THE INFLATED COST OF THE ENERGY TRANSITION: 1.6% FOR 1.5°

The energy transition, while of course necessary, will result in a series of economic, environmental and social trade-offs over the next decade. One of these trade off's is related to inflation. In this paper, Lloyd McAllister, head of sustainable investment, Raphaël Gallardo, chief economist, and Michel Wiskirski, commodities specialist, at Carmignac explore the inflationary impact of the energy transition.

The energy system has a unique role in future inflation dynamics. It is an enabling input into the rest of the economy and due to the drive to reduce carbon emissions, is undergoing a significant transformation. This means when energy prices rise, it has an amplified impact across the economy and headline inflation rates compared with more isolated sectors of the economy.

Comprehension of inflation dynamics is essential for investors. It allows us to better understand risk and make projections. But beyond this, inflation has a profound societal impact – it is a silent tax impacting everyone's purchasing power.

This is why it is critical to consider the effects of the climate transition on inflation over the next 10 years. Assessing the inflationary impacts, from the underlying economic consequences related to cost competitiveness of net zero technologies, commodity dynamics, energy security, physical climate impacts to the health consequences of reduced air pollution, the conclusion is stark: attempts to limit temperature rises to 1.5 degrees (the stretch target of the 2015 Paris Agreement) compared with pre-industrial levels will put upwards pressure of approximately 1.6 percentage points per year on inflation over the next decade, according to Carmignac research.

The unmitigated scenario

Climate change is a permanent, potentially self-reinforcing negative supply shock on the main factors of production of the economy: labour, capital, land, energy, and total factor productivity (technology, industrial organisation etc). Unmitigated, this global shock would produce a regime of elevated and volatile inflation.

Climate change will impact goods price inflation through two primary channels:

1. For raw materials: due to changing weather patterns and natural disasters affecting supply capacities (crops, mining activity and energy installations), but also inducing temporary spikes in demand (e.g. heat waves boosting power consumption).
2. For semi-transformed and manufactured goods: natural disasters and changing weather patterns may destroy some critical nodes in complex supply chains (e.g. a flood in Thailand affects the supply of a key component for the auto industry; a drought in Taiwan forces a slowdown in TSMC foundries).

There are also scenarios where natural disasters lead to upward pressure on services prices. For example, a massive influx of climate-related migration to certain areas would certainly put pressure on goods availability (food, drugs, for example) but also on services like housing and healthcare.

Serial climate shocks on goods and services prices would probably contaminate wage and expectation formation mechanisms and lead to generalised inflation pressures. We note that the European Central Bank (ECB) estimates that unmitigated, physical impacts of climate change would put upward pressure of 0.3% to 1.18% on annual inflation over the next decade[1].

(1) ECB Working Paper Series No 2821 (May 2023) The impact of global warming on inflation: averages, seasonality, and extremes.

The more-some foursome

The energy transition will impact the economy through a different process, as it is a combination of a positive demand and negative supply shocks. But the inconvenient truth is, because of the nature of the economic shocks, the transition will also be inflationary. The big difference with the unmitigated scenario is that this demand-led inflation will be *transitory*, admittedly over a long 20-to 30-year horizon, during the time needed to reconvert the capital base of our energy system. This is better than a *permanent* regime of disaster-related, supply-led inflation, i.e. a permanent state of 'climateflation', and output losses in the future.

Undoubtedly, there is considerable uncertainty on the endogenous path of climate change, and as much uncertainty on the eventual actions governments, private firms and citizens will take to mitigate it, or on the strategy adopted by producers of fossil fuels during the transition, not to mention the potential technological improvements ahead of us. However, in order to limit temperature rises by 1.5° versus pre-industrial levels, the inflation 'more-some foursome' – namely greenflation, fossilflation, demandflation and strandflation – can be reasonably expected to add 1.6 percentage points to annual inflation over the next 10 years.

THE INFLATIONARY IMPACTS OF THE ENERGY TRANSITION OVER THE NEXT DECADE*

Greenflation:
+0.1% on annual inflation

- Wind turbines 40% more expensive than previously.
- Green metal prices expected to double over the next 10 years.

Fossilflation:
+0.8% on annual inflation

- Maintenance and investment slowing on fossil fuel infrastructure – decay.
- Drop in output.
- Oil prices to rise by 20% per year.

Demandflation & strandflation:
+0.7% on annual inflation

DEMANDFLATION

- Resources being diverted from other areas of the economy.
- Consumption postponed as a result.
- Higher prices and higher interest rates ensue.

STRANDFLATION

- Price premium of 25% to 300% on new technology adoption: green cement, heat, aviation, shipping.
- Forced creation of stranded assets – government intervention – will have a large inflationary effect.

*All figures based on Carmignac research

Greenflation

The transition to a green energy system generates demand pressure on some critical resources (metals, minerals, skilled labour) needed for the manufacturing of new energy-producing capital goods (wind turbines, solar panels, EV batteries, grid infrastructure...) – 'greenflation'. We are already seeing this happen, with the cost of wind turbines having increased by 40% since 2022 due to increased input costs[2].

Greenflation impact on headline inflation over the next decade: +0.1% per annum.

Let us consider the 'greenflation' for metals and minerals critical to the transition, where nickel, chromium, manganese, zinc, copper and magnetic rare earth metals are key components of wind turbines; silver and silicon are needed for solar panels; copper and aluminium are the core metals used for the construction of grids; while lithium, cobalt and nickel are required for EV batteries.

Supply of these metals is relatively inelastic as mining projects take between five and 10 years to complete, and sometimes up to 20 years in developed countries due to environmental regulations and local resistance.

Official forecasts estimate a multiplication in demand for these metals by a factor from two to seven by 2040[3]. In addition, processing of these critical minerals is another potential bottleneck, geopolitical this time, as China has a dominant market share in the processing and refining stages of such metals. More generally, resource nationalism and geopolitical fragmentation are likely to add another layer of risk premium to the price of such commodities, and more volatility to their trajectory. So far, the total cost of renewable electricity has been reduced thanks to technological progress, steep learning curves and economies of scale. But once green capex reaches a certain critical mass, resource scarcity could begin to partly offset the gains from such favourable factors.

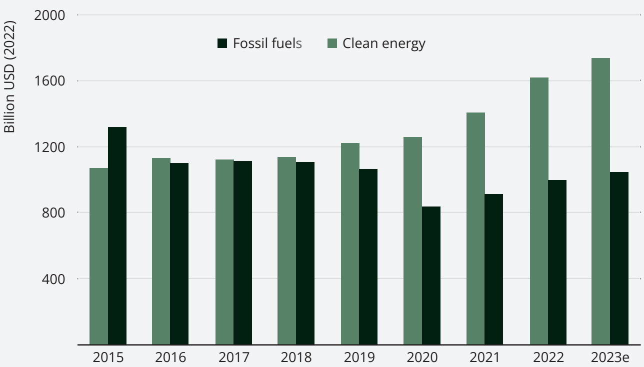
(2) https://www.weforum.org/agenda/2023/11/why-offshore-wind-cost-pressures-rising/
(3) Bloomberg New Energy Finance Transition Metals Outlook 2023

While it is very hard to estimate the cost of greenflation given the heterogeneity of scarcity, substitutability and demand elasticity of the various metals, a 2021 IMF study, using some supply and demand elasticities indicates a likely doubling of the real price of green metals in the next 10 years[4]. Using historical elasticities, our guesstimate is that this greenflation should add around 0.1% to CPI. This is a negligible impact on overall CPI, and one that would probably be a one-off, unlike the multi-year 20% inflation path we consider for oil. But we arrive at this result based on the standard sensitivity of CPI to metal prices for developed economies which was calculated before the recent acceleration of the green transition. Indeed, 0.1% is a conservative estimate and in all likelihood, this sensitivity will be larger in the future due to the increase in metal-intensity of a green energy system.

FRONT LOADING THE INFLATIONARY SHOCK?

An interesting feature of green electricity sources is that they incur high capital costs and low operational costs, as opposed to the high-opex/low-capex nature of the fossil-based legacy system. This significant brought-forward capital cost, while maintaining/slowly declining the legacy system, results in a significant cost-push inflation into the economy that will drive overall inflation. The significant rise in total energy system capital investment is highlighted below.

Global investment into clean and fossil fuel energy



Source: IEA, Global energy investment in clean energy and in fossil fuels, 2015-2023, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-energy-investment-in-clean-energy-and-in-fossil-fuels-2015-2023, IEA. Licence: CC BY 4.0.

Once capex has been spent and installed for renewable sources, marginal costs are minimal. Thus, greenflation in electricity generation is a one-off cost. The next generation of consumers will benefit from a lower marginal cost of electricity. Another feature of renewable sources of electricity is its relative abundance and uniform distribution around the planet compared with fossil fuels (finite resources and high concentration of oil and gas deposits in a few countries). For many countries, particularly in Europe and Asia, switching to renewable electricity sources should reduce their energy import bill. All things being equal, this should lead to stronger currencies for any given interest rate differential. This should be a source of disinflation, at least once the green capex transition is completed and countries no longer need to import critical green metals at elevated prices. We can consider the impact of the US shale revolution on the US current account as demonstrative of the effect this will have for other energy importers longer term.

Fossilflation

The transition will also incentivise fossil fuel producers to reduce or outright halt maintenance and upstream investment in hydrocarbon exploitation. Given the rapid rate of natural decay of existing fields (estimated to be around 5%)[5], this will lead to a drop in global hydrocarbon output. This is a negative supply shock. The consequent rise in fossil fuel prices can be called 'fossilflation'.

Fossilflation impact on headline inflation over the next decade: +0.8% per annum.

Even in the optimistic scenario of swift EV adoption and slow growth of non-gasoline demand, oil demand should remain stable at 100 million barrels/day (mbd) until 2030[6]. On the contrary, OPEC sees demand rising to 110mbd by 2040[7], and this is a key input of their production decision[8]. The natural decline rate of global oil supply is 5% per annum[9]. And we've heard estimates that current upstream investment is 75% of what is needed just to keep production constant. As a result, we estimate a natural drop in output of around 1.25%/year. In order to balance demand with production, given standard demand elasticity in developed markets, we need an oil price increase of around 20% per year. This translates into a 0.8% increase in headline annual CPI inflation.

(4) https://www.imf.org/en/Publications/WP/Issues/2021/10/12/Energy-Transition-Metals-465899.
(5) https://www.woodmac.com/horizons/shortage-of-quality-oil-and-gas/
(6) & (7) The energy transition and its macroeconomic effects (May 2023) The Bank for International Settlements (paper 135)
(8) OPEC world oil outlook, December 2023.
(9) https://www.iea.org/data-and-statistics/charts/oil-production-with-no-new-investment-from-2018-and-demand-by-scenario-2010-2040

Of course, once oil demand has reached what producers estimate to be a plateau, we expect them to maximise the intertemporal value of their fields by producing at maximum capacity in a price war analogous to the 1980s. But in the first phase of the transition, with capex in non-OPEC countries declining, OPEC countries have an incentive to maximise price and extract more rents from consuming nations by limiting their own supply (by halting upstream investment and outright production cuts).

In the grand scheme of things, this will increase the cost of the transition, but could also hasten its pace. Indeed, a 20% inflation path for oil lasting several years would be a huge shock to oil-importing nations, and real economies would adjust by reducing their oil intensity (the amount of oil needed to produce one unit of GDP), as they did after the 1970s oil shocks or as Western Europe did after the 2022 Russian gas shock. So, the related increase in inflation would be an initial shock that would be mitigated through the years by a faster decline in the fossil-fuel intensity of developed economies.

Demandflation and strandflation

The huge investment effort required by the objectives of the transition also requires, more generally, a diversion of resources from other uses in the economy. Any increase by 1% of GDP in green investment on the *demand* side will have to crowd out a similar amount of consumption in order to free up resources on the *supply* side. This postponement of consumption demand will be achieved through a combination of higher prices and higher real interest rates. Unlike typical private investment led by profit expectations, this investment demand will be, in large part, driven by subsidies and tax incentives, making it less sensitive to cyclical and rate fluctuations. Therefore, the price and rate impact will be higher than in a private-led capex boom. We may call this inflation source 'demandflation'.

At present, it is only when green technologies are cost competitive or considered superior that they are being widely adopted. For example, renewable electricity generation is competitive compared with fossil fuel or nuclear, even when you build in the costs of grid upgrades and the like. However, for many areas of green technology, such as green cement, steel, heat, aviation and shipping, we estimate there is a price premium of between 25% to 300%. If there is a forced or natural creation of redundant and stranded assets – for example, governments forcing the creation of redundancy through intervention – there will be a negative supply shock on productivity, and another inflationary effect of the transition, 'strandflation'.

Demandflation and strandflation impact on headline inflation over the next decade: +0.7% per annum.

It is estimated that green capex should increase to 2% - 2.5% of global GDP permanently during the period of the transition[10]. This demand shock would be all the more inflationary as it would not generate an increase in 'wealth', i.e. the best outcome from mitigating climate change is that the climate remains stable, and life continues as normal. Thus, demand would increase for the whole period of the transition, while productive potential would not move much. Using some standard elasticities from traditional macroeconomic models, we assume that this push on demand would generate an increase in inflation of around 0.6% per year during the whole period of the transition.

It is noteworthy that, although the acceleration of the green capex cycle has been well flagged for several years now, equity market capitalisation, which we may use as a proxy for wealth, has continued to surge as a percentage of GDP, and the household savings rate, in the case of the US, has not shown a clear structural upward trend. It therefore seems that the private sector is not integrating the reduction of wealth entailed by the energy transition, or in other words, the fact that mitigating climate change means lower consumption possibilities in the future. This state of affairs could result from expectations that the green productivity drag will be compensated by positive shocks, such as an artificial intelligence (AI) industrial revolution. However, the energy transition is not the only negative shock that financial markets should factor into future GDP prospects: an ageing demography, deglobalisation and geopolitical fragmentation should also weigh down the productive potential. Overall, we think the tug of war between a 'green' push on demand versus a cocktail of negative structural forces reducing the path of future GDP will have to be resolved by even larger price and real rate shocks given the complacency of current asset price valuations. In light of these considerations, our aforementioned estimate of the demandflation impact could prove to be on the conservative side.

The shift to greener energy sources (i.e. the move from ICE engines to EVs) is capital intensive and requires producers to consider the opportunity cost of retiring 'brown' capital assets early. To value this strandflation, we must look at the loss of productive potential stemming from the early mothballing of both energy-producing (e.g. coal mines and coal-firing plants) and unadaptable fossil-powered capital goods (e.g. ICE vehicles). This economic cost is not equivalent to the loss of output that would be calculated if these capital structures were suddenly destroyed by a natural disaster. The counterfactual scenario cannot be one where these structures continue to produce output unaffected at all by the energy transition, i.e. where maintenance and

[10] World Economic Forum: Costing the earth: What will it take to make the green transition work? Based on work of IEA, Barclays, IRENAm NGFSm BCG and McKinsey (September 2023)

reinvestment remains as usual. Rather, the transition cost is the *difference* between the stream of output obtained in the early retirement scenario versus a counterfactual scenario where this 'brown' capital is left to produce until its terminal economic decay date (through physical amortisation and obsolescence) without any re-investment into maintenance or technical upgrade.

Because the planned rate of stranding these assets is not very far from a reasonable assumption about their natural rate of decay, we find that the full impact of strandflation should be rather muted. By conducting assessments on the coal industry (for the fossil-energy producing side) and the ICE auto sector (for the user side), we have found a combined upward impact on inflation of only 0.1%.

OTHER FACTORS TO CONSIDER

Energy security

Following Russia's invasion of Ukraine in 2022, energy security has become a greater focus for corporates and regulators. This is essentially a trade of higher energy prices for greater resilience. While we think this will remain a permanent feature over the coming decade, the effects of energy-security related price shocks typically quickly dissipate within one or two quarters as the system re-organises itself and efficiencies are found. As a result, we see this creating gentle upwards inflationary pressure but reducing inflation volatility over the next 10 years.

Healthier prospects?

Some 11% of deaths have risk factors associated with air pollution, translating into an estimated economic cost of 5-6% of GDP per annum.[(11)(12)] Thinking beyond pure human health benefits, while it is tempting to believe that improved health relating to reduced air pollution would lead to economic gains in productivity and labour supply, and thus downward pressure on inflation, we find that these benefits will be long-dated and muted.

This is because 1) the main beneficiaries of reduced air pollution are typically older demographics and therefore already retired, thereby reducing the impact on labour supply, 2) the benefits of reduced air pollution are subject to a time lag due to long time horizons for new energy infrastructure to materially reduce air pollution levels, and 3) the productivity gains from avoided illness at a global level represent a minute proportion of 'days off work' saved.

Carbon taxes

We have not explicitly quantified the impact of carbon taxes on inflation. Firstly, these pose inextricable measurement issues. From a strict CPI point of view, tax wedges can be embedded, or not, in the official inflation statistics depending on their technicalities, which make them fall in the category of 'indirect' or 'direct' taxes. Besides, the proceeds of carbon taxes will be used to subsidise the production and consumption of green energy – but the precise recycling of the proceeds into reduced prices for green energy or targeted subsidies is at the discretion of governments, which conjures another layer of uncertainty. Lastly, we have estimated that the implicit price trajectory of a CO2 ton that should be achieved by a universal carbon tax would be inferior to the explicit price of carbon resulting from an extinction strategy by fossil fuel producers. Thus, the inflation derived from a carbon tax can be 'looked through' for the purpose of this study as it is overachieved by the working of fossilflation.

A central bank headache

We expect the energy transition to add approximately 1.6 percentage points to inflation each year over a 10-year horizon, before fading away as fossilflation turns into deflation and the capex cycle peaks. But this long transition period would still pose considerable challenges to monetary policy. Ultimately, central banks are the guardians of price stability, and they will be the ones to decide whether this transitory inflation should be 'looked through' at the risk of de-anchoring inflation expectations, or if central banks must lean against it and provoke deflation in other parts of the economy in the name of price stability.

It is a very thorny issue as preserving price stability would help the private sector plan and invest for an orderly energy transition (volatility in input costs is particularly detrimental to upstream mining investment), but this price stability would be achieved at the cost of higher interest rates. This means a higher cost of capital, which would reduce the economic rationality of long-term investment into new energy systems.

An optimal scenario would see global monetary co-operation on such issues, adopting a common approach, to avoid likely spillover effects through import prices, currency impact and global interest rates. Otherwise, these are very likely given the differential effect of climate change on different monetary areas. However, this is unlikely in our view; especially since the US Federal Reserve – as the globally pre-eminent central bank – will likely play a backseat role in any such debate, fearing implications for its independence should it enter this controversial area and instead pass the baton primarily to US Congress.

The ECB and the Bank of England are likely to take a "do no harm" approach initially. Firstly, by favouring green industries and penalising others in their collateral frameworks and any future purchase programmes involving private sector assets. More significant steps are possible but are more difficult. These could involve allowing a wider range of inflation outcomes, so long as inflation expectations are under control; for example, inflation running between 2% to 3% for several years.

Ultimately, we would not rule out the potential exemption of some climate costs from inflation definitions or lengthening the period during which 'price stability' is achievable. These would only follow after a clear re-anchoring of inflation expectations in the current cycle.

For central banks and governments to navigate the social upheaval of the energy transition, governments will need to provide more detailed transparency on the investment costs, benefits and burden sharing within and between countries. By doing this, governments will be able to provide greater certainty to investors on the economic characteristics of the energy transition and achieve sustained democratic support for essential but disruptive climate regulation and adaptation measures.

(11) World Bank (2021) The Global Health Cost of PM2.5 Air Pollution
(12) Murray CJL, Aravkin AY, Zheng P, et al., GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet2020;396:1223-49. doi:10.1016/S0140-6736(20)30752-2 pmid:33069327.

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