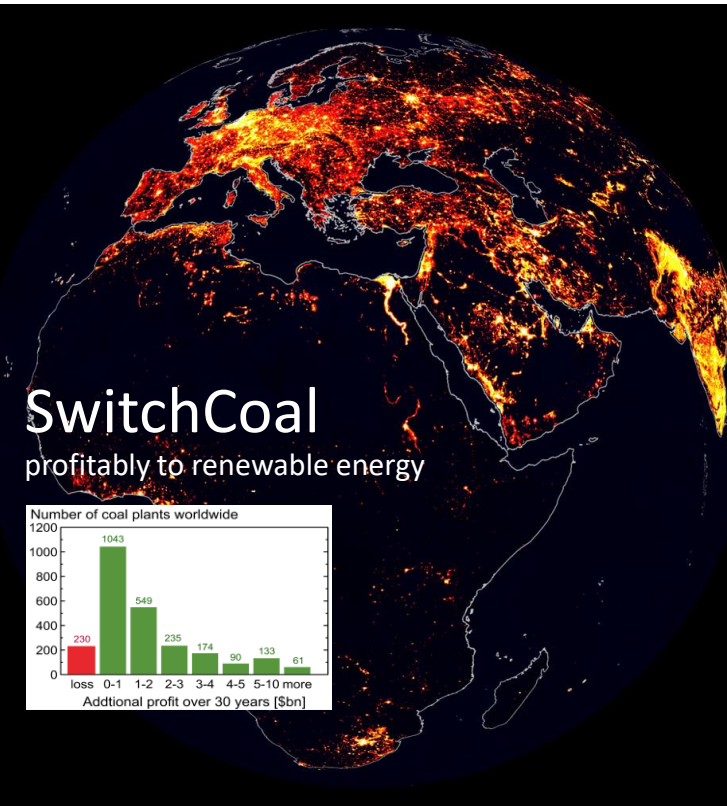
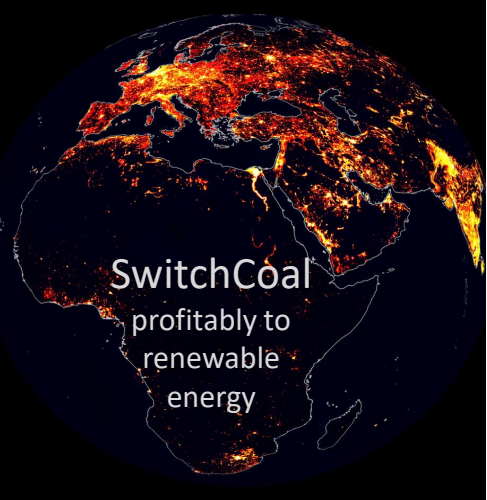


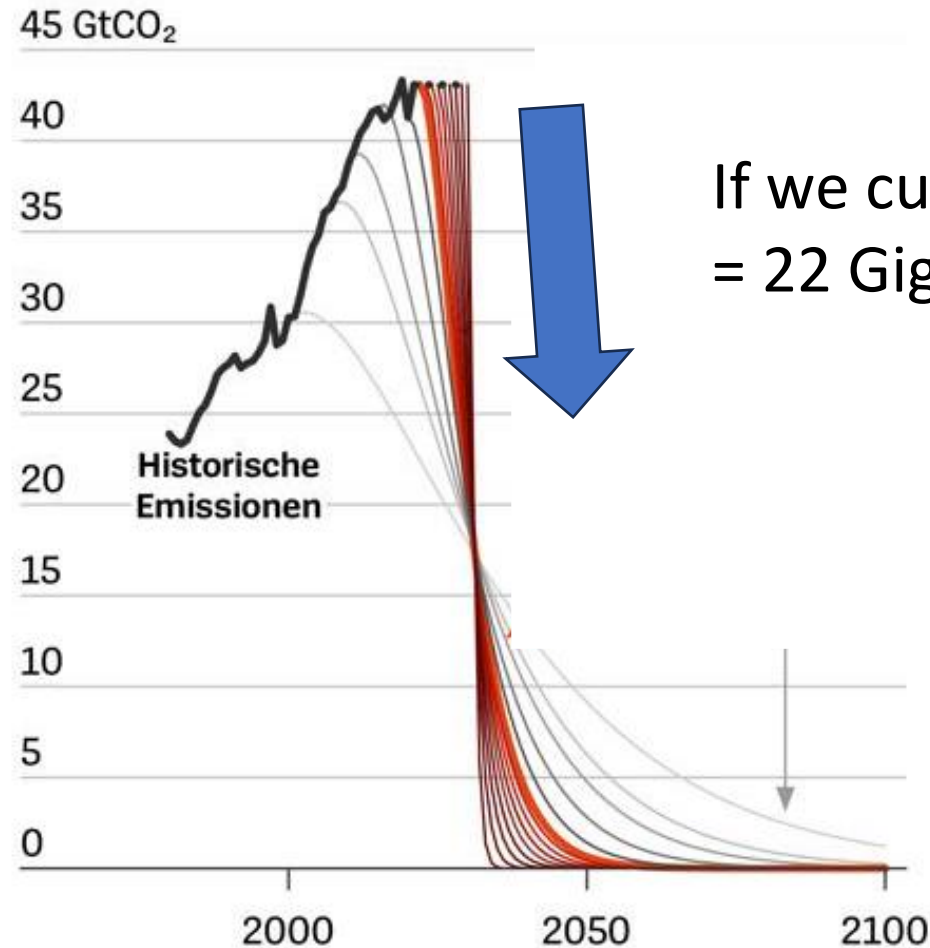
“We need to reduce
22 Gigatons by 2030”



Dr Sultan Al Jaber, COP28 president

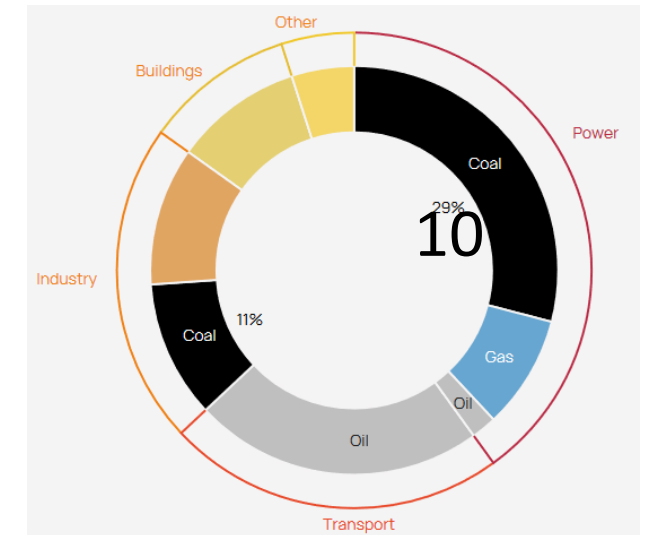


Climate tipping points - „1.5 degrees still within reach“ Dr Sultan Al Jaber



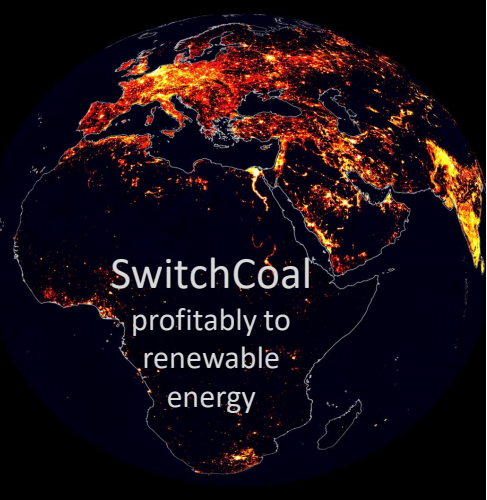
If we cut emissions in half by 2030
= 22 Gigatonnes

10 Gigatons is coal plants



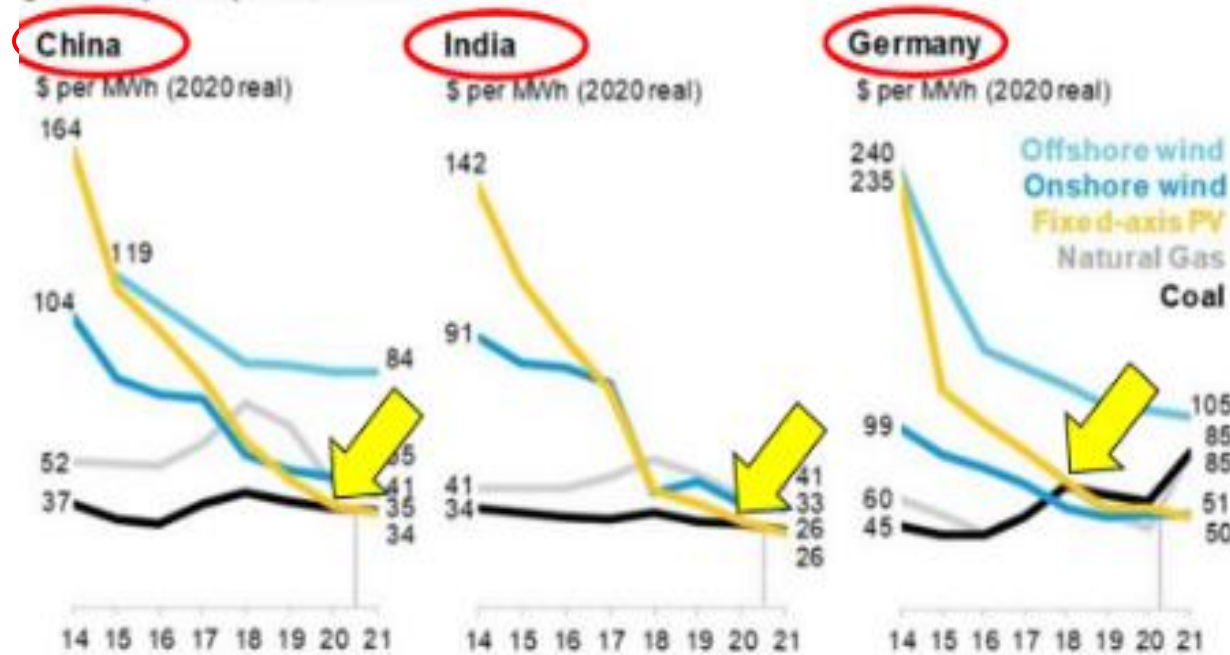
Note:
Despite the World Climate
Paris Agreement (2015),
emissions are still rising

=> to avoid uncontrollable catastrophic climate change, beyond 1.5°



Bloomberg: Economic tipping point reached

Figure 1: Levelized cost of electricity for new solar and wind versus running costs of existing coal- and gas-fired power plants, 2014-2021



Germany (2017)
China (2019)
India (2019)

Note:
same in the US

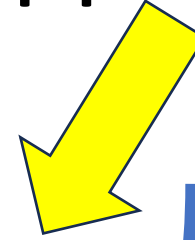
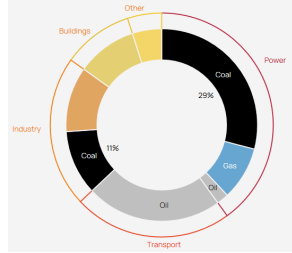
Note:
- OPEX of coal plants (black)
- LCOE of new wind (blue)
and solar (yellow)

Source: BloombergNEF. Note: LCOE exclude subsidies or tax-credits and reflect utility-scale power plants.

=> New wind + solar cheaper than existing coal!



10 Gigatons + economic tipping point



SWITCH COAL
key question
= cheaper?

Can we switch each of the 2,500 coal plants in the world to WIND-SOLAR-BATTERY SYSTEMS?

SwitchCoal profitably to renewable energy

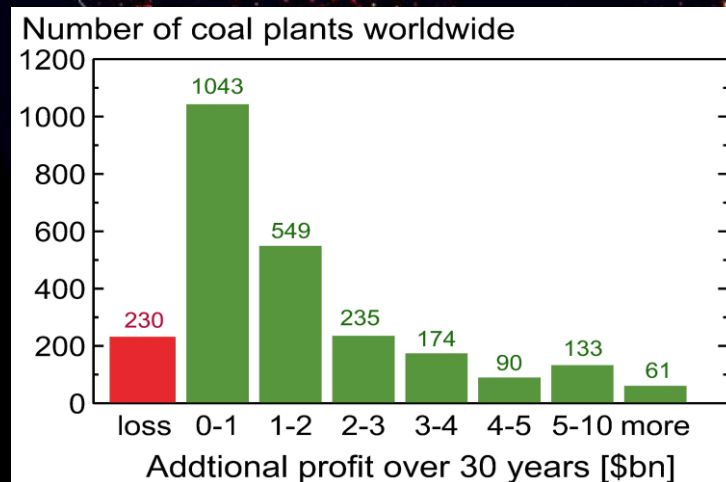
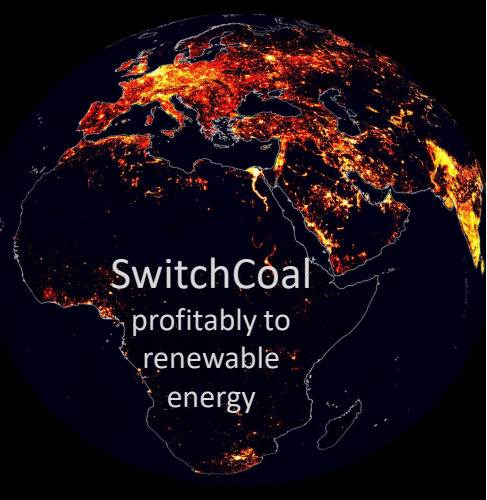


Foto: Nasa - CO2 emissions

Dr Ingo Stuckmann 1
Thomas Schmidt 1
Thomas Ladwig 1
Frank Haferkorn 1
Nancy Birkhölzer 8
Leonidas v Bothmer 8
Stefan Golla 2
Solvejg Nasert 4
Prof. Felisa Tibbitts 3
Prof. Holger Jahn 4
Prof. Claudia Kemfert 5
Prof Pietro Altermatt 6
Jochen Wermuth 7

1 Zero Emission Think Tank, Berlin
2 Scientists for Future
3 Chair in Human Rights and Higher Education UNESCO, Faculty of Law, Economics and Governance, Utrecht, NL formerly Columbia University, NY
4 FH Design, Potsdam
5 DIW Berlin
6 University of Oxford, UK
Lead scientist Trinasolar
7 Climate impact investor
8 Web and Grafics design



Prof. Dr. Pietro P. Altermatt



Nancy Birkhölzer



Leonidas von Bothmer



Dipl.-Phys. Stefan Golla



Dipl.-Phys. Frank
Haferkorn



Prof. Holger Jahn



Dr. Solvejg Nasert



Prof. Dr. Claudia Kemfert



Dipl. Inf. Thomas Ladwig



Dipl. Ing. Thomas Schmidt



Dr. Ingo Struckmann

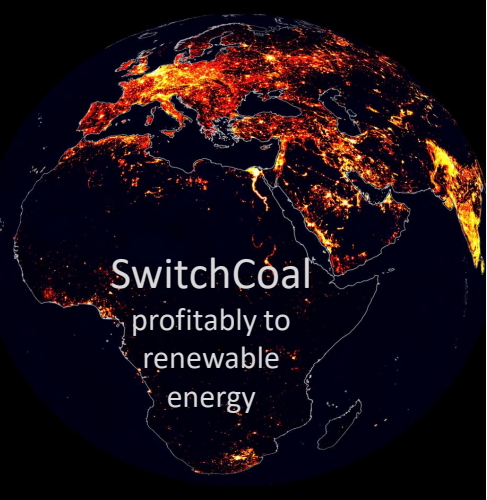


Jochen Wermuth

Science

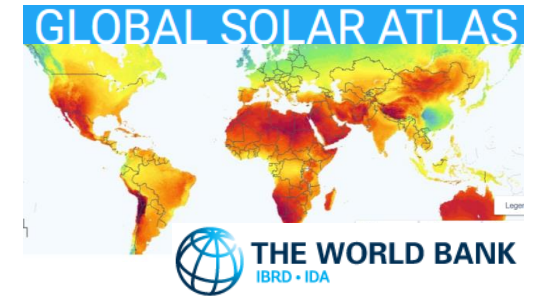
Business

Economics

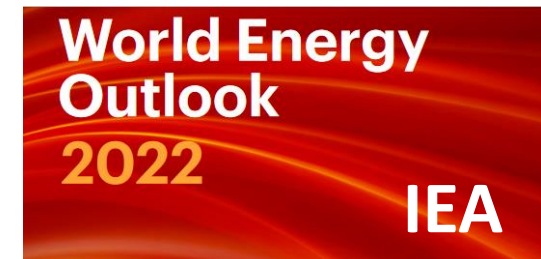


Solutions Study in 3 Steps

Step 1: Wind & solar potential
at each coal plant site



Step 2: Economics

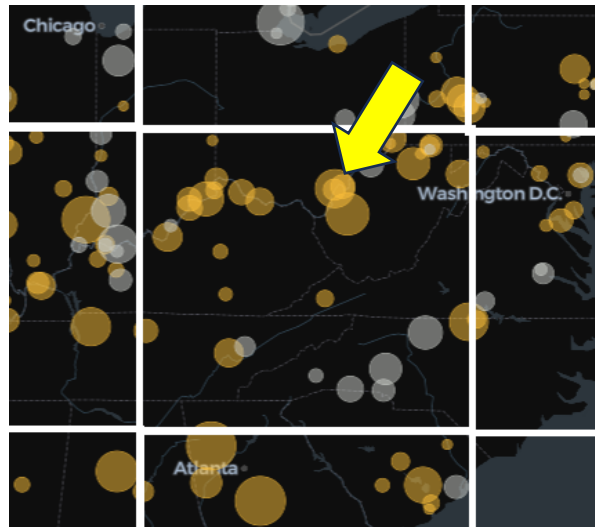


Step 3: ABC guide for delegates

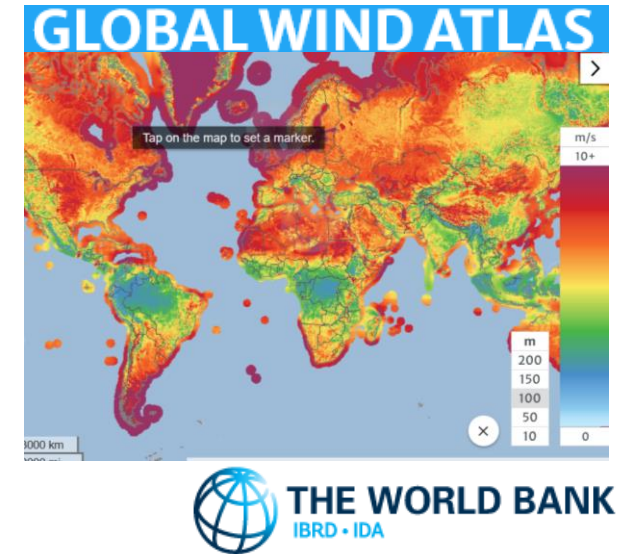
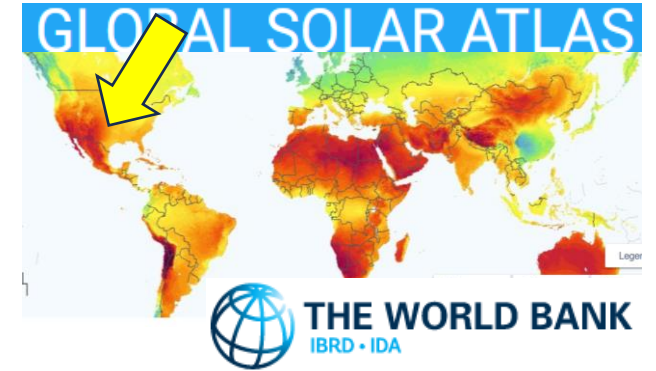
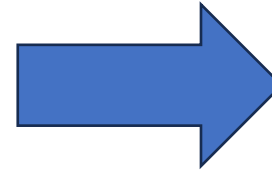




Step 1: Wind + solar potential?



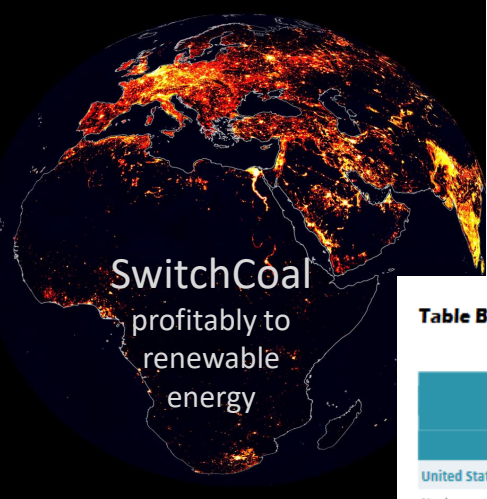
2,500 coal plants
individually



www.globalsolaratlas.info
www.globalwindatlas.info

Source: Carbon Brief

Source: World Bank



Step 2: Economics

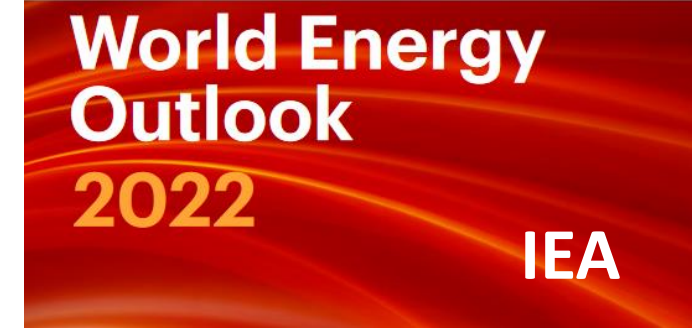


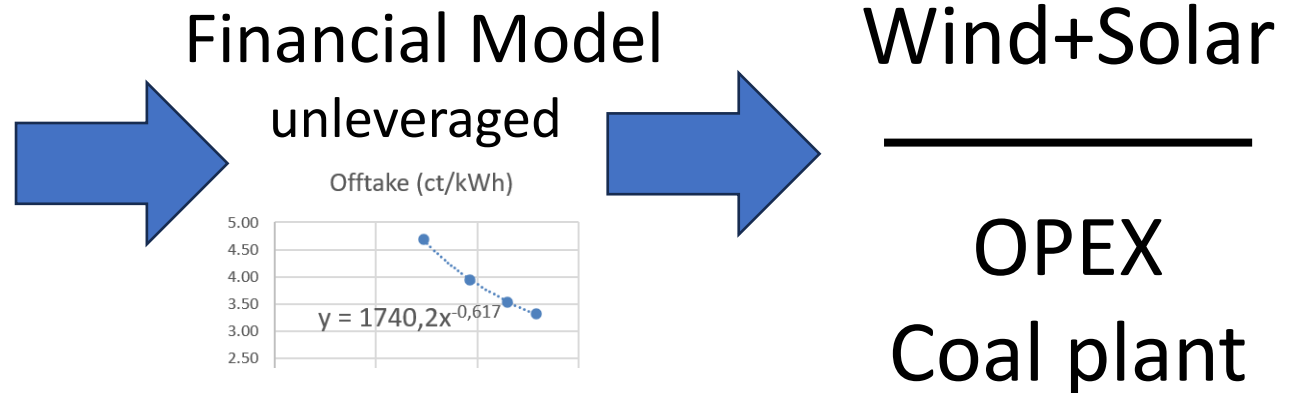
Table B.4b ▶ Technology costs in selected regions in the Announced Pledges Scenario

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO ₂ and O&M (USD/MWh)			LCOE (USD/MWh)		
	2021	2030	2050	2021	2030	2050	2021	2030	2050	2021	2030	2050
United States												
Nuclear	5 000	4 800	4 500	90	90	90	30	30	30	100	100	100
Coal	2 100	2 100	2 100	30	n.a.	n.a.	85	150	180	165	n.a.	n.a.
Gas CCGT	1 000	1 000	1 000	50	25	n.a.	60	85	95	85	130	n.a.
Solar PV	1 090	680	470	21	22	23	10	10	10	50	30	25
Wind onshore	1 380	1 290	1 220	42	43	44	10	10	10	35	30	30
Wind offshore	4 040	2 360	1 620	42	46	49	35	20	15	120	65	45
European Union												
Nuclear	6 600	5 100	4 500	80	80	70	35	35	35	140	115	115
Coal	2 000	2 000	2 000	30	n.a.	n.a.	135	175	210	220	n.a.	n.a.
Gas CCGT	1 000	1 000	1 000	25	10	n.a.	110	130	135	160	240	n.a.
Solar PV	810	510	360	14	14	14	10	10	10	50	35	25
Wind onshore	1 590	1 490	1 410	29	30	30	15	15	15	55	50	45
Wind offshore	3 040	1 920	1 320	51	56	59	15	10	5	60	35	25
China												
Nuclear	2 800	2 800	2 500	85	80	80	25	25	25	65	65	60
Coal	800	800	800	60	50	20	65	85	150	80	105	195
Gas CCGT	560	560	560	30	25	25	95	110	130	110	130	155
Solar PV	630	400	270	17	18	19	10	5	5	35	20	15
Wind onshore	1 160	1 080	1 020	26	27	28	15	10	10	45	40	35
Wind offshore	2 860	1 780	1 200	33	39	43	25	15	10	100	55	35
India												
Nuclear	2 800	2 800	2 800	75	85	90	30	30	30	70	65	65
Coal	1 200	1 200	1 200	65	75	35	40	65	170	60	85	205
Gas CCGT	700	700	700	40	45	30	70	85	115	90	105	145
Solar PV	590	360	240	20	21	22	5	5	5	35	20	15
Wind onshore	930	870	800	26	28	30	10	10	10	45	40	35
Wind offshore	2 780	1 740	1 140	33	37	39	25	15	10	120	70	45

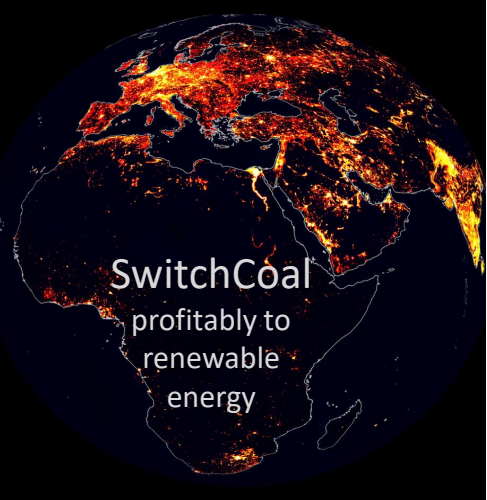
Notes: O&M = operation and maintenance; LCOE = levelized cost of electricity; kW = kilowatt; MWh = megawatt-hour; CCGT = combined-cycle gas turbine; n.a. = not applicable. Cost components and LCOE figures are rounded.

Sources: IEA analysis; IRENA Renewable Costing Alliance; (IRENA, 2022).

Source: IEA



OPEX = operating expenses
LCOE = levelized cost of energy



Coal plant operating expenses (OPEX) USA/India

examples

Notes:

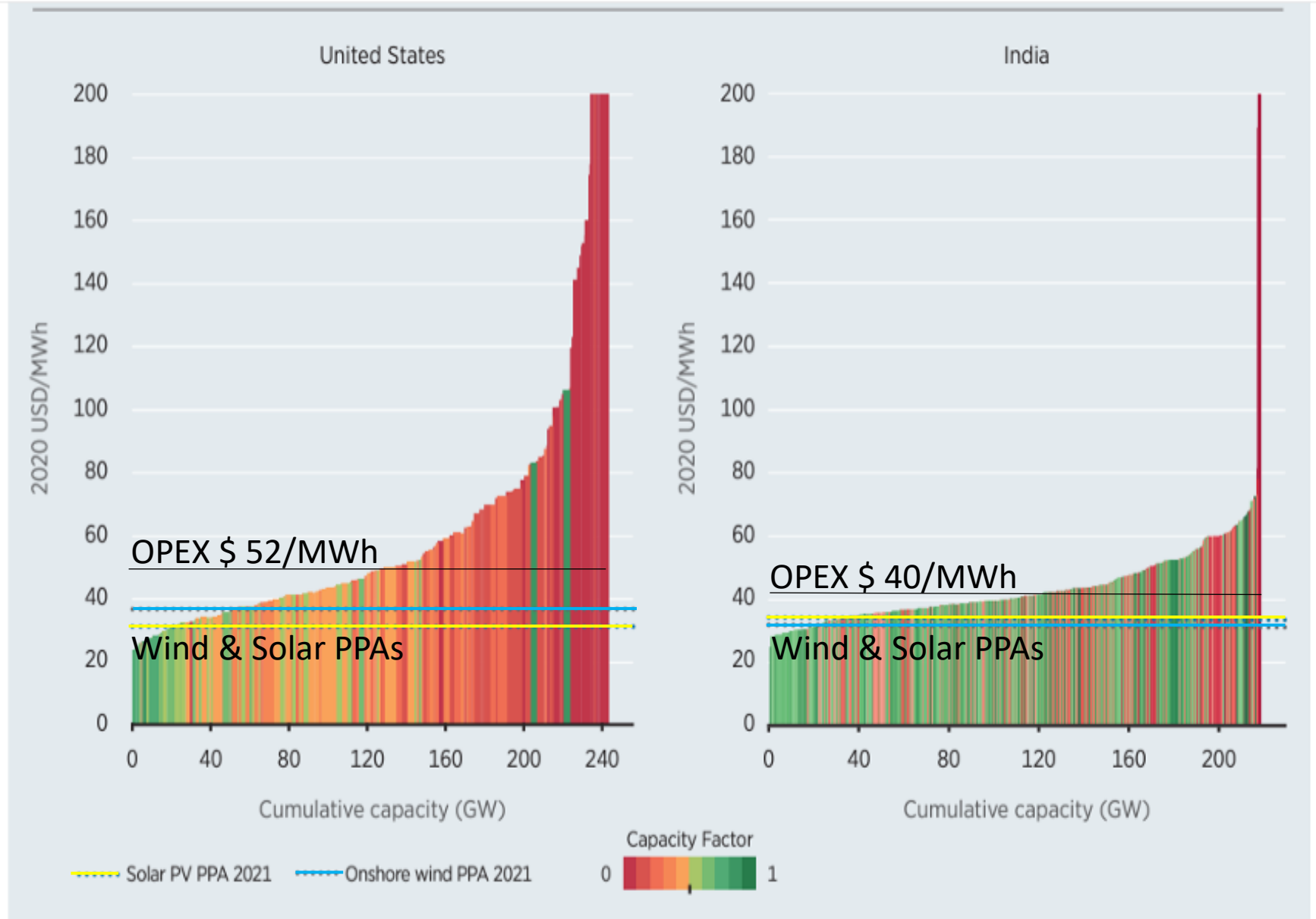
Source: IRENA 2021

Average OPEX price

drawn in based on:

OPEX US: Lazard

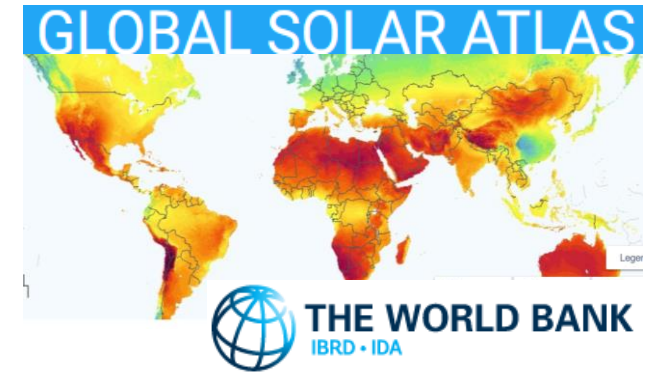
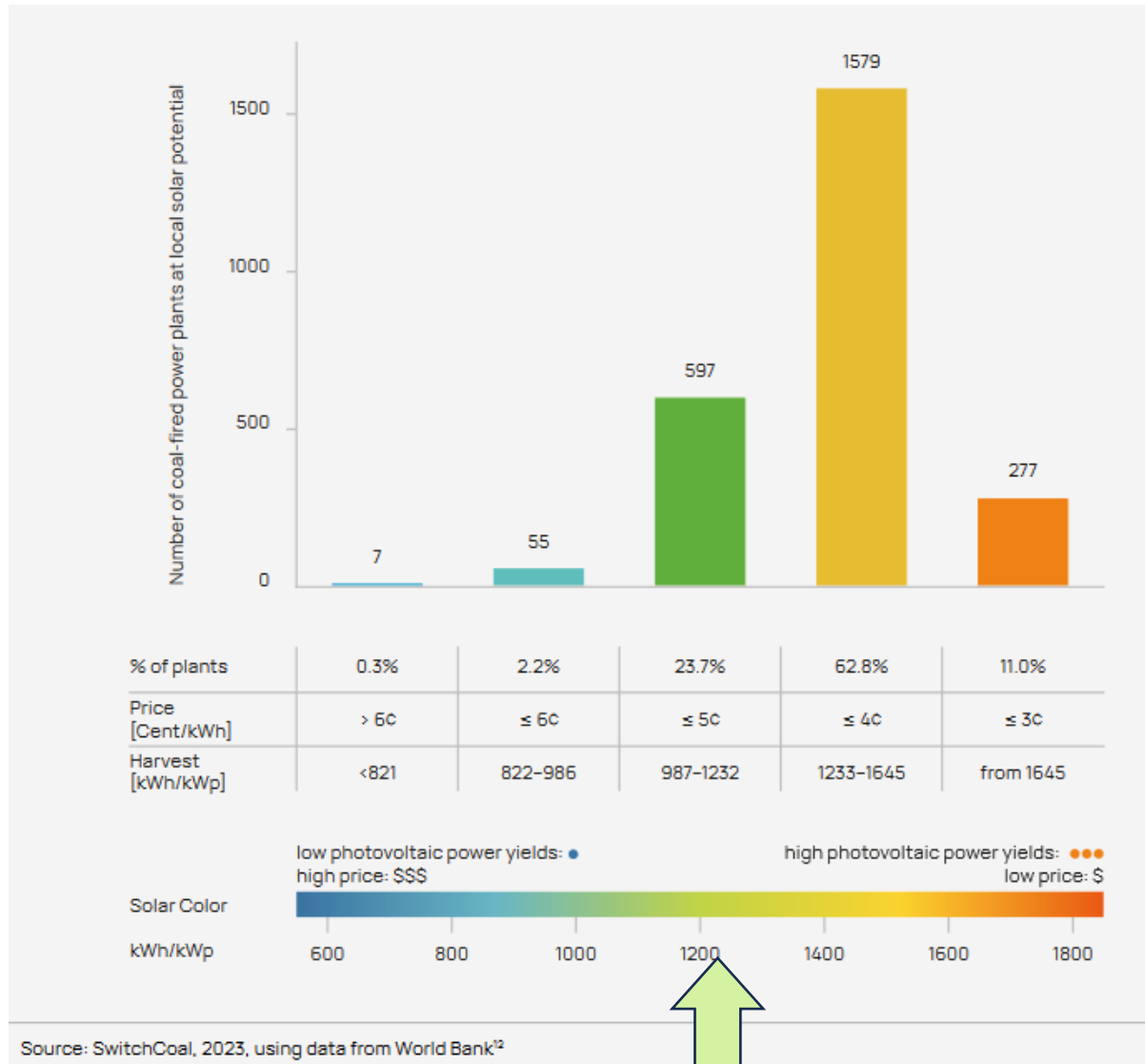
OPEX India IEA



Source: Booz&Co, 2014; Carbon Tracker, 2018; Coal India, 2020; DIW Berlin, Wuppertal Institut and EcoLogic, 2019; IEA, 2021; Öko-Institut, 2017; Energy-charts.de, 2021; Gimon, et al., 2019; NPP, 2021; US EIA, 2021; Szabó, L., et al., 2020 and IRENA Renewable Cost Database.



Results / Solar → @ 4 cents

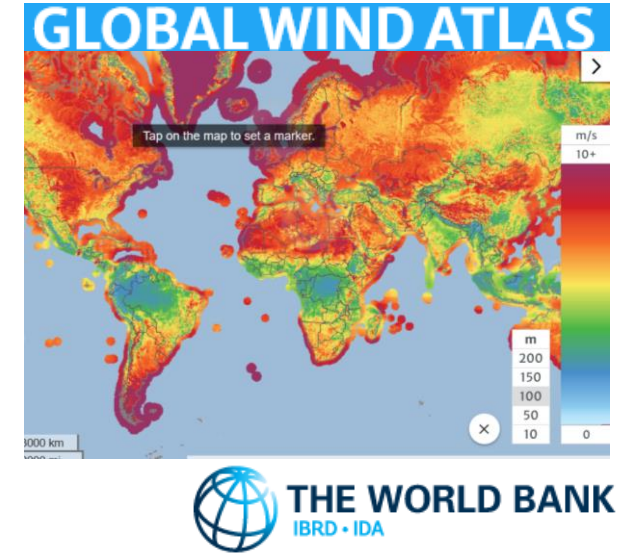
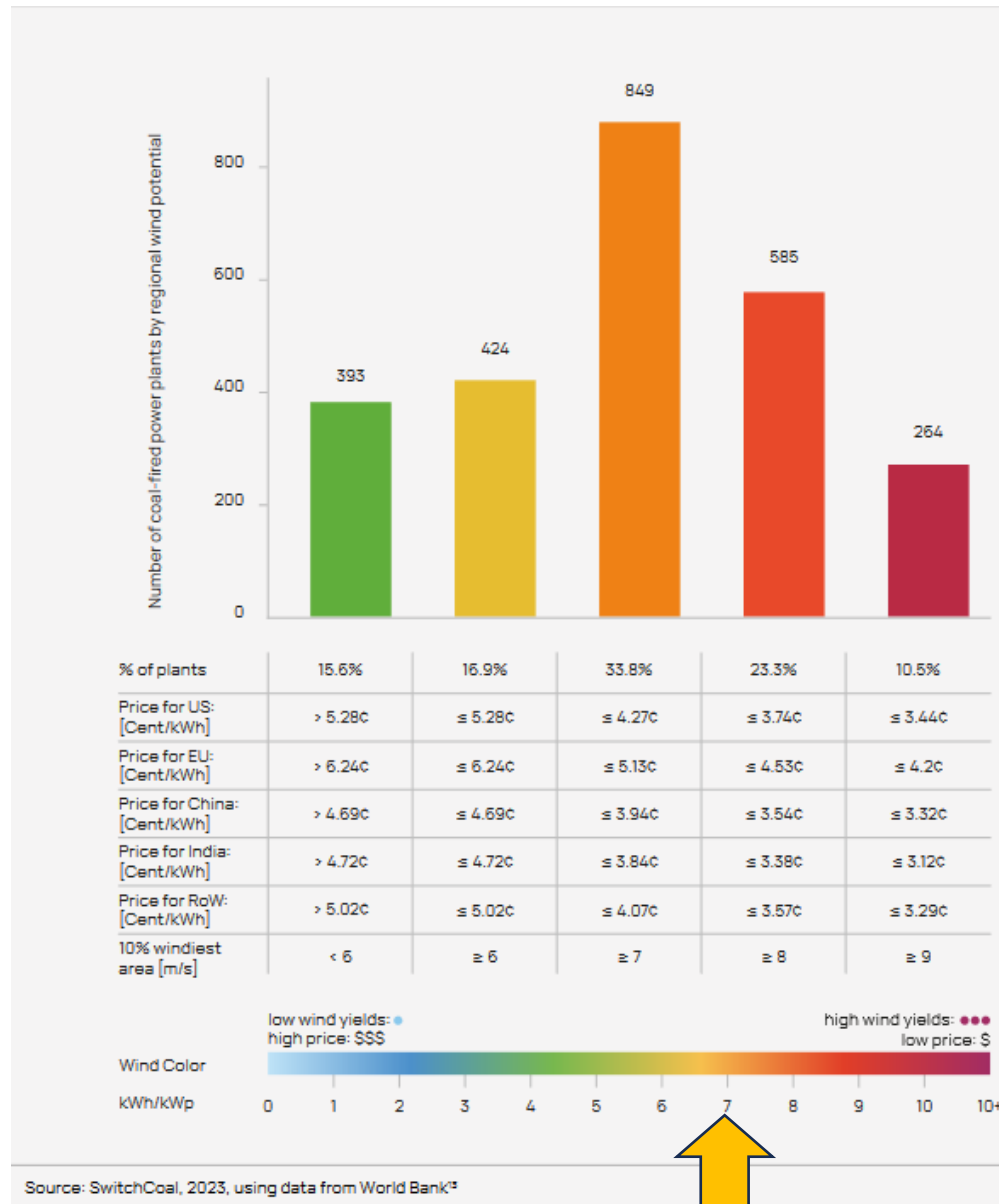


=> 74% of coal plant sites produce solar energy < \$4ct

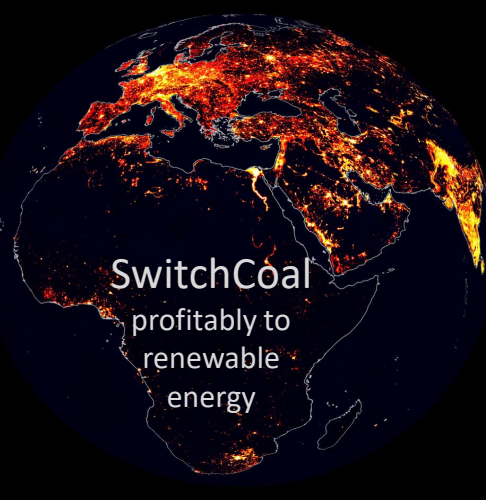


Results / Wind

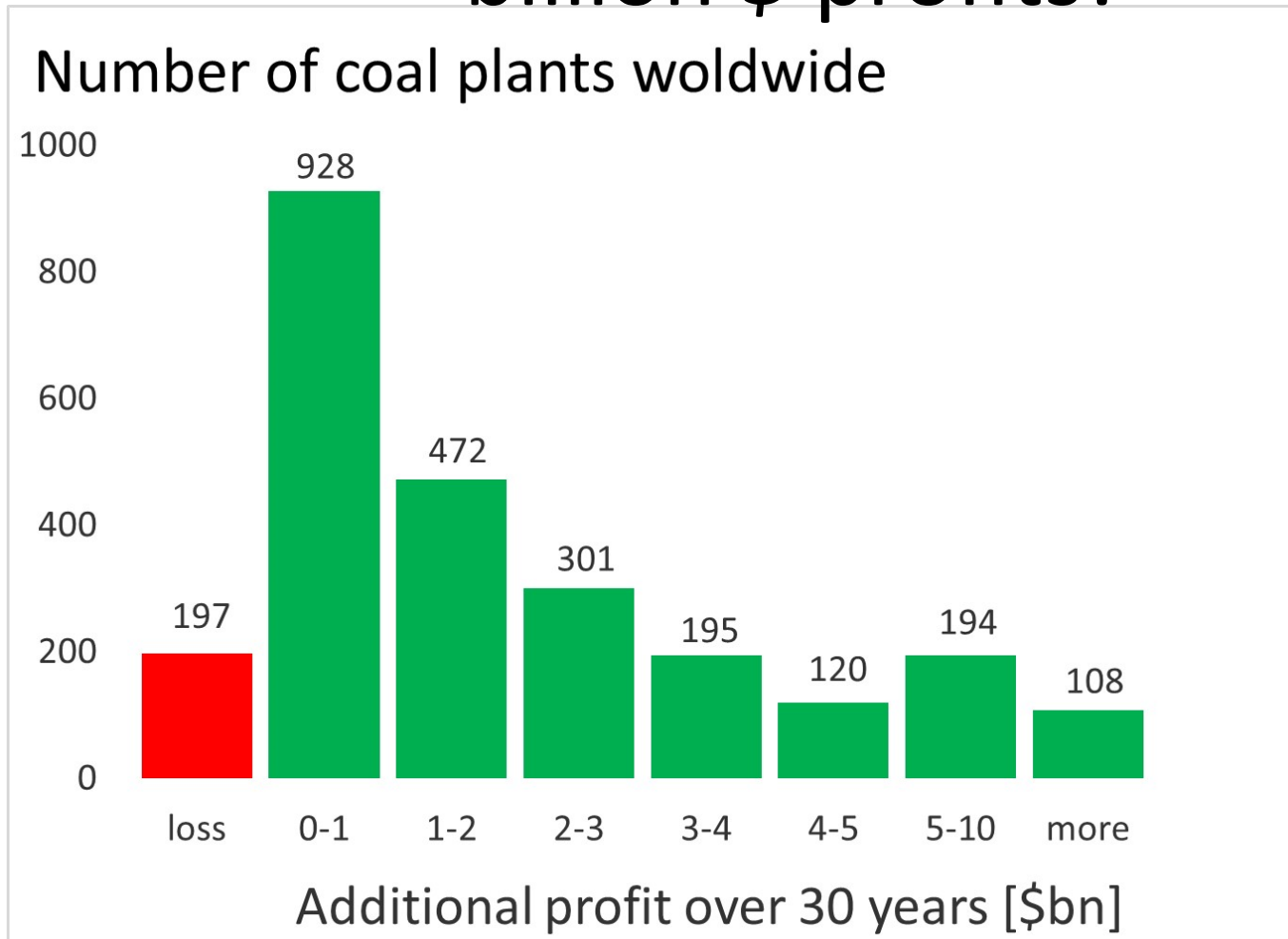
➔ 7m/s = 4 cents



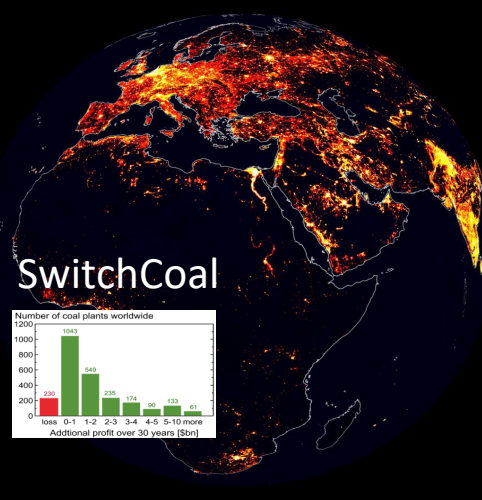
=> 68% of coal plant sites produce wind energy < \$4ct



Results 90% of all coal plants switched to Wind-Solar-Battery systems + billion \$ profits!

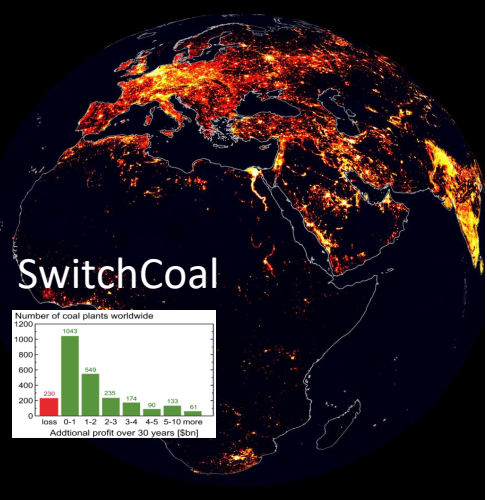


Note: Battery 50%



Details

2 questions



How many batteries?

3 Scenarios

„load following“ (historical power markets)
= **50% battery** capacity for 8h per day



„flexible use“ (new market design w/ RE price signal)
= **10% battery** capacity for 8h per day



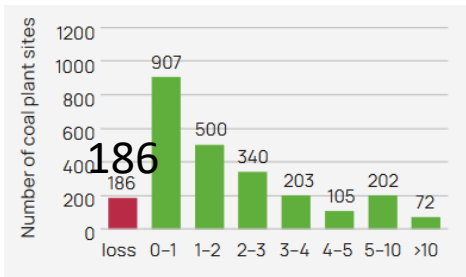
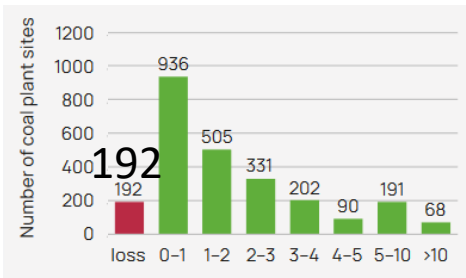
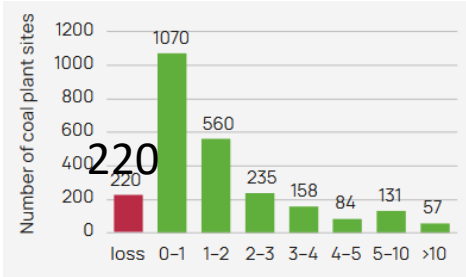
„no battery“ = reality of power markets <50% RE
= **0% battery**

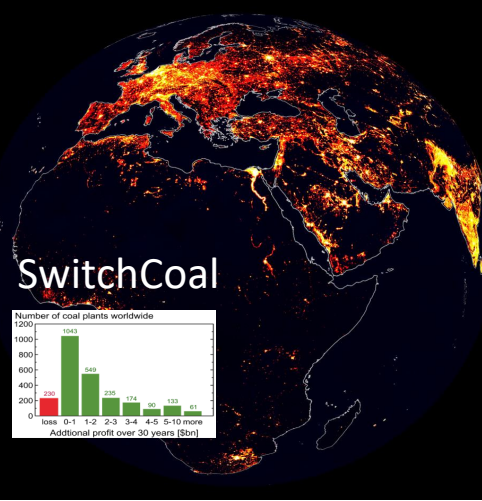


= **90% coal plants switched w/ profits**
= batteries do not matter

Number of coal plants worldwide

Additional profit over 30 years (\$bn)





How much wind : solar?

2 models

Economic model

=> 90% of cheapest RE



Market reality <50% RE



ratio

Note: Both model give Very similar results (next slide)

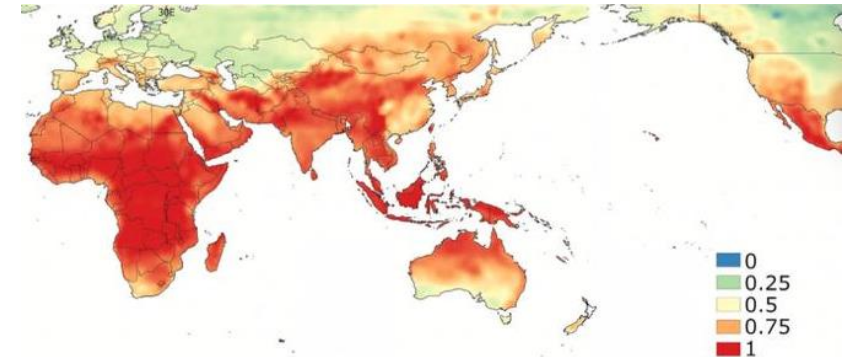
50% Wind : 50% Solar
90% Solar, 10% Wind
10% Solar, **90% Wind**
= Argentina wins on wind!

Physical model (Kapic et al.)

=> optimize ratio daily & seasonally

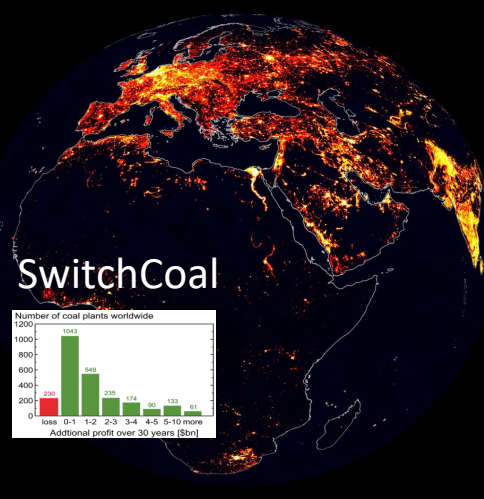


Best results >50% RE



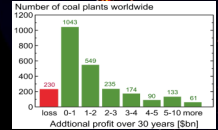
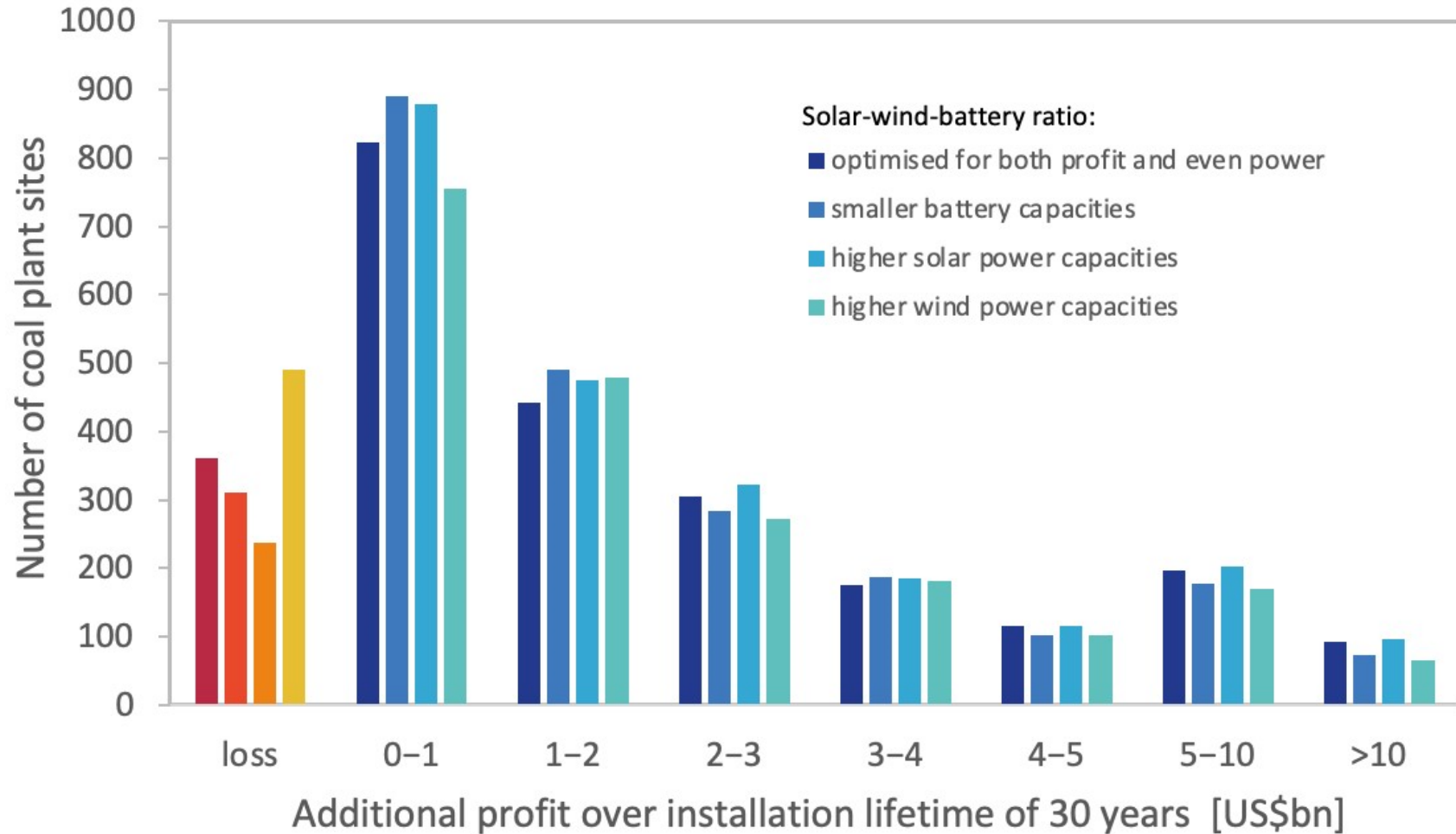
Germany 1:1
India 1:0

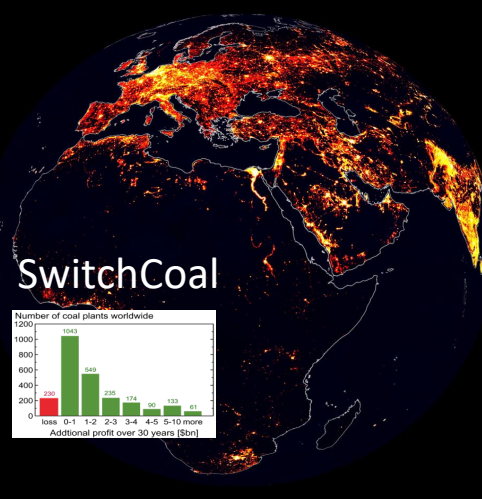
= India wins on solar!



Sensitivity: Robust Results

90% of coal plants profitably switched





SUMMARY

Country	Switchable	Mt CO2	Invest[\$bn]	Project R[\$bn]	add'l Profits[\$bn]
United States	202 / 216	1004.7	475.1	950.1	553.7
Uzbekistan	0 / 2	0,0	0,0	0,0	0,0
Vietnam	27 / 28	131.2	70.6	141.2	49.7
Zambia	2 / 2	1.5	0.6	1.2	1.0
Zimbabwe	3 / 3	10.2	4.6	9.3	8.2
Global (sum)	2318 / 2515	9806	4917	9834	6172

Wind farm installations
Solar PV installations

1.5 TW
4.8 TW

Investment Wind-Solar-Battery
Project Returns On Investment
add'l **profits** (cheaper OPEX)

\$ 5 Trillion
\$ 10 Trillion
\$ 6 Trillion

CO2 reductions

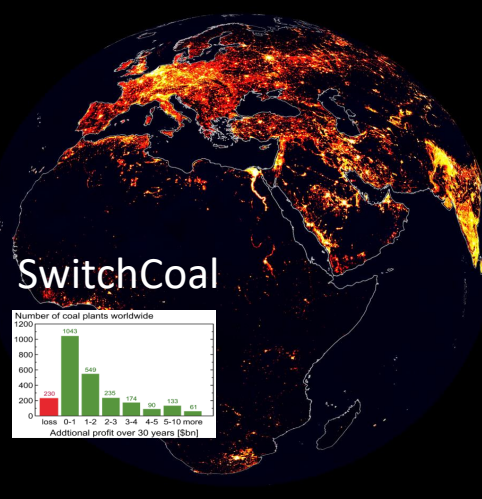
10 Gigatons

=> switch **90%** coal plants
=> make **trillion \$ profits**

Note: Wind-Solar-Battery systems calculated with **standard project ROI**.

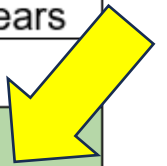
In addition, with much lower OPEX compared to coal plants, renewables produce **add'l profits**—billions of dollars for distribution!

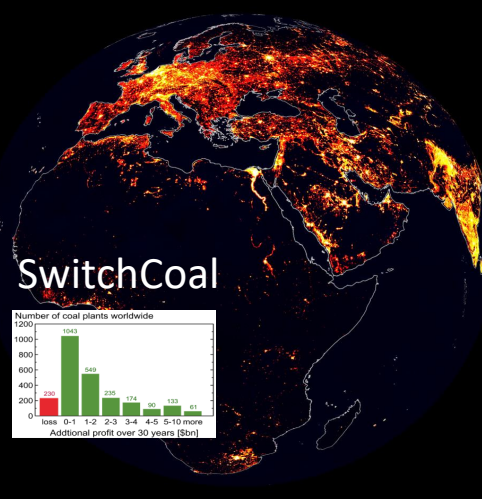




Country by Country – Billions of profits!

Country	Number of coal plants profitably switchable	Annual CO ₂ emissions, saved by switching	Investment in wind-solar-battery sys	Project Return on investment 5-6% IRR, approx not compounded	Additional profits from switching, over 30 years
	profitable/all	Mt/yr	\$bn	\$bn	\$bn
Argentina	2 / 2	3.2	1.2	2.5	2.3
Australia	16 / 19	98.6	43.8	87.7	60.8
Bangladesh	7 / 7	34.6	16.8	33.6	15.0
Bosn and Herz	0 / 5	0.0	0.0	0.0	0.0
Botswana	2 / 2	3.6	1.6	3.3	2.8
Brazil	7 / 7	15.7	7.2	14.4	9.1
Brunei	1 / 1	1.2	0.5	1.1	0.8
Bulgaria	10 / 10	28.3	15.2	30.4	77.4
Cambodia	5 / 5	8.0	4.0	8.1	3.0
Canada	10 / 10	17.2	10.0	20.0	13.4
Chile	8 / 8	22.6	10.7	21.4	13.5
China	1162 / 1187	5261.1	2671.0	5341.9	2826.7





STEP 3 COP28 guide



- A) **Act on climate**: delegates can **pledge** coal plant retirements – increase NDCs
- B) **Borrow** - delegats can **find financing** for renewables @COP28
- C) **Cash in** - Delegates can bring home **billions of profits** for distribution

Country-by-Country

Zimbabwe example only

3 coal plants

Investment renewables

Project Return on Invest

+ add'l **Profits**

Country	Switchable	Mt CO2	Invest[\$bn]	Project R[\$bn]	add'l Profits[\$bn]
United States	202 / 216	1004.7	475.1	950.1	553.7
Uzbekistan	0 / 2	0,0	0,0	0,0	0,0
Vietnam	27 / 28	131.2	70.6	141.2	49.7
Zambia	2 / 2	1.5	0.6	1.2	1.0
Zimbabwe	3 / 3	10.2	4.6	9.3	8.2
Global (sum)	2318 / 2515	9806	4917	9834	6172

10 Mt →

NDC/Global Stoke Take

\$4.6 BN →

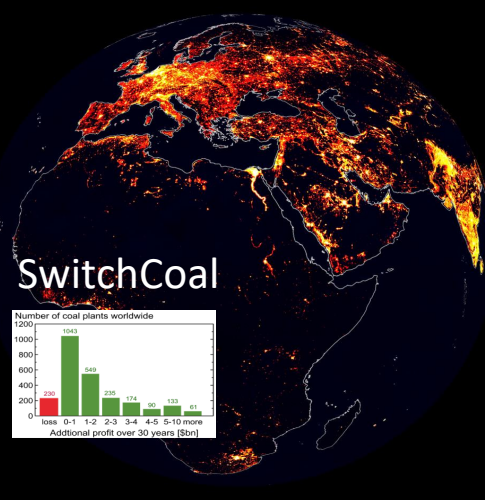
Find Financing @COP

\$9.3 BN

\$8.2 BN →

Distribute @home

Note: „know your ABC“



COP28: Delegates can bring home billions of dollars for distribution

Note: Wind-Solar-Batt systems calculated with **standard project ROI**
Source: IEA



Additional profits
\$8.2 BN



Project Return on Investment
\$9.3 BN

Boost returns

Utilities in oligopolistic structures often highly profitable

Lower electricity prices for all

US: Public Utility Commission (PUC) mandates lower rates

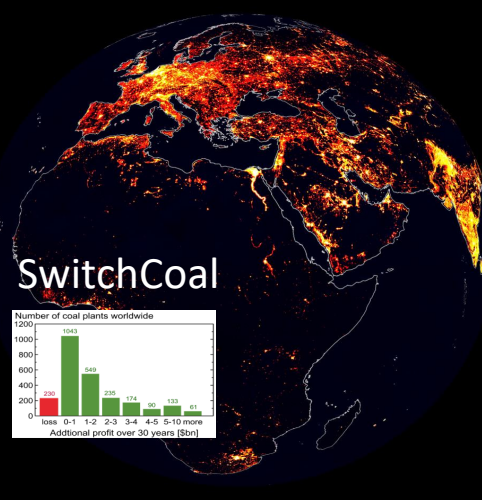
+Add'l tax revenues



Investment

Zimbabwe
Investment renewables \$4 BN
Project Return on Invest \$8 BN
+ add'l Profits **\$6 BN**

Project Return



Feasibility 2030 - manufacturing

Annual global PV manufacturing capacity

2021	168 GW
2022	239 GW
2023	790 GW (anticipated)
2024	> 1 TW (anticipated)



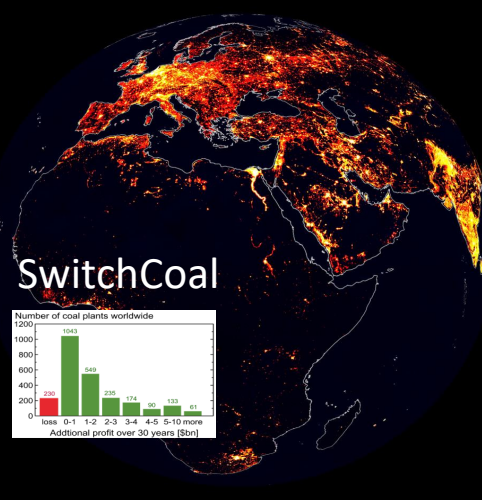
Annual global wind turbine capacity

2021	94 GW
2022	78 GW
2023	117 GW (anticipated)
2025	250 GW (possible by switching to larger 6-7MW wind turbines)

Wind capacity needed: 1.5 TW 5-6 years

Solar PV capacity needed: 4.8 TW 4-5 years

= sufficient manufacturing capacities



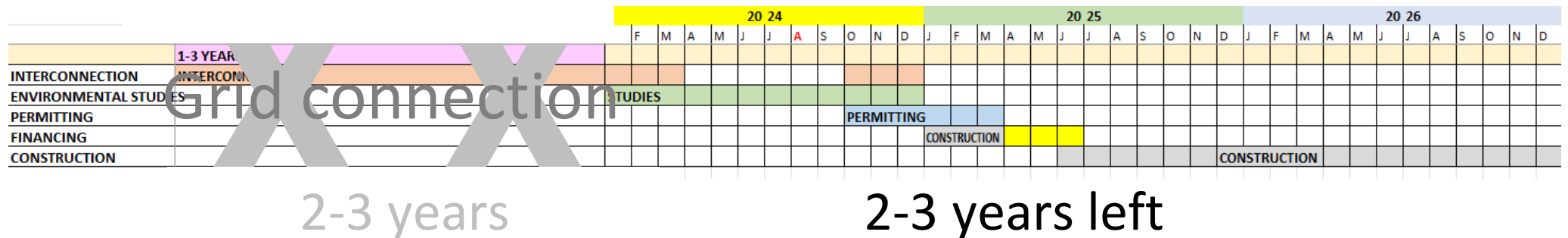
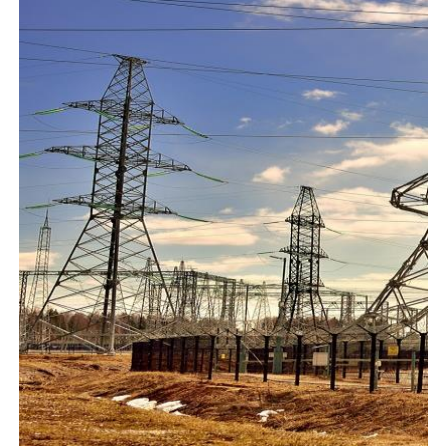
Feasibility 2030 – planning

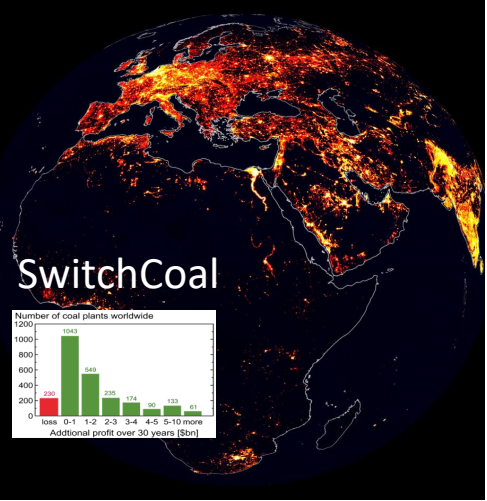
Typical project development timelines for Wind-Solar-Batt systems: 4-6 years

TRICK:

Using **existing** grid connection of coal plant = shaves off 2-3 years

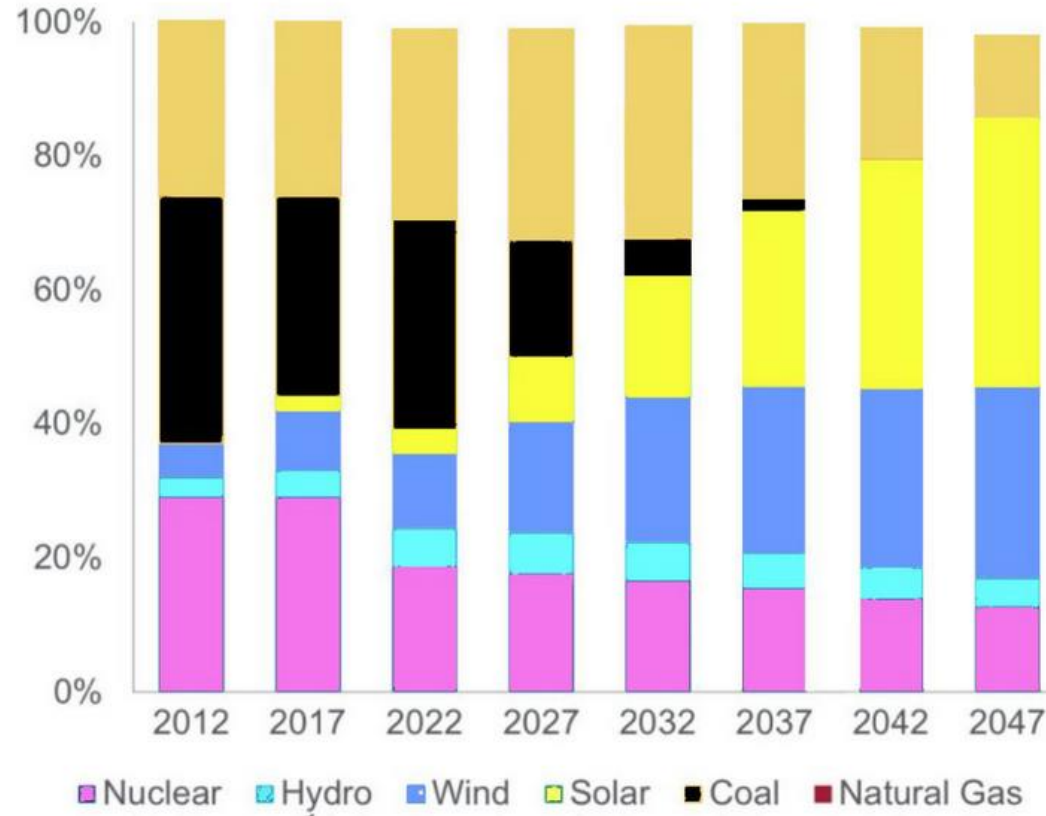
= planning possible in **2-3 years**





US has shut down 50% of coal plants

because renewables are cheaper



Note: on economic grounds

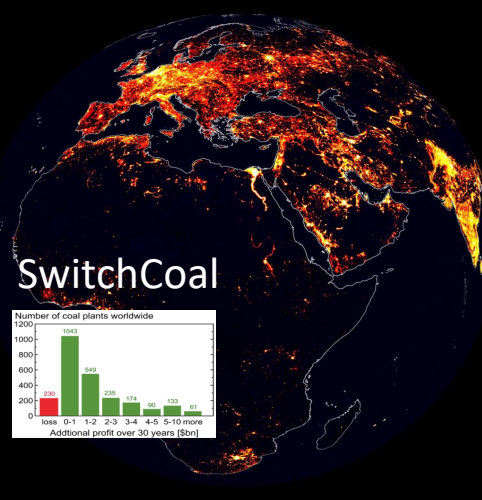
Proof of concepts

Note:
2022 higher coal usage due to energy crisis with high gas pricing.

Note:
Past 10 years approx. 50% coal plants replaced by gas and renewables.
Renewables are cheapest.

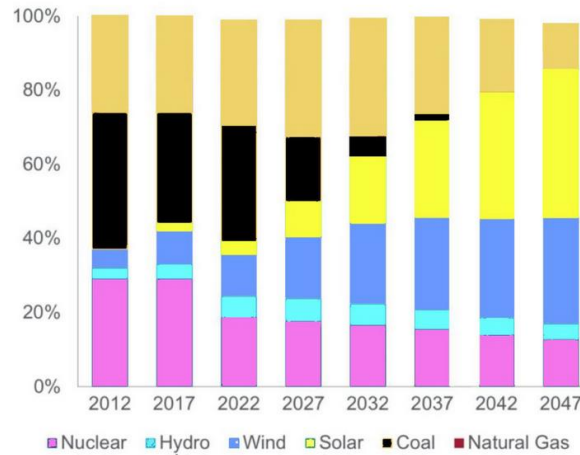
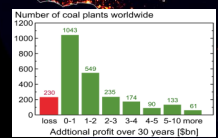
=> approx 50% of coal plants shut down (290/510)
=> most coal plants shut down around 2030

Source: (recoloured) Wood Mackenzie IEA



US shuts down coal

- on purely economic grounds
- because renewables are cheaper



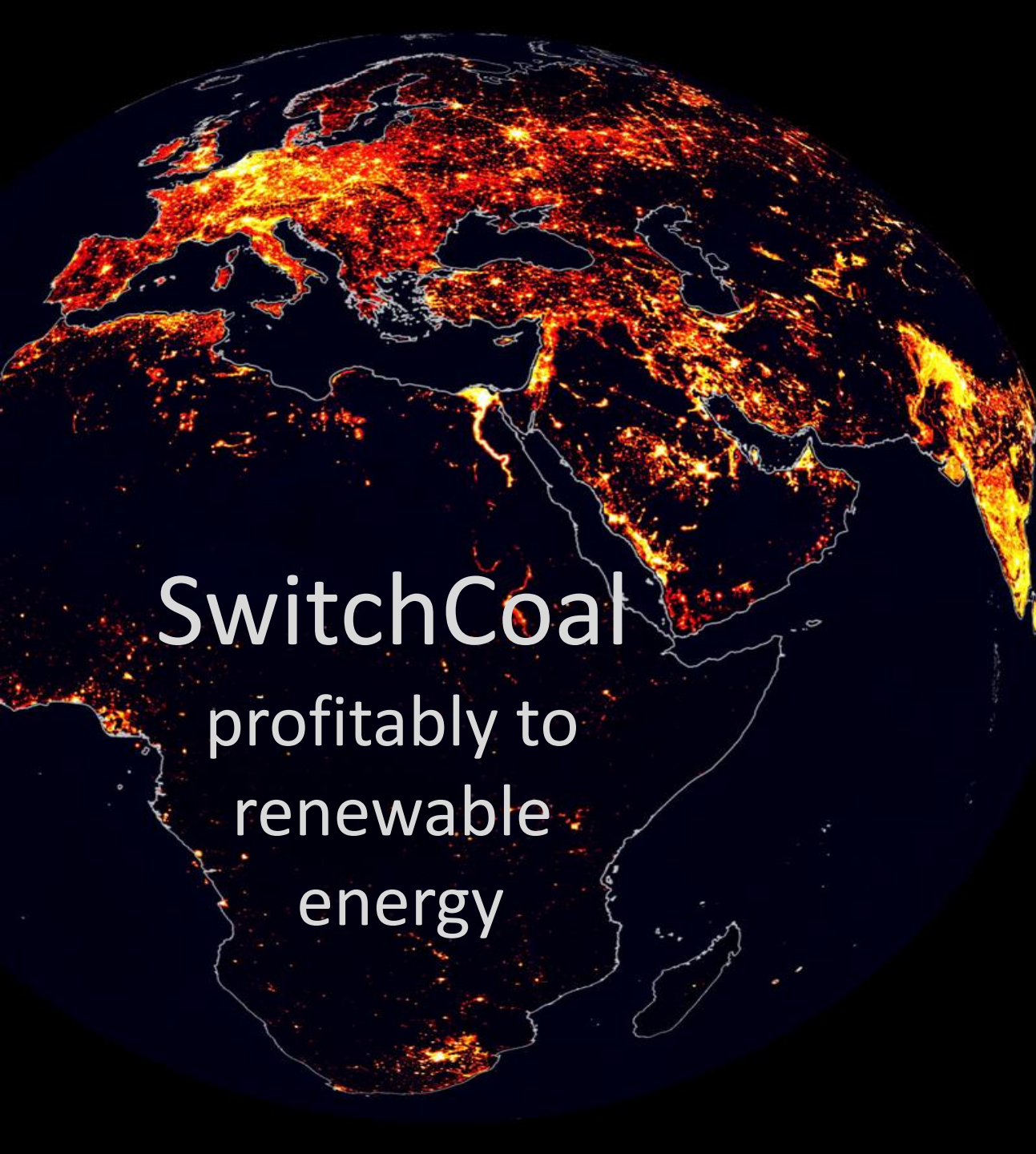
Source: (recoloured) Wood Mackenzie IEA

Will the world follow?

& keep 1.5° in reach?

That's *exactly* why we did this Solutions Study:

We show it pays off!

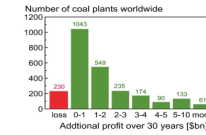


SwitchCoal
profitably to
renewable
energy

Global Relevance



Switch coal



-low hanging fruit

10 Gigatons less + billions in profits

- ONLY chance to cut CO2 emission by 2030

- LAST chance to keep 1.5°C in reach

- SHIFT in paradigms / new mind-set

study switches UN motto “act on climate”
to “act on climate & profit from it!”

illustrating a new mindset for effective climate solutions

, with a win-win approach = *everybody understands this*

= **this is the silver bullet** to solve the
climate crisis once and for all

Make no mistake, with global climate
tipping points dangerously close to tipping
into an uncontrollable climate beyond 1.5°C
SWITCH COAL - *is* - our LAST CHANCE



“I am
doing this
for you,
little girl”

(our lead author)



Thank you!
please,
act on climate
& profit from it!



30 years of climate conferences



It is a common perception that climate policy has not delivered over the past 30 years, given that carbon **emissions** are **still rising**, despite the Paris Climate Agreement (2015). The question is

Why?

We identified a single reason for it.



30 years of climate conferences



It is a common perception that climate policy has not delivered over the past 30 years, given that carbon **emissions** are **still rising**, despite the Paris Climate Agreement (2015). The question is

Why?

We identified a single reason for it.

The cost trap!



30 years of inaction – Why?



Act on climate – too expensive?

Politicians and voters often think it's **too expensive** to act on climate; I do **not want to pay** for it is popular, and, even social politics comes in, I **cannot afford** it – so let's rather do nothing.

ssssnappp !!

And the cost trap snapped again.

30 years of political inaction continues.

The UN motto “act on climate” has not worked.

Cost trap as effective as climate denial

And, by observation, the cost trap in Europe and other countries has been as effective as climate denial in the US in preventing any real action – and that's why we have seen 30 years of political inaction.

The cost trap!





30 years of inaction – new mind-set



How can we break the spell?

We have shown in our switch coal solutions study, that switching coal plants to wind-solar-battery systems is now **highly profitable**, delegates at the COP can bring home **billion \$ profits**, if they pledge to retire coal plants:

Let`s “act on climate & profit from it!” We may have finally figured it out!

New mind-set “act on climate & profit from it”

Therefore, the authors suggest to change the UN motto “act on climate” to reflect the new mind-set switch coal is bringing to the table, let`s say “act on climate & profit from it”

Everybody understands it.

A new, pragmatic and highly effective win-win approach.

*Note: This is the **silver bullet** to solve the climate crisis. Once and for all.*

Call to action

The authors urge COP delegates to pledge coal plant retirements - and come home with billion \$ profits for distribution. Let`s go for it & profit from it! It gotta be fun.