tcbb RESOURCE

Response to Requests for Commentary on the Preparation of a National Policy Statement on the Bio-economy

tcbb RESOURCE is pleased to submit the following observations in respect of the preparation of a national policy statement on the bio-economy.

1. Does the broad definition outlined adequately encompass the opportunities presented by the bio-economy?

There are many components to the bio-economy.

- The bio-economy is comprised of a collection of discreet but related Agri-food, Marine, Forestry and Municipal Wastes (AMFM) sectoral interests, each of which generates (or can generate) substantial economic activity in their own right, employing an established and skilled workforce, deploying existing production infrastructure, supported by skilled technical/marketing/financial services sectors with established stakeholder relationships.

  A breakdown of sectoral interests in Ireland might reflect:

  - *Dairy Sector* – includes applications that integrate into dairy farming and diary processing activities to add value to milk production and processing activities;
  - *Meat Processing Sector* – includes applications that integrate into cattle, sheep, poultry and pig farming and the related meat and poultry processing activities;
  - *Tillage Related Food and Beverage Production* – includes applications that integrate into tillage, orchard and horticultural production as well as the related food and beverage processing activities;
  - *Forestry Sector* – includes applications that integrate into forestry and timber processing;
  - *Marine Sector* – includes applications that integrate into fish, shellfish and algae production and processing;
  - *Municipal Waste and Wastewater Management* – includes applications that integrate into domestic and commercial municipal waste management as well as the wastewater treatment, to add value from processing organic waste resources in compliance with the waste hierarchy and waste management regulations;
  - *Bioenergy and Nutrient Recovery* – is not necessarily a discreet sector but includes prospective (current?) cross-cutting applications that can integrate into each of the other bio-economic cycles, adding value to processing a wide range of biomass feedstocks via energy recovery, nutrient recycling and/or reduced residue disposal costs.

Market opportunities within each of these AMFM sectors arise in respect of "traditional" products and services (e.g. food/beverage and feed products, construction materials, waste management services, etc) in both domestic markets, driven by economic recovery, as well as in export markets impacted by population growth and the emergence of consuming middle classes in developing economies. Improvements in productivity and competitiveness are required to compete effectively with growing competition arising from low cost, developing economies. These "traditional" market opportunities comprise a large part of the bio-economy.

- Bio-economic development objectives are aligned with sustainability objectives, which in a world experiencing exponential population growth, targets balanced economic growth to achieve societal cohesion, distributing wealth and resources more equitably across rural and urban sectors of society. It targets improved health and wellbeing by mitigating environmental and ecological impact, meeting the needs of current generations while leaving the planet in a state fit for future generations.

  These sustainability objectives are clarified and reinforced by a wide range of strategies, policy initiatives and implementation measures (broadly termed EU Sustainability Policy) that more specifically target:

  - *Energy decarbonisation and climate change mitigation*
  - *Maintenance of soil, water and air quality*
  - *Habitat maintenance to support bio-diversity*
  - *Resource efficiency and improved waste management*
  - *Energy and resource security*
  - *Sustainable re-industrialisation to maintain a productive manufacturing base*
  - *Development of a knowledge based economy to improve wealth creation, wealth retention and maintain a sustainable tax base and balance of trade*

  Sustainability drivers promote the transition to a low carbon economy that progressively displaces finite supplies of oil and other extractive raw materials with renewable alternatives. Sustainability drivers promote re-industrialisation of the economy, targeting use of locally sourced renewable resources to restore and secure an indigenous manufacturing base.

  These sustainability drivers present economic growth opportunities which Ireland's traditional bio based sectors are potentially well placed to exploit. "Non-traditional" bio-economic applications such as bio-energy, bio-chemicals and bio-materials, as well as low-volume high-value applications such as functional foods, nutraceuticals, cosmeceuticals and fine chemicals also form part of the bio-economy.

- Ireland has yet to exploit these new "non-traditional" development opportunities, as products must be identified, supply chains developed, process technologies optimised and market outlets secured to manifest the potential benefits. This will take time, especially in the context of immature technologies, unproven market demand and new, untested products. The technology development, as well as development of the professional support services required to achieve this transition, comprise an element of the bio-economy.

- Given Ireland's history as a trading nation, bio-economic development opportunities are many times viewed in the context of expanding Irish exports, enabling Irish companies to leverage established market positions to supplement traditional bio-economic exports with "non-

traditional" products. Given the complexities associated with developing export opportunities in immature markets, in the near term may be easier to promote bio-economic development by displacing imports rather than pursuing new export markets. Near-to-market bio-based import displacement opportunities include:

Import Displacement Opportunities:

- Fossil fuel imports valued at c. €6,500m annually which supply an estimated 85% of Ireland's annual energy demand;
- Organic chemical imports valued at an estimated €3,778m annually which provide the inputs to Ireland's substantial pharm-chem and medical devices industries;
- Paper imports valued at €918m which supply Ireland's packaging and printing needs;
- Primary plastics imports valued at €850m which supply Ireland's packaging and materials demand;
- Sugar product imports valued at €374m which supply confectionary demand;
- Animal feed imports valued at €779m which support the livestock sectors; as well as
- Fertiliser imports valued at €448m which supports production of the fodder supply for Ireland's livestock as well as grain production for food & beverage products.

- Irrespective of whether bio-economic development arises on the back of expanding traditional outputs or developing supply chains for new non-traditional (import or export) products and services, Ireland's primary producers will have to increase primary outputs to supply growing demands. This will require measures to improve margins by increasing productivity and competitiveness as well as overcoming severe fragmentation, to finance the requisite capital investment. The increase in primary production, and the corresponding services and technologies required to support this increase, comprise another element of the bio-economy.

- Sustainability policies impose certain obligations on Irish AMFM sectors to mitigate environmental impact from production and processing activities, especially in the context of intensification and increasing outputs from the supply chain. These obligations will require measures to mitigate emissions, improve residue and waste management, maintain biodiversity and means to measure and manage a healthy environment for flora and fauna as well as comply with EU agreements underpinned by statutory obligations. Development of the technologies and the support services necessary to achieve environmental mitigation comprise another element of the bio-economy.

- The bio-economy definition as outlined in the Document draws from these concepts, as further clarified in the EU bio-economy strategy 2012 – Innovating for Sustainable Growth: A Bio-economy for Europe. The bio-economy intrinsically covers a broad spectrum of the Irish economy. Arguably, it is advisable to retain as wide a definition as possible so as not to implicitly exclude or inadvertently impede any areas of it in a public administration or economic development context. In terms of Ireland's international obligations and its commitments to climate action, the development of a bio-economy strategy should reflect the opportunities to support the state's

transition to a low-carbon economy, as enacted in our climate legislation and in stated policy positions on for example energy, transport, agriculture, forestry and the marine. It may be helpful to define the Irish bio-economic transition in the context of the specific bio-economic development opportunities, juxtaposed against the environmental obligations and societal considerations, as discussed above.

2. How can a high-level policy statement on the bio-economy assist in progressing the development of the priority value chains identified?

If properly structured, a high-level policy statement on the bio-economy will be a significant aid to coherence in governance and policy implementation across all sectors:

- Firstly, preparation of a high-level policy statement on bio-economic development can solidify Ireland's aspiration in respect of transitioning to a more sustainable bio-based economy. Such a statement can recognise from the outset that Ireland has particular natural resource advantages in terms of its marine territory and its grass-growing and forestry-growing conditions. Ireland ranks very highly amongst European Union member states for these natural environmental conditions, and a statement on bioeconomic development can establish the intent to sustainably exploit these resources to underpin Ireland's economic development.

- Preparation of a high-level statement on development of the bio-economy offers an opportunity to establish clear objectives, targets and timeframes within each of the relevant bio-economic value chains, clarifying what Ireland aspires to achieve in developing its bio-economy, leaving definition of the actionable implementation programme that defines "how" these objectives will be achieved to more detailed sectoral development strategies. In establishing targets and timeframes, it would be important to acknowledge that measurable impact from expenditure of public resources may require a certain minimum scale and degree of market development, which is likely to be achieved progressively over time.

- Ireland's current market and regulatory frameworks may have to be adapted to capitalise on its bio-economic development opportunities. This will require a high degree of cross departmental cooperation. A high-level statement will put a name/title and a definition on this area for a cross-section of relevant public policy officials in government departments, state agencies, regional agencies and local authorities. It will assist in the necessary awareness-building and knowledge-building required across various sectors of public administration to enable the type of joined-up decision-making and policy implementation required to allow for the development of the bio-economy. It can establish an obligation on the relevant stakeholders to actively participate in achieving the stated objectives.

- Sustainable exploitation of Ireland's natural competitive advantages requires an integrated approach to planning for bio-economic development. In the context of an economy that increasingly looks to bio-based materials as the source of raw materials, a balance must be maintained between economic development and protection of the natural resources that underpin supply of bio-based raw materials. A policy statement in respect of bio-economic development may provide an opportunity to confirm the intention to maintain this balance, assuaging concerns of both environmentalists and entrepreneurs, as well as providing guidance on maintaining the balance between the need for timely decision making and public participation. In the context of a

bio-economy designed to improve sustainability, a review of certain governance frameworks may improve the fitness-for-purpose (such as some of the planning and licensing protocols which have evolved in the context of different market circumstances).

- A high-level statement offers another tool to address the integration of near term responses to societal imperatives such as climate action, maintaining a healthy and bio-diverse environment, energy de-carbonisation, resource security and other sustainability challenges. In this regard, a high-level statement can incorporate an objective to create the governmental structures that facilitate the development of integrated frameworks and coherent, coordinated policies required to underpin bio-economic development. A high-level statement will assist in justifying the near-term allocation (re-allocation) of public resources to achieve specified sustainability objectives.

3. What lessons can Ireland take from the European approach, including to the Circular Economy?

There are several lessons Ireland might learn from observing the successes and failures from other jurisdictions (USA and Asia as well as Europe), including:

- **An integrated approach is required to align interests of new and existing stakeholders across the value chain -** Exploitation of bioeconomic development opportunities is complex, requiring a comprehensive bio-economic strategy that aligns the societal and commercial drivers across a wide range of commercial, governmental and societal stakeholders.

  Successful bio-economic development is dependent on a "triple helix" approach that develops the supply chains along with market outlets together with the regulatory and commercial frameworks necessary to support viable market structures. Exploitation of bio-economic development opportunities requires stakeholders to develop integrated "systems" rather than linear applications. Bioeconomic systems require a sustainable raw material supply, development of conversion technology, timely deployment of processing and support infrastructure, routes to market and sustainable demand for the product.

  Optimal exploitation of bio-economic growth opportunities may require adaptations to existing commercial and regulatory frameworks to overcome constraints imposed by legacy market structures, and better align commercial and regulatory frameworks with development requirements. Cross-departmental governmental cooperation may be required to develop these integrated frameworks.

  Early, successful market entry is key to establishing momentum required to sustain stakeholder interest. For example, delays in establishing Ireland's bioenergy framework has ceded momentum to other EU member states such as Germany, Netherlands and the UK, and as a result technology development as well as design of the export market framework for renewable energy is being undertaken in other jurisdictions.

  Successful bio-economic development may require intensification to increase supply of primary outputs. It may require re-orientation of resource utilisation, targeting an appropriate balance between traditional and non-traditional growth opportunities in a manner that can attract finance as well as public and political support. Land use protocols, possibly integrated with re-structuring of existing support payments (e.g. such as direct farm payments or forestry payments) to de-

fragment supply chains, incentivise productivity and improve competitiveness as well as to mobilise residues for renewable energy recovery, may be the least costly route to achieve and increase a supply chain from primary production outputs.

Growth in traditional food, beverage and timber construction products with non-traditional outputs may require engagement of previously unconnected stakeholders (e.g. Ireland's substantial pharma-chemical, medical devices, energy, paper, plastics and other processing industries with traditional AMFM sectors). For example, the production of PLA bioplastics required the collaboration of a Dutch chemical manufacturer (Purac Corbion) with a French fuel producer (Total). Formal structures and programmes may be required to integrate the interests of these diverse stakeholder groups.

EU biorefining strategies have highlighted that the economic viability of "non-traditional" bio-economic process chains are likely to require co-development of multiple product outputs that can utilise each fraction to valorise the entire mass of the biomass feedstock supply. Every bio based process generates a residue, and in this regard, development of renewable energy and nutrient recovery applications are key, as they are ubiquitous applications that valorise the by-products not otherwise used in higher value applications.

Development of multi-product processes are complex, and will require integrated approaches to technology development that cross academic disciplines with process engineering, and may require adaptations to RD&D programmes to directly align technology development with sectoral industry needs. Development programmes need to progress in a structured, coordinated manner from bench scale scientific development to pilot scale process engineering to commercial demonstrator. These integrated development programmes need to be established from the beginning. Pilot scale facilities are required to develop the process engineering protocols.

Infrastructure deployment may require adaptations to planning and licensing protocols to expedite infrastructure deployment. Market structures that rely on transfer pricing between primary producers and processors to govern distribution of proceeds between the relevant stakeholder groups can be difficult to organise in new markets where risks are difficult to define. New structures may be required to overcome these concerns, and to access public sources of finance that are required to support development of the supply chain, which may also require public measures to support market entry for new products.

Bio-economic development strategies need to address public interest concerns, balancing economic development issues with health, wellbeing, environmental and societal issues. Information programmes need to provide accurate and scientifically supported information to allow stakeholders to make rational decisions.

Bio-economic development strategies must be consistent with the EU market vision to ensure ongoing market relevance and compliance with sustainability objectives. They must also be cognisant of the impact on the State exchequer, facilitating an efficient use of public resources by leveraging use of existing support frameworks to better align available resources with requirements, as well as better leveraging State resources to access extensive EU support resources.

- **Build on established strengths – compliment rather than cannibalise established value chains:** near term realisation of bio-economic benefits may be best realised by leveraging an existing raw

material supply, as well as skills, resources and infrastructure from established processing industries to add revenues from "non-traditional" applications. Near term bio-economic development is most likely to be optimised by promoting complimentary co-existence of traditional and non-traditional opportunities rather than cannibalisation. Valorisation of residues from within established value chains potentially offers the easiest route to add value.

Examples of this concept can be seen in the earliest commercial deployments of European biorefineries, such as:

- Pomacle Bazancourt in France has integrated biofuel and bio-chemical production with an established sugar processing plant to create a biorefining complex that uses each fraction of agricultural production from a radius surrounding the complex to generate different bio products. The basis of the complex was the sugar refinery.

- SEKAB in Sweden is a similar example of biorefining that has arisen from developing different applications for forestry outputs

- **Unwarranted concerns re use of 1st generation biomass for chemical and material applications** – arising from experiences in the early days of transitioning from oil to renewable energy, concerns arose over the impact that use of 1st generation feedstocks to generate biofuels would have on food prices and availability. These concerns were based on the volumes of 1st generation biomass that would be required to satisfy the enormous demand for transport fuel. These concerns, however, do not similarly apply to use of 1st generation feedstocks to produce bio-chemicals or other bio based materials, which are being used in the USA and Asia to migrate from fossil based chemicals and materials to bio-based alternatives (e.g. see Natureworks PLA producers in the USA, Total-Corbion PLA venture in Asia. Petrobras PET producer in Brazil).

  The volumes of biomass that is required to supply chemical or bio-plastic demand is orders of magnitude less than that required to supply fuel demand. Additionally, biomass molecules are highly oxygenated while fuel molecules are highly saturated (de-oxygenated), which means that significant mass is lost when oxygen is removed during conversion. Organic chemicals and plastics, on the other hand, are comprised of oxygenated molecules, which means that mass conversions from biomass to chemical or material products is much greater. Lastly, biofuels cost more to produce than fossil fuels, and biomass prices are influenced by the price of crude oil, which means that ongoing governmental support will be required to maintain a viable biofuel market. Conversely, the market prices for chemicals and materials is determined to a greater extent by the cost of conversion rather than the commodity price of the raw material. Prices for chemicals, polymers and plastics are greater than fuel prices, which correspondingly means that developing market outlets for bio-based chemicals and materials may require much less government support, and in future may require no support at all.

  First generation biomass feedstocks are homogenous and much of the processing technology is mature and market ready. Accordingly, it may be advisable to target use of 1st generation feedstocks for development of higher value bio-chemical and bio-material applications to achieve viable, sustainable near-term market positions in these rapidly developing markets.

- **Requirement for active and coordinated intervention** – while growth in traditional bio-economic activities can rely on commercial imperatives and existing market structures to govern and manage

these activities, many of the drivers for development of new "non-traditional" applications are societal rather than commercial (e.g. the need to mitigate GHG emissions by decarbonising the energy supply, for example). Additionally, the risk/return profile in respect of developing new bio-based applications is outside of acceptable commercial norms. Accordingly, the active and coordinated intervention of governments are required to stimulate this development.

Examples of successful governmental interventions across the EU include various bioenergy applications. In Member States that where support frameworks have been established (e.g. the German biogas sector, for example) there has been substantial corresponding bioeconomic development. An integrated approach to development of the supply chain and routes to market, as well as monetisation of the respective societal benefits to be achieved, provide the commercial imperatives and form key components of the successful support framework. Having established an infrastructure framework, these member states are now able to migrate the production infrastructure to more market led frameworks.

Contrasted against areas where there is limited active or uncoordinated intervention (e.g. EU bio-plastic production, for example) and there is much less bioeconomic development activity in evidence, even though such technologies are commercially deployed internationally.

- **Sustainable Development of Biomass Supply Chains** – while more applicable to deforestation in Brazil and some of the tropical climates, promoting development of bio based economies must be undertaken in the context of maintaining the sustainability of the supply chains, not only for economic exploitation, but also for preservation of biodiversity. Many of the requisite protections are already in place in EU governance frameworks, however especially in respect of marine resource development, a comprehensive approach is required.

- Arguably, Ireland can take lessons from other European Union member states in terms of prioritising resource recovery from residues, by-products and resources currently considered wastes, before looking at extraction of first-generation resources for use in the bio-economy.

- Ireland can also take lessons from other EU Member States in respect of the structure of its RD&D programmes. Programmes that are established at a certain scale (VTT in Finland, VITO in Belgium, Fraunhofer in Germany, for example) and more directly aligned with commercial interests are perceived to generate more impact and perceived to leverage greater development funding.

- Especially in the context of the UK exit from the EU ("Brexit"), it is important to be cognisant that the existence of a tariff or market support mechanism in one jurisdiction on the island could have the effect of acting as a pull factor for materials out of one jurisdiction into the other.

4. Given the cross-sector nature of the bio-economy, how can a national policy best support development?

A national policy on bio-economic development may consider some of the development opportunities relevant to the respective bio-economic sectors, including the following:

- *Bioenergy and Nutrient Recovery* – waste/residue to energy applications are the most viable as they leverage -0- cost feedstocks to fuel the applications. Thermal technologies can be deployed to process mixed black bin wastes in CHP applications, however require re-activation of the REFIT supports to underpin viability.

Biogas applications can process digestible feedstocks such as food waste and livestock manures, and can leverage use of the gas grid to supply renewable gas to an established gas demand. It can potentially expand by integrating grass into the feedstock supply chain. Viability of the biogas sector requires establishment of a biogas feed-in tariff and support mechanisms to mobilise slurry feedstock supplies.

Biomass solid fuels (wood biomass) require an RHI incentive to levelise cost of woody biomass heat with the cost of natural gas heat, and to provide an incentive for users to change to biomass boilers, overcoming the market inertia that may otherwise constrain development of this application. Announcement of an RHI is expected imminently.

Biofuels opportunities may be limited to niche opportunities to convert waste products to liquid fuels, until technology RD&D can develop a technology to convert wastes and residues to a 2G drop in biofuel

- *Municipal Waste and Wastewater Management* – opportunities arise in respect of developing a domestic paper pulping industry that can regenerate pulp from the waste paper that is currently routed out of the country at very low value (Ireland correspondingly imports virtually all its paper / fibre requirements at much higher costs)

  Renewable energy opportunities arise in respect of thermally processing mixed black bin wastes as well as anaerobically digesting source separated food waste and grass greenwaste. Improved protocols are required to encourage source separation and collection of digestible wastes at kerbside, and given the multi-operator structure of the waste management sector, public funding of renewable energy processing infrastructure may be required to overcome the market fragmentation.

  Deployment options for publicly funded waste processing infrastructure may include community based sustainable energy structures. Corresponding development of district heat networks, especially in jurisdictions not otherwise served by the gas grid, may provide an opportunity to use biomass wastes and residues to reduce the cost of heat for community residents. Such a programme would require publicly funded supports, but would likely become self-sufficient over time.

  In municipal wastewater treatment, opportunities exist to deploy primary solids separation with High Rate Anaerobic digestion to improve energy efficiency and reduce sludge costly sludge generation. Such technologies may also provide a low-cost route to increase the processing capacity at overstretched WWT plants. Thermal processing of WWT sludge provides an opportunity to recover renewable energy. Deployment of community based renewable energy centres at WWT plants potentially offers a means to convert WWT cost centres to profit centres.

- *Dairy Sector* – In respect of dairy processing opportunities arise to extract added value from whey residues which are comprised of proteins and carbohydrates (as well as minerals and other small fractions) the specific composition of which varies depending on the originating process. Whey residues originate from a hygienic food processing process so may be a very suitable material for supply of extracts to the pharma or medical sector.

  Protein fractions can potentially supply bioactive or nutraceutical peptide or amino acid extracts. Carbohydrate fractions, including residual lactose sugars comprised of readily metabolised glucose and galactose monomers, are potentially suitable as a feedstock for a

wide range of nutraceuticals, bio-chemicals or bio-materials. Production of human bio-active saccharides has been demonstrated. Organic acid fermentations (e.g. lactic, propionic or succinic acids, for example) can potentially be achieved at high mass conversions, offering routes to high value platform bio-chemicals. These platform chemicals have an inherent market value or can be further transformed into end-products such as solvents or components of bio-based plastics Development of downstream products from within a food processing value chain may offer high value components suitable for Ireland's pharma-chemical or medical device sector. Technology development is required and the Food for Health programme hosted at UCD is engaged in this work.

In respect of dairy farming bioeconomic opportunities potentially arise from identification of systems to improve fodder production or identify viable alternative supplies of fodder. Additional opportunities arise in respect of the development of feed supplements (e.g. protein extracts from other biomass processing activities, for example) that can enhance health, growth and milk productivity. Mechanisms that can mobilise manure supplies for renewable energy recovery will have to be structured to improve returns to farmers. Technologies to mitigate environmental impact from fodder growth (e.g. improved organic nutrient recycling, for example) or from animal husbandry (e.g. methods to reduce enteric emissions from dairy cattle, for example) may also improve dairy farm sustainability.

- *Meat Processing Sector* – In respect of grass fed cattle farming, improvements in competitiveness and economic growth may be derived from consolidation of small, part time farms into larger more intensive economic units to drive economies of scale. Increased stocking rates and herd size will require increases in feed supplies. Micro managing nutrient applications to optimise grass production may support increased intensification. Use of recycled organic nutrients in forms that facilitate targeted application may mitigate environmental impact from more intensive fertilisation. Developing technologies to increase indigenous supplies of low cost feed supplements can reduce importation and cost of feed, while recovery of renewable energy and nutrients from manures and residues, especially during period where land spread of slurries is restricted, may add value in the primary livestock supply chain.

  In respect of intensive pig and poultry farms, margin improvements may also be driven by developing technologies to supply indigenous sources of low cost feed. Additionally, development and deployment of technologies that recover renewable energy and nutrients from the manure residues can reduce energy costs and cost of manure disposal.

  The meat and poultry processing generates substantial 5th quarter residues (e.g. offal, hides or poultry feathers, tail, hooves, blood and fluid, bone and sinew materials, etc) which can represent up to +40% of the live weight of an animal. These materials currently generate a very low economic value when valorised via tanning (hides), incorporation into pet foods, rendering and disposal via incineration or landfill. Development of alternative routes to valorise the proteins, possibly extracting peptide or amino acid derivatives, or alternatively conversion into hydrolysate feeds that could be used to expand fish farm aquaculture, may provide a route for improved valorisation.

  Development of bioenergy and nutrient recovery applications may offer routes to valorise 5th quarter residues, as well as manures from livestock husbandry. Structures (other than

transfer pricing) will have to be developed that allow the feedstock owners to benefit from such applications to mobilise this feedstock for energy recovery.

- *Tillage Related Food and Beverage Production* – In respect of tillage farming. development of 1st generation sugar / starch biorefining applications can progressively target indigenous supply of the €374Mn of Irish sugar imports, as well as €3.5 Bn of organic chemicals imported as raw materials each year, may provide a means to increase margins in tillage farming. Sucrose from sugar beet, like starch from cereals, is readily converted to monomeric sugars that are the base building blocks for a wide range of bio-chemicals and bio-materials. Development of small scale, modular sugar refining technologies would be required to underpin a supply of beet-derived sucrose that can be used interchangeably for food grade table sugar or as a bio-chemical feedstock, offering multiple market outlets that could provide a route to progressively re-introduce sugar beet into the crop rotation.

  Bio-chemical values compare favourably to the wholesale value of white sugar. Supplementing production of food grade sugar with higher value bio-chemical outputs could facilitate a competitive positioning based on technical knowledge and expertise rather than the cost of beet production, avoiding competition solely reliant on commodity beet pricing. Initially, target bio-chemical outputs could include organic acids such as isomerically pure lactic acid or succinic acid that benefit from established market demand as well as relative mass conversions / product prices that generate attractive potential returns. Structures other than transfer pricing are likely to be required to overcome barriers that will otherwise constrain co-development of the primary production capacity together with processing technology.

  Intensification in the dairy and beef farming will create an increased demand for animal feed. Currently, residues such as brewer's and distiller's grains as well as fruit and vegetable discards, are disposed of in a raw form as animal feed. Development of low cost technologies that can "pre-digest" fibrous materials may facilitate introduction of cereal or oilseed straw into the animal feed supply chain, providing a source of bulk fodder. Alternatively, technologies that facilitate fractionation and recovery of the respective protein and carbohydrate concentrates, may generate functional feed concentrates that may attract a higher value.

  Tillage generates substantial quantities of straw or crop toppings, while food and beverage processing activities generate significant volumes of organic residues (e.g. spent brewer and distiller grains, apple pomace, fruit and vegetable discards or cuttings, etc) that are currently valorised in very low value applications as animal feed, or otherwise disposed of as waste. Mushroom growers and horticultural industries generate spent bio-based growth media, such as mushroom compost or coir, that is also disposed of at a cost. A programme to promote energy recovery and efficient nutrient recycling from these residues may offer an improved route to valorisation, improving the competitiveness of the sector as well as a contribution toward the State GHG and RES obligations.

- *Forestry Sector* – Ireland's forestry sector is under-exploited. The forestry sector supplies timber based construction materials as well as woody biomass residues for bioenergy. Expanding market outlets for biomass fuelled energy is the nearest to market opportunity to add value from forestry outputs. As noted above introduction of the anticipated RHI will be required to stimulate demand. Additionally, much of the forestry brash residues are currently left uncollected at site. This resource is of variable character, however potentially

offers a viable energy source if adaptations to biomass boiler or other thermal technologies can be shown to efficiently process this resource.

Ireland imports its paper and packaging supplies. Development of scaled, modular pulping technology that could be deployed coincidentally with paper de-inking technologies (referenced under waste management above) could provide an indigenous supply chain to displace imported supplies of paper, packaging or other fibre products. A government initiative to procure sustainably produced paper and packaging products could underpin market entry, leading to a broader market penetration that adds significant value to each of the respective municipal waste and forestry sectors.

Over time, panel board plants or a commercial pulping plant may be able to integrate lignocellulosic biorefining capabilities to add further value in the forestry sector. Lignocellulosic biorefining is advancing quite rapidly, as evidenced by commercial demonstrators for biofuels, polymers, and chemicals being deployed in Canada, Scandinavia and the Netherlands. Given Ireland's position as a supplier of construction materials, development of a lignin based resin for use in the panel board production could offer a niche market that is consistent with the current product portfolio. A large proportion of wood products rely on petroleum derived phenol-formaldehyde (PF) as the commercial resin. Alternative bio-based resins, such as lignin derived adhesives are being developed as a viable bio-based substitute. Alternatives to resins for panel board could include production of the polymers for fibre reinforced composites. Lightweight composites are increasingly used in construction and manufacturing operations as replacements for wood and metal. The polymers are is usually comprised of an epoxy, vinyl ester, or polyester thermosetting plastic. Bio based technologies can be developed to generate these materials. An integrated approach to product development may offer a means to expand the current product portfolio and add value in the forestry sector.

- *Marine Sector* – Ireland's marine footprint is c 8 X larger than its land mass, and in the context of the available supply chain and a global demand for fish protein is growing rapidly and steadily, Ireland's economic exploitation of this resource is underdeveloped. This underperformance is driven primarily by constraints in licensing inshore or coastal aquaculture activities, which may drive opportunities to develop alternative forms of aquaculture such as deep-sea aquaculture, which could potentially be deployed in locations that are less environmentally sensitive than inshore areas. Deep water sites operate in more exposed environments than inshore aquaculture, and potentially costs more than inshore fish farming. To offset increased costs, deep water designs could possibly incorporate larger structures than conventionally deployed at inshore locations, and aggregate individual farm sites into viable economic units to facilitate development of the requisite support infrastructure.

  Additional bio-economic development opportunity arises in respect of fish processing, which if appropriate scale can be established can expand to include production of processed foods, which can dramatically improve the marine sector product portfolio (which currently relies on premium priced fresh fish as its primary product). Improved processing capacity can also use the co-product stream, comprised of heads, tails, skeletons and offal to extract functional food products (e.g. protein hydrolysates, bioactive peptides or amino acids, for example).

Ireland's marine algae and aquatic plant sector is currently a niche sector that predominantly relies on harvest of natural shoreline supplies of macroalgae to generate plant and animal nutritional extracts. Higher value opportunities are available for valorisation of macro algal feedstock, that include nutraceuticals, functional foods and specialist industrial chemicals and materials. Sustainable bio-economic development can be promoted by expanding the macroalgal product set and developing market outlets for new products, however will have to be accompanied by coincidental development of the macroalgal supply chain. This may include development of multitrophic aquaculture integrating both fish and algal production, if licensing issues can be addressed.

For each individual sector, strategy adaptations are required to identify non-traditional bio-economic outputs, each establishing detailed, realistic and targeted objectives, devising and resourcing implementation measures to align societal and commercial objectives with the interests of the various stakeholders, overcoming barriers and incorporating measures to:

- **Identify Specific Product Opportunities that Add Value to Existing Value Chains:**

  Near-term manifestation of benefits from bio-economic development would be expedited and optimised by developing applications that compliment rather than cannibalise existing value chains, leveraging skills, infrastructure and resources to develop new market opportunities and add incremental value within existing AMFM sectors.

  Within each value chain there are a wide variety of potential bio-economic development opportunities ranging from low volume, high value functional foods, nutraceuticals, and fine chemicals to moderate value bulk bio-chemicals and bio-materials and low value biofuels, bio-energy and agricultural inputs. Within Irish institutions, there is a strong understanding of traditional agriculture, food and beverage, forestry, marine and related food or nutritional products and production processes. A knowledge gap exists, however, in respect of detailed bio-chemical and bio-material market opportunities which poses a barrier to near term, integrated bio-economic development. Ireland imports a large volume of organic chemicals to supply its pharma-chemical, medical and agricultural import needs. Initially, cross referencing organic chemical imports and medical device material requirements against potential "non-traditional" product specifications and estimated production data may identify routes for an indigenous bio-based supply. Comparison of key data estimates such as mass conversions relative to unit market value and local market demand would inform a detailed prioritisation exercise.

  Identifying specific new product opportunities requires specialist resources who understand the complex relationship between product functionality and specifications, market potential and production technology in the context of the available supply chain, market outlets and regulatory environment. Formal collaborations with new "non-traditional" stakeholders (e.g. from within the pharma-chemical, medical devices, energy, construction materials, plastics and paper product sectors) are required to identify specific products, develop viable business cases, and define and implement adapted AMFM sectoral development plans.

  A programme is required, possibly organised within the context of sectoral centres of excellence that are directly aligned with each value chain, to engage specialist resources that continuously evaluate and prioritise value-add opportunities taking account of the relevant value pyramid, composition of feedstock and process side-streams within each value chain.

Bio-energy and Nutrient Recovery: Bio-energy applications, especially those using wastes or co-products from existing AMFM activities, can deploy mature and market proven technologies to serve an established energy demand. While bioenergy and nutrient recovery applications are the lowest value application within a biorefining value chain, the associated revenues or cost savings may very well be required to make an entire value chain viable. While the bio-energy applications and market opportunities are well understood, an integrated framework is required to mobilise feedstock supplies, promote infrastructure deployment, access routes to market and stimulate demand.

Within Ireland, biomass solid fuels for heating, and biogas for bio-based heat and Combined Heat and Power (CHP), are the largest and nearest-to-market bio-energy valorisation opportunities. In a transport context, transport electrification is the ultimate objective for passenger and small commercial vehicle transport, however is likely to require development of additional technologies capable of overcoming range anxiety and extended recharging times prior to broad acceptance. In respect of busses and HGV transport, Bio-Compressed Natural Gas (BioCNG) transport applications are the nearest-to-market development opportunity. The market opportunity for liquid biofuels, while widely promulgated internationally, in an Irish context is likely to be comprised of niche applications targeting valorisation of specific waste streams, as Ireland's fragmented feedstock supply chain precludes large scale supply of homogenous biomass required to compete in this high volume, low value market.

Bio-Technologies: Market opportunities arise not only in respect of sustainable, non-traditional products, but also in the context of processing technologies associated with bio-products and bio-energy. In immature markets, technology development is dependent on co-development of supply chains and market outlets for the corresponding product outputs, or the availability of mature markets in other jurisdictions. Indigenous bio-economic impact from technology development will be optimised if undertaken in the context of an integrated programme for co-development of product applications directly aligned with value chains relevant to the Irish bio-economy.

- **Develop Sustainable Market Outlets -** demand stimulation to facilitate timely market entry, coupled with commercial and regulatory frameworks that support competitive positioning, are keys to establishing and maintaining momentum that engages stakeholders, as well as achieving optimal market penetration and maintaining long term bio-economic sustainability.

  Import Displacement vs Export: As noted in 1 above, displacement of imported bio-based products with indigenously produced like-for-like alternatives may be the nearest-to-market bio-economic development opportunities, as market entry can leverage established market demand and routes to market, as well as an established regulatory framework. Market entry requires only the development of a sustainable, indigenous supply chain, whereas development of new products for new export markets requires not only development of the production technology and the supply chain, but the market outlet and corresponding regulatory structures as well. Displacing imports to establish a small indigenous market for bio-based products such as paper or sugar may provide the economic base and production infrastructure that can be leveraged to develop associated "non-traditional" applications. Development of indigenous market applications may also provide the commercial demonstration of processing technologies, as well as validation of technical and economic viability, facilitating expansion into export markets. Historically, allocation of some of the State's economic development resources favoured development of export opportunities, however allocation of the State's substantial economic development resources may be best prioritised

based on prevailing and anticipated market conditions, giving equal emphasis to import displacement or export opportunities, as market circumstances dictate.

Market Interventions: EU policy gives preference to market-led structures to govern patterns of production and consumption. Governments, however, have an interest in promoting penetration of sustainable bio-based products and technologies to achieve the associated benefits, and accordingly are justified in introducing intervention measures to promote transition toward sustainable patterns of production and consumption. Sustainability is currently a societal imperative rather than a commercial imperative, as when making choices, consumers prioritise conventional value measures such as price and product functionality as opposed to sustainability benefits. Consumers also display a strong tendency toward the status quo, rather than changing to new products when making decisions. Accordingly, one of the biggest challenges to penetration of "non-traditional" products and services will be overcoming established (and powerful) market inertia.

Interventions can take several forms. Governments can assist market entry and market penetration of "non-traditional" bio based products with informational programmes as well as protocols supporting sustainability certification backed up by targeted market supports that monetise sustainability benefits. The EU Biofuels Directive establishes sustainability criteria in respect of EU biofuels, which may inform development of sustainability criteria relevant to other bio-based products such as chemicals or materials. Programmes to certify sustainability, based on accepted principles of life cycle analysis, may be increasingly required to validate the social, environmental and economic impact of bio-economic value chains. These sustainability certification activities can leverage work from the LCA PLATFORM, who has published a handbook detailing an accepted LCA regime intended to be used to underpin sustainability criteria. LCA criteria, however, can be complicated and heavily reliant on a wide range of baseline variables, the values of which could change depending on estimated operational parameters. In the context of quantifying sustainability, the proximity principle (which promotes use of local resources to supply local demands) may offer a legitimate argument for initially showing preference for indigenous sources of supply until markets mature, provided such measures accurately quantify the benefits associated therewith. This concept, however, needs to be reviewed in the context of compliance with state aid and competition frameworks to avoid excessive interference with normal operation of markets.

Provided sustainability benefits can be measured and quantified, monetisation of the associated sustainability benefits has been shown to be a successful method to stimulate market demand and/or incentivise near term supply chain development. Expenditure of public funds to enable sustainable products to establish a market position, and compete based on accepted commercial criteria as well as overcome powerful market inertia, was believed to be an acceptable use of public funds. Lessons from Europe indicate that support for the development of bio-economy industries will be required to be put in place during the economic life cycle of the initial capital investment, which in many cases can be a 10 to 15-year time-frame, with tariff supports tapering off towards the end of that life-cycle as a market becomes established and bedded down.

Where introduction of "pull" measures are required to initially incentivise supply chain development or stimulate market demand, introduction of "pull" measures should be designed with a view to migrating to market led measures as markets mature. Market led measures can include "push" mechanisms that increasingly obligate incorporation of sustainable products and

services into normal patterns of production and consumption (e.g. obligations to incorporate biogas into the gas supply or renewable electricity into the electricity supply, for example).

Fully implementing the government's "green" public procurement programme that incorporates sustainability criteria is considered one of the most viable, near-to-market and under-utilised mechanisms available to support market entry. While the Green Tenders programme has been published, it is not believed to be widely implemented.

Routes to Market: A successful market entry strategy requires a viable route to market.

- Bio-product routes to market can leverage the global marketing strength of indigenous AMFM companies, provided such activities are appropriately supported with measures to stimulate initial demand, levelise cost of production with competing products as well as support market growth and penetration. SME companies may require increased levels of support relative to larger corporate enterprises.

- Bio-energy and Associated Nutrient Recovery applications can ubiquitously add value to each bio-economic value chain, particularly via processing of wastes and residues. Bioenergy market entry would require adaptations to existing grid access and distribution protocols to facilitate timely access to energy market outlets, as current protocols pose barriers to market penetration. They noted a bio-energy support framework would initially require state supports to levelise unit cost of production with fossil-fuelled energy and wind or solar RES E applications. "Pull" support measures would initially be required until the supply chain is established at a level sufficient to underpin transition to market led measures. Thereafter, market led measures could increasingly incorporate carbon taxation or "push" obligations imposed on licensed suppliers to promote integration of an increasing percentage of renewable energy into the energy mix. Sustainability certification, that gives effect to the benefits inherent in the proximity principle, will be required to support introduction of "push" support measures.

  Development of a community based bio-energy model may provide a route to market for efficient valorisation of wastes and side-streams. An integrated bioenergy framework would be required to coherently address integrated development of the supply chain, cost-effective deployment of processing infrastructure as well as access to distribution infrastructure and demand stimulation.

- **Sustainable Expansion of Primary Production**

Ireland's AMFM sectors benefit from natural competitive advantages such as attractive climatic conditions, highly productive pasture, tillage and forestry acreages as well as large scale, accessible marine resources. These benefits are offset by severe fragmentation resulting from economic, agricultural and environmental factors, as well as historical and societal factors impacting land ownership, usage and mobility. Additionally, the existing structures of some of the establishment grants, support payment schemes and municipal waste and aquaculture licensing frameworks are believed to be contributory factors that perpetuate fragmentation within the supply chain.

Fragmentation results in excessive cost, precludes aggregation and associated benefits of scale. In the context of producing commodity outputs, prices of which are set in highly competitive global

markets that are heavily influenced by large scale producers in low cost economies, it contributes to margin pressures that restricts access to development capital, constrains optimal residue valorisation and restricts options to place marginal lands into productive use. It precludes deployment of new conversion technologies that can add value and results in over-reliance on direct payment programmes to maintain primary producer incomes. De-fragmentation of the primary supply chains is required to optimise development of the bio-economy.

Agriculture - Over time, one of the critical challenges in respect of a successful bio-economic development strategy will be how to facilitate expansion of raw material supplies in a manner that can meet both the requirement to maintain and grow traditional bio-economic outputs while facilitating introduction and development of new non-traditional market opportunities. Sectoral development strategies identified that new technologies, and operational protocols will be required to increase intensity and productivity in each of the primary supply chains. Intensification will have to be coupled with measures to mitigate and regulate corresponding environmental impact.

"Non-traditional" bio-economic applications such as renewable energy and nutrient recovery from residues can contribute to growth of the agricultural supply chain by improving environmental sustainability and possibly margins, if structures can be devised that allow the feedstock owner to participate in value created (conventional transfer pricing structures are unlikely to be workable in respect of low value energy and nutrient recovery). This, in turn, may improve access to capital required to intensify production and increase productivity.

In the agricultural supply chains introduction of land use protocols may be required to manage allocation of land for different uses. Additionally, adaptation of direct payment frameworks may assist to manage land use allocations. Tying direct payments to levels of productivity may promote (and finance) sustainable intensification. Establishing criteria such as minimum size of economic units eligible to receive productivity payments may assist to promote co-ops or other structures that can overcome fragmentation within the primary supply chains. Development of sustainability criteria incorporated into a sustainability certification schemes might be utilised as a method to measure and promote sustainability improvements in each of the AMFM primary supply chains. Adapting the direct payment structures to promote compliance with the sustainability schemes may provide a means of monetisation. While no doubt there is a political sensitivity to changes in direct payment structures, these frameworks do provide very significant resources that could be deployed to promote development of the supply chains.

In addition to productive agricultural lands, there is a large land bank comprised of lands not optimally deployed in existing AMFM applications (termed "hidden hectares"). These could include lands ranging from poor quality pasture land to wetlands and peat bogs. As much as 12% of Ireland's land mass could be classified as wetlands, which, if means can be found to sustainably exploit these areas together with means to bring underutilised pasturelands into productivity, may offer a very significant resource to underpin bio-economic expansion.

Marine: The Irish marine resource is 8X the geographic size of its land mass. In this context, it is highly under-developed. The global demand for fish proteins is growing rapidly. In sea fisheries, given the restrictions on harvests of wild stocks imposed by the CFP quota system, growth in the marine supply chain would be most viably served by increasing fish farm aquaculture. This will require adaptations to the aquaculture licensing system, offering greater predictability and more

timely responses to licence applications. Technology development may be required to adapt fish farm technology to deep sea applications. These technologies are being developed and tested in Norway. A review of industry structures in competitor nations highlighted that scaling up the supply chain in a manner that facilitates efficient aggregation of the outputs could facilitate deployment of efficient mechanised processing capabilities, which may open prospects for new products and further bio-economic expansion. Development of fish farm aquaculture may also underpin development of multitrophic systems that integrate growth of macroalgae together with fish supplies.

In the marine sector, the Marine Spatial Planning Directive requires completion of a marine spatial plan by 2021. A Norwegian licensing system has been very successful in stimulating development of the aquaculture industry, which licenses approved sites in perpetuity to create a system of "property rights" that underpins access to development capital. Replication of such a system in Ireland, noting that technical criteria and sustainability criteria could be incorporated as part of the scheduled licensing obligations, could be coupled with measures that monetise sustainability benefits to provide methods to ensure licensed activities are undertaken in an environmentally friendly manner.

Forestry: Ireland's forestry potential is also under exploited. Growth in the supply chain is highly dependent on growth in private sector forestry, which in turn is dependent on driving land use changes via afforestation programmes. Current structures of afforestation grants are comprised of a combination of establishment and fencing grants to contribute toward plantation establishment costs, forestry road grants to contribute toward costs of road construction and premium payments to provide interim cash flow to plantation owners during the long period prior to harvest. The payments are all structured as grants. Establishment grants and premium payments may be considered state aid, and the value and timing of these payments may be subject to corresponding state aid limitations.

Afforestation policies have fallen short of policy targets, ascribed, in part, to the current structure of afforestation supports, which may be insufficient to incentivise land use change. They result in a private forestry sector that is highly fragmented and may not be sufficient to develop a supply chain that meets future demands. Construction of forestry roads has fallen short of targets, which may burden thinning, harvesting and re planting activities, and result in inefficiencies caused by lack of scale, both of which may burden financial returns.

The present value of current forestry payments is significantly less than the present value of the harvest proceeds. Harvest proceed many time excludes valorisation of brash residues which are too variable to provide a homogenous biomass fuel supply for highly tuned boilers but which could potentially be used in gasification or pyrolysis applications. It may be feasible to adapt the forestry payment structure to incorporate part or all the payment as an advance, repayable against the proceeds of future harvest, rather than a grant. It would have to be investigated whether payments structured in this fashion qualified as state aid, as they are effectively loans that are repayable. If this is feasible, however, it may be possible to increase the levels of payments and the amounts that can be paid to any one landholder, facilitating support of larger afforestation plots, overcoming fragmentation and increasing prospects to achieve afforestation targets. It may also reduce the current expenditure on grant aid, which in financial parlance would be exchanged for a finance a programme funded by low cost debt. If such payments were also tied to a sustainability programme that required delivery of brash residues as a biomass fuel, for example, it would

promote bioenergy application rollout and increase proceeds of the harvest and lessen any risk of default or inability to repay advances.

It may be possible to introduce such a scheme in conjunction with a spatial planning framework that could accelerate de-fragmentation of private forestry sector. A test programme may be required to determine economic viability and inform final programme designs, if implemented.

Municipal Waste and Wastewater: ongoing restructuring and consolidation of the waste collection industry, supported by targeted regulatory measures such as the landfill levy, has resulted in effective recycling and recovery across a range of targeted (recyclable and recoverable) wastes. It underpins an increasing trend toward domestic processing of waste, reversing a historical tendency to export waste.

Specific organic fractions within the municipal waste stream that may be offer valorisation opportunities include waste paper, which is currently collected and exported for recycling, rather than used to produce recycle pulp for the indigenous paper productions.

Food wastes from restaurants and supermarkets are collected, aggregated and routed for AD, however the domestic fraction of food waste is not yet effectively separated, and is predominantly incorporated with mixed black bin wastes for disposal. A mechanism to encourage and enforce deployment of the 3 X bin pay by weight system to separate food waste at the kerbside could result in an increased supply of waste for energy recovery. The structure of such a system would need to include sufficient incentivisation and enforcement measures to underpin compliance, as well as a public education programme to inform and promote the benefits amongst the consuming public.

There is currently a lack of valorisation options for grass greenwaste, a supply of which could potentially be sourced both from domestic collections as well as from commercial and local authority landscaping activities. In respect of domestic supplies methods could potentially be designed to encourage routing of domestic clippings into a multi-bin pay by weight system, offering an increased supply of domestic renewable energy feedstocks. Within public and commercial landscaping activities, grass is primarily mulched and returned as a function of the landscaping activities. Lawn and landscaping equipment is available that could support collection and aggregation, however adapting landscaping contracts, and introduction of an incentive perhaps tied to a sustainability certification mechanism, may be required to promote increased recovery and re-use of grass greenwaste.

Treatment of mixed black bin wastes varies. The preponderance of the material is suitable for energy recovery (e.g. paper and plastics, for example) however different waste management companies separate the materials to different standards, and disposal depends on availability and relative cost of market outlets. If no market outlets are available, mixed black bin fractions are pre-treated and disposed of at landfills. Ireland deploys a multi-operator municipal waste management system that creates fragmentation within the supply chain resulting in excess transfers, handling and transport. Fragmentation precludes economies of scale that exacerbates margin pressures and constrains investment in technology development and optimal deployment of processing infrastructure. This in turn poses barriers to local valorisation, especially in rural markets where waste volumes are not large.

Municipal waste collection may be better structured as a natural monopoly, oriented as a single licensed service provider within a designated geographic area subject to appropriate regulation to

oversee performance and pricing criteria. In the event restructuring of the waste collection industry proves unfeasible, an alternative may be to deploy publicly financed local processing infrastructure that is available for all licensed waste collectors. Such an infrastructure programme could reasonably be undertaken as part of a community renewable energy scheme, and potentially coupled with a sustainability certification programme, incorporating monetisation measures designed to encourage waste management companies to route local waste supplies into the local processing infrastructure.

In respect of municipal wastewater treatment, bio-economic development opportunities arise in respect of recovery of renewable energy from the organic load in municipal wastewaters, as well as sludge generated from aerobic WWT activities. Most Irish WWT plants use aerobic processing technology, which is mature and market tested, however is energetically intensive and converts the organic load to a bioactive sludge that incurs cost and generates bio-hazard concerns on disposal. High Rate AD technologies convert the organic load in wastewaters to biogas, and may potentially be adaptable to use in municipal WWT plants. A recent restructuring of the sector has resulted in organisation of municipal WWT activities under a single semi-state operator, which, if HRAD technologies can be tested and optimised, opens prospects for wider deployment of HRAD technology and use of the organic loads in municipal wastewaters as a renewable energy feedstock.

- **Facilitate Timely Development of Relevant Processing Technologies**

Near term bio-economic expansion will require timely development and demonstration of conversion technologies, which are at different stages of Technology Readiness Levels. State and EU frameworks provide substantial support resources for technology RD&D. Organisation of existing development programmes, however, is quite fragmented. RD&D programmes are rarely designed to progress the relevant value chain from bench scale inception to process engineering and onward to commercial demonstration. They rarely integrate development of the processing technology with development of the corresponding supply chains, market outlets and commercial frameworks necessary to support end-to-end value chains. It results in knowledge accumulation rather than product development. Adaptation of RD&D programmes to adopt a more integrated approach to product development may result in more rapid and assured results.

The State has a role to play in technology development and de-risking, especially where the imperatives driving development are societal rather than purely commercial. A focused technology development programme is required to expedite development, de-risking and deployment of conversion technologies. Programme adaptations are required to directly align existing RD&D programmes with sectoral development priorities. An integrated approach that addresses supply chain issues, technology development, market entry strategies and commercial/regulatory support frameworks may optimise impact within the respective value chain.

Creating centres of excellence aligned with each existing sectoral value chain may provide a mechanism to better integrate RD&D activities. The recent introduction of sectoral centres of excellence (i.e. The DPTC aligned with the dairy sector, the MTI aligned with the meat processing sector, for example) may provide examples of “best practice”.

Funding for current bio-economic RD&D activities is currently sourced from multiple government agencies under multiple programmes. It is spread very thinly across multiple Research Performing

Organisations (RPO's). This structure results in a highly fragmented approach to RD&D that reduces integration, focus, efficiency and impact. Aligning the different governmental agencies' RD&D priorities in the context of specific sectoral value chains, and supporting these priorities with collaborative funding contributions from each departments' research budget, may result in a more integrated approach to bio-economic RD&D.

Current RD&D programmes require re-orientation towards activities further along the product development curve to attract commercial interest. Integration of process engineering disciplines into a sectoral RD&D programme will be required. Within each sectoral value chain, shared scale up facilities are required to link initial scientific investigations with pilot scale process engineering to optimise end-to-end production processes and validate the related business cases. Pilot scale facilities could be managed as a function of a related centre of excellence. Increasing the proportion of RD&D funding allocated toward direct funding of company RD&D will increase commercial engagement and focus RD&D expenditure on product development.

In an Irish context, modular, moderate scale commercial technology designs are required to match processing capacities with the scale of raw material supplies and market outlets. To improve sustainability of the RD&D funding model, consideration could be given to having sectoral centres of excellence target development and commercial demonstration of moderate scale near-to-market production technologies, pursuing small scale production of a commercial product that would generate ongoing revenue streams capable of being used as matched funding to facilitate ongoing RD&D work. Commercial demonstrator models have been developed in locations in France and the Netherlands which suggest that such a model may be able to better leverage state resources to attract ongoing EU funding.

State aid considerations impact the ability of the State to use public resources to underpin economic development. Consideration could be given to alternative forms of recovery for State RD&D supports (e.g. structuring RD&D supports as equity contributions as opposed to licensing payments to be paid during financially sensitive development years, for example) to overcome perceived constraints imposed by state-aid regulations.

- **Facilitate Timely Deployment of Production Infrastructure**

Public attitudes, particularly toward waste processing infrastructure, can vary. Information programmes targeting dissemination of scientifically validated information may assist to inform public opinion in a way that underpins timely demonstration and deployment of new technologies.

Current planning and licensing processes can potentially hinder bio-economic development, and could be adapted to become an enabler rather than a deterrent. Delays in planning and licensing cause project developers to transfer activities to other jurisdictions. The RED II proposals incorporate provisions that obligate member states to expedite planning and licensing of renewable energy projects, suggesting that a single point of access and an integrated planning and licensing process may be more efficient than a serial, multi-point-of-access process. Rapid implementation of this concept will assist bio-economic development.

Additionally, the current planning process allows appeals to An Bord Plaenala on any grounds at a very low cost to the objector, which can tie up planning approval for an extended period. Rigorous enforcement of decision-making timeframes within the planning process (e.g. as they relate to appeals to An Bord Pleanala) may address these concerns.

Demonstration of new technologies, some of which process raw materials currently classified as wastes, may be environmentally and economically beneficial, however can be difficult to organise within the Irish planning and licensing system. The EU waste management frameworks (including directives governing thermal processing of wastes) provide a degree of flexibility to undertake commercial demonstrations of new technologies, to expedite evaluation of environmental impacts from new technologies or to determine "end-of-waste" designations. Providing the EPA with resources (specifically, procurement of equipment for gaseous and emissions analysis, deployed in a waste management centre of excellence, say at a University) could inform and facilitate timely decision making, as well as provide relevant environmental information that will allow formation of informed policy while limiting potential environmental risks. Adaptations to organisational structures and remits to balance bio-economic development with environmental protection, may expedite bio-economic development.

Access to finance poses a barrier to timely bio-economic development, as market based financing conventions precluded acceptance of risks associated with immature technologies as well as risks associated with supply chains not bound by long term contractual supply agreements. These market failures constrain infrastructure deployment and exploitation of market opportunities. Bio-economic development opportunities could provide the basis for redevelopment of brownfield industrial sites currently available across the State, for which there are potential funding mechanisms within the European Regional Development Funding programme (e.g. JESSICA financial instrument programmes, for example). Introduction of these mechanisms require adaptations to existing Regional Assembly Operational Programmes, which reference the possibility of introducing financing mechanisms, however such mechanisms are not currently activated. It will also require establishment of designated budget holders within the governmental agencies to trigger availability (the current understanding is that this is an administrative requirement to facilitate accounting for the receipt and distribution of proceeds rather than a requirement for additional state funding, although this needs to be confirmed). Implementing these measures could provide financing both to redevelop brownfield sites and overcome market failures in respect of financing for early stage bio-economic technology deployment.

- **Promote Viable Business Models that Fairly Allocate Risk and Rewards**

Traditional horizontally aligned business models are designed for mature markets rather than new applications. They expose primary producers to commodity pricing risks influenced by competition from low cost economies. This creates transfer pricing tensions between primary raw materials suppliers and processing companies that preclude acceptance of undefined operational risks, which in turn constrains access to capital and development of integrated supply chains. Coupled with fragmentation within the supply chain, horizontally aligned business models make it difficult to aggregate feedstock supplies of scale.

Vertically aligned business models may initially be required to ensure operational risks and proceeds of new business opportunities are equitably distributed between raw material suppliers and processors, facilitating efficient development of supply chains. Different business models, such as the co-operative model, may be available to achieve this. The co-operative model was utilised in the dairy sector to concentrate the primary producer supply chain around the processing infrastructure, improving returns to farmers and establishing a supportive relationship between the processor and the primary supply chain. Other structural options include a corporate model, where the entire supply chain is integrated into a single economic entity. While this may result in

the primary producer losing some of his independence, it does facilitate security of the supply chain and facilitates access to capital. Large scale corporate farming models are increasingly deployed in the USA, for example.

Such models may be integrated with Public Private Partnership (PPP) financing structures. Engaging public bodies to assist with procurement and oversight of public funding may assist development and infrastructure deployment in a manner that can address risks and proceed distribution. A PPP model may facilitate design of market structures and frameworks in a manner that achieves sustainability objectives, overcoming some of the early stage market uncertainty. Properly structured, it may facilitate recovery and recycling of development funding in a manner that complies with state aid requirements

5. **Can we identify a common set of principles, including in particular the application of the cascading principle, which will assist in the development of both the bio-economy and circular economy?**

There are several principles implied in some of the responses noted herein. In addition to the cascade principle and the circular economy concept referenced in the question, the following may be considered:

- Principles of Sustainability – the ultimate purpose of the exercise is to achieve the sustainability objectives as referenced more fully in 1 above

- Transparency and Openness – bio-economic development will not occur without the willing support, cooperation and active participation of the general population. A programme of active engagement is required to define, promote and deliver the anticipated benefits

- Self Sufficiency and the Proximity Principal – it is best, where possible, to use local resources to meet local demands

- Transition to Market Mechanisms – while the nature of the bioeconomic development programme will require State participation, State participation should be designed with a view to planned transitions to market led methods of production and consumption

- Compliment rather than Cannibalise – there are numerous options to consider in respect of bioeconomic development. Those that build on our existing strengths, and can leverage our existing skills and resources, are most likely to be successful

- Value for Money – there will be numerous opportunities to allocate State resources for bio-economic development. Any State support measures introduced for purposes of developing the bio-economy should have clearly defined, measurable objectives that can be related to the resources required for development

- Policy based decision making – development and implementation of bio-economic policy may require very difficult political decisions. These decisions should be based to the greatest degree possible on agreed policy.

- Market Coherence and Cooperation – the requirement for State intervention into markets always brings with it the possibility of market imbalances and unanticipated consequences. To the greatest degree possible, it would be advisable to design market supports and policies that are consistent with those of our nearest neighbours, and the EU market as a whole

6. How can a national policy statement support local and regional co-operation around the use of renewable biological resources?

- Local Authorities have a very significant role to play in the planning and licensing process, the management of environmental monitoring services, the delivery of community based services and the implementation of development plans. A national policy statement could offer an opportunity to:
    - Encourage development of local sustainability plans within each local authority jurisdiction. Sustainability plans can incorporate integrated renewable energy, waste and resource management as well as facility development (redevelopment) plans. These can be integrated and cross cutting plans that address economic and environmental considerations, and can underpin development of bio-economic applications within a local authority jurisdiction

    - Outline methods of resourcing implementation measures. EU programmes (particularly ERDF) programmes are organised to assist local authorities with funding for delivery of public benefit programmes. Defining an integrated sustainable economic development programme, structured to leverage these resources, offers prospects for early delivery of sustainability benefits. Resourcing Local Authorities can enable hiring of skills and resources, such as those that are available within local Energy Agencies, to deliver the development programme.

- A national policy document could give guidance to local authorities and local authority planners in relation to decisions with implications for the development of the bio-economy. Timeliness and consistency in planning decisions across various local authorities will become critical to the market development of the bio-economy.

- A national policy statement can assist by building awareness amongst local authority and regional agency officials and planners of the role of the bio-economy and the implications of their decisions around the use of renewable biological resources. It can also offer stakeholders a reference point to which they can point when making proposals or applications to local authorities.

7. How can waste policy, including an examination of the definition of waste, best support developments in the bio and wider circular economy?

- As referenced herein, waste to energy applications offer the best available option for valorisation of Ireland's waste resources. This will assist with compliance with the regulatory and policy drivers requiring continued migration away from landfill and will comply with the accepted waste management hierarchy.

- Deployment of waste to energy infrastructure may be difficult in the highly fragmented private waste management sector. A programme to publicly fund local waste to energy processing infrastructure, possibly structured as a community sustainable energy scheme, may offer means to improve renewable energy recovery from waste. Such a programme would benefit from:

    - Development of a programme to incentivise improved supply of separated domestic food waste and grass greenwaste at the kerbside;

    - A sustainability certification programme incorporating some monetisation mechanism designed to encourage waste management companies to route waste supplies to local waste to energy processing infrastructure;

    - A limited re-activation of the REFIT support scheme for power generated from waste to energy projects (thermal processes for CHP is the most viable method of valorising mixed black bin wastes);

    - Development of finance mechanisms to finance construction of district heating microgrids in rural communities;

- An increase in thermal processing of waste for energy recovery may necessitate better monitoring and analysis of emissions from thermal waste processing. The State is currently lacking technical resources to monitor emissions, and providing this equipment, within the EPA or a designated service provider to the EPA (e.g. such as a University or centre of excellence, for example) may facilitate improved emissions measurement and analysis, which can benefit both monitoring of existing installations as well as development of new technologies to better treat waste derived emissions.

- The definition of waste or end-of-waste is a critical component that determines licensing, handling, processing and other requirements in respect of how certain materials are required to be handled. This definition has a significant bearing on valorisation of these materials, and can determine their ability to contribute to bio-economic development. In the context of a wide variation in the types of materials to be used and the processes to be deployed, it may be difficult to completely re-structure the regulatory framework governing handling and management of waste. EU Directives, however, provide national authorities some latitude in determining how specific materials should may be handled to achieve the objectives of the waste management framework. Providing the EPA with a remit to balance bio-economic development objectives against the obligation to protect the environment, and establishing a regulatory framework around how this remit may be fulfilled, (including powers to establish processing and handling conditions in respect of individual process applications as well as an appeal process for review by an independent body) may improve utilisation of organic wastes for bioeconomic development. Resourcing the EPA with the necessary expertise and facilities (e.g. which may include establishment of a centre of excellence with the necessary analytical equipment and processing expertise) may facilitate timely decisions in respect of waste vs end-of-waste designations or corresponding evaluations of appropriate process technologies and conditions.

- Irish Water has published a National Wastewater Sludge Management Plan (2016), which suggests maximising the operational efficiency of satellite sludge de-watering and regional sludge hubs -as a potential option for consolidating otherwise fragmented supply chains of sludge for resource recovery. It also states that the use of existing anaerobic digestion infrastructure should be maximised to increase resource recovery. A national bio-economy policy statement could benefit from reflecting a similar approach generally within local authority areas and regions to facilitate the consolidation of feedstock supplies. It may be expanded to include thermal processing of sludge (which will eliminate any biohazard concerns arising from subsequent disposal) and could promote development of sludge processing facilities in the context of establishing community based sustainable energy centres.

8. How can we stimulate demand for bio-economy products? What is in it for the consumer?

- Behavioural change is a key challenge of which some government departments and state agencies are becoming more aware. Some are taking steps to focus on behavioural change as something to integrate into their own areas of service delivery. The European Union bio-economy strategy of 2012 recognises that a more involved dialogue with the consumer will be required to develop the bio-economy. Arguably, to stimulate consumer demand for bio-based products, we are ultimately talking about engaging with the consumer on tangible quality of life fundamentals such as clean air, clean water and affordable energy

- As noted previously, until consumers accept the benefits associated with sustainable production and consumption patterns, they tend to base purchase decisions based on conventional functionality and value for money criteria rather than sustainability measures. Accordingly, design of certification measures that inform consumers as to the functionality of a product, as well as its sustainability credentials, coupled with support mechanisms that monetise the sustainability benefits, may facilitate early market entry.

- Support mechanisms, however, can only be available for a limited period (as the State has other demands on its limited resources). Accordingly, pull support mechanisms should be designed in a manner that ultimately transitions the placement of the relevant product or service based on market led mechanism. Such market led mechanisms, however, can include push obligations imposed on product users to incorporate a certain proportion of sustainably produced products or services in their value chain. For example, a biogas blending obligation or RES E obligations could be established to require licensed energy suppliers to incorporate an increasing proportion of biomethane or RES E, respectively, into their energy supply. Similar concepts can be developed for placement of chemicals such as solvents, or for the composition of plastics. The success of push measures, however, is dependent on the development of reliable and cost-effective supply chains.

- To achieve greater penetration of sustainable bio based products, a method to quantify and certify relevant sustainability characteristics will be required.

- Green public procurement offers an opportunity to stimulate demand for bio-economy products, with the Green Tenders policy statement already in place since 2012 and the EPA having published guidance to public bodies on green procurement in 2014.

9. What is the most appropriate mechanism to co-ordinate development and monitor progress?

- Initially it will be important to establish tangible, measurable indications of success for each of the relevant value chains that make up the bio-economy. Measures of success can include measures of economic output, both traditional and non-traditional outputs, as well as measures of relevant sustainability criteria applicable to each value chain.

- It will be important to establish an "owner" of each measure of success within the governmental structure. Each owner should have the relevant authority and capacity to influence performance against the respective criteria.

- Performance against each set of criteria should be evaluated by a body with the requisite seniority and authority to intervene and assist where required:

  - Within the system of government and public administration, a Department of An Taoiseach-chaired working group reporting to a Cabinet Committee with representation from Dept. of Communications, Climate Action and Energy (DCCAE), Dept. of Agriculture, Food and the Marine (DAFM), the Dept. of Rural & Community Development, the Dept. of Public Expenditure (DPER) and the Dept. of Finance, Dept. of Jobs, Innovation & Enterprise (DJEI) and DFAT (Dept. of Foreign Affairs and Trade) may be the appropriate body.

- For direct broad and sectoral engagement with key stakeholders, the inter-departmental working group should run a broader forum on a quarterly basis, or as required. This broad forum should include industry, higher-education research institutes, third sector (social enterprise having a role as loss leaders) and national representative organisations. Within that forum, it is suggested that there would be provision for enabling direct engagement and outreach to the citizen to share information and enable behavioural change.

10. Are there any other issues to be addressed through a national policy statement?