)
China	**GB/T 1596**	**2017**	Fly ash used for cement and concrete
Russia	**GOST 25818**	**2017**	Fly ash for concrete

Relationship between PCR – LCA - EPD



Product Category Rule (PCR) fly ash/products

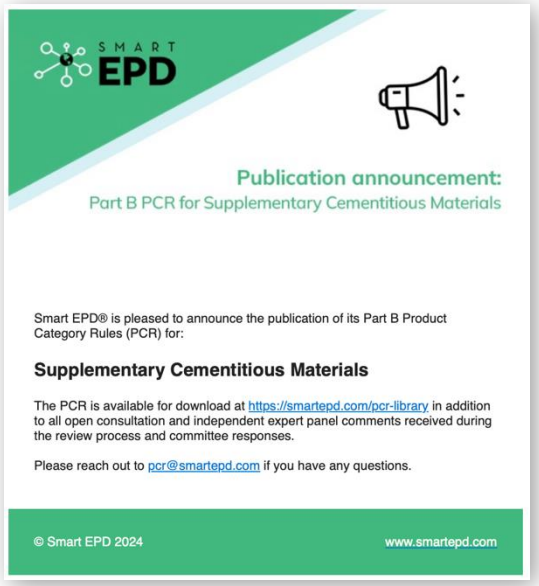
List of environmental parameters in European Environmental Product Declaration (EPD); 38 parameters to be evaluated by specific modules

Annex C - Essential characteristics related to environmental sustainability

Table 12 - List of essential characteristics related to environmental sustainability

Essential characteristic	Declaration	Assessment method	Clause	Dimensions	Statistical value	Unit	Rounding	Comments
climate change - total	Global Warming Potential total (GWP-total)	EN 15804+A2		M	modelling	kg CO_2 eq.	N/A	LCA environmental impact indicators
climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	EN 15804+A2		M	modelling	kg CO_2 eq.	N/A	LCA environmental impact indicators
climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	EN 15804+A2		M	modelling	kg CO_2 eq.	N/A	LCA environmental impact indicators
climate change - land use and land use change	Global Warming Potential land use and land use change (GWP-luluc)	EN 15804+A2		M	modelling	kg CO_2 eq.	N/A	LCA environmental impact indicators
ozone depletion	Depletion potential of the stratospheric ozone layer (ODP)	EN 15804+A2		M	modelling	kg CFC 11 eq.	N/A	LCA environmental impact indicators
acidification	Acidification potential, Accumulated Exceedance (AP)	EN 15804+A2		N	modelling	mol H^+ eq.	N/A	LCA environmental impact indicators
eutrophication aquatic freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	EN 15804+A2		M	modelling	kg PO_4 eq.	N/A	LCA environmental impact indicators
eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-marine)	EN 15804+A2		M	modelling	kg N eq.	N/A	LCA environmental impact indicators
eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	EN 15804+A2		N	modelling	mol N eq.	N/A	LCA environmental impact indicators
photochemical ozone formation	Formation potential of tropospheric ozone (POCP)	EN 15804+A2		M	modelling	kg NMVOC eq.	N/A	LCA environmental impact indicators
depletion of abiotic resources - minerals and metals	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	EN 15804+A2		M	modelling	kg Sb eq.	N/A	LCA environmental impact indicators
depletion of abiotic resources - fossil fuels	Abiotic depletion potential for fossil resources (ADP-fossil)	EN 15804+A2		ML2T-2	modelling	MJ, net calorific value	N/A	LCA environmental impact indicators
water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	EN 15804+A2		L3	modelling	m^3 world eq. deprived	N/A	LCA environmental impact indicators
particulate matter emissions	Potential incidence of disease due to PM emissions (PM)	EN 15804+A2			modelling	Disease incidence	N/A	LCA environmental impact indicators
ionising radiation, human health	Potential Human exposure efficiency relative to U235 (IRP)	EN 15804+A2		S-1	modelling	kBq U235 eq	N/A	LCA environmental impact indicators
ecotoxicity (freshwater)	Potential Comparative Toxic Unit for ecosystems (ETF-fw)	EN 15804+A2		M-1	modelling	CTUe	N/A	LCA environmental impact indicators
human toxicity, cancer effects	Potential Comparative Toxic Unit for humans (HTP-c)	EN 15804+A2		M-1	modelling	CTUh	N/A	LCA environmental impact indicators
human toxicity, non- cancer effects	Potential Comparative Toxic Unit for humans (HTP-nc)	EN 15804+A2		M-1	modelling	CTUh	N/A	LCA environmental impact indicators
land use related impacts / soil quality	Potential Soil quality index (SQP)	EN 15804+A2			modelling	unitless	N/A	LCA environmental impact indicators
use of renewable primary energy excluding renewable primary energy resources used as raw materials	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
use of renewable primary energy resources used as raw materials	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
use of non-renewable primary energy resources used as raw materials	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
use of secondary material	-	EN 15804+A2		M	modelling	kg	-	Resource use indicators
use of renewable secondary fuels	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
use of non-renewable secondary fuels	net calorific value	EN 15804+A2		ML2T-2	modelling	MJ	-	Resource use indicators
net use of fresh water	-			L3	Modelling	m^3	-	Resource use indicators
hazardous waste disposed	-	EN 15804+A2		M	modelling	kg	-	Waste indicators
non-hazardous waste disposed	-	EN 15804+A2		M	modelling	kg	-	Waste indicators
radioactive waste disposed	-	EN 15804+A2		M	modelling	kg	-	Waste indicators
components for re-use	-	EN 15804+A2		M	modelling	kg	-	Output flows indicators
materials for recycling	-	EN 15804+A2		M	modelling	kg	-	Output flows indicators
materials for energy recovery	-	EN 15804+A2		M	modelling	kg	-	Output flows indicators
exported energy	per energy carrier			ML2T-2	modelling	MJ	-	Output flows indicators
biogenic carbon content in product	-	EN 15804+A2		M	modelling	kg C	-	Biogenic carbon content indicators
biogenic carbon content in accompanying packaging	-	EN 15804+A2		M	modelling	kg C	-	Biogenic carbon content indicators

Example for a recently published PCR for supplementary cementituous materials



Examples for fly ash EPDs (from fresh production) based on EN 15804

Example for fly ash EPDs (from processing plants) based on EN 15804

from landfill with re-drying

Global Warming Potential (GWP) in the specific EPD is 47,5 kg CO_2 eq.

from separation with cyclons technique

Global Warming Potential (GWP) in the specific EPD is 60,9 kg CO_2 eq.

Summay/Outlook

- **Coal still plays** an important role in worldwide energy production in Annex II countries; but significant > 90% **reduction** in Annex II [e.g. US, EU and Australia]
- CCPs production stablising 1.2 BTPA. Embedded in construction materials @ 0.75 BTPA.
- Reduced CCPs production creating focus on **stored resource** which contribute to **Circular Economy** and sustainability of construction materials.
- Tools: **PCR, LCA's and EPD's** are of **critical importance** to stimulate use.

Challenges ahead – be part of it!

SAVE THE DATE

EUROCOALASH 2025

International Conference

June 16-18, 2025

Lille / France