“A decision support platform for bioenergy technology deployment and policy making in Mexico” 540821111

Additional Newton Fund Impact Scheme questions for Researchfish

1. In general, has the Newton Fund Award supported/contributed to capacity strengthening activity that has improved the ability to direct research/translation efforts towards local development needs and global challenges? (Please provide details)

The Newton Fund Award supported/contributed to capacity-strengthening activity that has improved the ability to direct research/translation efforts towards local development needs and global challenges. The strengthening of capacity has been achieved at various levels (multi-level). Knowledge exchange has happened between the University of Surrey (Surrey) and the Institute of Mexican Petroleum (IMP) in the areas of technical and life cycle sustainability assessment framework development. Surrey has developed TESARREC™ [1,2] and IMP has developed IMPBio2Energy® [3] through the knowledge exchange whereby two organisations validated their models with each other. The frameworks have been widely communicated and reached out to stakeholders via social media, i.e., LinkedIn. Figure 1 shows the countries with several thousand users.

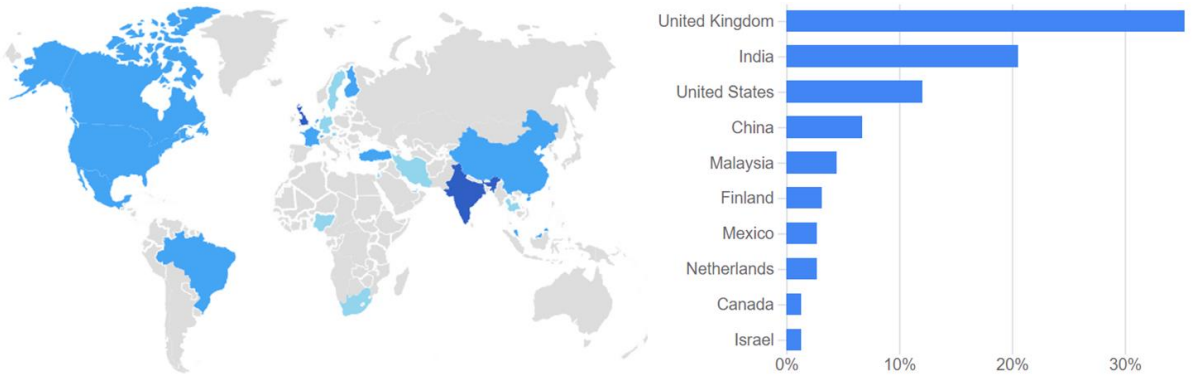

Figure 1. TESARREC™’s global outreach.

At a local community level, questionnaire surveys, interviews, workshops, and Delphi processes helped to build capacity in bioenergy system management for sustainability. Figure 2 shows the sustainability indicators generated because of community engagement [4]. A sawmill-operated 1 MWe bioenergy system can provide electricity, water, and sanitation services by supplying electricity to local communities in Durango state with some extreme deprivation/poverty in some municipalities [4]. The area of influence of the cooperative is depicted in Figure 3 and spans 8 municipalities in Northeast Durango State (Santiago Papasquiaro, Otáez, Canelas, Topia, Tepehuanes and some parts of Guanaceví, Tamazula and San Dimas). The map also shows the degrees of social deprivation in these municipalities. Figure 3 shows that at least five of the municipalities have a medium degree of social deprivation, while one municipality (Tamazula) is classified as of high social deprivation and two as having low social deprivation (Santiago Papasquiaro and Tepehuanes). Social deprivation indicators include poor access to a potable water and sewage network and poor access to electricity, amongst other indicators.
The potential use of excess electricity in the generation expansion scenario to supply energy and water services to the communities local to the case study mill has been carried out to show the improvements in SDG6: clean water and sanitation for all and SDG7: affordable and clean energy. The percentage of households without access to electricity in the various municipalities involved in the forest-based value chain are Canelas: 6.2%, Guanacevi: 6.6%, Otaez: 4.8%, Tamazula: 12.3%, Tepehuanes: 3.8%, Topia: 7.5%, Santiago Papasquiaro:

4.0%, San Dimas: 6.4%. The total number of households without access to electricity is for 2202. The sawmill-operated 1 MWe bioenergy system can meet their total unmet electricity demand of 2.5 GWh/y [4]. Further, the sawmill-operated 1 MWe bioenergy system can support access to clean water and sanitation requiring 0.33 GWh/y electricity [4]. The local community scale impacts include the delivery of the UN SDGs 5-8 and 15.

Bioenergy process modelling	Bioenergy economic analysis	LCA of Bioenergy (avoidance or saving/year)	SLCA (in-country improvements from import from Mexico)	Community impacts
1. Biomass throughput: **12.47 kt/year**	1. Capital cost: **$1.6million**	1. Global warming potential (100 yrs): **6 kt CO_2 eq.**	1. Labour rights and decent work: **Guatemala > Nicaragua > Panama > Colombia > Costa Rica**	1. Total forest area (SDG15): **445676 ha**
2. Electricity generation: **1 MWe**	2. Internal rate of return: **10%**	2. Abiotic depletion potential (fossil fuels): **74 TJ**	2. Health and safety: **Panama > Nicaragua > Guatemala > Colombia > Costa Rica**	2. Direct permanent jobs (SDG8): **550**
3. Steam generation: **50 kt/year**	3. Operating cost: **$0.2million/year**	3. Photochemical ozone formation potential: **8 t NMVOC eq.**	3. Human rights: **Guatemala > Nicaragua > Colombia > Panama**	3. Indirect jobs (SDG8): **2000**
4. Energy efficiency: **0.62**	4. Feedstock cost: **$0.3million/year**	4. Acidification potential: **37 t SO_2 eq.**	4. Governance: **Nicaragua > Guatemala > Panama > Colombia**	4. Gender equality (SDG5): **40% women**
	5. Cost of production: **$0.023/kWh**	5. Water use: **6620 m^3**	5. Community infrastructure: **Nicaragua > Panama > Guatemala > Colombia > Costa Rica**	5. Energy access (SDG7): **2.945 GWh/year for electrical energy**
	6. Economic margin: **$0.0628/kWh**	6. Eutrophication potential: **1.755 t N eq.**		6. Water access (SDG6): **0.095 GWh/year for potable water access**
		7. Ecotoxicity potential: **1.664×10^6 CTUe**		7. Sanitation access (SDG6): **0.235 GWh/year for access to sanitation**
		8. Sustainable forestry residue availability per land: **7.6 kg/m^2**		

Figure 2. Sustainability indicators of bioenergy system [4].

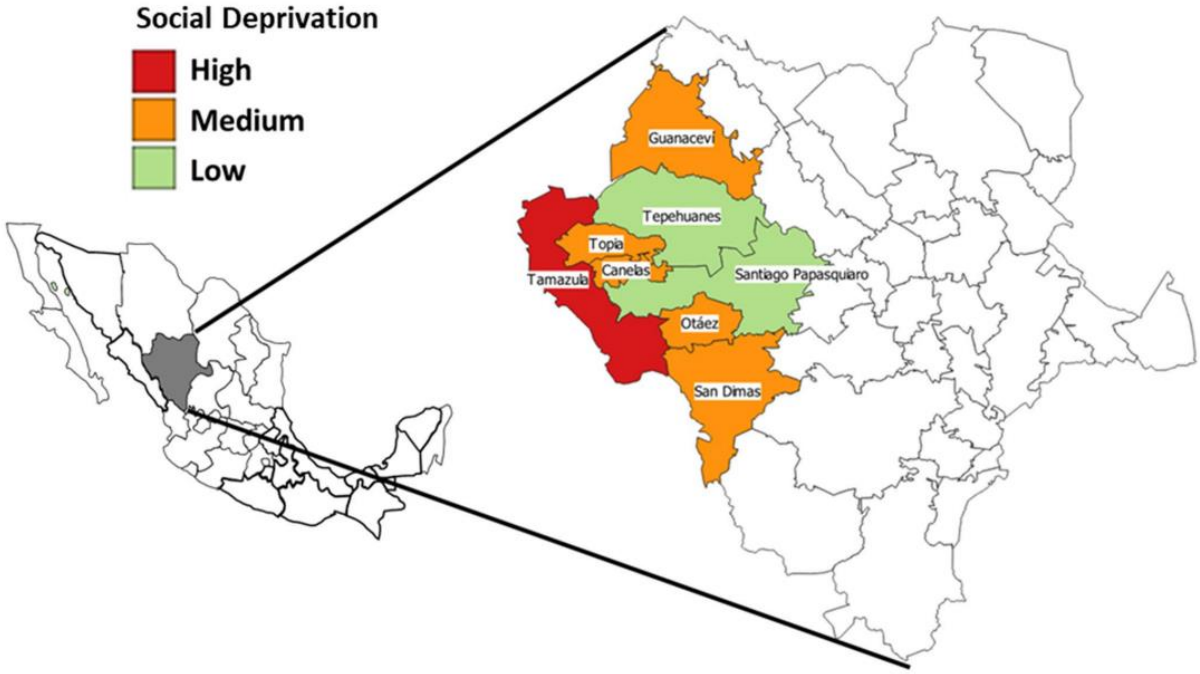

Figure 3. Outreach and impact generation of bioenergy system in Durango state, Mexico [4].

Mexico's position in the global context has been improved/reinstated through this project. Electricity from Mexico can be imported into five countries, potentially sharing electricity interconnection systems including Guatemala, Nicaragua, Panama, Colombia, and Costa Rica. Exporting average grid electricity from Mexico into The Central American Electrical

Interconnection System (SIEPAC) is desirable for improving social conditions both in the individual countries and across all the countries (SIEPAC) collectively [4].

2. To your knowledge, has the Newton Fund Award helped strengthen the capacity and skills of the partner country and/or UK partner country researchers and innovators? If so, which skills bases have been increased and to what extent has capacity been strengthened. improved?

The Newton Fund Award helped strengthen the capacity and skills of the partner country and/or UK partner country researchers and innovators. Skill bases have been improved in the following areas.

Process Engineering and Digitalisation [3-7]: We had the fundamental knowledge base in Process Engineering (Process design, modelling, synthesis, and optimisation). However, turning the knowledge base into a decision-making platform only evolved through this Newton Fund Award [3-7]. The accompanying web-based open-source software can be found in [1,8].

Life cycle sustainability assessment: A whole system sustainability is challenging, however, can be addressed systematically and holistically through the three pillars' analyses, environmental (life cycle assessment, LCA), life cycle costing (LCC) and social life cycle assessment (SLCA), deeper skills including in turning the knowledge bases (ISO14040-44 and ISO26000) into practical user-friendly open-access decision-making software, in which have been developed through this Newton Fund Award [1,8]. TESARREC™ has been populated with bioenergy, biofuel and bio-based chemical and material production systems, biorefineries and bioeconomy [1,8-14].

Early career researcher development: All investigators got to support and develop early career researchers. As a result of this Newton Fund Award, 4 women and 4 men early career researchers have been helped with progression in their careers. For example, Dr Arick Castillo Landero can advance his career from postdoc to researcher at IMP, and Ms Diana Dominguillo had the opportunity to collaborate in research activities and publish work [6] in high-impact journals which have motivated her to pursue postgraduate studies in engineering. The project also allowed for contact with new researchers thanks to the networking at the AIChE conference by Dr Martinez-Hernandez which led to Prof Rafiqul Gani's visit to IMP, a recognised leading expert in process systems engineering. Furthermore, the 1st seminar for Process Intensification was organised on March 3, 2023, with Mexican experts invited and one researcher from the University of West Virginia. The researchers working on the project had also the opportunity to attend the courses on the topic in January 2023 to acquire new skills and training in these topics. These contacts and activities had a great impact on introducing the topic and opened up opportunities for this new area and its applications to bioenergy research and other topics at IMP.

Social science: Dominant usage of social science theories including some innovative ways of engagement processes can be seen in the Newton Fund Award. We applied novel methods in engaging with the local communities. We also carried out questionnaire surveys, interviews, workshops, and Delphi processes for evidence-based decision-making.

Space4sustainability: This Newton Fund Award has further generated a UKRI-funded GCRF grant "*A UK/Mexico partnership in Earth Observation (EO) for biomass: Developing a new Surrey UK/Durango Mexico collaboration under Surrey University's 'Space4Sustainability' initiative.*" These two grants run in parallel have enhanced our expertise and capabilities in the use of satellite (and other) Earth Observation (EO) technologies to enhance the sustainable use of bioenergy.

3. To your knowledge, have you and/or your partner established new practices or developed new systems as a result of the Newton Fund Award (i.e. adoption of new IT systems, tools for increased transparency, tools and methods for evidence-based policy making, organisational structures or new frameworks.)

Both organisations have established new practices or developed new systems because of the Newton Fund Award (i.e., adoption of new IT systems, tools for increased transparency, tools and methods for evidence-based policymaking, organisational structures or new frameworks.). We have adopted Python as the programming tool for IMPBio2Energy® (IMP) [2] and open-source web-based TESARREC™ for informed decision-making [1, 8-14]. TESARREC™ is transparent through its 'Read Me' functionality on the user interface and its GitHub repository [15]. We have analysed tools and methods for evidence-based policy making – a manuscript is under preparation [16]. A close working group with policymakers on 18 January 2023 at the Hotel Fiesta Inn Centro Histórico, Mexico City, led by Surrey and IMP has been conducted for evidence-based policymaking. New frameworks include the sustainability indicators' data collection to align technology developments, implementation, policies, and multi-level, from organisations through local communities to the global level, impacts.

4. To your knowledge, has the Newton Award contributed to local or national science and innovation strategy? (Including arts, humanities and social sciences.)

The Newton Award contributed to local or national science and innovation strategy. They can be observed in social interaction, sustainability indicators, policy and LCSA innovations [1-3,16-18]. A specific case study on bioenergy for energy poverty alleviation in Durango state has been exemplified [4].

5. To your knowledge, has the Newton Award contributed to commercialisation of discoveries and/or translation of research into benefit, including the diffusion and adoption of ideas/solutions?

The Newton Award contributed to the commercialisation of discoveries and/or translation of research into benefit, including the diffusion and adoption of ideas/solutions. Surrey's TESARREC™ [1,8-14] and IMP's IMPBio2Energy® [3] are the testaments of the successful commercialisation of basic research into benefit, including the diffusion and adoption of ideas/solutions. Furthermore, the policy and sustainability indicators frameworks developed help the diffusion and adoption of ideas/solutions [16,17].

6. To what extent has your project impacted on gender inequalities? Have there been any unexpected impacts? Have there been any negative impacts, expected or not, and how have they been mitigated against? Please describe any positive benefits that have resulted from your project.

Bioenergy projects should also seek to enhance the quality of employment and leverage the attractiveness of jobs in the renewable energy sector for women to promote gender equality and contribute to UN SDGs 8 and 5. In this Newton Fund Award, the society pillar indicators are differentiated into the Well Being and Poverty Alleviation class which is related to basic human needs (food, energy, water, and sanitation), and the Cultural and organisational class which includes aspects such as public acceptance or gender equality. The type of responses included multiple choice and dichotomous; gender and income as well as information and perceptions on the environmental, organizational, economic, and social areas were requested. The gender composition of the pertaining group validated the contextual information provided by the company, while the spectator group was mostly composed of women which also validates the reported higher attractiveness of renewable energy topics for this gender. This also helped us later to understand the responses on the importance and prioritisation of the indicators. Women's participation had low priority even in the expectant group which was mainly composed of women. This can be explained mainly due to their positions as researchers or as part of the active labour force. This means they already have certain empowerment within their contexts, so the gender issue is less important for them. The publication of these findings is being considered [17].

Another remarkable positive impact was that the project funding enabled the participation of Ms Diana Dominguillo as a young researcher which has truly changed her prospects after graduation and is now in the process to start an MSc degree and considering further postgraduate studies in the topics of the project. She has also recently published her first first-author article in the Fuel journal on a neural network model for predicting biomethane in the anaerobic digestion of biomass [18]. In a recent seminar (03/03/2023) on process intensification organised at IMP, most of the invited speakers (3 out of 5) were young female researchers.

7. To your knowledge, what further opportunities has the Newton Fund opened up for the research group (i.e., further funding/collaborations/links to industry/formal networks/research consortia/career advancement/interfaces with policy makers/interfaces with local communities/engagement activities other research output)? Please tell us about the key highlights and successes.

Further funding: Space4sustainability: This Newton Fund Award has further generated a UKRI-funded GCRF grant "*A UK/Mexico partnership in Earth Observation (EO) for biomass: Developing a new Surrey UK/Durango Mexico collaboration under Surrey University's 'Space4Sutsinability' initiative.*" These two grants run in parallel have enhanced our expertise and capabilities in the use of satellite (and other) Earth Observation (EO) technologies to enhance the sustainable use of bioenergy. A joint publication has also resulted [19].
Collaborations: The Instituto Tecnologico of Durango and the Department of Energy of Durango State, Mexico have collaborated with us on this project. They put us in touch with the Durango State Sawmill and other companies in Durango during our visit, as well as with the Durango State Council for Science and Technology where we also organised a workshop.
Industry links: Our collaborations include the area of influence of the cooperative depicted in Figure 3 and span 8 municipalities in Northeast Durango State (Santiago Papasquiaro, Otáez, Canelas, Topia, Tepehuanes and some parts of Guanaceví, Tamazula and San Dimas). GRUPO SEZARIC ZEPEMIN AR DE IC, Durango, Mexico Sezaric provided data on the sawmill and bioenergy system operation for the case study [4]. They also helped us organise the workshop at their site. Dr Enelio and Dr Martinez-Hernandez visited another two forestry industry plants (ARAUCO, and "La Gloria") during the visit to the region.
Formal networks/research consortia/career advancement: A consortium with eighteen researchers has resulted from close interactions. We helped each other in questionnaire surveys, interviews, workshops, and Delphi processes. We also conducted the consultation with local leaders deemed important for local distributed bioenergy system development. Nine members of the consortium are early career researchers, who were closely supported by the other senior consortium members. After completing they have found their career pathways in government departments and industries.
Interfaces with policymakers: Martinez-Hernandez provided technical expertise in chemical processes, emissions, and definition of criteria to evaluate low carbon chemical production in industry, participated in expert panel meetings and workshops, and led the writing up and revisions. Related to this project, expertise in bioenergy, green hydrogen and biomass feedstocks for chemical production was a key enabler in contributing to this activity. Multiple continents/international engagements occurred in 2022 in the Chemicals, Energy, Environment, Financial Services, and Management Consultancy, Manufacturing, including Industrial Biotechnology sectors. Impacts include an improved regulatory environment, effective solutions to societal problems and improved sustainability. The criteria developed were the first of its kind defining clear-cut criteria for financing climate change mitigation activities in the production of basic chemicals which contribute up to 15% of direct CO_2 emissions. This will have a great impact on green financing with clear climate targets to limit global temperature rise to 1.5^{o}C, which results in improved environmental sustainability, regulatory environment, and effective solutions to societal problems [20]. Mexico PI, Aburto's activities in 2021 impacted the legal and regulatory framework of the production, transport,

conversion, and use of biofuels in Mexico. UK PI, Sadhukhan, provided various consultations including biodiversity and bioeconomy for Singapore, the UK and The Philippines in 2022-23.
Interfaces with local communities:
16 December 2022: Criteria for low carbon chemicals and decarbonisation of basic chemicals industry
A formal working group, expert panel or dialogue occurred with about 500 participations at an international level with Industry/business, Policymakers/politicians, Professional Practitioners, the General public and Third sector organisations. Martinez-Hernandez contributed with technical expertise in an expert panel for developing criteria for low-carbon basic chemicals including decarbonisation of production activities. Key strategies and measures in the final standards included the use of bioenergy for the decarbonisation of energy-intensive production processes and the use of biomass as a low-carbon feedstock for chemicals. The outcome was a standard document and background information incorporating recommendations from the technical expert panel, an industry panel, and public consultation from practitioners and organisations. This will be used by the Climate Bonds Initiative, a leading charity for certification of green bonds which has an international audience including Mexico and the UK.
20 October 2022: Stakeholder Engagement Workshop
Around one hundred stakeholders (Policymakers/politicians, Professional Practitioners, the General public, Industry/Business, Postgraduate students, Other audiences and Third sector organisations) have participated in the Newton Fund Award workshop. In this activity, we carried out workshops and visits to Durango state. Community representatives, local businesses and entrepreneurs related to biomass use for bioenergy were consulted with the support of a community-led cooperative running a wood sawmill and using bioenergy in the municipality of Santiago Papasquiaro. In Durango city, a group of researchers, students and the public attended a dissemination workshop on the project and related bioenergy topics. During both events, we collected essential data to assess socioeconomic impacts on the local population so that we can validate the relevance, importance and impact of bioenergy systems and direct further research and development of indicators for the decision support platform. This was also the basis for useful feedback discussions on the project activities. In addition, we visited a colleague at the university of Durango and two companies which run their main processes using bioenergy from wood residues. The workshop was run by Martinez-Hernandez and Torres with support from project PIs Aburto, Sadhukhan and Amezcua, and Castillo, Andries and Margarita who are researchers participating in the project. We were also supported by the sawmill cooperative directives, the Durango state secretariat of economic development, and the Durango state council for science and technology. This has also enriched the technical and business perspective of the project and more realistic developments. A report and research article reporting results are currently under preparation [17].
2 July 2021: Participation in the Working Group on amendments to the Mexican Law of Promoting and Development of Biofuels
A formal working group, expert panel or dialogue engaged over 500 national Policymakers/politicians, Professional Practitioners, Industry/Business and Third sector organisations. The Mexican Energy Secretariat integrated a Working Group for amendments to the Mexican Law of Promoting and Development of Biofuels and its regulation, to assemble conventional and alternative biofuels into the aforementioned Law and their regulation to promote the production, transport and conversion of biomass into biofuels and their blending with fossil fuels.
2 July 2021: Member of the National Normalization Committee of Hydrocarbons, Petrochemicals and Petrolifers
More than 500 participants from national Policymakers/politicians, Professional Practitioners, the General public, Industry/Business and Third sector organisations were communicated for revision, amendments and proposals for the regulation of the production, transporting, selling and quality of fuels in Mexico. The National Normalization Committee of Hydrocarbons,

Petrochemicals and Petrolifers with the responsibility of the Energy Regulatory Commission of Mexico made up the Committee.
30 June 2021: Durango State stakeholders meeting
A formal working group, expert panel or dialogue took place with ten local Policymakers/politicians, the General public, Other audiences and Study participants or study members. The virtual engagement meeting was with a policymaker in the Durango State, Efraim Castellanos, Energy Director of the Government of Durango. We also engaged with colleagues from the Instituto Technológico de Durango, and the Universidad Juarez of Durango State interested in the project results and collaborations. As a result, several common areas of interest were agreed to collaborate, including support in conducting socio-economic surveys. Efraim offered access to information on the local government policies, strategic programmes and support for renewable energy, as well as technical and research collaboration on the bioelectricity transmission infrastructure analysis.
17 March 2021: Engagement-focused website, blog, or social media channel
About 50 international/national participants from Policymakers/politicians, Professional Practitioners and Industry/Business were engaged in the virtual activities. https://tesarrec.web.app/sustainability has attracted a wide number of visits to learn about the technology focus of the grant. On the day, there were 183 users of TESARREC™. 60% of users are from the UK, 15% from Panama, and the rest is from Nigeria, the USA, Canada, Finland, France, India, South Korea, and the Netherlands. They accessed our deployable eco-innovative sustainable biorefinery designs at advanced technology readiness levels (9 and above for biomass cogeneration, bioethanol and bio-jet fuel, and 5-8 for chemical) on TESARREC™ (Trademark: UK00003321198) https://tesarrec.web.app/sustainability

8. In general, to what extent do you feel the Newton funding has allowed you to carry out new impact activities that you could not have done otherwise?

Surrey's TESARREC™ [1,2,8-14] and IMP's IMPBio2Energy® [3] would not have been developed and widely disseminated to stakeholders worldwide (Figure 1).
Collaborative research and innovations between the UK and Mexico would not have taken place without the Newton Impact Award which resulted in many joint and individual publications [1-24].
We have combined the bioenergy technology strand with the policy, strategy, and life cycle sustainability assessment strands, combining the strengths of IMP (technical) and Surrey (Sustainability and policy). Without this grant, IMP and Surrey could not have delivered an internationally leading program.
Three areas have been particularly strengthened, i.e., policy, sustainability indicators and Space4Sustainability, enabled by this Newton Impact Award. We were aware of biomass, bioenergy and bioeconomy strategies in the UK, EU and South-East Asia [25]. However, Mexico has a different set of geopolitical and climate impact challenges – this grant allowed a greater understanding of these challenges and enabled us to propose more holistic systemic effective policies and strategies.
Our learning shows the scope for more joined-up approaches from a fragmented approach to policies. Transformation into a circular bioeconomy system from a fragmented bioenergy-based approach needs to be accelerated. Bioenergy policy and strategies appear at the intersection between the National Development Plan 2019-2024 (PND) and the "Transition Strategy to Promote the Use of Cleaner Technologies and Fuels" (Energy Transition Law, LTE) by SENER in Mexico. The former stresses agroecological and sustainable practices, soil conservation, water, and agro-diversity, while the latter on bioenergy (electricity, heat, cooking fuel and biofuel), with both seeking to support rural communities, small, isolated communities and micro, small and medium private companies. Little stress has been given to organic waste, residues and food discards that may generate from agro-industrial activities and added-value production opportunities in conjunction with bioenergy, unlike in the EU bioeconomy strategies [26] and in our integrated biorefining [24,25]. Thus, there are opportunities for a bioeconomy to exceed the benefits of bioenergy to empower rural, small, and isolated communities and

micro, small and medium enterprises. Bioeconomy has been defined in [26] as "The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services (excluding medicines and health biotechnology). To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment and will enhance biodiversity." – See Figures 4-5. Bioeconomy will allow adapting innovations to site-specific needs, involving the relevant stakeholders and facilitating their further adoption and deployment [16]. With these observations made, we have been able to communicate to policymakers/politicians the integrative policy framework [16]. Our bioeconomy policy framework development would not have materialized without this grant.
Surrey had a strong track record in developing sustainability indicators for Sub-Saharan Africa, but not for Mexico. Inevitably, in the process of developing a sustainability indicators framework for Mexico, we faced a dramatically different set of needs and challenges, which resulted in a novel framework [17] and could not have resulted without this grant support.
This Newton Fund Award has further generated a UKRI-funded GCRF grant "*A UK/Mexico partnership in Earth Observation (EO) for biomass: Developing a new Surrey UK/Durango Mexico collaboration under Surrey University's 'Space4Sutsinability' initiative.*" [19]
We are also co-editing a journal special issue: https://www.mdpi.com/journal/energies/special_issues/biorefineries_circular_bioeconomy On successful completion, this special issue will result in a book from this project.

9. What have been the key challenges and how have you overcome these?

The key challenge was access to local communities due to the Pandemic. We eventually got around the problem – thanks to the project extension for a year to allow us to travel and conduct face-to-face events. These activities resulted in the bioenergy policy and sustainability indicators frameworks [16,17] much needed to conclude this project successfully.

10. Do you intend to continue the current collaboration with your partner institution(s) beyond the funding cycle and if so, how will you sustain the partnership?

We intend to continue the current collaboration with your partner institution(s) beyond the funding cycle. Digitalisation, policy, life cycle sustainability assessment, sustainability indicators and Space4Sustainability for bioenergy and bioeconomy will be the areas for us to collaborate in the near-term future. Our joint publications [16] and [17] between the institutions are under preparation. We are also co-editing a journal special issue: https://www.mdpi.com/journal/energies/special_issues/biorefineries_circular_bioeconomy On successful completion, this special issue will result in a book from this project. We have also identified project opportunities in the two workshops, 20 Oct 2022 and 16-19 Jan 2023.

11. Why was a partnership with the UK important? Would the project/activity have been possible if the Newton funding was not available? What other avenues for funding would you have explored? Can you tell us in as much detail what would not have been possible without the funding?

The partnership with the UK was important because of the UK team's leading expertise in bioeconomy and sustainability. The technology and policy landscape are fast changing in bioenergy towards the circular bioeconomy for net zero. Renewable and bio-based resources can offer product and service benefits, nutraceuticals, pharmaceuticals, speciality and commodity chemicals, materials and energy commodities in a chronological, cascaded, and

integrated manner, displacing fossil resources and waste resources are kept in circulation (Figures 4 and 5) [21-24]. For e.g., UK's net zero and biomass strategies and circular economy hubs are timely for Mexico to benefit from. Surrey leads the Circular Chemical Economy Hub of the UKRI.

Knowledge transfer including joint publications in the areas of biomass, bioeconomy, biorefinery, net zero and sustainability would not have happened without this fund. Although IMP had technology bases developed, local community-level sustainability impacts including the delivery of SDGs were only possible because of this grant, which brought together Surrey and IMP teams to deliver the impacts on the ground.

We are a research and innovation active team and are engaged in many projects. The PI is investigating the BBSRC EBNet (Environmental Biotechnology Network), BB/X011372/1 and BB/X011615/1 (CoI), Innovate UK Knowledge Transfer Partnership (PI), NE/W003627/1 (CoI), TS/T011637/1 and TS/X017648/1 (CoI) and investigated EP/N009746/1 (CoI), NE/R013306/1 (Supervisor) and NE/L014246/1 (CoI), etc. and many industrial funds attracting over £5M. From this portfolio, it can be seen that our main funding body is the UKRI. However, only limited opportunities are available that fund overseas partners as well.

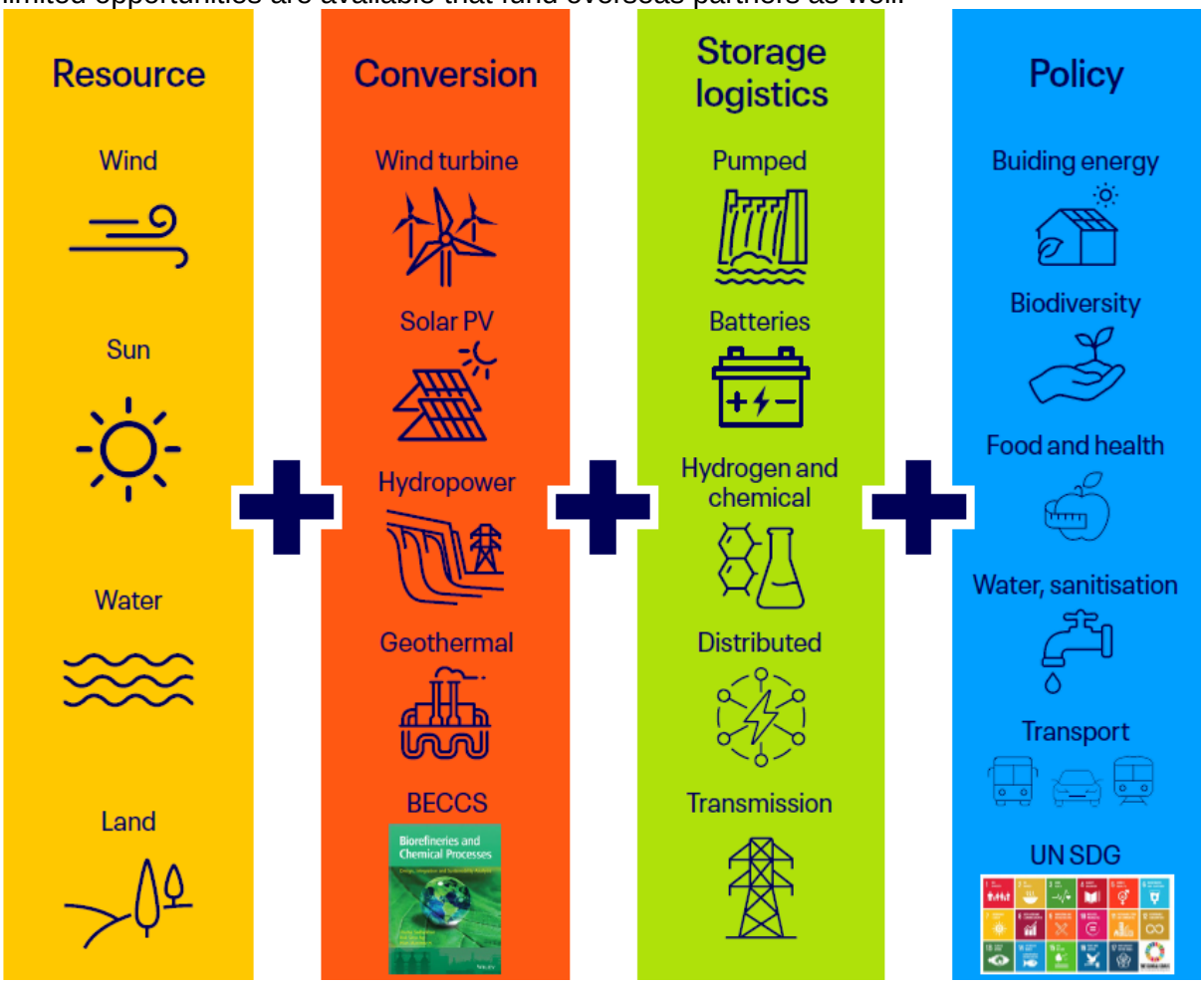

Figure 4. A whole system approach to renewable and circular bioeconomy systems [20].

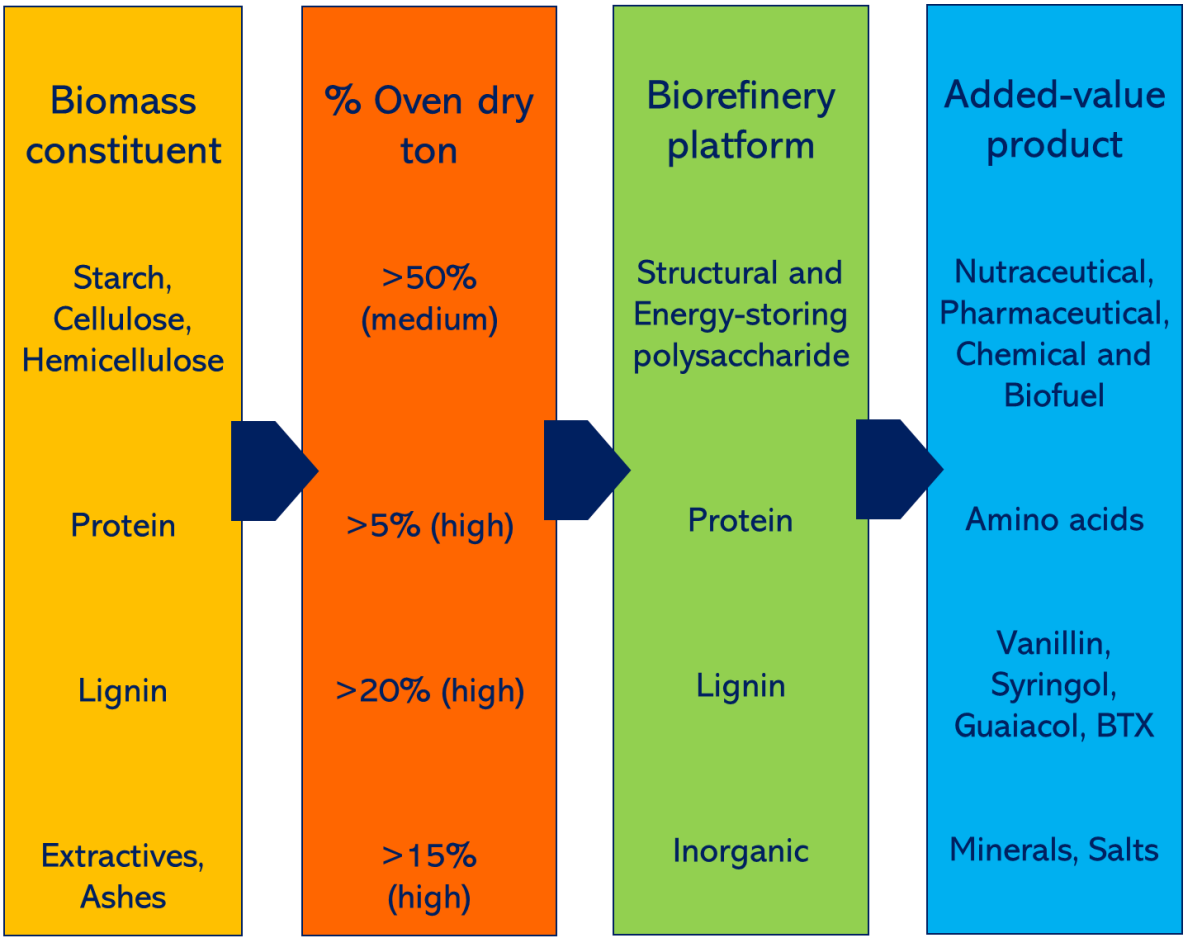

Figure 5. Biorefining to extract added-value products [20,23].

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