Organisation for Economic Co-operation and Development

DSTI/STP/BNCT(2022)14/FINAL

Unclassified

English - Or. English

9 February 2023

DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INNOVATION
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY

**Working Party on Biotechnology, Nanotechnology and Converging Technologies**

# Conference proceedings: Technology in and for society: innovating well for inclusive transitions

6-7 December 2021

This document presents results from the multi-stakeholder OECD Conference, "Technology in and for Society," on 6-7 December 2021. It explored values, design principles, and mechanisms for leveraging good governance for critical sociotechnical transformations. The first part provides an account of the primary themes of the conference. A more detailed proceedings is presented in the Annex.

The conference yielded a number of possible directions for BNCT's work on technology governance and responsible innovation. Concretely, it informed the STI Outlook 2023 Chapter 6 "Emerging technology governance: Towards an anticipatory framework".

The conference proceedings were presented to the BNCT Working Party at its 15th meeting in May 2022. With no comments received, the document will be made publicly available at https://oecd.org/officialdocuments

*PWB: 1.3.2.2.1*

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**JT03512084**

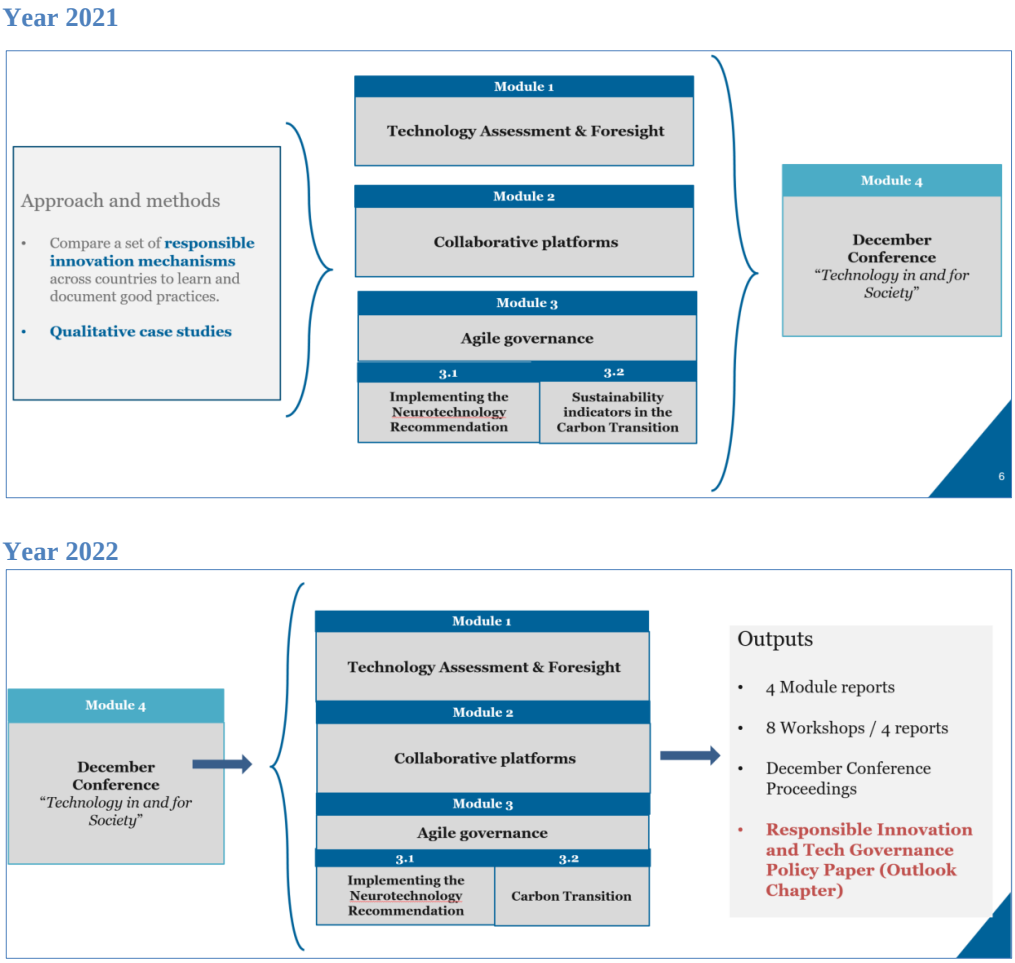
# *Note from the Secretariat*

This paper represents a workshop report for the multi-stakeholder OECD conference, "Technology in and for Society" held 6-7 December 2021. The conference explored values, design principles, and mechanisms for leveraging good governance for critical sociotechnical transformations. This report consists of three parts: (i) an executive summary (1 page), (ii) a section of key messages (13 pages), and (iii) an annex with the longer conference proceedings (50 pages).

## *Posture of the Conference in the current biennium*

The conference, and this report, represent a centrepiece of the project, "Technology in and for Society" under the BNCT's Programme of Work and Budget 2020-2021 (DSTI/STP/BNCT(2020)6/REV1). Modules 1-3 enriched the Conference and made distinct contributions to panels. The Conference findings will now feed into the final reports and outputs of the Modules (see Fig.1).

**Fig.1. Flow diagram showing the relation of Modules to the December Conference**



The conference is also a centrepiece of the CSTP Programme of Work and Budget 2020-21 and its pillar on the technology and data governance.

On the basis of further research and interviews in 2022, this current paper will be developed into a report and/or chapter in the STI Outlook that lays out gaps in knowledge and norms with respect to the governance of emerging technology and responsible innovation. It will also set out a more general policy framework featuring **design principles and associated good practices** concerning responsible technology development, e.g. participatory goal-setting, technology assessment and foresight, co-design, and upstream governance mechanisms like standards and soft law.

### *Possible directions for BNCT's tech governance work identified at the Conference*

In the final session of the conference, the Chairs of BNCT and CSTP, as well as the STI Director, were asked what two or three key points they would take away from the Conference. In general, there was agreement that this conference marks an important milestone for CSTP and BNCT, and its findings should be reflected in CSTP's S&T Policy 2025 agenda. A portfolio of ideas and actions were collected, and include:

- *Build anticipatory capacity and tech assessment on emerging technologies*. Develop strategic intelligence around a portfolio of technologies. Support the anticipation of technology disruption as a pillar of a new strategic intelligence approach being developed in the CSTP, so-called "S&T Policy 2025". Help develop an OECD-wide technology assessment methodology that includes next generation of risks and opportunities rooted on shared values and deploying a concept of a dynamic governance toolkit and continuum.
- Imagine, design and propose *new converging technology governance standards,* tools and mechanisms, leveraging recent work on the *Recommendation of the OECD Council on Responsible Innovation in Neurotechnology*, and be the source of further principles on emerging technology.
- Leverage the OECD's knowledge infrastructure like the *STIP compass.*
- *Research and knowledge sharing function.* Document and share good practices on wider stakeholder involvement. Systematically take stock of current efforts at anticipatory technology governance, where can one can learn lessons which could support the learning from "real world laboratories".
- *Promote multi-stakeholder cooperation and communication*. Build current policy dialogues with relevant STI policymakers and stakeholders. Keep identifying and encouraging win-win opportunities for cooperation, including in the emerging technology space. Promote communication and literacy across publics, policymakers and technical experts and other stakeholders.
- Convene an *expert advisory group* to follow up on future actions in this policy stream, and provide guidance.

**In this context, delegations will be invited to discuss the following question:**

- how should ideas from the conference inform planning for the work of biennium 2023-24, especially the Project 1, "Enabling the responsible development of emerging technologies"?

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# *Executive Summary*

The multi-stakeholder OECD conference, "Technology in and for Society" held 6-7 December 2021, explored values, design principles, and mechanisms for leveraging good governance for critical sociotechnical transformations. Transforming the energy, agrifood, health, and manufacturing systems will require not only major sociotechnical changes but also good technology governance. Knowledge gaps and policy deficits were identified with respect to societal capacities to assess, promote, steer and cope with longer-term sociotechnical change. The conference generated ideas for better realising more just and effective technological transitions, for instance:

- Enrich societal deliberation on the values, purposes and agendas of technology; this will require enabling a cultural convergence of key actors and stakeholders, informing and educating policymakers as much as publics in the governance issues raised by particular novel sciences and technologies.
- Balance the need to drive the development of technologies and scale them up quickly while anticipating and mitigating social disruptions that will likely follow.
- Identify human rights and human interests at stake, and setting the challenge of realising "values-based technology".
- Lay out tangible and diverse vehicles for more inclusive innovation, e.g. making knowledge for problem-solving more transdisciplinary, broadening definitions of expertise, involving users in technology design, experimenting in public engagement methods, and attending to regional inequalities.
- Co-develop technology and governance through multi-sectoral collaborative initiatives and platforms.
- Rethink and strengthen foresight, horizon scanning and technology assessment to be more goal-oriented; promote inclusive exercises to consider technological futures.
- Expand the technology governance toolkit to include elements like "ethics by design", co-designed governance, standards, and other forms of soft law.
- Invest in global processes and approaches for greater international cooperation on technology development and technology governance to address critical problems.

The conference examined these and other elements in three technological contexts, neurotechnology, carbon management technologies like carbon capture storage and utilisation (CCUS), and health innovation. For all three areas, responsible innovation will require greater attention to governance, inclusive and multi-stakeholder processes and cross-sector cooperation, and alignment with goals articulated by society.

At the end of the conference, some speakers called on the OECD for the development of further policy ideas to harness technology for common good and the formulation of principles to make sure innovation takes place within inclusive processes, with values at the centre, and with lasting positive impact.

What follows is a thematic summary of the discussions that occurred at the "Technology in and for Society" conference with more detailed proceedings of the conference included in the report Annex.

# *Conference key messages: Realising "technology in and for society"*

## 1. The great challenges ahead

The world faces unprecedented challenges in health, food, climate change, biodiversity, and these require the very transformation of sociotechnical systems like energy, agrifood, health innovation and manufacturing. These transitions demand simultaneous political, economic, behavioural, cultural and technological change, at multiple levels of governance. In the face of mounting global challenges, governments must be more ambitious and act with greater urgency in their technology policies. For instance, existing clean technologies such as solar and wind will not be enough to meet low-carbon objectives, nor to meet demand for energy in the developing world. More investment in STI is necessary to accelerate mobility, waste management and social innovation. Mission-based innovation programmes are an important way to align the development of technology with grand societal challenges, yet they pose significant coordination challenges.

Emerging technologies such as genome editing, 3D printing, artificial intelligence, nano-scale technology and cyber-physical systems will also have a critical role to play in finding solutions. Advances in fields like synthetic biology, reaching for solutions to problems like nitrogen fixation in plants, can play a significant role in addressing climate change and other global challenges. Nevertheless, rapid technological change can carry negative consequences and risks for individuals, societies and environment, contributing to social disruption, inequality, and threats to security and human rights. A great policy challenge ahead is how we reap the benefits of novel technologies while attending to the possible negative or exclusionary impacts they might have. Another is how to redress global technological divides. The same Covid-19 vaccines that have been so critical towards alleviating illness in the industrialised countries have unevenly reached the others.

The very urgency of sociotechnical change raises a dilemma: effective intervention requires quick and dynamic action, but the more quickly we act, the greater the likelihood of social disruption. Good policy must attend to the social challenges of scaling technology up too quickly and be accountable to society and communities. In this vein, anticipatory governance will be critical for setting the terms of research, technological development and innovation. Countries would benefit from greater future-orientation in policymaking, perhaps even having ministerial portfolios dedicated to the future, to improve technology forecasting and governance. Having longer time horizons in policy development also requires innovation in governance, so as to escape the short-termism inherent in political cycles.

In these processes, citizen engagement and greater inclusivity will be indispensable, but they must be reduced to practice so experimentation and knowledge sharing will be important. STI policies and institutions may undermine public trust if the social contexts of innovation, and citizen views and values are not taken on board. Given the stakes of technological change, the time is ripe for deeper forms of public deliberation on the values that should guide scientific and technological development; and on the ways and means of achieving "technology in and for society".

## 2. Getting the right model of science, technology and society

In the face of such challenges, prior models of the science, technology and society relationship may be untenable, for they may tend to shut down opportunities for broader social actors to engage STI system. According to keynote speaker Sheila Jasanoff, the "social contract for science" in the post-WWII period assumed that more science meant more innovation, that governments had a duty to foster science and technology, and that S&T -- as self-regulating institutions -- should be left to formulate their own agendas. All of this implied a certain linear relationship between technology and progress, i.e. that technology is driven mainly by science, ingenuity and material resources, i.e., that it is "asocial"; that technology shapes society and drives history ("technological determinism"). In this account, the role of a broader set of innovators is not clear, nor is there room for broader society in engaging the STI system.

Contemporary sociological accounts of the science, technology and society relationship reflect the realities that knowledge is increasingly produced in contexts of application, that publics are aware of how STI affect their interests and values, and that these interests can shape innovation. Further, these more contextual and social models of technological change present theoretical space for meaningful social and political engagement, whether it is in making new knowledge, building groups, shaping the languages we use, or intervening in institutions. Technology policy then should be something normative, a space worth fighting for; tractable, as a space of calculation and measurement; and accountable, a space of representation and voice, and of calling into question. Technology policy should also be something collective, a space for community building. The very idea of inclusion is, at the end of the day, very much connected with the kinds of communities we expect to serve through our technological developments (Jasanoff).

## 3. Human rights and human values

Delivering on the promise of emerging technology will depend on the governance of these technologies and the extent to which technology policies embed and promote core democratic values and human rights. A key question for OECD countries is whether policy can help technologies deliver on citizen needs and societal challenges. Emerging technologies such as Artificial Intelligence, quantum computing, advanced microelectronics and biotechnology are critical to innovation and competiveness of modern economies. But governments must be mindful of the threats to human rights from the misuse or biased applications of emerging technologies.

For example, technology is increasingly becoming a tool in the mass surveillance of telecommunications, the propagation of misinformation, and the compulsory conduct of genomics research. It is important therefore to have norms and standards for both the bottom up research that drives discovery and for the application and use of technologies in society. Building safety, security and ethics "by design" is one modality of integrating rights and technology.

The social context of technology deployment might dictate how such rights might be applied. Informed consent is a critical governance of individual privacy and freedoms, but it may not be sufficient in some cases. For instance, the use of invasive technologies in the workplace may require safeguards that go beyond the rights of individuals to informed consent, as there may be power imbalances between individual workers and their employers that constrain individual choices. Here, collective consent might better protect workers from human rights concerns.

Achieving "values-based technology" will of course require societal discussion and work on what the critical human values should be. Policy makers and stakeholders should address not only technological challenges and practical social needs, but also the social values on which the future will be built. This conversation must be with an expanded scientific and technological community, and include citizens.

## 4. Putting inclusivity into practice

Different forms of inclusivity in science, technology and innovation will be critically important for achieving just transitions. Inclusivity as a goal seeks to remedy diverse and ingrained types of *exclusion*, especially with respect to differences in geography, socioeconomic status, gender, and ethnicity identification. Inclusivity should be understood not only in terms of outcome (broadening access to knowledge and technology), but also in terms of participation in the processes of technological development (process-based inclusion). In fact, the goal of inclusivity has multiple dimensions (see Box 1). The justification for inclusivity rests both in democratic legitimacy and in the improvement of science and technology.

Tangible vehicles for more inclusive innovation include, for example: redressing geographical inequalities, so-called "transdisciplinarity", broadening definitions of expertise, involving users in technology design, attending to diversity in training programmes, and promoting participatory agenda-setting.

### Box 1. Seven types of inclusion in STI systems

1. **Enjoying the benefits of innovation and avoiding the exacerbation of inequality.** Inequality and technological divides are especially stark with respect to the developing world, as well as poorer rural areas.
2. **STI agenda-setting**. Inclusivity and diversity in deciding which research and development choices should be made.
3. **Producing of science and technology, and skills and training.** Exclusion of affected groups, including users and those in need.
4. **Workers and workforce in the face of sociotechnical transitions.** Lack of diversity in the STI workforce including gender, ethnicity and age. Creation of skilled jobs to mitigate social disruption.
5. **Definitions of expertise**. Experiential expertise tends to get less recognition, and social scientists have a bigger role to play. Transdisciplinary expertise is often required in complicated contexts.
6. **Governance of technology.** The power to shape technology deployment and diffusion often sits with elites.
7. **Geographical inclusion**. Technology can exacerbate inequalities across the Global North and Global South. Further, innovation theory and practice can overlook the rural context, especially in the developing world.

*Source: OECD as reported from conference.*

*Geographical inclusion*. Technology can exacerbate inequalities across the Global North and Global South. Further, innovation theory and practice can overlook the rural context,

especially in the developing world. There are too few mechanisms for understanding the local needs of users. Incorporating local consultation, and greater understandings of demographics, social structure and skill levels in innovation might render technologies more relevant for rural communities.

*How knowledge is produced*. How knowledge is made, and what counts as science or expertise, are a key terrain for inclusion/exclusion. "Transdisciplinarity" refers to the integration of knowledge from different academic disciplines and of broader stakeholders and relevant communities into the making of science and technology. These broader groups can produce more robust understandings of complex problems. Transdisciplinary approaches to scientific and technological problems can help equip policymaking for sociotechnical transitions. For example, programmes on urban transformation initiatives in Europe and South African are experimenting with broad-based knowledge production to support policy for urban transformation.

*Definitions of expertise*. Narrow definitions of expertise can leave out valuable perspectives. Expertise beyond its academic forms should be recognised, especially "experiential expertise" across a variety of stakeholders. Communities can bring experimental wisdom to the innovation process.

*Considerations for designing public deliberations on technology*. Power imbalances are prevalent in current public engagement exercises where technical experts tend to set the terms of the discussion. Processes tend to not recognise that the stakes for experts and communities are different, with traditional decision makers having more to gain while marginalised communities may carry the risks. Implementing meaningful public participation requires capacity building and training. Not only are researchers and innovators often not incentivised by the funding structure to build engage broader communities, but even when they are committed to do so, they may lack appropriate training or knowledge.

*Training*. The implementation of inclusion will also depend on developing a diverse community of scientists and engineers, who themselves must be trained on the importance of inclusion. This mission motivates the iGEM Foundation, a non-profit organisation dedicated to the advancement of synthetic biology, education and competition. A key part of the programme is a global student competition, where students work together to address local problems with synthetic biology. The iGEM mantra is "Local people solving local problems, using synthetic biology". Societal and ethical considerations are always at the forefront and are a key criteria in the judging of the competition.

*Participatory agenda-setting*. Governments have already started experimenting with mission-oriented innovation policies prior to the Covid-19 pandemic, as a way to mobilise STI to address clearly articulated social objectives. When combined with participatory-agenda setting, governments can better align their innovation strategies and social priorities. Participatory agenda-setting provides a platform for publics to communicate their priorities and incorporates those into the decision-making from the very beginning. As a tool, it inherently promotes inclusivity by shifting citizens into a central role.

## 5. Linking emerging technology to social goals and missions

How should such goals and "missions", once they are shaped with societal input, bear on policies for the development of critical and emerging technologies? New and emerging technologies will be critical tools for achieving many of the Sustainable Development Goals (SDGs), for example, but how to marry the open-endedness of technological innovation with the goals of achieving specific grand challenges? Too early directing a

hand over research threatens to limit the full potential of emerging technologies, while the need for transformative change calls for earlier engagement in shaping the trajectory of technology towards the most critical problems.

A design principle of responsiveness might help balance the need for bottom-up research to help produce general-purpose tools and platforms with the critical need for novel technology that is serviceable in the shorter term. Such a principle might suggest that an adjustment towards a goal orientation might be warranted due to the urgency of problems, but that blue-sky science and engineering should clearly continue. Striking the right balance will of course be context dependent, and relies on analysis within particular technological areas and social needs and values.

In the 6-7 December 2021 OECD Conference, "Technology in and for Society", this dilemma was examined by linking three of these emerging technology areas to their larger goals: neurotechnology, carbon management technology, and critical health technologies. A number of analytical points emerge from this juxtaposition that could help guide the assessment an development of emerging technologies.

- First, linking larger societal goals to questions of emerging technology policy brings questions of access to the fore: if these technologies are developed, in what ways will people actually benefit? Will access and the distribution of benefits be fair? Answers to these questions could help guide emerging technology policies.
- Second, this juxtaposition puts an emphasis on scale-up as a key object of technology assessment. What would be the social, political, ethical and cultural impacts if such technologies were put into place at scale? Thought experiments about scale-up could illuminate better policy pathways.
- Third, keeping goals and objectives in mind for emerging technologies helps reveal the importance of governance dimensions throughout the development process. This recommends thinking not just about technological innovation but institutional innovation.
- Finally, since the private sector will have to play a critical role in delivering innovation, engaging that sector in broader public missions and the creation of public goods will be essential. Collaborative and multi-sector platforms and other forms of public-private partnerships can provide important infrastructure for the co-development of technology and governance.

## 5.1. Neurotechnology and global mental health

Hundreds of millions of people live with brain disorders and diseases of the nervous system; indeed, neurological diseases and mental illnesses – from Alzheimer's to multiple sclerosis to stroke – account for a great portion of our healthcare expenditure. Advances in neurotechnology have the potential to enhance the treatment of brain disorders and build human capabilities, opening new pathways to diagnose and treat brain disorders and improve health and well-being. However, there are ethical, legal and social challenges associated with the advance of neurotechnology related to privacy, human enhancement, autonomy, and equity. A number of particular governance challenges derive from the commodification of brain data, AI-neurotechnology convergence, the rise of consumer neurotechnology, and equitable access.

Neurotechnology policy requires more debate and clarification on what the ultimate goals might be: global mental health should clearly be a guiding star, and this calls for looking carefully beyond the technology and at the social determinants of brain health at multiple

scales. The need to support science and entrepreneurship, a strong investment environment and ethics to nurture promising technologies might be an important means to an end. However, how exactly the engagement of the private sector will translate into access to existing and future neurotechnologies, particularly in the developing world, is less than clear. Although cost of treatment may seem the most important issue affecting equitable access to neurotechnologies, it is a multifactorial problem that includes lack of education, technological disparities, and regulatory issues.

Implementing systematic approaches to responsible innovation in the private sector encounters challenges for all of the major kinds of actors involved. For early-stage entrepreneurs, incorporating (time consuming) ethical consideration into their workflow is particularly challenging. Most venture capitalists want to align with positive outcomes for society, but they are often unaware of how to structure that alignment. Executives at larger companies are more equipped to engage with ethical issues as compared with early entrepreneurs. Big tech companies often welcome regulation at the government level because it can serve as a barrier to entry to future competitors. The main concern is the question of how the private sector can engage with neuroethics while doing exemplary/cutting edge work. Philanthropic organisations often lack a clear playbook on how to incentivize implementation of neuroethics guidelines in their granting workflows.

Promising ideas lie in the development and maintenance multi-sector innovation platforms that promote data sharing within privacy boundaries, and common infrastructure to develop new approaches to global mental health. Actors should find the right mix of public and private governance to advance the objectives of the field.

## 5.2. Carbon management technology and net carbon neutrality by 2050

Reaching net carbon neutrality is one of the central challenges faced by the global community, and technological solutions will play a key role. Now is the time to bring industry sectors into view, especially those where emissions are high and the alternatives few, e.g. chemistry, cement, steel. Here, the demand needs to be filled by an appropriate mix of bioresources and chemical carbon recycling.

Technology is increasingly making it possible to recycle industrial sources of carbon, thus making them renewable. The idea of "carbon management" may capture the different facets of the answer: reduce the demand for carbon; reuse and recycle the carbon in the bio- and technosphere; and remove carbon from the atmosphere. But a reliance on technologies for carbon capture and usage (CCU) and carbon capture and storage (CCS) may present barriers for other more radical transformations, i.e. truly low-emissions technologies.

There are three specific challenges that emerge around an expanded use of CCU and CCS:

*First, a political challenge*: There is still a lack of clarity on the future of fossil fuels. As a result, investments in fossils fuels might continue for some time, despite the possibility of stranded assets. The transition will also have winners and losers, and it is politically necessary to focus on losers and create opportunities in the post-fossil age. This is not just about finding technological pathways, but about finding political pathways towards those deep cuts in emissions.

Holistic policy approaches will be necessary to avoid unintended, unwanted consequences that jeopardise social acceptance. Climate is not the only imperative. There are other environmental imperatives. Market imperatives include making energy markets function efficiently and competitively. Security imperatives include access to affordable and reliable energy. Government departments/ministries often operate in silos, rendering holistic approaches impossible.

Technology deployment decisions and broader policy frameworks for carbon management should include issues beyond emissions reduction, e.g. consideration of other issues that have proven to be critical for publics, including local environmental impacts, pressure on bioresources and energy affordability, security, and reliability.

*Second, a social challenge*: Can carbon management technologies with uncertainties be deployed at scale with the level of community and social support that is going to be necessary? The required transformation is on such a fundamental scale that social acceptability and participation will be essential, and at different political scales.

The construction of new energy infrastructures, especially pronounced in transforming economies, will require inclusive project decision-making processes. Communities want to be consulted and engaged and have the ability to help shape project outcomes. There is a real requirement on the part of the communities to have trust, clarity and confidence in the processes that are utilised to make decisions around energy infrastructure. But that takes time, and time is lacking. It will be difficult but critical to engage communities even as we need to act urgently.

*Third, a policy and regulatory frameworks challenge*: In a recent study around CCUS (Gattinger, Bird and Larkin, 2021[5]), perhaps the number one recommendation was the need for policy stability, including a price on carbon, to provide motivation for CCUS development. Risks can polarise society and policy makers must consider risk management options to improve public confidence in CCUS.

Thus, in the domain of carbon policies and technologies, there are unprecedented opportunities not just for technological innovation, but also institutional innovation: reforming our decision-making systems so that they are not only functional, but adaptable to technological change, fundamentally legitimate and seen as legitimate.

## 5.3. Novel health technology and health resilience

How can new kinds of collaborations bridge research, economic, and societal priorities to achieve a key societal mission in health innovation: to strengthen health resilience. The Covid-19 pandemic has highlighted the importance of interdisciplinary and multisector collaboration to address unmet medical needs and emerging societal priorities. When markets and return of investment are limited, for example in novel antibiotics, pandemic vaccines, and some diagnostics, innovators find it difficult to secure funding, develop a sustainable pipeline, and ensure financial returns. Current frameworks for investment, innovation and large-scale supply of critical health technologies do not deliver where return of investment is limited. New business models are needed to diversify investment, innovation and manufacturing in order to strengthen R&D for global health priorities.

Sustainable innovation, access and equity can only be achieved through a whole-of-society approach. How can collaborative partnerships and novel business models between governments, public research institutes, industry, funders and philanthropy help overcome economic barriers to sustainable health innovation where traditional markets do not deliver?

Policy makers have a leading role to provide the adequate frameworks for R&D investment and equitable access to critical health technology. New economic incentives and governance approaches are needed to bridge research, economic, and societal priorities to achieve key societal missions for health resilience.

Strengthening health technology innovation and access where traditional markets do not deliver requires that further research investment must be balanced by adequate incentives for product translation, manufacturing and supply. More inclusive and anticipatory

approaches to health technology innovation would deliver ecosystems that support both innovation and equitable access.

Business models for health technology innovation should include long-term access planning, provisions (pull mechanisms) for manufacturing infrastructure, supply chains and financial returns. For instance, in order to deliver essential health technologies and services that are not adequately provided by traditional markets, return of investment should be based on value to society: delinking price from sales volume. Novel approaches to intellectual property (IP) management and technology transfer partnerships are important pillars of cross-sector partnerships, investments and sustainable product delivery.

Investment for health technology innovation (push mechanisms) should be matched by sustainability measures for health system infrastructure (pull mechanisms). There is a need for a collective commitment across all stakeholders to build and sustain ecosystems for quality of care where traditional markets fail.

Collaborative innovation platforms, such as CARB-X[1], CEPI[2], and IHI[3], offer fertile ecosystems to spearhead sustainable and anticipatory solutions for global health. Their governance mechanisms should be fit for purpose and allow for acceleration and speed when there is a need. Innovators in health technology, especially small- and medium-sized enterprises (SMEs), should build local networks and engage in global partnerships to de-risk operations, leverage financial resources and generate revenues. A higher innovative diversity and stronger representation of local stakeholders in international collaborative partnerships would help connecting research investment with local healthcare provider needs.

## 6. Revitalising technology assessment and foresight

In the face of unchartered global changes – e.g. around digitalisation, climate change, pandemics, and shifting geopolitical landscapes – it has never been more important to develop anticipatory capacities to guide technology policy and governance. Indeed, governments are looking to different forms of "strategic intelligence", e.g. horizon scanning, anticipatory technology assessment and foresight, to help ensure that emerging technologies can deliver on citizen needs and a positive technological future

However, there are significant challenges in the development of higher strategic intelligence. For one thing, the turn to more goal-oriented technology STI policies (e.g. the European "missions") demands the analysis of technology with respect to certain normative goals. Tools such as anticipatory technology assessment and foresight must adapt to this new demand of society-centric perspectives as opposed to traditional technocentric approaches.

Other challenges include the following:

[1] Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator (CARB-X) is a global non-profit partnership dedicated to accelerating antibacterial research to tackle the global rising threat of drug-resistant bacteria. https://carb-x.org/about/overview/.

[2] The Coalition for Epidemic Preparedness Innovations (CEPI) is a global partnership launched in 2017 to develop vaccines to stop future epidemics. https://cepi.net/.

[3] The Innovative Health Initiative (IHI) is EU public-private partnership funding health research and innovation. https://www.ihi.europa.eu/.

- Increasingly, anticipatory technology assessment must address multiple policy domains and complex goals at different scales. The interlinkage of policy domains necessary to address problems like net zero, for instance, puts new demands on how technology-related policies need to be assessed. For instance, many African societies find it challenging to assess and nurture city-level innovation ecosystems, which is a precondition to solve interlinked problems of job creation, well-being and democratic belonging for youth.
- If anticipatory governance must ensure its accountability to society, participatory modes of technology can be useful. There are, however, significant challenges for making these approaches work, e.g. sometimes processes can fall short on inclusion and sometimes they fail to feed into decision-making.
- Not all regions are equivalent in foresight and anticipatory governance capacity. For example, at the moment, most research and development infrastructures in African societies are small and under-funded, as well as stuck with a national industrial outlook perspective.

A number of promising policy avenues and solutions can be found:

- *Co-imagining and re-imagining technological futures*. It is difficult to imagine the possible impacts, of new and emerging technologies, early on and thus the capacity for "imagining" and "re-imagining" must be supported. Emerging technologies open up entirely new worlds, potentially transforming industries and society. For, example, Re-imagine Europa's work on narratives and cognitive frames are addressing blockages on gene editing techniques and their contribution to agricultural strategy[4].
- *Scaling well*. Explore the variety of scaling strategies and identify how foresight and other forms of strategic intelligence can be integrated along the whole journey from small scale to large scale. As part of this recommendation, a focused effort on scaling foresight processes is proposed.
- *Connect with private sector capacities*. The role of the private sector in both innovation and scaling of new technology options cannot be overstated. If the transformative role of the private sector is to be harnessed and incorporated into technology policies, new forms of interaction between policy-driven and industrial foresight and strategic planning are essential.
- *Real time assessment capacity*. The complexity, rapidity and uncertainty of emerging technologies, raises a need not just for better horizon scanning, but for a more continuous and near real-time monitoring of technological developments. This could be achieved by technology and tech policy observatories, such as the OECD AI Observatory[5].
- *Experiment with the inclusion of citizens and other stakeholders*. Participatory forms of technology assessment have been around for some time. Given the urgency of sociotechnical change, it is time to experiment with forms of technology assessment

[4] Re-Imagine Europa (RIE) is a nonpartisan think-tank, founded by President Valéry Giscard d'Estaing as the first "incubator" for new political ideas, in honour of the friendship and partnership with Chancellor Helmut Schmidt and their efforts to define a future that goes beyond personal, national or partisan interests. https://reimagine-europa.eu/farms-forks-and-the-green-deal.

[5] The OECD AI Observatory provides data and multi-disciplinary analysis on artificial intelligence, and involves a diverse global community of partners in making this a platform for information sharing and dialogue on AI. https://oecd.ai/en/

that can improve on known challenges. A range of possible approaches can be a source of inspiration, for example, societal dialogues, policy co-design, living labs for testing new technologies.

- *Directioning*. Use "guiding principles" and informed processes of integrating normative considerations into the design and early development of new and emerging technologies. Further, in polarised debates like GM agriculture, it may require active processes to engage with widely divergent cognitive frames of stakeholder to try to re-imagine different pathways.

## 7. Anticipatory and agile governance options

Good governance and ethics will be necessary to harness technology for the common good. But technology governance faces a dilemma: governance of emerging technologies too early in the development process could be overly constraining, but governing too late can make technologies harder and more expensive to shape as they become institutionalised. In order to address this dilemma, new forms of governance must operate "upstream" and throughout the process of scientific discovery and innovation.

Upstream approaches aim to engage possible stakeholder concerns and values, address them through open and inclusive processes, and embed values of open societies – such as the protection of human rights, open and trusted markets, and diversity – in the development of new technologies. Further, as novel technologies can have unforeseen consequences, and adverse events or outcomes occur, the governance system must be adaptive in order to build resilience. Communities of technological practice have become more creative in the embedding of social values, not just safety but also ethical considerations, into the development of emerging technology using techniques like soft law, private governance, standards and ethics-by-design.

*The role of regulation*. Well-structured legislation is able to address novel questions. Not every technology requires new governance or new regulation, and ideally, if regulations are framed well, they will protect the main interests at stake. Nevertheless the fast pace of technological change and the movement between and across typical regulatory jurisdictions mean that traditional regulatory approaches may be ill-suited to govern emerging technology, at least at earlier stages of development.

*Soft law*. Soft law – commitments and obligations that are not directly enforceable by government – is an increasingly common tool of emerging technology governance. Types of soft law include professional guidelines, technical and normative standards, codes of conduct and good practices. Soft law offers more flexible interim solutions in emerging technologies, such as AI and block chain. However, more empirical analysis of soft law mechanisms and tools is required in order to better understand the factors that make it work – or not. There are major implementation gaps. Even so, a set of good practices offer a sort of toolbox for achieving adherence to soft law (see Box 2).

### Box 2. Mechanisms to improve adherence to soft law commitments

- Liability regimes with contractual force
- Collaborations between trusted non-profit groups and industry
- External ethics committees
- Independent auditing and monitoring
- Insurance companies might require compliance and performance
- Government off-ramps (if conditions of governance not satisfied, government regulator will step in.
- "Ethics by design" approaches: standards built into product engineering and specification.

*Source: Gary Marchant, Arizona State University, US.*

The OECD offers a number of Recommendations in the field of technology governance that represent international soft law[6]. These OECD Recommendations feature regular reporting requirements by Adherents to promote progress in their implementation as well as transparency. An exemplary case of implementation work concerns the Recommendation of the Council on Artificial Intelligence, under which the OECD convened multi-stakeholder group, developed a practical toolkit, created an "observatory" of existing policies to promote mutual learning, and helped give birth to an ongoing policy forum called the Global Partnership on AI.

*Industrial codes of practice*. At the industry level there are codes of practice dealing with new kinds of risks and benefits brought by new and emerging technologies. The biopharmaceutical industry is experiencing intense changes with a number of frontier technologies, e.g. AI, impacting the way it does research, commercialises products and collaborates with partners across the world. New ethical standards are currently being designed to include diverse stakeholders and to be transparent, featuring participatory approaches with patient organisations, health authorities, social scientists, philosophers and civil society.

*Self regulatory product standards*. Environmental NGOs are partnering with industry on the development of product standards for new food products driven by new and emerging technologies. Retailers can leverage their market power to influence how technology developers are considering unanticipated consequences throughout the supply chain -- from design, to sourcing, to disposal. Companies carry a form of accountability as they have duties to report back to their investors through their reports. They have the power to make sure these concerns are "baked in" as these new technologies, chemistry and innovations come on line. Recently, Environmental Defense Fund worked with the private sector to develop principles and standards for ensuring the environmental sustainability of cell-based

[6] Recommendation of the Council on Artificial Intelligence (AI), which establishes principles and mechanisms to promote trustworthy AI; Recommendation of the Council on Responsible Innovation in Neurotechnology, the first international instrument in the field laying out principles and mechanisms for responsible innovation in that field; Recommendation of the Council on Agile Regulatory Governance to Harness Innovation, laying out principles and approaches for regulation to promote innovation while safeguarding public well-being

meat and seafood. An important question is how to translate mechanisms and principles of co-design and upstream engagement into practice. Having multiple stakeholders involved is key for the quality and legitimacy of the standards.

*Ethics-by-design*. In what is called an "ethics-by-design" approach, some firms in the biopharmaceutical sector are looking at the ethical implications of new technologies at different stages of development of a technology, e.g. the idea, prototype, pilot, scale up. This ethics-by-design approach seeks to embed societal values -- whether that is privacy, ethics, diversity and inclusion -- through clear protocols. For example, in the AI field bias can lead to failures to diagnose certain diseases among certain populations if the systems are not trained on the right dataset, so it is critical to have the right protocol. Analytical tools can be used to assess privacy impacts, safety impacts, diversity, inclusion and human rights impacts.

*Codes of scientific and engineering practice*. Novel and specialised codes of practice in science and engineering may be necessary, especially where the potential risks and harms of a new technological area are anticipated but not well-known, or where, e.g., research could be weaponised. Registering experiments might be required by journals, thereby supporting the development of international registries and observatories. Such a system might be piloted with experiments on engineering the environment.

## 8. Strengthening international cooperation

Technology policy must cope with major turbulences in global relations, instability and possible reconfigurations of global and regional alliances. New and renewed concerns over dependence and sovereignty have arisen, e.g. access to key natural resources and reshoring industries threatens a more isolationist approach. "Technological sovereignty" has emerged as an important theme in STI policy.

Now more than ever, a commitment to global cooperation for promoting values-driven technology development will be key for addressing global challenges and sustaining national innovation. First, the transboundary nature of many governance issues necessitates coordinated approaches for, e.g. the privacy of data or internet governance. Second, cooperation is necessary to maintain the integrity of the international standards in the face of geopolitical shifts and tensions. Third, international cooperation is also required to generate the scale of resources necessary to meet global challenges and to provide global public goods – in particular a low-carbon atmosphere – which cannot be realised through individual country efforts. Finally, global cooperation is also important to reduce digital, energy and climate divides between OECD/G20 countries and the developing world.

# Annex A. Conference Proceedings

## *High-level roundtable: Realising inclusive technological transitions*

**Moderator**: **Ulrik Vestergaard Knudsen**, Deputy Secretary-General, OECD

**Speakers:**

- **Roberto Cingolani**, Minister for Ecological Transition, Italy
- **Yuko Harayama**, Executive Director, RIKEN, Japan
- **Manuel Heitor**, Minister for Science, Technology and Higher Education, Portugal
- **Lim Hyesook**, Minister of Science and ICT, Korea (by video)
- **Jason Kelly**, CEO Ginkgo Bioworks, United States
- **Esther Lynch**, Deputy General Secretary, European Confederation of Trade Unions
- **Jean-Eric Paquet**, Director-General, Research and Innovation (DG RTD), European Commission

### The central questions raised by the panel

Ulrik Knudsen, Deputy Secretary-General of the OECD, moderated the session and framed the issues in question. Briefly stated, the world needs rapid progress in many economic and social systems. This involves, among other things, transitioning to clean energy production, improving global health, coping with rapid population ageing, and increasing cost-efficient mobility, particularly in urban areas. An additional and overarching concern is the need to understand how to develop, use and adjust to new technologies, such that their impacts assist economically sustainable transitions without generating unsustainable social disruption.

### Analysis of the problem

#### *Putting technologies to work for an urgent transition*

Roberto Cingolani, Italy's Minister for Ecological Transition, highlighted the scale and urgency of global challenges. While a minor share of the global population, rich countries produce the major part of greenhouse gas emissions. Meanwhile, a billion people lack access to clean water.

The carbon transition will depend on context – there will not be one unified solution. Further, if we move too slowly, we will not hit the Paris targets. If we move too fast, there may be unprecedented social crisis. He stressed that clean energy is key in the next decade. Only 20% of global energy production is through electricity and only part of that is renewable. The world needs new energy sources, such as small modular nuclear reactors and nuclear fusion, along with smart grids, better batteries and carbon capture technology. Waste must become something useful.

The COVID pandemic has illustrated the central importance of science, technology and innovation (STI). The mRNA vaccines, for instance, have resulted from decades of basic research, as well as the major investments in R&D that began as the crisis took hold.

Jason Kelly, the CEO of Ginkgo Bioworks, gave a similar example from synthetic biology, a science that is learning how to programme cells to perform specific and useful functions. Making nitrogen fertilizer generates huge amounts of carbon dioxide. Synthetic biology could help by creating genetically modified microbes capable of fixing nitrogen and lowering demand for fertilizer. Among innumerable other uses, synthetic biology will modify bacteria to produce inputs to vaccines.

### *The need for anticipatory technology governance*

Yuko Harayama, Executive Director of REIKEN, Japan, commented on how technology shapes society and vice versa in interactive ways. Nevertheless, at the present moment society is experiencing an accelerated pace of technological change. As technologies such as AI, gene editing, and neurotechnology illustrate, technological disruption is happening beyond absorptive capacity. An important challenge, raised by various panellists, is how to anticipate the scope and implications of technological change. Technologies rarely emerge from scratch, with the implication that prospective technical developments can be understood to some degree. However, it is often difficult to forecast the social reactions to a technology.

Chris Philp, UK Minister of Technology and the Digital Economy, underlined the central role of technology governance in the challenges ahead. As digital and emerging technologies underpin evermore aspects of our lives, and promise to disrupt them, how we choose to govern them will have huge implications for our prosperity, safety and society: "responsible governance" can help deliver the benefits and managing the risks and disruptions of deep technological change. More anticipatory governance is needed and must always include taking a multi-stakeholder approach.

Lim Hyesook, Korea's Minister of Science and ICT, emphasised key elements of the "Fifth Version of the Science Technology Basic Plan of Korea for years 2023-2027". The draft plan highlights the role of anticipatory governance in addressing national and social issues: the complexity and uncertainty inherent in technology and society makes it crucial to pre-emptively respond to risks.

### *Building an inclusive science and technology policy*

In the Fifth Version of the Korean Basic Plan, an "inclusive society" features as one of four key pillars. The participation of stakeholders will be welcomed, as will be experts from diverse disciplines and citizens so that they can express their views and participate in policymaking.

Manuel Heitor, Portugal's Minister for Science, Technology and Higher Education, together with other panellists, argued that a key issue is to guarantee citizens' participation in developing policies for STI. Because more investment in knowledge and institutional innovation is necessary, committing the necessary public resources requires public understanding of why these investments matter.

Panellists judged that, in this context, weakening trust in science in some parts of the population is concerning. Extensive dialogue with citizens and society is essential. Such dialogue could also help societies navigate a problem related to the timing of transitions, namely that if solutions are too slow, a looming problem might become an actual crisis, for instance with respect to climate change, but transitioning too fast could also create social stresses.

### *The need to address values*

As promotors of science and technology, policymakers should not only address scientific and technological challenges, and respond to practical social needs; they should also work on the social values on which our future will be built with an enlarged scientific and technological community, as well as include ordinary citizens. We have a collective responsibility to do so (Harayama).

With the ascendance of geopolitical discourse within the area of STI, the adoption of this approach becomes crucial. No doubt that within this context sustainability remains one of the foundational values. Here we as promotors of science and technology need to build a sense of community by being inclusive and open to a diversity of ideas and voices and staying humble.

### *The concerns of workers*

Esther Lynch, Deputy General Secretary of the European Confederation of Trade Unions, raised another aspect of engagement, which is equally relevant to technology governance and inclusive economic development: the possibility that artificial intelligence (AI) could lead to intrusive workplace monitoring. She drew attention to gaps in the emerging conceptual framework on AI governance. In particular, she held that the notion of individual consent is insufficient in this context because of power imbalances: workers, sometimes desperate for a job, often cannot negotiate terms and conditions in interviews, including conditions of AI use. A dystopian situation might even arise in which AI is used to gauge workers' emotional states, the technical capability for which is developing rapidly. Collective consent is needed for the use of technology in workplaces. A further suggestion raised by Esther Lynch is that patents should not protect machines that control humans in inappropriate ways.

## Takeaways and ways forward

### *Governments must be more ambitious and act with greater urgency*

Jean-Eric Paquet, Director-General of the European Commission's Directorate for Research and Innovation, argued that existing clean technologies such as solar and wind will not be enough to meet low-carbon objectives, nor to meet demand for energy in the developing world. More investment in STI is necessary to accelerate mobility, waste management and social innovation (including with respect to lifestyle choices).

Examples of ambitious policy goals also cited by the panellists included: free access to science education, with more opportunities for second- and third-chance learning for middle-age and older workers; reversing stagnant levels of public R&D spending; creating 'world laboratories' for long-term challenges; and, setting plans for paradigm-changing research breakthroughs, such as developing a digital twin of the human body and advancing fusion technology. In a similarly ambitious vein, among other mission-based innovation programmes it is advancing, the European Commission is in the process of identifying 100 cities that could benefit from collective knowledge on climate-related transformation in urban areas. This mission is creating platforms to discuss solutions city by city, setting key objectives, providing investment resources and support for implementation processes, all with an aim to achieve carbon neutrality in 10 years.

### *Multidisciplinary and all-of-government responses*

The challenges faced require multidisciplinary and all-of-government responses in fields as diverse as education, public policies on research, digital connectivity, and even space

and the oceans. Lessons must be learned and acted on, drawing on prior experiences of far-reaching initiatives for mission-oriented innovation. Finding efficient ways to steer STI is critical, especially because all governments are under severe budgetary pressures, exacerbated by COVID and population ageing. Unfortunately, not many governments are connecting research outcomes with policy goals.

As one example of an all-of-government approach, Manuel Heitor pointed to the need for new satellite observation and space systems to help improve mapping of carbon stocks and land management. Many sub-regional authorities need access to space systems in order to operate carbon markets. At the same time, a new regulatory and institutional landscape is needed to break up some existing monopolies in the space sector. The process of developing systematic, whole of government approaches in policy making must also include business and civil society.

### *Rapid deployment of technologies coming from scientific discovery*

There needs to be an emphasis on rapid deployment of technologies coming from scientific discovery. Jean-Eric Paquet drew attention to the European Commission's large-scale partnerships with government and industry aimed at accelerating technology deployment. More generally, co-creation approaches are needed, engaging research actors and the businesses that can commercialise useful research outputs.

### *Build anticipatory capacity and a future orientation*

Governments must build anticipatory capacity and a future orientation. Countries would benefit from greater future-orientation in policymaking, perhaps even having Ministerial portfolios dedicated to the future, to improve technology forecasting and governance. Having longer time horizons in policy development also requires innovation in governance, so as to escape the short-termism inherent in election cycles.

### *Citizen engagement*

In marshalling STI to address global challenges, citizen engagement is indispensable. Public engagement matters because significant technological transitions often bring some measure of social dislocation. In this connection, it will be important to engage with workers and other stakeholders and publics, to help foresee technological changes and to develop policies to achieve collective goals and mitigate possible hardships. Citizens needs to comprehend why these commitments and changes are happening. Without effective transparency, engagement and understanding, governments will not obtain the political support needed to advance ambitious STI agendas.

### *International cooperation*

More international cooperation is needed. Global cooperation for promoting values-driven technology development was identified as key to addressing global challenges and sustaining national innovation. International co-operation is also required to generate the scale of resources necessary to meet global challenges and to provide global public goods – in particular a low-carbon atmosphere – which cannot be realised through individual country efforts. Global cooperation is also important to reduce digital, energy and climate divides between OECD/G20 countries and the developing world.

### *Roles of the OECD*

The panellists highlighted valuable roles that the OECD can exercise on behalf of OECD member and non-member countries. For example, the OECD can:

- Act as a convener, bringing together leading thinkers, and actors from business and civil society, and linking their ideas to policy.
- Help identify and encourage win-win opportunities for international cooperation.
- Help countries extend foresight horizons from 10 to 50 and more years, and to develop visions of how technologies could be mobilised to meet long-term global challenges
- Through its joint engagement with the private and public sectors, help to identify opportunities for public-private partnerships, such as those that have been eminent in the race for COVID vaccines (and where the OECD has studied multiple examples of what works and what doesn't).
- Produce policy-relevant analytic work, drawing on unique access to data and cross-country experience, on such topics as:
    - Connecting research outcomes with policy goals.
    - Improving trust in science and mechanisms for greater citizen engagement in STI.
    - Setting STI priorities in systematic and inclusive ways.
    - Improving understanding of governance-related topics, such as the (albeit still limited) experience of collective bargaining on the use of technology in the workplace, and corporate/employer accountability in how technology is deployed.
    - Understanding what works in anticipatory governance.
    - Understanding how best to effect directionality and inclusiveness in research and innovation systems.
    - Understanding policies to facilitate co-creation of innovations.

# *Keynote by Sheila Jasanoff – "Science and Emerging Technology for Inclusive Transition: New Directions"*

**Moderator**: **Alessandra Colecchia**, Head of Division, Science and Technology Policy (STP) Division, Directorate for Science, Technology and Innovation (DSTI), OECD OECD

**Keynote Speaker:**

- **Sheila Jasanoff**, Pforzheimer Professor of Science and Technology Studies, Harvard University, United States

## Introduction: Scientific progress in an unequal world

Science progresses in an unequal world. On the one hand we have the miracles of science rolling new vaccines in record time. All over news one hears about scientists building on prior discoveries, and the remarkable efficacy in providing remarkable levels of protection. On the other hand, we have persistent worries about equity and the inadequate supply of vaccines for all. This juxtaposition makes the subject of this meeting so important: it poses the challenge for OECD and for all international organisations looking at the frontiers of technological development.

## The received models of innovation, technological change and progress

In order to identify where problems of inclusion might present themselves, we have to consider our traditional models of how and why innovation occurs. The so-called linear model – the concept that innovation works in a straight line from basic research, to applied research and development through to commercialisation and diffusion – is the most basic model of how research gets into innovation and eventually gets out into societies. Any student of science and technology knows that this model is a vast oversimplification, and yet this policy model lodges in some of the highest establishments of science and technology policy. The model was embedded in the core bargain set out in social contract for science and technology in the United States after World War II, which assumed that more science meant more innovation, that governments had a duty to foster science and technology (S&T), that S&T are basically self-regulating institutions and should be left to formulate their own agendas, and that imperfections in the ideal contract could be corrected by markets, regulation, and/or ethics.

### *Smaller, faster, cheaper?*

All of this implies a certain relationship between technology and progress, where operate certain articles of faith. There is the strong belief that technology progresses and improves lives; that it is driven mainly by science, ingenuity and material resources, i.e., that it is "asocial"; that technology shapes society and drives history ("technological determinism"); and that while beneficial consequences are intended, negative impacts on society are unintended ones. Some of our most consequential innovations seem to bear out this idea. Digital and information technologies that have transformed all of our lives; and this has come about by inventions that made communication smaller, faster, and cheaper; that is the model of technological progress.

## A different model: Mode-2 science and technology

Certain European scholars have pointed out that STI now conforms to a different model, sufficiently different that we should refer to it as Mode-2. In this, we recognise that:

- It is not pure science that leads to diffusion and innovation. Knowledge is increasingly produced in contexts of application. All science to some extent is applied science;
- Science is increasingly transdisciplinary. Draws on and integrates elements from many fields;
- Knowledge is generated in a wide variety of sites: i.e. not only universities and industry, but also research centres, consultancies, think-tanks and business;
- Scientists are motivated by the societal implications of their work, and are not simply curiosity driven;
- Publics are aware of how science and technology affect their interests and values and lives;
- Science as a political resource: science has become far more political than what used to be.

So if Mode 2 is the real way that science happens, how does technology progress? If progress does not happen by the linear model, how does it operate?

Luckily there are a number of other frameworks coming out of the sociology of science and technology: The Social Construction of Technological systems (SCOT) emphasises how social needs and user demands drive technology. Actor-network theory identifies technology as a heterogeneous network of social, material and abstract elements, implying that change can happen at any node (e.g. in materials, economy, lay or user groups, society). And finally, that technologies have "politics", i.e. political values can be baked into technology. All of these frameworks generate different accounts of the origins and primary actors in technological development, as well as a theory of change.

## What's missing from all typical accounts?

While these accounts in some ways are necessary correctives for the linear model, they are still missing important elements of context. In particular, three critical dimensions will help in identifying new directions for inclusivity in science and technology policy. First, what about large historical shifts in the background against which innovation happens and technology emerges? These would include things like structural changes (decolonisation, globalisation), ideologies and shocks and surprises. Second, they miss the salience of conflicts and controversies in the setting the pathways of technological change. The Fukushima disaster has exerted forces on the development of nuclear energy, just as masking controversies have affected how Covid has played out medically and socially. Controversies over CRISPR babies and designed reproduction as well as geoengineering are shaping those fields. Finally, the issue of responsibility, one where the OECD is currently making inroads in this new programme of work: who wins and who loses? Who is harmed and who is responsible? Where is the recourse? Does it matter and to whom?

## Opportunity spaces for technology policy

"Co-production" theories offer another promising approach. The idea of co-production in Science and Technology Studies is not simply about multi-actor production of science and

technology. Rather, it attempts to sweep in more of this contextual side of innovation in a descriptive as well as prescriptive theory. Built on an examination of processes of emergence, S&T controversy, standardisation and cultures of knowledge-making, this approach underscores that

> *"We can bring entire worlds, more inclusive worlds… into being through our innovation policies."*

Coproduction as model of technological change presents opportunities for meaningful social and political engagement, whether it is in making new knowledge, building groups, shaping the languages we use, or intervening in institutions. Technology policy then should be something normative, a space worth fighting for; tractable, as a space of calculation and measurement; and accountable, a space of representation and voice, and of calling into question. Technology policy should be something collective, a space for community building; and the very idea of inclusion is of course very much connected with the kinds of communities we expect to serve through our technological developments.

### *Globalising inclusion?*

Vaccine innovation has proceeded incredibly rapidly with respect to corona virus vaccines, but here is a sobering assessment: vaccine science would not have produced such fast results without the funding. There is a huge difference between Ebola and Covid-19, because Ebola was located and stayed contained within a relatively poor part of the world. If we're talking about globalizing inclusion, there are clearly a set of different challenges ahead. Into this mix we can place the OECD. And still, the phrase you often hear in relation to OECD is "a club of mostly rich countries". What could inclusivity mean there? It is a very particular geographic space that OECD sets out to include benefits of innovation.

### *A new imaginary of harmonization:*

We have to take the idea of harmonization and think of it laid against this re-theorisation of technology and innovation.

- We recognise that technological innovation does not follow a singular trajectory, but it gives us a choice of competing futures;
- Nation states can be thought of as political experiment stations, and they have different styles;
- The new directions have to begin with a set of questions that transform the older questions of science and technology policy, e.g.:
    - Not what is the expert consensus, but what are the assumptions underlying the consensus?
    - Not how good is the knowledge, but what knowledge was in/excluded?
    - Not how knowledgeable are the publics, but whose questions were left in/out?
    - Not what are the costs/benefits, but who loses and who wins?
    - Not what is the right standard, but in what context will the standard be fitting? Who will be served by those standards?

Any new way forward for an international organisation, that is poised to make a difference in science and technology policy, has to take those kinds of questions and rethink them in the context of the world as we know it, especially in, we hope, the tail end of this pandemic.

### *Question and answers*

Q. How can we engage younger generations in the political processes you describe?

- In some ways, the younger generations are involving themselves already. I don't think we've seen so many youth movements for decades. Of course Greta Thunberg's face is known the world over.
- The question in part is to be more reflective about the work that more technical bodies are doing.
    - The great swathe of technology policy remains to be in large part hidden; we don't teach those in engineering schools about the context of innovation. The people that we train in STEM fields are those coming to do science policy. There is a gap in perception between the younger generation.
    - What is needed is a constant refertilisation of the entirety of the eco-system with the energies that we already see.
- The North-South differences, the economic area differences remain more fundamental to the problem of inclusion and exclusion. This is true inside and outside of countries.
- Experiments we need to look at are those that are perhaps not so visible, for example, efforts that are happening inside cities rather than at level of nation states to engage people.
- To get public engagement one has to go to the public, and where the public is willing to listen, and not just assume that if you open the door, it will be a party to which the public will come.

# *Panel 1: Building inclusivity upstream: engaging diverse actors in the development of new technologies*

**Moderator**: Angela Simone, International Initiatives Scientific Coordinator, Bassetti Foundation, Italy

**Speakers:**

- **Richard Johnson**, Chairman of the BIAC Technology & Innovation Committee, OECD, Director, iGEM, United States
- **Anil Prakash Joshi**, Founder, Himalayan Environmental Studies and Conservation Organization (HESCO), India
- **Shobita Parthasarathy**, Professor of Public Policy and Director of the Science, Technology, and Public Policy Program, University of Michigan, United States
- **Flurina Schneider**, Scientific Director ISOE (Institute for Social-Ecological Research), Professor, Goethe University Frankfurt, Germany
- **Henriette Van Eijl**, Head of Unit of "Economic and social transitions", European Commission

## Central questions of the panel

Inclusivity in science and technology is an important design principle for innovating well. Inclusivity is often framed in terms of access to knowledge and equitable enjoyment of technological benefits. This panel, however, framed inclusivity in terms of access to the processes of technology development, where enriching diversity of participants is linked to the creation of more socially relevant science and technology.

- What are tools and mechanisms for involving more diverse actors "upstream" in the development of emerging technology?
- How can involving new actors – such as knowledge-producers, entrepreneurs, co-creators, co-owners, and research participants etc. -- present pathways towards more just and inclusive transitions?

## Analysis of the problem

### *A narrow definition of innovation*

Shobita Parthasarathy, Professor of Public Policy and Director of the Science, Technology, and Public Policy Program at the University of Michigan, emphasised that we define innovation too narrowly and that may impact our ability to make transformative change. Innovation is often perceived as primarily market-driven, commodifiable and separate from social context. This tends to exclude social innovation and draws attention away from the how technology actually engages users and communities.

### *Innovation is disconnected from users and local needs*

The rural context is a particular blind spot for innovation theory and practice. Anil Prakash Joshi, founder of the Himalayan Environmental Studies and Conversation Organization (HESCO), works on developing sustainable technologies for rural mountain regions in

India. There are few mechanisms where technology experts can gain an understanding of the characteristics and needs of rural communities where new technologies could contribute greatly to development. This mechanism is missing throughout the pipeline, with communities unable to provide feedback even after they had a chance to experiment. Such lack of consultation, combined with producers' often poor understandings of demographics, social structure and skill levels often renders technologies irrelevant for rural communities. While lack of public participation has disproportionate impacts for rural and disadvantaged communities, the issue is broader: publics are generally assigned a passive role in the innovation process, i.e. as end-of-pipe consumers.

### Box 3. Five Types of Exclusion

1. **Exclusion from the benefits of innovation or exacerbation of inequality**. This inequality is especially stark with respect to the developing world, as well as poorer rural areas.
2. **Exclusion from STI policymaking.** Inclusivity and diversity in deciding which research and development choices should be made.
3. **Exclusion in the making of science and technology**. Lack of diversity in the STI workforce including gender, ethnicity and age. Exclusion of affected groups, including users and those in need.
4. **Exclusion from definitions of expertise**. Transdisciplinary expertise is often required in complicated contexts. Experiential expertise gets less recognition.
5. **Exclusion from the power to govern technology**. Who has the ability to shape technology deployment and diffusion?

### *Need for more inclusive knowledge production*

Narrow disciplinary approaches to understanding complex problems miss key facets of the issue and are not well prepared to engage the normative deliberations that are endemic to these situations. Innovation does not occur in a vacuum, and experts often need to make a number of value-based judgements throughout the research and development process. Flurina Schneider, Scientific Director of ISOE and Professor in Social Ecology and Transdisciplinarity at Goethe University, works on transdisciplinary research and science policy for sustainability. As an example, she highlighted the complexity of cases in sustainable use and governance of natural resources. When conducting research on sustainable land management in Myanmar, Laos and Madagascar, her team looked at cases where access to land was contested, with a number of competing interests. While NGOs and environmental agencies may want to establish a conservation area to protect biodiversity, locals may need to use the land for agriculture and to earn a living.

With mainstream processes being primarily disciplinary, there is a risk of excluding expertise that is required for the successful implementation of projects. Additionally, issues around social, political and ethical impacts raise questions around the legitimacy of experts to carry out normative judgements.

> *"In democratic societies, these normative questions cannot be decided by science, they must be based on societal deliberations." (Flurina Schneider)*

### *Challenges for meaningful public participation*

The need for participatory processes was echoed throughout the panel, both to help build technologies that are relevant for communities, and as a tool to address complex and normative issues surrounding development. Nevertheless, a number of challenges remain in their mainstream implementation.

Shobita Parthasarathy highlighted the ways in which power imbalances are prevalent in current public engagement. First, publics and stakeholders have limited influence over the conversation, with technical experts setting the terms of the discussion. Second, processes do not recognise that the stakes for experts and communities are different, with traditional decision makers having more to gain while marginalised communities may carry the risks.

## Solutions and policy interventions

### *Inclusion of equity and inclusivity considerations*

In order to prevent disproportionate impacts on marginalised groups, technology development and assessment processes need to incorporate elements of inclusion and equity from the beginning. This includes adding impacts on marginalised communities into the risk/benefit analysis.

### *Participatory models for technology development & co-creation*

Overall, panellists agreed on the need to include a variety of stakeholders across the innovation pipeline at a systemic level, and that public participation should be done via meaningful, quality engagement and not just via "inclusion for the sake of inclusion".

Greater emphasis on public engagement can help align emerging technologies with societal needs and add an element of democratic legitimacy to innovation (OECD, 2018[1]). In addition, providing citizens with a platform to express their concerns can also foster a trusted relationship between publics and experts, thereby creating a society that is more open to the adoption of new technologies.

In the traditional innovation process, publics normally "participate" at the end, via their role as consumers. Notwithstanding, Flurina Schneider's research found that stakeholder participation is often needed from the very beginning of a project, with the exact type and timing of the collaboration varying on a case by case basis. Occasionally, communities may at first be reluctant to participate, but will engage the process after some time passes.

### Box 4. Case Study: International Genetically Engineered Machine (iGEM) Foundation

In addition to the need to feature diverse kinds of expertise in STI problem solving, there is also a general need to train scientists, engineers and other technical experts on ideas and methods of inclusiveness. The iGEM Foundation, introduced by Richard Johnson, Director of the foundation, as an example of finding innovative ways to do that. iGEM is "an independent, non-profit organisation dedicated to the advancement of synthetic biology, education and competition, and the development of an open community and collaboration."

A key part of the programme is a global student competition, where students work together to address local problems with synthetic biology. The iGEM mantra "Local people solving local problems, using synthetic biology" resonates with a number of the principles outlined by other panellists. Technologies are developed with specific societal goals in mind and teams work with local communities to assess their needs. Furthermore, societal and ethical considerations constitute key criteria in the judging of the competition.

The Foundation is also an example on how new actors can be involved in innovative ways that will could support more inclusive transitions. With over 60,000 alumni, iGEM is an example of how young people can mobilise and contribute to inclusive transitions outside of traditional processes (Johnson).

### *Broadening definitions of expertise*

Narrow definitions of expertise can leave out valuable perspectives. Flurina Schneider emphasised that her team usually involves diverse forms of expertise, from natural scientists to social scientists, with the inclusion of various stakeholders or societal actors that have experience in the local area. There are two key lessons to be drawn from this and related findings from the panel:

1. *Include expertise beyond its academic forms and recognise "experiential expertise" across a variety of stakeholders.* For example, Anil Prakash Joshi highlighted the importance of experiential wisdom that communities can bring to the innovation process. Creating a platform that connects users and tech developers would allow communities to provide information on their needs and circumstances.
2. *Add transdisciplinarity*[7] *to research and community engagement practices.* In particular, Shobita Parthasarathy emphasised the valuable contribution that social scientists and humanists could make:
    a. they could contribute key dimensions to the assessment of social and political implications, and help identify required accompanying social change.
    b. they could help facilitate public engagement, as they often already have a longstanding relationship with communities and have methodologies that can facilitate the engagement process.

### *Participatory agenda-setting & Mission-oriented innovation policies*

The COVID-19 pandemic has put science, technology and innovation at the forefront, highlighting the key role of STI in resolving global challenges. Governments have already

[7] Transdisciplinarity has been defined by the OECD as "the integration of academic researchers from different disciplines with non-academic participants in co-creating new knowledge and theory to achieve a common goal" (OECD, 2020).

started experimenting with "mission-oriented innovation policies" prior to the pandemic, as a way to mobilise STI to address clearly articulated social objectives. When combined with participatory-agenda setting, governments can better align their innovation strategies and social priorities.

Participatory agenda-setting provides a platform for publics to communicate their priorities and incorporates those into the decision-making from the outset. As a tool, it inherently promotes inclusivity by shifting citizens into a central role.

### *Transformation of STI policy and funding systems*

STI institutions can be a powerful lever to promote inclusivity and upstream engagement. For instance, systematic changes in the funding structure could incentivize the uptake of inclusive practices such as co-creation and participatory-agenda setting.

#### Box 5. Horizon Europe 2020

The European Commission has a long history of policies devoted to the diffusion of upstream engagement, and has shown previously re-organised its funding system to support challenge-oriented work. Horizon Europe, the EU's key funding programme for research and innovation is organised along the sustainable development goals and aims to tackle climate change. According to Henriette Van Eijl, Head of the 'Economic and Social Transitions' in the European Commission's Directorate-General for Research and Innovation, co-creation and co-design were part of the funding programme from the very beginning. While creating a more resilient, inclusive and democratic society is part of Horizon's Europe strategic principles, special attention is dedicated to gender equality as a cross-cutting principle.

The EU-funded TRANSFORM projects aims to integrate citizen's voices, values and needs in strategic policy-making and is putting Responsible Research and Innovation principles into practice. The project engages Lombardy (Italy), Brussels-Capital (Belgium) and Catalonia (Spain) in local participatory decision-making to design, test and disseminate co-creation methodological frameworks.

### *Capacity building*

As noted by Angela Simone, Scientific Coordinator of the International Initiatives at Bassetti Foundation, implementing meaningful public participation requires capacity building and training. Not only are researchers and innovators often not incentivised by the funding structure to build inclusivity, but even when they are committed to do so, they may lack appropriate training or knowledge.

# *Conversation with Tarun Chhabra: Values-Driven Development of Emerging Technologies in an International Context*

**Interviewer**:

- **James Wilsdon**, University of Sheffield, United Kingdom

**Speaker:**

- **Tarun Chhabra**, Senior Director for Technology and National Security, United States

## The central questions raised by the panel

Drawing on recent experience in the United States, the question this interview addressed centred on the role that government policies can play in ensuring that emerging technologies enhance national and economic security, address societal challenges such as climate and global health, and preserve and advance democratic values.

## Values-based technological development

Emerging technologies such as Artificial Intelligence, quantum computing, advanced microelectronics and biotechnology are critical to innovation and competiveness of modern economies. These technologies have helped accelerate productivity and helped countries reap the economic benefits of globalisation. At the same time, these technologies have been used by autocratic regimes to stifle individual liberties and human rights for example through the mass surveillance of telecommunications or conducting compulsory genomic testing. Furthermore, the globalisation of the production of these technologies has also revealed supply-chain vulnerabilities that expose democratic countries to disruptions or imports of products from regions and countries that practice worker and human rights abuses.

A key question for the United States and other OECD countries is whether policy can help technologies deliver on citizen needs and address societal challenges. The answer to this question depends on the governance of these technologies and the extent to which democratic values are embedded in technology policy. The current US administration is taking several actions to ensure emerging technologies can deliver on citizen needs and protect democratic values. These include:

- Technology assessment to determine the upside and downside risks of technologies and appropriate policy and regulatory options;
- Boosting investment in R&D critical technologies such as AI, biotechnology, quantum computing and next generation telecommunications;
- Increasing manufacturing capacity in semiconductors (i.e. Chips Bill) and advanced microelectronics in order to reduce supply chain vulnerabilities;
- Reform of Commerce Department regulations on technology export controls;
- Reform of data regulations to preserve privacy of personal data in cross-border data flows;

- Setting international norms and standards through multilateral organisations such as the OECD.

## Governance gaps in the framework for values-based technology development

There are three main gaps in the framework for values-based technology. These are:

- *Ethical and responsible use of technology*. Technology must not just be directed to societal needs but it should be developed and used ethically and responsibly. It is therefore important to have norms and standards for both the bottom up research that drives discovery and for the application and use of technologies in society. Governments must be mindful of the threats to human rights from the misuse or biased applications of emerging technologies. This requires technology assessment that is risk-based and involves stakeholders. It also requires remaining vigilant regarding the export of critical technologies to prevent misuse. The US is planning to launch an export control and human rights initiative to develop a regulatory framework that includes dialogue with companies and industry groups to align positions on technology export control.
- *Equity gaps*. Technology can be a tool to enhance equity in society but it can perpetuate equity gaps in access resulting from differences in education, socioeconomic status, gender, geography, ethnicity and racial identification, or physical and mental handicaps. The White House Office of Science and Technology Policy has announced a plan to develop an "AI bill of rights" to protect against potentially harmful anticipated and unanticipated risks such as bias, surveillance and privacy infringement.
- *Unfettered access to sensitive data.* Unfettered access to sensitive data by certain actors poses a threat to democratic values-based technology. The Biden Administration has issued an executive order to protect national data on an evidence-based approach to evaluate threats to data security. Co-operation among countries is also important to facilitate cross-border data flows across like-minded countries. In this respect national guidelines on ownership, control and management of data can strengthen data security.

## Role of multilateral organisations in advancing democratic values

As regards the role of international organisations, both panellists highlighted the important role the OECD is playing in the discussion on values-based technology, notably through its convening power to bring different actors together. The OECD is also a values-based organisation comprised of countries sharing democracy as a form of government and a market-based economy grounded in the rule of law. The data provided by OECD helps Member countries scan the horizon for science and technology and anticipate new policy challenges and needs. Finally, the OECD can reinforce international norms and standards such as the *OECD Recommendations on AI* and on *Responsible Innovation in Neurotechnology* to advance value-based technologies among like-minded Members and Partners.

## Areas for deepening international co-operation for values based technology policy.

The United States has identified several priority areas for strengthening international co-operation on values-based technology development such as:

- *Climate technologies*. Against a background of meeting national Net-zero goals and reducing reliance on imports of clean energy technologies made in regions using forced labour, the US Department of Energy (DOE) has launched several "Earth Shots": mission-oriented innovation programmes to accelerate science and technology for green hydrogen and energy storage technologies;
- *Advanced microelectronics*. The US Commerce Department plans to scale up research and manufacturing capacity in semiconductors and this will require international co-operation with global firms and governments on standards and regulations;
- *Commercialisation of new technologies*. Alongside increases in funding at DOE and the National Science Foundation for research and new technologies, new initiatives and good practices for commercialisation will be required;
- *Technology protection*. It is important that national technology export controls be co-ordinated with allies and like-minded countries to ensure their effectiveness given the complexity and interdependence inherent to global value chains;
- *Data protection*. On the data front, efforts to create a new regime for the protection of sensitive and personal data such as health data also require international co-ordination and co-operation;
- *Technology standards*. Co-operation is necessary to maintain the integrity of international standards in the face of geopolitical shifts and tensions.

# *Introduction to Day 2: Emerging technologies for critical missions*

**Speakers:**

- **Douglas Robinson**, CNRS / Senior Associate Researcher, Innovation Analysis and Policy Intelligence, France

Present calls for "goal oriented" and transformative innovation display a new level of urgency to better connect emerging technologies to specific challenges and goals like the SDGs (Borrás and Edler, 2020[2]). Missions have been touted as one approach to tackle such complex societal grand challenges (Mazzucato, 2018[2], OECD, 2021[3]).

Missions have been around for a long time, the often-mentioned Apollo lunar missions and the Manhattan project are given as examples of early mission-oriented policies. New missions, what Robinson and Mazzucato (2019[4]) have labelled as Type-2 missions, are an ongoing experiment in mobilising innovation ecosystems and innovation governance actors to work in concert to achieve ambitious goals. Differing from Type-1 missions, where a large and powerful central actor directed collective action towards the mission goal, Type-2 missions are undertaken in a distributed ecosystem of innovators and governance actors, requiring the capacity to handle complex coordination, facilitate inclusivity of many stakeholders and agility (to manage and change strategic direction in real-time).

New and emerging technologies promise to contribute solutions to many of the Sustainable Development Goals, but how do we marry the open-endedness of technological innovation with the fixed goal of mission-oriented, and other goal-driven, policies? How can policies and practices by government and other stakeholders help ensure that the development of novel technologies addresses the most important problems? What kinds of tools and policies are needed to help ensure that emerging technologies contribute to the overall advancement towards "mission success" and how to do this in an ethical and just way?

In this section, three technology-focused, and goal-driven, panels were be presented. Each was challenged to explore specific challenges and opportunities for technological innovation with regards to societal goals.

# *Panel 2a: Harnessing Neurotechnology for Brain Health*

**Moderator**: **Siobhán O'Sullivan**, Royal College of Surgeons Ireland, Ireland

**Speakers:**

- **Hervé Chneiweiss**, CNRS / director of the Neuroscience Paris-Seine laboratory at the Sorbonne University, France
- **Tarun Dua**, Head of Brain Health Unit, Department of Mental Health and Substance Use, World Health Organisation (WHO)
- **Philipp Kellmeyer**, Head of Neuroethics & AI Ethics Lab, Department of Neurosurgery, Epilepsy Center, University of Freiburg, Germany
- **Diana Saville**, Co-Founder and Chief Creative Officer, BrainMind, United States
- **Gabriel Villafuerte**, Chief Science Officer Actipulse, Mexico

## The central questions raised by the panel

Hundreds of millions of people live with disorders of the brain and neural systems and diseases of the nervous system. Indeed, neurological diseases and mental illnesses – from Alzheimer's to multiple sclerosis to stroke -- account for a third of our healthcare expenditure. Advances in neurotechnology have the potential to enhance the treatment of brain disorders and build human capabilities, opening new pathways to diagnose and treat brain disorders and improve health and well-being. However, there are ethical, legal and social challenges associated with the advance of neurotechnology related to privacy, human enhancement, autonomy, and equity. Some of these issues come from outside the medical field. Governance approaches have already been advanced to address ethical, legal and social issues, e.g. in 2019 the OECD Council adopted the *Recommendation on Responsible Innovation in Neurotechnology* to help guide the development of these technologies. Approaches for responsible innovation are needed in the field.

- What kinds of tools and policies are needed to help ensure that emerging neurotechnology advances the mission of promoting brain health in an ethical fashion? How can we help ensure responsible innovation in this field?

## Analysis of the problem

### *Framing the problem*

Panellists framed the core problem in different ways. Billions of dollars are being allocated for applications like the transcription of thought on the computer screen or memory enhancement. Would such applications fulfil societal goals? How societies balance the concerns of individuals and those of collectives are fundamental to what kind of societies we wish to live in (Chneiweiss). Significant discussion focused on the need for clear goals for neurotechnology development, and what those guiding goals might be. Others stressed a ground-up rather than goal-oriented approach, stressing the role of science, entrepreneurship, a strong investment environment and ethics to nurture promising technologies.

### *Global health access*

Proponents of goal-driven innovation emphasised the importance of global health needs as a guiding star. As noted by Tarun Dua, Head of Brain Health Unit at the Department of Mental Health and Substance Use, World Health Organisation (WHO), at the WHO, this is consistent with the Global Action Plan on Epilepsy and other Neurological disorders, which is anticipated in 2022.

Neurotechnology firms should be aligned with the goals of access, a point made by Gabriel Villafuerte, Chief Science Officer of Actipulse, a neurotech start-up: psychiatric and neurological disorders are not just of interest to companies, but mark global well-being problems, and should therefore attract public-private partnerships. A number of panellists stressed the importance of equitable access to existing and future neurotechnologies, particularly in the developing world. Although cost of the treatment may seem the most important issue affecting to neurotechnologies, access is in fact a multifactorial problem that includes lack of education, technological disparities, and regulatory issues.

### *Translation of neurosciences and the acceleration of innovation*

Some panellists framed the problem as one of accelerating innovation, especially the translation of the neurosciences into markets in part by encouraging more risk-taking and attracting best-in-class talent.

### *Holistic solutions rather than technological reductionism*

Philipp Kellmeyer, Head of Neuroethics & AI Ethics Lab, University of Freiburg, Germany stressed the importance of looking at the social determinants of brain health rather rushing to the idea of technological solutions. Finding effective therapies for individuals and groups requires a more holistic understanding of mental illness, and one that is sensitive to scale – individual, groups, national, global – for understanding the impact of different disease factors whether environmental or biological.

## ***Governance problems***

### *Commodification of brain data*

"Brain data" has become a sought-after commodity within and beyond the medical sector. The market for neurotechnology is expanding into other areas such as digital phenotyping, affective computing, video games or neuro-gaming and commercial promotion or neuro-marketing. Education is also a targeted field. This increasing extra-medical availability of brain data poses a challenge for ethics and human rights, and obviously requires governance. Risks include identification of individuals and intrusion into their most intimate privacy, hacking of data and/or unauthorized reuse, exploitation of sensitive data, breach of confidentiality, and digital surveillance.

### *AI-neurotech convergence*

A number of governance challenges issue from the convergence of AI and neurotechnology. For "classical" neurotechnologies as medical devices, the translational and regulatory pathways are comparatively well defined. For AI-based neurotechnologies, e.g. a novel brain-computer interface that uses artificial neural networks for deep learning on neural data, the regulatory landscape is more heterogeneous (e.g. when comparing approaches from the US and in the EU) and also more complicated (e.g. including validation standards and notions of "design freeze" that are difficult to meet with adaptive, learning devices). Therefore, a lot of work is necessary to define translational and

regulatory pathways that unlock the enormous clinical potential of AI-based neurotechnologies.

#### *Consumer neurotechnologies*

Unlike for clinical devices, consumer-oriented neurotechnologies lack an effective and comprehensive approach to regulation. They are marketed using terms such as "wellbeing", "relaxation" and other paramedical notions. This means, however, that the consumer market is becoming inundated with products with unproven and sometimes fraudulent claims. Such applications may not only be ineffective but also create harms for those who use them for recreational or health-related purposes.

#### *Lack of private sector incentives to implement governance/ethics guidance (Saville)*

Diana Saville, Co-Founder and Chief Creative Officer at BrainMind noted that implementing systematic approaches for responsible innovation in the private sector encounters challenges for all of the major kinds of actors involved. Incorporating (time consuming) ethical considerations into their workflow is particularly challenging for early-stage entrepreneurs. They tend to look for shortcuts, for example, relying on more established companies to set up "guardrails" for product development. Investors focus on financial returns and scalable innovation. Many investors are more concerned about their personal ethics (reputation is king in this industry) versus the ethical implications of the products they back, taking the view that predicting a technology's harmful impact is next to impossible, or that the important thing is to screen for entrepreneurs with good ethics. Angel and seed stage investors are in a better position to influence a company and product in its early stages. Most VCs want to align with positive outcomes for society, but they are often unaware of how to structure that alignment. When Heads of Research at major tech companies think about implementing neuroethics guidelines, the specter of "yet another committee" looms large. Research directors fear that this type of engagement would slow their progress. Executives at larger companies are more equipped to engage with neuroethics as compared with early entrepreneurs. Big tech companies often welcome regulation at the government level because it can serve as a barrier to entry to future competitors. The main concern is the question of how they can engage with neuroethics while doing exemplary/cutting edge work. Philanthropic organisations often lack a clear playbook on how to incentivize implementation of neuroethics guidelines in their granting workflows.

#### *The complexity of the global governance system*

Technology governance, including neurotech governance, exists at multiple levels (global, national, and local) and works across the public and private sector through, e.g. soft law and standards. Data protection is a case in point. Such complexity poses challenges for the development of streamlined and agile governance that can target specific issues, such as scientific review of consumer neurotech markets.

## Policy interventions

### *Filling gaps in the R&D System*

#### *Support multi-sector and inclusive R&D platforms*

The research and development landscape will require public-private partnerships and diverse kinds of platforms for data sharing and collaboration in order to drive ahead the

search for and development of therapies for neurological disorders. In this context, fostering global research collaborations including data sharing is vital to reduce duplication, identify knowledge gaps, fast-track innovation and build capacity in low-income settings. Such platforms should include not just funders and researchers but also people with lived experience of neurological disorders, including from developing countries. Such inclusion and a commitment to a diversity of stakeholders can help drive product development and access as value propositions, ensure that all approaches used are person-centred and tailor discoveries to local contexts.

*Consider subscription models to promote investment and access.*

A change in the current business model of medical device companies might be considered, e.g. a move to subscriptions and long-term care that could be as profitable as one-time fees and much more adequate for lower income countries.

### *Filling gaps in the governance ecosystem*

*Find the right mix of regulation and self-regulation*

Given that the neurotechnology innovation systems and their activities operate across the public and private sector, and within different scales of activity, governance must operate as a kind of ecosystem in order to be effective. Panellists emphasised different mechanisms within such an ecosystem, including human rights, regulation and soft law, and self-regulation. Panellists emphasised the need for all of these mechanisms, though to different degrees.

*Leverage human rights frameworks*

Some panellists noted the importance of human rights norms in safeguarding fundamental rights, though there was divergence on what that would mean in practice. Hervé Chneiweiss, CNRS / director of the Neuroscience Paris-Seine laboratory at the Sorbonne University highlighted that for UNESCO's International Bioethics Committee for instance, neuro-rights engage certain human rights already recognized in national laws, international laws and other consensus documents. Other panellists called for a new human rights treaty akin to the Helsinki Declaration that that might clearly state the rights and ethical limits of neurotechnology in order to promote clarity and universalism (Villafuerte).

*Regulatory policies are required in the context of consumer products and AI*

Some panellists argued that a "regulatory gap" between the "misregulated clinical neurotechnology area and under regulated consumer neurotechnology market" needed to be addressed with effective policies and regulations (Kellmeyer), including:

- Establish a certification system for consumer neurotechnology devices that includes, inter alia: scientific evidence-based standards; a transparent explanation of the data and algorithms used in the devices; a mandatory reporting system of adverse events; regular audits of the companies producing and disseminating these devices;
- Ensure there is a transparent regulatory framework to ensure that standards are met for quality, safety and ethics for medical products (Dua), as well as regulatory pathways concerning the clinical translation of neurotechnologies for translational research of AI-based neurotechnologies (Kellmeyer).

### *Soft law: implement the OECD Recommendation and other guidelines*

A number of guidelines for responsible innovation in neurotechnology now exist, of which the OECD Recommendation on Responsible Innovation in Neurotechnology is an important and early example. Such guidelines and sources of soft law should not remain rhetorical exercises. Difficult work must now proceed on their implementation. The OECD Working Party on Bio-, Nano- and Converging Technology are currently working with OECD member states and other partners on this challenge. Outside of the OECD, BrainMind, a non-profit platform and community of the world's leading neuroscientists, entrepreneurs, investors, and philanthropists, is laying the foundation for what it calls "Asilomar for the Brain and Mind". This global, multi-sectoral summit will focus on implementing existing neuroethics frameworks, including the OECD Recommendations. Asilomar will be the catalyst for ongoing, active engagement with experts who can help scientists and industry to navigate ethical questions throughout the innovation process.

### *The role of self-regulation*

Guidelines can be developed from the bottom up as key dilemmas and issues arise, creating a form of agile self-regulation. In this process, direct engagement with private sector communities is important because of the tremendous influx of resources committed to brain research by private companies today (Google, Facebook, IBM, Neuralink, Kernel, etc.), and the powerful influence that commercialization of brain technologies will have on individual lives and societies. Within this community, neuroethics can be positioned as a problem-solving framework, as essential to neuroscience development for relevant stakeholders (Saville). One panellist was more sceptical about the adequacy of self-regulation, concerned that companies would not take a pro-active approach if it went against immediate interests (Kellmeyer).

### *Tangible institutional approaches*

UNESCO Working Group on Neurotechnology calls for the establishment of a multidisciplinary group of experts to deepen the gap analysis in neurotechnology governance and pursue the development of an international normative instrument addressing the need to protect neuro-rights and to complement the existing core human rights treaties (Chneiweiss).

BrainMind sees the need for a living organization, led by neuroethicists, which works with startups, investors, and scientists and creates bespoke tools for implementation of neuroethics guidelines. Over time, an organization like this may offer certifications or a "seal of approval" to foster widespread adoption of a new set of cultural norms in neuroscience. BrainMind has the opportunity to form a "practical layer" between conceptual neuroethics frameworks and their functional applications in research and product creation (see BrainMind's 2020 White Paper for a summary) (Saville).

# *Panel 2b: Realising Net Carbon Neutrality: The Role of Carbon Management Technologies*

**Moderator**: **Hans-Jörn Weddige**, Chair of the BIAC Environment & Energy Committee and Head of Climate Funds Strategy, Thyssenkrupp Steel Europe AG, Germany

**Speakers:**

- **Michael Carus**, Founder and Managing Director at NOVA-Institute, Germany
- **Paolo Frankl**, Head of the Renewable Energy Section, International Energy Agency (IEA)
- **Monica Gattinger**, Professor, University of Ottawa, Canada
- **David Keith**, Professor of Applied Physics, Harvard School of Engineering, Professor of Public Policy at the Harvard Kennedy School, United States

## The central questions raised by the panel

Reaching net carbon neutrality is one of the central global challenges we face, and technological development will play a key role. A sustainability transition will necessitate policies that promote sustainable management of the carbon stored in biomass, but not exclusively so: technology is increasingly making it possible to recycle industrial sources of carbon, thus making them renewable. The idea of "carbon management" may capture the different facets of the answer: reduce the demand for carbon; reuse and recycle the carbon in the bio- and technosphere; and remove carbon from the atmosphere. But a reliance on technologies for carbon capture and usage (CCU) and carbon capture and storage (CCS) may present barriers for other more radical transformations.

- What are the opportunities and challenges for finding the right mix of carbon management technologies and policies?

### *What is at stake?*

It is vital that the public realises the vast challenge the net-zero goal entails, which will require the transformation of our energy systems and economies at an unprecedented pace and scale. Effectively, the fossil economy has accounted for 80% of end-use energy for about the last 50 years. The transition demands a new system based more than 70% on renewables and some nuclear, and then the rest will likely consist of fossil plus CCS in less than 30 years.

In one view, "the new global energy economy" is emerging. The magnitude of this transition presents significant opportunities for business, whose investment and finance must be harnessed. But government is still required for setting the rules and incentives.

Previous energy transitions were driven predominantly by market forces and more convenient, affordable energy sources of higher energy density. The net-zero transition, however, is driven by the existential climate threat. Much more than previously, policy choices are going to become a driving factor. It calls for governments to develop holistic approaches to policy, but governments famously struggle to do exactly that.

In 2021, the IEA published its net-zero emission roadmap to 2050 (IEA, 2021[3]). Bioenergy is an essential resource; thus the roadmap focussed on emissions. To meet the

2050 goal, 50% of the technologies needed are not yet commercial today, with the precondition to this being massive deployment of all currently available technologies. Under theme models, 7 Gigatonnes of CCS would be needed in 2050. By comparison, only 40 Megatonnes of CO2 removed in 2020.

### *The carbon management frame and the focus on industry*

One participant defined carbon management as properly organising across all industrial sectors the complex transition from the extraction of carbon in the ground to renewable energy and renewable carbon. Another participant worried that the term carbon management might conflate a range of terms that are quite different in character e.g. carbon capture, utilisation and storage (CCUS), carbon dioxide removal (CDR), direct air capture (DAC) and others. In the drive to get to net-zero carbon by 2050, relying on storing carbon in biological reservoirs is fraught with hazard. Storage of carbon in, for example, trees, is a short-term fix, and this carbon can easily return to the atmosphere through phenomena such as fire, but also simply through changes in management.

A second option is to make a flux of carbon back to permanent storage that really undoes the flux of carbon that is causing the problem, that is, the flux from deep underground reservoirs (as fossil resources) to the active biosphere. Utilisation is generally seen as a good thing, but there are very few significant examples where utilisation has proven to contribute to overall, economy-wide emissions reduction. Perhaps the next decades should focus on reducing emissions rather than emission and recapture. The former could work out to be cheaper and less socially and environmentally harmful.

According to some speakers, what is needed is an overarching carbon management strategy for the chemical sector that enshrines the sustainable, circular economy approach. Greatest policy attention has been given to energy, but other sectors will also have to be addressed (McKinsey Global Institute, 2022[4]). The chemicals industry represents a large opportunity for CCU. Chemicals and material use will inevitably increase over the next decades. Carbon is an absolute necessity and full decarbonisation is impossible. Chemistry can only be 'defossilised'. The renewable carbon family of bio-based carbon and CO2-based carbon and carbon from recycling represent huge, relatively untapped resources.

### *Three specific social challenges for governments*

- *Political challenge*: There is still a lack of consensus on the future of fossil fuels. The role(s) of oil and gas production are going to be crucial in securing political consensus for deep emissions reductions. This is not just about finding technological pathways, but about finding political pathways towards those deep cuts in emissions.
- *Social challenge*: Can carbon management technologies with uncertainties be deployed at scale with the level of community and social support that is going to be necessary? The transformation we need is on such a fundamental scale that social acceptability and participation will be essential, and at different political scales.
- *Policy and regulatory frameworks challenge*: In a recent study around CCUS (Gattinger, Bird and Larkin, 2021[5]), perhaps the number one recommendation was the need for policy stability, including a price on carbon, to provide motivation for CCUS development. Risks can polarise society and policy makers must consider risk management options to improve public confidence in CCUS.

## What do we need to know to make holistic technology and policy choices in carbon management?

There is not a lack of information, but a lot of bad information. There are sharply divergent perspectives involved and vested interests that are opposed to net-zero carbon. To manage this situation, better institutions are needed. Governments need to ensure there is clarity about where we really are, and build an emissions counting system that does not rely on offsets, which could lead to increasing confusion and inefficiency. Relatively simple policies could be devised that focus on big emissions sources. However it is easy for governments to point to some innovation that pushes the problem into the future. Governments by now must be aware of the need for urgency.

The IEA roadmap makes a distinction between the short term (say to 2030) and the long term (2030 to 2050), which should be of great value for governments. One of the problems for government is how to manage the risks posed by uncertainty that inhibit deployment. Deployment frameworks and broader policy frameworks for carbon management are crucial. There are other imperatives that need to be incorporated into these frameworks, e.g. local environmental impacts, affordable energy, as social resistance and unrest could slow emissions reductions.

In the carbon-requiring sectors such as steel and chemicals, it should be borne in mind that carbon may never be as cheap as now. The heavily extractive fossil industries are not paying external costs. Meanwhile, bio-based carbon, carbon from CO2 and carbon from recycling is about 1-2 times more expensive. One option would be a worldwide realistic fossil carbon tax to incentivise industries to avoid fossil resources.

The transition is going to have winners and losers. It is politically necessary to focus on the losers as they will be many and they will need new opportunities in the absence of global governance. However, there is global finance. A message from the IEA is that future investment in fossil resources will be at higher cost and risk. On the other hand, investing in renewables and clean energy technologies, where the costs are decreasing, creates financial opportunities. The financial sector acts in an environment of rules, but it is still the responsibility of governments to make the right rules because finance only does the job of maximising profits.

### *Holistic approaches, social acceptance and unintended consequences*

Holistic policy approaches will be necessary to avoid unintended, unwanted consequences that jeopardise social acceptance. Climate is not the only imperative. There are other environmental imperatives. Market imperatives include making energy markets function efficiently and competitively. Security imperatives include access to affordable, reliable energy. Government departments/ministries often operate in silos, rendering holistic approaches impossible.

Along the way social acceptance must be secured. Governments and intergovernmental processes need to provide opportunities for civil society engagement. Given the imperative of urgency, channels such as television, social media and targeted community meetings work quickly to reach a large proportion of the population. To acquire accurate information needs new social innovation in institutions to get the information in a way that is coherent and trusted.

Inclusive project decision-making will be critical in the face of the economic transformations that will require extensive new infrastructure. Communities want to be involved in those processes: they want to be consulted and engaged and have the ability to help shape what the project is going to look like at the end of the day. There's a real

requirement on the part of local communities to have trust and confidence in the processes that are utilised to make decisions around energy infrastructure. But that takes time, and we don't have much time: how do we square the circle that we need that community engagement but have to act quickly?

## Policy implications

### *Science and technology*

- *Clarify what is meant by carbon management*. Sometimes unintentional, sometimes deliberate on the part of vested interests, there are many terms regarding different technologies and what they are for. The term may have been misused by vested interests and may therefore need to be rescued rather than replaced.
- *Focus on reducing emissions rather than emission and recapture*. There is a risk that investing in the latter will delay the search for technologies that are truly low in emissions.
- *Build greater consensus on the future of fossil fuels*. Without this, governments can choose to delay, and investments in fossil fuels will continue, even if the possibility of stranded assets remains.
- *Bring heavy industry into view*. Now is the time to bring industry sectors into view, especially those where emissions are high and the alternatives few e.g. chemistry, cement, steel. Here, the demand needs to be filled by an appropriate mix of bioresources and chemical carbon recycling.
- *Governments could better incentivise "learning by doing"* by helping certain experimental technologies -- first of a kind, second of a kind -- move into demonstration phase. Academic studies on the potential performance of new technologies will not supply the requisite knowledge base for good policy.

### *Governance*

- *Innovations in policy and institutions*. There are unprecedented opportunities not just for technological innovation, but also institutional innovation: reforming our decision-making systems so that they are not only functional, but adaptable to technological change, fundamentally legitimate and seen as legitimate.
- *Integrated approaches will be necessary to avoid unintended, unwanted consequences* that jeopardise social acceptance. For example, increased reliance on renewable technologies and energies might place greater pressure on land and water, creating issues such as land rights and urban/rural polarisation.
- *Policy choices are going to become a driving factor in this transition*. In previous transitions the private sector was a greater driver. It is still the responsibility of governments to make the right rules.
- *A realistic price on carbon and a (global) carbon tax*, to provide motivation for CCUS development, and to make fossil investments unattractive and unprofitable.
- *Risk management*. Policy makers must consider risk management options to improve public confidence in CCUS.
- *Look beyond emissions*. Technology deployment decisions and broader policy frameworks for carbon management should include issues beyond emissions reduction, e.g. consideration of other issues that have proven to be critical for

publics, including local environmental impacts, pressure on bioresources and energy affordability, security, and reliability.

# *Panel 2c: Innovating Global Health: collaborative action where markets fail*

**Moderator: Francesca Colombo**, Head of Health Division, Directorate for Employment, Labour and Social Affairs (ELS), OECD

**Speakers:**

- **Julie Louise Gerberding**, Executive vice president and chief patient officer, Merck Sharp & Dohme Corporation (MSD), United States
- **Jayasree K. Iyer**, CEO, The Access to Medicine Foundation, Amsterdam, The Netherlands
- **Hani Kim**, Executive Director, The Research Investment for Global Health Technology Fund (The RIGHT Fund), Korea
- **Pierre Meulien**, Executive Director, Innovative Medicines Initiative (IMI), Brussels, Belgium
- **Kevin Outterson**, Professor of Law & N. Neal Pike Scholar in Health and Disability Law - Boston University and Executive Director, CARB-X, Boston, United States

## Introduction

This panel was the latest milestone in a series of events led by the BNCT on collaborative platforms for pandemic preparedness and health resilience. The theme of the panel was "Innovating Global Health: collaborative action where markets fail". It provided the opportunity to elaborate on how new kinds of collaboration could bridge research, economic, and societal priorities in order to achieve a key societal mission: to strengthen health resilience.

At the heart of the issue is what constitutes a sustainable pharmaceutical market: research, innovation, demand, clinical and cost-effectiveness, manufacturing, access, and return of investment. When markets and commercial prospects are limited, innovators find it difficult to secure funding, develop a sustainable pipeline, and to ensure financial returns. The pandemic offers a case of how multi-sector collaboration can accelerate research, development, and regulatory review of health technologies to address global health crises and novel societal priorities. It has also exposed long ignored innovation gaps across all types of pathogens, such as bacteria, fungi, parasites, and viruses as a source of epidemic outbreaks, human suffering, and negative economic consequences.

Despite a growing support for more sustainable approaches to health technology innovation and the emergence of multiple frameworks for changing the global health innovation ecosystem, key elements of a robust ecosystems remain absent. This panel discussed recent developments across governments, non-profit partnerships, funders, and the pharmaceutical industry to drive innovation and sustainable market development for technologies that are critical for health resilience but where the return on investment has been limited.

## Discussion

In her welcome address, the moderator, Francesca Colombo, Head of Health Division, Directorate for Employment, Labour and Social Affairs (ELS), OECD gave a brief overview of the current projects at the OECD on health resilience and on the causal links between technology innovation and the sustainability of health systems. Referring to Covid-19, she noted how alarmingly unprepared the world was to deal with a crisis of such scale and intensity. She pointed out that while not all threats can be predicted, nor their effects anticipated, limiting vulnerability to future shocks will be paramount, and strengthening the resilience of health systems will be essential. This will require investment in the development of health technologies needed to address future threats. Viable mechanisms are therefore needed, not only to incentivise investment in research and development for health technologies that strengthen pandemic preparedness, but also to ensure access and health equity for all.

An introductory comment by all panellists looked at the key challenges and opportunities for policy action to better balance the economic, health and social externalities of health technologies, such as vaccines, antibiotics and diagnostics that critical for health and well-being. As a prime example**,** Kevin Outterson, Executive Director, CARB-X highlighted the vital role of antibiotics in human health, longevity, and economic growth.

*"Antibiotics are a precious resource we take too much for granted. Probably antibiotics are the most valuable class of drugs ever discovered in terms of public health impact." (Kevin Outterson)*

Jayasree K. Iyer, CEO, The Access to Medicine Foundation, Amsterdam, The Netherlands, pointed out that over the past 10 to 15 years, numerous infectious diseases have emerged, with widespread effects on health and society (e.g. Ebola virus disease, Zika, Covid-19). For many infectious diseases with high burden in LMICs such as HIV, TB, and other EIDs and NTDs, treatments are simply not available or not developed and/or adapted to local contexts. Reasons are, for examples:

- **Highly concentrated markets for vaccines**: very few companies are involved in the vaccine space despite strong and increasing global demand. Vaccine manufacturing remains concentrated. Four large manufacturers (GSK, Pfizer, MSD and Sanofi) provide 90% of global vaccine value, and five produce 60% of global volume (Serum Institute of India (SII), GSK, Sanofi, Bharat Biotech and Haffkine).
- **Market failure for novel antibiotics**: companies developing antibiotics present low investment returns due to a lack of incentives. For this reason, most Big Pharma companies have left the field, closing antibiotics BUs where knowledge on the topic was wasted. Also, most investors still have short-term returns in their core strategies.
- **Gaps in infrastructure for diagnostics**: contrary to pharmaceutical R&D, innovation and use of diagnostics often requires a combination of engineering and biological science. Low- and middle-income countries (LMICs) often lack the adequate infrastructure to implement diagnostic tools into health systems. In turn, this prevents companies for reaching and expanding their diagnostic products in news markets. Profitability is thus limited for developing new products.

A more diverse and competitive group of companies committed to innovation in therapeutic areas with smaller and complex markets would be a key driver for health resilience globally. Both patients and the pharmaceutical industry play an active role in health innovation, supply and access. Policy makers, funders, and civil society organisations should join forces to prepare for future epidemic outbreaks, incentivize innovation, and

increase the availability of health technologies for these pathogens. In this context, the importance of diagnostics for clinical development, early detection of health threats, and rational use of medicines is often underestimated. A major issue in the field of diagnostics is that often novel technologies and processes are not compatible with existing health infrastructure (including reimbursement) in local environments.

*"Those willing to take action and risks often have a bigger positive impact on patients' lives. We need to further invest into R&D pipelines for priority conditions listed by the World Health Organization." (Jayasree K. Iyer)*

Pierre Meulien, Executive Director, presented the important work of the Innovative Health Initiative (IHI), in precompetitive, cross-sectoral health innovation in Europe. The newly formed IHI builds on successful partnerships between the European Commission (EC) and the pharmaceutical industry through the Innovative Medicines Initiative (IMI). Recognising the convergence between technologies, IHI will take a more integrated approach across medtech and pharmaceutical industry in order to de-silo health innovation. Large, highly networked public-private consortia and collaborative platforms offer key stakeholders in health innovation, such as researchers, clinicians, policy makers, regulators, investors, industry, payers and patients an optimal ecosystem to de-risk research and product development for global health.

*"Essential health infrastructures, such as clinical trial platforms and pandemic vaccines, require sustainability plans that ensure functioning and longevity of large-scale investments." (Pierre Meulien)*

Equitable access as an ultimate measure of the efficiency of health innovation has been highlighted by all panellists. However, as Julie Louise Gerberding, Executive Vice President and Chief Patient Officer, MSD put it, there is a need to further deconstruct the concept of access in terms of:

- Actualisation: often science is lagging in order to provide novel preventive, therapeutic and diagnostic approaches. Research should be further supported in order to help deliver novel targets and therapeutic options.
- Availability: policy, regulatory, and financial innovation would be needed in order to ensure products are available to markets and can be supplied.
- Acceptability: product acceptability and uptake depends on trust among innovators, health professionals, and patients.

MSD has been a leader in global health. For example, MSD has been a key partner in emergency responses to health threats – both through donations (e.g. the MECTIZAN® Donation Program (MDP) for river blindness and lymphatic filariasis) and the clinical development of novel vaccines and therapies (e.g. rVSV-ZEBOV vaccine for the prevention of the Ebola virus disease). As Julie Gerberding noted, innovative finance mechanisms, such as the Pasteur Act, are more experimental than established public-private product development partnerships. The sustainability of new business models to incentivise innovation outside traditional, large-scale pharmaceutical markets can be tested in platforms like IHI and the AMR Action Fund.

*"Health product acceptability and uptake often gets the least attention, but represents the most important factor in order to realise the full value of medicines to patients." (Julie Louise Gerberding)*

Hani Kim, Executive Director, The Research Investment for Global Health Technology Fund (The RIGHT Fund), Korea, alluded to the significant concentration of R&D infrastructure among industrialised countries as a major obstacle to health equity. With an emphasis on partnerships between Korean and LMIC researchers, the RIGHT Fund

supports development of essential health technologies as global public good as well as evidence generation and training curricula in vaccine manufacturing.

*"The RIGHT Fund requires a commitment from grantees to offer royalty-free, nonexclusive licenses and pricing structures that support public procurement in low- and middle-income countries." (Hani Kim)*

The Covid-19 pandemic has exposed where the biggest issues are in global access to medicine, and how much more must be done to fix them. But it has also been a period of innovation and partnership, with the pharmaceutical industry showing just how quickly it can move to address a healthcare crisis. Panellists pointed out that lessons learnt from the Covid-19 pandemic would be of value to create a more anticipatory ecosystem that offers the right policies, economic models and cross-sectoral partnerships for common pool resources.

### Box 6. Lessons learnt from Covid-19

Panellists were asked how Covid-19 has been a trigger for change and what are the key learnings from the pandemic:

- Health and wellbeing depends on equity, and equitable access to health technologies needs significant public ownership and oversight. Investment in science, infectious diseases R&D and health system strengthening offers significant positive societal externalities.
- It has triggered debates and actions to respond to the deficiencies in our current model of governance over the development and supply of essential health-related technologies. It is crucial that global health stakeholders, governments and investors capitalize on this momentum.
- Global solutions should be based on local and regional contexts experiences. The lack of manufacturing on the African continent has been the topic of multiple discussions as its population is dependent on external players, thus last in line.
- The development of manufacturing infrastructure and supply chains requires horizontal, cross-sectoral approaches. Traditional vertical initiatives focused on selected disease areas and products are not sustainable.
- **Equity is not charity, but a key principle of health resilience. Inclusivity in research, knowledge sharing and equitable access to healthcare can only be achieved through a whole-of-society approach.**
- The pandemic has changed everything except deeply entrenched behaviours of rich countries who politically have had no choice but to service their own first, which in turn has exposed everyone to the threat of new variants of the virus emerging from countries where the viral load has not been decreased through vaccination.
- Collaborative platforms, such as CARB-X, CEPI, and IHI have proven their critical function in health innovation and resilience. They drive the development of global goods of science that can be translated into common pool resources and pandemic preparedness.

The sustainable delivery of health technologies as common pool resources has been a leading theme of the panel discussion. With reference to antimicrobial resistance (AMR), experts noted analogies with other global challenges, such as climate change and environmental protection. The scale and complexity of issues across science and society in order to address global challenges requires a much broader community of stakeholders to join forces towards shared goals. However, as Kevin Outterson and Hani Kim **pointed out, issues in AMR can be solved through shared investment and the identification and application of the key ingredients of existing business models that enable health**

**technology innovation and equitable access: shared values, goals, and a collective alignment.**

Analysis by the Access to Medicine Foundation has shown a pronounced investment and risk-taking by the pharmaceutical industry in areas that have been considered as high-risk and low return of investment, such as antimicrobials, vaccines, and diagnostics. In this context, the significant reputational risks due to complex ethical, legal, and social issues in global health and opportunity cost should be mentioned. The development of an Ebola virus disease vaccine by MSD has been a leading example of a successful public-private collaboration in an area of a significant health need and limited financial resources.

Panellists expressed support to further strengthen the role of collaborative platforms as an ecosystem for innovators to develop and test economic models, approaches to intellectual property (IP) licensing, and access planning under real-world conditions. For example, MSD has been developing approaches to social impact investment in close collaboration with the Global Impact Investing Network (GIIN) and other stakeholders in global health. Through impact investing MSD has been able to deploy financial resources in ways that may generate not only improved access to health care for underserved populations, but also financial returns and commercial opportunities.

## Conclusions

Innovation of health technologies that support pandemic preparedness, health resilience, and that address infectious diseases in LMICs often do not promise a return of investment adequate to attract investment. There was a general recognition across the panel policy makers have a leading role to provide the adequate frameworks for R&D investment and equitable access to critical health technology. New economic incentives and governance approaches are needed to bridge research, economic, and societal priorities to achieve key societal missions for health resilience. However, most countries are uncertain which incentives may be appropriate for their country.

Key challenges and barriers to sustainable health technology innovation and access are: (1) current frameworks for innovation and large-scale supply of essential health goods do not deliver where return of investment is limited; (2) concentrated markets and a small number of innovators and investors committed to R&D for WHO priority health issues; (3) inadequate infrastructure and coordination.

The panel discussion presented important considerations to strengthen health technology innovation and access where traditional markets do not deliver. There was general agreement that further research investment must be balanced by adequate pull incentives for product translation, manufacturing and supply. More inclusive and anticipatory approaches to health technology innovation would deliver ecosystems that support both innovation and equitable access.

Policy messages from the panel are:

- In order to deliver essential health technologies and services that are not adequately provided by traditional markets return of investment should be based on value to society: **delinking price from sales volume.**
- Business models for health technology innovation should include **long-term access planning**, provisions (pull mechanisms) for manufacturing infrastructure, supply chains and financial returns.

- Novel approaches **to intellectual property (IP) management and technology transfer partnerships** are important pillars of cross-sector partnerships, investments and sustainable product delivery.
- Innovators in health technology, especially small- and medium-sized enterprises (SMEs), should **build local networks and engage in global partnerships** to de-risk operations, leverage financial resources and generate revenues.
- Collaborative platforms, such as CARB-X, CEPI, and IHI, offer fertile ecosystems to **spearhead sustainable and anticipatory solutions** for global health. Their governance mechanisms should be fit for purpose and allow for acceleration and speed when there is a need.
- A **higher innovative diversity and stronger representation of local stakeholders** in innovation partnerships would help connecting research investment with local healthcare provider needs.
- Investment for health technology innovation (push mechanisms) should be matched by **sustainability measures for health system infrastructure** (pull mechanisms). There is a need for a collective commitment across all stakeholders to build and sustain ecosystems for quality of care where traditional markets fail.

# *Panel 3: Setting goals and agendas through foresight and technology assessment*

**Moderator: Duncan Cass-Beggs**, Counsellor for Strategic Foresight, OECD

**Speakers:**

- **Sebastian Pfotenhauer**, Professor, Munich Technical University, Germany
- **Edgar Pieterse**, Director of the African Centre for Cities and the South African Research Chair in Urban Policy, University of Cape Town, South Africa
- **Aida Ponce Del Castillo**, European Trade Union Institute (ETUI)
- **Matthias Weber**, Head of Centre Innovation for Systems & Policy, Austrian Institute of Technology, Austria
- **Erika Widegren**, Chief Executive, Re-Imagine Europa

## Introduction

In the face of global transformations – e.g. around digitalisation, climate change, and pandemics – it has never been more important to develop anticipatory capacities and strategic intelligence for setting goals and agendas for science, technology and governance. The speed of technology developments, and the urgency and rapid evolution of global challenges, means that the pace of decision-making concerning technology policy and governance is increasing. The future of both technology and society carries great uncertainty, so tools such as anticipatory technology assessment and foresight will be critical, especially if we seek to innovate to address key challenges. This requires robust and timely strategic intelligence, and approaches such as anticipatory technology assessment and foresight may provide solutions to some of these demands.

To get to grips with these challenges, and to embrace emerging opportunities, this panel explored the following key questions:

- What are the current gaps and needs in capacity for strategic intelligence for emerging technologies?
- What kinds of diverse actors and practices will better foster this intelligence?

## Analysis of the problem, what is at stake? What are the gaps in knowledge, governance, or process?

A number of themes emerged regarding problems and gaps in forward-looking approaches to inform technology policy. Six major gaps and challenges were put forward by the panellists.

### *Inherent uncertainty around emerging technologies*

A major problem for technology policy and governance is the high level of uncertainty associated with emerging technologies. Emerging technologies open up entirely new worlds, potentially transforming industries and society. It is difficult to imagine the possible impacts, of new and emerging technologies, early on and thus the capacity for "imagining" must be supported. Interdisciplinary exchange and collaboration with social

scientists, futurists and creative thinkers is one way to address this lack of imagination. Further, the pace of technological change challenges governance systems which are not well equipped to keep pace. Foresight and anticipatory technology assessment can provide a reflexive space to be better equipped. The complexity, rapidity and uncertainty of emerging technologies, therefore, raises a need for a more continuous and near real-time monitoring as well as more adaptive and agile governance approach supported by strategic intelligence.

### *Turbulence in global systems*

Technology policy needs to be defined amidst major turbulences in global relations, instability and possible reconfigurations of global and regional alliances. New and renewed concerns over dependence and sovereignty have arisen; for example, access to key natural resources and also a move toward reshoring certain industries threatens more isolationist approaches. "Technological sovereignty" has emerged as a political theme. With regards to emerging technological innovations, these turbulences raise concerns that may inhibit the potential positive impact of new and emerging technology options, for example regarding the reliability of global value chains effected by these disruptions.

### *The turn to goal-oriented technology policy*

Societal challenges, and climate change in particular and its various consequences, are raising new requirements with regards to what is expected and desired from emerging technologies. A key challenge for anticipatory technology assessment and foresight is the shift from (a) efforts to predict what will happen with regards to technology emergence and its eventual impact and (b) what ought to happen with regards to technology emergence. Currently there is a predominance of framing (a) which focuses on managing technologies in the name of global competition and with an assumption that diffusion and adoption of technological innovation is inevitable. Framing (b) opens up the question "What kind of future do we want from this or that technology?".

### *The mandate to scale up*

To be able to transform promising technologies into solutions, innovation must be scaled and generalised to lead to desirable socio-economic benefits. For urgent grand societal challenges, such as climate change, so called "Blitz Scaling" is required. Currently, technology and innovation policy instruments are insufficiently equipped facilitate scaling of innovations at a pace necessary to provide technological solutions for urgent societal challenges. This is a major concern since, this puts policy makers anticipatory capacity at a disadvantage. There is real-time pressure to anticipate as a continuous process from small scale to large scale.

### *Citizen participation*

Calls for wider citizen participation and the emergence of new actors make the landscape of emerging technology policy more complex. With the increasing attention to societal missions and grand challenges, the issue of directing technology development in societally desirable directions is growing. Tools such as anticipatory technology assessment and foresight must adapt to this new demand of society-centric perspectives as opposed to traditional technocentric approaches. However, reaching consensus or agreement on common orientations of how to pursue technological change remains a challenge, especially at global level. In particular, there is not enough transparency about emerging developments in research, innovation and industry, and therefore the public or even

political discourse is too slow when compared with the speed of technological development.

There are two concerns: (1) sometimes, processes can fall short of participatory inclusion and (2) decisions are made elsewhere, outside those processes. If anticipatory governance is going to be the model to govern technology in the future, it needs to include regulation and soft law but also ensure the participation of all sectors of civil society.

In polarised debates, where different worldviews abound, it is a great challenge to organise constructive debate and resolution of issues and differences. Anticipatory technology assessment and processes can provide spaces to "probe each other's worlds" to place the positions in broader contexts. Often, the rationales behind a position are not the obvious ones: for instance, the scepticism around COVID vaccines was less about mistrust in science than mistrust of elites and lack of trust in the business models of the pharmaceutical companies.

### *Regional capacity deficits and the urban context*

Not all regions are equivalent in foresight and anticipatory governance capacity. For example, at the moment, most research and development infrastructures in African societies are small and under-funded, as well as stuck with a national industrial outlook perspective or heavily focusing on the STEM disciplines. As a result, many African societies find it challenging to nurture city-level innovation ecosystems, which is a precondition to find contextual solutions for the interlinked problems of job creation, well-being and democratic belonging for the youthful populations. This sense of belonging is key if emerging technologies are to be impactful both on the socio-economic conditions of African societies and if societal grand challenges are to be addressed. A key question remains: how to design, invest in and sustain city-level innovation ecosystems? This gap is exacerbated by a lack of finance and a low level of leadership from city-level institutions, be they public, private or educational.

Contextual issues are also important to consider when developing mission-oriented policies. Whilst, at face value, innovation missions, such as those currently underway at the European Commission, are a move in the right direction, their design and implementation leave many open questions. What does it mean to have 100 Climate Neutral Cities in Europe, if the rest of the globe is not acting in concert with Europe? Moreover, the definition of Climate Neutrality, the mechanisms to achieve this goal and the impacts that will be generated from moving towards this goal, will differ in cities across Europe. How to manage this heterogeneity in terms of difference contexts? This poses serious challenges for foresight and anticipatory technology assessment if it is to inform and drive technological innovation that with contribute to meeting mission aims.

## How can these challenges be met? How can solutions be supported by policy?

The panellists provided a number of suggestions of how these challenges could be met, providing examples of current activities that provide inspiration. In the following, eight main suggestions are presented.

### *Mobilise foresight and anticipatory technology assessment for future proofing*

There should be more efforts to think broadly and creatively about potential uses and consequences of emerging technologies, and this should be done at early stages to maximise utility of this source of strategic intelligence. A range of foresight approaches have been developed to explore different futures and scenarios. These range of futures can

be used to inform policy making by providing alternative futures as options and, thus, can be considered as a means of exploring opportunities and challenges. A key challenge is the integration of such futures into the policy making space.

One example provided by the panellists was the activities at the Austrian institute of Technology, where work is currently ongoing on disruptive context scenarios and socio-technical developments for the European Commission's future R&I policy. This requires a great deal of imagination, the sourcing of S&T as well as socio-economic-political knowledge. Sourcing such insights requires the integration of multiple disciplines and expertise (cf. next point).

### *Integrate insights from the social sciences*

Targeting technology policy for emerging technologies requires active reflection on the institutional embedding of emerging technologies. For example, standards and regulations are key enablers of innovation and market formation. However, such "market enablers" take time and if not anticipated may become a bottleneck for technological innovations that can benefit society.

Social scientists can play a key role in supporting such reflections, providing key insights into the relationships between technology, innovation and society, as well as providing insights into market formation processes and diffusion and embedding of technologies in society. A key approach is to nurture and support interfaces of social and technical sciences at early stages of research and development of new and emerging technologies.

### *Address issues of scaling of new technologies and foresight*

Scaling and the generalisation of new technologies into society is an essential element of technology policy that considers societal goals as a priority. However, the variety of scaling mechanisms and the differences across national contexts means there cannot be a one size fits all solution for such "scaling of technology policies". A key recommendation from the panel was to (a) explore the variety of scaling strategies and (b) identify how foresight, and other forms of strategic intelligence, can be integrated along the whole journey from small scale to large scale. As part of this recommendation, a focused effort on scaling foresight processes is proposed.

### *Take the transformative role of start-ups and finance more seriously*

For the scaling issue described previously, a key question remains: What does it mean for the private sector if they are the most likely to drive the scaling of new solutions? What does this mean for governance options? The role of the private sector in both innovation and scaling of new technology options cannot be overstated. Therefore, new forms of interaction between policy-driven foresight and industrial foresight and strategic planning are essential, if the transformative role of the private sector is to be harnessed and incorporated into technology policies.

The key role of the financial sector is key with respect to new technologies for achieving societal grand challenges. One relevant ongoing project is the Deep Transitions Futures Panel for Transformative Investment. This brings together a variety of stakeholders from the financial sector to explore a variety of future system transformations and to identify roles for investors and identify key targets for action.

### *Actively include citizens and other stakeholders*

Short and long-term technology policies need to design and implement inclusive and participatory processes, enabling and empowering civil society, and other stakeholders, to become agents of technological transformation. They need to open a space for genuine societal contribution, as opposed to the limited approach usually used, which often limits itself to sharing information, seeking acceptance or collecting views. A range of possible approaches can be a source of inspiration, for example, societal dialogues, policy co-design, living labs for testing new technologies to name but a few. Whilst such inclusion in policy design provides broader and richer insights and builds trust, such societal engagements may also throw up opposing (and legitimate) views which will have to be taken into consideration. Thus, policy makers require the capacity for digesting and integrating the outcomes of such exercises.

One suggestion from the panellists would be to create a Global Forum on Emerging Technologies, bringing together stakeholders working on and potentially affected by emerging technologies, and giving a voice to the various hopes and concerns. Such a forum could share insights on emerging technologies and their far-reaching potential effects, be they desirable or not. In addition, such a forum could also share experiences on inclusion of a variety of stakeholders in the policy design process.

### *Create guiding principles for challenge-driven technology policy*

Mission-oriented policies and other challenge-driven policies, call for setting societal goals and steering innovation systems to provide solutions. Such steering poses major challenges for technology policy for new and emerging technologies, which are often open-ended and highly uncertain. This high uncertainty of emerging technologies coupled with clear societal requirements described in mission-oriented policies provides a potential paradox: how to manage the unknown of emerging technologies whilst driving towards contributing to the mission targets? The answer is to focus on real-time steering of research and development whilst incorporating future-oriented strategic intelligence.

Such steering based on societal goals requires new ways of developing and implementing technology policy. Therefore, there is the need for the elaboration and use of "guiding principles" and informed processes of integrating normative considerations into the design and early development of new and emerging technologies. Such guidelines can draw inspiration from RRI-principles in research and innovation activities, but must be tailored to provide approaches for near real-time monitoring, debate and adjustment processes.

### *Recognise contextual differences when dealing with global challenges*

Often mission-oriented policies are national, and more recently, at the European level, but many challenges, such as the Energy Transition are global in nature, and thus, any kind of approach for developing strategic intelligence, should well integrate the different contexts in which mission actions will take place. This calls for multinational comparisons, concertation and coordination in foresight around how new and emerging technologies will contribute to global and local mission aims.

### *Build capacity*

Based on all of the points above, there is a clear need for capacity building in the production and use of strategic intelligence from foresight, anticipatory technology assessment and other approaches. This includes policy makers, but also other stakeholders, for example NGOs, industrial actors, civil society organisations and trade unions. For the latter, one panellist offered the example of organisations such as the European Trade Union Institute

(ETUI) who train Trade Unions on how to do foresight and how to make use of the foresight outcomes so that they can define better strategies and influence policies. Trade Unions have short mandates, but foresight enables long-term strategizing as well as incorporating many diverse actor's perspectives and factors to develop robust strategies.

## Conclusions

The recent return to a stronger goal-orientation in innovation policy reveals a growing appreciation that technological innovation is not good per se. This "return" means that foresight and anticipatory technology assessment should be inclusive and participatory, to avoid technology rejection and to formulate robust strategies and policies. The challenge remains, how to do this. Action should be taken to bring together best practices and to identify new needs so that new forms of foresight and anticipatory technology assessment can be developed and appropriately targeted.

Strategic intelligence, such as foresight, can help create a better and more even conversation and participatory approaches are advantageous for reasons of (a) inclusivity and (b) drawing on multiple perspectives to produce robust strategic intelligence.

There are, of course, two complicating factors to the agenda of taking a more considered stance towards the technological future. The first is that "Global competition" as a driver of technology policy tends to overrule efforts to slow down the speed of change to produce and make use of diverse forms of strategic intelligence – there is a pressure to move rapidly. The second factor is that policy domains are increasingly interlinked, requiring a transformation in how science and technology policies are developed. It also places new requirements on anticipatory technology assessment and foresight to develop tools and provide strategic intelligence that incorporates multiple policy domains.

# *Panel 4: Tools of Upstream Technology Governance: Soft Law, Standards, and Ethics-by-Design*

**Moderator**: **Julia Black**, Strategic Director of Innovation and Professor of Law at the London School of Economics and Political Science, UK

**Speakers**:

- **Boma Brown-West**, Director of Consumer Health, Environmental Defense Fund, USA
- **Julien Durand**, Chief Ethics & Compliance Officer Sanofi, Non-executive Chairman of the Board of Health Tech Ventures, Global expert to WHO on Digital Health, Chair of IFPMA's Future Health Technologies and Bioethics WGs
- **Kevin Esvelt**, Assistant Professor of Media Arts and Sciences, Massachusetts Institute of Technology (MIT), USA
- **Gary E. Marchant**, Faculty Director and Regents Professor, Center for Law Science & Innovation, Arizona State University, USA
- **Stephan Naundorf**, Counsellor of Minister of State, Federal Chancellery, Germany
- **Andrew Wyckoff**, Director, Directorate for Science, Technology and Innovation, OECD, Paris, France

## The central questions raised by the panel

Governance of emerging technologies too early in the development process can possibly be constraining; but governing too late can make technologies harder to govern as they become widely diffused and adopted. This panel explored a range of tools that seek to enable "innovating well" by working through tool and mechanisms of upstream governance. Communities of technological practice have become more creative in the embedding of social values, not just safety but also ethical considerations, into the development of emerging technology using techniques like soft law, private governance, standards and ethics-by-design.

Key policy questions addressed by the panel:

- What are current trends and best practices for enacting agile and robust approaches to upstream governance that enable innovation but align technological development with societal goals?
- Soft law, private governance, standards and ethics-by-design are key tools in technology governance. What can and/or should be done to strengthen use and ensure compliance?

## Analysis of the problem

Gary E. Marchant, Professor, Faculty Director and Regents Professor at Center for Law Science & Innovation, Arizona State University presented certain challenges of emerging technology to traditional regulatory systems:

- First, the speed of technology advances has accelerated, making it difficult for traditional regulation to keep up ("the Pacing Problem").
- Second, novel and broad ethical, social and/or economic issues that are outside the legal jurisdiction, traditional expertise and/or comfort zone of many regulatory agencies.
- Third, applications across multiple industries and government agencies, are creating an inter-agency coordination problem within governments.

### *Technology specific governance needs*

While governance challenges clearly differ depending on the type of technology (Black), the overall questions that need to be addressed remain the same:

"How can we ensure that technologies are developed in a way that they are socially useful, responsible, and trustworthy? Who is responsible to ensure that these goals are met and what should be done?"

Julia Black, Strategic Director of Innovation, Professor of Law at the London School of Economics and Political Science proposed three categories of emerging technology:

- **Physical technology**, including engineering and semiconductors have high barriers to entry in terms of cost and expertise.
- **Digital technology** can be developed in such a way to make it easy for relative non-specialists to build new applications on existing platforms. Lower entry barriers contribute to a higher distribution of digital innovation. Further, digital innovation is producing general purpose technologies, enhancing their distributed nature across sectors and regulatory domains.
- **Life science technology** carries greater societal expectations than in any other sector. This is why ethics principles and business integrity are critical for the biotech and pharma industries (Durand). In the area of biotechnology, the history of GMOs shows there is a significant danger of mistrust and misuse. The prospect of do-it-yourself biotechnology has expanded the distributed nature of the technology.

### *Developing anticipation and adaptive approaches*

An important question to be addressed is the timing of governance and which tools should be best applied at the different stages of technology innovation. The need for upstream anticipatory governance was a major theme. However, the adaptive capacity of governance once the systems are in place is also important. As novel technologies can have unforeseen consequences, governance mechanisms must be both, anticipatory and adaptive: there are going to be surprises and when those surprises happen and we have a bad consequence, we need to have adaptive capacity to build in resilience. How can both anticipatory and adaptive approaches be achieved?

### *The complex landscape of technology governance*

Global governance exists today as a complex system of actors and institutions at different levels, sectors and jurisdictions. Most emerging technologies are being developed by many nations at once, operating under different legal regimes and ethical concepts, creating an international governance challenge. Furthermore, a variety of institutions play a governance role. Governance exists in both hard law and regulation or soft law (as described below). The same is true about the global governance landscape of novel

technologies. This "polycentric" or complex nature of technology governance raises important questions of design of the ecosystem as well as coordination.

## Governance mechanisms and considerations

### *Public regulatory approaches*

Stephan Naundorf, Chair of OECD's Regulatory Policy Committee, Better Regulation Unit, Federal Chancellery, Berlin, Germany, opined that in general the dynamics of technological advances should be addressed through a continuous review and adaptation of existing regulations and processes. Not every new technology needs a new regulation. The key question is how does an innovation relate to this general framework that reflects political preferences?

### *Soft law approaches*

#### *General considerations*

A number of panellists argued that while soft law mechanisms should not in every instance replace government regulation, it is nevertheless an essential tool in the realm of emerging tech because the fast pace of change means there should not necessarily be regulation yet; or, there are gaps that need to be filled.

> *"Soft law could be defined as commitments and obligations that are not directly enforceable by government, for example professional guidelines, standards, codes of conduct and good practices" (Gary Marchant)*

For example, soft law offers more flexible interim solutions in emerging technologies, such as AI and block chain. However, more empirical analysis of soft law mechanisms and tools is required in order to better understand the factors that make it work – or not; in particular in its interplay with regulation. Further, it is crucial to ensure that there is "meaningful" participatory mechanisms where those concerned (citizens as well as SMEs) are invited into the design of governance systems. Ultimately, soft law should be built on evidence, accountable to the public and not only to industry (Naundorf), and be transparent to enable its public character. Finally, standardisation needs to invest in outreach. There needs to be a level playing field for all innovators including small- and medium-sized enterprises (SMEs): keeping in mind that SME's often don't have the resources to contribute effectively to standardisation. Companies adopting standards should have to demonstrate their commitment to fair and ethical behaviour.

#### *Implementation mechanisms / tools.*

While soft law for technology governance is attractive in theory, the majority of soft law instruments are not successful. In order to realise their full potential systems must be in place to ensure implementation and compliance. For instance, two thirds of the many Artificial Intelligence (AI) sources of soft law have no enforcement mechanisms whatsoever. Nevertheless, good practices exist and represent a sort of toolbox, including:

- Liability regimes with contractual force
- Collaborations between trusted non-profit groups and industry
- External ethics committees
- Independent auditing and monitoring
- Insurance companies might require compliance and performance

- Government off-ramps (if conditions of governance not satisfied, government regulator will step in.
- "Ethics by design" approaches: standards built into product engineering and specification.

*OECD Recommendations on technology governance*

More anticipatory approaches to technology governance are also being discussed across the G7 and other international fora, including at the OECD. In his comment Andrew Wyckoff, Director, Directorate for Science, Technology and Innovation (STI), OECD, highlighted three recent OECD Recommendations as good examples of how diverse groups of stakeholders work together globally in order to shape the future of technology "in and for society".

- Recommendation of the Council on Artificial Intelligence (AI), which establishes principles and mechanisms to promote trustworthy AI.
- Recommendation of the Council on Responsible Innovation in Neurotechnology, the first international instrument in the field laying out principles and mechanisms for responsible innovation in that field.
- Recommendation of the Council on Agile Regulatory Governance to Harness Innovation, laying out principles and approaches for regulation to promote innovation while safeguarding public well-being.

Andrew Wyckoff spent time detailing the pathway towards the development of OECD soft law in AI, putting special weight on the question of the challenge of implementation. In that context, the OECD reconvened multi-stakeholder group, developed real practical tools, created an "observatory" of existing policies to promote mutual learning, and helped give birth to the Global Partnership on AI. He emphasised that this is just one technology: how do we scale this up, make it more systematic, and apply to other areas such as biotech that deserves attention?

*Co-designing industry standards*

***Industry-wide codes: the pharma sector***

The biopharmaceutical industry is experiencing intense changes with a number of frontier technologies impacting the way it does research, commercializes its products and collaborates with partners and stakeholders across the world. At the industry level IFPMA has responded by creating new bodies like global future health technologies and bioethics working groups to look at what is the next generation of risk as well as benefits. Julien Durand, Chief Ethics & Compliance Officer Sanofi, Chair of IFPMA's Future Health Technologies and Bioethics working groups pointed out that that from an industry perspective, standards must be designed to include diverse stakeholders and be totally transparent, featuring participatory approaches with patient organisations, health authorities, social scientists, philosophers and civil society. This co-creation is critical early during the development of soft law instruments for self-regulation. Co-design will make public acceptance more likely, which facilitates their use at scale to enhance and save patient lives.

***Environmental product standards: NGO and Industry partnerships***

Boma Brown-West, Director of Consumer Health, Environmental Defense Fund (EDF), highlighted the importance of partnering with industry to create new standards for products

involving novel technologies, especially where gaps in regulation exist. Retailers can leverage their market power to influence how technology developers are considering unanticipated consequences throughout the supply chain – from design, to sourcing, to disposal. Companies carry a form of accountability as they have duties to report back to their investors through their reports. They have the power to make sure these concerns are "baked in" as these new technologies, chemistry and innovations come on line. An important question is how to translate mechanisms and principles of co-design and upstream engagement into practice. Having multiple stakeholders involved is key – governance cannot simply be a question of inventors, but must be in concert with government agencies, advocacy organisations, and academics.

Recently, EDF developed principles and standards for ensuring the environmental sustainability of cell-based meat and seafood. A strong case could be made about this being healthy and sustainable food, but when we talk about this new field, benefits need to substantiated and broader issues considered, e.g. as cell-based meat and seafood grows, it may have big implications for the global food system. Millions work in this system, so there's a huge impact there. On top of that, as technology is still being developed, what are the other inputs being used? An analysis of the health and environmental impacts must be baked in.

### *"Ethics by design" at the firm level*

Being a "purpose led" enterprise can be a strategic differentiator and patients and health care professionals need to be able to trust the products that are brought onto the market. Industry provider of advanced health technologies have to look upstream at the different stages of development of such a technology, e.g. the idea, prototype, pilot, scale up. What is very important is to embed "ethics by design" based on societal values -- whether that is privacy, ethics, diversity and inclusion -- through clear protocols. For example, in the AI field bias can lead to failures to diagnose certain diseases among certain populations if the systems are not trained on the right dataset, so it is critical to have the right protocol. Analytical tools can be used to assess privacy impacts, safety impacts, diversity, inclusion and human rights impacts.

### *Fostering transparency and responsibility in bioengineering*

Kevin Esvelt, Assistant Professor of Media Arts and Sciences, Massachusetts Institute of Technology (MIT) brought up the question of who and how to govern biotechnologies might have a profound effect on humans and other species. In the context of his field, the development of so-called "gene drives," he noted that the increasing complexity of technology and governance challenges. As the power of technology grows, the consequences of mistakes become increasingly dire. Even in the wake of a global pandemic taking millions of lives, we struggle to make scientists take the prospect of engineered pandemics seriously.

Kevin Esvelt raised the question about what can be done to avoid discovering and disseminating technologies that are a threat to civilization. It will be important to incentivise transparency and disclosure, but there are challenges: scientists want to be at the cutting edge and may not want new governance requirements to slow them down. There must be incentives to disclose new ideas and prototypes before technology development. He suggested that we might begin with ecological technologies such as gene drive, which also feature exponential growth as well as ethical questions regarding how to ensure that local communities have a voice in guiding critical early research design decisions intended to change their environments.

A few specific ideas were shared to help address the incentives problem. Funders and journals could require to share ideas early and publicly. A problem is that there is no coordination mechanism. To remedy this, international organisations could establish a registry for all ecological engineering research and require active community guidance for projects to be registered; funders and journals could then require advance registration before lab studies begin. This would begin changing norms in a relevant and high-profile area of science to favour early guidance of research by diverse parties, which in turn could help identify major technological hazards in time to address them.

## Policy messages

- Short-term:
  - Perform empirical analysis of soft law mechanisms and tools, recognizing its interplay with regulation in order to optimise their use, further increase the credibility and effectiveness of technology governance.
  - Strengthen the use of and compliance with governance tools: tie funding, publication, and regulatory approval to compliance with safety standards, access, transparency and ethical, legal, and social principles.
  - Analyse cases of "ethics by design" approaches. Discuss practical steps, good practices and possible roles and responsibilities for applying ethics by design in key technology areas.
  - Give civil society a weight in major policy decision-making. Engagement of citizens and SMEs should be strengthened in the design phase of public and private research.
- Mid-term:
  - Develop oversight mechanisms for soft law implementation and compliance, e.g. implement third party audits of technology governance as part of an effective quality control infrastructure.
  - Develop technology oversight and governance approaches that are calibrated according to the need, nature of the risks, and possible harm.
  - Digital innovations have been less regulated in their production, but regulators are experimenting with controlled test environments for their use (e.g. "sandboxes").
  - Incorporate explicit considerations of risk magnitude into policy and law. Anything potentially catastrophic should receive much greater scrutiny.
  - Decision-makers in the technology ecosystem should consider not only aggregate impact but also whether communities could experience disproportionate health, environmental and social impacts.
  - Develop and support standard setting organisations from technology specifications, professional associations to technology governance, but clarify whether compliance with standards is truly voluntary, privileged by legal conditions or clearly binding. Strengthen their role in responsible and ethical technology use. The OECD and other organisations could support international mutual oversight networks between nations.

  - Enable public research institutions, start-up companies, small- and medium-sized enterprises (SMEs) as well as government officials (in their capacity as an interested party) in the standard setting process.
  - Develop funding mechanisms to support technology governance and co-operation.
- Long-term:
  - There is a need for coordinated approaches to change the incentives for researchers in favour of more transparent processes for the selection, funding, and monitoring of early prototype plans for technology innovation. Funders should require and provide the adequate incentives for peer-review and community engagement early during the design phase of disruptive research.
  - Policy should support the development of institutions that can incorporate and apply the collective knowledge in order to guide scientists as they explore the possibility space of technology.
  - Introduce legal liability and require insurance for research with serious adverse consequences, such as labs working with potential pandemic-capable pathogens.

## *Conclusions and next steps for the OECD*

Panellists were asked what two or three key points they would take away from the Conference.

Françoise Roure**,** French Ministry of Economy and Finance, Chair, OECD Working Party on Bio-, Nano- and Converging Technologies focused on two points: first, that there is a sense of urgency to address obvious governance gaps. This should be done in a systematic way by BNCT and CSTP but in concert with other parts of the OECD. Second, that in order to deliver converging technology for transition, there must be a deeper "cultural convergence" in order to build the capacity of society to engage in meaningful deliberation. A truly productive dialogue will require a huge investment in policymakers' literacy in emerging technology issues and multi-disciplinary education and training. Without this cultural convergence, the ongoing conversation could fail in setting the right standards.

However, there are barriers to a cultural convergence. First, the sheer complexity of emerging technology policy in terms of economic, technological, scientific, political factors. Consider for example, the complexity of creating collaborative platforms for developing technology, where complex IP mixes will be necessary for sustainability. The second barrier lies in current definitions of academic excellence, which deny the cross-over or merging of scientific disciplines. Synthetic biology and cyber-physical systems are just two examples.

Yongsuk Jang, Senior Research Fellow of the Science and Technology Policy Institute (STEPI) in Korea, Chair, Committee on Scientific and Technological Policy, OECD noted the importance of continuing the national support of science and technology in the long-term, and of continuing to address global grand challenges in partnership with industry. He noted the importance of multi-disciplinarity and all-of government approaches to innovation, and the possible utility of "missions" towards that end. Second, he noted the utility of policy experimentation: we can aim to create real world laboratories to enact anticipatory governance. Of course, governing well requires good knowledge and wider citizen engagement would be critical to building policy-relevant knowledge and to help establish public trust. Without public engagement of various kinds, STI will lack necessary societal and political support. We must mitigate social dislocations created by transitions, e.g. workers need to be informed of and participate in shaping these changes.

Andrew Wyckoff, Director of the OECD's Directorate for Science, Technology and Innovation, mentioned first that achieving the right technology policies will require building trust among stakeholders in which people have the same level of knowledge and skills, especially on the policymaker side. Some of these issues cut across different communities and ministries, also different stakeholder groups, which makes this task difficult. At the recent Future Technology Forum held this past November in London, the idea that countries should each have a "tech sherpa" was floated.

There are three conceptual questions that still require some thought. First, we have heard the shortcomings of the linear model of innovation, but talking about anticipatory or "upstream" governance implies a linear progression of technology. Second, technologies

differ quite a lot. The health sector has always been more anticipatory, while others like digital, allow people to ship software with known flaws. Different technology areas perhaps may perhaps have different governance cultures and environments. Finally, what constitutes the future, how far forward do we really need to be to get the relevant stakeholders to work together? When we began splitting atoms, we knew there would be major ethical and political implications; on the other hand, with respect to social media, it's not clear that we could have anticipated its trajectory. We need a bit of humility with respect to our capacity to predict.

**Panellists were asked for one or two ideas for what the OECD might do in this area.**

Françoise Roure. The BNCT stands ready to support the anticipation of technology disruption as a pillar of a new strategic intelligence approach with CSTP. **The BCNT is ideally placed within the OECD to imagine, design and propose new converging technology governance standards, tools and mechanisms**. I will cite only one, which is, for instance, an OECD joint technology assessment methodology maybe including next generation of risks and opportunities rooted on shared values and deploying a concept of a dynamic governance continuum.

Yongsuk Chan. We need to identify the right actors and communities for co-development of a common agenda on "technology for good". CSTP is currently doing a series of dialogues with relevant STI policymakers; on international cooperation, CSTP needs to help identify and encourage win-win opportunities for cooperation. There are in fact many standards relevant to technology governance under the Committee, and work should go on in the implementation of such standards. CSTP must leverage work done BNCT – which recently developed the Neurotechnology Recommendation, and will be source of further principles on emerging technology. This Conference marks an important milestone, and its findings will be reflected in our S&T Policy2025. There needs to be build more room for policy experimentation, we need to develop strategic intelligence around a portfolio of technologies, share best practices on wider stakeholder involvement, and leverage the OECD's impressive knowledge infrastructure like STIP compass.

Andrew Wyckoff. The first thing to do is to seize on the sense of urgency; harvest and digest the insights from the meeting, and this will help guide the way. I might encourage the CSTP to convene an expert advisory group to follow up on this, and to direct that Committee and the Working Party for that matter on how they should go forward. On horizon scanning: we do it, but maybe it hasn't been as systematic; further, we could take stock of the current efforts at anticipatory tech governance, what has worked well and where can we learn lessons. As usual, we try to collect everything we know about a topic to inform a pathway going forward.

# Annex B. Event Speakers and agenda overview

## Table 1. Event speakers and agenda overview

| Session | Name | Affiliation | Country |
|---|---|---|---|
| Welcome, Scene-Setting and High-Level Roundtable: Rethinking Technology for Inclusive Transitions | Mathias Cormann | OECD | N/A |
| | Chris Philp | Parliamentary Under Secretary of State (Minister for Tech and the Digital Economy) | United Kingdom |
| | Ulrik Vestergaard Knudsen (moderator) | OECD | N/A |
| | Roberto Cingolani | Minister of Ecological Transition | Italy |
| | Yuko Harayama | RIKEN | Japan |
| | Manuel Heitor | Minister of Science, Technology and Higher Education | Portugal |
| | Lim Hyesook | Minister of Science and ICT | Korea |
| | Jason Kelly | Ginkgo Bioworks | United States |
| | Esther Lynch | European Trade Union Confederation | European Union |
| | Jean Eric-Paquet | European Commission | European Union |
| Keynote: Science and Emerging Technology for Inclusive Transition: New Directions | Sheila Jasanoff | Harvard Kennedy School | United States |
| | Alessandra Colecchia (moderator) | OECD | N/A |
| Panel 1. Building Inclusivity Upstream: Engaging Diverse Actors in the Development of Emerging Technology | Angela Simone (moderator) | Bassetti Foundation | Italy |
| | Richard Johnson | iGEM | United States |
| | Anil Prakash Joshi | Himalayan Environmental Studies and Conservation Organization | India |
| | Shobita Parthasarathy | University of Michigan | United States |
| | Flurina Schneider | Institute for Social-Ecological Research / Goethe University Frankfurt | Germany |
| | Henriette Van Eijl | European Commission | European Union |
| Conversation: Values-Driven Development of Emerging Technologies in an International Context | James Wilsdon (moderator) | University of Sheffield | United Kingdom |
| | Tarun Chhabra | US National Security Council | United States |
| Introduction to Day 2 and Panel 2 | Douglas Robinson | CNRS | France |
| Panel 2a. Harnessing Responsible Neurotechnology for Brain Health | Siobhan O'Sullivan (moderator) | Royal College of Surgeons Ireland | Ireland |
| | Hervé Chneiweiss | CNRS | France |
| | Tarun Dua | World Health Organisation | N/A |
| | Diana Saville | BrainMind | United States |
| | Gabriel Villafuerte | Actipulse | Mexico |

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| Panel 2b. Realising Net Carbon Neutrality: The Role of Carbon Management Technologies | Hans-Jörn Weddige (moderator) | BIAC Environment & Energy Committee, Thyssenkrupp Steel Europe AG | Germany |
| | Michael Carus | NOVA-Institute | Germany |
| | David Keith | Harvard University | United States |
| | Monica Gattinger | University of Ottawa | Canada |
| | Paolo Frankl | International Energy Agency (IEA) | N/a |
| Panel 2c. Innovating global health: Collaborative action where markets fail | Francesca Colombo (moderator) | OECD | N/A |
| | Pierre Meulien | Innovative Medicines Initiative (IMI) | Belgium |
| | Jayasree K. Iyer | Access to Medicine Foundation | The Netherlands |
| | Kevin Outterson | Boston University, CARB-X | United States |
| | Hani Kim | The RIGHT Fund | Korea |
| | Julie Louise Gerberding | Merck Sharp & Dohme Corporation (MSD) | MSD |
| Panel 2. Rapporteur and wrap-up | Marcello Ienca | Swiss Federal Institute of Technology | Switzerland |
| | Ole Marvik | Innovation Norway | Norway |
| | David Winickoff | OECD | N/A |
| Panel 3. Setting goals and agendas through foresight and technology assessment | Duncan Cass-Beggs (moderator) | OECD | N/A |
| | Matthias Weber | Austrian Institute of Technology | Austria |
| | Edgar Pieterse | University of Cape Town | South Africa |
| | Aida Ponce Del Castillo | European Trade Union Institute (ETUI) | N/A |
| | Sebastian Pfotenhauer | Munich Technical University | Germany |
| | Erika Widegren | Re-Imagine Europa | Sweden |
| Panel 4. Tools of upstream technology governance: soft law, standards, and ethics-by-design | Julia Black (moderator) | London School of Economics and Political Science (LSE) | United Kingdom |
| | Andrew Wyckoff | OECD | N/A |
| | Gary E. Marchant | Arizona State University | United States |
| | Boma Brown-West | Environmental Defense Fund | United States |
| | Kevin Esvelt | Massachusetts Institute of Technology (MIT) | United States |
| | Julien Durand | Sanofi, WHO, IFPMA, Board of Health Tech Ventures | |
| | Stephan Naundorf | Federal Chancellery | Germany |
| Conclusions and next steps | Andrew Wyckoff | OECD | N/A |
| | Yongsuk Jang | OECD Committee on Scientific and Technological Policy | Korea |
| | Françoise Roure | OECD Working Party on Bio-, Nano-, and Converging Technology | France |

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