## Climate and Energy Mission: Shifting to clean energy while restoring a safe climate

The global energy system based on fossil fuels accounts for close to 80% of primary energy today. Transforming this system to reach net-zero carbon emissions by 2050 and at the same time to provide universal energy access without increasing the use of fossil fuels is one of the major challenges in the 21st century. Transforming to a net-zero carbon global energy system is essential to limit global warming to 2°C in this century and reduce negative impacts of climate change threatening nature and societies.

Achieving net-zero by 2050 would require decarbonization of the energy systems, accompanied by a transformation of land use and food systems (detailed in another mission). To decarbonize the world's energy system by mid-century, transformative actions would need to be built on four pillars:

- Reduced energy demand and improved energy efficiency in all sectors;
- Shift of electricity generation from fossil fuels to renewable sources;
- Electrification and fuel switching, the conversion of current uses of fossil fuels outside of power generation (such as the internal combustion engine, boiler and heaters in buildings and various industrial processes such as steel production) to zero-carbon electricity; and
- Reduced energy poverty and universal access to low-carbon, clean cooking and electricity for all, especially those excluded today (TWI2050, 2018).

Although the energy transformation is considered feasible and affordable for the world, there are a number of barriers (e.g. institutional constraints, current energy systems design, market control by incumbents and policies that favour fossil fuel technologies and business models) that slow the transformation process. To increase the world's chances of achieving the 2°C goal, ways of overcoming these barriers must be urgently identified.

### Critical areas for scientific inquiry:

- Integrating the social, behavioural, and economic factors in energy and climate models;
- Developing robust transformative pathways to energy system decarbonization while achieving universal energy access, taking into account differences in energy use across countries;
- Understanding of barriers to just energy transformation and identifying ways of overcoming them;
- Assessing the potential of distributed energy generation in different contexts, facilitated by the digital technologies;
- Identifying options for reducing energy demand and improving energy efficiency in all sectors;
- Developing sustainable and smart mobility solutions;
- Developing battery-life extension and improved energy storage solutions;
- Developing pathways of achieving universal energy access in low- and middle-income countries, while avoiding path dependence in fossil fuels;
- Building multidimensional knowledge on the costs of inaction, delay or limited action to achieve net-zero energy systems and universal energy access;

- Advancing understanding of transformative climate mitigation and adaptation strategies and pathways, assessing the effectiveness of these strategies, and translating results into actionable information;
- Transforming the capability of global and regional climate models through coordinated efforts;
- Downscaling of climate data and making the data accessible and usable to impact researchers and planners/decision-makers;
- Improving understanding of the solar influence on climate change;
- Improving understanding of the synergistic impacts of air pollution and climate change on human and ecosystems health and development;
- Building a better understanding of carbon storage in soils and plants;
- Improving understanding of the effects of climate change on the distribution of non-native and native species at different geographic scales; and
- Transdisciplinary interventions and scenarios to manage the global climate system.