Recommendation from RD20 Early Career Researchers

attending the

First RD20 Summer School

Prapoutel-Grenoble, France, 2-7 July 2023

When Japan hosted the G20 summit in 2019, Prime Minister Shinzo Abe launched the **RD20** initiative to foster collaboration among key research and development organisations from across the G20 in order to accelerate innovation on clean energy technologies and build international partnerships (https://rd20.aist.go.jp/). The first RD20 conference was organized in October 2019 in Tokyo, and since then every October (remotely in 2020 and 2021). The next conference will be held October 4-6 in Fukushima, Japan.

Creating an annual **International RD20 Summer School** was one of the important recommendations from the RD20 Leaders Statement that codified the urgency to significantly increase international collaboration, in order to accelerate Research and Development (R&D) to enable the clean energy transformation.

For this first edition of the RD20 Summer School held July 2nd to 7th, 2023 in Prapoutel – France, we were more than 50 early career researchers attending this exceptional event, coming from 5 continents and 15 different G20 countries. Interestingly, we have different backgrounds ranging from production of renewable energies, energy storage to decarbonization of energy systems or energy economy. We had lectures from 14 experts on several topics that allows enhancing our knowledge and increasing our skills. One objective of the school was to set together a *common vision on desirable G20 contributions to achieve carbon neutrality by 2050*.

We are all aware that unmitigated climate change will affect the stability of our nations, and beyond, through severe weather conditions expansion, multiplicity of natural disasters, agriculture losses and economic decline. Our main messages, expectations and recommendations for actively pursuing carbon neutrality are summarized herein, and include but are not limited to the need for innovation and our optimism that science and technology can have significant positive impacts.

From a technological perspective, we would like to highlight three priorities:
- To ensure large-scale deployment of low-carbon technologies while avoiding critical resource, supply and environmental issues, we recommend more investment in research and innovation for the development of innovative, cost-effective technologies using **eco-design and environment-friendly manufacturing and recycling processes**.

- To limit fossil fuels consumption and related greenhouse gases emissions in many economic sectors, we propose to adopt a **carbon capture, utilization, and storage framework** (CCUS) associated with massive production of renewable energies and reducing agents (for example hydrogen) to **convert or store CO_2 in valuable materials and chemicals** to create a circular carbon economy.
- To meet society decarbonization goals while **limiting soil and water contamination,** and other environmental impacts, we advocate for monitoring and minimizing impacts of **waste** production, transportation, treatment and utilization, including fostering **local utilization and conversion of waste into low carbon footprint products**.

From societal perspectives, we believe that energy sobriety and sustainability should become part of our common culture and education is the main lever towards this objective:

- Implementing a just and efficient energy transition requires public awareness and acceptance. This requires drastically **increasing education and outreach** to decision makers and the general public on topics such as climate change impacts, the role for innovation and the clean energy transition and the need for more environmental protection. We recommend developing and making easily available an "**Energy and Sustainability Literacy**" explaining information sources, reformulating problems and adapting presentation layouts for various ages and cultures.

From policy perspectives:

- To promote a "**Just Energy Transition**" or a "**World Inclusive Climate Transition**" and overcoming the numerous barriers existing such as differences between local policy frameworks or restricted movement of people, goods and services, we believe that G20 should promote a global energy justice and inclusion based on **transparency, collective responsibility and common actionable regulatory frameworks**.
- To facilitate accurate decision making, we recommend to develop and share at the international level:
    - an agreed and common set of parameters and methodologies for evaluating energy and technology systems by **Life Cycle Assessment** (LCA), **levelized cost of energy** (LCOE), and **energy payback time**;
    - a large access to **Harmonized** or **Universal Footprint Indicators** incorporating greenhouse gas emissions, fossil carbon content and other indicators like land and water use or toxicity.

    This approach, by allowing different regions to evaluate with acknowledged methods their energy choices according to their specific interests, situation and resources, respects both, national sovereignty and collective awareness.
- Finally, we consider a coordinated effort to make a **global carbon trading system** is mandatory to provide an economic environment which incentivizes decarbonization. Such a system will only be effective so long as there is **participation by large carbon intensive economies**. For ease of adoption, it could rely on an existing, well-respected infrastructure, which most countries already subscribe to, such as the World Trade Organization (WTO).

Detailed propositions from young researchers 'groups

1. Carbon Capture and Utilization or Sequestration (CCUS)

The adoption of a carbon capture, utilization, and storage framework (CCUS) will attenuate fossil fuel emissions from many economic sectors. Large-scale adoption of such systems will incentivize CO_2 capture by increasing value (demand) and will accelerate the deployment of renewable energy projects to produce value-added chemicals.

The shift towards a carbon economy will require the implementation of CO_2 capture technologies on a large scale (point source and direct air capture). In addition, local purification and distribution networks are required. We propose the mass production of renewable energy and reducing agents to store CO_2 in essential materials and chemicals. Identification of strategic storage locations is needed (oil fields and basalt in the long term).

Failure to implement CCUS programs will have profound impacts on all member of the G20. Unmitigated climate change will affect the stability of our nations through agriculture losses, severe weather, economic decline and other natural disasters (for example, ongoing wildfires in Canada). This poses real concerns for economic prosperity and national security. CCUS will mitigate damage and reverse climate change in long term.

The success of a carbon economy requires that all G20 nations implement fair and transparent measurements strategies for CO_2 emissions. An accurate carbon accounting and pricing framework should be developed. Large investments in CCUS infrastructure is needed from all G20 nations and private entities.

2. Bioresources and waste utilization

Currently, G20 countries do not handle their waste and bioresources adequately. A better emphasis must be made on creating low-carbon footprint products out of the waste to meet the decarbonization goals. The lack of transparency and dialogue among countries, associated to treatment of waste limits the resource recovery from waste.

Our recommendation to the G20 countries is to develop novel transparent tools and an open database to monitor waste production, transportation, treatment and utilization to foster reduction and local utilization of waste.

Waste generation is a persisting issue that will continue to generate greenhouse gas emissions, soil and water contamination and represents a significant loss of potential resources. Our recommendation will promote collaboration and trust between countries, which will enhance innovative technological development to improve the waste management.

Collective responsibility is essential to implement necessary changes. Governments need to lead the action by implementing effective policies and nurture an enabling environment to share data, digitize the waste information, encourage viable business models and optimize waste management efficiency across the value chain. The implementation of the above actions will enable the closing of local carbon loops.

3. Energy Efficiency and Sobriety

The cleanest energy is the energy not used. To evaluate our progress in improving energy efficiency and make informed data-driven decisions, we need comparable data. To achieve this, we need consensus on indicators and definitions and harmonization of the collected dataset. What could limit the action is the lack of transparency and lack of involvement of all relevant stakeholders.

The success of the energy transition within the limited timeframe depends on the engagement of policy makers and key industries with a high demand for resources. Future policies need to shift capital for innovation and labour into energy efficient and low carbon technologies. Long term investments into sustainable innovations are necessary to increase the usage of energy efficient technologies for industries and individuals. As a major contributor to GHG emissions through inefficient use of energy, industries and companies need to be further involved and evaluated based on their compliance with energy efficiency guidelines.

On an individual level, national governments need to create a legal framework to encourage energy efficient behaviour within the population. Therefore, to raise acceptance of such policies within the population, it becomes essential to promote the education of future generations through awareness programs to create awareness for the need for energy efficient in policies and economic decisions. Energy sobriety should become a part of our culture and key indicator for the promotion of technologies. Furthermore, we recommend the implementation of regular surveys initiated by a representative G20 panel for citizens to partake in voluntarily and evaluate the policy framework, which should facilitate energy efficient and sobriety in all sectors of living

4. Circular Economy Critical Material Awareness and Recycling

We recommend taking action to address the foreseen supply issues of critical materials (and resources in general) that are essential for low-emission energy production, storage, and decarbonization technologies. While we currently might have enough resources, it is crucial to conduct research on design of processes, components, and systems that allow recycling of critical materials, and to ensure that readiness of such technologies is at the commercialization level within the next five years.

We suggest investing in research and development for cost-effective and environment-friendly recycling processes. Financial incentives should be introduced to encourage industries to adopt large-scale recycling. Standardization of technologies should be established in parallel, and regulations should be enforced on the disposal of critical materials to facilitate effective waste management and subsequent recycling. These efforts will help mitigate the costs associated with transitioning to a circular economy.

Mindful extraction and sustainable consumption of critical materials should be emphasized. This requires educating society, particularly the younger generations, and launching social campaigns to raise public awareness. Besides, eco-design and sustainable manufacturing need to be accelerated to allow for careful consumption of critical materials.

It is crucial for all G20 countries to unite and support the circular economy by implementing policies, investing in research and development for recycling critical materials, and fostering social awareness of sustainable consumption. Additionally, inter-country collaborations should be encouraged and facilitated to expedite the implementation of these initiatives.

5. Environmental Awareness and Harmonized Footprint Indicators

Promoting environmental awareness and carbon footprints are crucial for climate change mitigation, but current methodologies lack consistency and transparency, leading to inaccurate decision-making.

To overcome these challenges and facilitate a rapid transition to net-zero emissions, we propose the ACT (Action, Consistency, and Transparency) Framework.

- The Action pillar of ACT acknowledges communities' rights to environmental health and sustainability. It is based on the principle that all communities are entitled to environmental human rights and may therefore demand legal action in response to environmental health violations.
- The Consistency pillar strongly support the ongoing development of guidelines for a single, universal environmental footprint, encompassing the global economy including high-pollution industries. These international guidelines should allow standardizing calculations, scope, and data considerations, incorporating both greenhouse gas emissions and other indicators like water use and toxicity.
- The Transparency pillar emphasizes public awareness and access to footprint calculations, data, and results, complemented by educational materials.

Implementing ACT will involve, in addition to expert panels defining relevant baselines for evaluating environmental footprint and sustainability, an independent international agency to conduct footprinting and enforcement. Regular revision of guidelines will ensure alignment with the latest scientific knowledge. Despite participation challenges, ACT is an opportunity to globally harmonize footprint indicators, fostering real climate action for a sustainable and equitable future.

6. Sustainable Energy Mix

Achieving a sustainable energy mix, to meet energy demand whilst minimizing carbon dioxide (CO_2) emissions, requires the evaluation and implementation of different energy sources and technologies depending upon their economic feasibility, social acceptability, and negative environmental impacts.

To facilitate global efforts to minimize CO_2 emissions, it is recommended that the G20 establish an agreed set of parameters for the evaluation of energy technology systems by life cycle assessment (LCA), and levelized cost of energy (LCOE) methodologies. LCA evaluates the environmental impact of energy systems from production to end of life disposal whilst LCOE allows for a comparison of cost associated with energy generation over the lifetime of a project.

Agreement regarding appropriate parameters and correct processes for evaluation technologies based upon LCA and LCOE would provide a framework for the evaluation and comparison of the environmental and financial costs associated with different sustainable energy technologies. Furthermore, we recommend that policymakers in each nation legislate the agreed upon LCA and LCOE parameters, making them legally binding with respect to their jurisdictions.

Implementing this proposal would provide a clear direction for sustainable energy development and allow nations the freedom to choose their energy mix based on local factors, within the framework of the agreed assessments. This approach respects national sovereignty and recognizes that different regions may have specific interests and resources that influence their energy choices.

To facilitate transparency and accountability, the empowerment of a new or existing independent body to audit national LCA and LCOE assessments is recommended. This independent auditing body would provide oversight and verification of the assessments made by individual nations and entities operating within them, enhancing credibility and trust in the evaluation process.

Regular review LCA and LCOE targets for sustainable energy systems is also recommended due to ongoing development regarding, evolving technologies, scientific understanding, and global emission reduction goals. Such a dynamic approach allows for adjustments and improvements over time, ensuring that the energy mix continues to align with the objective of reducing global emissions.

7. Capacity Building and Education

Implementing a just and efficient energy transition to mitigate climate change requires to drastically increasing public awareness and education of next generations on fundamental topics such as environmental protection utility and climate change impacts. To do so we recommend to develop and make easily available an "Energy and Sustainability Literacy" in order to share knowledge about the entire process which stays upstream the energy consumption phase, knowing how human activities and natural systems interact. The production of such a Literacy needs to explain information sources, to reformulate problems and to adapt presentation layouts for various ages and cultures. Specific attention should be given to analysing demographic data and to personalize messages accordingly (for example visually engaging content for younger people, clear, concise text for older ones).

We believe this approach is important because it can enhance the effectiveness of educational materials and increase engagement among different age groups and cultures.

8. World Inclusive Climate Transition

There are various barriers to the World Inclusive Climate Transition (WICT) that can also be called Just Energy Transition. They include: policy frameworks, and restricted movement of people, goods and services. To overcome them, the WICT should focus on global energy justice and inclusion while taking into account context and providing nuanced solutions. These solutions include:
1) cooperation and facilitating the movement of people, goods and services;
2) including all stakeholders throughout the decision-making process;
3) accounting for the diverse physical and human characteristics of different jurisdictions;
4) engagement with the concerns and proposed solutions from diverse regions;
5) making resources (e.g. finance, skills, & technologies) available;
6) codifying these objectives into actionable regulatory frameworks.

Without actionable policy, law, and regulation there will not be meaningful action. Moreover, unless resources are shared there will not be an inclusive energy transition. A climate solution that works only for the G20 countries won't work to address global climate change. Neither will focusing solely on the G20 priorities necessarily achieve the G20 objectives. We recommend the G20 expand the remit of the G20 Energy Transitions Working Group (ETWG) establish into a World Inclusive Climate Transition Body to enact the proposed solutions by:

i. creating fora for engagement with stakeholders;
ii. creating a just energy transition fund; and
iii. reviewing existing legal, policy, and regulatory frameworks.

9. RD20 statement on carbon trade

Regional carbon markets do not have the necessary global impact to provide an economic environment which incentivizes decarbonization. A coordinated effort to make a global carbon trading system is needed. It will be critical to develop international standards and an agreed-upon carbon pricing mechanism, including independent monitoring, verification, and coordination. In addition, such a system must be able to set a global price for GHG emissions. To increase the attractiveness of adopting a trade system, a mechanism to stabilize the carbon price should be put in place. Further, such a system is only effective so long as there is participation by large, carbon intensive economies. For example, a tariff system, based on the carbon intensity of exported goods by a country, can be levied to promote participation in a global carbon market. For ease of adoption, we believe standards should be amended to an existing, well-respected infrastructure which most countries already subscribe to, such as the World Trade Organization (WTO) utilizing the general agreement of trades and tariffs (GATT). Enacting such a system will accelerate innovation, adoption, and investment into decarbonization technologies, and protect the world against non-participation of large economies in the energy transition.