Sustainability considerations for excellent materials research conducted in WISE

Research activities follow the outlined topics and thematic areas of the WISE matrix, see below. Sustainability, defined to lie on three pillars (environmental/climate, economic, and social), is included in all research activities of WISE as an integrated component with respect to relevance and significance. This implies that research within WISE should contribute to developments in materials and technologies – from new fundamental insights to real-world implementation – that meet the needs of the present generation, without limiting the possibility for future generations to solve their needs and demands. Research projects funded by WISE should primarily focus on:

ENERGY. Research will include the studies and development of materials that enable a fossil-fuel free society, with net-zero emissions, that can fulfill the Paris Agreement. This includes technologies to generate, convert, store, and distribute energy, including large-scale centralized systems, via mobile tools and vehicles, to heavily distributed intelligent and miniaturized systems. Emphasis is devoted to a wide range of fossil-free, efficient, safe, and/or renewable energy carriers, including electricity, heat, solids, liquids, and gas. Advancing materials for energy technologies should enable future technologies to become affordable, scalable, manufacturable, implementable, and based on abundant materials. They should rely on compounds produced and processed using sound environmental and ethical conditions, and with the lowest possible impact on the environment. While at use in technological setups for energy applications, materials are developed targeting performance parameters such as efficiency, energy and power density, stability, cyclability, lifetime, and capacity retention, etc.

CIRCULARITY AND REPLACING MATERIALS: Circular materials. There is an urgent need to shift from the linear production model that depletes resources, is harmful to the planet, and generates large amounts of waste, to circular systems that eliminate waste and pollution and circulate products and materials at their highest value. Circularity considers the full loop of prime extraction, beneficiation, design, manufacturing, use, disposal, and finally recycling, reusing and/or remanufacturing (upcycling). Circular materials research will include studies on materials design to prevent waste, natural resources management, novel use of by-products, substitution of hazardous, rare and costly components, and efficient recycling and upcycling of high-performance materials with minimal generation of hazardous chemicals. Important aspects and considerations include: end-of-life materials design, life cycle analysis, energy consumption, CO_2 footprint, release of chemicals and (other) novel entities with hazardous properties, safety, atom-efficiency, durability, behaviour and cost of recycling or reuse vs. cost of extraction of (non)renewable resources.

CLIMATE: Cleaning, mitigation, and protection. Climate change and pollution are the challenges of our generation. Deriving and producing new materials are processes associated with the use of solvents and generation of undesired by-products such as hazardous chemicals/pollutants, micro/nanoparticles, solid and liquid waste, greenhouse gases, and more, that are distributed into and absorbed by our atmosphere, biosphere, and geosphere. First, it is crucial to develop material systems and technologies that enable reductions of pollutants and undesired by-products preferably to zero. Secondly, functional materials is a potent tool which can serve as

passive/active systems that collect, store, separate, and transport by-products/pollutants and then finally transform those into desired high-quality materials, possible to recycle, or into suitable sinks such as for carbon. Research will aim to reduce the emission of greenhouse gases and hazardous chemicals using safe, flexible, and energy efficient processes and materials. Methodologies to sense and monitor hazardous components in the atmosphere, biosphere, and geosphere are also included.

DISCOVERY. New challenges coupled to sustainability will arise as our society further develops along with the growing global climate and environmental crises. New methods and techniques within materials research are continuously developing and enable novel technical solutions. This gives room for material scientists to act swiftly by suggesting radically new forms of material systems and techniques to combat arising and future challenges, as well as older yet unsolved problems. Material research develops according to both long-term knowledge-seeking strategies and sudden unforeseen findings, which provide novel opportunities on the facets of material science, ranging from modelling, synthesis and processing to structures, properties, and performance. Discoveries will be highlighted as a critical component of WISE to provide necessary dynamics in enabling transformation of our world into a sustainable society, and the focus of this research should be in line with the WISE mission.

WISE will support scientific projects where necessary sustainability components have been considered and treated in a holistic and balanced manner. It is especially crucial to encompass and treat sustainability criteria that, for instance, are interconnected or are mutually in conflict with each other. Your suggested research will most likely include sustainability measures not only residing within one thematic area (WISE Matrix i-iv), but rather in several. It is important that an integrated sustainability consideration of your suggested research is detailed and outlined in a transparent and honest manner, openly addressing ecological/ environmental/ sustainability/ economic/ social pros *as well as cons.*

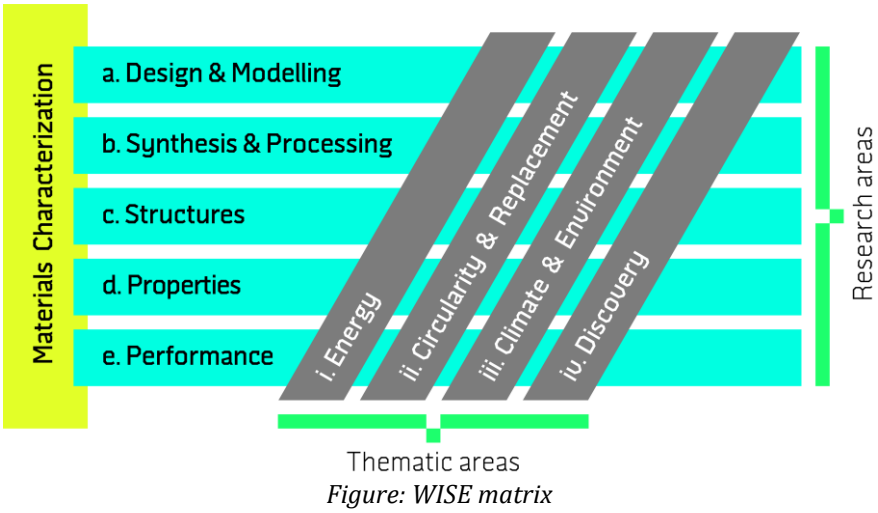

Figure: WISE matrix

Typically, your reasoning for sustainability should include both analytical motivations (*e.g.*, calculations), combined with logical rationales worded as a discussion. In addition to relevance, your suggested research should contribute to the strategic development goals, as identified by the United Nations (https://sdgs.un.org/goals). Very often this requires solutions either at large scales, while in use as a future advanced material operating in energy technologies, as a circular material, or some other way serving our environment, while creating resources for society.

While the perspective and impact of WISE is much longer than for 2030, an “Agenda 2050” should be envisioned.

For WISE, the considerations for sustainability are, and should be, substantial, and naturally reflect the urgency of reorienting our world toward long-term environmental, economic, and social sustainability. In the end, your sustainability outline and motivations will make your suggested science more relevant, significant, and competitive at the forefront of material science for the future. We look forward to receiving your proposal.