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Waste 2.0: The future of the waste industry

In the previous article, https://www.dpcleantech.com/medias/notice-board/waste-2-0-it-s-time-to-stop-wasting-resources we outlined the view that in the build up to COP 26, the role of 'waste' in the economy is set to be redefined - with significant and far reaching implications for the industry and society.

To summarise the key points:

- The waste generated by society; and how it is currently managed has a very significant negative impact on climate change and the environment.
- Waste is generally viewed through the very narrow prism of household waste; or that which society directly interacts with or 'throws out'. Whilst this includes food waste, this overlooks the true magnitude of other 'waste': agricultural, livestock, industrial, medical etc and includes all those elements upstream and downstream of what we physically consume. We can and must consider the problem more holistically to make the necessary changes.
- Despite the growth in circular economy thinking and an increase in 'reuse and recycle', the basis of most waste management strategies still treats waste from a 'removal and disposal' perspective. This treatment of waste in a 'linear' manner disregards the role that all types of waste can play in the circular economy and misses the opportunities to make waste a more fundamental resource.

If we are to take one sentence from the first article, "Proactive waste management is not about renewable energy, it is not about environmental management and emissions reduction, it is not about pollution. An active waste management strategy is all the above and more".

Waste 2.0 is a complete 'sustainability' solution that will positively and holistically address all the above issues. The premise for Waste 2.0 requires a systemic shift in emphasis in how waste is defined and how it should be handled. Fundamentally, these changes are that:

- 'All waste' is a core component of the carbon and the energy cycle.
- Waste is a resource. As with all resources, the focus must turn to the 'efficiency' of its recovery and use.

The remaining articles address how a change of approach can shape Waste 2.0; and how it can be delivered from a few different perspectives:

- The Role of Technology
- The Role of Government
- The Role of Capital, Finance, and free markets.
- Waste 2.0: Delivering the complete 'sustainability' solution; renewable energy, environmental management, emissions, and pollution control.

The Role of Technology in delivering Waste 2.0

The bad news is there is not going to be a ‘silver bullet’ technical invention that will revolutionize waste management. The good news is that we do not need one to bring about Waste 2.0. Waste 2.0 will come from a more comprehensive understanding of the sources of waste and its combined negative impact on our environment in order to form a global resolve to embrace a change in approach and reap the proportionately positive benefits. Once we change the paradigm and generate opportunities, the innovations and enhancements to exploit them will follow. As a society, we cannot address climate change until we address waste.

1. Delivering Waste 2.0: A change in mindset.

From ‘problem’ to ‘resource’; from ‘end product’ to ‘a stage in the cycle’, from ‘out of sight, out of mind’ to ‘a resource we must use’. At a conceptual level, none of this is complicated: catch phrases never are. However, it is our actions that betray us, not our words. ‘Waste’ is estimated to represent one of the two largest contributors to GHG in every country, largely because of the way it is managed. Today, over 75% of MSW still goes to landfill; the global volume and proportion of agricultural waste that is recovered is negligible, and in some economies toxic ‘field burning’ remains prevalent. A significant industry also still exists in exporting waste from country to country. The typical path for waste management strategies moves in a linear fashion from open dumping, to landfill, to mass burn (sometimes accompanied by limited energy recovery). The use of mass burn and landfill as typical ‘end points’ are a direct reflection of the prevalent attitudes and policies in place; and although there has been, and continues to be progress towards a more sustainable approach, it has been glacially slow. Understanding the full extent of the waste we generate, its direct link with climate change and the positive impact we can make by changing approach is a matter of education. Changing it will be a matter of resolve.

2. Prevailing Waste Management Solutions and technologies.

Landfill

More than 75% of MSW goes to landfill and of this, it is estimated that over 65% is biodegradable and will eventually rot. As it degrades, it releases CO_2 and methane which are greenhouse gases. Whilst CO_2 is the most recognized GHG, methane is a far bigger problem. According to UNECE, the global warming potential of methane over a 20-year period is 84 times more potent as than CO_2. In using landfill, we are simply removing the ‘waste problem’ from view whilst seriously compounding GHG emissions with the production and release of methane. Recognition of this is very slow. The EU and some other countries have put in place steps to phase out or eliminate landfill for organic matter. However, many countries, including some G8 countries have not followed suit. As we know, climate change does not respect boundaries, and as long as landfill containing organic matter remains an accepted ‘solution’, the climate situation will deteriorate.

Mass burn incineration and mass burn W2E plants

The first generation of MSW incineration plants simply combusted all waste as a method of removing it from the economy. Waste is generally not separated. Things have moved on as developers and Governments realized that the ‘costs of disposal’ could be reduced by producing some power in the process of incineration and so waste to energy (“W2E”) plants came into existence. In first generation incineration plants, the revenues came exclusively from gate fees, ie. being paid to receive waste. So, the more waste you can receive and 'remove', the more profitable the plant. There was zero incentive to be efficient because there was no 'recovery' from the waste. Subsequent generations of MSW plants have added an additional income stream through the sale of power and, occasionally heat. However, the economic models are still very much driven by gate fees: the more waste the plant can receive, the greater the gate fee revenues and the greater the profitability. The key point to understand is that, in the majority of MSW plants today, the economic driver is gate fees, not the recovery of energy extracted from waste.

'Field Burn' Technologies for Agricultural Waste
Of course, putting 'field burn' and 'technology' into the same sentence is somewhat tongue in cheek. However, for a farmer in many highly agricultural economies such as India/Thailand/ Africa, South America, this is the main technique employed to remove unwanted waste from the fields. In case we believe this to be only an emerging markets problem, sugar plantations in Australia and South Africa continue the practice, as do palm oil plantations in Malaysia. The logic behind field burn is that it enables the fields to be replanted for the next crop and the 'ashes' return nutrients to the soil. In the case of sugar cane, burning off the cane trash makes for faster and more efficient cane harvesting and transportation.

'Tilling Straws back into the soil'
This remains the prevalent technique across Europe and the US for straw residues. A small portion is used for animal sileage and bedding; and the remainder is tilled back into the soil. The logic behind tilling is the return of nutrients to the soil through decomposition. Whilst this is correct, the accompanying issue is that the process of decomposition releases significant CO_2 and heat energy to the atmosphere, thereby losing energy from the carbon cycle. Tilling does not drive airborne and soil pollution as such, but if waste is ploughed back into the soil, so too are heavy metals and toxins from fertilizers and acid rain.

Bagasse/ Rice kernel/ Palm kernel Power plants
Crop processing plants such as sugar, rice and palm oil mills have been using their 'collected waste' for many years to produce power and heat for use in the plant. This sounds like an ideal microcosm of the circular economy, but it is important to recognize that the wastes used (rice husks, bagasse from cane crushing and palm oil kernels from palm oil production) are a necessary byproduct of the processing of crop and are wastes that present an immediate problem. They are therefore regarded as residues that must be collected and/or disposed of. The mindset echoes that of the mass burn MSW plants - with disposal as the primary objective, and with little to no point in producing more 'free' energy than required, and the heat and power plants are typically of low efficiency.

Almost all the prevailing technologies have one thing in common: the focus is on removing the problem of waste, not maximizing the potential returns. The reason for this is purely economic. The various waste streams referred to above are considered to have a very low economic value, and the incremental value that could be gained from more sophisticated technical solutions for 'recovery' is insufficient justification for capital expenditure.

This brings us back to the 'transition' in thought and action needed to bring about Waste 2.0. From many angles, the conditions are primed for this to happen. Historically, the economic picture has distorted the environmental costs of our actions and behaviours. In requiring us to only consider the direct costs in the collection and removal of waste, the environmental costs of our waste treatment methods have been conveniently disregarded. Broadly, and collectively, we have been given a 'free pass' on the environmental costs; and these costs quite literally being passed down the line to the next generation.

By adopting a 'free pass' / unregulated "environmental freeloading" mentality, the waste industry, the policies, and the management of waste at all levels has been distorted and has effectively denied the efficient functioning of capitalism by obfuscating the information transparency which determines economic behaviour. Now however, the true and complete environmental costs are becoming ever more self-evident and must enter the equation. In so doing, the economic models will change and the validity of waste as a resource will become more obvious, forcing us to think about how we can recover or retain the most value from waste.

Successful long term economic models all have one defining characteristic: "efficiency". The greater the efficiency of the business throughout its value chain, the more competitive and successful it becomes. So now the important question becomes how to ensure that 'waste' becomes an effective and efficiently exploited resource.

3. Waste 2.0 Technologies.

Waste 2.0 technologies will tackle this question. The critical success factor for technologies in Waste 2.0 will be "efficiency". Deploying technologies, systems and practices that prioritise efficiency will be important throughout the process, from feedstock collection to internal power consumption.

MSW and Industrial Waste

Greater Efficiency in Sorting and Separation to reduce feedstock variability.
Solid waste (MSW) is, by definition, a co-mingled waste type, generally consisting of metals, plastics, paper, foods, and other biodegradable/non-biodegradable materials. If all these materials could be separated rigorously at source (in our homes and factories and offices) this will have by far the greatest impact on efficiency in terms of MSW processing.

In some countries this is standard practice and well accepted. Without separation at source, the separation process (if it happens at all) is pushed further down the chain, adding an extra process before the waste can be 'reclassified' into fractions with energy or economic value. In other countries, if separation is conducted, it will take place in waste management or collection facilities and will use straightforward technologies to separate basic materials such as metals, glass etc, as these have some immediately tangible economic value.

We can all easily grasp the idea that different waste streams can have some value; there are rare metals in computers, recycled paper can have a value, glass recycling - however the separation of these can be more complex and/or not economically viable. Other difficult to separate elements – plastic coated papers, food contaminated paper and plastic, coated woods etc.) have little apparent value. However, the production of 'Refuse Derived Fuel' - which consists of combinations of non-readily biodegradable wastes such as non-recyclable plastics, textiles, and woody residues, is becoming more prevalent.

Most MSW is made up of over 50% water, essentially the organic fraction. If this water is extracted, we immediately shrink the volume of the waste 'problem', and in fact, the separation of non-readily biodegradable waste from moisture-laden biodegradable (organic waste) can be done relatively easily and efficiently. This Organic Fraction of MSW or OFMSW is then a separated feedstock which can be exploited for its energy value. Despite the obvious win/win, the potential complexities of downstream treatment mean this is not often the current practice.

'Refuse Derived Fuel' Power Plants

The processing of RDF fuel has some similarities with 'mass burn' plants, but there are some key differences. As with MSW, RDF is not a product of high economic value, however unlike MSW, it is no longer carrying a significant negative value. It is also a dry fuel – the moisture having been largely taken to the organic fraction. RDF is an 'engineered' fuel, which can be further classified into homogeneous categories, which immediately allows specific changes to be made to technology for greater efficiency.

They are vastly different from a conventional mass burn plant, in which waste is not homogenous. In mass burn, the majority of energy in the waste is 'consumed' in evaporating moisture from the mixed fuel, sending it up the stack as steam, effectively the equivalent of leaving a kettle to boil. Furthermore, one of the more notable marketing pitches for conventional MSW plants is how robust or 'strong' they are in handling waste such that "even a Ford V8 engine can pass through". This somewhat unrefined approach reflects the current economic model emphasizing disposal, rather than utilization and optimisation.

The usable or available energy in RDF is high, as is the potential for revenues from power and heat sales and thus the economic model changes. RDF is also in demand from other industries such as cement kilns that can use RDF to replace fossil fuel. With homogeneous engineered RDF, plants can be more refined, the process can be streamlined, and the designs can become more modular with lower costs and lead times.

The most significant difference between today's 'mass burn' plants and RDF processing plants lies in the design philosophy and construction; and it is the development of technologies that support the greater efficiency of RDF processing that will transform W2E in the coming decade. Plants that process RDF will become the mainstream waste to energy plants of the future. In designing and building around the objective of maximizing the efficiency of energy conversion rather than the volume of waste consumed, the economic imperative immediately becomes focused on how to deliver the most efficient RDF plants, thereby enabling capitalism to drive innovation.

Organic Fraction of Municipal Solid Waste ("OFMSW") biogas plants

If the MSW is separated and the non-biodegradable elements are removed, we are left with organic matter which is a highly usable feedstock. Using the moisture already present, the natural biological processes can be put to work, generating methane and other gases which, once captured, can be used productively for power, heat, in the process for creating hydrogen, compressed biogas etc. The biogas process for 'pure' organic waste is well established, however there are challenges in using the separated organic fraction of MSW as feedstock. To date, it has proved problematic because of the presence of contaminants in OFMSW which can inhibit gas production and block pipes. The cleaning or refinement of the organic slurry is key to making OFMSW an effective and economically viable energy resource.

Integrated MSW solutions

Integrated technology solutions that are designed and deployed with the objective of deriving maximum value from ***every*** element of MSW - rather than simply disposing of a problem - will be the next significant phase in development, representing a convergence in technological innovation, economic impetus, and environmental imperative. Separation, sorting and recycling will allow the integration and streamlining of complementary, advanced technologies downstream to produce RDF, the effective use of organic waste fraction from MSW, the production of biogas for electricity, heat, the offtake of heat for internal power consumption, and the production of fertilizer.

This scope - from the initial sorting to the final output – will be achieved only by those companies which have the depth and breadth of expertise to understand and facilitate the inputs, outputs, and related technologies. The ability to scale this solution up and down will also be key, to meet the demand for small community as well as metropolitan facilities. At DP we have been developing a groundbreaking 'one stop' solution that does exactly this. Designed to enable owners and operators to utilise waste resources more completely, the Advanced Integrated Multifuel System (AIMS) encapsulates the change in thinking and technology design needed for long term profitability and sustainability.

Next Generation technologies around MSW

Gasification converts various feedstocks, including MSW and RDF, to a syngas, which can be converted into higher value products such as chemicals, transport fuels, fertilizers; used in hydrogen production or as a natural gas substitute. Theoretically, gasification is a more efficient energy recovery process than incineration with lower dioxins, SOx, and NOx in the emissions. Gasification technologies are not new, and yet they are not widely deployed, largely due to the technical complexities in scaling and high costs. However, as high quality, homogenous RDF/SRF becomes more available, targeted technology advancement will overcome these problems, and a focus on internal efficiency and the broadening of higher value end products will further improve the economics of RDF gasification plants at scale.

Agricultural Waste solutions

Biomass power plants

With the recognition that better utilization and management of agricultural biomass has a huge role to play in significantly reducing CO_2 as well as increasing energy security and the use of renewable resources, there is clearly a long-term role for biomass power plants. From a technology perspective, optimizing plant efficiency - in terms of energy output and in handling multiple or complex feedstocks will be the major differentiator. To capitalize on local feedstocks, smaller plants will be an important factor. To date, small scale plants have rarely achieved the efficiency or reliability levels needed to yield profits, nor have they been able to handle multiple feedstocks. Going forward these will be critical success factors.

Agri-biogas plants

Biogas plants using anaerobic digestion are ideally suited to produce syngas and other products from organic wastes and organic fractions. Biogas plants can be very small scale and for this reason, they are ideally suited for processing locally produced feedstocks and providing locally distributed power. This can include agricultural wastes as well as livestock or food wastes. Whilst agricultural crop wastes are organic, they are not best suited to this process because of their physical and chemical composition (lignin is hard to break down biologically). Pre-treatment can help, and there are various methodologies being pursued to this end and in the long term, may become viable. However, for livestock waste (manure) the process is much simpler, and on-site development of small-scale biogas plants is an obvious solution. The issue of food and restaurant waste is becoming much more top of mind and this is where there is significant potential for growth, with biogas solutions on a smaller scale providing community heat and power. The efficient functioning and optimisation of these plants and the maximum extraction of energy will be the focus, and for this, the quality of pre-treatment will be critical.

4. Summary.

Over the last 10-15 years, technological progress has been hampered by the convenience of 'good enough' disposal solutions without due regard to environmental considerations. 'Waste' is not a homogenous product and we cannot manufacture any single piece of equipment that will address the waste issue. Understanding the full extent of 'waste' in all its forms and its collective impact on GHG emissions and environmental degradation is critical to a change in thinking from 'waste disposal problem' to 'resource management'. This emphasis will drive developments in policy, technology, capital deployment around waste management; and if aligned, will be a powerful factor in redefining the waste industry. Going forward, the recognition that competitive advantage will be derived from efficiency improvements in resource management will be a key driver of innovation throughout the value chain, providing opportunities for industry players to re-evaluate their business models and operations to create sustainable business that are also environmentally responsible and aligned with the changing energy needs of society.

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