

## Investment Newsletter – March 2023

**“I know of no way of judging the future but the past”**

**-Patrick Henry, 1775**

We normally start to plan the contents of this letter at the commencement of each month. But sometimes our planned topics get shelved to make way for addressing more immediate news of the month.

Over the past ten days, global markets have been gripped by the news of the two US regional banks that have failed and a possibility of a major European bank teetering on the brink. Naturally, such news rouse concerns especially when the news media is providing a running commentary with an overdose of negative inferences for investment markets. The visuals of long queues of depositors outside the branches of failed banks trigger that inner voice of fear that says *‘what if that happens to us in Australia? Are my investments safe?’*. Rather than going through the mundane details of each bank’s failure we are going to use this as an opportunity to rise above the immediate issues concerning the markets and go right to the top and get perspective. After this letter you should get a wider perspective, feel settled, and optimistic about staying the course of your investment plan.

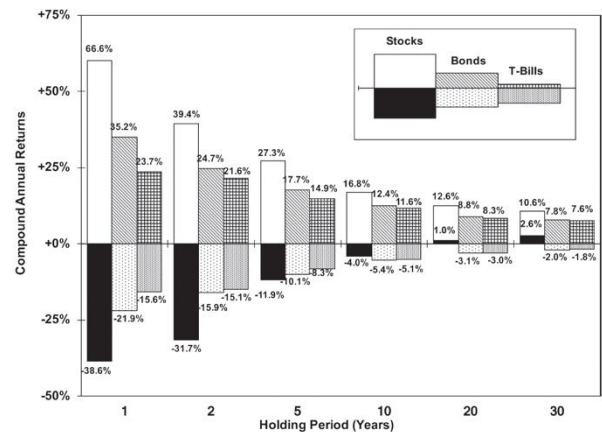
*P.S. We will just make a quick comment here on the failing banks and contagion risks. Banks in the US fail almost every year (yes, see Figure 6 later) and if there is a large bank failure that jeopardises the stability of the US banking system then the US federal regulators are mandated to prevent that from happening. Australian Banks are well capitalised, have sufficient liquidity to meet their near-term obligations, and importantly they don’t punt depositor funds on investments in fixed income markets like the failed US banks did, and APRA is ahead on the Basel III global banking standards.*

**Let’s start from the very top.** Markets are likely to remain volatile and uncertain in the coming months. On a short-term basis, make sure you have sufficient cash on hand and income coming from your investment portfolio(s) to continue funding your expenses in the coming months. To put it another way, don’t depend on capital growth in the near term. This is an important investing mindset for the rough economic times as it is for the good times. While capital growth across assets is almost certain over the long term, it is equally uncertain over the short term. Income is where you get more certainty during uncertain market periods.

Speaking of uncertainty of total real returns, the chart below shows the volatility of real returns (after inflation) across stocks and bonds over the very long period of 1802-2021. Over this 220-year history, the best ever and worst ever real returns are shown over 1 year holding

period, 2 year holding period, 5 years, 10 years and so on.

**Figure 1: Maximum and minimum real holding period returns, 1802–2021 - US Market**



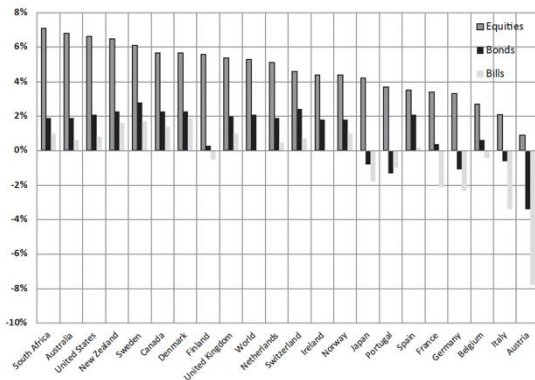
Source: Stock Returns - Measurement and Valuation, Mcgraw Hill 2022, Jeremy Siegel

What the above chart is telling you is that stocks are unquestionably riskier than bonds over one and two-year periods. However, in every five-year period since 1802, the worst performance in stocks, at -11.9% p.a., has been only slightly worse than the worst performance in bonds. And for 10-year holding periods, the worst stock performance has actually been better than that for bonds.

For 20-year holding periods, stock returns have never fallen below inflation, but returns for bonds fell more than 3% p.a. below the inflation rate from 1961–1981. During that inflationary episode, the real value of a portfolio of Treasury bonds, including all reinvested coupons, fell by nearly 50% (we have covered that bond bear market in past letters also). The worst 30-year return for stocks remained comfortably ahead of inflation by 2.6% p.a. (1902–1932), a return that is not far below the average performance of fixed-income assets.

Furthermore, Australia and the US have continued to be the best source of real returns across stocks and bonds when averaged over the past 120 years to 2020.

**Figure 2: Average annual real stock, bond returns, 1900–2020**



Source: Stock Returns - Measurement and Valuation, Mcgraw Hill 2022, Jeremy Siegel

So the message is to invest for the long term as you can see from the past long term returns that markets have endured the two bloodiest world wars in human history in the past century, it suffered pandemics, revolutions, cold wars, hyperinflation, deflation, technological revolutions, globalisation, and so on and so on. Play the long game as they say.

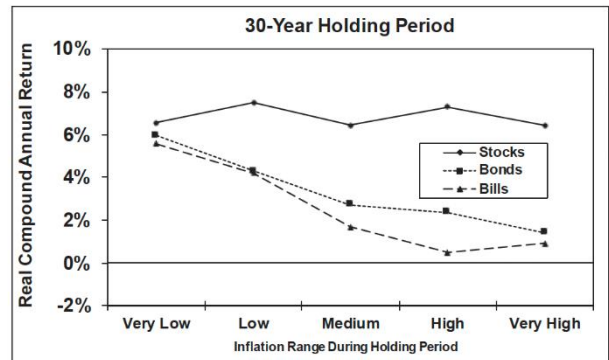
**The big topic right now in markets is inflation.** Australia's inflation rate is close to 8% p.a. and while we expect this inflation to start coming down in the coming months as interest rates start to bite into consumption, we are not convinced that inflation will return to 2% anytime soon.

Furthermore, we can offer quite a convincing argument for inflation to remain in the moderate range of 4-6% p.a. for a long period ahead. If the reasons that contributed to falling inflation over the past decades start to reverse as they are, i.e. ageing population leading to shrinking labour pool, rising dependency ratios (wage increases anyone??) and lower tax revenue for the government, right at the wrong time when healthcare budgets are soaring, basic welfare income increases are being demanded, infrastructure spending for transition to renewable energy requires trillions of dollars, China turning more into a circular economy and consumption focused and thus unwinding the disinflationary benefit of cheap exports to advanced economies and so on. We have also entered a long period of cold war between the US/Allies and China/Russia, which means that global supply chains will likely continue to be disrupted (and reset into more expensive jurisdictions) causing spikes in prices of commodities, finished goods, labour, and energy. This all reads into supply side inflation, which our central banks frankly will have little impact on without driving our economies into a recession and keeping them there.

For central banks to hold economies in a recession to contain inflation whose origin is structural and supply-side in nature, frankly, is not a politically sustainable fight. It is thus no surprise that treasurer Jim Chalmers has RBA's governance and decision-making structure currently under review and the current governor's tenure is anything but guaranteed beyond 17 September 2023. It is all too plausible that our central bank may move away from the 2-3% inflationary target to a moderately higher range. The current target is a made-up range without much science behind it. It was first coined in the early

1990s speeches of the then RBA governor Bernie Fraser as an aspirational target for inflation. If inflation remains sticky and moderately higher compared to the experience of the past decade, then stocks are going to be the place to hedge your portfolios for inflation. However, you will need to hold through the short-term volatility. Stocks are an inflation hedge over the long term but can struggle over the short-term holding period such as 1 year.

**Figure 3: Long term holding period returns and inflation - 1871-2021 - US Stocks**

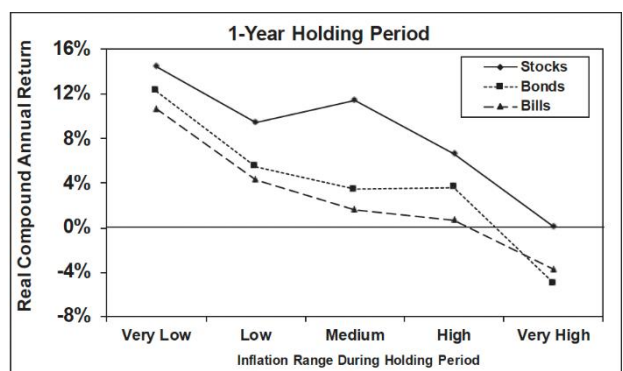


Source: Stock Returns - Measurement and Valuation, Mcgraw Hill 2022, Jeremy Siegel

Stocks serve as excellent long-term hedges against inflation whether it is low, medium, or high. In fact, stocks continue to hold real return premiums of roughly 6% in all inflationary scenarios provided you hold through the short term volatility (see Figure 3 above). Bonds tend to deliver the highest real return (above inflation) when inflation is low but real returns on bonds can just about keep up with inflation if it remains higher for a long time!

Please note, the data also indicates that neither stocks nor bonds are good short-term hedges against inflation. The chart below shows that over a short term such as 1 year, as inflation adjusts from very low, to low, to medium, to high (as has been the experience of the past year), the expected real returns from stocks and bonds also fall over the short term.

**Figure 4: Short term holding period returns and inflation - 1871-2021 - US Stocks**



Source: Stock Returns - Measurement and Valuation, Mcgraw Hill 2022, Jeremy Siegel

**If stocks represent real assets, why do they fail as a short-term inflation hedge?** A popular explanation is that inflation increases interest rates on bonds, and higher interest rates on bonds depress stock prices. In other

words, inflation must send stock prices down sufficiently to increase their future return to match the higher rates available on bonds. **However, this explanation is largely incorrect.**

Certainly, expectations of rising prices do increase interest rates. However, higher inflation also raises the expected future cash flows to shareholders as companies pass on higher prices on goods and services, though these increases can take a lead time before companies can become confident that their customers will largely absorb higher prices and start to update their menu prices and stock catalogs. Stocks are claims on the earnings of real assets, whether these assets are machines, labour, land, or ideas. Inflation is defined as a rise in the prices of outputs, and as long as the price of inputs does not rise more than those outputs, profits will rise as much as inflation. And so, this supports higher share prices over the long term.

**You can't have interest rates rise so aggressively and not hurt a few investors near term**

The number of interest rate increases in the past year by the central banks of US, AUS, NZ, and Europe has been unprecedented and nothing short of a shock therapy for market participants. The U.S. Federal Reserve raised its official interest rate from 0% to 4.75% within 10 months, this rate of increase has no match in history and so it shouldn't come as a surprise that there will be some market participants who would have borne the brute force of this blunt tool of the US central bank in its attempt to contain inflation. Victims thus far have been investors in crypto currencies, investors in high growth technology companies, investors in government bonds, and the latest victims as of last week are two regional US banks. **The only thing common amongst all of these investors was their access to cheap money at low interest rates.**

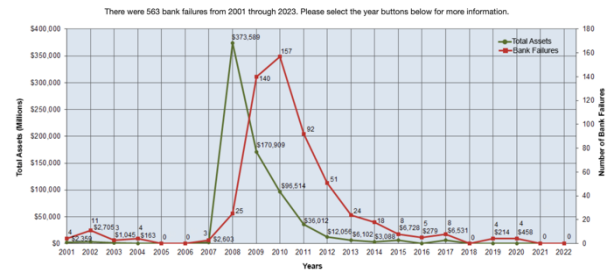
Figure 5: US Federal Reserve Interest Rate



Small regional bank failures are quite a common occurrence in the U.S. There were 563 bank failures from 2001 through 2023 (See Figure 6). And, as you can see by the red line on the chart in Figure 6, the number of bank failures counted in the hundreds during the GFC years of 2008-2010 but even during the relatively quiet period of the past ten years there continued to be handful of bank failures every year in the US throughout the past decade. In fact, having no bank failure in any given year would be considered unusual. The important thing for investors to note is that in the worst-case scenario of a bank failure being large enough to cause a systemic risk to the US economy, US federal

regulators have written into the law to step in and effectively do what-ever it takes to stop the bank failure turning into a contagion for the US banking system.

Figure 6: US Bank Failures 2001-2022



Source: US FDIC

Another major concern roiling the markets over the past week has been the possibility of Credit Suisse, a major European bank including wealth management, falling into bankruptcy. It needs to be said that Credit Suisse has been a weakening franchise ever since the Global Financial Crisis in 2008. Credit Suisse has been mired in a number of scandals over the years and most recent were accounting issues, compliance failures, penalties, outflows of billions of dollars from its asset management business, and loss of confidence of its shareholders in management's ability to turn the business around. Nevertheless, the swiss central bank has stepped in to provide assurances of available liquidity to the bank if they need it and its competitor, UBS, has also made a takeover offer of \$1 billion. All this amounts to the risk of Credit Suisse failing and causing a contagion for the banking system as either manageable or negligible if the bank is taken over by UBS or another bank.

Figure 7: Credit Suisse shares peaked in 2007 and have been declining ever since



**Final Comment**

Use cash to take care of your expenses near term but apart from that remain invested across credit, gold, real assets, and stocks. Relax and try not to pay too much attention to the market commentariat which thrives on getting your attention by sensationalising economic news stories and yes sometimes you will hear of even banks failing in the US but hold your nerve. While the near-term economic headwinds and inflation will keep asset classes volatile, the markets will just work through these turbulent times like they always have in the past!

## GLOBAL MARKETS OVERVIEW

	Units	Month End Value	Price Performance (% Chg)			
			1-day	1-mth	6-mths	1-year
<b>Developed Markets Equities</b>						
ASX 200	AUD	7,258	0.46%	-2.92%	3.89%	2.97%
ASX 200 Futures	AUD	7,198	0.43%	-3.06%	5.10%	5.37%
Dow Jones	USD	32,657	-0.71%	-4.19%	3.64%	-3.65%
S&P 500	USD	3,970	-0.30%	-2.61%	0.38%	-0.23%
Stoxx Europe 600	EUR	461	-0.32%	1.74%	11.08%	1.77%
FTSE 100 (UK)	GBP	7,876	-0.74%	1.35%	8.13%	5.60%
DAX (Germany)	EUR	15,365	-0.11%	1.57%	19.71%	6.25%
CAC (France)	EUR	7,268	-0.38%	2.62%	18.66%	9.15%
Nikkei 225	JPY	27,446	0.08%	0.43%	-2.30%	3.46%
<b>Emerging Markets Equities</b>						
MSCI Emerging Markets	USD	964	-0.33%	-6.54%	-3.03%	-17.70%
Shanghai Composite	CNY	3,280	0.66%	0.74%	2.42%	-5.28%
South Korea	KRW	2,413	0.42%	-0.50%	-2.39%	-10.61%
Taiwan	TWD	15,504	0.00%	1.56%	2.71%	-12.17%
Brazil	BRL	104,932	-0.74%	-7.49%	-4.19%	-7.26%
South Africa	ZAR	71,694	0.25%	-2.37%	18.04%	2.97%
<b>Foreign Exchange</b>						
AUDUSD	Currency	0.6729	-0.15%	-4.62%	-1.65%	-7.35%
AUDGBP	Currency	0.5597	0.20%	-2.26%	-4.93%	3.42%
AUDEUR	Currency	0.6363	0.17%	-2.03%	-6.52%	-1.70%
AUDCNY	Currency	4.68	-0.10%	-1.90%	-1.11%	2.32%
<b>Commodities</b>						
LME ALUMINUM 3MO (\$)	USD/mt	2,373	0.42%	-10.25%	0.59%	-29.55%
LME COPPER 3MO (\$)	USD/mt	8,961	1.81%	-2.84%	14.86%	-9.33%
LME NICKEL 3MO (\$)	USD/mt	24,794	-2.79%	-18.29%	15.80%	2.11%
SILVER FUTURE May23	USD/oz	21.07	1.34%	-12.35%	16.05%	-15.15%
ICE Newc Coal Fut Apr23	USD/mt	194.10	-1.47%	-19.24%	-45.18%	7.53%
62% Import Fine Ore in USD	USD/t	116.87	0.16%	-0.85%	22.70%	-7.43%
Gold Spot \$/Oz	USD/oz	1,827	0.54%	-5.26%	6.77%	-4.30%
WTI Oil	USD/bbl	77.05	1.81%	-2.68%	-0.38%	-2.53%
Henry Hub	USD/mmbtu	2.49	-3.11%	-6.60%	-72.13%	-42.07%
Corn	USD/Bu	629.50	-2.06%	-7.39%	-6.57%	-9.75%
Wheat	USD/Bu	691.50	-0.65%	-9.16%	-14.52%	-25.48%
<b>Fixed Interest</b>						
<b>10-Yr Bond Yield</b>						
Australia	AUD	3.85%	-0.02%	+0.30%	+0.26%	+1.71%
US	USD	3.92%	+0.01%	+0.41%	+0.73%	+2.10%
Germany	EUR	2.65%	+0.07%	+0.37%	+1.11%	+2.52%
Japan	JPY	0.51%	-0.00%	+0.01%	+0.28%	+0.31%
Italy	EUR	4.48%	+0.06%	+0.32%	+0.58%	+2.77%
<b>Australian Rates</b>						
Cash Rate	AUD	3.35%	+0.00%	+0.25%	+1.50%	+3.25%
90-Day BBSW	AUD	3.60%	+0.03%	+0.26%	+1.13%	+3.53%
180-Day BBSW	AUD	3.95%	+0.03%	+0.28%	+0.93%	+3.70%
<b>CBOE Options</b>						
CBOE VIX (Volatility Index)	Index	20.70	-1.19%	6.70%	-19.98%	-31.34%

Data as of 28 February 2023

## ECONOMIC NEWS

• **In Australia** the Reserve Bank of Australia (RBA) raised interest rates to 3.35%, the highest level since September 2012, and said further tightening will be needed to crush stubbornly high inflation as it (1) Downgraded 2022 economic growth (GDP) forecasts to 2.75% while maintaining 2023 and 2024 growth forecast of 1.5% and 2025 growth forecast of 1.75%. (2) Upgraded 2022 and 2023 core inflation (CPI) forecast by to 6.9% and 4.25%, respectively, while downgrading 2024 forecast to 3% and forecasting 2025 core CPI of 3%, while warning that a "price-wage spiral" could cause high inflation to persist for longer than expected. (3) Forecast cash rate peaking at 3.75% in half year to 30 June 2023 before declining to 3% by mid-2025.

• **In Europe** the European Commission raised its euro area 2023 GDP forecast to +0.9% while maintaining 2024 forecast at +1.5%, forecasting the currency bloc to narrowly avoid a recession as it downgraded 2023 CPI forecast to 5.6% and

2024 to 2.5%. Euro-area inflation slowed by less than anticipated in February with CPI rising +8.5%, while underlying price pressures surged to a new record with core CPI up +5.6%.

• **In U.K.** the country avoided recession in 2022 with GDP growing +0.4%. Consumer confidence rebounded by the most in almost two years in February.

• **In India** the central bank (RBI) slowed the pace of interest-rate increases, raising the benchmark repurchase rate to 6.50%, while keeping the door open for further policy tightening to curb core inflation. GDP growth slowed in December Quarter 2022 with GDP rising +4.4% as manufacturing contracted for a second straight quarter, but ministry maintained its estimate for a +7% growth in 2023.

• **In Japan** the economy rebounded at a slower pace than expected in December Quarter 2022 with GDP expanding at an annualized pace of +0.6% over the quarter, turning positive after a revised -1% contraction in September quarter 2022, with consumption recovering, helped by domestic travel spending. However, businesses cutting back on their outlays more than forecast and inventories dragging heavily on the economy.

• **South Korea** the central bank (BOK) paused its monetary policy tightening campaign, holding the seven-day repurchase rate at 3.5%, however, BOK Governor announced intent to keep the door open to resuming policy tightening as the bank downgraded both 2023 GDP and inflation growth forecast to +1.6% and 3.5%, respectively.

## GLOBAL MARKETS

**US markets** declined, with the Dow Jones down -4.2% and S&P500 down -2.6%, as Fed's semi-annual report revealed officials expect that ongoing increases in the target range will be appropriate in order to attain a stance of monetary policy that is sufficiently restrictive, leading to Fed swaps upgrading odds of 0.25% increase at each of next 3 meeting to 'near-certainty' and pricing in a peak policy rate of 5.5% in September.

**The ASX200** declined -2.9%.

• **Long-dated US treasury yields** were higher, with the 2-Yr yield at 4.82% and 10-Yr yield steady at 3.92%.

**Asian markets.** Asian markets were mostly higher over the month, with the Nikkei up +0.4%, as BOJ Governor nominee Kazuo Ueda said current policy easing was appropriate. KOSPI was down -0.5%, as South Korean Finance Minister Choo Kyung-ho warned a "considerably difficult" environment is likely to continue in the economy through at least for half year to June 2023. The Shanghai Composite rose +0.7%, as PBOC forecast China's economy to rebound in 2023 and pledged to strike a balance between supporting growth and preventing inflation risks.

**Commodities.** Over the month, WTI oil price declined -2.7% to US\$77.05/bbl, as positive sentiment from Russia announcing plans to cut March oil production by 500k barrels a day and Fed Bank of Dallas forecasting U.S. shale growth to halve in 2023 on labor crunch was more than offset by U.S. announcing sell 26m barrels of crude from SPR and IEA forecasting global oil markets to likely remain in surplus in June half 2023 amid surprisingly robust output from Russia, while boosting forecasts for global oil demand by 500k



barrels a day for March quarter 2023 and by ~250k barrels a day for the year as a whole, anticipating world consumption to climb by 2m barrels a day this year to average 101.9m a day.

## THE LONG READ

### HYDROGEN ENERGY WILL SOON EMERGE FROM THE SHADOWS

After a century of its existence in relative obscurity, Hydrogen energy is set to step-up and play a critical role in transitioning the global economy's reliance on fossil fuels (coal, oil, natural gas) to a world that runs exclusively on renewable energy sources such as wind, solar, and yes, Hydrogen.

To that end, Hydrogen economy is racing towards mass adoption in the next ten years. Governments are beginning to boldly declare their vision statements for Hydrogen and outlining their road maps. Suppliers and buyers in the hydrogen ecosystem are starting to arrange themselves in a queue that is largely dictated by their turn on the Hydrogen energy's falling cost curve - read in simple terms as 'Hydrogen is becoming affordable in stages'. Investors too have an important role to play as providers of capital to fuel, an un-intentional pun, the nascent hydrogen economy.

Before we dive into the economics & investment opportunity of Hydrogen economy we shouldn't be so presumptive to assume that the average reader of this article has kept up their chemistry knowledge taught in high school.

#### What is Hydrogen?

If you remember the periodic table from science class at school, or if you just google it, you will see that Hydrogen is the first amongst 118 basic and naturally occurring elements on earth. At room temperature Hydrogen exists as a colourless, odourless, and highly combustible gas but it doesn't just float around in the air. Hydrogen at room temperature usually occurs as a building block of other matter, in fact, 75% of all matter in the universe can thank Hydrogen as being one of the ingredient elements. And to put you further at ease with Hydrogen can I just add that each one of us has 10% Hydrogen (by mass) in our bodies. So, Hydrogen should not be feared as something foreign and unfamiliar! On earth, Hydrogen joins forces with oxygen to form water and many other hydrocarbons. Water has two atoms of Hydrogen and one atom of Oxygen; this is important information as Hydrogen energy economy sources Hydrogen atoms, for energy purposes, from water molecules through a chemical splitting process called electrolyses.

#### Manufacturing & Supplying Hydrogen Gas

Hydrogen is infinitely available and is totally renewable and climate friendly, it's not mined from the earth like fossil fuels which leave a scared landscape and gaseous emissions that are clearly suffocating the living beings

through pollution and warming the climate to a point where, if not addressed, we will soon reach a point of no return. On the other hand, Hydrogen is produced entirely from an above ground manufacturing process known as electrolyses. Just imagine electrolyses as a process that takes each drop of water, which is a cluster of hydrogen and oxygen atoms attached together by tiny bonds or branches just like a cluster of grapes are attached to each other by tiny branches or pedicels. Electrolyses process splits apart the cluster of hydrogen atoms from oxygen atoms. Scientists have known for over a hundred years that pure hydrogen gas escaping from this process can be captured and stored in a high-pressure gas tank.

This captured and safely stored hydrogen gas is a rich form of energy that can be used with incredible versatility such as heating your home, or cooking a meal by burning hydrogen, the same way many homes burn natural gas except that with burning hydrogen you get water vapour as a by-product and burning natural gas you get carbon emissions. Similarly, we can use hydrogen gas instead of natural gas for power generation. The turbines at the heart of gas-fired power stations need relatively little modification to run on Hydrogen instead of natural gas. The jet engine is a close cousin of the gas turbine, so hydrogen can be used to fly aeroplanes, again, the main waste gas is water vapour (i.e. steam) in all of these applications instead of toxic carbon dioxide and other greenhouse gases that arise from burning natural gas, oil, and coal.

Let us introduce one further important knowledge for you to appreciate Hydrogen economy. ***While it is simple enough to understand the electrolyses process, you are probably wondering where does the energy come from to power the electrolyses process to begin with as it's very energy intensive and not going to run on its own?*** You are right! The idea here is to set up industrial scale solar panel farms in the hottest and most sun exposed parts of the world such as the arid central parts of Australia, the Sahara desert in Africa, parts of the US, and South America are all perfect places for setting up these solar panel farms to generate renewable power which will directly run the giant electrolyses machines, installed right next to these solar panel farms, to produce hydrogen gas. And no, we are not talking massive use of landscape to set up wind and solar farms here either, in fact, only 1.2% of the Sahara Desert is sufficient to cover all of the energy needs of the world in solar energy.

We can apply the same method for wind turbine power stations installed in high wind geographies to power electrolyses to produce Hydrogen gas. The captured hydrogen gas can then be containerised in liquid form at low temperature (-252 degree Celsius) to ship to major cities anywhere in the world or even pushed through traditional natural gas (transmission) pipeline infrastructure that is already in place everywhere in the world. You are probably wondering come on now, that must be a very expensive shipping journey for having to keep Hydrogen in liquid form at such low temperatures. And you are right!

To bring down the heavy cost of liquifying Hydrogen for shipping purposes, there is a very smart and affordable work around and it is called Ammonia gas. Industrial chemists can mix Nitrogen gas with captured Hydrogen gas to form a third gas called Ammonia which forms a molecule where one nitrogen atom binds with three hydrogen atoms (NH<sub>3</sub>). You have to remember these molecules are carrying the energy which was initially produced from renewable sources such as solar and wind power (also remember the concept that energy always merely transforms from one form to another and not simply disappear, the trick is to maintain control over energy production and transformation). Once pure hydrogen is attached to nitrogen gas to form Ammonia, it can now be converted to liquid form at much affordable temperature of -33 degree Celsius for shipping to anywhere in the world. Once Ammonia gas is received wherever the demand for renewable energy is in the world, at the receiving country the reverse electrolyses process is carried out to strip Nitrogen gas away from Hydrogen gas and the latter is then used as a form of energy in that country's energy grid. This is the entire process Australia is planning to adopt as part of its vision to become a Hydrogen super power and make use of the continent's abundance of solar and wind energy and ship this energy via Hydrogen stored in Ammonia to countries in Asia and Europe that are not as well endowed with renewable energy.

#### **How does Hydrogen fit into the renewable energy future of the world?**

There are varying degrees of estimates but the short of it is that while solar and wind energy can produce electric power during hot and windy days and in the right seasonable conditions, these conditions are not constant and are unreliable. Clearly, there is no sun at night and there is no guarantee of a wind at all times of the year yet power and energy need of households and industry is a 24/7 requirement in every country. So, you do need a third form of energy to balance and bridge this inconstancy of availability of renewable energy from solar and wind. You need a way to produce excess renewable and solar energy in countries that can produce these at scale such as Australia, then store it in the form of Hydrogen (inside Ammonia) and distribute it around the world to balance the intermittency of domestic sources of renewable energy.

***You might now be wondering, why are we not mentioning the role of lithium ion batteries which are touted as store of renewable energy?*** The reason is that lithium ion batteries while definitely are more efficient than hydrogen fuel cells in converting the stored energy to usable energy, however, Hydrogen molecules pack a lot more energy than lithium ion batteries and are a lot lighter to carry around. By virtue of having lot more energy density, hydrogen fuel-cells based cars can run for lot longer than lithium ion batteries e.g. Toyota Mirai can hold 5 kg of Hydrogen in its tanks, giving it a range of 650 km, which is similar to petrol cars, it has quick refuelling like a petrol car, and its only by-product is water vapour.

Comparatively, lithium ion battery pack's range for each recharge cycle would be around 250-300km and the vehicle is likely to be a lot heavier which reduces the range as more energy is required to lug heavier load. And you would have to replace the expensive battery pack after some years which is not the case with hydrogen fuel cells that last the lifetime of the car.

Moreover, lithium ion batteries also take several hours to recharge. Imagine if you are running a commercial fleet of cars, buses, trucks that need to be constantly on the road. This is where Hydrogen fuel cells step in as a solution to heavy and commercial & mining industries that cannot rely on lithium ion batteries as they would be impractical in satisfying the requirements of energy intensity, duration, and maximum uptime of many commercial applications.

All this means is that, eventually, after the world has transitioned totally away from fossil fuels in the coming decades then, it is being estimated, 70% of world's energy demand will be sourced directly from renewable energy such as solar and wind (and geothermal, hydro, nuclear etc) and 20% from Hydrogen.

As with most technologies, falling cost is usually the key driver of adoption. The department of Energy in the U.S. launched an 'Energy Earthshot' initiative in 2021 aiming to get clean Hydrogen to fall from \$5/kg today to \$1/kg by 2030, at which point it will become competitive with coal!

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