Welcome to the Energy Transition… Again!

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Sitting amongst the ruins of Derrydiddle Mill here in West Yorkshire, surrounded in the spring by wild garlic and bluebells, it is hard to imagine the hive of activity this would have been 200 years ago. The clatter of the carding and spinning machines, the water wheels turning, the carts coming back and forth over the narrow bridge to the Bradford Road.

Today, we talk about 'the' energy transition as if this is the first time. But our relationship with energy has changed before.

Here at Derrydiddle Mill, we have part of the record of one of those earlier energy transitions. In this case, from the power of running water to that of steam. This was a transition from mediaeval technology to that of the Industrial Revolution.

What lessons can this history give us about how transitions happen and what to expect as we pursue our own 21st-century energy transition?

Derrydiddle Mill: From Water To Steam. A 19th-Century Energy Transition

When, in 1815, Joshua Dawson and William Ackroyd travelled the short distance across the Chevin Hill from Guiseley to the Wharfe Valley, they established their first worsted wool mill here on Gill Beck (Ellar Ghyll), as it cuts down through a narrow gorge in the Millstone Grit on its way to join the River Wharfe at Otley. This site was a logical location with flowing water to drive the water wheels that would power the mills.

But within a few years of establishing Derrydiddle Mill, Dawson and Ackroyd had moved the main centre of their operations to a location on the banks of the River Wharfe in Otley at what is now called Otley Mills.

When I first read of this sudden move, I assumed this would provide an example of the energy transition from water to steam and proof of how quickly such changes can happen. But the story is a little more complex because this new site was also powered by water. Indeed, it was not until the 1840s that Ackroyd installed a steam-driven beam engine at Otley Mills. Only then, from the mid-1840s to 1850s, do we see the rapid adoption of steam power across the north of England and the development of the large mills that still dominate many cities and towns today.

So, why the sudden move to Otley? Why did the transition to steam not happen immediately? Is this really a guide to how energy transition works? Can history tell us anything?

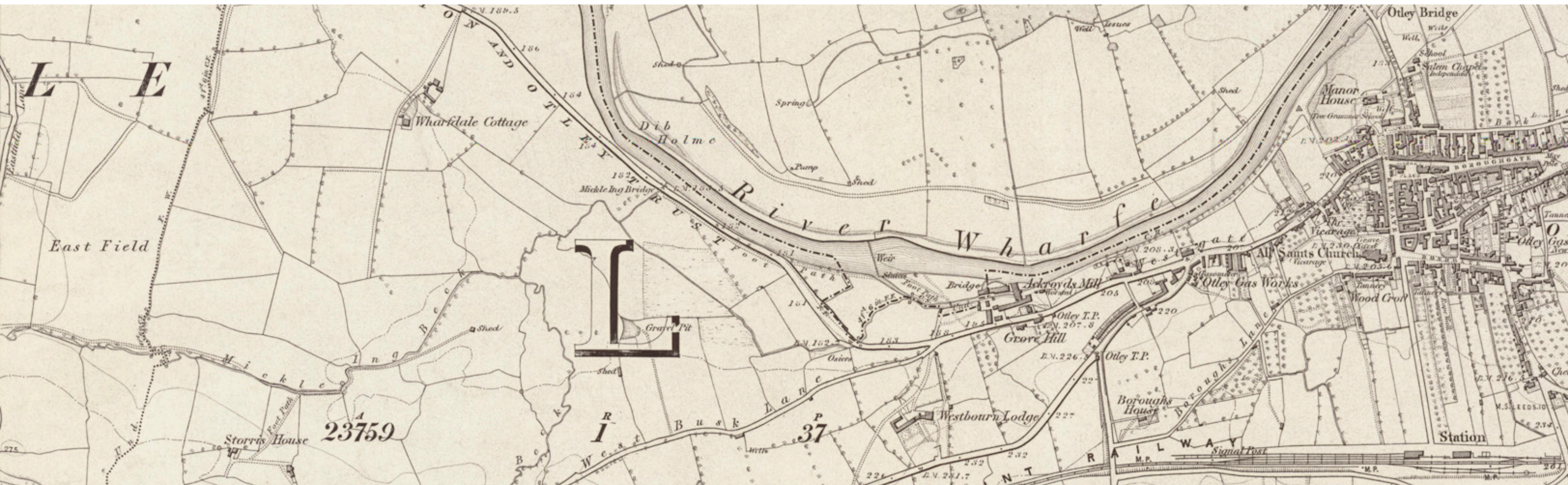

Figure 1. The northwest part of the Ordnance Survey 1 mile to six-inch map, Yorkshire sheet 187, shows the position of Gill Beck and the mills (between the "I" and "S" on the left of the image) and Otley (top right). This map was purportedly published in 1851 based on surveys between 1847 and 1848 (Ordnance Survey 1851), but includes the Otley to Ilkley Joint Railway, which was not opened until August 1865 (Otley station opened in January of 1865). Figure 2 shows a blow-up of the mill complexes.

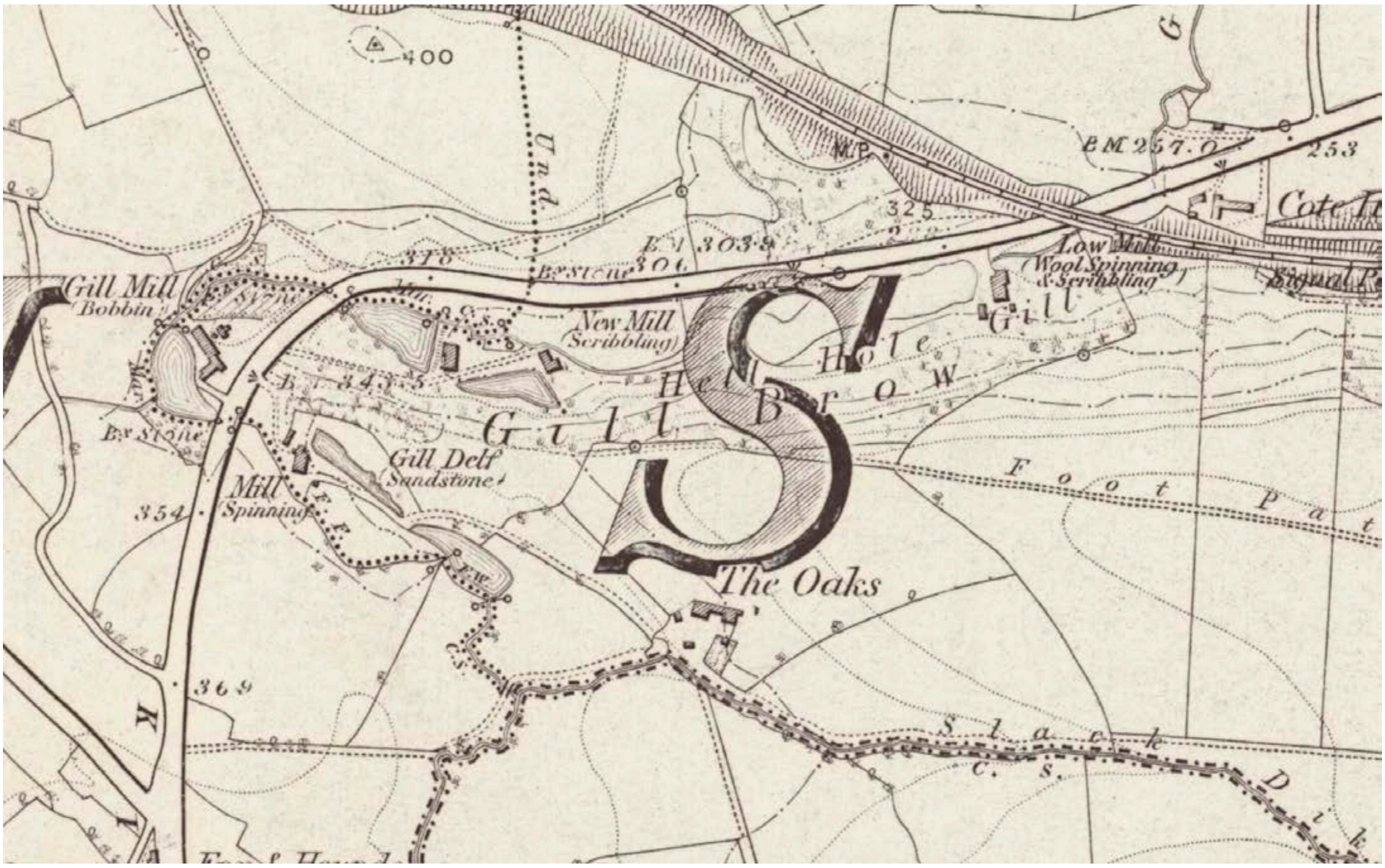

Figure 2. A detailed view of the upper part of the Gill Beck mills between Otley and Menston, West Yorkshire, as portrayed on this OS map from 1851 (Figure 1). Derrydiddle Mill would have been operational for 35 years by this map. On this map, Derrydiddle Mill is labelled as "Low Mill (Wool Spinning & Scribbling)"; scribbling refers to the process of breaking down knots and lumps in the wool ready for combing and then spinning.

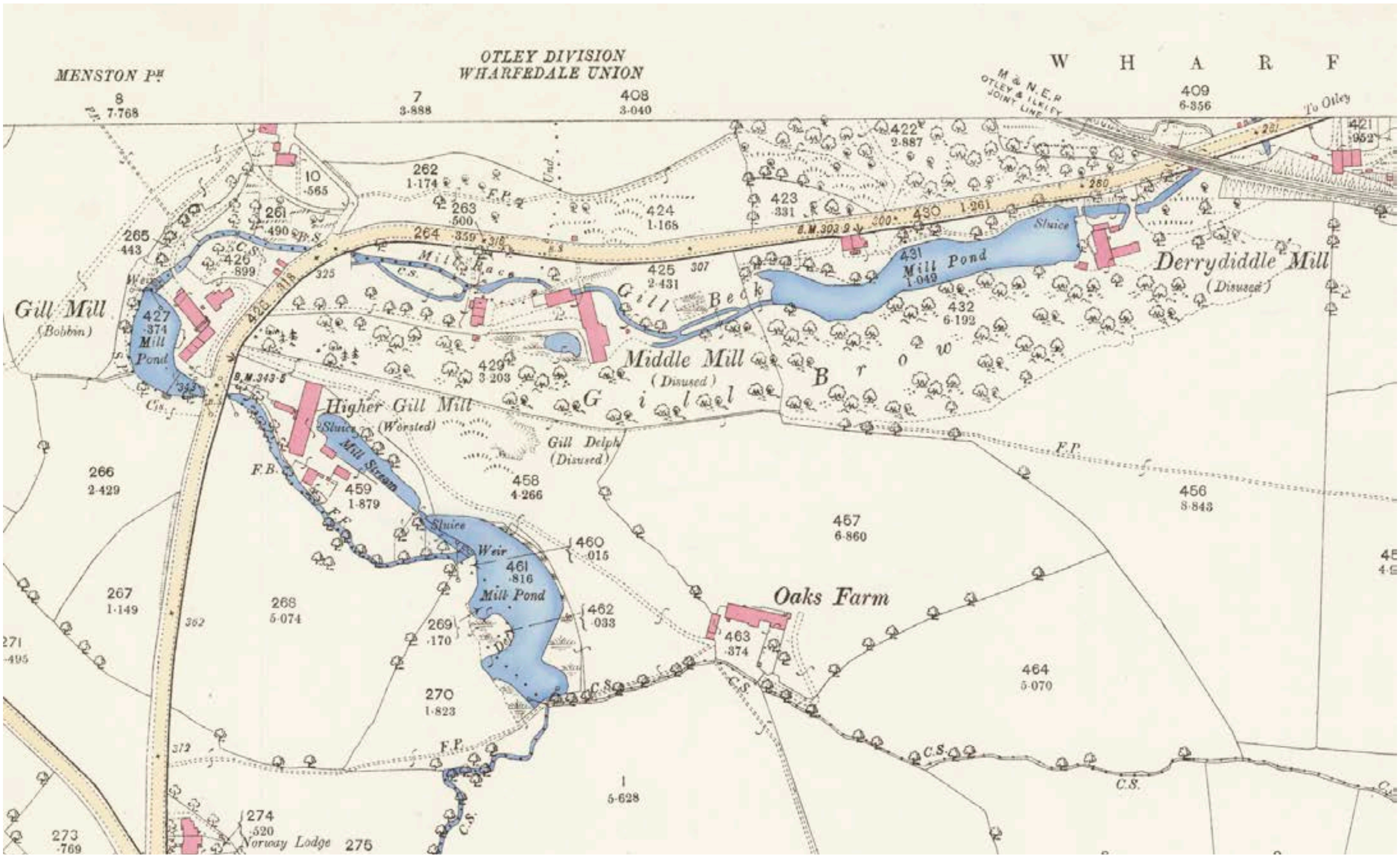

Figure 3. The Gill Beck mills between Otley and Menston, West Yorkshire, as shown on the Ordnance Survey 25-inch to a-mile map from 1893 (Ordnance Survey 1893). This extract provides one of the best representations of the number of mills, associated mill ponds, and water management systems. It also highlights the limited space available for expansion.

Energy Transition Can Happen Quickly, But Not Always When And Why You Might Expect!

Derrydiddle Mill was the lowest of a series of mills distributed for a kilometre or so (0.6 miles) upstream of Derrydiddle; each assigned a different part of the worsted wool workflow (Figures 1 & 2).

These early mills would have been relatively small compared to the large steam-driven complexes that developed later in the 1850s, such as Salts Mill in Saltaire. The size of the valley and stream power dictated the size and location of the mills. Each had an associated mill pond and water management system. Part of this can still be seen today, although the mill ponds have all largely been filled in. We can also see the small bridge that gave access to the main road and several courses of millstone grit stone blocks that define the former extent of the mill and related buildings (Figure 3).

The power of moving water had been fundamental to industry, especially the wool industry in England, since the early Mediaeval period, some 600 years before Derrydiddle Mill was founded. Much of that early development had been by monastic orders, such as the Cistercians of Fountains Abbey, some 20 miles (c.32 km) to the north of us here, who had developed a business model and processes for wool production that might be considered a mediaeval mini-industrial Revolution.

It was, therefore, not a surprise that Dawson and Ackroyd would start with this proven technology.

But after moving to Otley Mills Ackroyd and Dawson continued to use flowing water as their power source. This despite the fact that steam power had been around for 100 years before Dawson and Ackroyd moved their business to Otley. Thomas Newcomen's "atmospheric engine" – the Newcomen engine - was the first commercial steam engine (1712). Various engineers improved this concept over the next century, most famously James Watt in 1776, whose additions made the engine much more fuel-efficient. However, these early engines were relatively low-pressure and rarely produced the constant speeds needed for cotton or wool spinning. It was not until the latter part of the 18th century that high-pressure engines and other enhancements enabled steam engines to be applied beyond pumping water from mines, culminating in the first self-propelled steam train by Richard Trevithick in 1804.

It was not until the 1840s that Ackroyd built his first steam-driven engine house (Richardson and Dennison 2020).

So why move from Derrydiddle Mill? And why not which to steam straight away?

Energy transition can happen quickly, but not always when and why you might expect!

Well, in part because this was a mixture of cost and technology. The Boulton and Watt designs, which Watt had patented, dominated steam beam engines throughout the late 18th and early 19th centuries. It was not until William McNaught's compound beam engine in 1845, and especially the development of the Corliss engine in 1849 with its rotary valves, that the market really changed.

But also, there was no competitive need in those early days because most other mills were still running on water [sic].

The move from Derrydiddle Mill to Otley Mills appears to have been driven by two immediate considerations unrelated to energy transition: (1) Gill Beck did not provide the space for expansion, and (2) opportunity, the site was available, and a water management

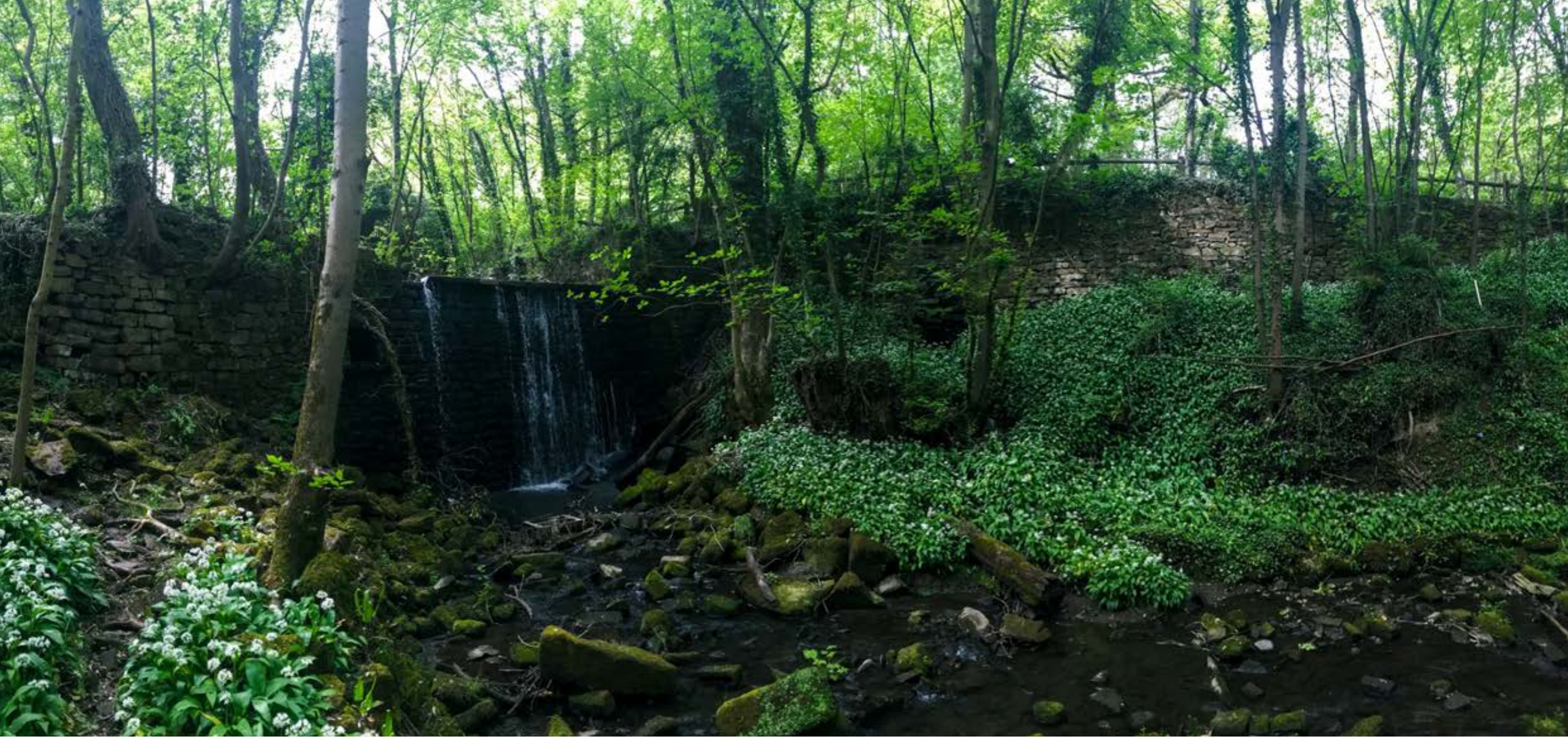

Figure 4. The ruins of Derrydiddle Mill in the spring, surrounded by wild garlic. It is difficult to imagine the hive of activity this would have been 200 years ago. Although these early mills of the Industrial Revolution were still relatively small-scale.

Worsted And Woollens

Worsted is a type of wool yarn that comprises longer, finer fibres that are more durable than typical wool. Fabrics made through the worsted process are better at keeping out wind and rain but not quite as warm as typical woollens that we associate with the knitted jumpers we get for our relatives at Christmas. This makes worsted fabrics ideal for suits and other tailored clothes.

The differences between worsted and woollens reflect the breed of sheep used and how this wool is processed. During the Middle Ages, new sheep breeds were introduced into England, raised in enclosed lowland pastures. These breeds produced long 'staple' wool ("staple" means a cluster of wool fibres or locks rather than a single fibre), compared with the older hillside breeds, which produced shorter fibres.

In both the worsted and woollen processing systems, the wool fibres are initially disentangled, a process called "scribbling". The fibres are then separated and arranged to create a continuous web of fibres that can be laid out flat, rolled into "rovings" (a roving is a long, narrow bundle of fibres), or split into spinning rolls. In the Worsted process, the wool goes through a further process called "combing", in which fibres are aligned parallel, and short fibres are removed. This is the major difference with the woollen process in which the shorter fibres are kept. Once prepared, the wool is then passed to the spinning machines to be turned into woollen fabrics.

In the 1780s, this whole preparation process was mechanised with carding machines (note that frequently in the literature, the term "carding" is used to describe the entire sequence of processes from scribbling to carding to combing and more). In fact, the carding machines were divided into two machines, one for "scribbling" and the second which formed the web of fibres. This separation can be seen on the map assignments for the Gill Beck mills (Figures 2 and 3). Derrydiddle Mill is shown as responsible for "Scribbling" and "Spinning."

Figure 5. The top of the old weir with sluices. This was the location of the wheel house, though whether a single wheels or multiple wheels is unclear.

system was already in place.

The space for expansion would become important in the following decades, not least because it allowed Ackroyd to bring all the worsted processes together into one integrated mill complex.

The Otley Mills site had been the location of an old cotton mill dating back to the middle of the 18th century when the course of the river Wharfe had been modified to provide power. So here was a ready-made site that could, and was, adapted to worsted wool.

But the world was changing, not just in terms of improving steam engine technology but also in terms of the business environment. It would be the combination of both of these developments that would ultimately drive the energy transition.

1815, the year Ackroyd and Duncan built their first mills on Gill Beck, was also the year of the Battle of Waterloo. The great upheavals that had stalked European politics since the French Revolution were starting to settle down, and with relative stability came an acceleration in Industrialization as international trade expanded.

This period also saw the increasing availability of bank loans, the development of the canal transport network, which by 1840 was starting to be replaced by trains, expanding international trade routes, increasing urbanisation as workers abandoned rural life for the industrial towns and cities, and a growing middle class with an appetite for buying things, including more woollen suits.

All these changes were soon to have an impact on that mediaeval technology of flowing water. When Ackroyd did switch to steam in the mid-1840s the effect on his business was immediate with a major expansion of the mill complex at Otley Mills. It also marked the growth of Ackroyd's fortunes as he became a significant player

So, the energy transition at the beginning of the 19th century was relatively rapid (decades) but not instant.

It was about technological advances but also about contemporary political, economic and societal changes.

It was also about the market – competition and demand.

in local politics.

But he was not alone. During the late 1840s-1850s, we see the consolidation of the numerous small mills in small towns into enormous single factories with their related communities. The largest of which was the famous Salts Mill (1853) at Saltaire (https://saltsmill.org.uk/), which at that time it was built was the largest industrial building, by floor area, in the world (Figure 7). Now, competition was driving businesses to transition to steam. In the middle of the 19th century, the bottom line was that if you didn't move to steam, you would lose out to those who had.

So, the 19th century energy transition here in Otley was not just about technology or a desire to change. It was about the broader context of political, economic and societal changes, and then when the transition happened, the pressure of competition that was being driven by consumers.

In our own time, we can think about the 'rapid' adoption of electric vehicles (EVs) over the last decade but how this varies by country. Tesla made owning EVs desirable. But they are expensive, so you need people with cash. You also need battery technology to the point where you can drive an EV as if it were a combustion engine. Finally, you also need a government willing to invest in infrastructure.

As a footnote here, Ackroyd was also the first President of the wonderfully named "Otley Useful Instruction Society" for "the improvement of workers". But that is a story for another time.

The Advantages Of Steam

Steam power has several advantages over the physical movement of water.

1. It provides a more continuous, reliable energy than flowing water, which would have depended on the hydrology upstream, which could vary seasonally, even with water management.
2. Greater power for your buck
3. It was not limited to a single-point source. If you had the money, you could build multiple turbines driving more looms more efficiently and reliably, which meant more production and greater revenues
4. Less labour intensive

Figure 6. Sluice in the retaining wall, which housed the water wheel(s)

Transitions Transition

It is unclear how long Derrydiddle and its associated mills on Gill Beck remained active. The buildings and mill pond at Derrydiddle are labelled as "disused" on the 25-inch to 1-mile map of 1893. However, Gill Mill and Higher Gill Mill are not. This suggests that at least some of these mills remained operational until the end of the century. Intriguingly, 1893 is the first time it was named on a map as "Derrydiddle Mill".

Part of the reason for this was probably to maximise Ackroyd's original investment in Gill Beck. But it was also because these older technologies still worked, just not as efficiently.

So water-power and steam-power, mediaeval and industrial technologies, ran in tandem for at least 50 years in the Wharfe Valley.

Adopting new technologies can be rapid, but this does not mean that older energy sources and technologies are instantly abandoned. Transition is about transition.

Change May Not Go In The Direction You Expect – The Unfortunate Case Of Unforeseen Consequences

The consequences of steam power were many and varied. Energy was no longer dependent on local sources, especially the power of flowing water, which had long kept businesses small and stuck in the hills. Although, it is no coincidence that much of the British Industrial Revolution was associated with the location of coal and iron fields.

For the mill owners, steam provided a sudden increase in productivity, a move away from a dependence on manual labour, and a way to make bundles of cash!

But perhaps the most significant change was the ability to move goods and people at speeds and 'ease' that had never been experienced in human history. For many, the steam train epitomises the Industrial Revolution and the modern age. The early experiments such as Stephenson's Rocket (1829) or the "Lion" built by Todd, Kitson, and Laird here in Leeds in 1837. These are just two of the many steam locomotives etched in our history that began a British love affair with steam trains. I must admit I like steam trains.

Steam trains also had an unexpected societal benefit as the network expanded and people realised how much they liked or had to travel, the benefit being that in moving and mixing populations, the bane of inbreeding began to recede.

But these early steam trains must also have been terrifying for a population that had grown up in the countryside, where nothing moved particularly fast. And not just the 'high' speeds and noise, but all that smoke.

To address this concern, the Railway Clauses Consolidation Act of 1845 stipulated that all engines had to 'consume their own smoke' (HMG Railway Clauses Consolidation Act 1845) (Figure 8):

> *"Every locomotive Steam Engine to be used on the Railway shall, if it use Coal or other similar Fuel emitting Smoke, be constructed on the Principle of consuming and so as to consume its own Smoke; and if any Engine be not so constructed the Company or Party using such Engine shall forfeit Five Pounds for every Day during which such Engine shall be used on the Railway."*
>
> Clause 114 p.193

Concerns about pollution and the environment are not just the preserve of more recent times. What can I say?

Sadly, by 1845, industrialisation and societal changes were happening so quickly that this law was quickly abandoned or, at the very least, conveniently ignored. The reasons will be familiar to us: the train system was rapidly expanding, and coal had replaced coke as the primary energy source due to the sheer cost of producing coke and the increased demand for energy. In short, consumer demand trumped environmental sense and good intentions.

For our current energy transition, it is clear that we will need more critical minerals such as cobalt and lithium. But as demand grows as we transition, what impact will that have on the countries that produce them and the politics of exploring for them? How much of our land are we willing to see turned over to solar farms? And what about nuclear? An excellent overview of the complexity of the problem can be viewed in Ed Conway's Sky News report on Chile and the consequences of the demand for critical minerals, https://news.sky.com/video/battle-for-chiles-critical-minerals-12643766).

History is clear; change begets change, and sometimes, despite our best intentions, it may take us in directions that have negative consequences.

This is a salutary lesson from the Past.

No matter how good your intentions are or how serious your (environmental) concerns are, the fear of individuals that they do not have enough money to buy food, heat their homes or care for their kids will trump everything else.

This is exactly what we are seeing today (2023) in the UK, with a cost of living 'crisis', energy 'crisis' and climate' crisis'. So many crises, and no guesses for which of the crises people are now focussed on! Just as in 1845, this is not a statement of which of these crises is the most important for the long term, but the sobering reality of realpolitik.

Figure 7. By 1853, when Titus Salt built Salts Mill on the River Aire, 12 km (7 miles) to the south of Otley, the Industrial Revolution was accelerating. When completed, Salts Mill had the largest floor plan of any industrial building in the world. This is a far cry from Derrydiddle Mill. Again, like the 1845 HMG Railway Clauses Consolidation Act, there was an attempt at Salts Mill to limit smoke pollution. According to Curl (1990), the chimney tower was "fitted with patent fuel economisers to remove 'annoying effluvium'". Quite what this entailed is not clear.

RAILWAYS' CLAUSES, 1845. 193

8 VICT. CAP. 20.

Engines to consume their smoke.

Penalty.

114. Every locomotive steam engine to be used on the railway shall, if it use coal or other similar fuel emitting smoke, be constructed on the principle of consuming and so as to consume its own smoke; and if any engine be not so constructed the company or party using such engine shall forfeit five pounds for every day during which such engine shall be used on the railway.

Engines to be approved by the company and certificate of approval given.

115. No locomotive or other engine, or other description of moving power, shall at any time be brought upon or used on the railway unless the same have first been approved of by the company; and within fourteen days after notice given to the company by any party desirous of bringing any such engine on the railway the company shall cause their engineer or other agent to examine such engine at any place within three miles' distance from the railway to be appointed by the owner thereof, and to report thereon to the company; and within seven days after such report, if such engine be proper to be used on the railway, the company shall give a certificate to the party requiring the same of their approval of such engine; and if at any time the engineer or other agent of the company report that any engine used upon the railway is out of repair, or unfit to be used upon the railway, the company may require the same to be taken off, or may forbid its use upon the railway until the same shall have been repaired to the satisfaction of the company, and upon the engine being so repaired the company shall give a certificate to the party requiring the same of their approval of such engine; and if any difference of opinion arise between the company and the owner of any such engine as to the fitness or unfitness thereof for the purpose of being used on the railway, such difference shall be settled by arbitration.

Unfit engines to be removed.

Penalty on persons using improper engines.

116. If any person, whether the owner or other person having the care thereof, bring or use upon the railway any locomotive or other engine, or any moving power, without having first obtained such certificate of approval as aforesaid, or if, after notice given by the company to remove any such engine from the railway, such person do not forthwith remove the same, or if, after notice given by the company not to use any such engine on the railway, such person do so use such engine, without having first repaired the same to the satisfaction of the company, and obtained such certificate of approval, every such person shall in any of the cases aforesaid forfeit to the company a sum not exceeding twenty pounds; and in any such case it shall be lawful for the company to remove such engine from the railway.

Carriages

117 No carriage shall pass along or be upon the rail-

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Figure 8. A screen capture of the 1845 HMG Railway Clauses Consolidation Act showing clause 114. An early environmental statute?

Driven By Demand - The Problem Of Increased Consumption

That problem of unforeseen consequences was largely driven by the growth in demand - the understandable desire to have a better life than your parents and to have all the new goodies that go with that way of life.

Industrialisation initially improved the life of the average country worker, but as the population increased and more people moved to the cities, and more mill owners sought to make more monies, things got out of hand.

When the population of Great Britain was 10.5 million at the turn of the 18th-19th century, switching to burning fossil fuels for energy was not such a problem. But during the 19th century, we see an increase in per capita energy consumption (1800: 37.750 kcal/day; 1900, 100,100 kcal.day; 2000, 135,800 kcal/day; Warde 2007), an increase in population (by 1900, the population of Great Britain was c.30.5m), and so a total increase in energy consumption.

The fastest levels of consumption growth were between the mid-1830s and mid-1870s, so it is no surprise that this coincided with high pollution, degradation, poverty, and disease. The "great stink" of 1858 in London was just one expression of this trend. Although many of these problems were ultimately overcome, for much of the 19th century, a life that had started to look so much better suddenly became rather unpleasant.

When we consider energy transition, do not forget what is driving our insatiable demand for energy.

Renewables require battery technologies, and these are resource-limited.

Consumption is the elephant in the room. And it is a very big elephant!

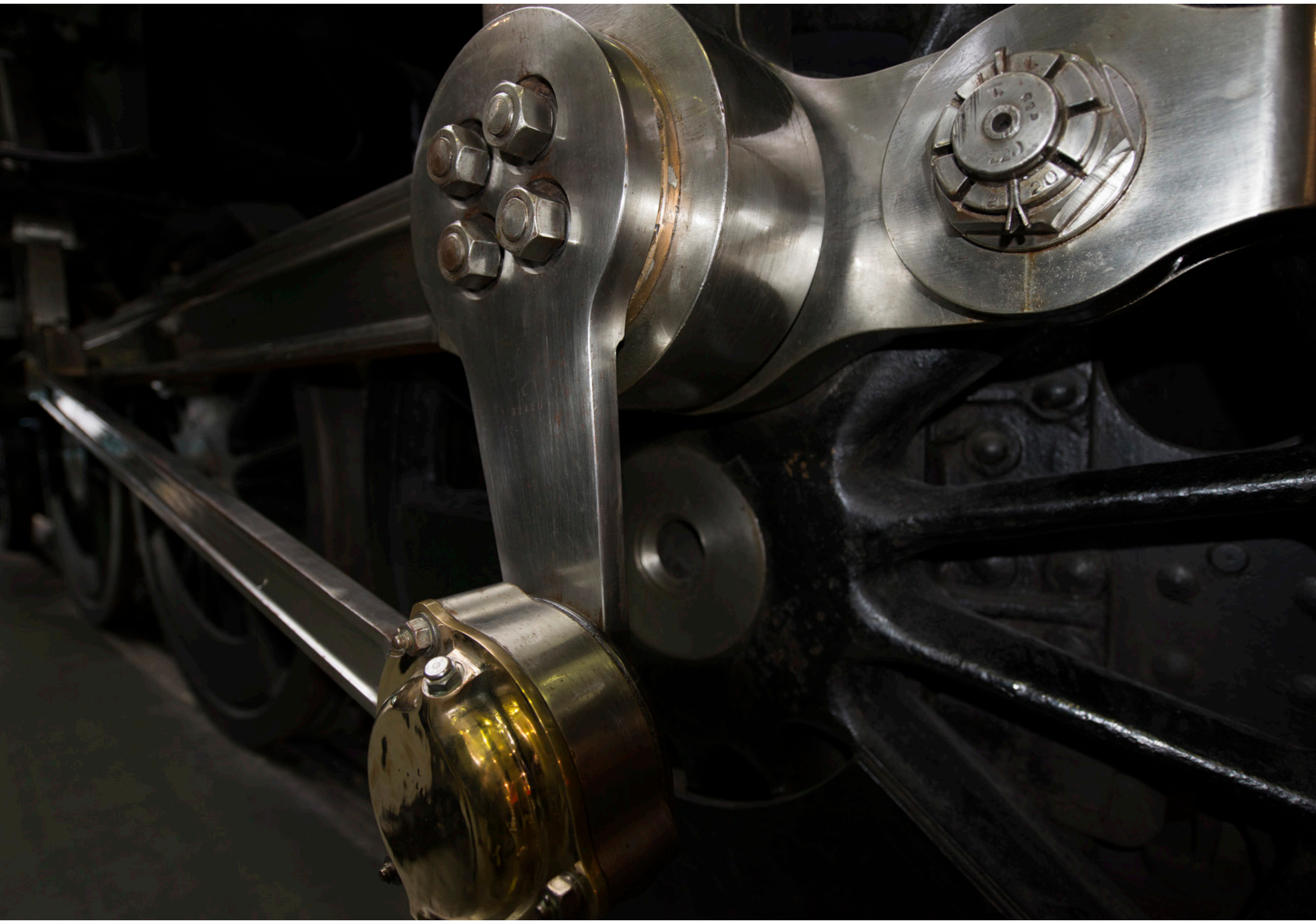

Figure 10. The steam engine is the epitome of the industrialisation. National Railway Museum, York https://www.railwaymuseum.org.uk/

Fountains Abbey near Ripon, North Yorkshire. The development of the wool industry in the North of England was driven mainly by the monastic orders of the early Mediaeval period.

Figure 10. The Hay Wain by John Constable (1821). The romantic view of a pre-industrial rural world. Image from https://commons.wikimedia.org/wiki/File:John_Constable_-_The_Hay_Wain_%281821%29.jpg

A Pre-Industrial Life Does Not Necessarily Mean A Good Life

One final thought on Derrydiddle Mill. There is often a rose-tinted view of the world before Industrialisation. We can see this in the words of many environmental groups today. But such a view is far from new. The Romantic movement of the late 18th and early 19th century harked back to an idyllic lifestyle that never actually existed unless you were independently wealthy, as most of the romantic poets were (or they knew someone who was!).

Life before the Industrial Revolution was not good. Life expectancy for the majority was short (less than 32.4 years for Londoners prior to the 1810s when Derrydiddle was built; Mooney 2002), and freedoms were limited. Working at Derrydiddle Mill, though based on water power, may not have been pleasant and was certainly not idyllic. But it was a paid job!

We also need to remember that before the Industrial Revolution and the rapid adoption of fossil fuels as the primary power source, it was not as though only water or wind were used. Coal and peat have a long history of usage, going back to the Romans. Indeed, for much of human history, the dominant source of energy was burning wood.

The past may not have been an idyll, but we can learn from it

What Clues Does the Past Give Us?

Today we have the benefit of advanced technologies, science and an ability to quickly and easily look at history through digitized records, from which we can draw on lessons and learnings. If we so wish.

What can we learn from that early 19th-century energy transition?

WHAT CAN WE LEARN?

What can we learn from that early 19th-century energy transition?

The adoption and transition to new energy sources can be rapid but not necessarily instantaneous , at least not when we would expect.

The timing of change is not only dictated by technology being available but also by political, economic and societal drivers. It is also driven by us, the consumers!

Energy transition does not mean that existing technologies are abandoned.

All energy sources have consequences. Do not assume that all change will be positive.

Consumption drives our need for energy. It is the elephant in the room that we need to talk about.

A pre-industrial life does not necessarily mean a 'good' life.

Of course, this is not a simple comparison.

Whilst the lessons from the 19th century may provide a guide to how change happens, there is a fundamental difference between then and now. **Today, the main driver for change is political and societal pressure for an energy transition to low or non-carbon sources in response to concerns over climate change.** This driver was not something that the early 19th-century business community faced, William Wordsworth notwithstanding (the subject of a future blog).

We will have to leave it to future historians to record whether such pressures are enough to drive the energy transition or whether, in the end, it is money and the market that ultimately dictate how and when change happens.

The ruins of Derrydiddle Mill today make for a very pleasant afternoon walk. They remind us of a past energy transition that shaped the modern world. How that energy transition happened may provide clues about dealing with similar challenges today, or at least the pitfalls and drivers to watch out for.

But one thing is clear: there is no going back.

Brick wall (fallen) or floor of the old mill at Derrydiddle.

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