

# Net Zero Investing

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LABORATOIRE DE FINANCE  
DES MARCHÉS DE L'ÉNERGIE

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<sup>1</sup>The opinions expressed in this presentation are those of the authors and are not meant to represent the opinions or official positions of Amundi Asset Management.

# Publications

Two main references:

- 1 Net Zero Investment Portfolios – Part 1. The Comprehensive Integrated Approach, WP-135, 110 pages, October 2022
- 2 Net Zero Investment Portfolios – Part 2. The Core-Satellite Approach, WP-147, 78 pages, October 2023

<https://research-center.amundi.com>

Other references:

- 1 Energy Transitions Commission (2021). Making Clean Electrification Possible: 30 Years to Electrify the Global Economy. Report, April, 108 pages.
- 2 Roncalli, T. (2023). Handbook of Sustainable Finance, SSRN, 4277875, 680 pages, [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=4277875](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4277875).

# How to define a net zero investment policy?

## Net zero portfolios vs. low-carbon portfolios

- Low-carbon portfolio: static approach of decarbonization
- Net-zero portfolio: dynamic approach of decarbonization in order to reach net zero by 2050
- Confusion between net zero and decarbonization?

At least two main differences:

- 1 Net zero implies a self-decarbonization of the portfolios ( $\neq$  sequence of decarbonization rates)
- 2 The transition must be financed ( $\Rightarrow$  greenness of the economy)

**Exogenous** decarbonization pathway  $\Rightarrow$  **endogenous** decarbonization pathway

**Carbon Intensity** + **Green Intensity**

## Rebalancing vs. self-decarbonization

- The decarbonization rate at the beginning of year  $t$  is equal to 30%
- The objective of the NZE policy is to have a decarbonization rate equal to 35% at the beginning of year  $t + 1$

### Bad case

- The effective decarbonization is equal to 25% at the end of year  $t$
- Self-decarbonization = 0% & Rebalancing = -10%

### Mixed case

- The effective decarbonization is equal to 33% at the end of year  $t$
- Self-decarbonization = 3% & Rebalancing = -2%

### Good case

- The effective decarbonization is equal to 36% at the end of year  $t$
- Self-decarbonization = 6% & Rebalancing = 0%

We can always reach a decarbonization pathway by rebalancing the portfolio!

# Decarbonization pathway(s)

Table: Reduction  $\mathcal{R}$  (2020, t)

Year	CTB	PAB	NZE
$\mathcal{R}^-$	30%	50%	IEA
$\Delta\mathcal{R}$	7%	7%	Scenario
2021	30.0%	50.0%	3.1%
2022	34.9%	53.5%	6.2%
2023	39.5%	56.8%	9.4%
2024	43.7%	59.8%	12.5%
<b>2025</b>	<b>47.6%</b>	<b>62.6%</b>	<b>15.6%</b>
2026	51.3%	65.2%	20.5%
2027	54.7%	67.7%	25.4%
2028	57.9%	69.9%	30.3%
2029	60.8%	72.0%	35.2%
<b>2030</b>	<b>63.6%</b>	<b>74.0%</b>	<b>40.1%</b>
2035	74.7%	81.9%	61.8%
2040	82.4%	87.4%	78.4%
2045	87.7%	91.2%	88.0%
2050	91.5%	93.9%	94.6%

## What are the issues?

- We have to compare apples with apples  $\Rightarrow$  emissions vs. intensity
- Transition policy sequencing:
  - 1 Decarbonization and then financing?
  - 2 Financing and then decarbonization?
- Decarbonization policy sequencing:
  - 1 Utilities & Energy (85% before 2035)
  - 2 Materials (70% before 2035)
  - 3 Buildings (60% before 2035)
  - 4 Transport (55% after 2035)
  - 5 Industrials (60% after 2035)

# Decarbonization pathway(s)

Figure: IEA, AO, CTB and PAB pathways

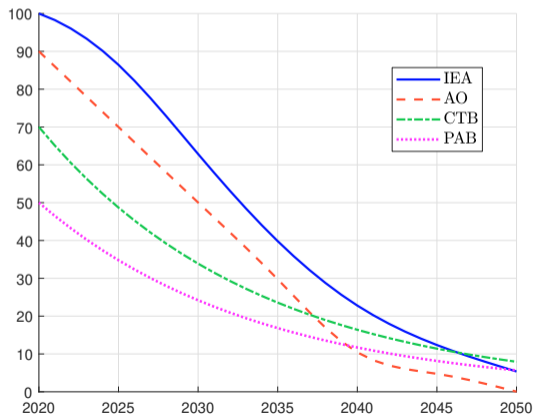
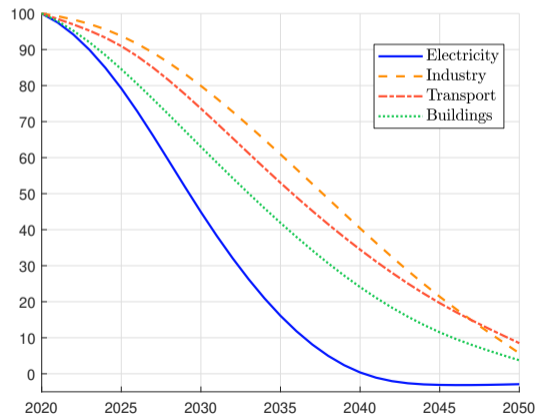


Figure: Sectoral decarbonization pathways



# The financial cost of climate change

## The Net Zero Transition: What it would Cost, What it could Bring

- McKinsey' Report (2022)
- Capital requirements under the NGFS Net Zero 2050 scenario: \$275 trillion in cumulative spending on physical assets over the next 30 years
- This represents approximately \$9.2 trillion per year between 2021 and 2050

*"[...] The transition to net-zero greenhouse emissions by 2050 will require an extra \$3.5 trillion a year in capital spending on physical assets for energy and land-use systems"*

That amount is the equivalent of:

- 1/2 of global corporate profits,
- 1/4 of total tax revenue,
- 7% of household spending in 2020,
- 4.1% of the world GDP

# Two approaches

## Integrated approach

- Equity and bond mutual funds
- ETFs
- Indexes

## Core-satellite approach

- Multi-asset portfolios
- Thematic investment
- Strategic asset allocation



# The integrated approach

⇒ Extension of portfolio decarbonization by considering self-decarbonization and transition issues

# What are the issues?

## 1 Measurement definition

- Scope 3 vs. scopes 1 + 2  $\Rightarrow$  closed system
- Location-based vs market-based scope 2 emissions  $\Rightarrow$  **Carbon emissions may be negative!**
- Forward-looking vs. current values

## 2 Data gaps

- Noisy data & manual/human errors
- Scope 3 emissions (15 categories)
- Transition metrics: green revenues, green opex, green capex, green R&D

# Static measure of carbon footprint

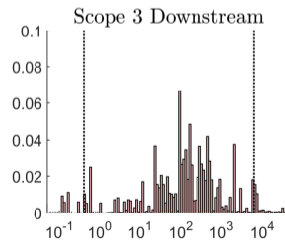
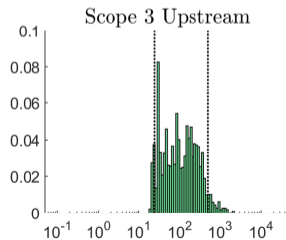
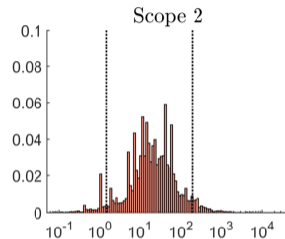
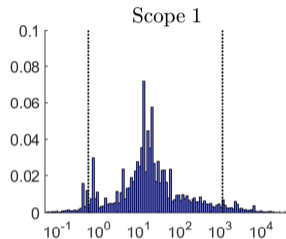
The GHG Protocol corporate standard classifies a company's greenhouse gas emissions in three scopes<sup>2</sup>:

- **Scope 1:** Direct GHG emissions (○)
- **Scope 2:** Consumption of purchased energy (○○)
- **Scope 3:** Other indirect GHG emissions (●●)
  - **Scope 3 upstream:** emissions associated to the supply side
    - 1 First tier direct (●)
    - 2 Tier 2 and 3 suppliers (●●)
  - **Scope 3 downstream:** emissions associated with the product sold by the entity
    - 1 Use of the product (●●●)
    - 2 Waste disposal & recycling (●●●●)

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<sup>2</sup>Measurement robustness: from ○○○○ (very high) to ●●●● (very low)

# Carbon intensity distribution by scope



# Importance of the value chain

Table: Examples of 2019 carbon emissions and intensity

Company	Emission (in tCO <sub>2</sub> e)				Revenue (in \$ mn)	Intensity (in tCO <sub>2</sub> e/\$ mn)			
	SC <sub>1</sub>	SC <sub>2</sub>	SC <sub>3</sub> <sup>up</sup>	SC <sub>3</sub> <sup>down</sup>		SC <sub>1</sub>	SC <sub>2</sub>	SC <sub>3</sub> <sup>up</sup>	SC <sub>3</sub> <sup>down</sup>
Amazon	5760000	5500000	20054722	10438551	280522	20.5	19.6	71.5	37.2
Apple	50549	862127	27624282	5470771	260174	0.2	3.3	106.2	21.0
BNP Paribas	64829	280789	1923307	1884	78244	0.8	3.6	24.6	0.0
BP	49199999	5200000	103840194	582639687	276850	177.7	18.8	375.1	2104.5
Caterpillar	905000	926000	15197607	401993744	53800	16.8	17.2	282.5	7472.0
Danone	722122	944877	28969780	4464773	28308	25.5	33.4	1023.4	157.7
Exxon	111000000	9000000	107282831	594131943	255583	434.3	35.2	419.8	2324.6
JPMorgan Chase	81655	692299	3101582	15448469	115627	0.7	6.0	26.8	133.6
LVMH	67613	262609	11853749	942520	60083	1.1	4.4	197.3	15.7
Microsoft	113414	3556553	5977488	4003770	125843	0.9	28.3	47.5	31.8
Nestle	3291303	3206495	61262078	33900606	93153	35.3	34.4	657.6	363.9
Pfizer	734638	762840	4667225	133468	51750	14.2	14.7	90.2	2.6
Samsung Electronics	5067000	10998000	33554245	60978947	197733	25.6	55.6	169.7	308.4
Volkswagen	4494066	5973894	65335372	354913446	282817	15.9	21.1	231.0	1254.9
Walmart	6101641	13057352	40651079	32346229	514405	11.9	25.4	79.0	62.9

Source: Trucost (2022) & Authors' calculations.

## On the difficulty of estimating emissions from scope 3 activities

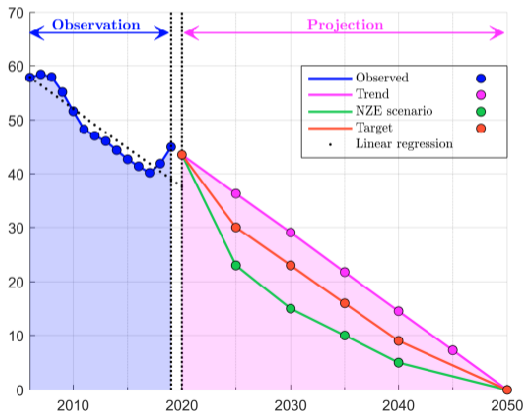
- S&P500: 53 companies have reported Scope 3 in 2022, 11 companies in 2021
- Scope 3 upstream emissions vs. Scope 3 downstream emissions
- Estimated vs. reported emissions

### All upstream Scope 3 emissions in commercial databases are estimated using input-output analysis

- 1 Purchased goods and services
- 2 Capital goods
- 3 Fuel and energy related activities
- 4 Upstream transportation and distribution
- 5 Waste generated in operations
- 6 Business travel
- 7 Employee commuting
- 8 Upstream leased assets

# Measuring self-decarbonization with carbon momentum

Figure: Illustration of the  $\mathcal{PAC}$  framework



- We assume a linear constant trend model:

$$CE(t) = \beta_0 + \beta_1 \cdot t + u(t)$$

- The carbon momentum is the ratio between the slope and the current carbon emissions:

$$CM(t) = \frac{\hat{\beta}_1(t)}{CE(t)}$$

# Measuring self-decarbonization with carbon momentum

**Table:** Statistics (in %) of carbon momentum  $\mathcal{CM}(t)$ , whole Trucost database

Statistics	Carbon emissions			Carbon intensity		
	$SC_1$	$SC_{1-2}$	$SC_{1-3}^{up}$	$SC_1$	$SC_{1-2}$	$SC_{1-3}^{up}$
Median	<b>1.7</b>	<b>2.6</b>	<b>2.6</b>	<b>-2.3</b>	<b>-1.7</b>	<b>-1.6</b>
Negative	43.3	37.7	34.9	69.5	66.6	72.0
Positive	56.7	62.3	65.1	30.5	33.4	28.0
< -10%	22.7	17.5	13.3	21.1	14.4	6.5
< -5%	30.0	24.4	19.9	31.5	22.1	13.3
> +5%	34.5	37.6	35.6	11.6	13.2	7.5
> +10%	<b>17.1</b>	<b>17.6</b>	<b>15.0</b>	<b>5.8</b>	<b>6.5</b>	<b>3.3</b>

**Sequential decarbonization**  
 (portfolio rebalancing)

versus

**Self-decarbonization**

Source: Trucost (2022) & Authors' calculations.



## Static measures of greenness

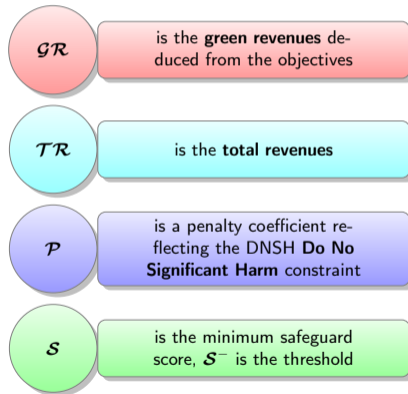
- 3-step approach of the EU taxonomy for defining the green intensity:

$$GI = \frac{GR}{TR} \cdot (1 - P) \cdot \mathbb{1}\{S \geq S^-\}$$

- The first term is a proxy of the turnover KPI and corresponds to the green revenue share:

$$GRS = \frac{GR}{TR}$$

By construction, we have  $0 \leq GRS \leq 1$



# Dynamic measures of greenness

## Green intensity trend

$$GI(t) = \gamma_0 + \gamma_1 \cdot t + v(t)$$

- $\hat{\gamma}_1$  is a dynamic measure of greenness
- no deep history

## Green CAPEX

- Early indicator
- Data availability : very weak
- Mandatory to disclose under the EU taxonomy
- Does not necessarily result in innovation

## Low carbon patent

- Lagging indicator
- Data availability : good
- A company may decide not to file a patent and still benefit from its innovation

# Portfolio decarbonization problem

The goal is to minimize the tracking error variance **under a decarbonization constraint**:

$$\begin{aligned} x^* &= \arg \min \frac{1}{2} (x - b)^\top \Sigma (x - b) \\ \text{s.t.} \quad &\begin{cases} \mathcal{CI}(x) \leq (1 - \mathcal{R}) \cdot \mathcal{CI}(b) & \longleftarrow \text{Decarbonization (static)} \\ x \in \Omega_1 \cap \Omega_2 & \longleftarrow \text{Portfolio constraints (diversification, liquidity, etc.)} \end{cases} \end{aligned}$$

where  $\Sigma$  is the covariance matrix,  $b$  is the benchmark,  $\mathcal{R}$  is the reduction rate,  $\mathcal{CI}(b)$  is the carbon intensity of the benchmark  $b$  and  $\mathcal{CI}(x)$  is the carbon intensity of the portfolio  $x$

# Portfolio decarbonization (equity portfolios)

Table: Sector allocation in % (MSCI World, Jun. 2022,  $\mathcal{C}_0$ , scope  $\mathcal{SC}_{1-3}$ )

Sector	Index	Reduction rate $\mathcal{R}$						
		30%	40%	50%	60%	70%	80%	90%
Communication Services	7.58	7.95	8.15	8.42	8.78	9.34	10.13	12.27
Consumer Discretionary	10.56	10.69	10.69	10.65	10.52	10.23	9.62	6.74
Consumer Staples	7.80	7.80	7.69	7.48	7.11	6.35	5.03	1.77
<b>Energy</b>	<b>4.99</b>	4.14	3.65	3.10	2.45	<b>1.50</b>	<b>0.49</b>	<b>0.00</b>
<b>Financials</b>	<b>13.56</b>	14.53	15.17	15.94	16.90	<b>18.39</b>	<b>20.55</b>	<b>28.62</b>
Health Care	14.15	14.74	15.09	15.50	16.00	16.78	17.77	17.69
Industrials	9.90	9.28	9.01	8.71	8.36	7.79	7.21	6.03
Information Technology	21.08	21.68	22.03	22.39	22.88	23.51	24.12	24.02
<b>Materials</b>	<b>4.28</b>	3.78	3.46	3.06	2.56	<b>1.85</b>	<b>1.14</b>	<b>0.24</b>
Real Estate	2.90	3.12	3.27	3.41	3.57	3.72	3.71	2.51
<b>Utilities</b>	<b>3.21</b>	2.28	1.79	1.36	0.90	<b>0.54</b>	<b>0.24</b>	<b>0.12</b>

Source: MSCI (2022), Trucost (2022) & Barahhou *et al.* (2022).

Strategy **long on Financials** and **short on Energy, Materials and Utilities**

# Portfolio decarbonization (bond portfolios)

Table: Sector allocation deviation in % (Global Corp., Jun. 2022, scope  $\mathcal{SC}_{1-3}$ )

Sector	Index	Reduction rate $\mathcal{R}$						
		30%	40%	50%	60%	70%	80%	90%
Communication Services	7.34	0.01	0.00	0.03	0.09	0.09	-0.03	-0.04
Consumer Discretionary	5.97	0.00	-0.01	-0.03	-0.04	-0.51	-1.49	-2.42
Consumer Staples	6.04	0.00	0.00	0.00	0.00	-0.02	-0.65	-1.98
<b>Energy</b>	6.49	<b>-1.00</b>	<b>-2.07</b>	<b>-2.65</b>	<b>-2.80</b>	<b>-3.26</b>	<b>-3.91</b>	<b>-3.97</b>
<b>Financials</b>	<b>33.91</b>	<b>0.73</b>	<b>1.75</b>	<b>2.05</b>	<b>2.18</b>	<b>3.45</b>	<b>4.95</b>	<b>5.09</b>
Health Care	7.50	0.00	0.00	0.00	0.00	0.00	0.02	-0.02
<b>Industrials</b>	8.92	<b>0.46</b>	<b>0.70</b>	<b>1.27</b>	<b>2.42</b>	<b>3.15</b>	<b>4.63</b>	<b>9.21</b>
Information Technology	5.57	0.00	0.02	0.02	0.03	0.03	-0.05	-0.30
<b>Materials</b>	3.44	<b>-0.01</b>	<b>-0.13</b>	<b>-0.26</b>	<b>-0.32</b>	<b>-0.80</b>	<b>-1.19</b>	<b>-1.58</b>
Real Estate	4.76	-0.02	-0.02	-0.02	-0.02	-0.10	-0.15	-0.83
<b>Utilities</b>	10.06	<b>-0.17</b>	<b>-0.24</b>	<b>-0.42</b>	<b>-1.54</b>	<b>-2.02</b>	<b>-2.14</b>	<b>-3.18</b>

Source: ICE (2022), Trucost (2022) & Barahhou *et al.* (2022).

Strategy **long on Financials and Industrials** and **short on Energy, Materials and Utilities**

# Portfolio decarbonization (equity portfolios)

Table: Green intensity in % (MSCI World, Jun. 2022, €<sub>0</sub>)

	Scope	Index	Reduction rate $\mathcal{R}$						
			30%	40%	50%	60%	70%	80%	90%
<i>GI</i>	$SC_1$	5.24	5.21	5.19	5.18	5.16	5.12	5.08	<b>5.01</b>
	$SC_{1-2}$		5.17	5.14	5.09	4.99	4.83	4.64	<b>4.52</b>
	$SC_{1-3}^{up}$		5.15	5.07	4.89	4.69	4.42	3.90	<b>0.68</b>
	$SC_{1-3}$		5.17	5.12	5.05	4.97	4.80	4.55	<b>3.73</b>

Source: MSCI (2022), Trucost (2022) & Barahhou *et al.* (2022).

Positive correlation between **carbon intensity** and **green intensity**?

# Net Zero optimization problem

The goal is to minimize the tracking error variance **under net zero constraints**:

$$x^*(t) = \arg \min \frac{1}{2} (x - b)^\top \Sigma(t) (x - b)$$

s.t.  $\begin{cases} \mathcal{CI}(t, x) \leq (1 - \mathcal{R}(t_0, t)) \cdot \mathcal{CI}(t_0, b(t_0)) & \leftarrow \text{Decarbonization (dynamic)} \\ x \in \Omega_{\mathcal{T} \text{ transition}}(t) & \leftarrow \text{Transition (NZE)} \\ x \in \Omega_1 \cap \Omega_2(t) \end{cases}$

The transition constraints can encompass:

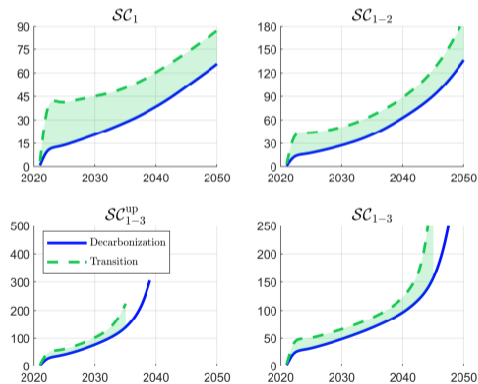
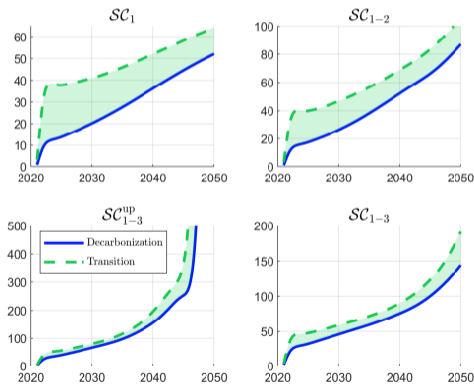
- 1 a **self-decarbonization** maximum threshold:  $\{x : \mathcal{CM}(t, x) \leq \mathcal{CM}^*\}$
- 2 a **greenness** minimum threshold :  $\{x : \mathcal{GI}(t, x) \geq (1 + \mathcal{G}) \cdot \mathcal{GI}(t, b(t))\}$
- 3 an **exclusion** constraint:  $\{\mathcal{CM}_i(t) \geq \mathcal{CM}^+ \Rightarrow x_i = 0\}$

# Net Zero optimization problem

Tracking error volatility of net zero portfolios (MSCI World, Jun. 2022,  $\mathcal{G} = 100\%$ ,  $\mathcal{CM}^* = -5\%$ , PAB)

Figure:  $\mathcal{C}_0$  constraint

Figure:  $\mathcal{C}_3(0,10,2)$  constraint



Source: MSCI (2022), Trucost (2022) & Authors' calculations.

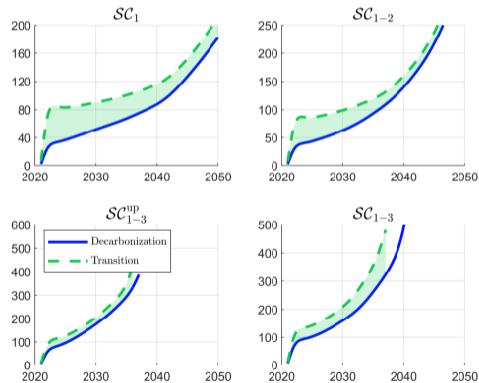
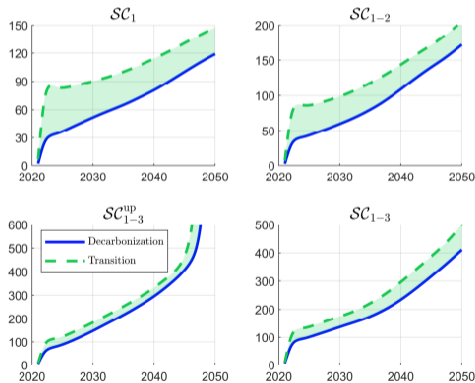


# Net Zero optimization problem

Tracking error volatility of net zero portfolios (MSCI EMU, Jun. 2022,  $\mathcal{G} = 100\%$ ,  $\mathcal{CM}^* = -5\%$ , PAB)

Figure:  $\mathcal{C}_0$  constraint

Figure:  $\mathcal{C}_3(0,10,2)$  constraint



Source: MSCI (2022), Trucost (2022) & Authors' calculations.

# Net Zero optimization problem

Tracking error volatility of net zero portfolios (MSCI USA, Jun. 2022,  $\mathcal{G} = 100\%$ ,  $\mathcal{CM}^* = -5\%$ , PAB)

Figure:  $\mathcal{C}_0$  constraint

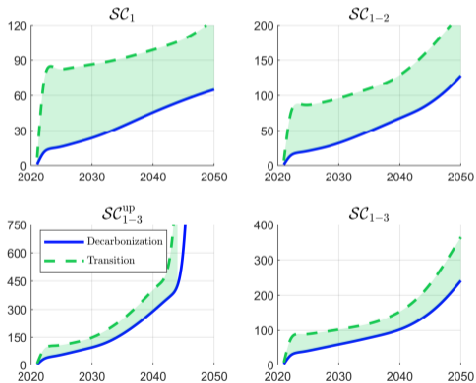
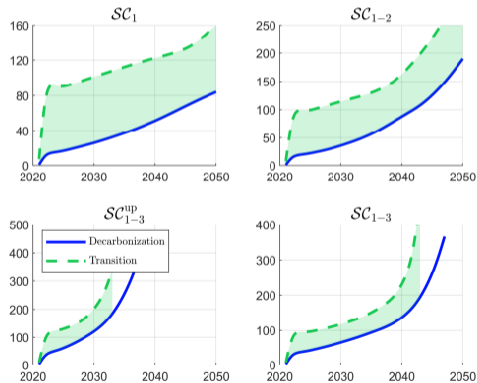


Figure:  $\mathcal{C}_3(0,10,2)$  constraint



Source: MSCI (2022), Trucost (2022) & Authors' calculations.

## What about other costs?

The tracking risk seems manageable. However, net zero alignment bears two hidden risks :

- 1 **Diversification cost**: due to sectoral concentration
- 2 **Liquidity cost**: companies providing solution to tackle the climate change are often pure players (small cap stocks)

# Investment universe shrinkage

MSCI World, Jun. 2022,  $\mathcal{C}_3(0, 10, 2)$  constraint,  $\mathcal{G} = 100\%$ ,  $\mathcal{CM}^* = -5\%$ , scope  $\mathcal{SC}_{1-3}$

Figure: Net zero policy

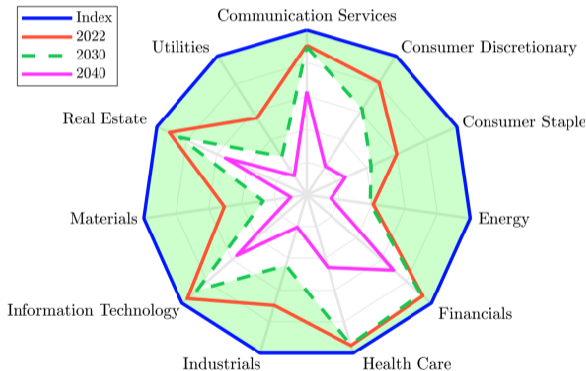
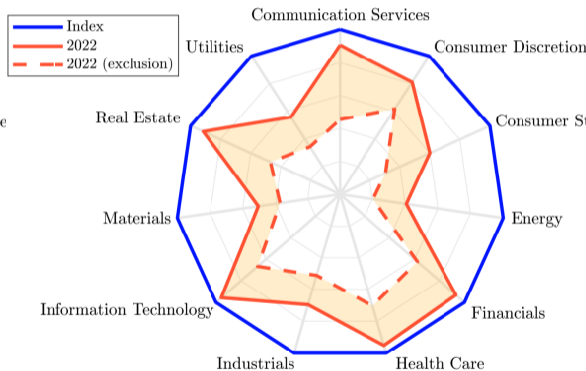


Figure: Momentum exclusion  $\mathcal{CM}^+ = 0\%$

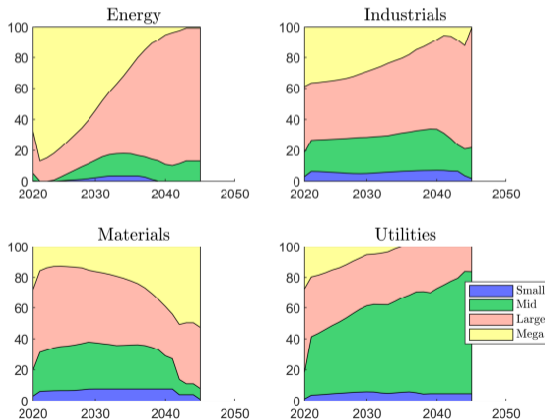


Source: MSCI (2022), Trucost (2022) & Authors' calculations.

# Liquidty risk

MSCI World, Jun. 2022,  $\mathcal{C}_3(0,10,2)$ ,  $\mathcal{G} = 100\%$ ,  $\mathcal{CM}^* = -5\%$ , PAB, scope  $\mathcal{SC}_{1-3}$

Figure: Breakdown of net zero allocation with respect to the market capitalization



# The core-satellite approach

Two building blocks of NZE portfolios

## Decarbonized portfolio

- Carbon intensity
- Decarbonization pathway(s)
- Top-down approach
- Portfolio construction
- Net zero **carbon** metrics

+

## Transition portfolio

- Green intensity
- Financing the transition
- Bottom-up approach
- Security selection
- Net zero **transition** metrics

$$1 - \alpha(t)\%$$

$$\alpha(t)\%$$

# The core portfolio

## Optimization problem (core equity portfolio)

The objective function is to minimize the tracking error variance:

$$\begin{aligned} x(t) &= \arg \min \frac{1}{2} (x - b)^\top \Sigma (x - b) \\ \text{s.t.} &\begin{cases} \mathbf{1}_n^\top x = 1 \\ \mathbf{CI}(t)^\top x \leq (1 - \mathcal{R}(t_0, t)) \mathbf{CI}(t_0, b, \mathcal{F}_{t_0}) \\ \mathbf{0}_n \leq x \leq \mathbf{1}_n \end{cases} \end{aligned}$$

- Problem  $\mathcal{P}_1$ : optimization with  $\mathcal{C}_0$  constraint;
- Problem  $\mathcal{P}_2$ : optimization with  $\mathcal{C}_3(0, 10, 2)$  constraint,  $\mathbf{CM}^* = -3.5\%$ ,  $\mathbf{CM}^+ = 10\%$ ;
- Problem  $\mathcal{P}_3$ : optimization with  $\mathcal{C}_3(0, 10, 2)$  constraint,  $\mathbf{CM}^* = -3.5\%$ ,  $\mathbf{CM}^+ = 10\% +$  IEA NZE scenario for the electricity sector

# The core portfolio

## Optimization problem (core bond portfolio)

The objective function is to minimize the active risk:

$$\mathcal{R}(x | b) = \underbrace{\varphi \sum_{s=1}^{n_{Sector}} \left| \sum_{i \in s} (x_i - b_i) \cdot DTS_i \right|}_{\text{DTS component}} + \underbrace{\frac{1}{2} \sum_{i \in b} |x_i - b_i|}_{\text{AS component}} + \underbrace{\mathbb{1}_{\Omega_{MD}}(x)}_{\text{MD component}}$$

where  $DTS_i$  and  $MD_i$  are the duration-times-spread and modified duration factors,  $\Omega_{MD} = \{x : \sum_{i=1}^n (x_i - b_i) \cdot MD_i = 0\}$  and  $\mathbb{1}_{\Omega}(x)$  is the convex indicator function

- Problem  $\mathcal{P}_1$ : optimization with  $\mathcal{C}_0$  constraint;
- Problem  $\mathcal{P}_2$ : optimization with  $\mathcal{C}_0$  constraint,  $\mathcal{CM}^* = -3.5\%$ ,  $\mathcal{CM}^+ = 10\%$ ;
- Problem  $\mathcal{P}_3$ : optimization with  $\mathcal{C}_0$  constraint,  $\mathcal{CM}^* = -3.5\%$ ,  $\mathcal{CM}^+ = 10\% + \text{IEA NZE scenario for the electricity sector}$



# The core portfolio

Without the IEA NZE scenario for the electricity sector (Problem  $\mathcal{P}_2$ )

Figure: Decarbonization pathway of the electricity sector (MSCI World, Dec. 2021)

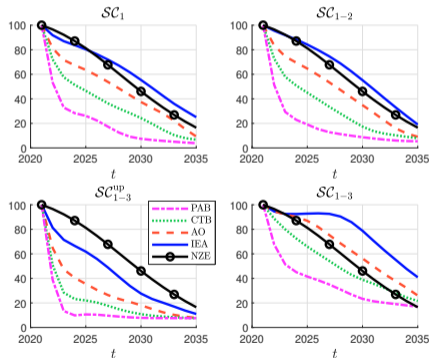
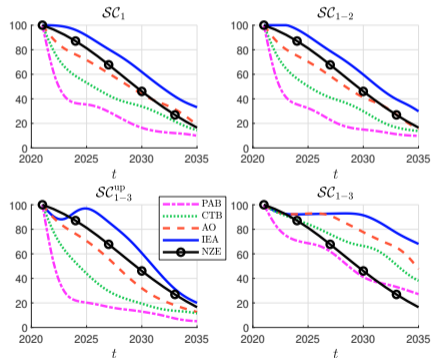


Figure: Decarbonization pathway of the electricity sector (Global Corporate, Dec. 2021)



Source: MSCI (2023), Trucost (2023), Bloomberg (2023) & Ben Slimane *et al.* (2023).

# Implications for strategic asset allocation

Figure: Implied risk premium  $\Delta\tilde{\pi}_j$  in bps of the Utilities sector (MSCI World, Dec. 2021, Scope  $SC_{1-2}$ )

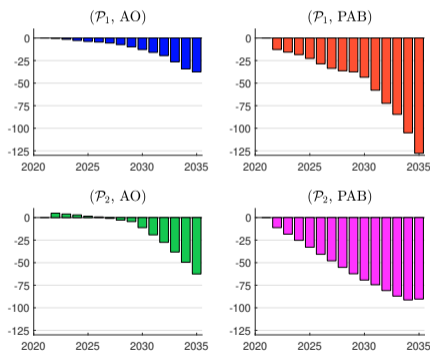
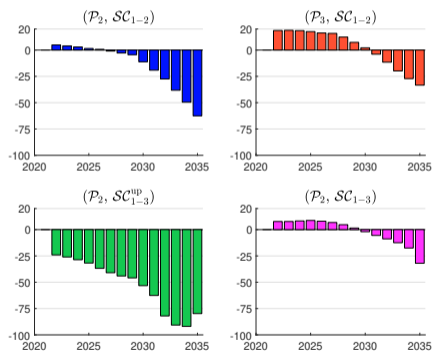


Figure: Implied risk premium  $\Delta\tilde{\pi}_j$  in bps of the Utilities sector (MSCI World, Dec. 2021, AO pathway)



Source: Ben Slimane *et al.* (2023).

# How to achieve net zero emissions

The main transformation involves the power sector in two directions:

- 1 Massive electrification of the world economy
- 2 Greening electricity to achieve clean power generation

**Table:** The 2050 net zero scenarios

	2020		2050		
Production	Energy Intensity	Carbon Emissions	Production	Energy Intensity	Carbon Emissions
30000 TWh	<b>500</b> g/kWh	<b>15</b> GtCO <sub>2</sub> e	100000 TWh	<b>20</b> g/kWh	<b>2</b> GtCO <sub>2</sub> e

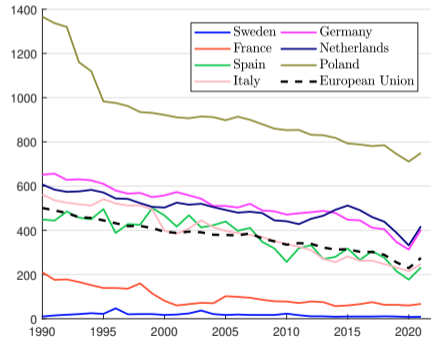
# How to achieve net zero emissions

**Table:** Emission factor in gCO<sub>2</sub>e/kWh of electricity generation in the world

Region	EF	Country	EF	Country	EF	Country	EF
Africa	484	Australia	531	Germany	354	Portugal	183
Asia	539	Canada	128	India	637	Russia	360
Europe	280	China	544	Iran	492	Spain	169
North America	352	Costa Rica	33	Italy	226	Switzerland	47
South America	204	Cuba	575	Japan	479	United Kingdom	270
World	442	France	58	Norway	26	United States	380

Source: Roncalli (2023).

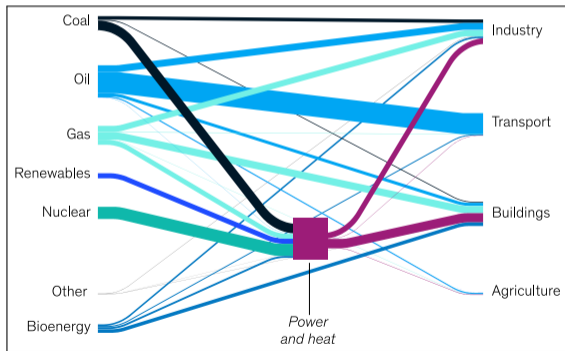
**Figure:** Emission factor in gCO<sub>2</sub>e/kWh of electricity generation (European Union, 1990 – 2022)



Source: Roncalli (2023).

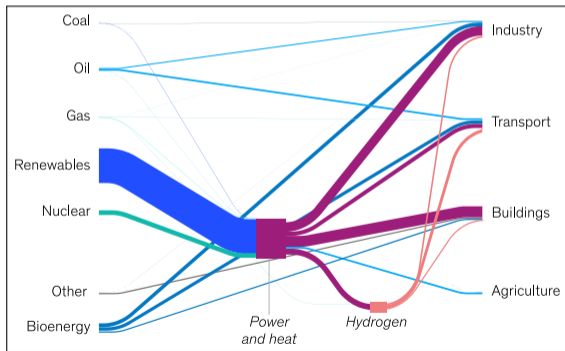
# Transforming the global value chain into a net zero economy

Figure: 2017



Source: McKinsey (2023, Exhibit 6B, page 12).

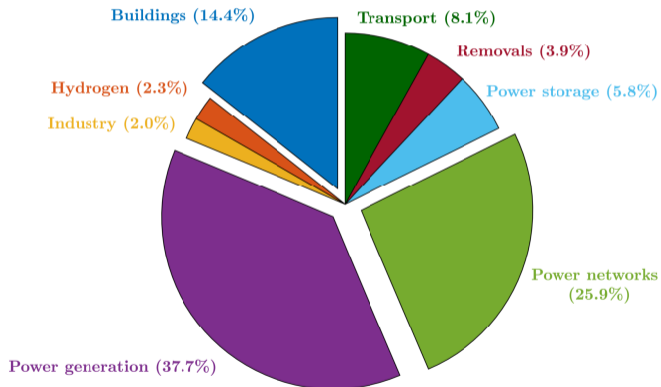
Figure: 2050



Source: McKinsey (2023, Exhibit 6B, page 12).

# Funding requirements

Figure: Net zero capital investments



Source: Energy Transitions Commission (2023a, page 6) & Authors' calculations.

# Narrow definition of the satellite investment portfolio

Figure: Narrow specification of the satellite investment universe

Sector	Industry Group	Industry	Sub-industry	Satellite
10				
15				
20				
25				
30				
35				
40				
45				
50				
55				
60				

## Other net zero issues

- Materials and critical minerals, e.g. rare earths (⇒ geopolitical issues)
- Who will finance the transition? (⇒ debt sustainability issues)
- How to track net zero progress? (⇒ monitoring issues)



## Investment universe

- Green, sustainability and sustainability-linked bonds
- Green stocks
- Green infrastructure
- Sustainable real estate

# Investment universe

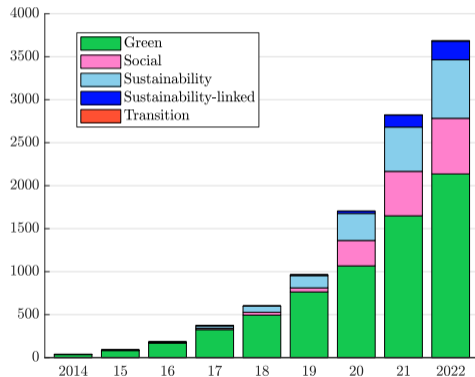
## Green bonds

Table: GSS+ bond issuance

Year	GB		SB		SuB		SLB	
	#	\$ bn	#	\$ bn	#	\$ bn	#	\$ bn
2022	1784	531.6	542	152.8	614	174.8	382	144.3
2021	1971	686.1	554	242.1	646	233.2	343	161.5
2020	1076	291.2	273	172.0	308	154.8	47	16.5
2019	877	268.0	99	22.2	333	85.2	18	8.9
2018	582	165.3	48	16.5	52	22.1	1	2.2
2017	472	160.9	46	11.8	17	9.2	1	0.2
2016	285	99.7	14	2.2	16	6.6	0	0.0

Source: Bloomberg, GSS+ Instrument Indicator

Figure: Outstanding of GSS+ debt (in \$ bn)



<https://www.climatebonds.net/market/data>

# Investment universe

## Green bonds

Table: What the GSS+ bond market does and does not finance

Sector	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	4
Power generation	1310	37.7%	207	6.0%	1103	31.7%	<b>15.8%</b>
Power networks	900	25.9%	135	3.9%	765	22.0%	<b>15.0%</b>
Power storage	200	5.8%	27	0.8%	173	5.0%	<b>13.5%</b>
Buildings	500	14.4%	225	6.5%	275	7.9%	45.0%
Transport	280	8.1%	180	5.2%	100	2.9%	<b>64.3%</b>
Removals	135	3.9%	90	2.6%	45	1.3%	<b>66.7%</b>
Hydrogen	80	2.3%	9	0.3%	71	2.0%	<b>11.3%</b>
Industry	70	2.0%	27	0.8%	43	1.2%	38.6%
Total	3475	100.0%	900	25.9%	2575	74.1%	25.9%

Source: Authors' calculations.

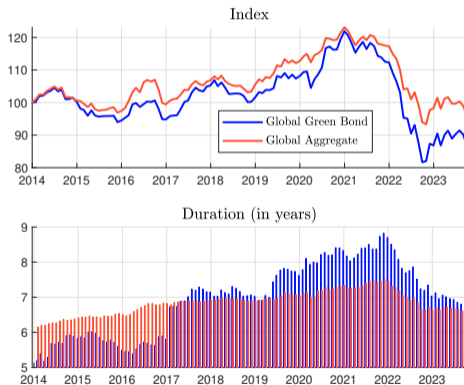
- Upper bound  $\approx$   
\$900 bn (25%)
- Lower bound  $\approx$   
\$400 bn (12%)

(1a) Funding requirement (in \$ tn), (1b) Break-down (in %), (2a) Financed (in \$ tn), (2b) Financed (in %), (3a) Non-financed (in \$ tn), (3b) Non-financed (in %), (4) Funding ratio (in %)

# Investment universe

## Green bonds

Figure: Performance and duration of the bond indices



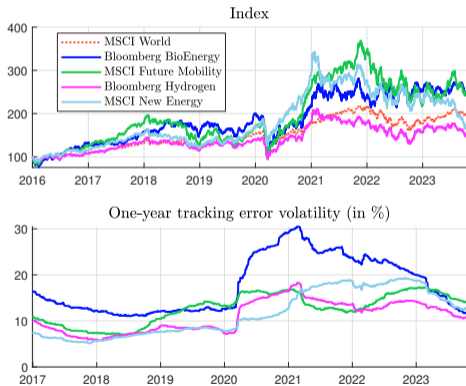
Tracking error volatility  
 $\approx 3\%$

Source: Bloomberg (2023).

# Investment universe

## Green equities

**Figure:** Performance and tracking error volatility of thematic equity indices



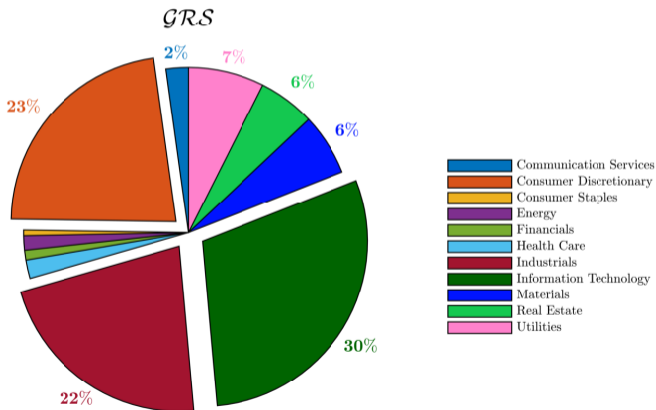
**Tracking error volatility  
≈ 20%**

Source: Bloomberg (2023) & MSCI (2023).

# Investment universe

## Green equities

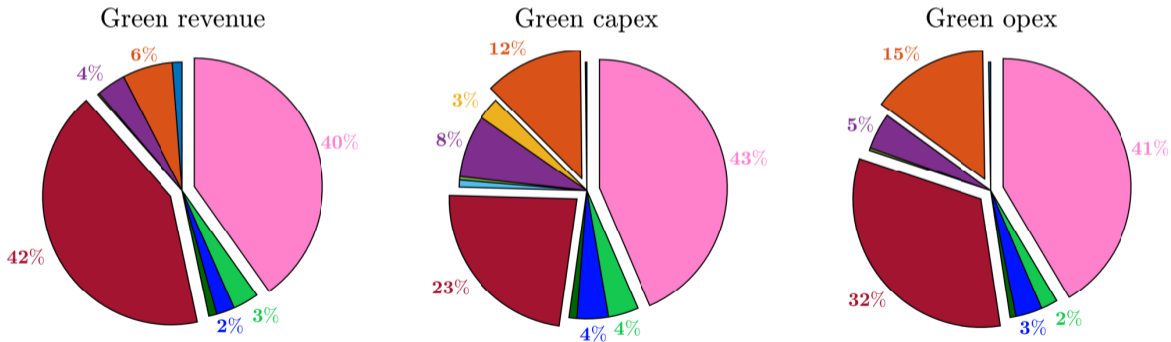
Figure: Breakdown in % of green intensities (MSCI World, Dec. 2021)



# Investment universe

## Green equities

Figure: Breakdown in % of green intensities (MSCI World, Dec. 2021)



# Investment universe

## Other asset classes

- 1 Sustainable infrastructure
- 2 Sustainable real estate
  - CRREM (Carbon Risk Real Estate Monitor) ⇒ whole-building approach for in-use emissions
  - GRESB ⇒ GHG Protocol principles to the real estate industry (corporate approach)
  - SBTi Building Guidelines
  - PCAF/CRREM/GRESB joint technical guidance ⇒ Accounting and reporting of financed GHG emissions from real estate operations (GHG Protocol)



# Tracking error risk of the core/satellite portfolio

## Assumptions

### Tracking error

- Core equity portfolio = 2%
- Core bond portfolio = 25 bps
- Satellite equity portfolio = 20%
- Satellite bond portfolio = 3%

### Correlation

- Lower bound:  $\rho = 0\%$
- Upper bound:  $\rho_{\text{intra-class}} = 80\%$

**Table:** Estimation of the tracking error volatility of the core/satellite portfolio (in %)

	$\alpha$	Bond	Defensive	Balanced	60/40	Dynamic	Equity
LB	10%	0.38	0.62	1.36	1.62	2.15	2.69
	20%	0.63	1.00	2.18	2.60	3.45	4.31
	30%	0.92	1.43	3.11	3.71	4.93	6.16
UB	10%	0.53	1.18	2.16	2.49	3.15	3.80
	20%	0.80	1.76	3.20	3.68	4.64	5.60
	30%	1.07	2.34	4.24	4.87	6.13	7.40

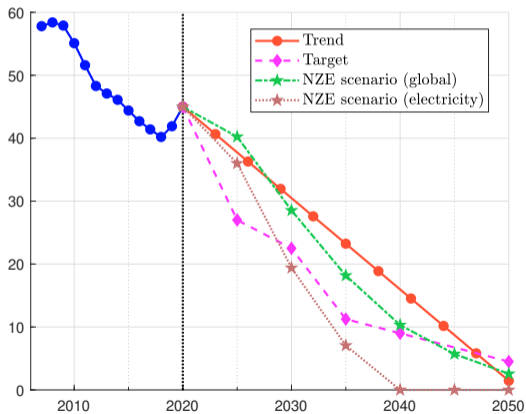
# Conclusion

- Net zero investment strategy  $\neq$  low-carbon investment strategy
  - Static **exogenous** decarbonization  $\Rightarrow$  Dynamic **endogenous** decarbonization
  - How to assess **self-decarbonization**?
  - **Transition** matters!
  - Issues on the short run will decrease on the long run if the **finance economy** decarbonizes
- The additional cost for equity portfolios will be greater than for bond portfolios (wrt to business-as-usual investing)
  - We must distinguish stock of capital and new fresh capital
  - Equity market portfolios are driven by old capital (**secondary market**)
  - Bond market portfolios are driven by fresh capital (**primary market**)
  - The **structure of bond benchmarks** changes faster than the structure of equity benchmarks
- **There are solutions**
  - Don't go too fast in terms of decarbonization pathway
  - Deeply understand the transition dimension and the relationships between net zero metrics
  - **Less is more**

# Self-decarbonization

The *PAC* framework

Figure: Carbon trend, targets and NZE scenario of company A



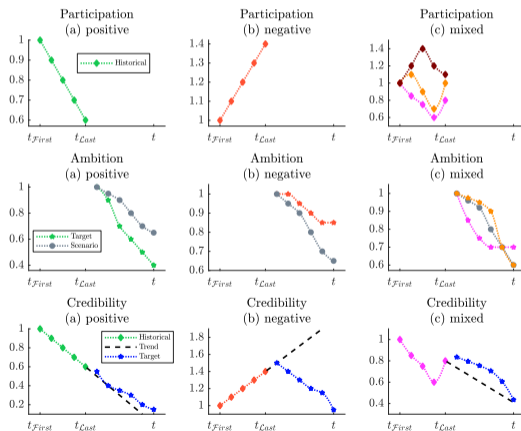
Three pillars:

- **P**articipation
- **A**mbition
- **C**redibility

# Self-decarbonization

## The $\mathcal{PAC}$ framework

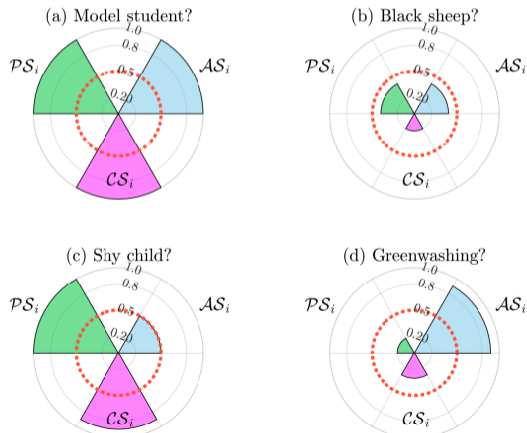
Figure: Assessment of the  $\mathcal{PAC}$  pillars



# Self-decarbonization

The  $\mathcal{PAC}$  framework

Figure: The  $\mathcal{PAC}$  scoring system



# Self-decarbonization

## Using temperature ratings

Table: Frequency of temperature ratings (in %)

Range	CDP				Iceberg
	Scope 1 + 2 + 3	Short-term	Mid-term	Long-term	
$\mathcal{T} \leq 1.0^{\circ}\text{C}$	0.00	0.00	0.00	0.00	1.01
$1.0^{\circ}\text{C} < \mathcal{T} \leq 1.5^{\circ}\text{C}$	1.44	2.92	10.68	2.71	2.60
$1.5^{\circ}\text{C} < \mathcal{T} \leq 2.0^{\circ}\text{C}$	6.20	1.26	13.03	3.94	3.14
$2.0^{\circ}\text{C} < \mathcal{T} \leq 2.5^{\circ}\text{C}$	6.86	3.07	7.46	2.68	21.76
$2.5^{\circ}\text{C} < \mathcal{T} \leq 3.0^{\circ}\text{C}$	7.64	1.99	4.21	0.48	30.87
$3.0^{\circ}\text{C} < \mathcal{T} \leq 3.5^{\circ}\text{C}$	76.95	89.77	62.80	90.07	32.30
$3.5^{\circ}\text{C} < \mathcal{T} \leq 4.0^{\circ}\text{C}$	0.78	0.81	1.44	0.09	2.23
$4.0^{\circ}\text{C} < \mathcal{T} \leq 4.5^{\circ}\text{C}$	0.12	0.18	0.36	0.03	3.31
$4.5^{\circ}\text{C} < \mathcal{T} \leq 5.0^{\circ}\text{C}$	0.00	0.00	0.00	0.00	0.77
$\mathcal{T} = 3.2^{\circ}\text{C}$	52.09	88.50	61.39	89.95	0.01

Source: CDP Temperature Ratings Dataset, version 1.1, February 2021 & Iceberg Data Lab (2021).

# How to achieve net zero emissions

## Material and resource requirements

Table: Mineral requirements for clean energy technologies

	Aluminium	Chromium	Copper	Cobalt	Graphite	Lithium	Neodymium
Bioenergy	●	○	●	○	○	○	○
CSP	●	●	●	○	○	○	○
Electricity Networks	●	○	●	○	○	○	○
EVs and Battery storage	●	○	●	●	●	●	●
Geothermal	○	●	○	○	○	○	○
Hydrogen	●	○	○	○	○	○	○
Hydropower	●	●	●	○	○	○	○
Nuclear	○	●	●	○	○	○	●
Solar PV	●	○	●	○	○	○	○
Wind	●	●	●	○	○	○	●

Source: IEA (2022, page 45).

# How to achieve net zero emissions

## Material and resource requirements

Table: Mineral requirements for clean energy technologies

	Nickel	Platinum	Polysilicon	REEs	Silver	Steel	Uranium	Zinc
Bioenergy	○	○	○	○	○	○	○	●
CSP	●	○	○	○	○	○	○	●
Electricity Networks	○	○	○	○	○	●	○	○
EVs and Battery storage	●	○	○	●	○	○	○	○
Geothermal	●	○	○	○	○	○	○	○
Hydrogen	●	●	○	●	○	●	○	○
Hydropower	○	○	○	○	○	●	○	●
Nuclear	●	○	○	○	○	●	●	○
Solar PV	○	○	●	○	●	●	○	○
Wind	●	○	○	●	○	●	○	●

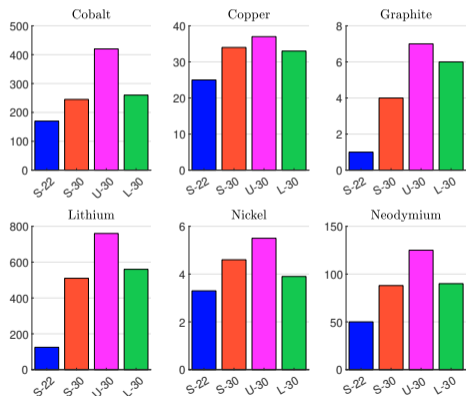
Source: IEA (2022, page 45).



# How to achieve net zero emissions

## Material and resource requirements

Figure: Demand and primary supply in 2023



Source: Energy Transitions Commission (2023a).

# How to achieve net zero emissions

## Funding requirements — global analysis

Total investment: **3.5 trillion per year to 2050**

# How to achieve net zero emissions

## Funding requirements — sector analysis

### Power (\$2 400 bn)

- Total electricity supply from around 30 000 TWh today to over 100 000 TWh by mid-century
- Extension of transmission and distribution networks from about 70 million km to up to 200 million km
- Green hydrogen production of 500-800 Mt per year

### Buildings (\$500 bn)

- Need to retrofit older buildings and create new carbon-efficient buildings
- \$500 bn per year invested in the buildings sector: incorporate new green technologies (\$230 bn), purchase renewable heat (\$130 bn) and install new heat pumps (\$150 bn)

# How to achieve net zero emissions

## Funding requirements — sector analysis

### Mobility (\$280 bn)

- The largest part of the transition from ICE (internal combustion engines) to EVs will require \$130 bn per year to develop charging and refuelling facilities
- \$70 bn will be spent on sustainable aircraft manufacturing facilities and aircraft batteries
- \$40 bn will be spent on greening the shipping system through new infrastructure, vessels and investments

### Sustainable agriculture and land use requirements (\$50 bn)

- The demand for wind and solar farms is far greater than the previous demand based on the fossil fuel system, but still far less than the demand for agriculture
- Agriculture is the largest driver of deforestation

# How to achieve net zero emissions

## Funding requirements — sector analysis

### Hydrogen (\$80 bn)

- \$80 bn investment will be allocated to the production and distribution of hydrogen
- \$40 bn will be used to produce green and blue hydrogen and to recycle grey hydrogen
- \$40 bn will help build pipelines, refuelling stations, exchange terminals and storage capacity

### Industry (\$70 bn)

- \$10 bn will be used to decarbonise steel
- \$10 bn for cement plants
- \$40 bn to fully develop and integrate CCS and other decarbonisation technologies
- \$10 bn to deploy low-carbon technologies in smelters and refineries

# How to achieve net zero emissions

## Funding requirements — sector analysis

### Waste management and circular economy (\$135 bn)

- Waste is generated at every stage of the transition, from food waste from agriculture to waste from solar panels, wind farms or even mining
- The energy transition will generate up to 13 billion tonnes of waste from all materials by 2050

### Water management (\$25 bn)

- Global water consumption will be 4000 billion  $m^3$  per year in 2050, of which 70% is used for agriculture (2800 billion  $m^3$ ), 58 billion  $m^3$  for clean energy production and 37 billion  $m^3$  for fossil fuels
- For clean energy production, water is used for nuclear power generation (14 billion  $m^3$  per year), hydrogen production by electrolysis (11 billion  $m^3$  per year), carbon capture (19–29 billion  $m^3$  per year) and cleaning solar panels
- Global energy use in the water sector expected to double by 2040

# How to achieve net zero emissions

## Tracking net zero progress

Table: What's on track (energy system overview)

---

Energy Efficiency	●
Behavioural Changes	●
Electrification	●
Renewables	●
Bioenergy	●
Hydrogen	●
Carbon Capture, Utilisation and Storage	●
Innovation	●
International Collaboration	●
Digitalisation	●

---

● on track, ● more efforts needed, ● not on track

Source: IEA (2023).

# How to achieve net zero emissions

## Tracking net zero progress

Table: What's on track (sector analysis)

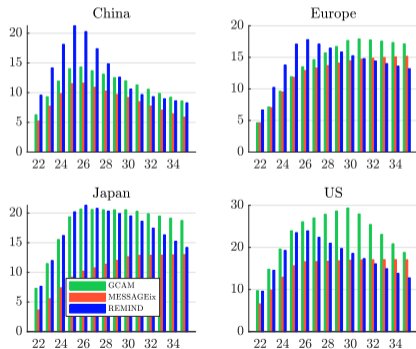
Transversal Technologies & Infrastructure	●	Electricity	●
CO <sub>2</sub> Transport and Storage	●	Coal	●
CO <sub>2</sub> Capture and Utilisation	●	Natural Gas	●
Bioenergy with Carbon Capture and Storage	●	Solar PV	●
Direct Air Capture	●	Wind	●
Electrolysers	●	Hydroelectricity	●
District Heating	●	Demand Response	●
Data Centres and Transmission Networks	●	Nuclear Power	●
Transport	●	Grid-scale Storage	●
Cars and Vans	●	Smart Grids	●
Trucks and Buses	●	Energy	●
Rail	●	Oil & Natural Gas Supply	●
Aviation	●	Methane Abatement	●
International Shipping	●	Gas Flaring	●
Electric Vehicles	●	Biofuels	●
Industry	●	Buildings	●
Steel	●	Heating	●
Chemicals	●	Space Cooling	●
Cement	●	Lighting	●
Aluminium	●	Appliances & Equipment	●
Paper	●	Building Envelopes	●
Light Industry	●	Heat Pumps	●



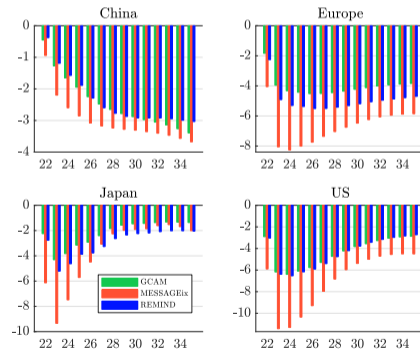
# How to achieve net zero emissions

## Public vs. private investments

**Figure:** Public investment – relative difference in % compared with the baseline scenario



**Figure:** Private investment – relative difference in % compared with the baseline scenario



Source: NGFS (2022) & <https://data.ene.iiasa.ac.at/ngfs>.

# How to achieve net zero emissions

## Public vs. private investments

### What are the narratives

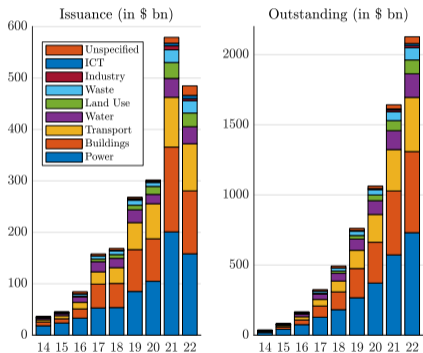
- Net zero emissions scenario  $\Rightarrow$  Huge cost
- This cost mainly concerns the Utilities sector
- Utilities  $\Rightarrow$  Huge capex  $\Rightarrow$  ROE  $\searrow$
- Private investors are reluctant to finance the utilities sector
- Private investment  $\searrow$
- A strong increase of public investment
- Debt  $\nearrow$   $\Rightarrow$  Interest rates  $\nearrow$
- Investors prefer to invest in sovereign bonds than financing directly net zero

**Vase communication between public investment and private investment**

# Investment universe of the satellite portfolio

## Green bonds

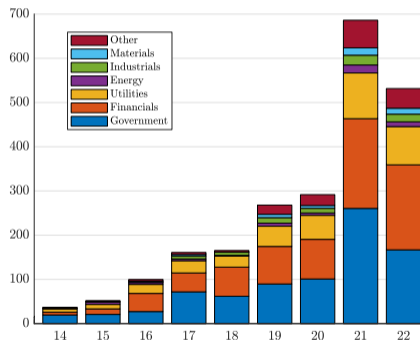
Figure: Issuance of GBs by use of proceeds



Source:

<https://www.climatebonds.net/market/data>.

Figure: Issuance of green bonds by sectors

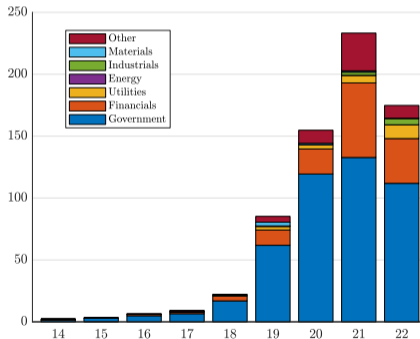


Source: Bloomberg, GSS+ Instrument Indicator.

## Investment universe of the satellite portfolio

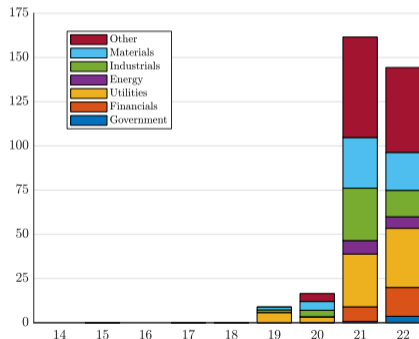
## Green bonds

Figure: Issuance of sustainable bonds by sectors



Source: Bloomberg, GSS+ Instrument Indicator.

Figure: Issuance of SLBs by sectors



Source: Bloomberg, GSS+ Instrument Indicator.

# Investment universe

## Green equities

**Table:** Statistics of the narrow definition (MSCI World, Dec. 2021)

Sector	Code	MSCI World			Satellite Target
		CW	Alignment	Breakdown	
Communication Services	50	8.35%			
Consumer Discretionary	25	12.25%	28.62%	30.9%	5 – 15%
Consumer Staples	30	6.91%	1.32%	0.8%	0 – 5%
Energy	10	3.12%			
Financials	40	13.16%			
Health Care	35	12.62%			
Industrials	20	10.21%	38.97%	35.0%	10 – 20%
Information Technology	45	23.68%			
Materials	15	4.10%	29.42%	10.6%	5 – 15%
Real Estate	60	2.79%	1.32%	0.3%	0 – 5%
Utilities	55	2.74%	92.80%	22.3%	50 – 70%
Total			11.37%	100.0%	

## Investment universe

## Green equities

## Net zero contribution metrics

- Green revenue share
- Green turnover (EU taxonomy)
- Green Opex (EU taxonomy)
- Green Capex (EU taxonomy)

Table: Average green intensities in % (MSCI World, Dec. 2021)

Sector	Code	GRS	Revenue	Capex	Opex
Communication Services	50	2.79	0.07	0.02	0.02
Consumer Discretionary	25	19.59	0.25	0.98	0.89
Consumer Staples	30	0.85	0.00	0.40	0.00
Energy	10	4.79	0.57	2.46	1.06
Financials	40	0.77	0.01	0.03	0.02
Health Care	35	1.52	0.00	0.07	0.00
Industrials	20	22.86	1.98	2.21	2.34
Information Technology	45	13.28	0.02	0.04	0.02
Materials	15	15.41	0.26	0.92	0.59
Real Estate	60	21.18	0.56	1.33	0.55
Utilities	55	28.88	7.08	15.46	11.13
Total		10.64	0.48	0.97	0.73

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