# The Green Bond

Your insight into sustainable finance

02 February 2023

# In this issue

## The material issue

# Letter to the reader

## A warmly welcomed Inflation Reduction Act (IRA) in 2022 – and an equally warmly welcomed European reaction

Is it a trade war – or a healthy competition to accelerate a long overdue investment plan – and what will it mean for the inflationary and Macro outlook?

Looking back at 2022, we saw that China invested massively into their energy system – primarily in solar – but also in other renewables to address their need for energy supply. Now, in 2023, with the US rolling out the IRA and the Europeans catching up with the "Green Deal Industrial Plan", we witness a global competition for talents, raw materials, and industrial experience. This global hunt for resources will encourage regulators to accommodate business with guidelines and regulations and thereby encourage "local" investments to secure jobs, exports, intellectual leadership – and eventually tax revenues.

This is exactly what is required to ensure the needed mobilization of investments for climate action. But this also means that the train is leaving the station. Those who want to benefit from the transition, be well positioned for client RFPs, broad and affordable capital, talents and be eligible for government support need to integrate competence, establish monitoring, define KPIs and develop their strategies accordingly. They need to do this now – if they haven't already done so – to stay competitive.

Additionally, the actions have further implications. Historically, our macro-economic research society has been reluctant to include the climate transition into its papers and assess the effect of decarbonization on the economy. However, we are currently seeing strong signals that this is about to change which will lead to increased activation of the financial system. We keep a positive outlook on the transition in our New Year edition – the IRA and the European response further support our believe and encourage investments.

Lastly – this is all about resources and how we use resources. In this edition of The Green Bond we are privileged to have contributions from the Geological Survey of Finland on material supply challenges facing the energy transition and Stena Recycling on circularity from a resource and economic perspective – both highly recommended.

Enjoy your reading

Christopher Flensborg

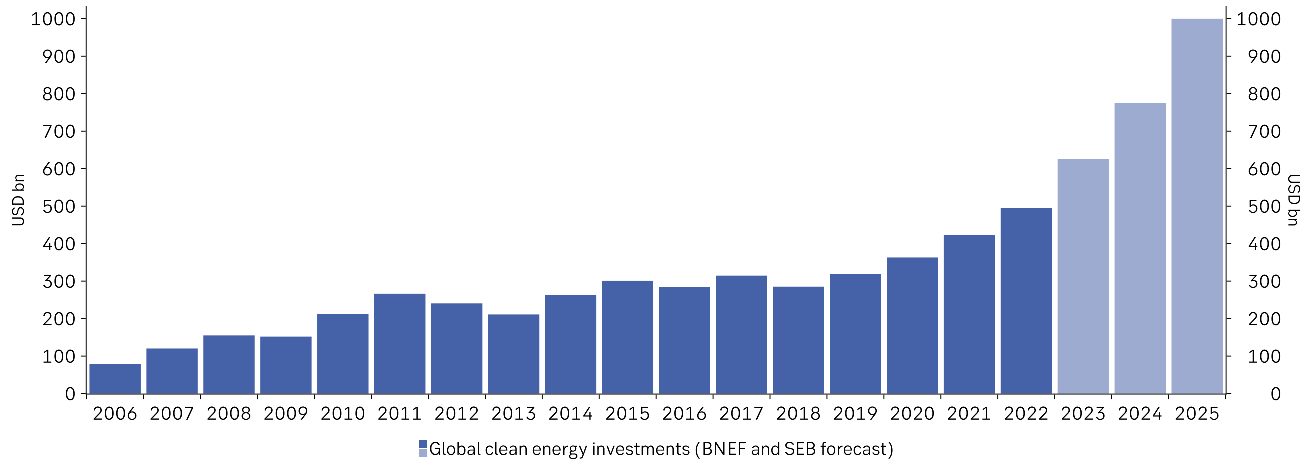
Head of Climate and Sustainable Finance
christopher.flensborg@seb.se

# Transition update

## European ambitions needed

Global transition investment surged in 2022 with China taking a clear lead. China and the US are ramping up plans to accelerate the transition, while Europe needs more ambitious policy to avoid getting left behind. The exponential growth shifts the focus to resource and capital requirements.

**Figure 1 Global clean energy investments**



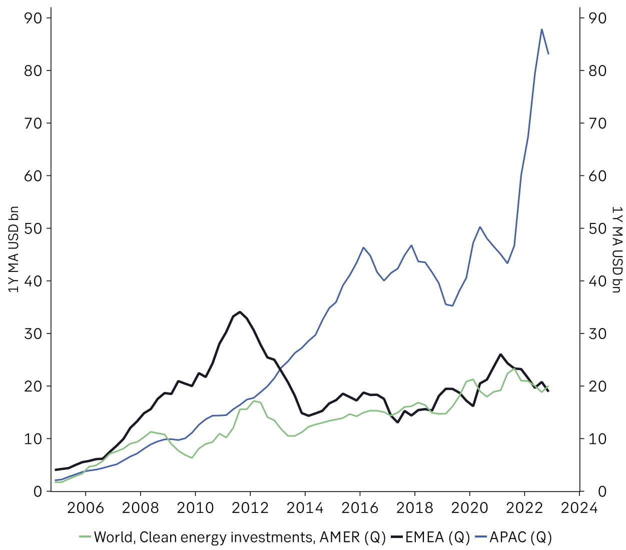

Source: Bloomberg New Energy Finance, SEB

### 2022 broke the past decade's trend

New data for 2022 confirm the acceleration in transition investment we had predicted in these pages. Global clean energy investments totalled USD 495bn in 2022 according to Bloomberg New Energy Finance (BNEF), beating our upbeat expectations of a 15% y/y increase (Figure 1) and taking us to the highest level on record. We expect this to be just the beginning: the exponential surge in investment is likely to continue. We therefore raise our estimate for renewable energy investment for 2023 to above USD 600bn and expect them to have doubled again by 2025 to more than USD 1tn.

The new clean energy investments are mainly driven by China's response to the energy shortages experienced in 2021. According to BNEF, China's investment doubled in 2022 compared with 2021(!), while investment in Europe and North America still haven't broken with the past decade's barely rising trend (Figure 2). In terms of renewable output, Europe's head start from the first decade of this century still leaves a strong starting point, but that will not last unless investment picks up.

**Figure 2 Global clean energy investments, regions**




Source: Bloomberg New Energy Finance

Fortunately, there are now clear indications of both easing disruptions that require a short-term political focus and higher political ambitions for the transition.

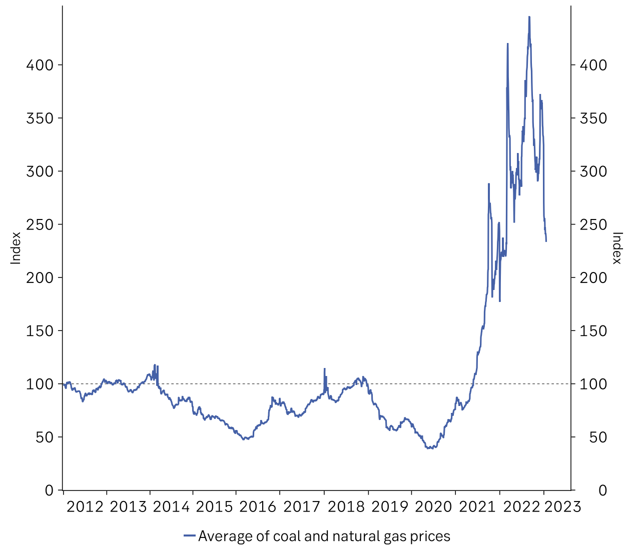
Thomas Thygesen
thomas.thygesen@seb.dk

Elizabeth Mathiesen
elizabeth.mathiesen@seb.dk

## From disruption to transition

Europe's transition has been held back by a major disruption of energy supply following Russia's invasion of Ukraine, but the average global price of coal and natural gas has declined by 37% since the beginning of December driven by a mix of fundamentals and mild weather conditions (Figure 3) and natural gas inventories are the highest they have ever been at this point in the year.

**Figure 3 Global coal and natural gas prices**




Source: Bloomberg

Europe has thus replaced the bulk of Russian supplies a year faster than we expected. However, SEB Commodity Research calculations show that 85% of the price decline in Europe's natural gas market was due to increased imports and demand destruction, while only 15% was due to weather conditions. It is now unlikely that there will be shortages next winter, even if the war in Ukraine continues.

Dealing with disruption has obviously forced Europe's governments to focus on the near-term problem. In 2022, reopening coal-fired power plants and adding more LNG terminals was the top priority, while laying the foundations for a faster long-term solution would have to wait. Now the door is open for increasing the time horizon, and there should be some sense of urgency.

## Europe risks getting left behind

The US already appeared to realize last year that they were falling behind in what could potentially be a key parameter in geopolitical competition. While there is still too limited political support for the climate crisis as a motivation for investment, as witnessed by the political backlash against ESG strategies in the US asset management sector, last year's oddly named 'Inflation Reduction Act' (IRA) marked a huge step forward in raising capital for a more modern infrastructure.

According to Princeton University's Zero Lab, the IRA will lift US annual non-fossil energy production growth from around 30GW to more than 120GW by 2030, raising the annual investment in solar and wind from around USD 100bn to more than USD 300bn. This would close the gap to Chinese investment, although more is likely needed to catch up as China's investment won't stand still either.

The new US initiative puts Europe on the spot, not just because it raises US investment but also because it tries to protect local producers. To receive the subsidies, the IRA currently stipulates that production must take place in countries within the North American trade agreement, so only Canada and Mexico are allowed in.

So now Europe must step up. The EU Carbon Boarder Adjustment Mechanism (CBAM) from December was intended to prevent 'carbon leakage' – i.e. companies moving production to somewhere with less strict laws on emissions – by subjecting certain imports to a carbon levy linked to the EU Emissions Trading System (ETS).

However, this is still about reducing the 'brown' part of the economy, and the real significance of the IRA is that it shifts the focus from regulation of the 'brown economy' to strategies that accelerate the deployment of the 'green economy'. The EU Commission is accordingly developing a larger 'Green Deal Industrial Plan' to match the IRA. As Ursula von der Leyen said recently, "to keep European industry attractive, there is a need to be competitive with offers and incentives. We must also step-up EU funding".

However, the initial launch of the plan was underwhelming. In the short term, the new plan aims to make existing funding (with a little bit of a boost) easier to access rather than add new funds. The EU will loosen the rules on subsidies and auctions to allow more direct support from national governments, but the cost will be borne by the countries themselves (with a little help), and this could lead to divergent policies depending on countries' ability to pay.

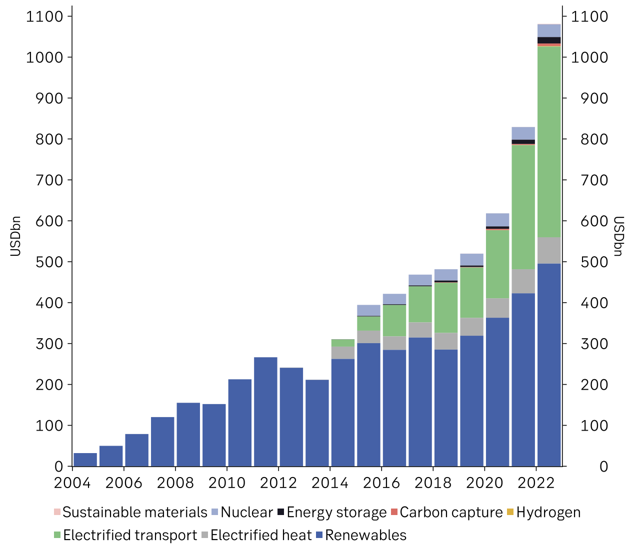
In the medium term, the EU may increase overall funding through a new Sovereignty Fund, but there were no details about the scale. We generally think that big plans with no new funding should be seen as relabelling rather than radical change, so from that perspective the plan was a big disappointment. There are some promising ideas as well, such as establishing common product standards across the EU, streamlining permit regulations to accelerate deployment and introducing reverse hydrogen auctions.

In the end, we think the EU and the US should merge the more protectionist parts of their agenda. This would be natural if they see each other as allies and partners rather than rivals, and our interpretation of the new geopolitical regime as Cold War 2.0 suggest this is the likely outcome.

## Accelerated transition requires more than energy

As we have highlighted in earlier issues of the Green Bond, it is important to include energy users as well as energy producers in an accelerated transition. This is becoming increasingly clear as electric vehicles continue to take market share from fossil-powered alternatives.

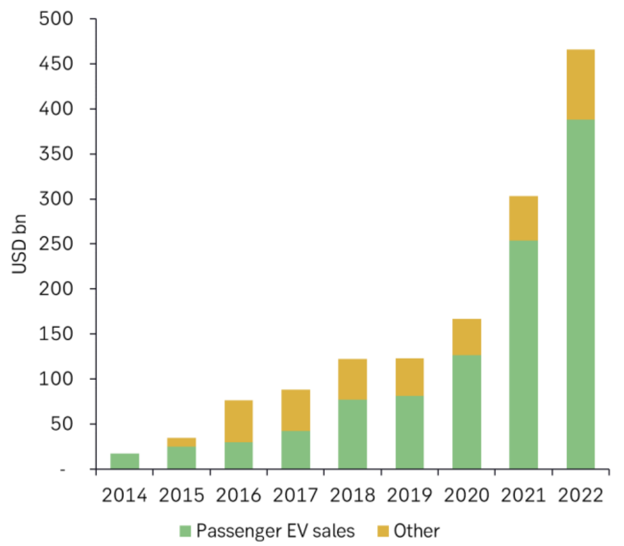
**Figure 4 Transition investments**




Source: Bloomberg New Energy Finance

According to BNEF, the annual investment in electrified transport exceeded USD 450bn in 2022, almost quadrupling compared with 2019's USD 123bn (Figure 4). 2022 was the first year when that number was higher than the investment in the supply of clean energy. Out of almost USD 500bn invested in clean transportation, BNEF estimates that 90% are in passenger EVs (Figure 5).

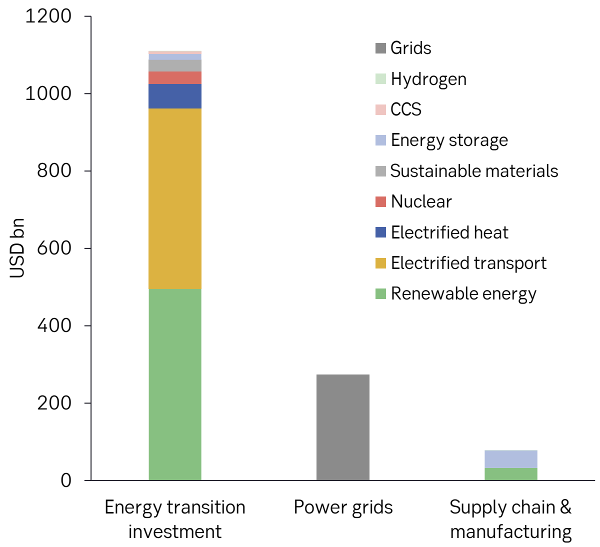
**Figure 5 Passenger EVs lead spending in clean transport**




Source: Bloomberg New Energy Finance

This is not surprising as the technology simply is not mature yet in any of the other areas. And as illustrated by Tesla's dramatic price reductions, the new technology continues to exhibit learning curve characteristics as it scales. Heavy trucks with both battery and hydrogen fuel cell drive trains are starting to diffuse but have yet to start scaling. Zero-emission ships are out there as prototypes but still look more like the equivalent of a Toyota Prius than a Tesla.

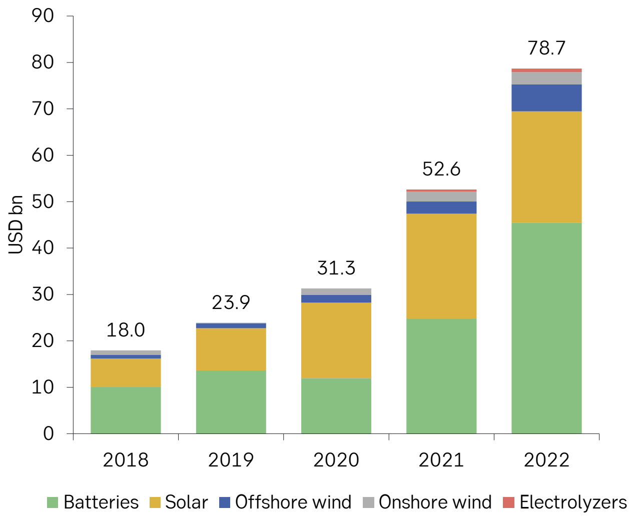
**Figure 6 Total 2022 investments across categories**




Source: Bloomberg New Energy Finance

Further investment is needed for grids and the supply chain that supplies the key elements of the new infrastructure (battery factories for instance). Grid investment amounted to USD 275bn in 2022. The investment in the supply chain and manufacturing supporting the transition is only just getting started and amounted to just USD 78bn (Figure 6).

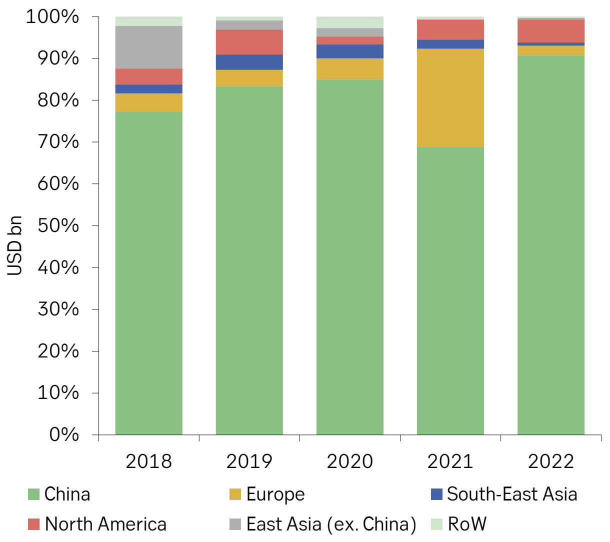
**Figure 7 Clean energy factory investment**




Source: Bloomberg New Energy Finance

Looking in more detail at these 'supporting' investments, they have been dominated by investment in solar panel production and batteries, while there is less activity when it comes to the expanding the supply chain for wind turbines and not least power-to-x technologies, which still appear to be in the embryonic stage where subsidies are required for profitable deployment (Figure 7). Furthermore, this investment is heavily concentrated in China. 90% of all investment in clean energy factories in 2022 took place in China, with Europe and the US lagging (Figure 8).

**Figure 8 Clean energy factory investment, by geography**




Note: Does not include wind
Source: Bloomberg New Energy Finance

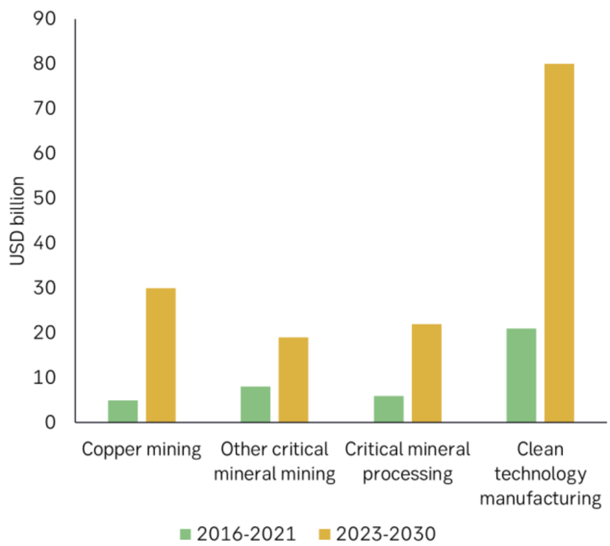
If Western economies are to avoid dependency problems in renewable energy similar Europe's dependency on Russian natural gas, they need to build their own capacity to support the transition. This will likely require financial incentives from governments, also because the cutthroat Chinese competition compresses margins.

## Commodities are a key pressure point

The overall investment required for a fast transition to net zero is breath-taking, but large parts of it are likely to be co-financed with governments. We do not think there is a shortage of capital for direct investment in renewable energy projects.

However, capital is also needed for the physical resources needed for the new infrastructure, both because they require a long lead-time and lots of capital and because they take place in hard-to-abate sectors with high emission levels in the early stages of the transition. The IEA has estimated the annual investment needed for critical commodities and factories in their Net Zero scenario amount to USD 151bn, up from USD 40bn in 2016-2021 (Figure 9).

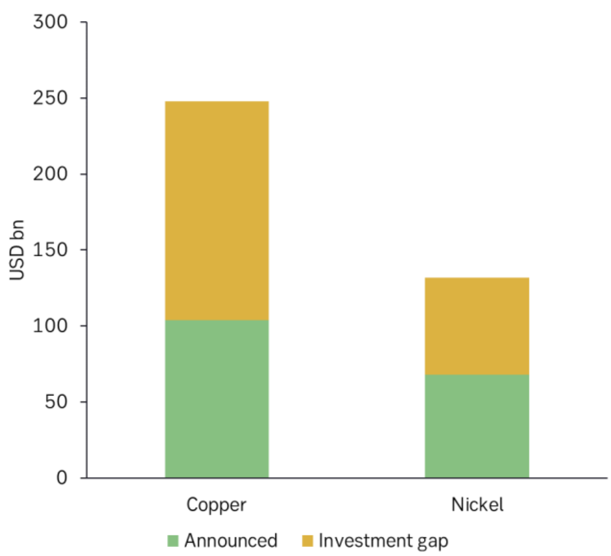
**Figure 9 Average yearly investment in clean energy technology supply chain in the NZ scenario**




Source: IEA

Copper mining alone will require USD 30bn annually, seven times the level from 2016-2021. This does not seem to have been fully anticipated by miners and investors More than half of the total investment required has yet to be announced, both for copper and for nickel, where the second largest investment is needed (Figure 10).

**Figure 10 Required investment to meet minerals demand in the NZ scenario, 2022-2030**




Source: IEA

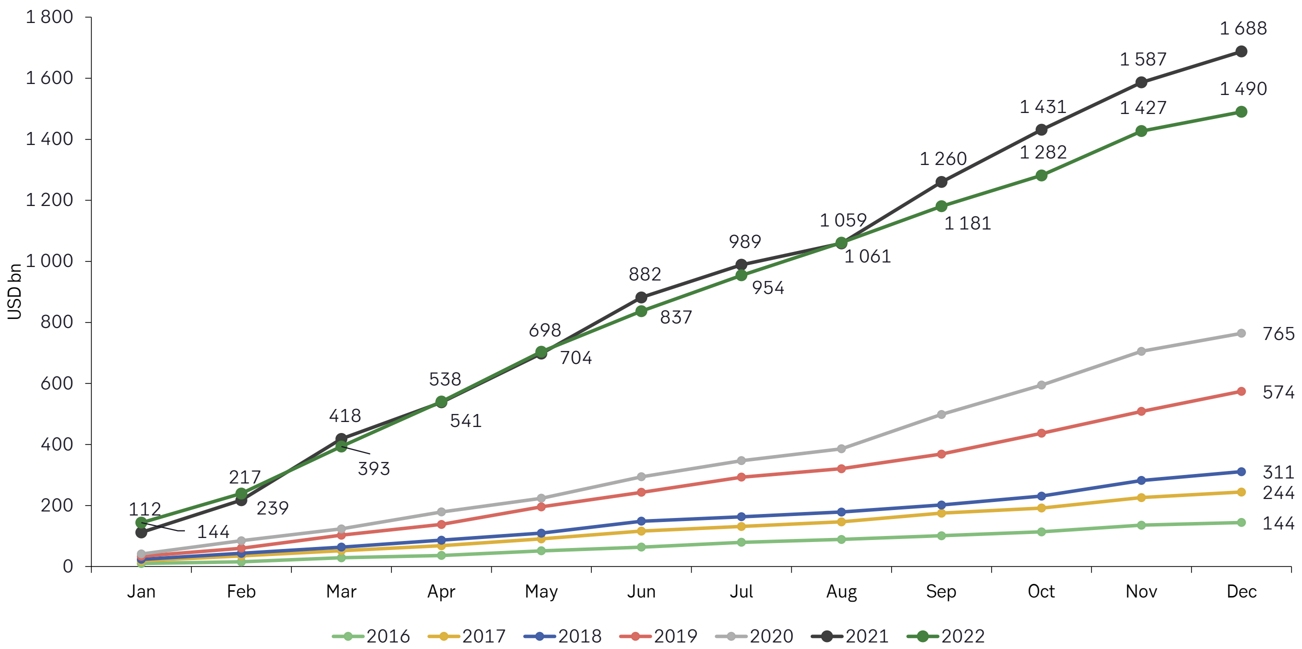
As new mining projects typically have a very long lead-time, our estimate is that all plans need to be in place by 2025 if they need to be completed by 2030. This means the coming 2-3 years need to see a huge increase in planned investment and highlights how capital requirements are front-loaded.

# Sustainable Debt Market Update

Resilience amid macroeconomic "perfect storm"

New transactions of sustainable bonds and loans fell in 2022 for the first time. However, sustainable bonds continued to take an increasing share of the corporate bond market issuance. Fund flows into ESG/SRI funds levelled off in both the equity and fixed income markets. The case for a rebound in flows is strongest in fixed income.

**Figure 11 Cumulative sustainable debt transactions**




Source: Bloomberg New Energy Finance 31 December 2022

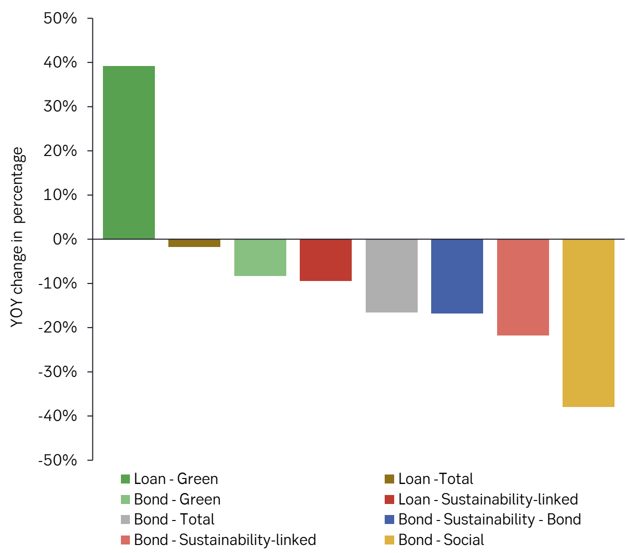
## Sustainable debt suffers setback in 2022

The total amount of new labelled bonds and loans in 2022 reached just under USD 1.5tn, down 12% Y/Y. This is the first time that the market for sustainable debt has declined year-over-year.

Figure 12 shows that the decline in new issuance affected almost all products. Social bonds and sustainability bonds suffered the largest and third largest Y/Y decline in new transactions of 38% and 17%, respectively. This can be explained by lesser demand for public funding of healthcare and furlough schemes as the world moved past the worst of the COVID-19 pandemic in 2022.

New funding needed to address the outfall of the war in Ukraine and cost of living crises have so far not resulted in a notable uptick in social or sustainable bond issuances.

**Figure 12 Y/Y change in issuance by product in 2022**




Source: Bloomberg and Bloomberg New Energy Finance 26 January 2023


Gregor Vulturius, PhD
gregor.vulturius@seb.se

Filip Carlsson
filip.carlsson@seb.se

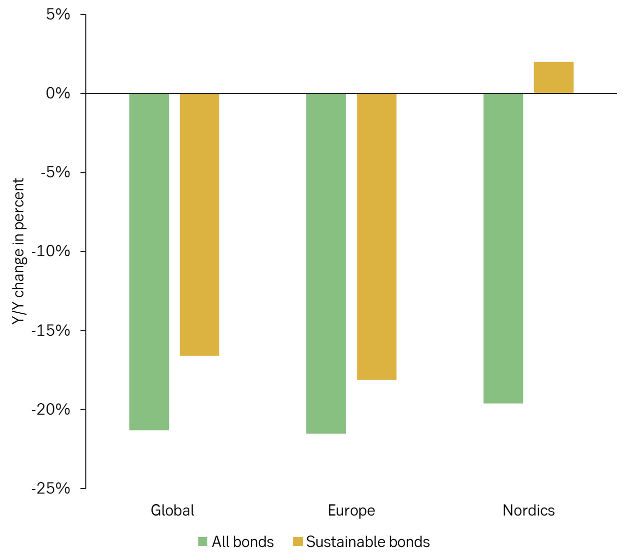
Debt instruments geared toward climate action and other environmental purposes fared best in the sustainable finance market of 2022. Green Bonds declined by only 8% and green loans experienced a late surge resulting in an increase of new transactions of 39%. Performance-linked debt also saw a decline in new transactions. Amid discussions in the market about greenwashing risks sustainability-linked bonds and loans fell 22% and 9%, respectively.

## Labelled bonds show resilience amid overall market decline

The fact that the market for sustainable debt shrank last year should not come as a surprise. Macroeconomic factors, including inflation, central bank rate hikes, the Russian war against Ukraine and the ensuing energy crisis all contributed the perfect storm for global debt markets.

Under these exceptional circumstances, the market for green, social, sustainability and sustainability-linked bonds showed greater resilience that the general market. Figure 13 shows that globally and in Europe, new issuances of sustainable bonds have declined less than the overall bond market. Data also indicates that the sustainable bond market in Nordics increased by 2% while the general bond market in that region shrunk by 20% in 2022.

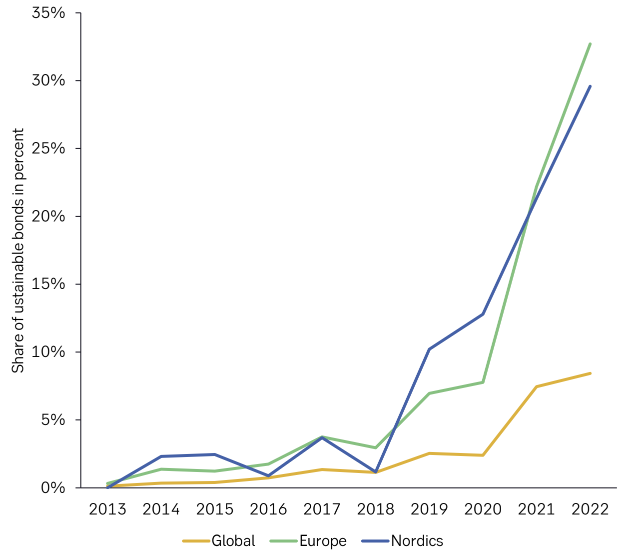
**Figure 13 Y/Y change in new issuances of overall and sustainable bond market by region**




Source: Bloomberg and Bloomberg New Energy Finance 26 January 2023[1]

Data also suggests that sustainable bonds increased their market share. Figure 14 shows that green, social, sustainability and sustainability-linked bonds increased their share of the global corporate bond issuance to 8.4% in 2022. In Europe and the Nordics, sustainable-themed increase their share to around a third of the market.

**Figure 14 Sustainable-bond issuance as a share of total corporate bond market (exc. real estate)**

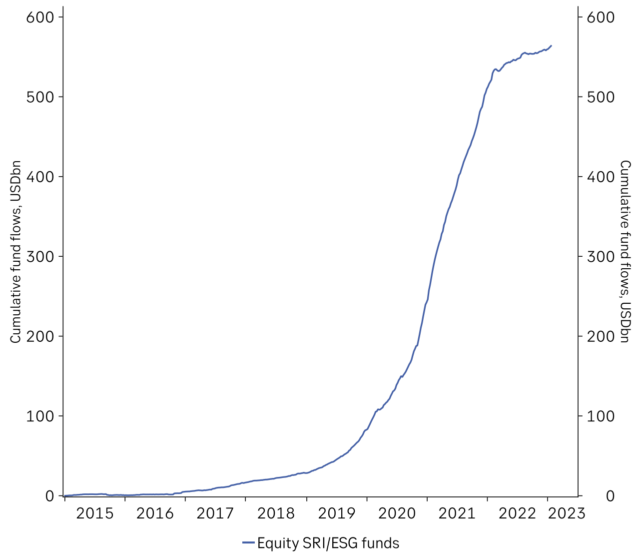



Source: Bloomberg 1 February 2023

## ESG/SRI fund inflows level off in 2022

Turning from issuance to investment, there was also a sharp slowdown in the inflows to ESG/SRI designated funds in 2022 (Figure 15). In the same way as with issuance, this is partly a reflection of a similar stagnation in the broader inflows to all funds.

**Figure 15 SRI/ESG fund flows: equities**




Source: EPFR, SEB

[11] Data for the general bond market are collected from Bloomberg terminal. Data for sustainable bonds are collected from Bloomberg New Energy Finance. The two sources are of limited comparability.

This is a challenge for the sustainable investor community, because it removes one key argument for companies to align with ESG or other guidelines: that they would be losing access to a larger and larger share of the investor community if they did not. With limited evidence to support the case for improved economic performance resulting from a higher ESG alignment, this was a large part of the motivation for this kind of investment to make a difference in the real world.

There were most likely several contributing factors to this change. The most obvious trigger is investment returns, as the bigger losses for ESG/SRI funds (and not least clean energy stocks) in 2021-2022 probably did not align with what investors had expected ex ante. The relabeling of the defense industry and Russian assets after the invasion of Ukraine may also have made the concept appear more complex and fluid. Exclusion rules for things like natural gas during an energy crisis also led to conflicts between the E and the S component in ESG screenings.

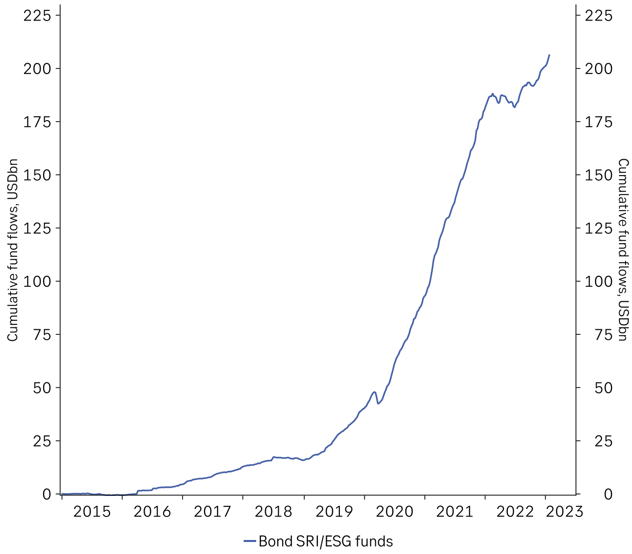
This inherent conflict is also a broader concern as investors generally are forced to reconcile a rising number of objectives in their sustainable portfolios, leading to too many constraints. This is most likely the reason why so many article 9 funds were relabeled as article 8 funds over the course of the past year.

## Stronger case for fixed income ESG/SRI funds

Comparing sustainable fund flows in the fixed income and equity markets, the signs are clearly more encouraging for the former. ESG/SRI labelled fixed income funds saw fund flows return in the second half of 2022 (Figure 16) and while they have not returned to the same growth trend as before, they at least have one.

This also makes sense from a more fundamental perspective. Bonds are less sensitive to profitability than equities, you get the expected return as long as companies do not default on their obligations, regardless of whether they are successful or not.

**Figure 16 SRI/ESG fund flows: bonds**




Source: EPFR, SEB

Sustainability-labelled bonds also have other supportive factors relative to equities. Transparency is much higher as you are funding the company directly when it issues, while equity transactions in the secondary market do not provide any fresh capital for the company that originally issued the shares.

Sustainability-labeled bonds also benefit from a more direct impact due to preferential treatment from central banks and regulators as well as commercial banks. One example: ECB board member Isabel Schnabel made it clear that 'we are now tilting our corporate bond portfolio towards issuers with better climate scores, with a view to removing the existing bias towards emission-intensive firms'[2]. There is thus a much more direct link to the cost of and availability of capital in bond markets.

[2] Monetary policy tightening and the green transition (europa.eu)

# Material Supply Challenges for the Green Transition to Phase out Fossil Fuels

Simon P. Michaux
Associated Professor, Geological Survey of Finland
simon.michaux@gtk.fi

## Current assumptions about the energy transition are flawed

The task to phase out fossil fuels is now at hand. Most studies and publications to date focus on why fossil fuels should be phased out.

Until recently, the belief shaping policy was that the transition away from fossil fuels will be a market force, where more efficient renewable technology would make fossil fuel systems (like Internal Combustion Engine ICE cars) redundant. The existing economic system and all its capability would be maintained and increased at a nominal growth rate of 2% per year. All batteries would be lithium-ion chemistry (this is reflected by the judgement that all funding for large scale upscaling will be Li-Ion only). There will be a hydrogen economy in some form. Wind and solar power generation will be the primary electrical generation technologies for the next industrial era. All stationary power requirements will be addressed with the use of battery banks (other tech was recognized but battery banks could be installed anywhere in all weather conditions). All future industry will be recycling based, founded in the Circular Economy.

The above paragraph describes the paradigm of almost all senior civil servants I met whom had influence of developing strategic planning for Europe in 2017. I would see this paradigm reflected in multiple strategic documents from the European Commission 2019[3].

This work presented in this article was done for the express purpose of addressing logistical difficulties in strategies proposed by EU Commission civil servants to phase out fossil fuels. The report (Michaux 2021 and Michaux 2023a) was to map out exactly what they thought was going to happen (based on what I saw personally at meetings in Brussels). The intention was to show that the existing EU plan had multiple structural flaws and would not work. After understanding this shortfall, we could all develop a more useful plan to transition away from fossil fuels.

## Assessing the industrial capacity required for the transition

This article which is based on previous research presents the physical requirements in terms of required non-fossil fuel industrial capacity, to completely phase out fossil fuels, and maintain the existing industrial ecosystem. The existing industrial ecosystem dependency on fossil fuels was mapped by fuel (oil, gas, and coal) and by industrial application. Data were collected globally for fossil fuel consumption, physical activity, and industrial actions for the year 2018.The number of vehicles in the global transport fleet was collected by class (passenger cars, buses, commercial vans, HCV Class 8 heavy trucks, delivery trucks, etc.). The rail transport network, the international maritime shipping fleet, and the aviation transport fleet was mapped, in terms of activity and vehicle class. For each type of vehicle class, the distance travelled was estimated. Non-fossil fuel technology units that are commercially available on the market were used as examples for how to substitute fossil fuel supported technology.

For each vehicle class, a representative commercially available example was selected, for Electrical Vehicle and

[3] Going climate-neutral by 2050 - A strategic long-term vision for a prosperous, modern, competitive and climate-neutral EU economy

Hydrogen fuel cell systems. The requirements to substitute the ICE rail network and the maritime fleet with EV and hydrogen fuel cell systems were presented. It was assumed that the performance specifications of each selected example were representative for that vehicle class. The quantity of electrical power required to charge the batteries of a complete EV system was estimated. The quantity of electrical power to manufacture the required hydrogen for a complete H-cell system was also estimated. An examination and comparison between EV and H-cell systems was conducted. Other fossil fuel industrial tasks like electrical power generation, building heating with gas and steel manufacture with coal were mapped and requirements for non-fossil fuel substitution were estimated.

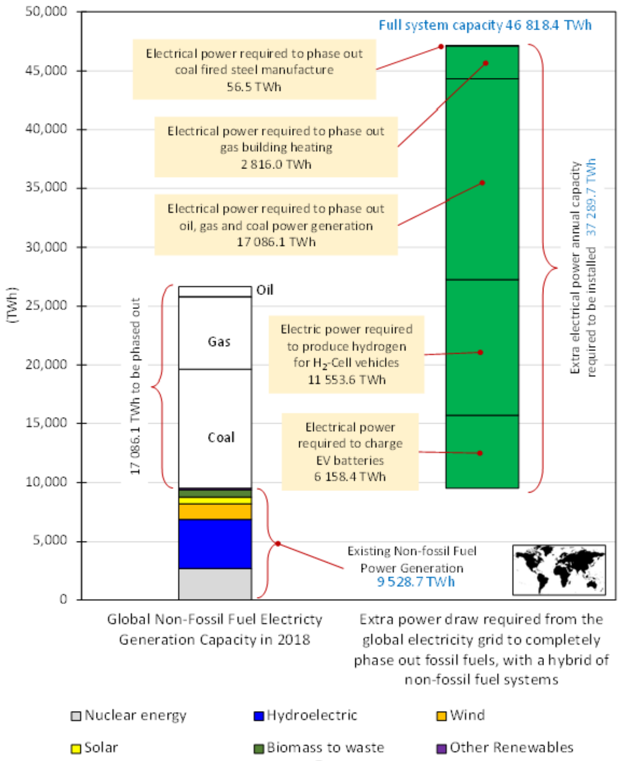
## Complete decarbonization requires 175% increase in total electricity consumption by mid-century

In 2018, the world generated and consumed 26 614 TWh of electrical power, 9 528.7 TWh of which was non fossil fuel (Figure 17). To phase out fossil fuels, 17 086.1 TWh of existing fossil fuel electrical power generation (oil, gas, and coal) would be phased out, and replaced with non-fossil fuel systems. In addition to this, the ICE vehicle transport network would have to be phased out, and replaced with an EV network, and a hydrogen fuel cell power vehicle network.

The estimated sum total of extra annual of non-fossil fuel power generation to phase out fossil fuels completely, and maintain the existing industrial ecosystem, at a global scale is 37 289.7 TWh, where this would be in addition to the existing non-fossil fuels power generation systems (9 528.7 TWh). The total annual global electrical power grid would become 46 818.4 TWh. So not only will 17 086.1 TWh of the existing system have to be shut down and replaced, but the completely non fossil fuel system will be 175% larger than the existing 2018 electrical power production.

If a non-fossil fuel energy mix based on an IEA prediction for 2050, and insights from previous work [4] is assumed[5], then 2 671.0 GW of installed fossil fuelled electrical power (oil, gas, and coal) would be shut down, and 22 793 GW of new non-fossil fuel capacity would have to be constructed. The existing total installed capacity in 2018 was 5 067.9 GW.

**Figure 17 Additional electrical power generation capacity required to completely phase out fossil fuels**




Source: GTK

Many more non-fossil fuel power stations will be needed compared to the existing fleet as most of the energy split is now wind (24.9% availability) and solar power generation (11.4% availability) (Global Power Observatory). The coal fired power stations being replaced had a 93.2% availability. This has resulted in many solar and wind power stations being constructed, with the understanding that most of the time they would not be producing due to weather constraints. This translates into an extra 607 052 new non-fossil fuel power plants will be needing to be constructed and commissioned[6].

[4] Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels
[5] Scope of replacement system to globally phase out fossil fuels, GTK Bulletin (in peer review)
[6] Ibid.

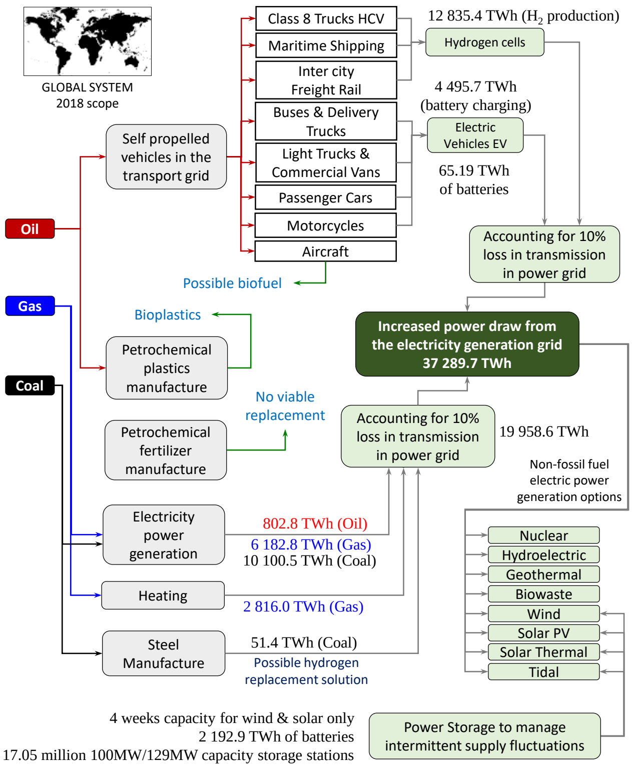
**Table 1 Energy split used and number of new power stations considered in this article**

| Power Generation System  | Proposed Energy Split non-fossil fuel electrical power systems (%) | Expanded extra required annual capacity to phase out fossil fuels (kWh) | Power Produced by a Single Average Plant in 2018 (kWh) | Estimated number of required additional new power plants of average size to phase out fossil fuels (number) | Estimated Installed capacity (GW) |
|---|---|---|---|---|---|
| Nuclear | 7.50 % | 2.80E+12 | 1.28E+10 | 218 | 447 |
| Hydroelectric | 13.36 % | 4.98E+12 | 1.33E+09 | 3 758 | 847 |
| Wind | 38.33 % | 1.43E+13 | 8.12E+07 | 175 933 | 6 545 |
| Solar PV | 34.50 % | 1.29E+13 | 3.30E+07 | 389 367 | 12 888 |
| Solar Thermal | 3.83 % | 1.43E+12 | 7.70E+07 | 18 555 | 1 428 |
| Geothermal | 0.74 % | 2.76E+11 | 6.03E+08 | 457 | 43 |
| Biowaste to energy | 1.74 % | 6.49E+11 | 3.46E+07 | 18 762 | 595 |
| | 100.00 % | 3.73E+13<br>37 289.7<br>Total (TWh) | | 607 052 | 22 793<br>Giga Watts |

Source: GTK

To mitigate intermittency of supply issues (from wind and solar) for just 28 days (4 weeks) of production, global stationary power storage would require an estimated 2192.9 TWh in capacity (or 17 million 100 MW/129 MWh capacity power storage stations) (Figure 18).

**Figure 18 Fossil fuel energy consumption by application and proposed substitution system**




Source: GTK

For the purposes of this study, power buffer storage for the proposed global electricity grid is assumed to be 4 weeks (28 days) capacity for just wind and solar power generation. It was presumed that this power buffer would probably take the form of a battery bank, based in a range of battery chemistries. A second calculation was done assuming a 48 hour +10%[7], to be used as a refence point. It is the authors opinion that both values are too low[8].In terms of required metal to phase out fossil fuels, this is the largest most significant task.

## Metals required compared against mineral reserves and resources

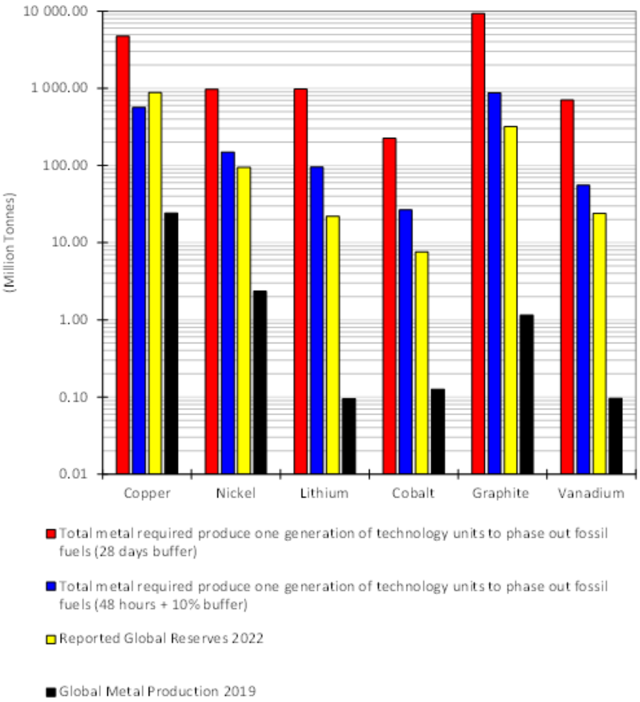
An estimate is presented for the total quantity of raw materials required to manufacture a single generation of renewable technology units (solar panels, wind turbines, etc.) sufficient to replace energy technologies based on combustion of fossil fuels (Figure 19)[9].

This estimate was derived by assembling the number of units needed against the estimated metal content for individual battery chemistries, wind turbines, solar panels, and electric vehicles. It was shown that both 2019 global mine production and 2022 global reserve estimates were manifestly inadequate for meeting projected demand for copper, lithium, nickel, cobalt, graphite, and vanadium. Comprehensive analysis of these data suggests that lithium-ion battery chemistry (on its own) is not a viable option for upscaling to meet anticipated global market demand. Consequently, the development of alternative battery chemistries is recommended. The calculated shortfall in copper and nickel production was also of concern, as both

[7] Based on Grid vs. storage in a 100 % renewable Europe. Renewable Energy, 50 (2013), 826-832
[8] The Energy Storage Conundrum, Global Warming Policy Foundation
[9] Quantity of metals required to manufacture one generation of renewable technology units to phase out fossil fuels, GTK Bulletin (in peer review)

metals are vital to the existing economy and there is no known substitute or alternative for either commodity.

**Figure 19 Quantity of metals needed to manufacture on generation of technology unit to completely phase out fossil fuels compared to global mining production in 2019 and reported mineral reserves in 2022**




Source: Mineral commodity summaries 2022, United States Geological Survey

## Conclusions

It is clear that the current paradigm to phase out fossil fuels will face some very serious challenges. The scale of the task is much larger than was previously understood. This puts some serious time pressure to deliver on commitments already made. For example, the European Union has committed to, for example a new renewable energy target of 32% by 2030[10].There is not enough time, even if the necessary capital was available to construct so many non-fossil fuel power stations.

The most challenging of all is the estimated volume of metals required to manufacture just the first generation of renewable technology units exceeds current mining production capacity to deliver in the time frame asked for. stated mineral reserves are also inadequate for the task.

Possible solutions could be to develop the industrial value chains for different battery chemistries, other than lithium ion. The current paradigm is to support lithium-ion chemistry in all large-scale development. The author has personally experienced this in observing what gets funded in research and development.

The largest industrial task before us is to establish some form of station power storage to manage electrical power generation intermittency from wind and solar stations. There is clearly not enough mineral resources to produce this. An alternative could be to develop an electrical engineering technology that could cope with variable power supply. This would reduce or even negate the need for a power buffer, and thus change our resource supply requirements. To do this requires a change in paradigm on multiple fronts though.

[10] Going climate-neutral by 2050 - A strategic long-term vision for a prosperous, modern, competitive and climate-neutral EU economy

# Circular economy in the real world

Mats Linder
Head or Consulting Stena Circular Consulting
mats.lindner@stenarecycling.se

We've talked about the circular economy as a concept for over a decade, but has it in fact been going anywhere? What does the circular economy look like today, and where is it heading in the next 10 years?

## Circular economy's coming of age

While for most people, circular economy still feels like a new idea, it has been around for a long time in some circles (no pun intended)[11]. I would argue that its real coming of age happened in 2012. In a small side event venue at the World Economic Forum meeting in Davos, an unknown think-tank called the Ellen MacArthur Foundation published Towards the Circular Economy[12]. From this moment, the dialogue shifted.

Suddenly an idea that mostly engaged the odd academic and environmental policy wonks was shown to be a matter of business opportunities and value potential. It went from the bulletin board to the boardroom. Leadership teams across the world were eyeing a new item on their agenda. And at the World Economic Forum anno 2023, circular economy is one of the most prominently featured topics.

## Policy pushes for circular economy, but we are still not dematerializing

So, what can the first 10 years of grown-up circular economy teach us? How far have we come in turning theory into practice? There are two answers to this question. And which is true for you depends on how you look at the problem.

The first is that momentum for circular economy is strong and accelerating. Some 49 countries, in addition to the EU, have national roadmaps for circular economy launched or under development. Circular economy is broadly recognised as a critical lever to reduce greenhouse gas emissions, as half of them emerge from extraction and refining of the virgin resources used by the economy.[13]

Among SMEs and start-ups, we see an accelerated increase in product-as-a-service and other circular business models[14]. And in finance, the number of public equity funds and corporate bonds with a sole or partial circular economy focus grew from just one in 2018 to over 20 by end of 2020[15].

The second answer is that on a macro level, we are still hopelessly addicted to the extraction of virgin raw materials.

Between 1970 and 2018, global GDP grew by a factor 4, while global resource extraction grew by 3.4 times[16]. This 85% correlation is quite mind-boggling. Did we not talk incessantly about sustainability in that same period? What of the grand promise to 'dematerialise' our lives offered by the digital revolution? By one measure, the world is on average only 7.2% circular (Sweden 3.4%) – a downward trend since 2018! – since we rely on mostly virgin

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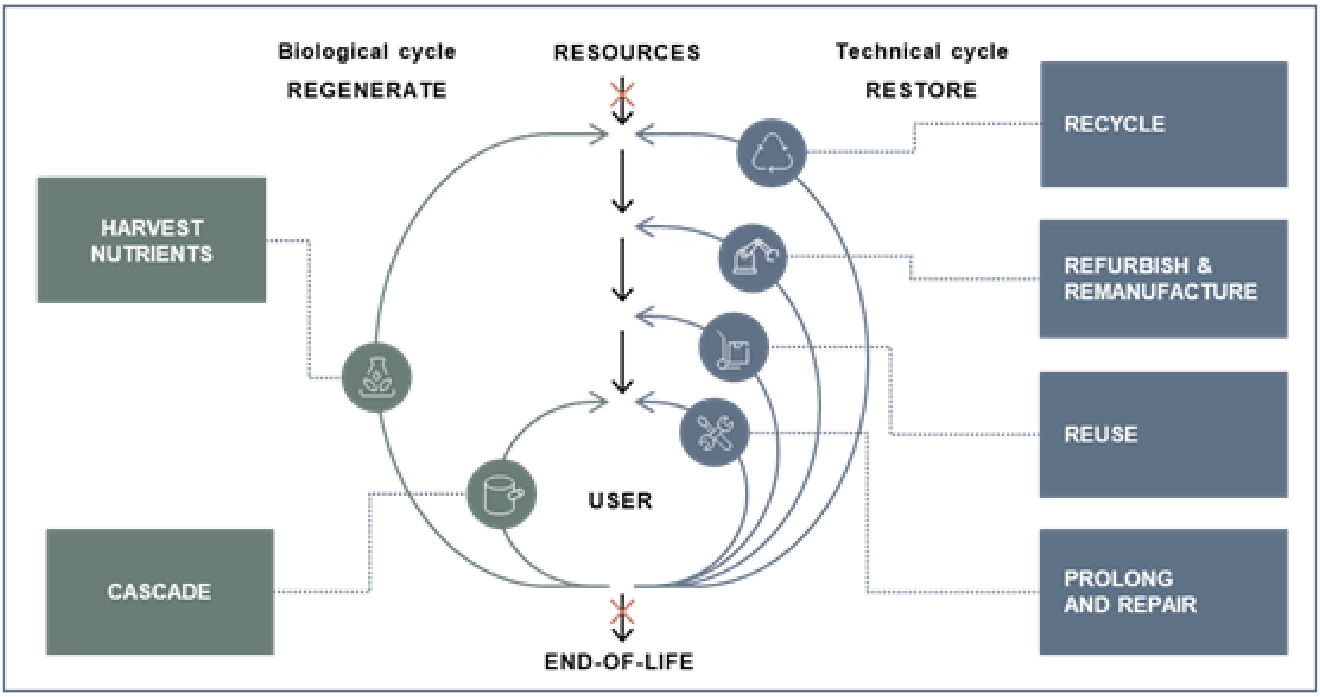
[11] For example, China adopted circular economy as a 'National Endeavor' as early as 2002
[12] Towards the Circular Economy
[13] https://www.clubofrome.org/wp-content/uploads/2022/10/Earth4All_Deep_Dive_Wijkman-2.pdf
[14] https://www.systemiq.earth/wp-content/uploads/2021/11/XaaS-MainReport.pdf
[15] https://emf.thirdlight.com/file/24/Om5sTEKOn0YUK.Om7xpOm-gdwc/Financing the circular economy - Capturing the opportunity.pdf
[16] https://www.resourcepanel.org/reports/global-resources-outlook

resources to drive our economy. Clearly, we still have a lot of ground to cover.

**Figure 20 Value preserving loops of a circular economy (Note that this contribution focuses on the technical cycle on the right-hand side)**




Source: Stena Circular Consulting, adapted from Ellen MacArthur Foundation

While the hallmark of a circular economy is to keep products in the economy through a series of concentric 'loops' (Figure 20) as of today, circular economy in practice is still mostly equivalent to the outermost loop of recycling.

That's understandable. Virtually all products on the market were not designed for any other end-of-life treatment. It takes serious intention and conscious design to design something to be remanufactured. Even business models must be re-examined. And since the products reaching end of life today are those designed yesterday, we are dealing with a significant backlog.

## Opportunities and limits to recycling

Good collection and recycling practices thus play an essential role of converting as much as possible of end-of-life products into high-quality resources. Modern recycling is a sophisticated process and logistics enterprise that can be remarkably efficient.

At Stena Recycling, we are proud to be among the leaders in Europe (Figure 21). We can shred and sort electronic components that were previously considered so complex they were lost. We can recycle or recover 9X% of the materials of a scrapped car, while supplying the automotive industry with recycled metals saving up to 95% of GHG emissions.  We're experts in recovering the precious critical raw materials making up the batteries of a brand-new global fleet of EVs.

This is important work, but until alternative product and business model design start penetrating the market, recycling will remain just the foundation of a circular economy. We need to build up the rest.

And recycling has its limits. It can lead to the misunderstanding that we've done our bit and All Is Well.

For most economic actors – from suppliers and OEMs to end-consumers – recycling is the easy and most intuitive thing to do. It does not demand the changing of habits, processes, or business models. But this perspective essentially views recycling as a big clean-up operation – an after-thought to whatever design decisions were made earlier.

Recycling has not traditionally been an integrated design consideration, leaving the industry in constant uphill struggle against increasing complex new products, made with new materials in new ways. Ask a recycler how many times they have been consulted by a manufacturer before they made a consequential decision on what materials or assembly technique to use. You'll be met by a blank stare. Recyclers don't get that question. At least not until now.

**Figure 21 Circular economy impact at Stena Recycling**


Source: Stena Recycling sustainability report 2021/2022

## Seizing value creation opportunities offered by a circular economy

This focus on recycling coupled with the lack of conscious design for it have two important consequences. First, it means that recycling is far less effective than it could have been. Complex, technical products and materials, such as many different plastics, electronics components and a long tail of materials are not recycled at all. The threshold of value and volume needed for it to make economic sense is too high. Second, we are missing out on a large part of the value creation opportunity offered by the circular economy. From the circular economy point of view, recycling loses more of the added value in products by destroying their structural integrity. It requires more resources to turn the resulting secondary raw materials into new products.

By contrast, the 'inner loops' of Figure 20 (refurbish & remanufacture, reuse, prolong & repair) circulate products and materials with more preserved structural integrity and value. The amount of resource – and value loss – incurred to keep them in the economy is reduced. Recycling plays a critical role of 'last resort' for material recirculation, but for the circular economy to mature and unleash its true potential, assets and products need to increasingly go through the inner loops as well[17].

Acknowledging this need for a broadened scope, Stena Recycling, along with other players in the industry, is looking to expand its value proposition towards the inner loops. Among other things, we have launched an electronics re-use service, partnered with customers to provide tailored take-back solutions, and we provide knowledge leadership and professional services to support our customers in future-proofing their business through circular economy strategy and innovation. Importantly, we have started to have those critical conversations with designers of manufacturers of products, which are bound to end up in the recycling stream one day. For example, we have worked with Electrolux to design a vacuum cleaner that is both made with 100% reused and recycled components and fully recyclable[18].

## Circular economy at the crossroads

Ten years on then? Well, there's rapid change and momentum bearing all the hallmarks of an exponential path which makes the outcome very difficult to predict. On the one hand, circular economy is moving forward at breakneck speed. On the other, we're still merely taking care of all the stuff that was not designed for circularity while trying to catch up with our addiction to virgin resources.

So which path will we choose? Will the prospect of moving beyond recycling be fully realized so that we can finally unlock the full value creation opportunity provided by the circular economy? Or will OEMs, suppliers, consumers and – yes – also the recycling industry, continue to do business as usual as if we were frozen in the headlights, panicked by the ever more urgent need to act?

Time will tell, but nothing will happen automatically. It takes daring leadership to continue to disrupt and explore the opportunities of a circular economy. It begins with you and me.

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[17] When recycling can be done using large-scale, automated processes, it can be more resource-efficient than any of the inner loops. However, for complex, highly value-added products made with relatively small amounts of material, an inner loop can capture more value.

[18] https://www.stenarecycling.se/insikter/made-to-be-re-made/

# The Green Bond Editorial Team

**Thomas Thygesen**
Head of Strategy, Head of Research
Climate & Sustainable Finance
thomas.thygesen@seb.dk

**Elizabeth Mathiesen**
Senior Strategist
Equity Strategy Research
elizabeth.mathiesen@seb.dk

**Gregor Vulturius, PhD**
Advisor
Climate & Sustainable Finance
gregor.vulturius@seb.se

**Tine Vist**
Senior Quantitative Strategist
Equity Strategy Research
tine.vist@seb.dk

**Filip Carlsson**
Junior Quantitative Strategist
Macro & FICC Research
filip.carlsson@seb.se

**Lina Apsheva**
Analyst
Climate & Sustainable Finance
lina.apsheva@seb.se

# Contacts at SEB

**Hans Beyer**
Chief Sustainability Officer of SEB
hans.beyer@seb.se

**Christopher Flensborg**
Head Climate & Sustainable Finance
christopher.flensborg@seb.se

**The Climate & Sustainable Finance Team**
greenbonds@seb.se

## SEB Norway:
**Ben Powell**
Head Climate & Sustainable Finance in Norway
benjamin.powell@seb.no

## SEB Finland:
**Anssi Kiviniemi**
Head of Sustainability in Finland
anssi.kiviniemi@seb.fi

## SEB Germany:
**Alexandra Themistocli**
Head of Sustainable Banking in Germany
alexandra.themistocli@seb.de

## SEB UK:
**Renato Beltran**
Client Executive, LC&FI
renato.beltran@seb.co.uk

## SEB Hong Kong:
**Carol Au-Yeung**
Client Executive, Financial Institutions Coverage
carol.au.yeung@seb.se

## SEB Singapore:
**Eng Kiat Ong**
Financial Institution Coverage Singapore
eng-kiat.ong@seb.se

## SEB Denmark:
**Lars Eibeholm**
Head of Sustainable Banking in Denmark
lars.eibeholm@seb.dk

## SEB USA:
**John Arne Wang**
General Manager
john.wang@sebny.com

## SEB Baltics:
**Aušra Šamšonienė**
Sustainability Officer, Baltics
ausra.samsoniene@seb.lt

**Viktors Toropovs**
Sustainability Officer in Latvia
viktors.toropovs@seb.lv

**Audrius Rutkauskas**
Sustainability Officer in Lithuania
audrius.rutkauskas@seb.lt

**Evelin Allas**
Sustainability Officer in Estonia
evelin.allas@seb.ee

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