ETMA
Environmental Technology & Management Association

NEWSLETTER October 2020

Chairman's Message

Humoud Al-Utaibi | ETMA Chairman

I would like to send you all warm greetings, with hopes that you and your families are well and in the best of health. The COVID-19 pandemic has created disruptions for all of us on a personal, national, regional and global level. To overcome this global crisis requires collaboration, experience sharing, partnerships and effective coordination.

Our association, ETMA, in alignment with Saudi Vision 2030, has a mandate for collaboration and knowledge-sharing to address environmental issues, some of which also relate to health crises such as the COVID-19 pandemic. ETMA continues to serve and deliver on its mandate through your participation and, specifically, by way of its bi-annual PetroEnvironment Symposium, workshops, technical dinner meetings, and newsletters. The theme of this newsletter is the Circular Carbon Economy (CCE), a pivotal framework to address resource and environmental issues holistically and comprehensively. In the right place, carbon is a resource and tool; and therefore can be recognized as an asset rather than a toxin. As such, CCE is an important step towards changing the perception about carbon where terms such as "low carbon" and "zero carbon" are widely used. The successful implementation of the CCE framework requires not only current scientific and economic knowledge, but also the creation of new language, knowledge and its wise application. It also requires well informed citizens who, by their daily actions, practice the principles of CCE.

I am excited to share with you this newsletter, a newsletter containing rich contributions from highly respected, national and international leaders in CCE. ■

The Circular Carbon Economy: Concept & Applications

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Over the past decade, the 'Circular Economy Concept' has been increasingly invoked in the media, corporate reports, and governmental policies. But what is this concept? Fundamentally, the concept suggests that any material (or product) should be designed and used in such a

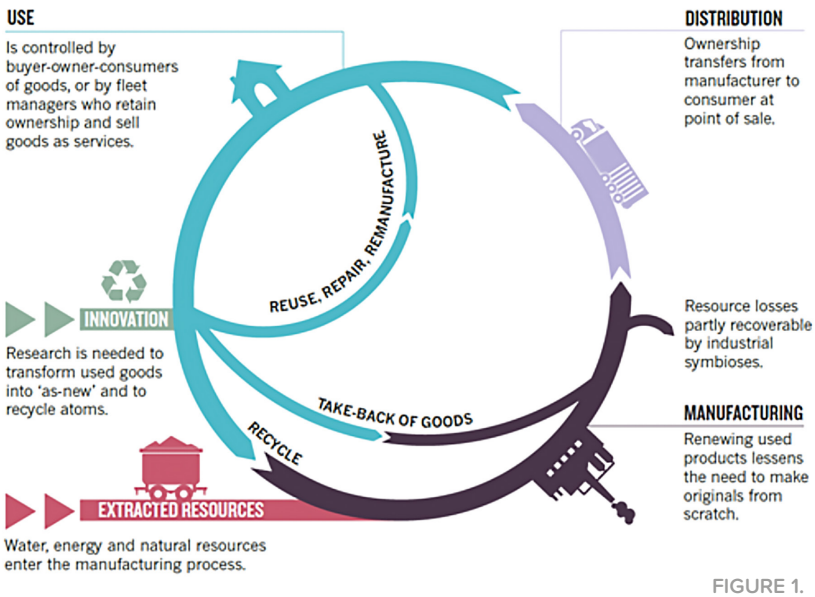

FIGURE 1.

way that it draws sparingly on natural resources and can, at the end of its functional life, be efficiently reused for its original purpose or used for another purpose. The concept is intended to maximize sustainability and to minimize wastes, including wastes destined for landfills. The concept is often depicted by a notional 'circle', as shown in FIGURE 1[1]. 'Reduce' refers to the sparing use of starting materials or extracted resources.

There is no universally accepted definition of 'circular economy', but numerous definitions are discussed, for example, by Sillanpää and Ncibi[2] and Gosh[3].

The Circular Economy is distinct from the traditional and still prevalent 'Linear Economy'. The latter is based on natural resources used for the manufacture of products, which generally become wastes at the end of their functional lives. Recycling and repurposing also occur in the Linear Economy, but they are usually not key objectives.

The 'Circular Carbon Economy' is a special case of the Circular Economy since its focus is on carbon-containing products, ranging from elemental carbon (like coal and activated carbon) to natural products (like wood and paper), hydrocarbons (like gasoline and diesel) and petrochemicals, including plastics (or polymers). For Saudi Arabia and many other countries, products based on oil and natural gas are of great importance. Hydrocarbon fuels generate greenhouse gases upon combustion. World-wide efforts are underway to store and/or utilize these gases, thereby aiming to meet the intent of the Circular Economy Concept. Plastics are typically designed to be long-lasting and pose a major waste problem, especially when they are improperly disposed. Plastic pollution of the oceans has become a well-publicized issue, but its prevention and mitigation remain to be fully resolved.

The United Nations Sustainable Development Goals, conceived to ensure a sustainable future for the world and adopted in 2015, reflect the Circular Economy Concept. They include a call for substantial reduction in "waste generation through prevention, reduction, recycling and reuse"[4], with the widely-used logos shown in FIGURE 2 expressing the idea.

Since their adoption and even earlier, many governments and corporations have embarked on implementing the spirit of the Goals. A good example is the Directive of the European Union regarding vehicles, which states that by "2015 .....the reuse and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year"[5]. This represents a major shift from earlier requirements and practices.

Examples of the Circular Economy

In Saudi Arabia, there is clear recognition of the challenges and opportunities regarding the Circular Economy. Two current examples are found in the articles 'Construction and Demolition (C&D) Waste Management, Gaps and Opportunities'[6] and 'Circular Carbon Economy in action: Aramco innovation: where the rubber meets the road'[7]. The latter describes repurposing used tires by adding them (upon shredding and processing) to asphalt binders used in road construction. This addition increases the quality and longevity of roads, while diverting tires from landfills. Another example is the incorporation of PET (poly-ethylene terephthalate), the plastic widely used for water bottles and single-use food containers, into road paving materials.[8] Asphalt road binders, derived from petroleum (with and without waste additives), are an excellent material that is already achieving near complete recyclability.

Future Needs and Directions

FIGURE 2.

The demand-supply outlook for petroleum and natural gas is evolving, with concerns about climate change, electrification of transportation, population growth, the state of the world economy, and global political stability representing complex, interacting forces. Diversification of petroleum products beyond energy that meet Circular Economy criteria is therefore a sound strategy. Key challenges are to identify, develop, and competitively produce products on scales that use a significant percentage of global petroleum and natural gas production. Before the current COVID-19 pandemic, the latter were approaching 100

million barrels per day and 3.9 trillion cubic meters per year, respectively. Promising opportunities, with major potential for Saudi Arabian producers and their partners, include the following...

1. **Advanced asphalt binders** for road construction, roofing, and water proofing. A major need for serving export markets is to provide the asphalt binders in solid, preferably pellet form, thereby avoiding problems of keeping the binders molten at approximately 150oC.

2. **Biodegradable polymers** for diverse applications, including single uses, and their wastes as potential soil amendments and animal feed.

3. **Controlled release fertilizers** to increase the efficiency of nutrient uptake by crops and minimize undesirable run-off. This application may also require biodegradable plastics (with nutrient value) if such plastics are used to control the release of conventional fertilizers.

4. **Carbon fibers** for polymer-, concrete-, wood-, and asphalt-composites. Carbon fibers have excellent strength to weight ratios but are currently costly to produce. Their use is therefore largely restricted to high-value applications, such as composites in the aviation, luxury car, and sporting goods sectors. Challenges include producing carbon fibers on a much larger scale than is presently possible, at a significantly reduced cost, and with well-determined uses of fibers when the composites reach the end of their functional lives.

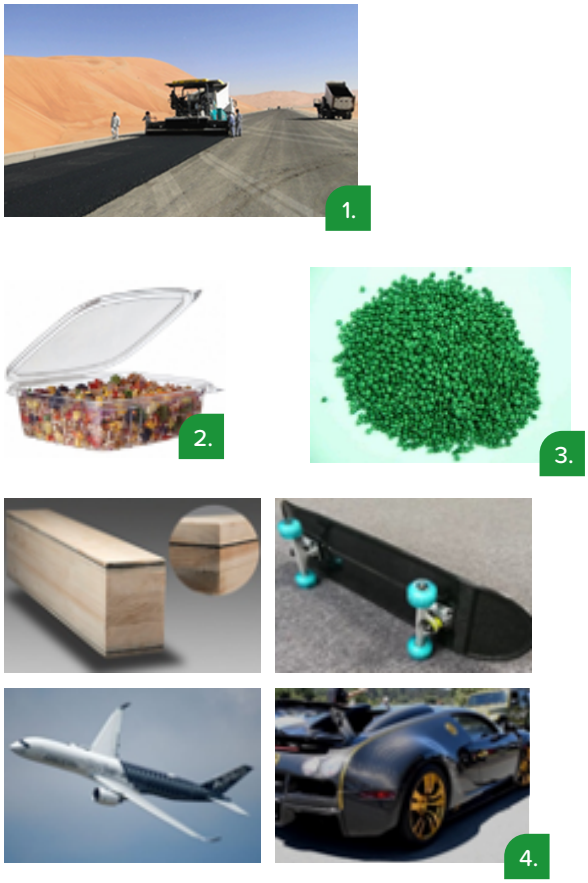

FIGURE 3. Future Needs & Directions

Actions

Alignment of the petroleum and petrochemical industries with the Circular Economy Concept is already in progress, but requires further action in three dimensions:

- **Ideation:** New ideas are needed for the identification, production, use, re-use and re- purposing, and ultimate disposition of products. This work is a combination of idea generation and demonstration, as well as understanding markets, social, and environmental contexts within which the products will be manufactured and used.

- **Education:** New products require not only appropriately trained personnel for their development, production, and marketing, but also users knowledgeable in product use, re-use, and end-of-life disposition. Education of all members in the value chain, including investors, governmental agencies (especially those involved in regulation and waste management), and members of the public are essential. Educational institutions and modern media all play important roles in providing such education.

- **Strategy portfolio:** Diversification of the oil and gas industry into new, non-energy products suggests a portfolio approach, i.e., identifying, developing, and producing products with diverse timeframes. Examples of products with short- and long-term time frames are asphalt binders and biodegradable polymers, respectively. Controlled release fertilizers and carbon fibers are examples with medium-term time frames.

Conclusions

Saudi Arabia and the members of its Energy Industry play a critical role in the creation of the global Circular Carbon Economy based on oil and gas. This role extends beyond energy products into materials and food. It requires the conceptualization and application of new ideas and draws on the support of a wide range of enablers and organizations, including industry, government, educational and research institutions, educators, researchers, practitioners, as well as members of the general public in the Kingdom and beyond. ■

Asphalt Rubber Pavement Pilot Project

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Embracing the concept of Circular Carbon Economy and the goals set forth in Saudi Arabia's Vision 2030, a collaborative team put into action an innovation that transforms waste tires produced in the Kingdom into a material to build up the Kingdom's highways.

Each year, approximately 20 million waste tires are generated Kingdom-wide, bringing environmental and safety concerns. Meanwhile, only about 5% of these tires are currently being reused in some form.

While this great number of tires presents an enormous waste-management challenge, it also provides the opportunity to be transformed into a valuable building resource. An innovative concept is to turn crumb rubber from these tires into a form of asphalt – asphalt rubber (AR) for use in laying and maintaining roads.

Globally, the use of crumb rubber to modify asphalt materials is not new. From its humble beginnings as an elastic rubbery patch membrane in the early 1960's, crumb rubber has found a way to increase its uses in the making of asphalt pavement materials: from repair patching membranes, to crack sealing material, to interlaying stress absorbing membranes, to binder modifiers, to high content Asphalt Rubber pavement.

Although asphalt rubber pavement mixtures have been widely used in the USA and parts of Europe for the last 30 years, in the GCC region and Saudi Arabia, these pavements have not been tried before. The use of crumb rubber has been only limited to low content asphalt modification – such as to improve the asphalt rheology.

AR minimizes scrap tires, thereby reducing tire stockpiles that are breeding grounds for a variety of pests, such as mosquitoes and other insects. Moreover, tire stockpiles are a prime component of illegal dumping and a source of air pollution when burned. No surprise, using recycled tires in asphalt pavement has signifi-

cant environmental benefits. Yet, the addition of crumb rubber into paving asphalt has demonstrated superior engineering properties that have been translated into pavements with increased performance, safety and cost efficiency.

Piloting asphalt rubber in Saudi Arabia

Adopting the principles of a Circular Carbon Economy – where carbon or its emissions are reduced, reused, recycled and removed (4R) an AR pavement pilot was executed in Jeddah.

The roadway section for the pilot was 160 meters long, 5 meters wide, and 7 centimeters thick, and included AR pavement with a rubber content equivalent to 20% of the asphalt binder content, or 1% of the total weight of the pavement mixture.

This initiative had the unreserved support of local and experienced construction and tire recycling enterprises; which collaborated throughout the planning and execution of the pilot project:

Nabaa Al Wessal (NAW Recycling), member of the SHAIRCO Group supplied the crumb rubber needed for the mixture. General Agencies & Contracting (GAC), a branch of Shabokshi Development & Trading Co. served as the paving contractor and was responsible of producing the AR mixture, transporting it to the project site and all construction activities needed for completion of the pilot segment.

The AR mixture was produced using an innovative “modified dry mix method” that had never been tried on a large-scale production previously. This method eliminates the process of pre-blending and conveying of an asphalt-rubber blend, as the crumb rubber was added directly into the hot mix asphalt plant.

The pilot proved successful from the constructability, quality and technical points of view. The paving mix was manufactured within the design boundaries, the transportation ran smoothly and the laying, rolling and finishing was completed without complications. Initial performance testing indicates that quality and technical requirements such as asphalt content and in-place densities were to the required levels. Nonetheless, the section will be monitored throughout the summer

to ensure performance and durability under extreme weather conditions.

Plans are to continue efforts to expand the deployment of progressively larger AR projects aiming to establish the foundation of a greener pavement industry in the region.

Technology unlocks a remarkable recycled product

AR is a special type of asphaltic paving material in which more than 15% of the binder content is crumb rubber from recycled waste tires.

From a pavement engineering point of view, AR offers mechanical properties that are superior to conventional asphalts. As an example, AR has better resistance to permanent deformation – yes, those depressions in the wheel paths commonly seen in highways. It also has better resistance to oxidation, meaning less cracking of the roads. Further, AR pavements are safer since they create enhanced friction between the road and the tires of the traveling vehicles, producing shorter stopping distances and reducing the risk of sliding and slipping. Lastly, asphalt rubber pavement is known to be quieter than conventional asphalt or concrete pavement, which helps reducing sound pollution at or near heavily transited highways.

Producing AR has its own challenges, as the high content of crumb rubber makes the binder much more viscous than conventional bitumen. This makes it difficult to handle with conventional mixing equipment.

Researching the state of the paving industry in the King-

dom found that the typical highway project would require pre-blending of the straight (conventional) asphalt from the refineries with polymer modifiers -including crumb rubber- to produce the required performance grade (PG) asphalt binder required by the Ministry of Transportation. The blending however, had limitations on the amount of modifiers that was able to be handled. Specifically, the viscosity of the blend has to be maintained low enough for the agitators and pumps to be able to operate. In the current practice, the equipment available can handle up to 10% of modifiers, yet, the crumb rubber content for AR blends is close to 20%. Pre-blended, also known as wet method AR was not possible with the available equipment.

To overcome this, the technical team researched and successfully developed an innovative method to produce the mix without need of pre-blending. The resulting pavement is expected to have a longer lasting service life with noticeable improvement in sustained quality.

Collaboration, Teamwork and Communication

The AR pavement implementation initiative was characterized from its inception with essential components of innovation; namely collaboration, teamwork and communication. The pilot project using crumb rubber for road construction provided an opportunity to employ a sustainable construction method in alignment with Sustainable Development Goal (SDG) 12 "Responsible Consumption and Production". The 17 SDGs, also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. ■

Circular Carbon Economy:
Opportunities in the Plastics Value Chain

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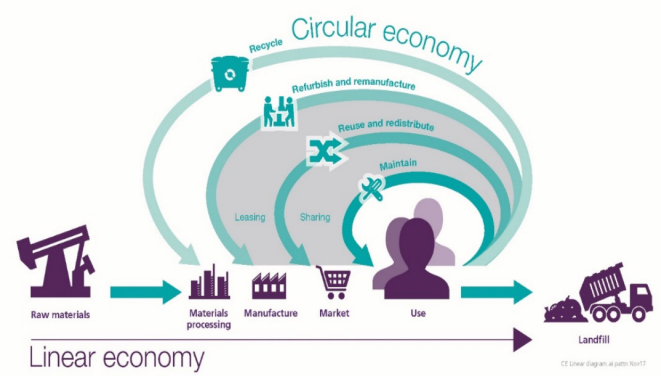
Waste management within the Kingdom of Saudi Arabia (KSA) is undergoing a period of significant change as the country adapts to the requirements of the National Transformation Plan and the Vision 2030 of increasing recycling to provide environmental benefits. A unique opportunity exists at this point in time for KSA to adopt a legislative and regulatory framework that prioritises the circular carbon economy resulting in an economic and environmental benefit.

A circular economy is an alternative to a traditional linear economy. The key principle is that a circular economy aims to keep resources in use for as long as possible and extract the maximum possible value for multiple uses rather than dispose of resources after a single use. A circular economy promotes the restoration of materials to reduce waste and energy, so reducing the negative impact of production and



consumption on the environment. This is achieved by identifying opportunities to 'close loops', continually returning materials into the economy to be reused or repurposed. In a circular economy, products made of non-renewable materials are designed to be durable, upgradeable, repairable and recoverable, extending the lifetime value of the materials and invested energy. This could comprise a whole product, or specific elements that can be replaced or repaired.

The three core principles of a circular economy are: designing out waste and pollution; retaining materials for use (and reuse); and regenerating natural systems. These principles can also be applied to carbon, and the circular carbon economy is a system where carbon emissions are actively reduced, reused, recycled and removed.

Adoption of circular economy principles positions industry for sustainable growth; enabling them to better manage resources and energy. This also includes generating value across the lifecycle of products. This approach improves the resilience of organisations, countries and regions to resource scarcity and price volatility arising, for example from the: climate crisis; population increases; government regulations and public scrutiny.

Fossil fuel derived (or synthetic) plastics are highly versatile and have revolutionised many aspects of modern society. They are both lightweight and durable, resistant to water and some chemicals and can be moulded or printed into nearly any shape. In addition, most plastics are relatively easy and cheap to manufacture and are used in a wide range of industrial and consumer applications. According to a recent report by the United Nations Environment Programme[1], plastics "have become one of the most ubiquitous materials used globally". Indeed, across the world, the plastic industry is worth the equivalent of around 7.2 trillion Riyal (UNEP, 2018). In 2017, up to 400 million tonnes of plastics were produced globally, with the majority of production and consumption in China, North America, and Western Europe.[2,3,4]

The life cycle of synthetic plastics is highly carbon intensive, emitting an estimated 1.8 billion metric tonnes of CO2eq in 2015[5]; or approximately three times the total annual emissions of KSA in 2014[6]. This is compounded by the very properties of plastics which

make them ubiquitous and particularly popular. Their combined properties of being light-weight, durable and resistant to water make them particularly popular for use in packaging. It has been calculated that by 2015, the world had produced 7.8 billion tonnes of plastic[7]. Of this total, only 9% has been recycled, with 12% incinerated and 79% landfilled or leaked to the environment[8]. According to data available, between 5.2% and 18% by weight of municipal waste in KSA is composed of plastics[9]; with the majority currently landfilled[10]. This is validated by waste composition analyses undertaken in Riyadh[11] and by Wood in Yanbu which indicate that the quantities of plastic in residual waste is around 13-16%.

When plastic waste is mismanaged, the plastic can be released or escape into the environment[12]. Here, the very properties which make them ubiquitous, cause plastics to have a serious negative impact on oceans and marine life around the world. Plastic pollution can have a particularly detrimental impact on this environment including being consumed by marine animals and weakening the ability of coral reefs to deal with overfishing, climate change and other forms of pollution[13]. Indeed, plastic pollution has been widely identified as one of the key environmental issues of modern society. This is a global problem with a direct local impact. Studies have shown that there are relatively low amounts of plastics pollution floating on the surface of the Red Sea[14]. However, further research on fish in the region indicates that microplastic pollution still presents an emerging threat on marine habitats[15]. Indeed, research from KSA has shown that more than 75% of coastline litter is of plastic origin.[16]

In a circular economy, the production of virgin synthetic polymer is reduced by reducing demand, particularly of short-lived plastic products and by driving improvements in recycling. Further changes include increasing reuse, using more recycled and biobased polymers in products and redesigning products that are in use to drive increased recycled content, reusability and recyclability.

A key challenge at present is that *not all polymers are easily recyclable*[17]. Where plastics are technically recyclable, there are a number of factors which affect whether they are actually recycled. These include: the design of the product; available waste management infrastructure and market demand for recycled polymer.

- **Design:** designing a product for recycling or recyclability requires consideration how that product is collected, sorted and processed as well as the end use of the recycled material. Design for recycling standards and guidelines focus manufacturers and (re)processors on the shape and size of products, the choice of polymer(s), the compatibility of materials, whether materials used are easy to separate (composition, use of barriers and coatings, presence of labels and sleeves) use of additives, colours, etc.

- **Waste Management infrastructure:** the effective management of any type of waste includes collection of waste materials, sorting and aggregation of those materials into defined streams and the processing, reclamation and recycling of waste into new raw materials. For plastics to be recycled cost effectively into quality recyclate, sufficient provision of both of clean waste plastics and of an infrastructure appropriate to the types of plastics produced, are needed to facilitate the segregation of target plastics from other materials.

- **Market demand for recycled polymer:** to be fully recycled, the recycled plastic needs to become a raw material that is used in the production of new products. Demand for recycled polymer is particularly affected by both price (both of virgin and recycled feedstock) and regulation (public procurement and green building regulations can drive recycled plastic demand).

Further development of the infrastructure to drive recycling is underway in KSA. This includes development of material recovery facilities and mechanical treatment plants which separate and recover recyclable material streams from municipal, commercial, industrial, and construction and demolition streams[18,19]. In addition, the Jazan City Municipal Waste Management Study identifies a number of areas where local action is required to drive this agenda forward. These include, improving recycling performance, expanding the range of materials targeted by recycling services and developing the required infrastructure.

Saudi Vision 2030 has at its heart the achievement of environmental sustainability by increasing the efficiency of waste management, establishing comprehensive recycling projects, reducing all types of pollution and the protection and rehabilitation of beaches, natural reserves and islands. The National Transformation Program 2020 includes as a strategic objective, the reduction of all types of pollution and as second theme objectives, the development of Municipal Waste Management Systems and the establishment of a regulatory framework to activate Waste Management in the Kingdom. Both frameworks could drive a circular

economy which effectively and sustainably manages plastics across the value chain and in particular, plastics wastes.

Waste management within KSA is in a period of transformation as it adapts to meet the targets and associated challenges within the Vision 2030 document. Meeting these targets will require constant efforts towards a paradigm shift in the country's approach to the management of its waste and resources. The continuous development of national and local legislation and guidance that places circularity at the forefront will allow the environmental benefits of the Circular Carbon Economy to be realised. Considering the requirements of circularity at the inception of all legislation will ensure that barriers and constraints are not placed in the way of KSA developing a modern circular economy and enjoying the potential environmental and economic benefits that this presents. ■

Catalyzing a Circular Economy of Plastics in Saudi Arabia

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Today, a new economic model is gaining momentum as countries, businesses, and households tackle the economic and environmental impacts arising from the current consumption model where ultimately all products are destined to become waste and enter the environment. This linear economic structure of 'Take-Make-Use-Dispose' results in strain on finite natural resources and an influx of waste that pollutes our water bodies, skies, and lands.

The Circular Economy is a relatively new model which can be traced back to some schools of thought from the late 1970s (Ellen MacArthur Foundation, n.d.). "A circular economy is an industrial system that is restorative or regenerative by intention and design." (World Economic Forum, n.d.). This model provides a viable solution that requires fundamental transformation, from re-thinking processes and existing infrastructure to re-designing products so that they can be "made to be made again". It is a disruptive structure that significantly deviates away from the status quo and existing industrial system.

The Transition to the Circular Economy in Saudi Arabia

Saudi Arabia hosts a population of approximately 34 million with an inflow of near 1.8 million pilgrims visiting

per hajj season (General Authority for Statistics Saudi Arabia, 2020). The rapid population growth, urbanization, and industrialization witnessed in Saudi Arabia has resulted in high consumption of resources and increased volume of waste, reaching approximately 1.7 kg per person per day (Bhargava, A. & Chidanamarri, S., 2018).

With a massive flow of disposables from citizens and pilgrims, plastic waste is a major component of the Kingdom's Municipal Solid Waste (MSW), comprising near 5 – 17% (Ahmad, I. et al., 2016). Currently, however, Saudi Arabia still predominantly manages waste by dumping at landfills, with only a 10% recycling rate recorded in 2016 (Anouti, Y. et al., 2019). Landfilling negatively impacts the environment, contributing to land contamination and degradation, as well as greenhouse gas (GHG) emissions. In addition, landfills in the King-

dom are matured and could reach capacity in the near future.

Transitioning to a circular economy will help Saudi Arabia address the environmental strain caused from waste mismanagement, as well as help create a more resilient economic model not solely dependent on the oil sector. This model can create green jobs, generate revenue and value from recycling, and reduce consumption of natural resources and GHG emissions.

In 2016, Saudi Arabia launched its 'Vision 2030', an ambitious roadmap to a diverse, thriving, and sustainable nation. This vision puts in motion the Kingdom's transition towards an environmentally conscious economy, focusing on preserving natural resources, increasing the efficient management of waste, enhancing recycling, reducing pollution and fighting desertification.

Circular Packaging Design

One fundamental step in the circular economy is to design out waste, especially for durables which are products made of materials not suitable to re-enter the environment (World Economic Forum, n.d.). These products, such as plastics, the second highest volume of MSW produced in Saudi Arabia, need to be redesigned in a way that ensures that there is no product end-of-life, rather restoration, reuse, repurposing, or recycling. This requires rethinking materials and structure in the world of packaging.

Re-thinking Materials

The circular economy focuses on creating economic growth decoupled from environmental stress caused by natural resource scarcity and depletion, as well as waste generation. By lightweighting packaging products, manufacturers decrease raw material consumption while maintaining the needed packaging properties, thus reducing impacts across the entire value chain.

To feed into the circular economy, it is essential for packaging producers to select renewable, recyclable, and non-hazardous materials which impact the ability to reuse, repurpose, or recycle the packaging. Plastics converters are also exploring new bio-based materials that allow for packaging to enter the consumables cycle and safely feed back into the eco-system. In cases of renewable or bio-based materials, it is equally important to secure sustainable sourcing so that renewable materials extracted from the environment are replenished, such as through Chain of Custody certified sustainable forests or farms.

Re-Designing Structure

Complex packaging structures are difficult to recycle, especially when using composite structures comprising of multiple layers of different materials. Flexible packaging manufacturers can use innovative homogeneous structures compatible for recycling, as well as explore compounding technology. There are various methods to compound compatible and incompatible polymers which provide enhanced recyclability, combined properties, and even in some cases synergistic improvement of properties.

Infrastructure & Partnership

Partnership is essential for a circular economy of plastics to really take effect in the Kingdom, as it requires a systemic and industry shift. To support such a transition, it is crucial to ensure the recycling infrastructure is in place and functioning with enough capacity and capabilities to address the main forms of waste in the Kingdom. As Saudi Arabia forges forward with its Vision 2030 objective to enhance recycling capabilities, it established the Saudi Investment Recycling Company (SIRC), a wholly owned subsidiary of the Public Investment Fund (PIF) of Saudi Arabia. SIRC aims to drive the circular economy in the Kingdom by partnering with society, waste management sector players, and private sector companies. The investment and development platform for the waste management industry works in the 4 core business areas: municipality waste, industrial waste, sector development, and technology solutions.

Packaging converters and brands also have a critical role to play in pushing forward the circular economy by partnering to create innovative solutions that help products or packaging be reused, repurposed, or recycled. In addition to partnering locally, it is of significance to partner with international associations working towards pushing the circular agenda globally. These partnerships will bring the local sector international expertise and know-how, as well as potential support on impor-

tant recycling projects in the nation.

Recycling Technologies

Different types of waste require different recycling capabilities. There are various recycling technologies available to handle the recycling of packaging. Where some require comparatively simple recycling processes (for monolayer packaging for example), others require complex recycling processes (for composite materials).

Furthermore, for highly contaminated products and packaging that cannot be reused, treated or recycled, the circular economy presents waste-to-energy as the final solution for problematic waste. As such, building recycling capabilities across the Kingdom is the building block to Saudi Arabia's circular economy.

Consumer Awareness

In a circular economy of plastics and durable materials, consumers become users since products are designed for circularity and not consumption. This requires a major shift in mindset for users and households. Brands and packaging producers must work together to increase public awareness on which products and packaging can be reused, as well as how to properly segregate waste and send for recycling.

Another critical factor for public awareness is to effectively communicate the wide variety of environmental attributes packaging and plastics in specific provide. In the Kingdom, for example, where food waste is the largest volume of municipal waste, one key benefit of plastic packaging is its ability to extend food shelf-life and preserve food. Amid COVID-19, the hygienic properties provided by plastic packaging also have come to light. As such, it is always important to give users complete information to drive effective societal change.

Article Credits

The Circular Carbon Economy: Concept and Applications

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