Aluminium Smelters as Catalysts for the Energy Transition

Empowering Renewable Energy Transport and Advancing Grid Decarbonization

Dr. Martin Iffert

MARTIN IFFERT CONSULTING GmbH

EP ENERGY POOL GmbH

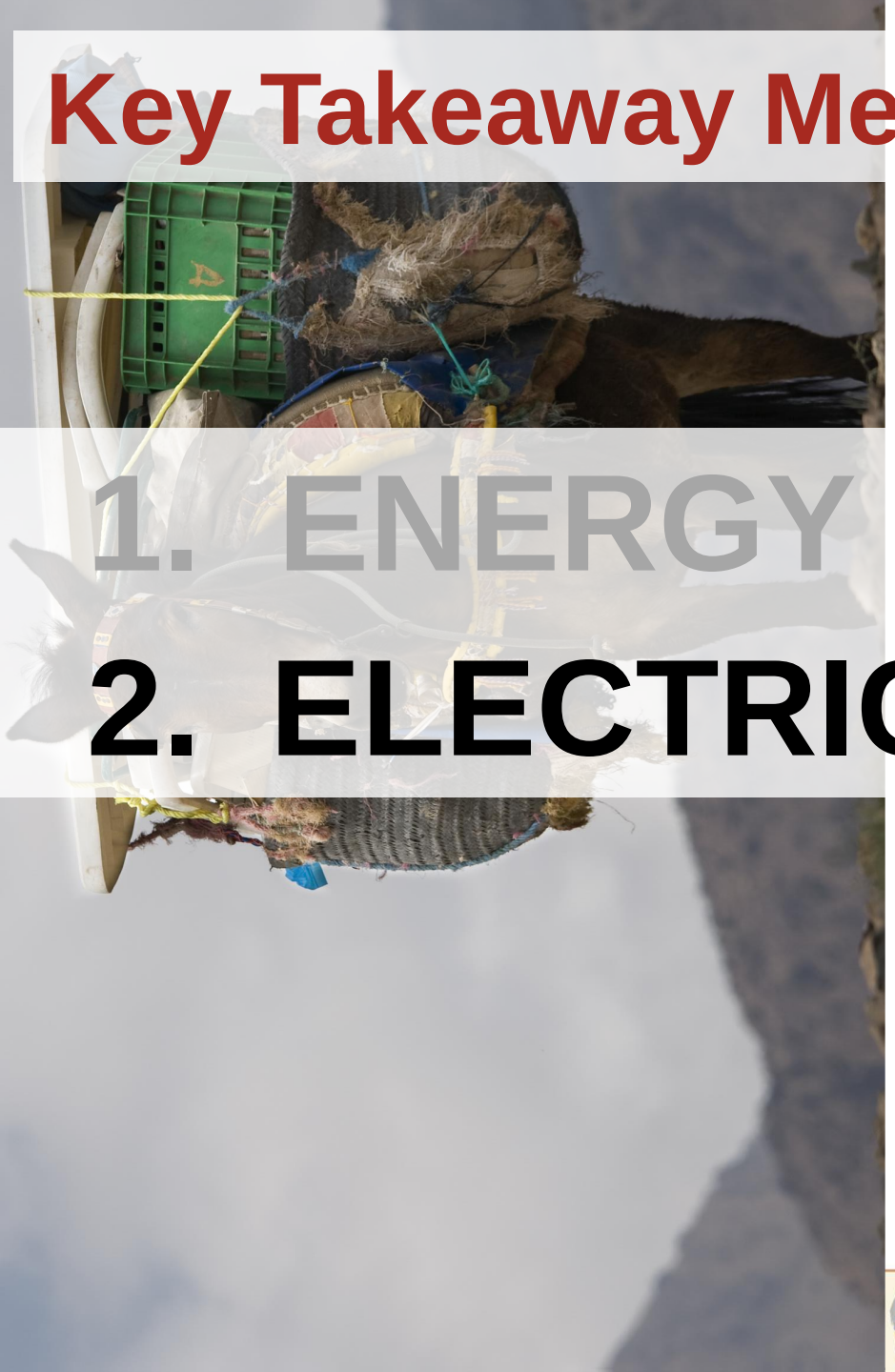
Key Takeaway Messages

1. ENERGY CARRIER ALUMINIUM

Key Takeaway Messages

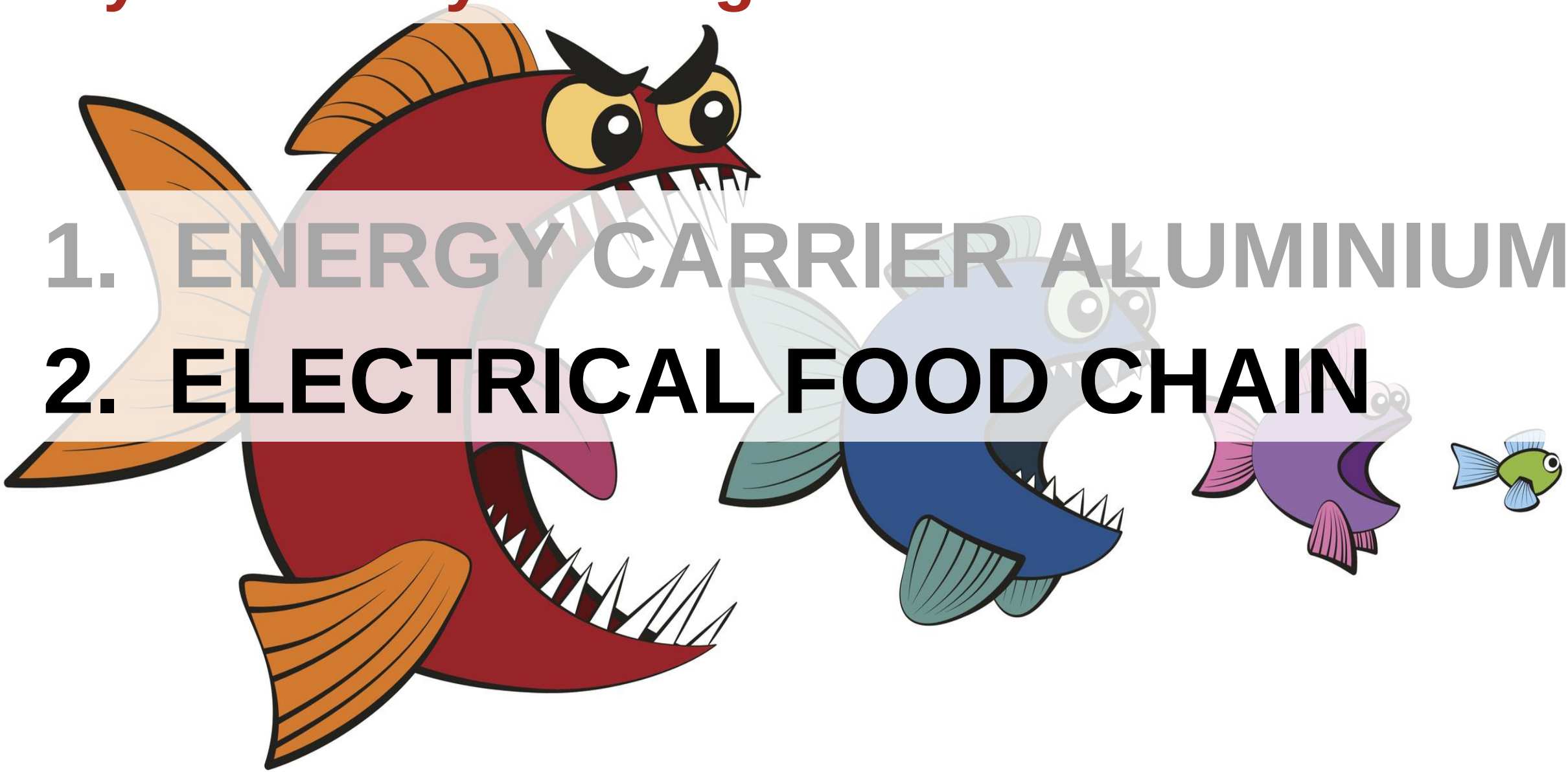
1. ENERGY CARRIER ALUMINIUM

Key Takeaway Messages



1. ENERGY CARRIER ALUMINIUM
2. **ELECTRICAL FOOD CHAIN**

Key Takeaway Messages

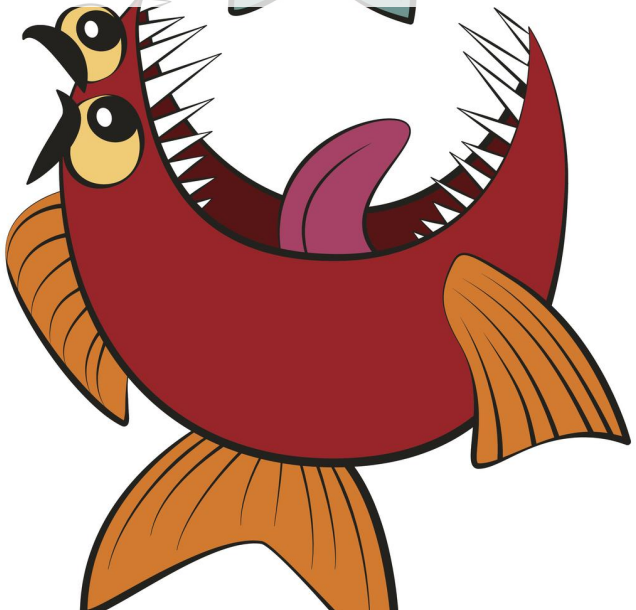


1. ENERGY CARRIER ALUMINIUM
2. **ELECTRICAL FOOD CHAIN**

Key Takeaway Messages

1. ENERGY CARRIER ALUMINIUM

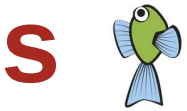
2. ELECTRICAL FOOD CHAIN

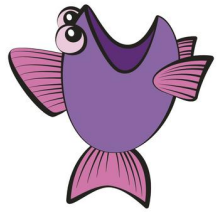


Key Takeaway Messages

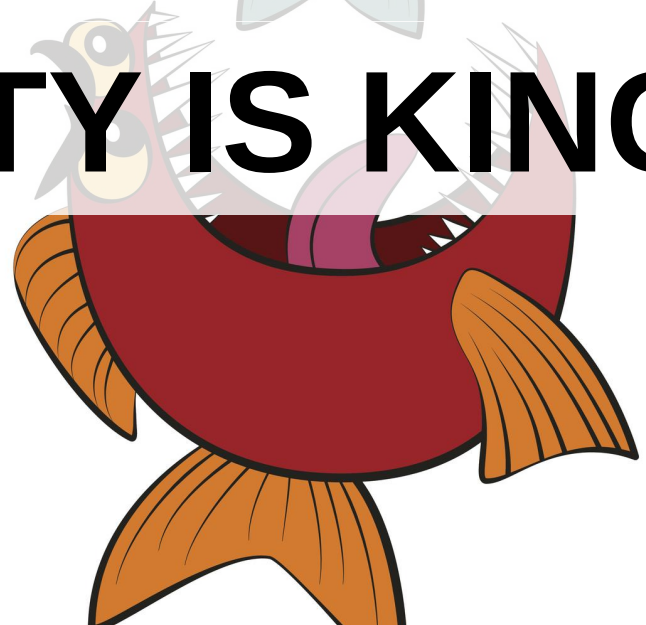
1. ENERGY CARRIER ALUMINIUM
2. ELECTRICAL FOOD CHAIN
3. **FLEXIBILITY IS KING**

Key Takeaway Messages





1. ENERGY CARRIER ALUMINIUM
2. ELECTRICAL FOOD CHAIN
3. FLEXIBILITY IS KING



Martin's Bio

Dr. Martin Iffert

Master Electrical Eng.
(1993 RWTH Aachen)
PhD Chemical Eng.
(2007 UNSW Sydney)
Executive MBA
(2009 IMD Lausanne)

The Networker for the Industry

Dr. Martin Iffert's Biography

- *30 years experience in Aluminium Smelting*
- *Former CEO of TRIMET and PdG TRIMET France*
- *Former President of German Association WVM*
- *Advisor for Policy Makers*
- *Advocate for Flexibility and Sustainability*
- *Founder of the Virtual Battery Concept*

MARTIN IFFERT CONSULTING GmbH

- Boutique Consulting Firm for Aluminium and Energy-Intensive Industries
- Operation, Leadership, Energy Politics, M&A

EP ENERGY POOL GmbH

- Flexibilization of Energy-Intensive Industries
- Centre of Excellence for Aluminium Smelting

Fear is the path to the dark side…

Fear leads to anger.

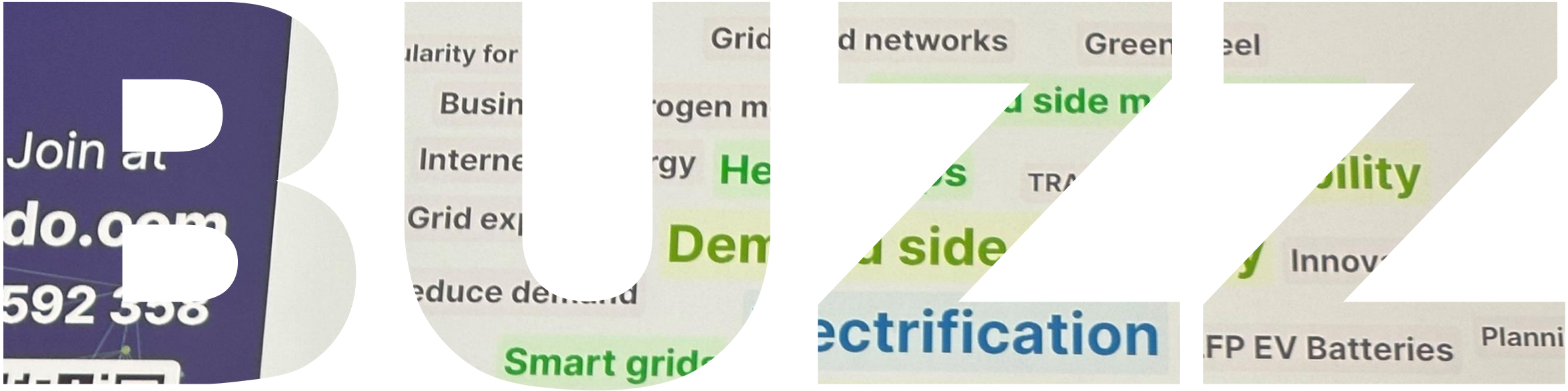
Anger leads to hate.

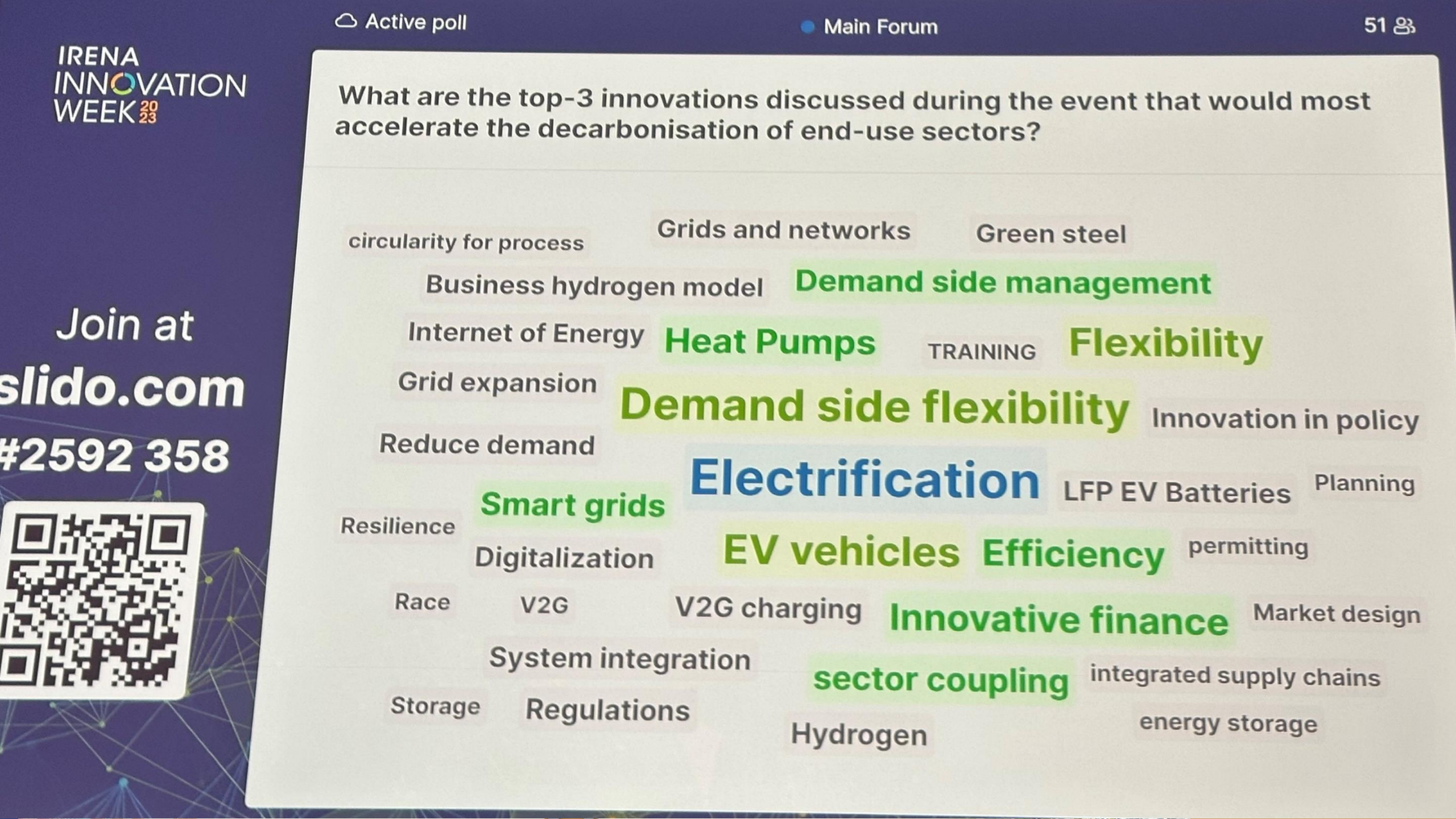
Hate leads to suffering.

The World on Fire

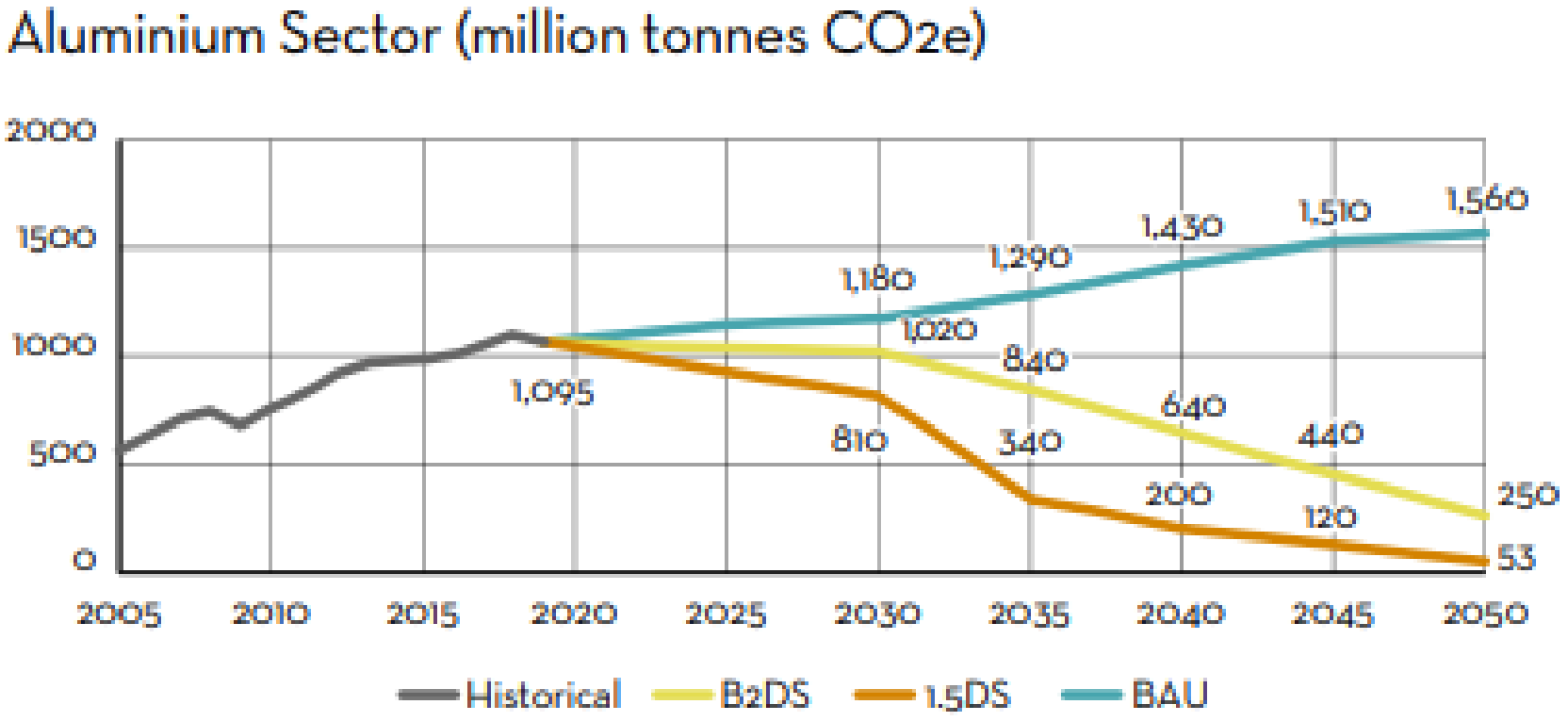
Wild Fires Canada
Sept-Iles

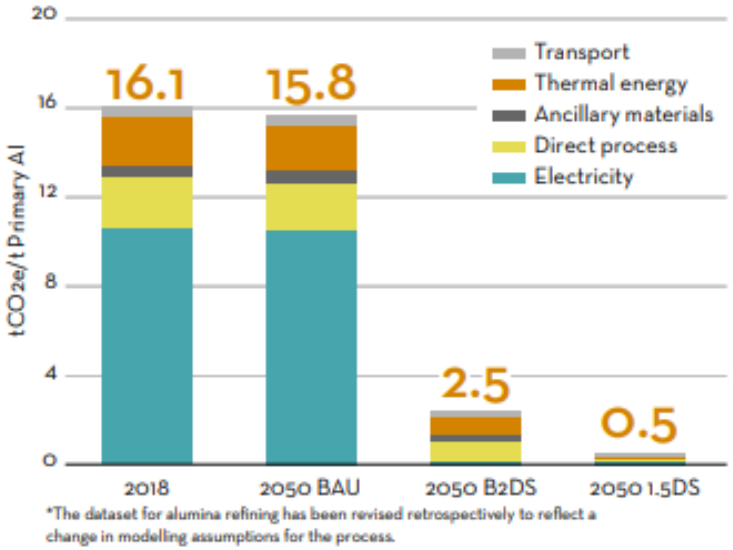
Wild Fires Canada


Join at
do.com
592 358
ularity for
Busin
Interne
Grid exp
educe demand
Smart grid
Grid
rogen m
rgy
He
Dem
d networks
Green
side m
TRA
side
ectrification
eel
ility
Innov
FP EV Batteries
Planni


IRENA INNOVATION WEEK 2023
Active poll
Main Forum
51
What are the top-3 innovations discussed during the event that would most accelerate the decarbonisation of end-use sectors?
circularity for process
Grids and networks
Green steel
Business hydrogen model
Demand side management
Internet of Energy
Heat Pumps
TRAINING
Flexibility
Grid expansion
Demand side flexibility
Innovation in policy
Reduce demand
Electrification
LFP EV Batteries
Planning
Smart grids
Resilience
Digitalization
EV vehicles
Efficiency
permitting
Race
V2G
V2G charging
Innovative finance
Market design
System integration
sector coupling
integrated supply chains
Storage
Regulations
Hydrogen
energy storage
Join at
slido.com
#2592 358

How to achieve the 1.5 DEGREES SCENARIO





- 60% related to Power Source
- 15% related to Carbon Anodes
- 25% related to other Scope 3

Decarbonization…

Playing not to Lose

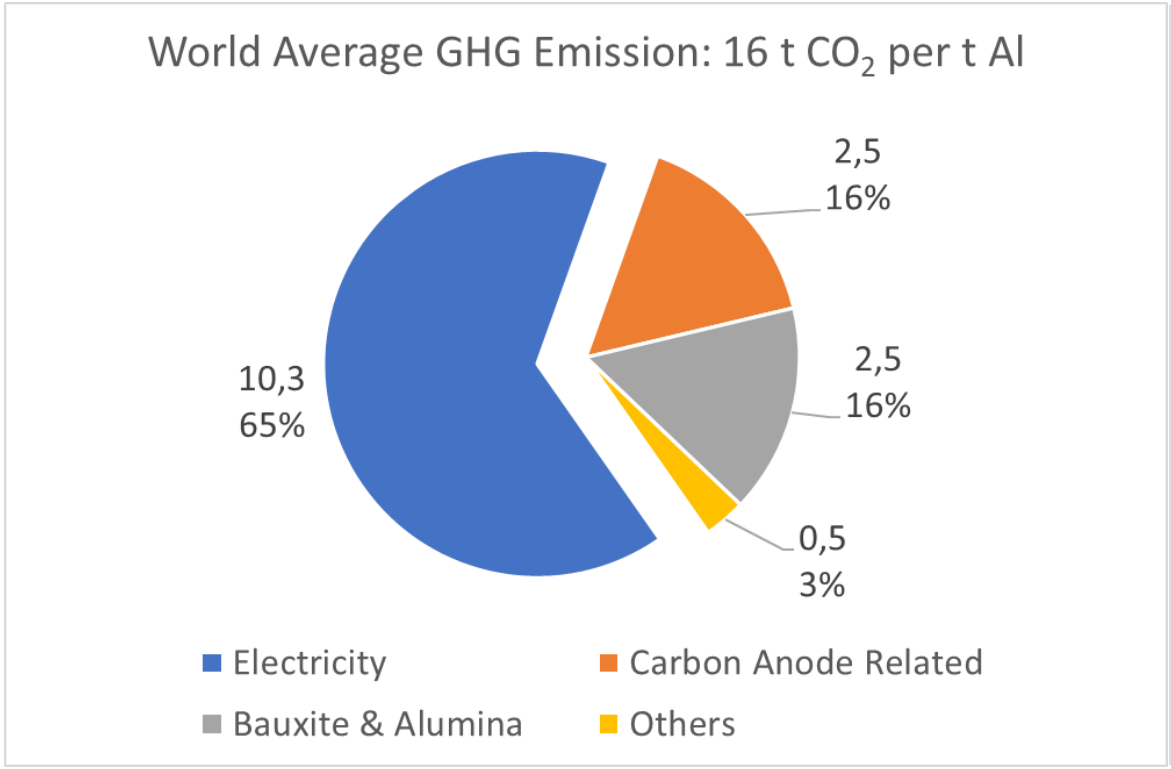
Playing to Win

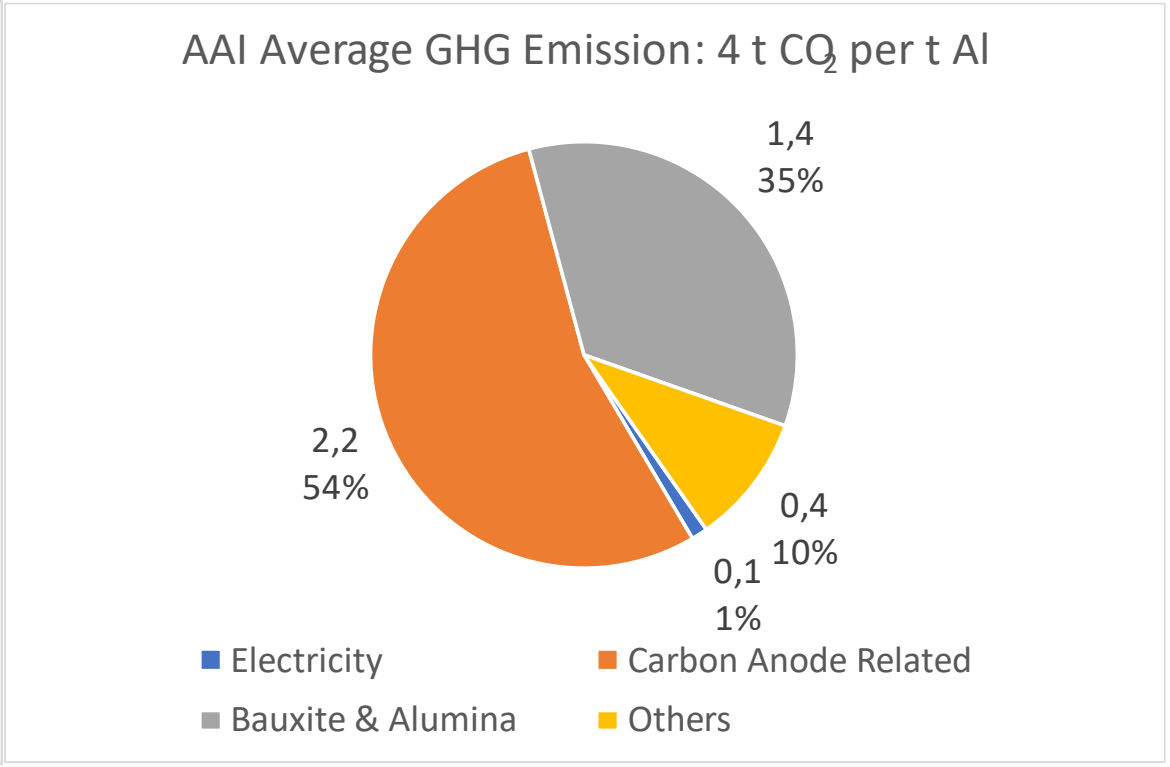
Decarbonization…

Playing not to Lose

Playing to Win

GHG – World vs. Best in Class, e.g. AAI

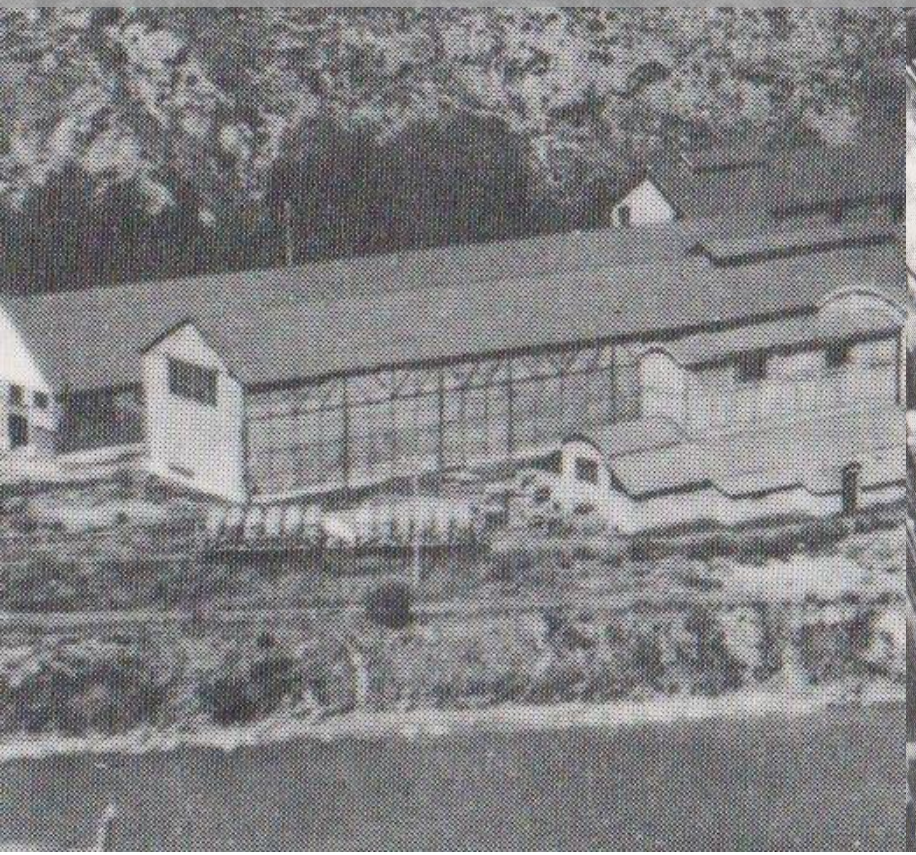


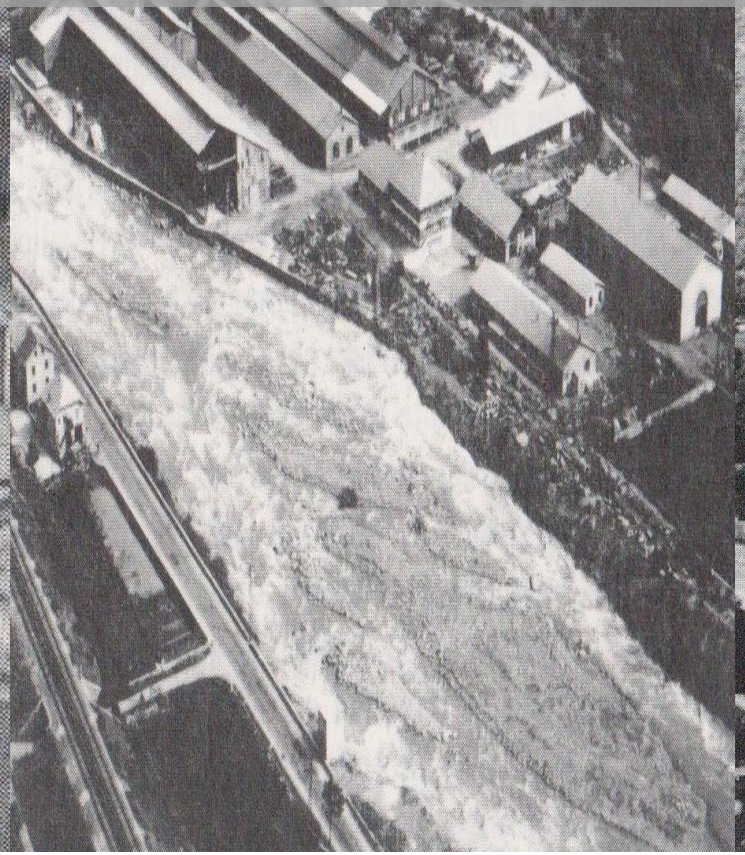


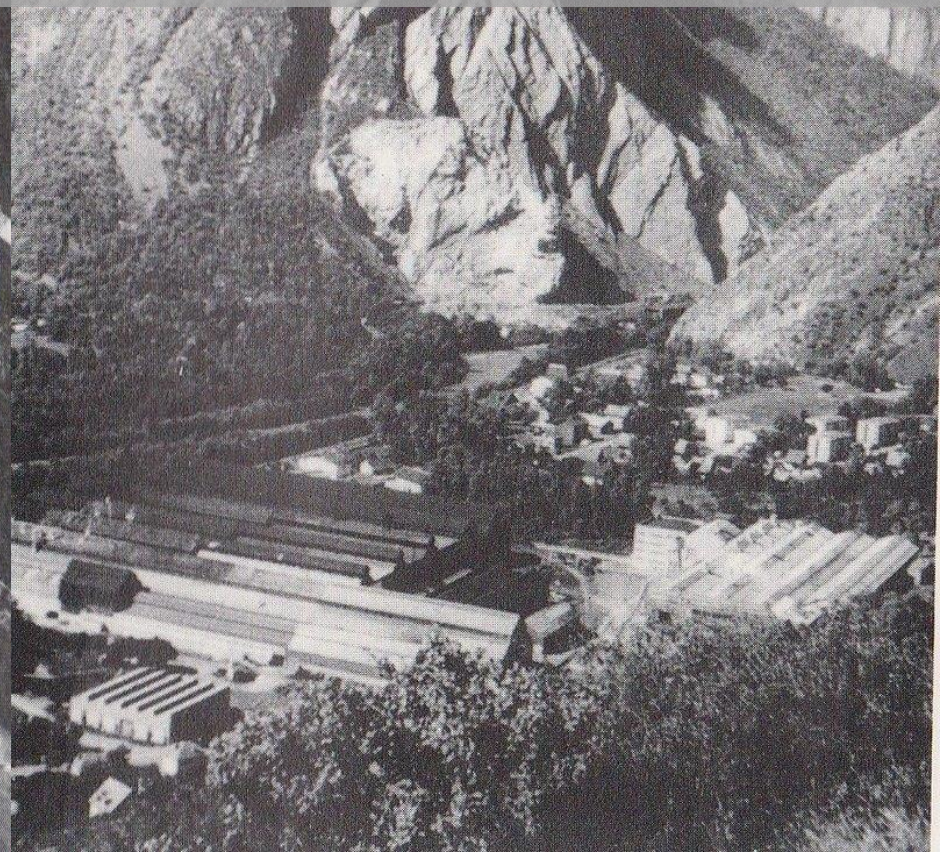
A Century of Energy Unlocking with Aluminum Smelters

Historical Overview of Aluminum Smelters

1892-1906: Maurienne Val
6 Aluminium Smelters



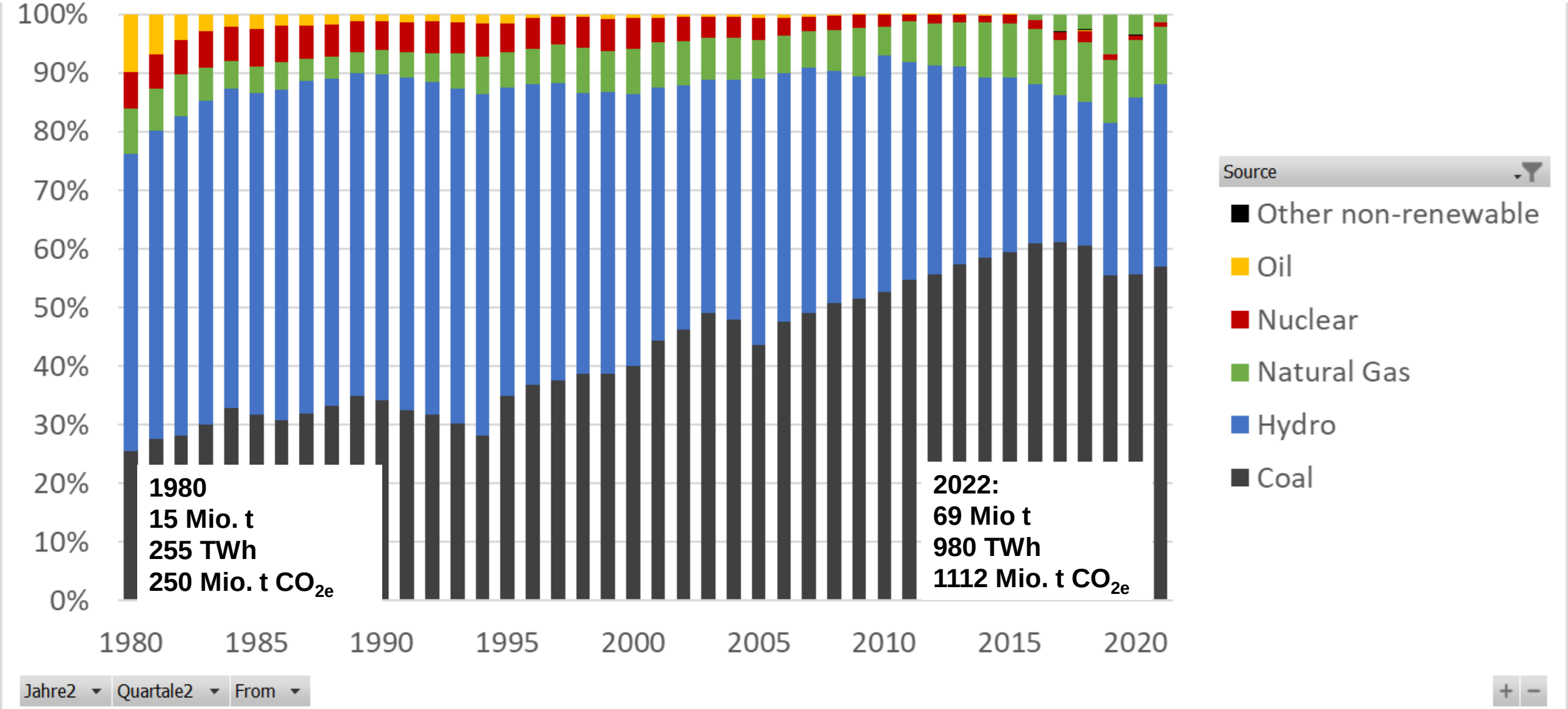




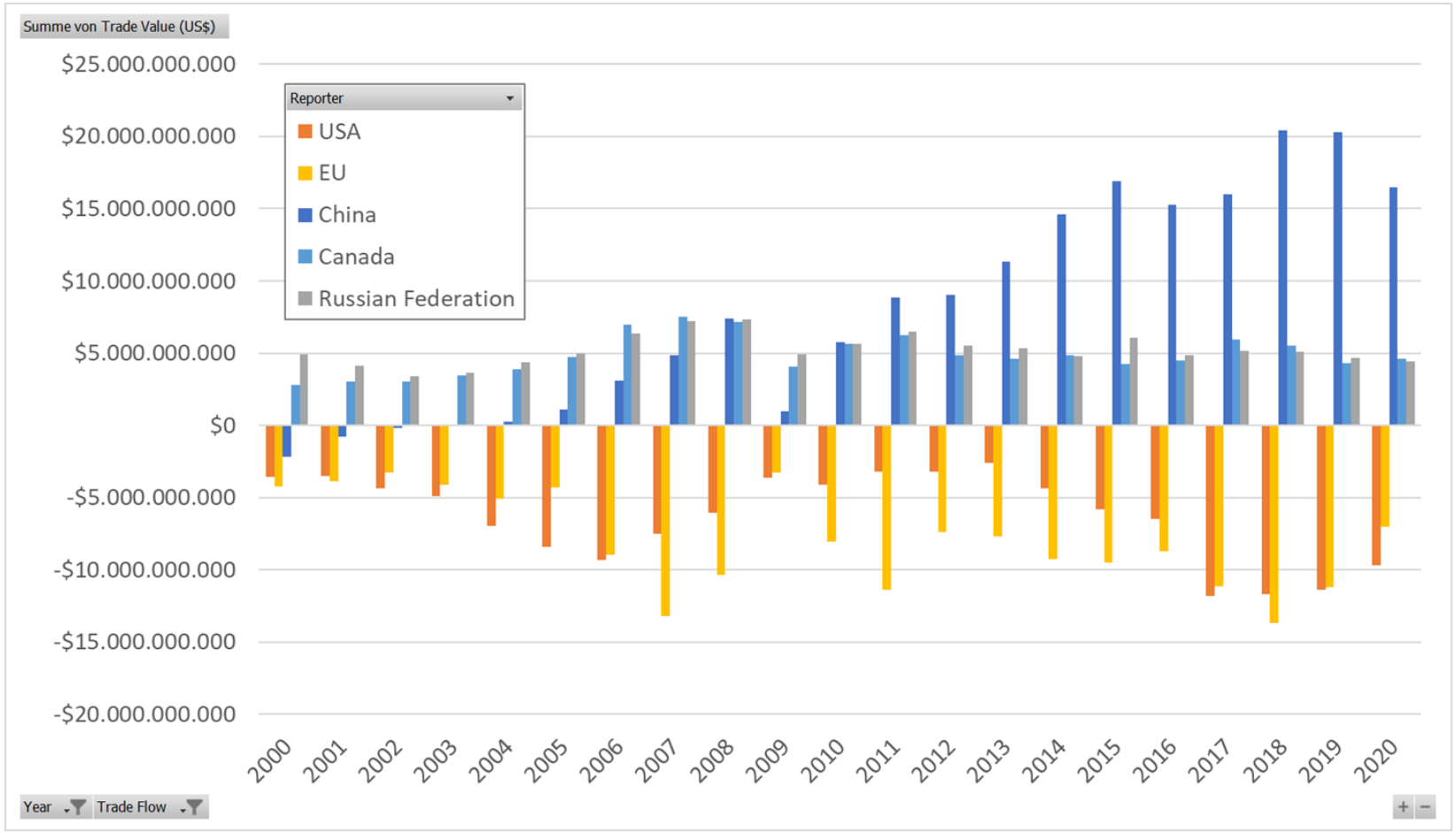
1906 to AP30/AP40

1906 to AP30/AP40

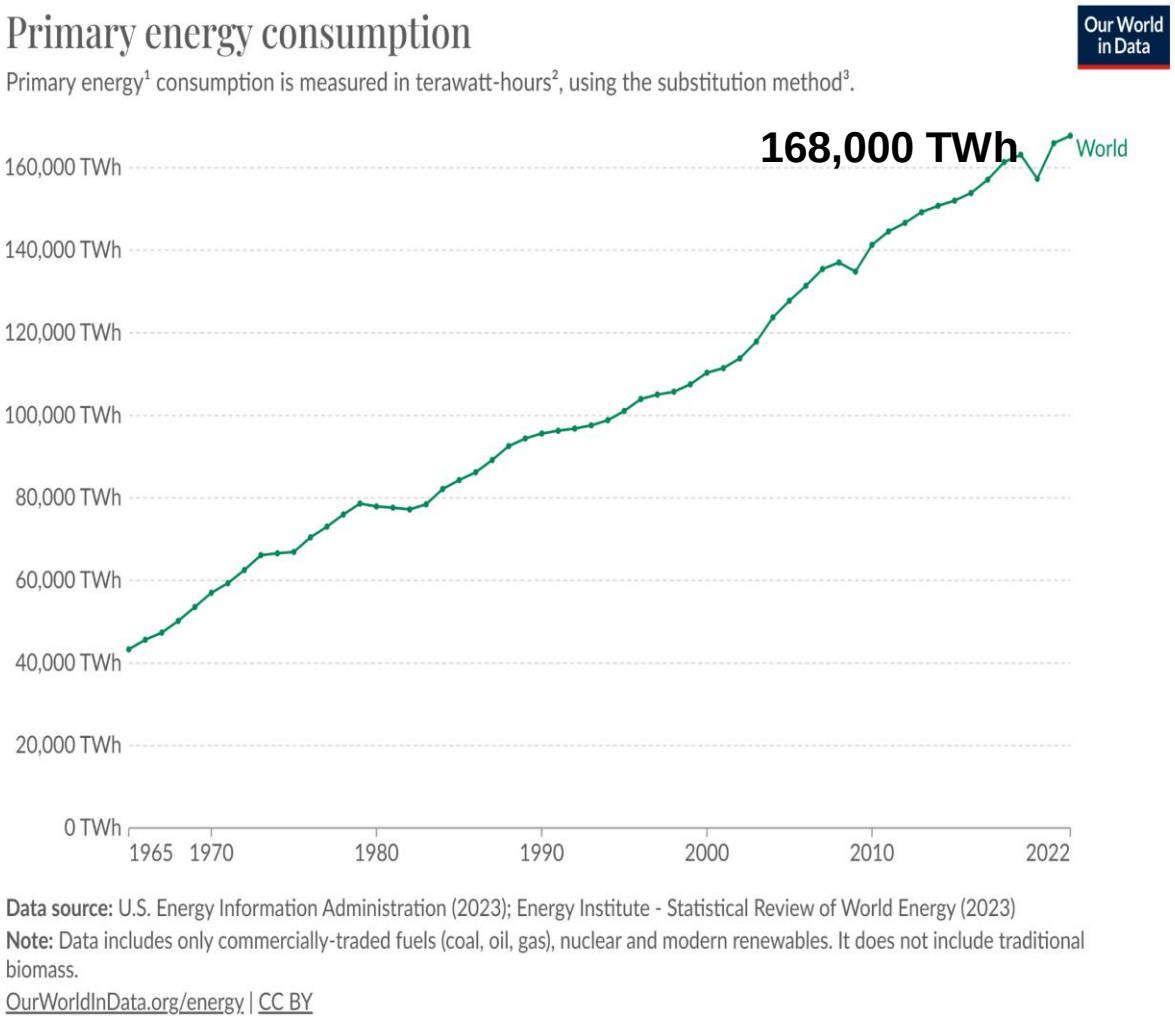
Past Energy Sources & Uses

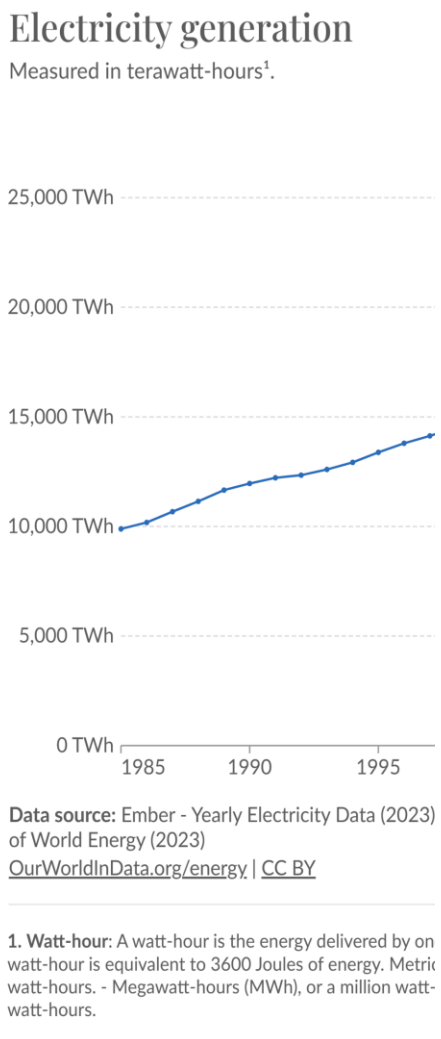


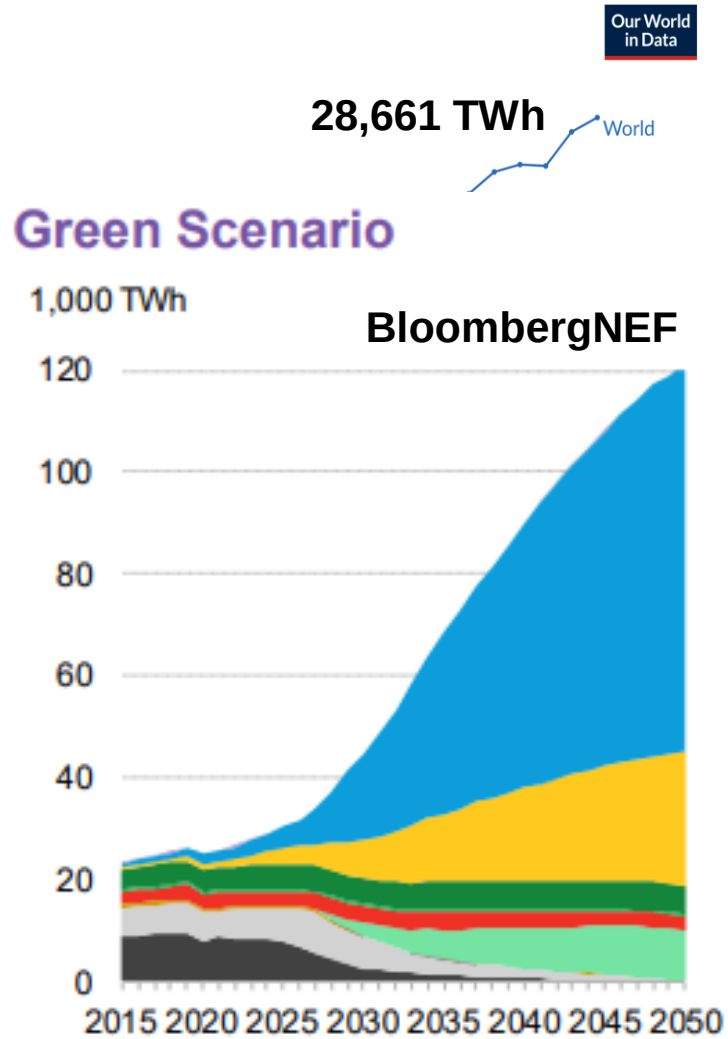
Evolution of Aluminum as an Energy Carrier



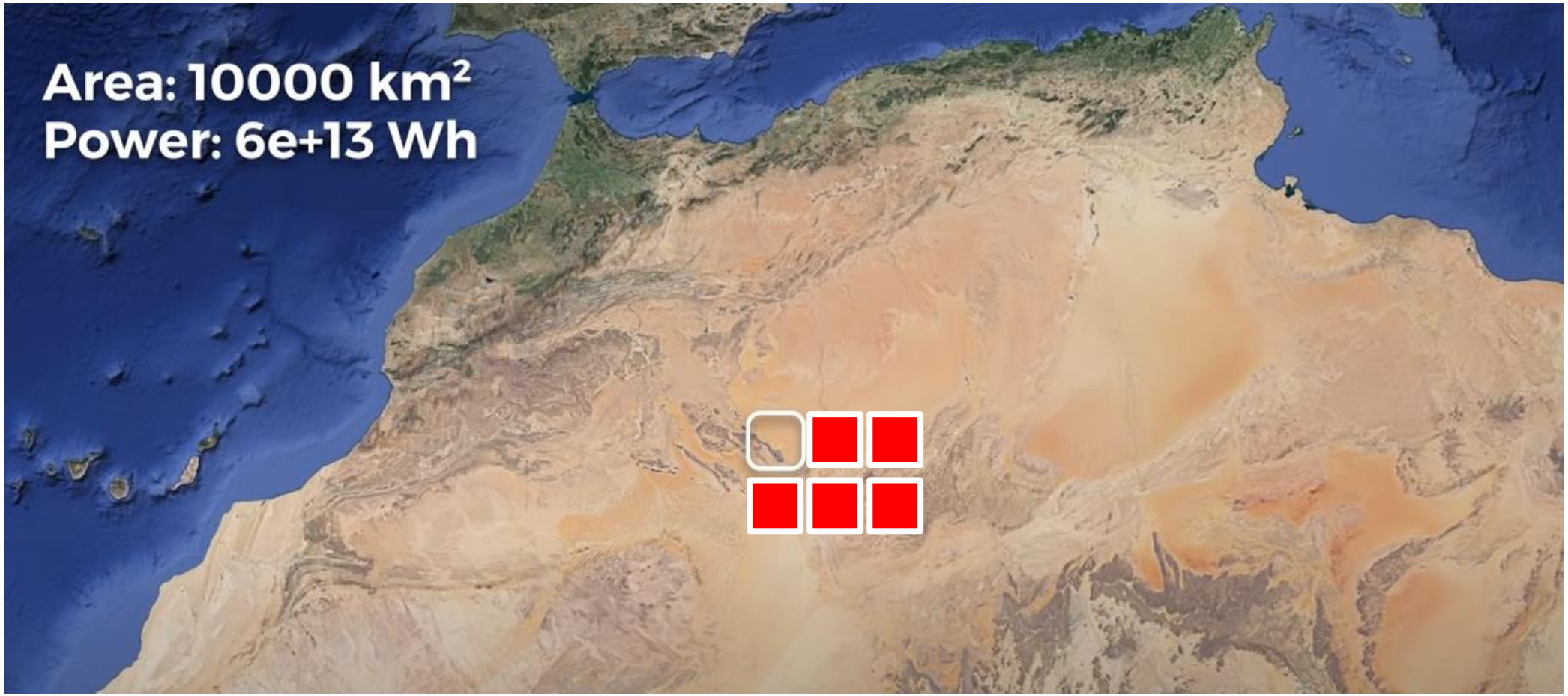
World Annual PE Consumption vs. EL Generation







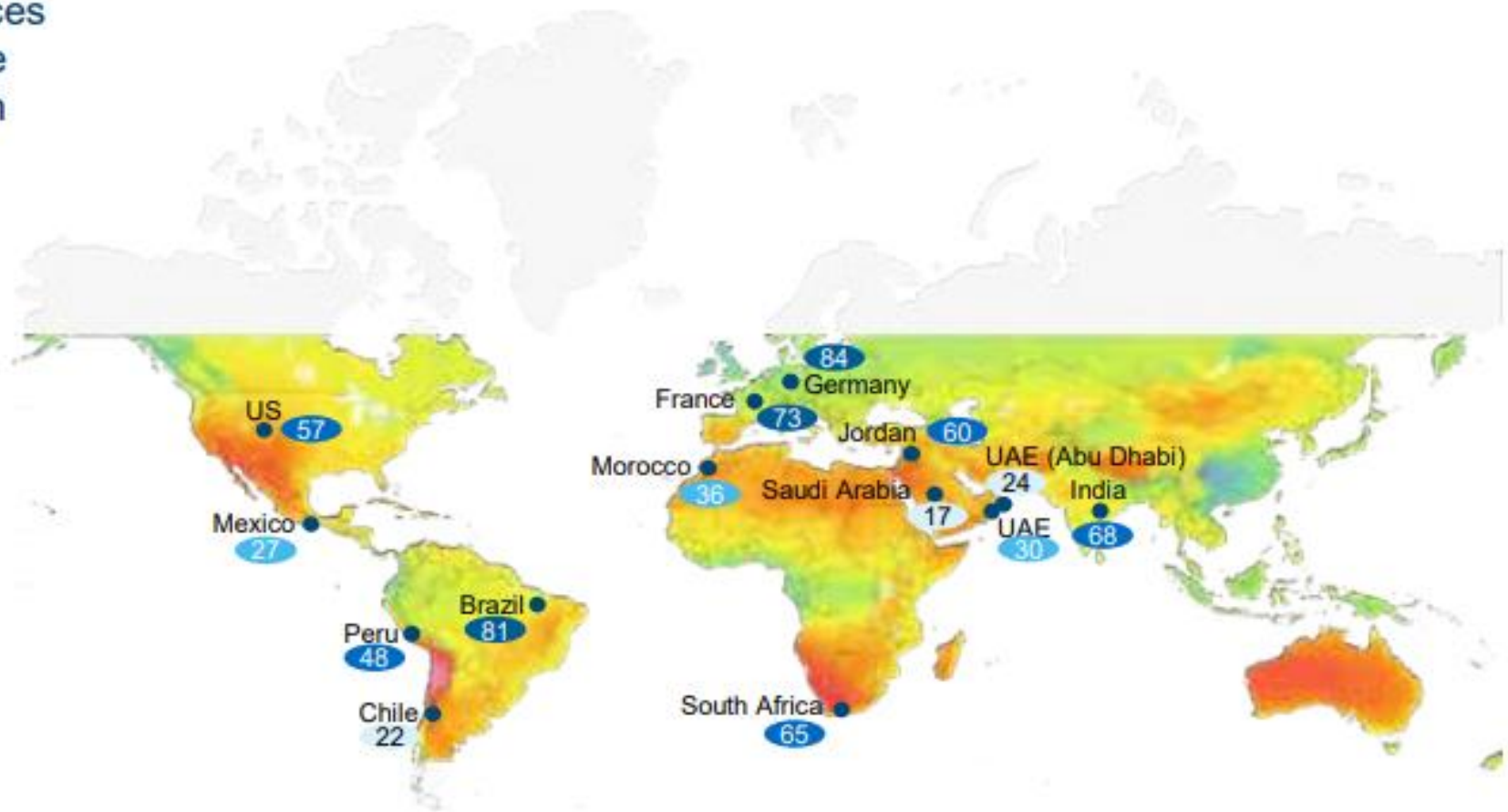
All we Need – 79 TWh per day = 28,861 TWh per year



[The Problem with Solar Energy in Africa (youtube.com)]

Very low electricity prices for solar PV energy are reached in regions with high insolation

SOURCE: WorldBank



Solar PV tender results
USD/MWh

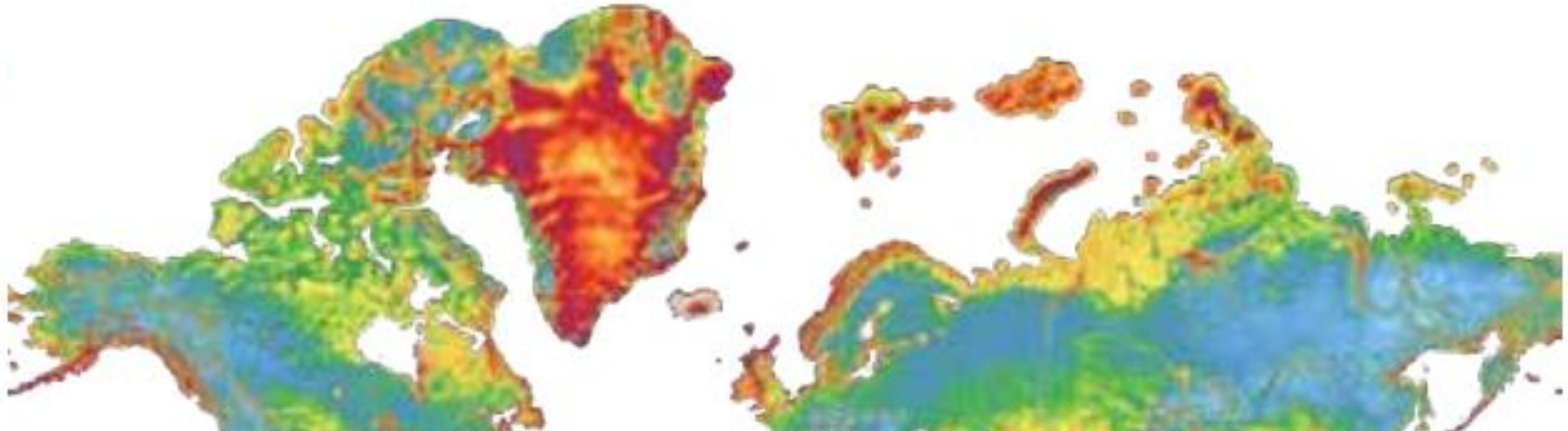
<25 | 25-40 | 40-70 | >70

Long term average irradiation
KWh/m², yearly sum

3,652
3,287
2,922
2,556
2,191
1,826
1,461
1,095
730
<365

Very low electricity prices for wind energy are reached in highly specific locations

SOURCE: WorldBank

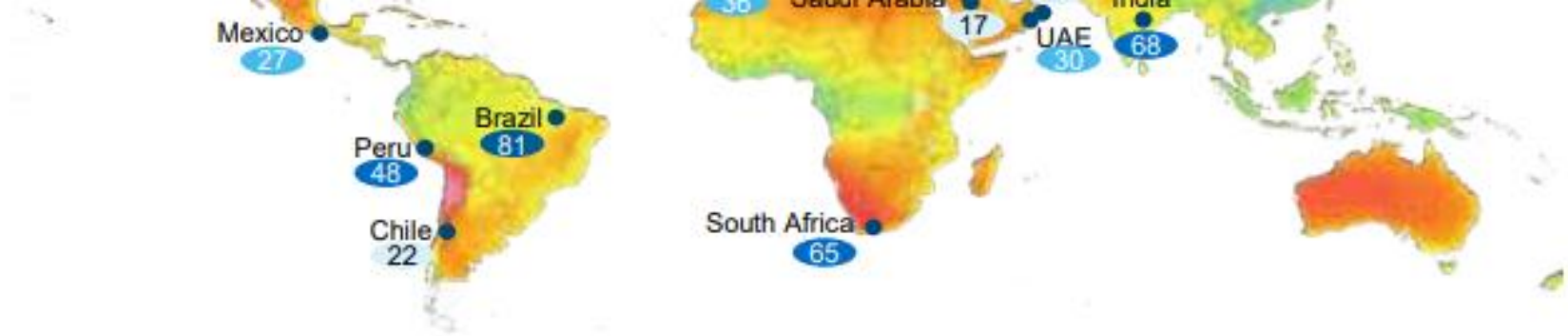


Wind PV tender results
USD/MWh

<25 | 25-40 | 40-70 | >70

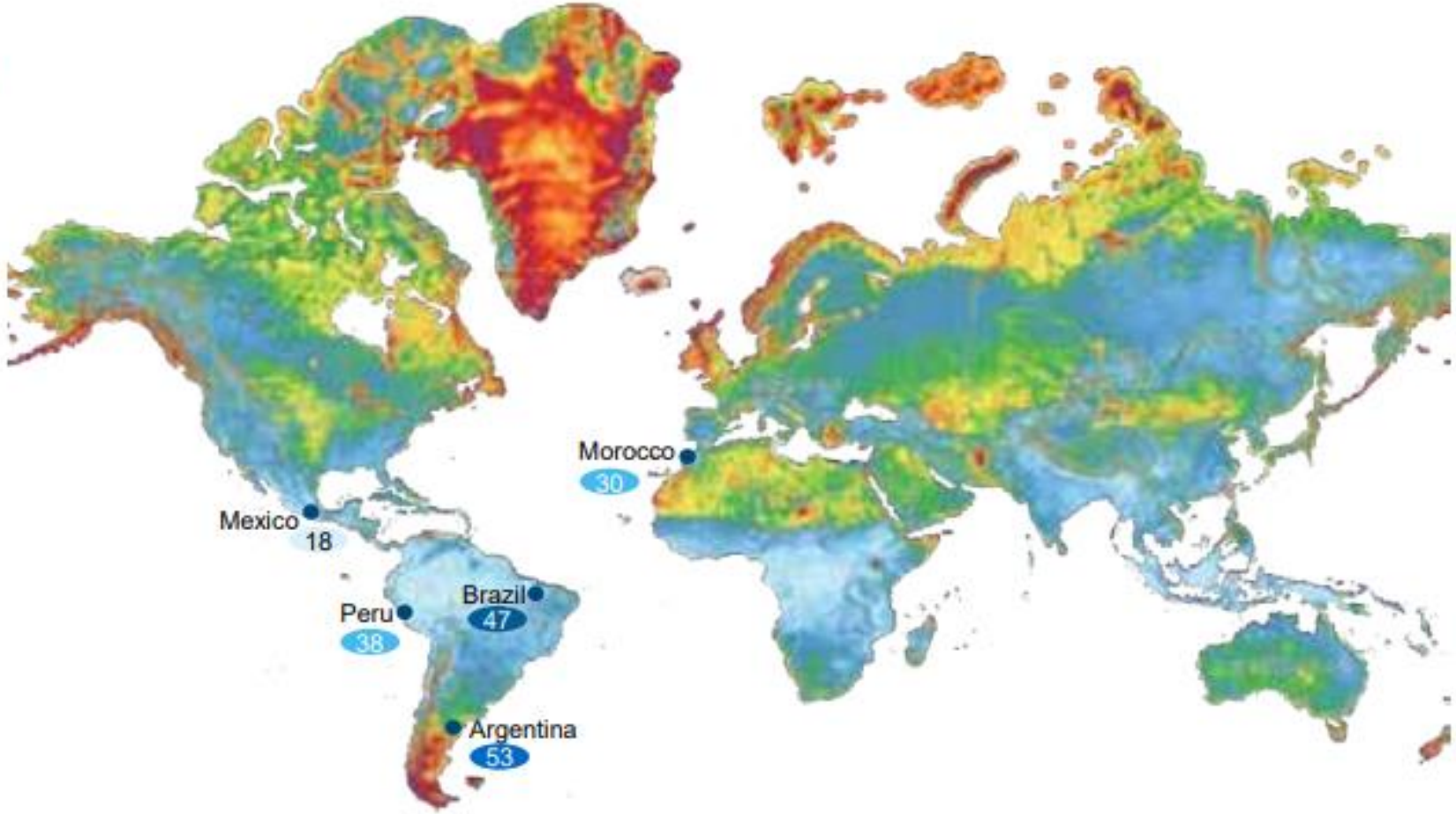
Wind resource
W/m²

>1300
1300
1200

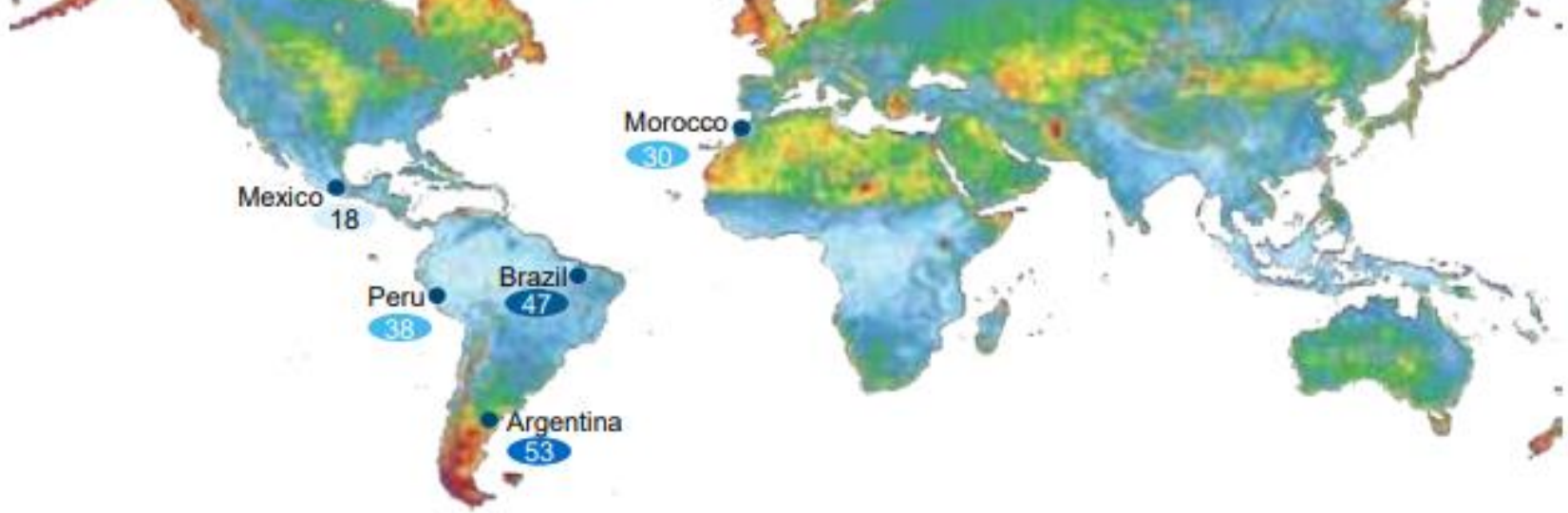


Very low electricity prices for wind energy are reached in highly specific locations

SOURCE: WorldBank

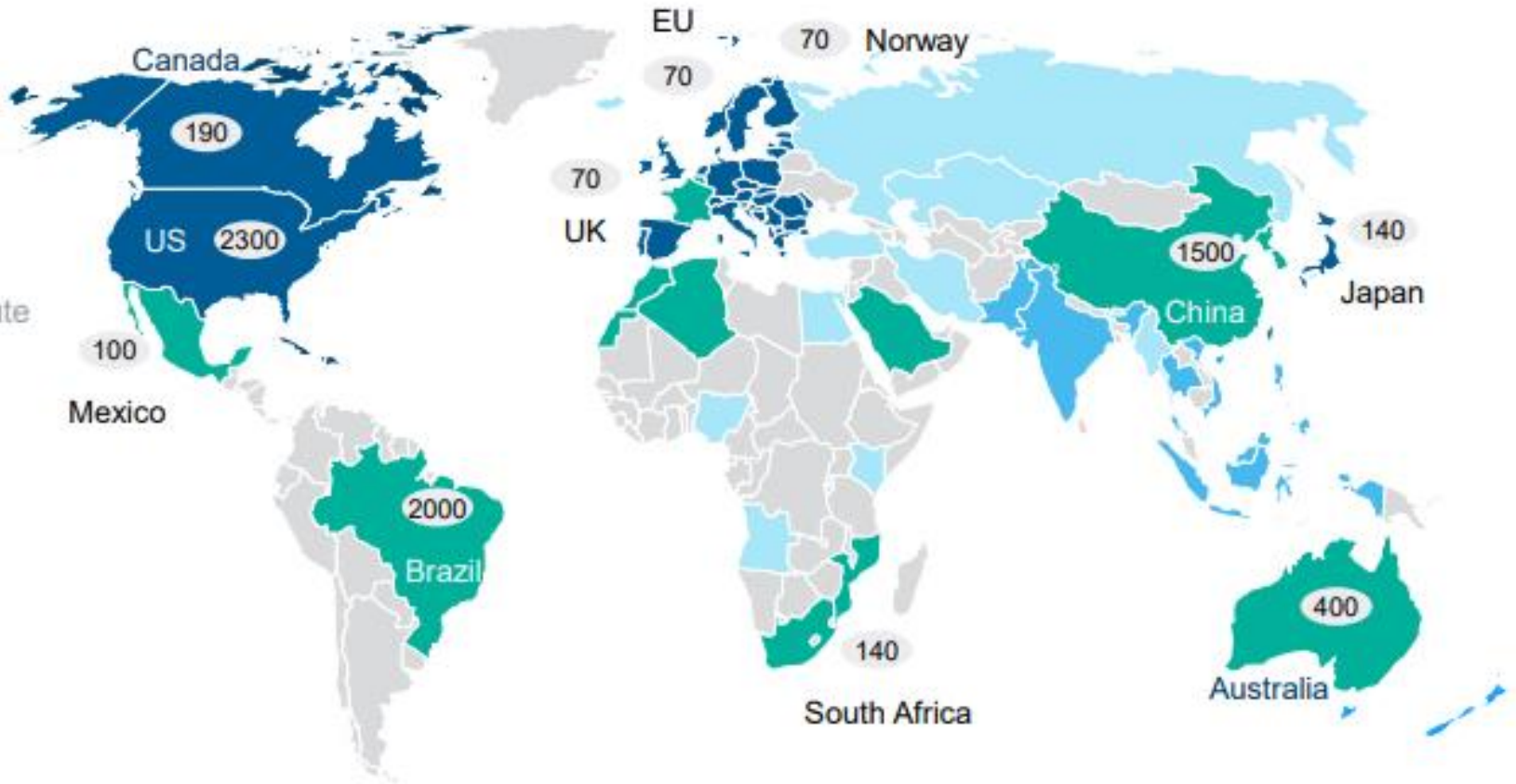


Availability of CO_2

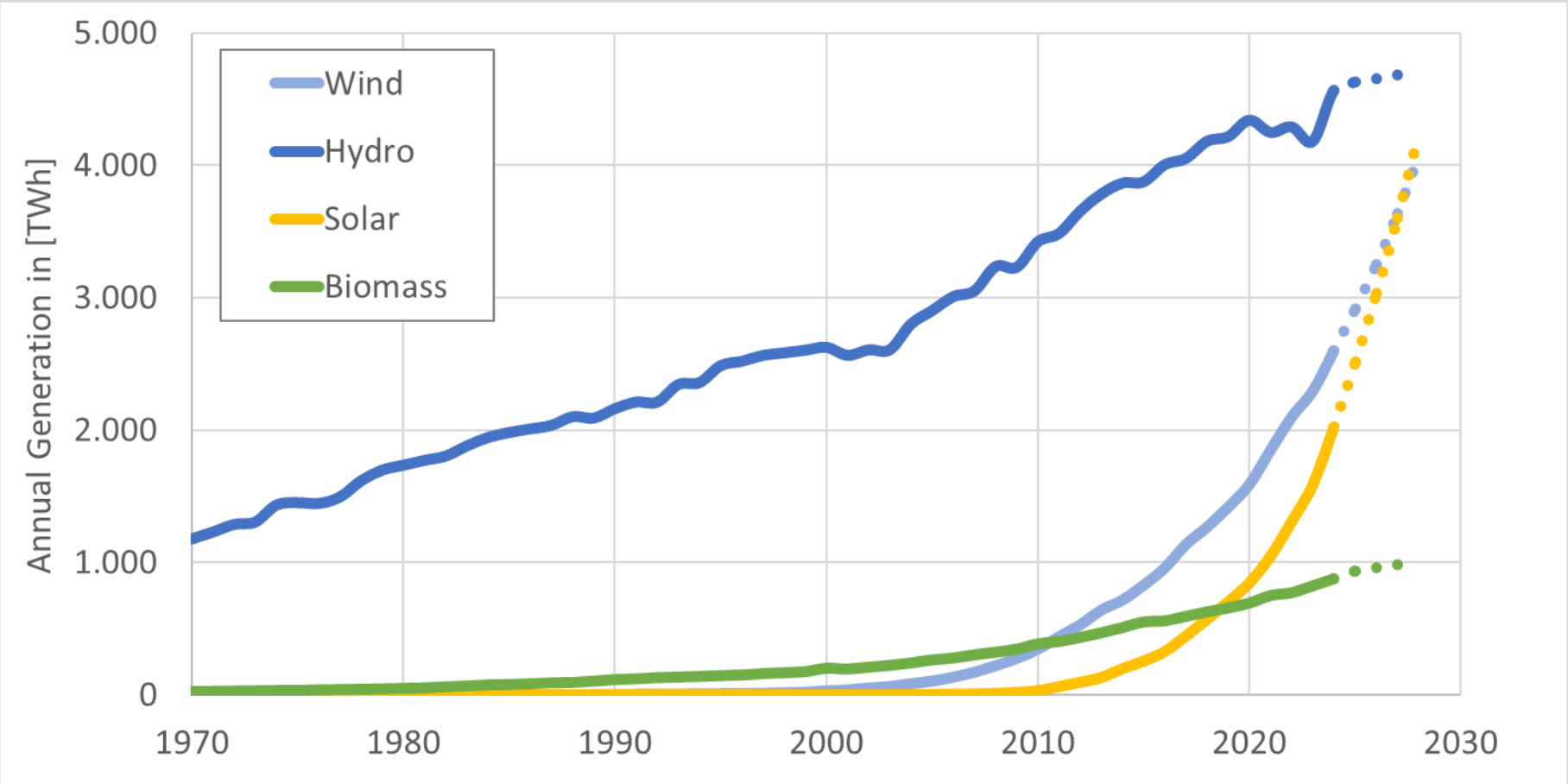


Availability of CO_2 storage resources differs locally

SOURCE: Global CCS Institute



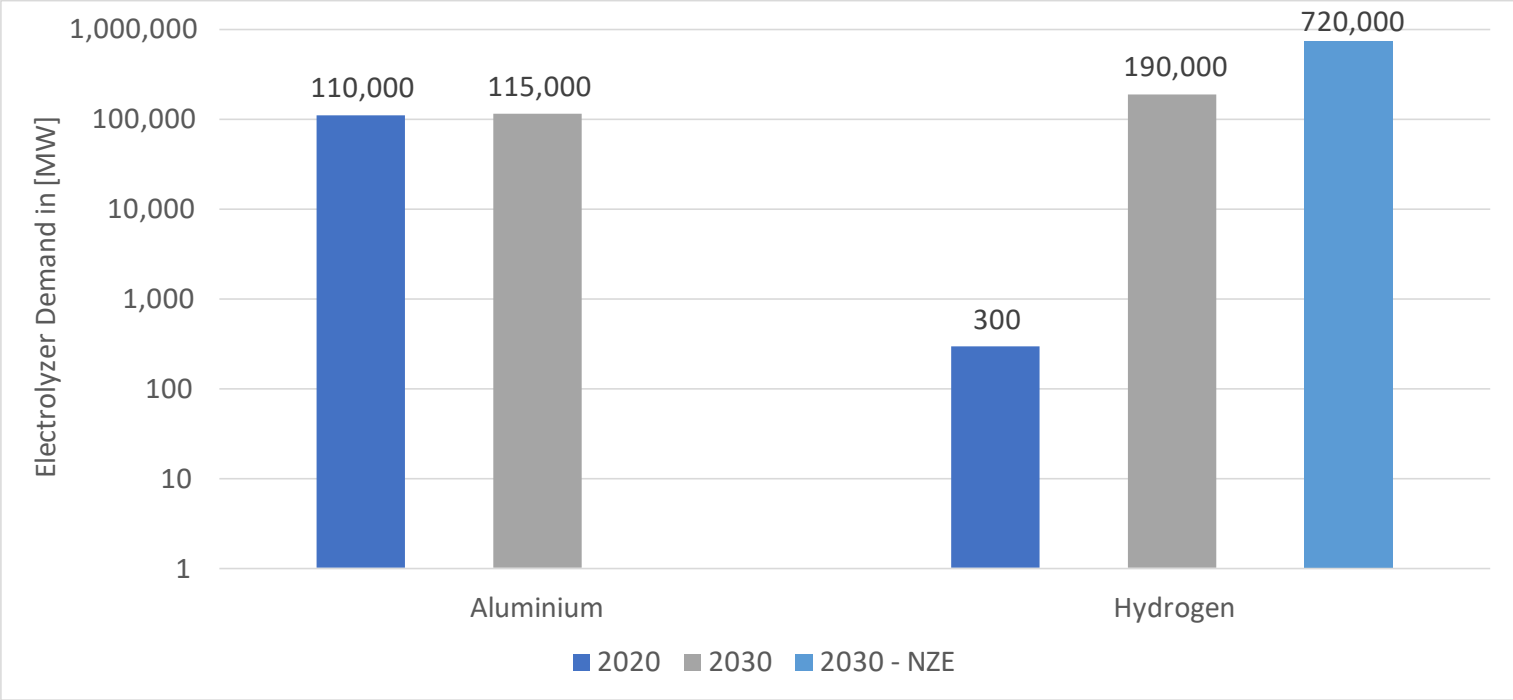
World Renewable Energies



Electricity Ratios in 2022 out of a World Total Electricity Generation of 28,660 TWh:
Hydro = 15.0% / Wind = 7.3% / Solar = 4.6% / Biomass = 2.7% →∑29.5% = 8,470 TWh

Share of renewable electricity generation by technology, 2000-2028 – Charts – Data & Statistics - IEA

GREEN Aluminium vs. GREEN Hydrogen



- Aluminium by far the biggest energy carrier today
- IEA forecast that hydrogen will be btw. 1.5x to 6x the size of aluminium by 2030
- Hydrogen and aluminium production are “twins”
- Aluminium smelter CAPEX @ 4 $/W
- H2 Electrolyser CAPEX @ 1 $/W

Potential long-distance Green Energy Carrier are Hydrogen, Ammonia, Green Steel, Green Aluminium
50 MWh → 1 t H2 → 12.5 MWh Power → 1 t Aluminium (without H2 transport losses)

Getting the Energy Transition right

OR

Why Germany should build an Aluminium Smelter in Namibia

New Locations for Energy Intensive Processes

BUSINESS | NAMIBIA

Germany eyes Namibia's green hydrogen

Jasko Rust | Lisa Ossenbrink

12/02/2022

Namibia wants to become one of the world's leading producers of green hydrogen. Germany is interested in the project, but not everyone is cheering in Namibia.

6 GW Renewables

15 TWh Electricity

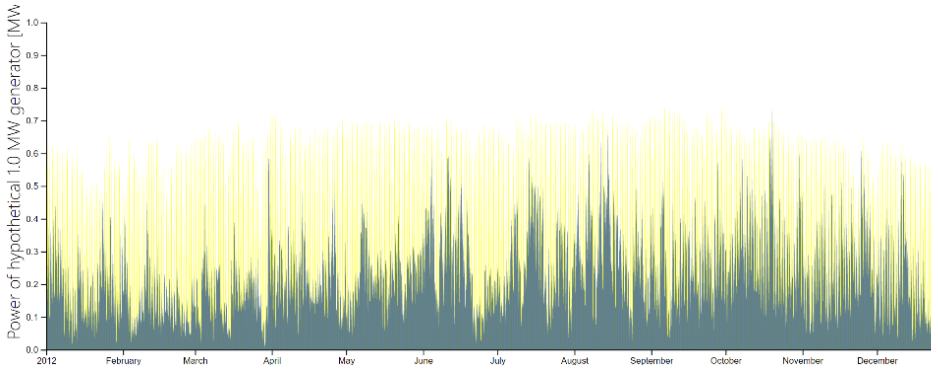
3 GW Electrolyser

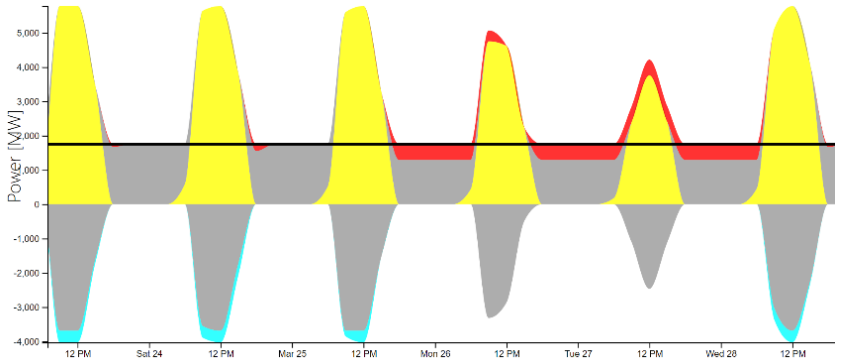
USD 10 bn CAPEX

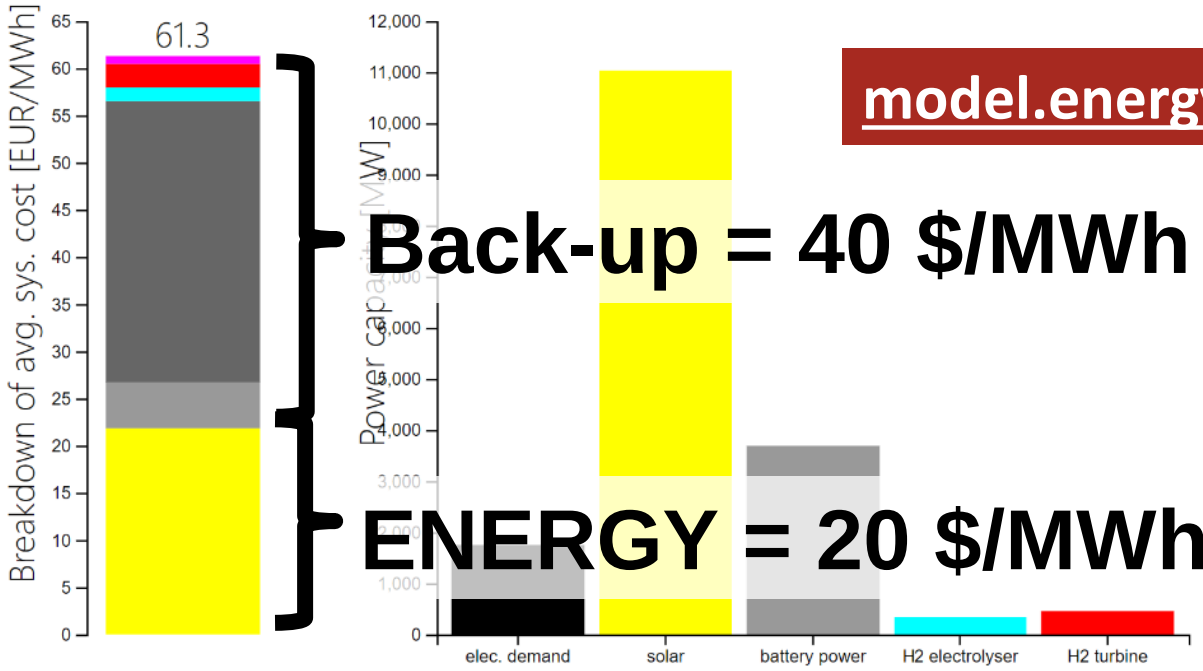
300 kt/a H2

(could also power 1 Mt smelter)

Example: Namibia
1,750 MW Zero Carbon Base Load



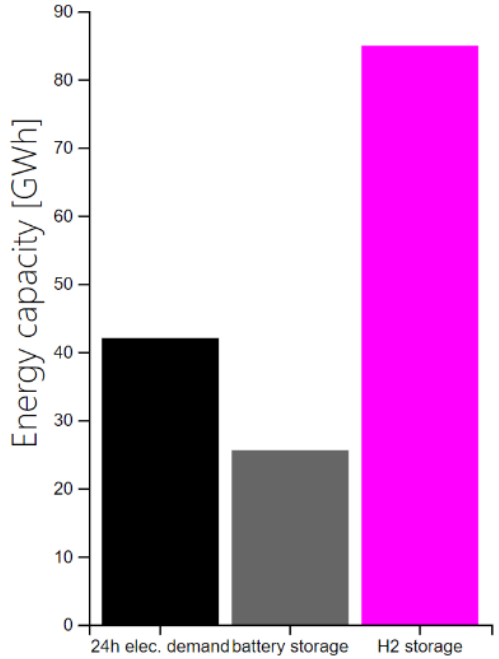




model.energy

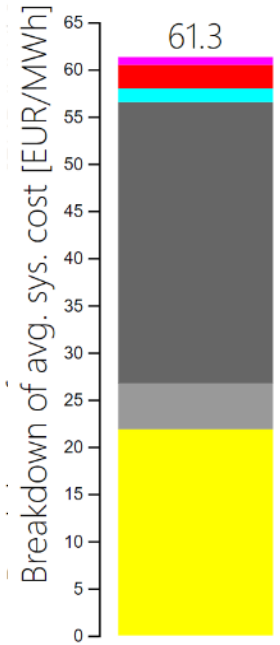
Back-up = 40 $/MWh

ENERGY = 20 $/MWh



@2,500 USD/t LME
20 → 12% Ratio
40 → 24% Ratio
60 → 36% Ratio

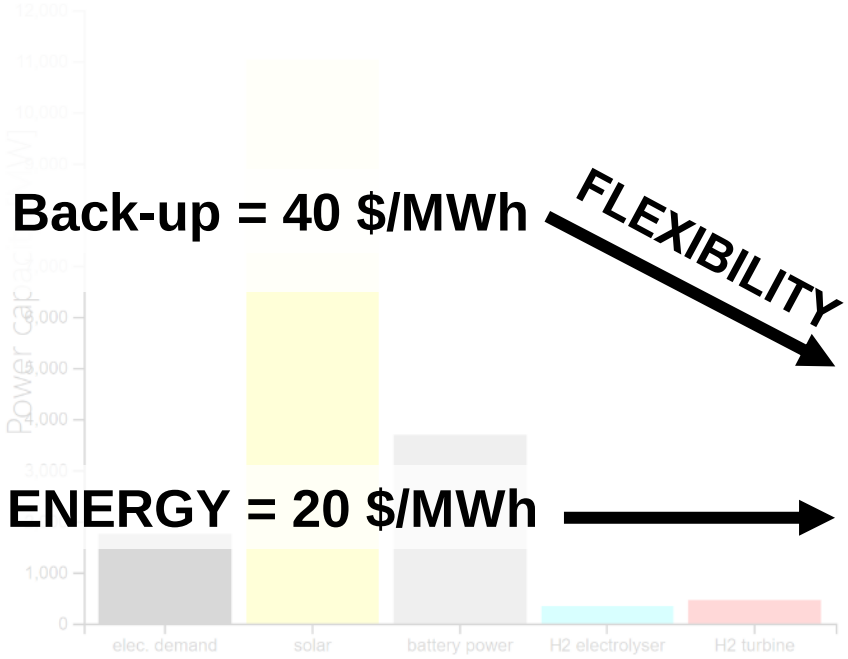
Example: Namibia
1,750 MW Zero Carbon Base Load

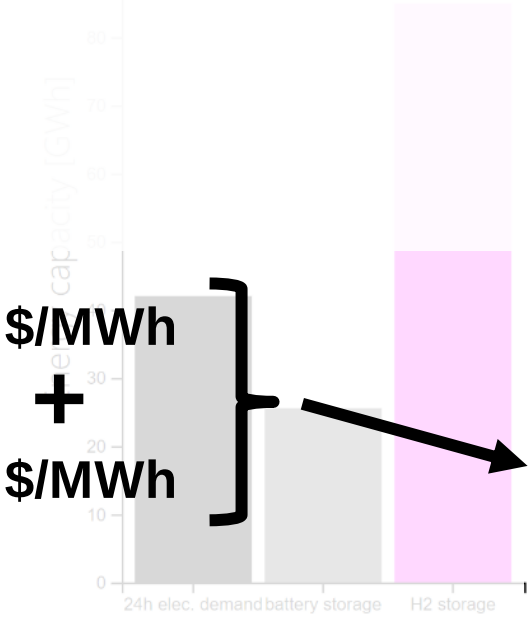


Back-up = 40 $/MWh → **FLEXIBILITY** → **20 $/MWh**

+

ENERGY = 20 $/MWh → **20 $/MWh**





@2,500 USD/t LME
20 → 12% Ratio
40 → 24% Ratio
60 → 36% Ratio

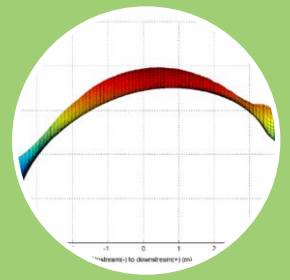
Virtual Battery Components

SHE

Modulating the Side-Wall Heat Loss from the Cell

GTC Flex

Modulating the Top-Heat Losses from the Cell



Magnetic Compensation

Reducing Magnetic Effects & Metal Pad Heave

Flex Control

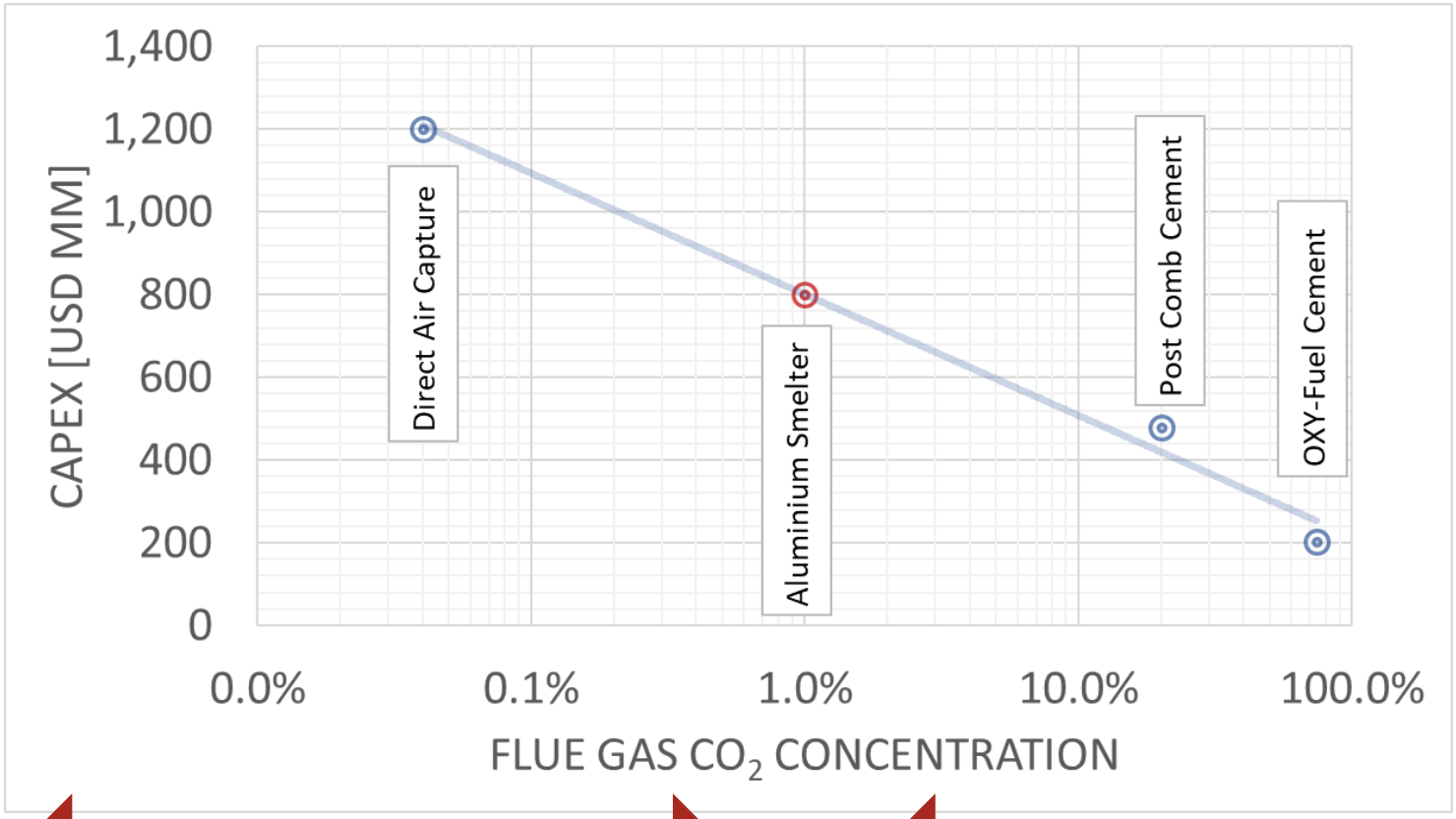
Adaptation of Process/Pot Control System

Energy Supply

Increase Responsiveness with Transducers

Thermal Regulation

CCS in different Industries & Al Smelter



Long-Term 2050 Potentials

- Hooding Efficiency 99%
- Carbon Capture Target – 80%
- Anode Effect PFC + 5%

→ Overall GHG Capturing 75%

→ @25% Biomass = Net Zero Scope 1, 2

MIC Estimates for 2040:

- CCS @ 100 $/t → +150 $/t Al
- 25% Biomass @ +200 $/t → +25 $/t Al

→ +175 $/t Al for Net Zero 1, 2

tion for 2040 with USD2022

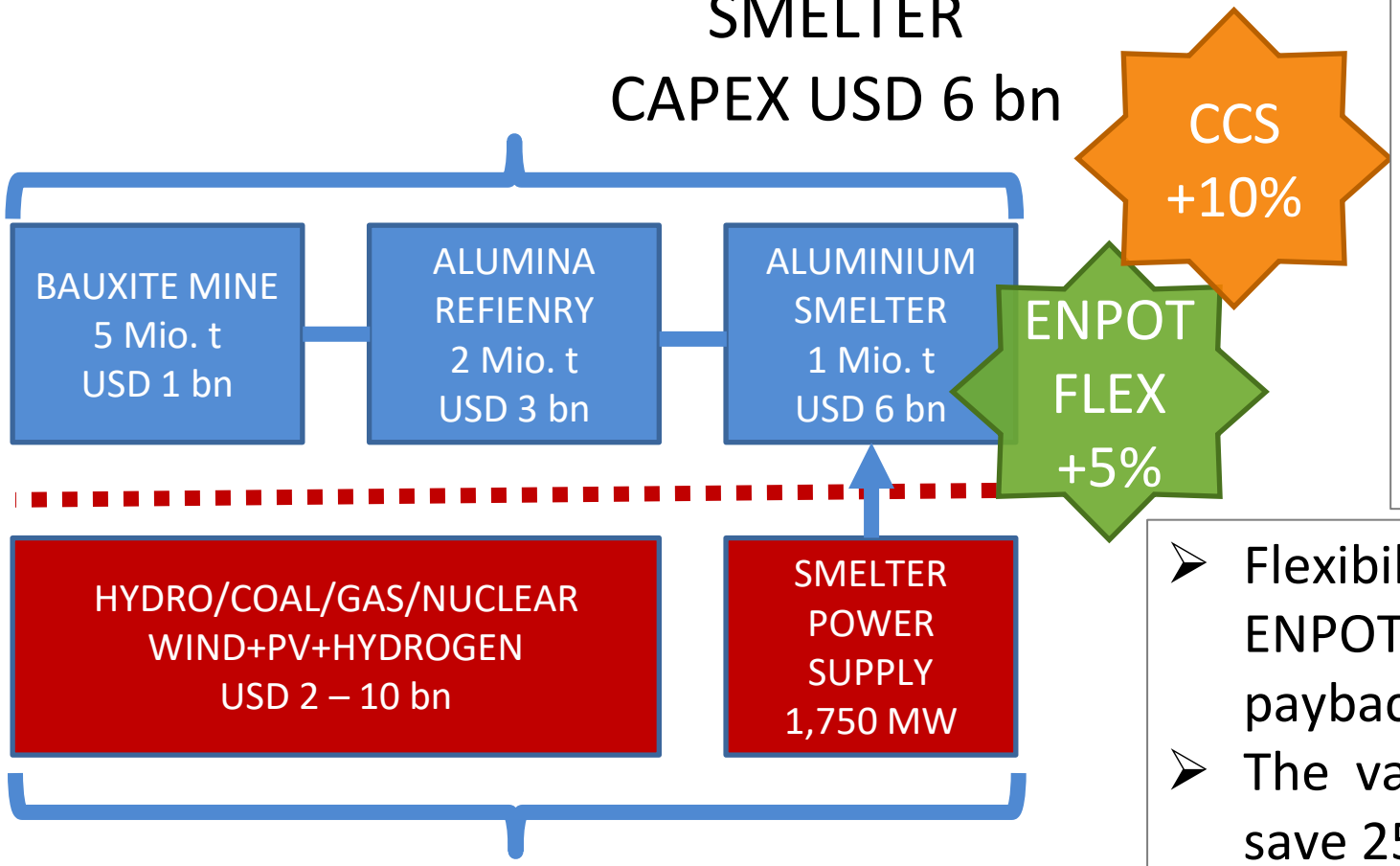
50 $/t CO2

50 $/t CO2

CCS Plant CAPEX → CCS Plant OPEX → CO_2 Transport → CO_2 Storage

Aluminium Production Value Chain CAPEX

1 Million ton Smelter → 15 TWh Electricity



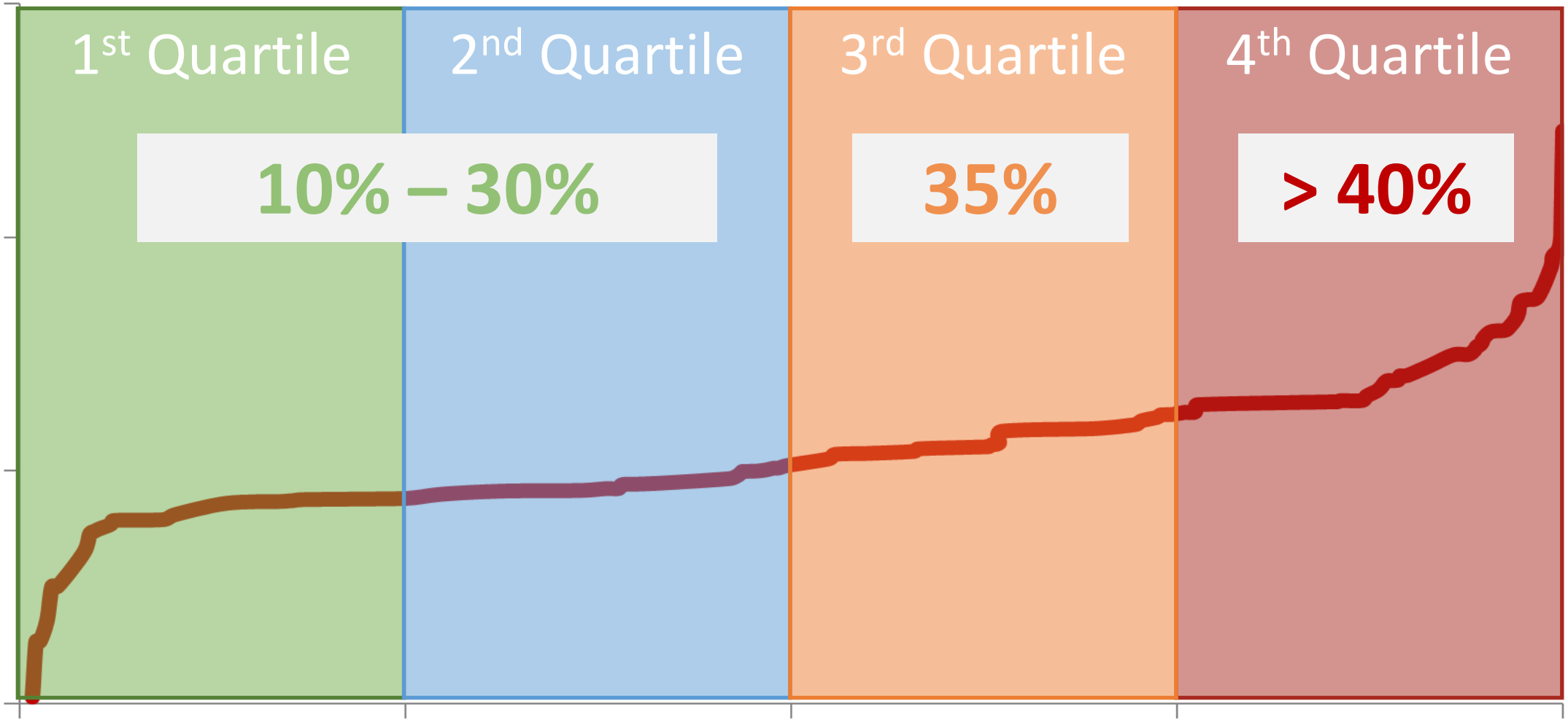
Baseload Renewable Energy Supply
PV/Wind/Battery/Hydrogen USD 9 bn

<u>1 Million Ton Smelter:</u>

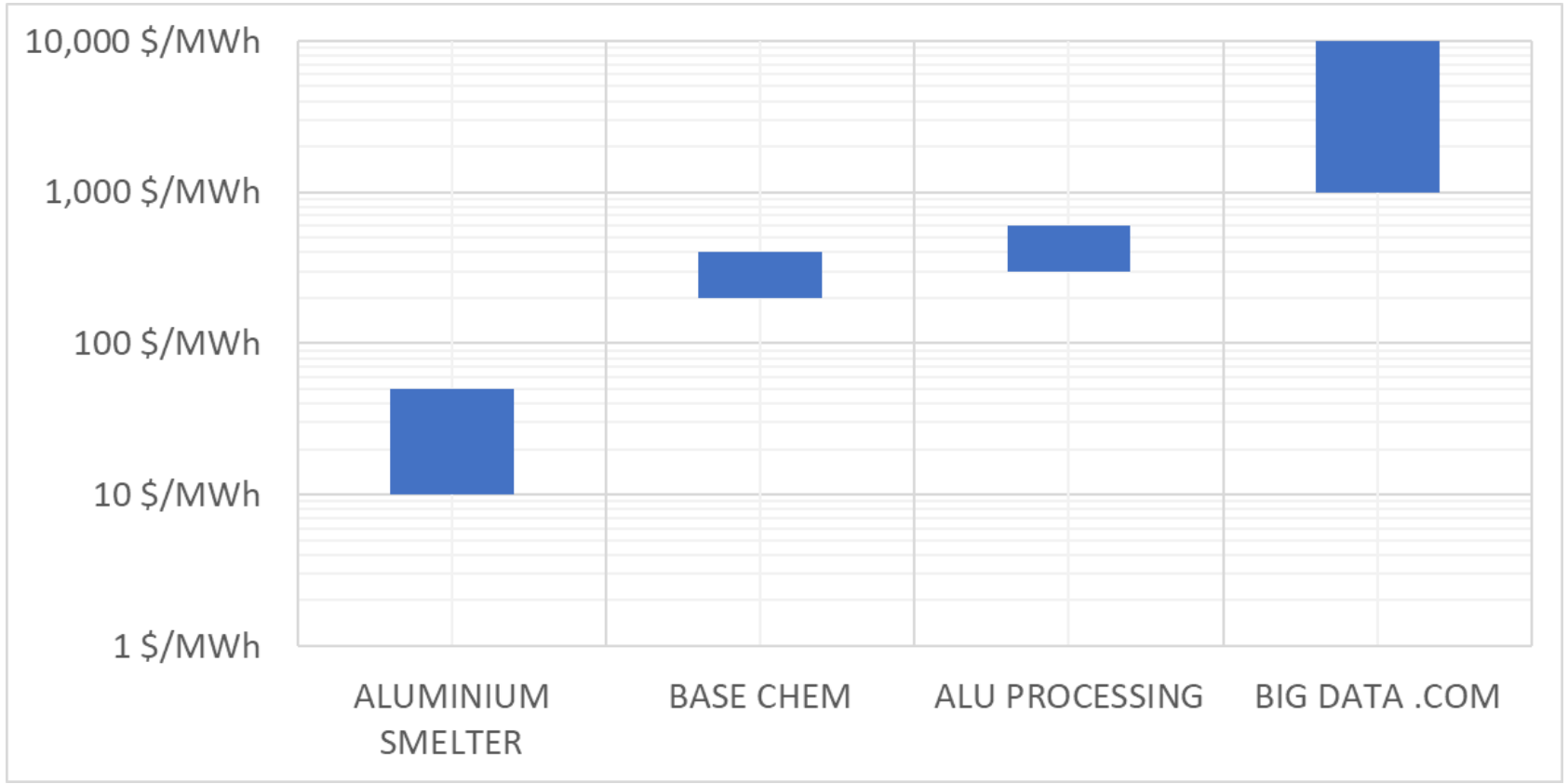
a. USD 6 bn Smelter CAPEX incl. Anode plant and Casthouse
b. plus 5% = USD 0.3 bn for Flexibility Magnetic Compensation, Aux. upgrade
c. plus 10% = USD 0.6 bn for Carbon Capture → Full CO2 capture plant (amine-based) 80-90% capture rate

- Flexibility Services plus Heat for CCS from ENPOT could save 100 – 250 MUSD (creating a payback period of less than three years)
- The value of the captured heat alone would save 25 MUSD per year → already, the heat for 12 years would pay the whole investment.

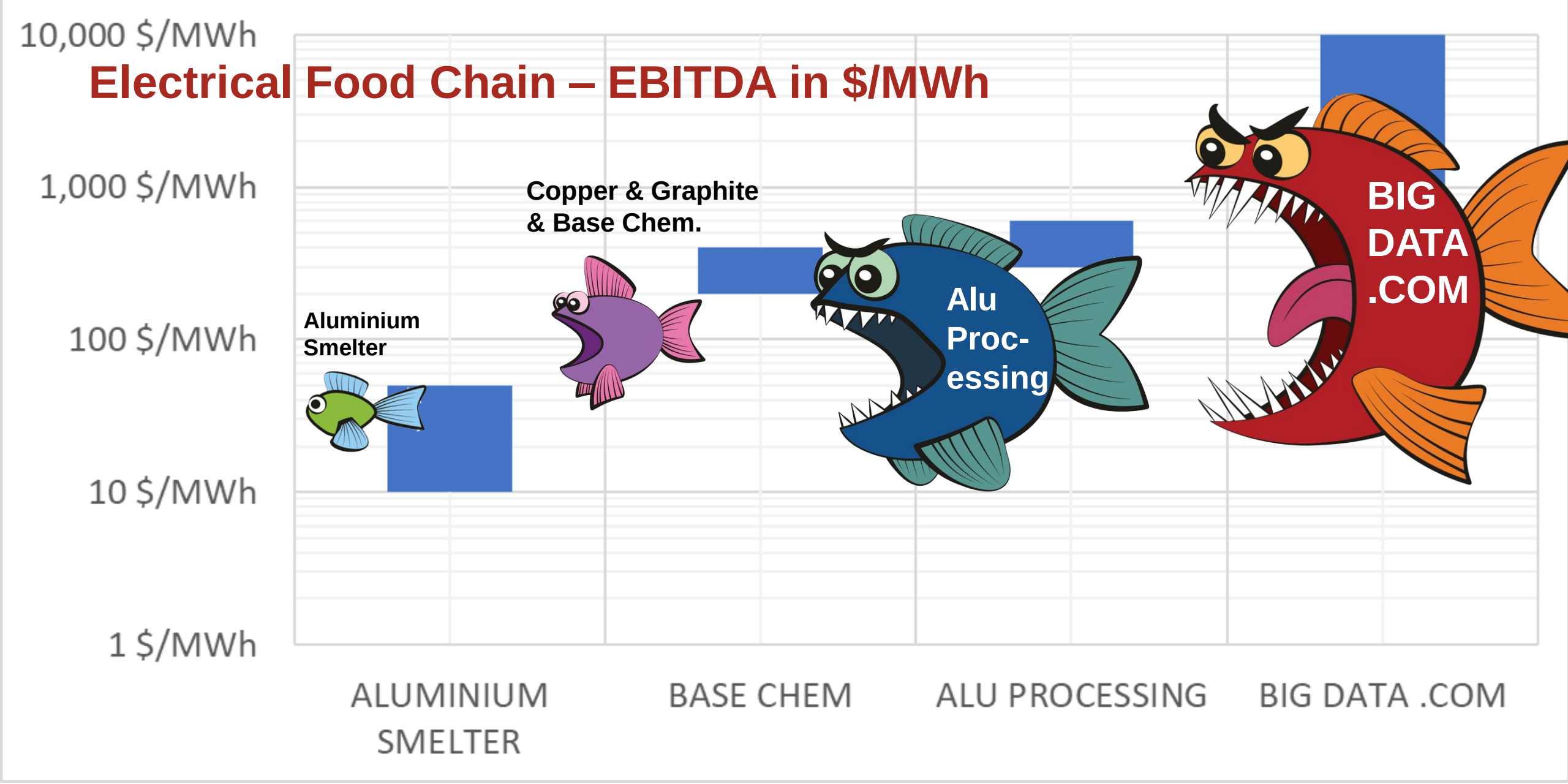
GLOBAL PRIMARY ALUMINUM SMELTING OUTPUT COST



Electrical Food Chain – EBITDA in $/MWh



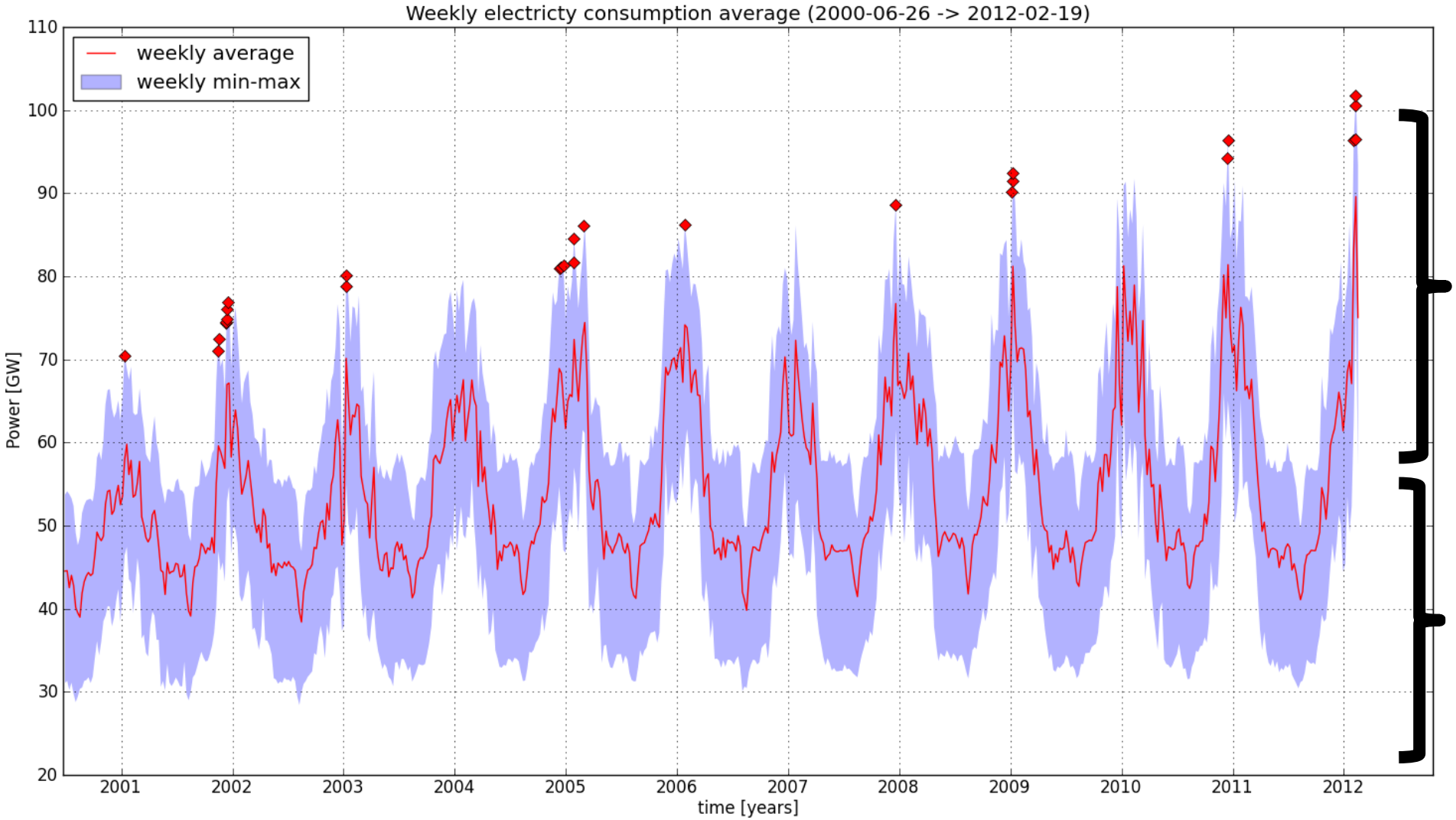
Electrical Food Chain – EBITDA in $/MWh



Transforming Power Grids


LOAD
SHEDDING

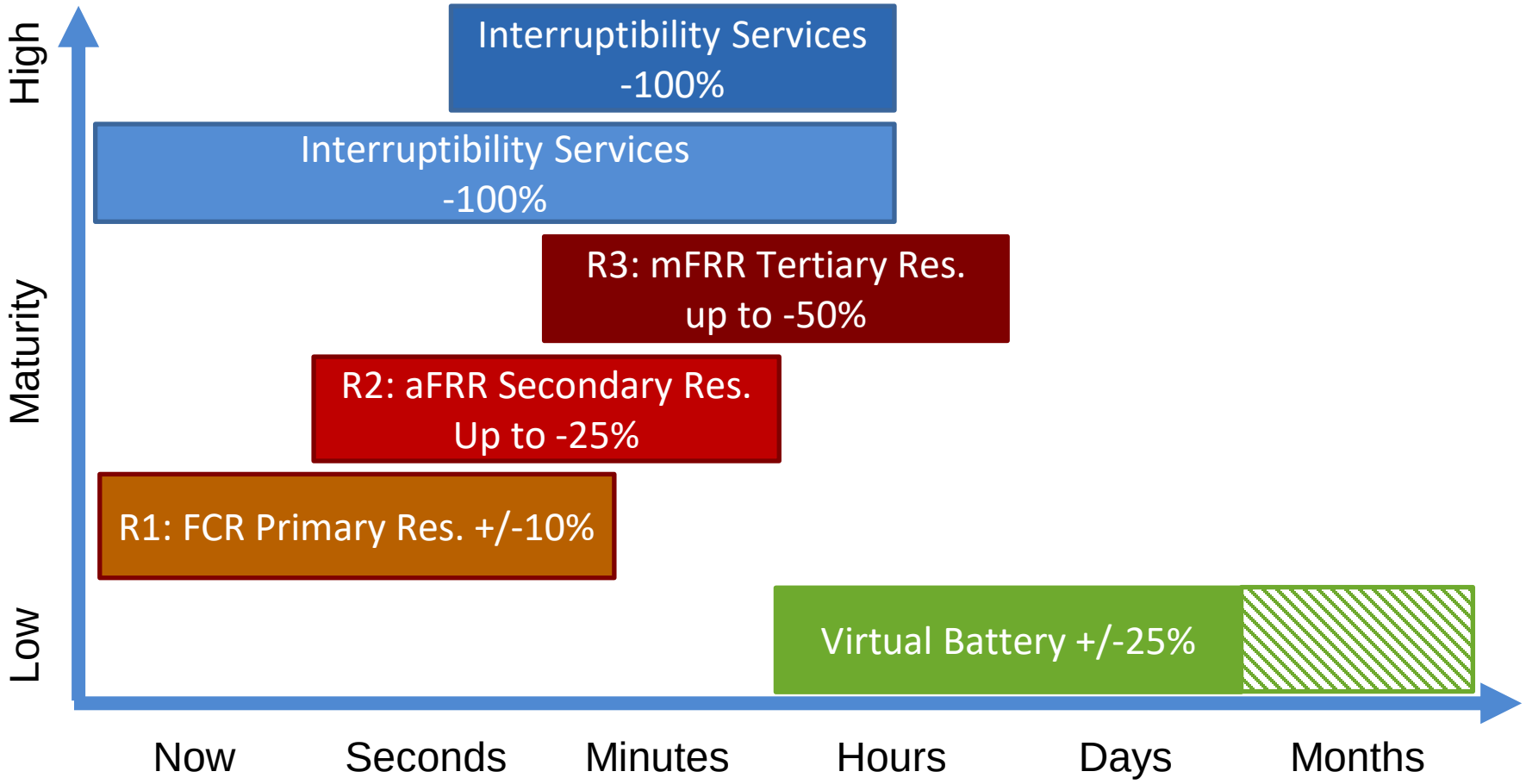
Grid Challenge in France



Winter = 50 MW

Summer = 50 MW

Balancing Services of Aluminium Smelters



FRENCH ALUMINIUM SMELTERS

Interruptibility	230 MW
Primary Reserve	30 MW
Fast Reserve	60 MW

Interruptibility	430 MW
Primary Reserve	20 MW
Fast Reserve	60 MW

Push the Limits…

"If everything seems under control,…

Mario Andretti

Push the Limits…

"If everything seems under control,…

…you're just not going fast enough."

Mario Andretti

Investment Incentives

		EBITDA per t Al	CAPEX per anual ton	Pay Back Period
Aluminium Smelter	LME+MB/MW = 2,500 USD/t	500 $/t Al	6,000 $/t Al	12 years
Carbon Capture	Green Premium = 250 USD/t	100 $/t Al	600 $/t Al	6 years
Flex + Heat	Power Discount 5 USD/MWh_{El} Heat 16 USD/MWh_{th}	100 $/t Al	300 $/t Al	3 years

Conclusion

Conclusion

NEAR ZERO ALUMINIUM is achievable

It requires:

- No Accounting Loopholes and Greenwashing
- Combine Flexibility and Heat Recovery
- Green Premium of 10-20% of LME


My boss told me to have a good day...
So I went home.

THANKS for your ATTENTION