FORGING

INDUSTRY-ACADEMIA FORUM TO UNCOVER THE POTENTIAL OF EMERGING ENABLING TECHNOLOGIES

FORGING Prototype Toolbox for responsible development and implementation of emerging technologies

About this document

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FORGING Toolbox Prototype – what is it?

Welcome to using the FORGING Toolbox Prototype!

FORGING Toolbox is a resource for developers and adopters of emerging technologies, offering tools and methods for responsible technology development processes. Especially the Toolbox is designed for academics and industrial entities, but anyone working with emerging technologies might find the methods and tools useful. Cross-sectoral co-creation and co-operation is at the heart of the FORGING values reflected in this Toolbox. The Toolbox introduces the co-creative approach of FORGING project, showcasing the methods and tools of the project.

This version is a prototype – a working version to be updated as the project evolves. The final FORGING Toolbox will be published in the autumn 2025. For the final version, more methods and tools will be added, reflecting the continuation of the FORGING project and additionally showcasing the great work of the larger FORGING community.

Introducing the FORGING project

FORGING is a new flagship initiative on emerging enabling technologies funded by the European Commission. The FORGING consortium consists of 6 European partners.

The aim of FORGING is to initiate a sustainable and interactive multi-level, multi-sector and multi-stakeholder forum that actively supports the co-creation and the uptake of the enabling technologies of the future in support to the digital and green transitions through human-centred technologies and innovations, respecting the boundaries of the planet, and maximising the benefits for society as a whole.
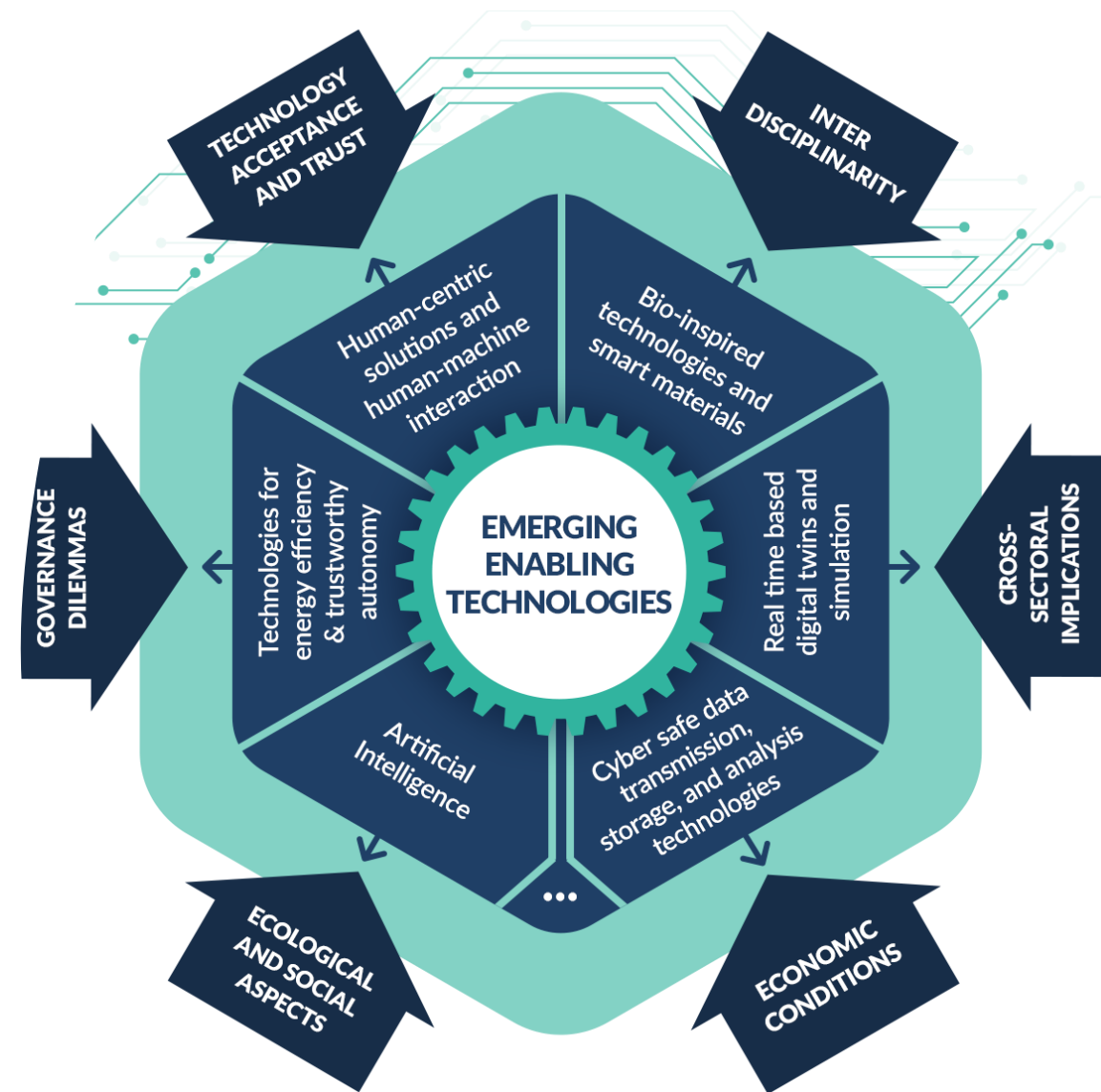
To learn more about the project and join the FORGING forum, visit the project website: https://forging-hub.eu/
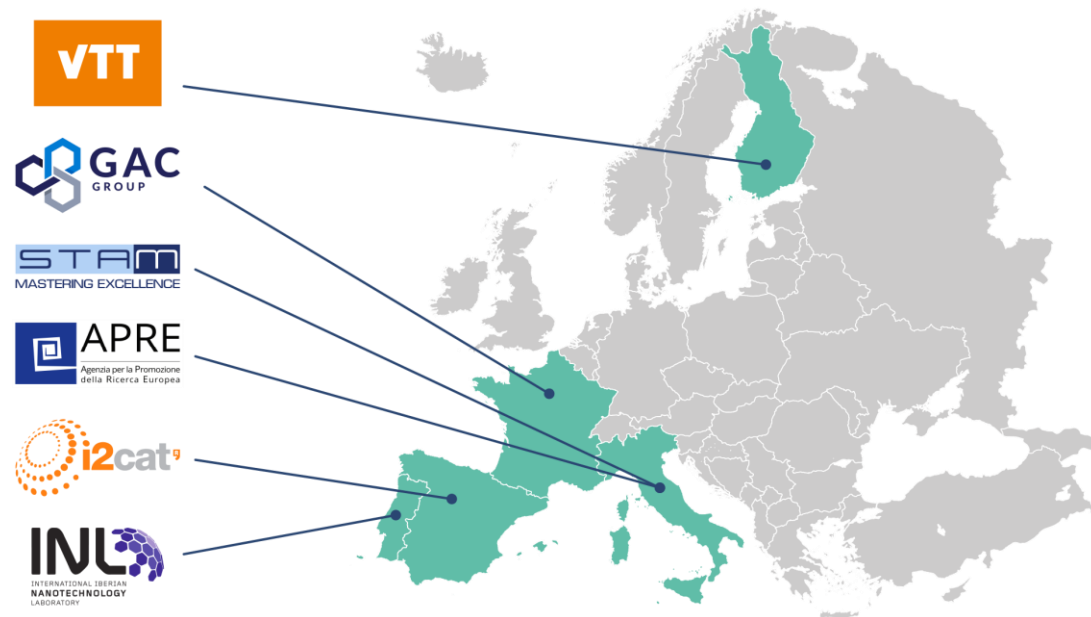
Emerging technologies: six technology frameworks

FORGING focuses on six technology frameworks. Each of these frameworks describes emerging technology sectors with huge potentials for future applications.

In the FORGING methodology, most of the same workshop methods are adapted for each of the six technology frameworks. Therefore, all of the methods and tools provided in this prototype Toolbox are suitable for all emerging technology frameworks.

Value sensitive innovation journey

Research

What is done?
Scientific research on new technological capacities and technologies

Key responsibility considerations:

Inclusive, ethical and open research practices

Potential future impacts of new technologies

Development of concepts & products

What is done?
Scientific discoveries are turned into concepts and products to be adopted by consumers/ users

Key responsibility considerations:

Designing for social good and fairness, anticipatory mindset

Sustainable & responsible design

Introduction & early implementation

What is done?
New technological products are introduced & adopted to use in a limited environment or by a limited group of people.

Key responsibility considerations:

Ensuring user rights

Monitoring environmental impacts & perfomance

Scaling-up & fine-tuning established technologies

What is done?
New technologies become part of the everyday life as "normal" or even necessary.

Key responsibility considerations:
Ensuring inclusion in shifts of hegemonic practices, understandability for users

Resource use, systemic impacts to patterns of consumption

Research organisations (universities & RTOs)

Big companies, technology startups

Public institutions

Early adopter consumers

Citizens

Value sensitive innovation journey

The Value Sensitive Innovation Journey is a depiction of the FORGING approach towards responsible innovation processes. It combines multiple existing approaches to innovation processes, adding the layer of value sensitive considerations into the widely shared phases of innovation process.

In the previous slide the overview of the different stages is presented. In Deliverable 1.4, complete innovation journeys for each of the six technology frameworks with more in-depth responsibility considerations are presented. The complete Innovation Journeys can be used as a reflection tools to identify themes that are important in different phases of the life cycle of emerging enabling technologies.

The FORGING project aims to cover all phases of the innovation journey, engaging all the most important stakeholders related to chosen technologies.

In this prototype version of the Toolbox, the tools from the first year of the FORGING project are presented. Therefore, the current emphasis of the presented tools is in the first two phases of journey.

How to use the FORGING Toolbox?

FORGING Toolbox is here to guide other projects and organisations dealing with emerging technologies into a responsible and co-creative journey of their own. This prototype Toolbox offers an array of methodologies and tools used in FORGING.

In the next slide, we offer suggestions for different tools to be used in different phases of the innovation journey. FORGING project predominantly deals with earlier stages of the journey, as it explores the emerging enabling technologies. However, many of the methods and tools can be used also in later stages of the innovation journey.

This prototype of the Toolbox will be complemented during the duration of the project. More methods and tools used in FORGING will be added, and input from the wider FORGING community will be gathered to create a more comprehensive Toolbox for academia and industry to tackle the challenges of emerging technologies.

This Toolbox is designed to work as a living document, also contributing to post-project sustainability.

Playbook: How to choose the methods and tools?

For all stages:
- To engage stakeholders in development ➡ 1. Co-creation in the field of emerging technologies
- To create empathy for and understanding of different stakeholders ➡ Perspective cards

Based on the phase of the Value Sensitive Innovation Journey you are currently working on:

Research

- To understand the potential future implications of research
  - → *Futures workshops*
- Widen research team's perspectives and gain new ideas
  - → *Cross-fertilization*

Development of concepts and products

- To build societal acceptability of technologies
  - → *Visualisation of workshop results*
- To prioritize the technologies with the most potential positive impacts
  - → *Technology clustering workshop*
- To build holistic understanding of potential societal impacts of certain applications
  - → *PESTLE analysis*

Introduction & Early implementation

- To understand which technologies might be growing soon
  - → *Strategic Matrix*
- To ensure responsible implementation and choice of technologies
  - → *Values exploration through expert interviews*
- To enrich user-understanding with expertise on the topic
  - → *Early co-creation workshops*

Scaling-up & fine-tuning established technologies

- To support responsible take-up of new technologies
  - → *Special Interest groups*

FORGING Methods & Tools

1. Co-creation in the field of emerging technologies

What is it and why should I use this methodology?

- Co-creation widely refers to methods to involve stakeholders to problem definition, research, design, analysis or interpretation of results.

- Including a wide range of stakeholders is especially important in the field of emerging technologies (ETs) as co-creation can significantly increase the possibilities of achieving societally acceptable and preferable technologies.

- While ETs cannot offer solid data about their future, they offer a unique opportunity to intervene in their early development process since it is still ongoing. An early intervention in the process makes it possible to prevent unintended results and embed those values that can lead to the most positive impact possible in society.

- Co-creation can ensure developing technologies and applications that are widely accepted and adopted for different uses, thus also boosting business success.

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How was this methodology used in FORGING?

- Different co-creation methodologies are utilised in different phases of FORGING, including series of different co-creative workshops.

- In this Toolbox, several co-creative methods used in FORGING will be introduced after this general introduction into co-creation.

1. Co-creation in the field of emerging technologies

What is needed when using this method?

- Diverse group of participants is the key to successful co-creation. Technology developers, policymakers, representatives from civil society, and end-users might be relevant to include.

- A collaborative space conducive to open discussion and interaction is needed as well as tools for ideation and documentation (whiteboards, sticky notes, markers, or alternatively an online space).

- Co-creation needs to be facilitated to promote mutual understanding between actors from different sectors and disciplines. Facilitators should take an impartial role. Experience in facilitation and understanding of the ETs being discussed are useful.

Phase-to-phase description of the methodology

1. Start by identifying the relevant stakeholders for the specific action or technology.

2. Develop a specific strategy to involve the mapped stakeholders. The strategy should be tailored to the type of actors to be involved.

3. Involve the stakeholders in dedicated co-creation sessions to: **i)** understand the current state and future trends of the emerging technology; **ii)** identify needs, challenges and opportunities the technology could address; **iii)** collaboratively generate solutions or prototypes; **iv)** engage stakeholders in testing and provide feedback loops for iterative improvement.

1. Co-creation in the field of emerging technologies – ethical considerations

Ethical considerations for co-creation activities

- Strive for inclusive participation that reflects the diversity of the community or sector impacted by the technology.

- Maintain transparency throughout the process about goals, methodologies, findings, and clearly communicate any plans for future use of collected data, respecting privacy and intellectual property rights.

- The ownership of the ideas is collective, and the results should be shared as collective outputs even when participant names are public. This creates a safe space for creative out-of-the-box ideas in the discussions.

- Ensure that all stakeholder data is handled in compliance with privacy laws (i.e. GDPR) and ethical standards. Ensure that all participants provide informed consent and understand their role in the co-creation process.

- Informed consent should address at least the following points: photographing and recording, using the results, publishing participant names, sharing contact details between participants.

2. Futures workshops

What is it and why should I use this methodology?

- A participatory co-creation method for building alternative futures images as a multi-perspective, societal framework for the contextualising of emerging technologies. The method proposes a value-driven analysis on interaction between technological frameworks and their socio-economic context.

- Futures workshop methodology proposes a creative approach to understanding potential impacts of emerging technologies, calling for experts to use their imagination as a tool for understanding implications of potential technological trajectories.

- The method aims to validate and create a shared understanding on emerging futures with technology framework experts ranging from technological to industry, policy and governance, and societal expertise.

- The method is especially valuable in situations where the maturity level of emerging technologies is still low and future directions are uncertain.

How was this methodology used in FORGING?

- Futures Workshops were used as a starting point for the overall co-creation approach.

- The societal emphasis of the Futures workshops aimed at creating a solid background understanding for the latter co-creation phases of the project.

- See in this Toolbox:
  - Warm-up: one-two-three
  - Core assumptions exercise
  - Signal Matrix
  - Future states PESTEC exercise
  - Futures narratives
  - Future news

2. Futures workshops

What is needed when using this method?

- The workshop should be hosted as a face-to-face event to allow for vibrant discussions, and ideally it should evolve throughout two days to allow the briefing of participants.

- Material surroundings needed include: computer and projector, tables for group work, templates, post-its and pens, catering.

- Ideally 20 participants, to be divided into four internally diverse groups concerning for example expertise and professional affiliations, gender, nationality, seniority, etc.

- Basic understanding about futures thinking for facilitators is needed. At least basic understanding of the technologies is also useful. Allowing for creative discussion, moderating the discussion to allow each participant space for expressing their views, and creating a safe space for even silly-sounding ideas is important.

Phase-to-phase description of the methodology

1. Careful planning of the workshop is essential. Consider that participant list to include the most important stakeholders for the topic. Reserve a space that suits groupwork (tables, noise levels, projector, etc.).

2. The workshop is ideally divided into two days to allow for briefing and orientation during the first day, and the working session on the second. It is important to reserve time for informal discussions and networking as well. See a suggested schedule in the next slide.

3. After the workshops, analyse the results by identifying key themes present in each group and compare between groups. For wider audiences, results can be visualised in a story format (see the method description).

2. Futures Workshops – suggested schedule and agenda

Day 1 (17.00-19.00)

17.00-17.05	Participants arrival and registration
17.05-17.15	Welcome and introduction
17.15-18.00	SESSION 1 | Setting the scene for the foresight workshop
18.00-19.00	Networking dinner

Day 2 (09.00-15.00)

09.00-09.07	SESSION 2 | Signals and characteristics of societal scenarios
09.10-09.15	Warm up
09.15-9.30	Group work – Core assumptions
09.30-10.00	Group work – Selecting signals of change
10.00-11.30	Group work – Describing the future states of signals
11.30-12.30	Lunch break
12.30-12.40	SESSION 3 | Methodology and ways of working on future narratives
12.40-14.30	Group work - Writing future images and narratives
14.10-14.45	Presenting the future narratives
14.45-15.00	CLOSING SESSION | Feedback and next steps

CONTINUED GROWTH

Scenarios are built around the ideal of economic growth as the most important value in ensuring a well-functioning society.

2/15/2023

PPT stock image

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COLLAPSE

Scenarios anticipate how system's internal or external change factors lead to a return to a significantly less developed society, or to a complete destruction. May be viewed positively as enabling renewal.
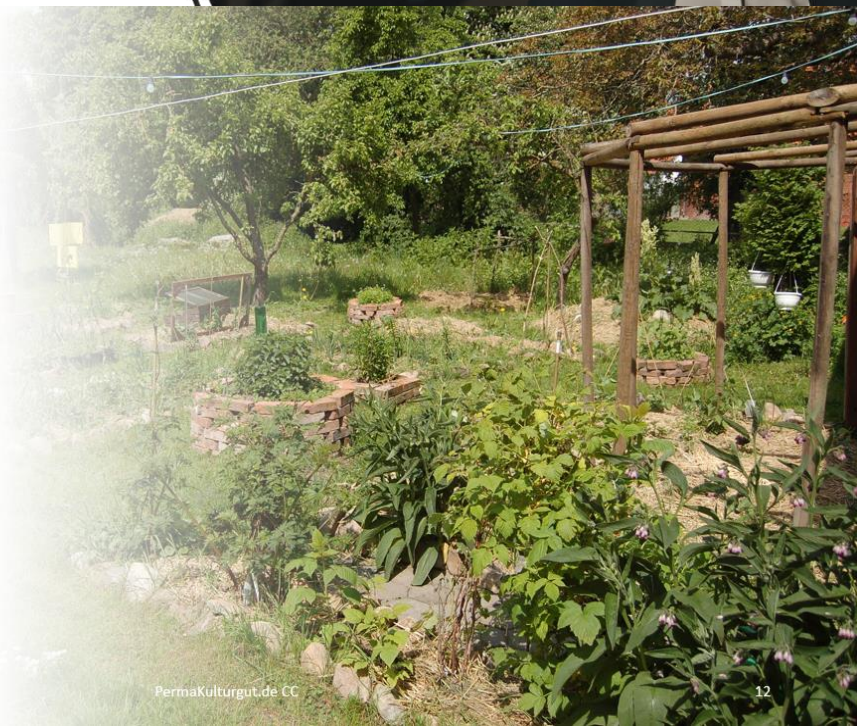
By Thomas Cole - Explore Thomas Cole, Public Domain, https://commons.wikimedia.org/w/index.php?curid=183045

2/15/2023

DISCIPLINE

Scenarios emphasize the required systemic changes needed to preserve well-being. The economy and the society refocus on survival, fair distribution, and preserving important places, processes and values that are felt to be threatened.

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TECHNOLOGICAL TRANSFORMATION

In these scenarios technology transforms all life, including humanity, from its present form into a new "posthuman" form.

2/15/2023

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TOOL – Warm-up: One-two-three

What is this and why should I use it?

This is an easy warm-up exercise and ice-breaker before starting groupwork. Despite being easy, the warm-up is also a safe way to fail and laugh together, breaking the ice. In addition to the laughter and connection with other participants, the method is physical, which enables creative thinking in the workshop.

How simple is this tool to use? What is needed?

Easy to use in face-to-face settings, requires only five minutes of time and no extra resources.

Any possible pitfalls to avoid?

Time use should be monitored, even though this exercise is fun, it should be kept short to not steal time from group work.

How to use this tool?

Everyone stands up and picks a pair, preferably someone they don't know previously. Facilitators demonstrate before each round. First round: first of the pair says "one", the second continues "two", the first again "three", after which the second starts from the beginning by saying "one". After the facilitators have demonstrated a few times, the participant pairs go through the first round. In the second round, "one" is replaced by snapping fingers, followed by "two" and "three". In the third round, "one" is snapping fingers, and "two" is also replaced by clapping hands. In the fourth round, "three" is also replaced by foot stomping, and no numbers are said aloud anymore. Most pairs will find the exercise surprisingly difficult, which provokes laughter and liberates the atmosphere.

TOOL – Identifying core assumptions

What is this and why should I use it?

In philosophy a core belief means an initial fundamental truth, a certainty, the base upon which other beliefs are constructed. Core beliefs are cornerstones of decision-making, they are often unspoken, partly unconscious and may even contain mythical elements. Therefore, they often are not questioned in scenario work. This exercise aims at identifying core beliefs. While not always easy, making core belief explicit and discussing them helps to broaden views of what could be possible.

How simple is this tool to use? What is needed?

Easy to use, requires 20 minutes of time, instructions, a template for writing down the assumptions, can be done either individually or in a group.

Any possible pitfalls to avoid?

This is an important phase in the workshop so enough attention and time should be allocated to the execution.

How to use this tool?

- Time: 20 min

- A core belief is something that you believe remains relatively unchanged over a period of time.

- Examples of possible core beliefs: "Economic growth is an important societal objective", "Human beings need physical interaction"

1. Which things you believe will not change by 2050? Identify 3-5 core beliefs and write them down on post-its.

2. Discuss the core beliefs in your group and place them on the template.

3. You can return to this list of core beliefs at the end of the workshop. Were any of these beliefs impacted by the work?

TOOL – Signal Matrix

What is this and why should I use it?

This tool helps to collect and analyse trends, megatrends, weak signals and drivers of change (signals of change) as basis for images of the future for each scenario.

How simple is this tool to use? What is needed?

The use of the tool is relatively challenging and requires background work on the topic and signals, along with a trained facilitator. The best results are obtained when the participants have expertise on the themes discussed.

Any possible pitfalls to avoid?

The facilitator needs to be able to support participants in the use of the matrix, and to manage time. Discussions easily go off the focus, so facilitation is needed to stay on the topic.
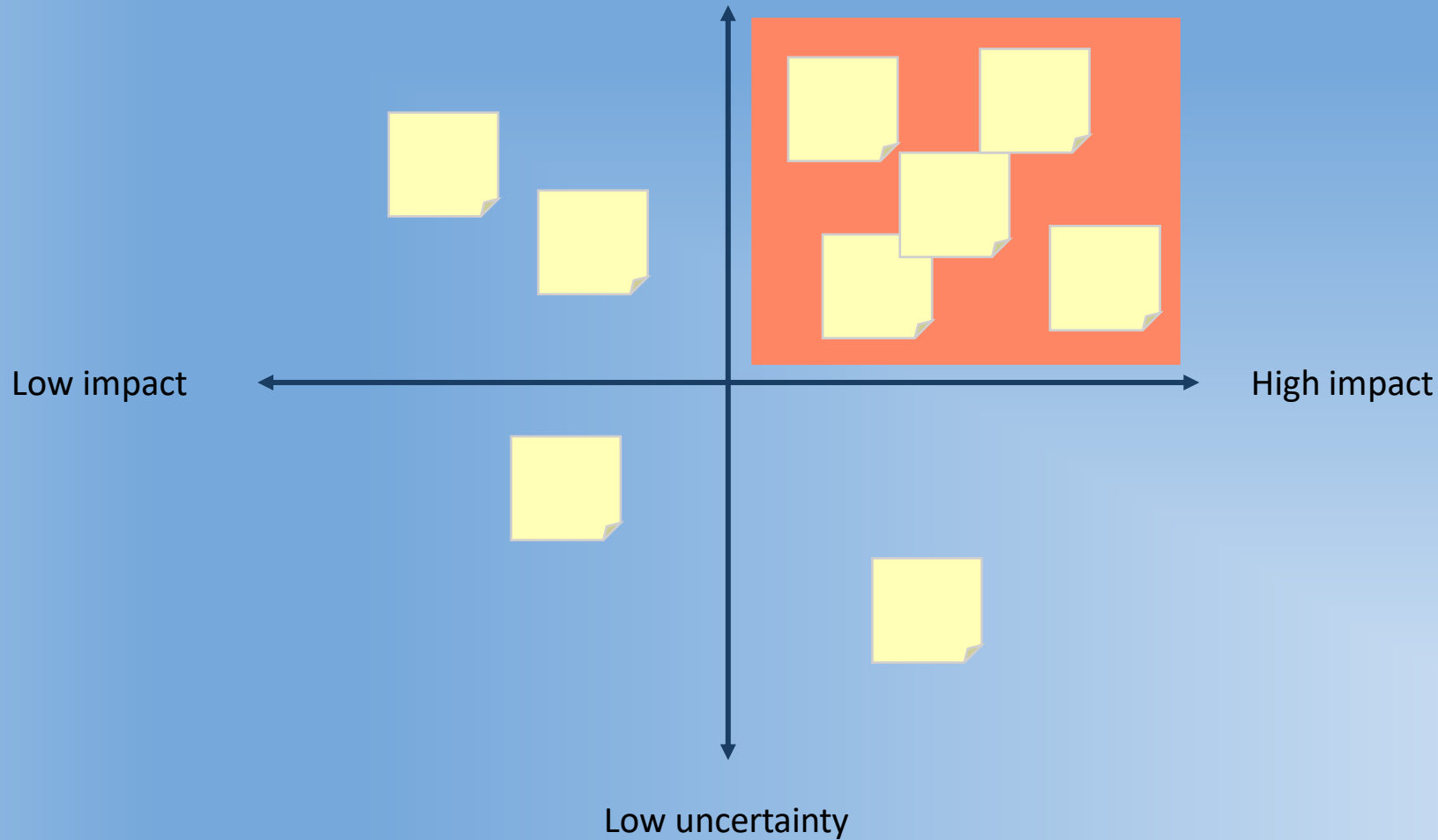
How to use this tool?

- Time: 30 min

1. Write on post-its your personal choices for significant signals of change for each PESTEC category

2. Discuss the selected signals together and place them on the signal matrix

3. Select ONE signal of change for each PESTEC category.

- You will base your scenario work on the selected signals.

TOOL – Futures Table

What is this and why should I use it?

This version of a Futures Table is a tool for describing the future states of the signals. It is used as a tool for prioritising the most impactful signals of change and for facilitating the description of the scenario.

How simple is this tool to use? What is needed?

With clear instructions this tool is relatively easy to use, as it builds on the previous phase and participants have already discussed the signals in detail.

Any possible pitfalls to avoid?

A challenging phase in the use of the tool is understanding the difference between the present day signal and their impact in the future (future state). This difficulty can be mitigated by clear instructions.

How to use this tool?

- Time: 50 min

- Imagine how the signals you selected could manifest themselves in your scenario in 2050:

1. Write your descriptions on post-its

- This can be done individually, in pairs etc.

2. Discuss the descriptions and form a coherent (short) description for each PESTEC category

3. Write the final descriptions on post-its in your futures table

- This is the starting point for the next phase

TOOL – Futures Table – A Template

FUTURES TABLE	Political (P)	Economic (E)	Social (S)	Technological (T)	Environmental (E)	Cultural (C)
SIGNALS						
FUTURE STATE 2050:						

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TOOL – Futures Images

What is this and why should I use it?

It is characteristic for humans to want to know about the future developing images of the future, both consciously and unconsciously. Some of the images are socially and mutually shared, while some are personal. The images are systemic by nature: they are formed from knowledge and flavoured with imagination. Images of the future emerge as hopes, fears, and expectations, and therefore influence decision making, choices, behaviour, and action. This tool helps to articulate the images of the future co-created in the workshop for each scenario.

How simple is this tool to use? What is needed?

This tool is relatively easy to use, as it draws together the different elements from the previous phase.

Any possible pitfalls to avoid?

This phase already requires imagination and an ability to find the key metaphor or idea carrying the image. The facilitator should support this phase so that it does not get lost.

How to use this tool?

- Time: 50 min

- Co-write a description of the world in 2050 according to your futures table
    1. Base your future image on your futures table bearing in mind the selected signals and their states in 2050
    2. Name your future image with a punchy name

- Select a secretary for your group

- Write with pen & paper or on a computer

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TOOL – Futures News

What is this and why should I use it?

A way to narrate the future image in a compelling way. Storytelling is a way to bring imagination and a human-centric element to the images. In creating a news piece about the future image forces the participants to concretize the societal impacts of technology.

How simple is this tool to use? What is needed?

The use of the tool builds on the previous phases and requires an open atmosphere and creativity so that even unconventional ideas about the future can flourish. Future news can be produced on a template but that is not a necessary element of the tool.

Any possible pitfalls to avoid?

Depending on the time management of the whole workshop, this tool may suffer from lack of time and also the participants may be tired at this phase. Therefore, this phase required careful facilitation.

How to use this tool?

- Time: 30 min

- You will spend a moment working in the editorial team of *Future News*.
  1. Create the front page in 2050. Create a headline that describes the image of the future you have created earlier and a small article describing an event.
  2. If you have time, you can add other news as well.

- Select a secretary for your group

- Write with pen & paper or on a computer

3. Visualisation of workshop results

What is it and why should I use this methodology?

- Visualisation is a method for presenting workshop results in a more popular format to reach a wider audience.

- Co-creative process between researchers and artist for creating stories that are visually persuasive, scientifically relevant and narratively coherent.

- The stories and images are created to capture the whole spectrum of technology uses and potentials present in the workshop results. Visualisation captures the complex ideas expressed by futures workshops participants, fostering a sense of empathy, and envisioning possibilities and opportunities through the lens of hope.

- The convergence of narrative-based approaches and visual arts provides an extended platform for critical interpretation of possibilities and opportunities.

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How was this methodology used in FORGING?

- The Futures Workshop results were visualised for a more popular format and wider audience.

- A visual artist and art educator was commissioned for a process of co-creation of the storyline and translation of the story into imagery.

- See for the final result:

  - https://forging-hub.eu/theseus/

3. Visualisation of workshop results

What is needed when using this method?

- A strong team is the key for the creative process. Commissioning an artist is crucial for the success of the whole process. The team should work well together, and to establish a working team interviewing different candidates for the artist role can lead to best result.

- A mindset that allows a creative process to be even chaotic at moments. The end results are not always clear at the beginning of the process, and allowing the results to emerge from the co-creative process might require several rounds of ideation and re-defining the format of the story and visuals.

- Publishing platform need to be considered: will the product be printed, published on a website, in a video format or something else? The publishing forum and needed expertise needs to be considered.

Phase-to-phase description of the methodology

1. Put together team for the co-creation. A visual artist should be commissioned in addition to the researchers.

2. Analyse the workshop results, specifically the stories or news created with narrative approach, for the prominent technology applications, potentials and risks envisioned. Special attention is paid at the depictions of technologies and their impacts on lifestyles, values and well-being.

3. Through co-ideation, create an overarching visual metaphor powerful enough to tie together all the envisioned uses of different technologies. Once an overarching metaphor is found, individual stories, both narrative and visual, are drafted through a co-creative process.

4. Publish the end result in a format that is compelling for a wider audience.

4. Early co-creation workshops

What is it and why should I use this methodology?

- A participatory co-creation method aimed at exchange on first round of analysis. The workshop also aims at detecting signals of new technologies.

- Early co-creation workshops approach started from the more technological perspective – introducing the results of Strategic Matrix analysis – while smoothly considering also the socio-environmental aspects – at the core of the value sensitive innovation journey.

- This method allows a structured exchange on existing knowledge, while creating new one through active discussion tackling specific goals.

- The workshop approach focuses on reviewing existing (preliminary) results with experts, gaining additional insights and validating the results.

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How was this methodology used in FORGING?

- This methodology was one of the early co-creation activities hosted during the project. It was valuable in understanding specific aspects of different technology frameworks in the early stage.

- In the workshops, results from desk research was introduced and discussed, while scanning new approaches for up-coming co-creation activities.

- See in this Toolbox:
  - PESTLE analysis
  - Cross-fertilization
  - Strategic Matrix

4. Early co-creation workshops

## What is needed when using this method?

- One or more facilitator(s) depending on the number of participants (one or more groups). The facilitator(s) should be well-prepared on the topic and willing to engage with experts guiding them to the overall goal of the workshops.

- Experts should be guided also prior to the workshops, by giving them supporting materials and research results. This allows experts to have a preliminary knowledge on the workshop content.

- A comfortable setting, possibly with round table and/or chairs in circles. This fosters interactions and decreases the barriers among participants. A template to note down desk research and new proposal may be useful as well.

- Selection of experts is crucial, as the methodology depends on their familiarity with the topic at hand, allowing them to share insights and knowledge.

Phase-to-phase description of the methodology

1. Select the facilitator(s) and organise meetings to organise the workshops. Facilitators should be aligned.

2. Provide initial desk research results and collect the experts' perspectives.

3. Analyse the application areas discovered. Use the PESTLE framework to create a holistic understanding of their impacts.

4. Bring together experts with expertise on different technology frames on a cross-fertilization exercise. Discuss with the experts the main aspects resulting from the co-creation and identify the initial main outcomes of the discussion

5. Reorganise the notes taken during the workshops and provide a final feedback such as a report or a more structured deliverable. Please consider the final audience when drafting the results report.

4. Early co-creation workshops – example of template

Results from desk analysis

DESK ANALYSIS

New Proposal
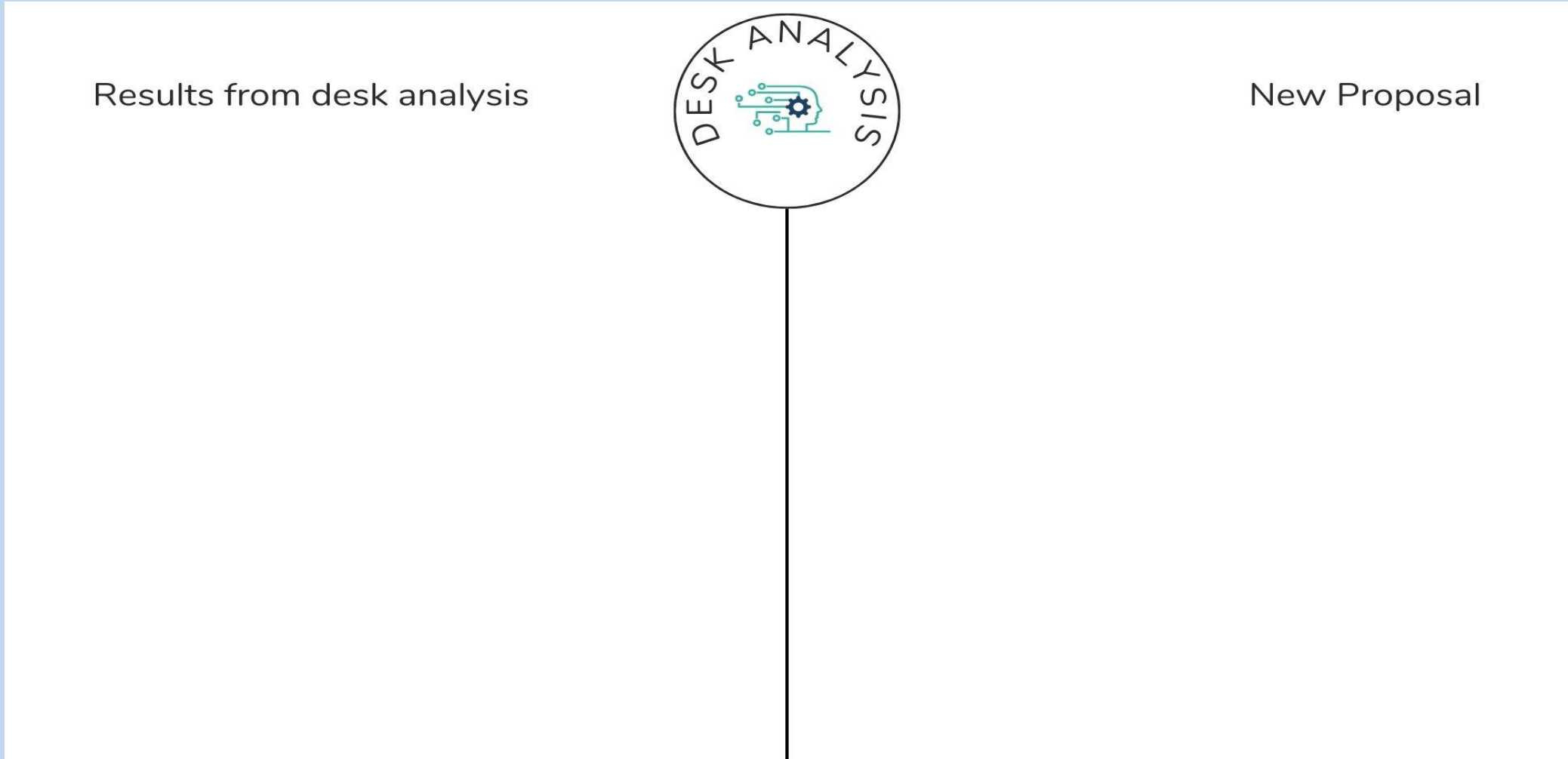
TOOL – PESTLE analysis

What is this and why should I use it?

This is a workshopping tool aimed at analysing challenges and barriers of emerging technologies. PESTLE stands for *Political, Economic, Societal, Technological, Legal and Environmental*, reflecting the different perspectives for the analysis. The tool allows a deeper and more precise understanding and identification of the challenges that may arise when reflecting on a new emerging technology.

How simple is this tool to use? What is needed?

Easy to use. Requires at least 1h of time and simple materials like pens, notebooks, sticky notes, empty papers for each of the six thematics that are discussed.

Any possible pitfalls to avoid?

To gain the full advantage of the tool, select experts with diverse expertise about the topics addressed. Too similar expertise areas might lead to limited perspectives during the discussions.

How to use this tool?

- This tool is used in a workshop setting, ideally face-to-face in a space suitable for horizontal discussions (e.g. chairs in a round shape).

- For the analysis, select one technology framework and ideally one technology within the framework.

- Establish one moderator to manage the discussion.

- In the beginning, allow time for self-reflection and note taking (e.g. on sticky notes) on each of the PESTLE categories.

- Discuss each of the six aspects of the PESTLE starting from the sticky notes produced individually.

- The tool should lead to a shared understanding of possible ways to foresee and overcome possible challenges related to the PESTLE aspects.

TOOL – PESTLE analysis – topics to be explored

POLITICAL	TECHNOLOGICAL
Political context which may effect a sector. E.g. Fiscal policy, rates and fares, import taxes	Progress and tech innovation. E.g. automation, tech change rates, tech incentives
ECONOMIC	**LEGAL**
Factors that may influencebusiness and industry tendecies. E.g. Economic growth, interest rates, inflation	Aspects related to people's rights. E.g. Antitrust, right to work; right to health; right to safety
SOCIAL	**ENVIRONMENTAL**
Social changes that may influece the society and having effects on consumers. E.g. demographic growth, age, health, security	Aspects related to global situation. E.g. gloabl warming, greenhouse effect, natural disaster

TOOL – Cross-fertilization

What is this and why should I use it?

It is a workshopping tool, aimed at fostering interdisciplinarity and increasing knowledge exchange across technological application areas. Using this tool may allow a broader understanding of a technological framework as it considers new perspective coming from another framework.

How simple is this tool to use? What is needed?

Easy to use. Requires at least 1 hour time for the discussions, depending on the chosen thematic. Easy material to be used: pens, notebooks. Experts from different technology frameworks with an open mind for peer exchange are the most important asset for this tool.

Any possible pitfalls to avoid?

Selection of experts is crucial; therefore, it is important to know in advance who will join the two groups in regard to the thematic addressed during the cross-fertilisation.

How to use this tool?

This methodology can be implemented by:

- Selecting two technological frameworks (possibly complementary and/or with affinities, e.g. artificial intelligence and digital twins).

- Selecting a thematic to by tackled during the cross-fertilisation (e.g. arising from the PESTLE analysis, if following early co-creation workshop structure).

- Placing the two groups in one place (e.g. a conference room) suitable for horizontal discussion (e.g. chairs in round shape).

- Establishing one moderator (possibly not from the two groups) to manage the discussion.

- The content should be related to both frameworks, so that to investigate what can be beneficial from one topic to the other one and vice-versa.

TOOL – Strategic Matrix

What is this and why should I use it?

This tool represents the actualisation of the FORGING approach in matching together potential areas of application with the technology's clusters. The methodology is based on reviewing current literature and extracting data from relevant databases to see which technologies are currently rising or emerging.

How simple is this tool to use? What is needed?

The tool refers to a desktop analysis, therefore its simplicity is strictly related to the object under analysis. Basic understanding about the area of analysis is needed. Access to relevant data bases and knowledge sources is also crucial.

Any possible pitfalls to avoid?

Limits of the research methodology are related to availability of information and complexity of the analysis. Therefore, it is important to consider the limits of the research and its possible solutions.

How to use this tool?

- This tool builds on a dynamic process, based on research databases and literature review.

- This tool is used for clustering technologies and potential application areas and combining them together to see whether there is a match among the two variables.

- Desk-top research analysing up-to-date information about emerging technologies' development by reviewing current scientific literature and relevant technology reports to scout for current trends.

- Data about patents and recent projects on specific programmes have been taken into account as part of the methodology.

5. Technology clustering workshop

What is it and why should I use this methodology?

- This is a collaborative workshop methodology designed to engage stakeholders in the evaluation and prioritization of Emerging Technologies. It focuses on co-defining evaluation criteria and establishing a priority clustering of technologies with an emphasis on responsible innovation and sustainability.

- The structure of the workshop is designed to take place online, but it can be easily adapted for a face-to-face format.

- The methodology leverages co-creation and participatory decision-making to ensure a broad range of perspectives are considered in assessing the potential impact and desirability of technologies.

- It facilitates a deeper understanding among stakeholders of the societal, environmental, and ethical implications of emerging technologies. The expected outcome is the development of a priority clustering of technologies that reflects a consensus on their potential impact and desirability, considering responsible and sustainable innovation aspects.

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How was this methodology used in FORGING?

- This workshop methodology was utilised for prioritising the most important technologies for the continued co-creation process of FORGING.

- A separate workshop was organised for each of the six technology frameworks.

- See in this Toolbox:
  - Ice-breaker: divergent thinking (ME-US)
  - Canvas for co-defining scoring criteria

5. Technology clustering workshop

What is needed when using this method?

- As an online workshop, a trusted and secure online meeting platform is required. Facilitators should have the role of host or co-host while participants should be given the ability to turn on the video, microphone and access the chat.

- Online co-working platform with used canvases should be used for visually presenting the discussions.

- Understanding the technologies being evaluated is important for facilitators to provide participants with informed guidance.

- Facilitators should encourage open dialogue and ensure all voices are heard. Prepare some questions and examples that can facilitate the discussion.

Phase-to-phase description of the methodology

1. Before the workshop: invite participants from varied backgrounds to ensure diverse perspectives. At the same time, limit participation to relevant stakeholders. Provide to the participants clear information about the goal and expected outcomes of the workshop, the role of participants, introduce the technology portfolio to be evaluated and the responsible innovation concept.

2. During the workshop:

   - Session 1: present the responsible considerations related to the technologies and engage participants in defining evaluation criteria, focusing on aspects such as societal impact, sustainability, human desirability other than feasibility.

   - Session 2: facilitate a co-creation session where participants use the defined criteria to cluster the technologies according to their potential impacts. Allow participants to vote the technology they consider most promising in terms of social impact.

3. After the workshop: share with the participants main results and takeaways from the event.

5. Technology clustering workshop – suggested agenda

Time	Topic
09:00 – 09:30	Welcome and Introduction Illustrate the workshop goals, go through the agenda, and conduct a short icebreaker session
09:30 – 09:50	Social and environmental considerations Introduce to the participants key social and environmental aspects
09:50 – 10:45	Session I: Co-definition of scoring criteria to select Emerging Technologies Participants will collaborate to co-define scoring criteria to evaluate the technological portfolio.
10:45 – 11:00	Coffee break
11.00 – 11.15	Presentation of the Technology Portfolio Present the set of technologies identified through desk analysis or previous co-creation sessions.
11:15 – 12:15	Session II: Co-creation of the Priority Clustering Based on the selected criteria, participants will revise the initial technological portfolio and create a priority cluster of the technologies.
12:15 - 12:30	Final discussion and Conclusions

TOOL – Ice-breaker: Divergent thinking (ME-US)

What is this and why should I use it?

This tool is an icebreaker to be used at the beginning of a workshop to engage the participants. It is a tool that can be adapted to multiple situations (both online and face-to-face) and regardless of the audience/type of stakeholders involved. It is very useful to let participants acclimatize to creativity preparing the mind for work.

How simple is this tool to use? What is needed?

This tool is very easy to use either online or face-to-face. It is sufficient to have any objects at hand.

Any possible pitfalls to avoid?

This ice-breaker tool is easy and fun to use. As long as all participants have their turn and the atmosphere is friendly and accepting, the participants can overcome the initial barrier of expressing their opinion.

How to use this tool?

This tool is organised following 3 easy main steps:

1. Everyone pick an object on hand or in sight. It has a primary purpose (i.e. how the object is ordinarily used). Think about how it could be used differently.
2. ME: List as many other purposes for the object as possible (2 min).
3. US: Declare the alternative uses we have thought of and see which of us have been more innovative (5 min).

TOOL – Canvas for co-defining scoring criteria

What is this and why should I use it?

This tool is used for co-creating criteria for evaluating emerging technologies. The aim is to co-define criteria that can be used to prioritize emerging technology applications that are likely to lead to sustainable and responsible outcomes.

How simple is this tool to use? What is needed?

Using the tool requires prior analysis to work on. Providing participants with a suggested set of criteria and technologies steers the work towards relevant application areas. Once the prior analysis is ready, the tool is easy to use.

Any possible pitfalls to avoid?

It should be ensured that the criteria is drafted for the relevant level of abstraction considering the technological applications that are being evaluated. Too narrow framing makes the exercise difficult, while too broad focus limits the usability of results.

How to use this tool?

- Start by introducing the background work for the participants. Let them know, which technology applications are being discussed and which types of criteria are you looking for.

- Allow time for individual thinking and writing in the beginning.

- Discuss the inputs together. At this point, it is important to give space for the participants' ideas and thoughts, and allow the criteria to be drafted co-creatively during the discussion.

- As the suggested criteria is in place, let the participants vote for the criteria which they find the most relevant. Let the voting define which criteria are taken up in the latter phases of evaluating emerging technology applications.

FORGING

6. Special interest groups

What is it and why should I use this methodology?

- Special Interest Groups (SIGs) are synergistic networks of individuals trained across different fields of expertise to elaborate pathways towards future technological applications of a variety of emerging enabling technologies stemming from the technological frameworks of the Industry 5.0.

- The SIGs stem from the FORGING FORUM, a community developed by FORGING project to provide an open, inclusive, and supportive bottom-up approach for the absorption and deployment of the most promising emerging enabling technologies.

- The aim of this methodology is to develop technology pathways for absorption and deployment of technologies stemming from 6 identified use cases during the co-creation stage. The method is a valuable analytical bottom-up tool enabling contrasting the use cases identified during the FORGING co-creation activities and the technology roadmaps of each one of the partnerships.

How was this methodology used in FORGING?

- This method is envisioned as a tool for the later stages of FORGING co-creation approach. It follows a series of prior workshops and further defines their outcomes.

- This methodology is still to be implemented in FORGING, and a more detailed description will be provided in the final version of the Toolbox.

6. Special interest groups

What is needed when using this method?

- The workshop should be hosted as a face-to-face event to allow for vibrant discussions. In order to enable high-level participation the workshops should be organised as parallel or sequential to relevant large event such as a conference or EU R&I flagship event.

- Material surroundings needed include: computer and projector, templates, post-its and pens, catering.

- Ideally 8-12 expert participants from academia, industry and EU partnerships.

- Experience in facilitation and technology transfer is helpful. Good understanding of EU emerging technologies landscape and the relevant EU partnership technological roadmaps is needed.

- Facilitation requires time-keeping and consensus-seeking bundled with an idea summarization competencies.

Phase-to-phase description of the methodology

Tentative methodology for pilot SIG workshop implementation:

- Setting the scene and presentation of use cases identified during the co-creation is sent to the participant prior to the workshop

- Start of the workshop with an ice-breaker and introductions of participants

- 2-3 groups of participants working on proposals of technology uptake pathways (answer the questions Who? What? Why? and How? related to acceleration of new enabling technologies into industry and society)

- Each group presents the results to the others

- Groups have an opportunity to discuss and challenge the pathways elaborated by each group

- Closure of the workshop

- Follow-up on the workshop will be done through Tech and Innovation Campaigns

7. Values explorations through expert interviews

What is it and why should I use this methodology?

- The method reveals potential for unintended consequences of emerging technologies in the society and the environment.

- Expert interviews are a foresight tool that enables in-depth access to a research topic through dialogue and consultation with qualified individuals.

- It is recommended to combine interviews with desk research when exploring an emerging topic. A good understanding of the experts' background is crucial for the results.

- A semi-structured approach is recommended. The use of probes such as the Value Sensitive Innovation Journey can guide the interview.

- The interviews can be done individually or in focus-groups, or the two approaches can be combined.

How was this methodology used in FORGING?

- The interviews were conducted with leading experts with distinct social sciences angle into the technology frames.

- The same experts were also invited into a focus group discussion around the topics. The focus group served to highlight common concerns between the technology frameworks.

- The interviews highlighted dimensions to be included into the value sensitive innovation journey and the perspective cards.

7. Values explorations through expert interviews

What is needed when using this method?

- At least basic understanding of the thematic area to be covered is needed.

- Selection of experts with deep understanding of the topics is crucial for achieving good quality results.

- An interview guide should be developed to ensure the coverage of similar themes in each interview.

- The interviews can be online or face-to-face. In either case, the interviews should be recorded for the analysis.

- For the focus group, online platform with structured probes for group work is needed if conducting the focus group online. A template for structuring the discussion is useful also in face-to-face settings.

Phase-to-phase description of the methodology

1. Background research in the themes of the interviews is important to be conducted before the interviews. Scanning potential candidates for the interviews is equally important.

2. Schedule and conduct semi-structured interviews with individual experts. Be prepared to deal with potential unavailability of some experts or last-minute changes to the original schedule. Use relevant probes to guide the discussion but leave room for open ended questions.

3. Organise of focus group with all the experts to explore themes that are common for all the thematic areas.

4. Transcribe and analyse the recorded interviews and focus group discussion using at least basic thematic analysis.

8. TOOL – Perspective cards

What is this and why should I use it?

Industry 5.0 takes humans to the centre of industry. These perspective cards are aimed to generate empathy for and understanding of the world views for the perspective holder when designing applications of an emerging technology. The card deck includes six perspectives, which are: Developer (the entity that creates, designs and releases an application); Citizen (including perspectives of agency, education and activism); User (individual, company); Regulator (different levels of governance, including non-traditional regulation actors); Malicious agent (interest group, organized crime, state, individual)

How simple is this tool to use? What is needed?

Six players for the six perspectives are needed for a full game. There is an additional technology card which presents an emerging technology within a use context. The technology card should be tailored for according to the goal of the game which might include refining the use-case, interregating applications of a specific technology, or identifying pathways or social and environmental development of a new product or service. A full round can be played in minimum 1 hour, but can take as long as new perspectives are generated.

Any possible pitfalls to avoid?

Time management is important, as the discussions can take a long time. Players should not pick a perspective card that represents their actual role. For example, a technology developer should **not** pick the "developer" perspective card.

How to use this tool?

They are best used in a role-playing game, where each player takes the perspective of the key stakeholder and examines the set of questions with a particular technology in focus. The card deck includes five perspectives and a technology card. The technology card provides a set of emerging technologies and their priority application areas that are to be discussed individually on each round of the game. The five perspectives provide detailed prompts around the interests of the actors, providing ground for the exploration of considerations about the societal impacts of technology.

This is a game with no individual winner or losers, but a good game will typically generate new ideas, contribute to identifying potential problems, and the solutions for those problems.

You can take multiple rounds and change the perspectives, and you can start the game over with a new technology.

You can find the Perspective Cards from the next slides – six decks for the six technology frameworks.

INSTRUCTIONS

Industry 5.0 takes humans to the centre of industry. These perspective cards are aimed to generate empathy for and understanding of the world views for the perspective holder when designing applications of an emerging technology.

They are best used in a role-playing game, where each player takes the perspective of the key stakeholder and examines the set of questions with a particular technology in focus. The card deck includes six perspectives and a technology card. The technology card provides *a set of emerging technologies and their priority application areas* that are to be discussed individually on each round of the game. The six perspectives provide detailed prompts around the interests of the actors, providing ground for the exploration of considerations about the societal impacts of technology.

The six perspectives are:

- Developer (the entity that creates, designs and releases an application)
- Citizen (including perspectives of agency, education and activism)
- User (individual, company)
- Regulator (different levels of governance, including non-traditional regulation actors)
- Investor/ venture capitalist (funder of companies and start-ups)
- Malicious agent (interest group, organized crime, state, individual)

This is a game with no individual winner or losers, but a good game will typically generate new ideas, contribute to identifying potential problems, and the solutions for those problems.

You can take multiple rounds and change the perspectives, and you can start the game over with a new technology.

Have fun!

TECHNOLOGY CARD

Use this space to describe the technology/technologies discussed.

PERSPECTIVE CARDS

DEVELOPER

QUESTIONS TO CONSIDER:

- How can I minimize the environmental footprint of the solutions both in the usage of equipment and in the conservation of energy?
- How can I design and implement secure systems that protect critical infrastructure, such as power grids, transportation networks, and communication systems, from cyberattacks?
- How can I place the user at the center of my design process in ways that adequately consider the ethical capture, storage and processing of data?
- How do I make sure that my design process addresses the unmet needs of traditionally unrepresented groups?
- Am I confident that the products or services I develop fully take account of social and environmental impacts?
- Can there be an alternative to a patching approach when confronting security gaps?

New questions?

CITIZEN

QUESTIONS TO CONSIDER:

- What kinds of safeguards can be implemented to protect my individual privacy rights?
- How much do I know about the roles and obligations of those that collect or process the data
- What is my personal responsibility over the protection of my privacy?
- Do I understand enough about the potential implications of the data usage to my life?
- Do I know enough to make others accountable for the breaches to the integrity of my data?
- To what extent can I take an active role in the design of the technologies that enable safe data collection, transmission and processing?

New questions?

USER

QUESTIONS TO CONSIDER:

- Do I understand the risks and implications involved in using data collection, storage and processing systems that might not be secure enough?
- Do I have the financial resources to implement cyber security measures?
- Do I understand where, how, by whom and for what purposes my data is being used?
- Am I confident in the degree of knowledge that I have about novel threats and vulnerabilities in the systems that I use?
- Do I have the capabilities to implement cyber security measures?
- Do I have a choice between more secure options

New questions?

REGULATOR

QUESTIONS TO CONSIDER:

- Can I establish sufficient incentives / deterrents to ensure the best possible data security approaches are being applied in the market?
- How can I make sure markets have enough players to avoid concentration of power for too few actors?
- How can I best create an environment of collaboration with cybersecurity experts, law enforcement agencies, citizens, and government regulators to combat cybercrime?
- How can I ensure there is a balance between the need for cybersecurity and other important factors, such as economic growth, privacy, and civil liberties?
- How can I further international cooperation to establish and enforce cybersecurity standards for critical infrastructure, financial institutions, and other sectors?
- How can I collaborate more proactively with technology developers to implement effective cybersecurity standards and practices?

New questions?

INVESTOR

QUESTIONS TO CONSIDER:

- Do my investment decisions consider the development of user-centric security solutions that offer users greater control over their data?
- How can I move beyond static defense principles and embrace proactive threat detection and response mechanisms?
- Do my investment decisions prioritise companies developing security solutions that are adaptable, compatible and interoperable with existing infrastructure?
- How can I prioritise sustainable security investments and identify companies developing cyber security solutions that offer robust encryption while minimising energy consumption and computational resources required?
- How can I support the development of open-source security frameworks that are based on community collaboration for faster innovation while maintaining robust access controls and the right mechanisms to prevent malicious exploitation?
- How can I ensure that companies developing AI-powered security solutions demonstrate a commitment to fairness, accountability, and transparency?

New questions?

MALICIOUS AGENT

QUESTIONS TO CONSIDER:

- How can I identify vulnerabilities in data collection, storage and transmission systems?
- How can I best exploit vulnerabilities in data collection systems, such as online forms, mobile apps, and social media platforms?
- How might I use emerging techniques to automate attacks, evade detection, and manipulate data?
- How might I use cyberattacks as weapons of war to disrupt critical infrastructure and compromise national security?
- How might I exploit the unique security challenges posed by the increasing integration of digital devices into critical infrastructure systems and the everyday life of citizens?
- How might I use targeted cyberattacks to manipulate financial markets, steal funds from financial institutions, or disrupt financial transactions?

New questions?

ARTIFICIAL INTELLIGENCE

PERSPECTIVE CARDS

FORGING

DEVELOPER

QUESTIONS TO CONSIDER:

- How can I design unbiased AI?
- What kinds of applications should I design to serve humanity's interests? What should I not?
- Can I design AI applications to help us become more ecological?
- Do I have the right data for building accurate models?
- How can I influence the most ecological hardware solutions?
- How can I develop solutions that require relatively less computing power?

New questions?

CITIZEN

QUESTIONS TO CONSIDER:
- How does AI contribute to a desirable future for all?
- Can I have influence on what kinds of AI applications are available?
- Do I understand enough about the training or build the models for AI?
- Will I be able to maintain enough connections to other humans, in physical settings?
- Can I resist the lure of technologies even if I felt they were not to my benefit?
- Am I more afraid of the negative outcomes that I can see the potential benefits?

New questions?

USER

QUESTIONS TO CONSIDER:

- Do I understand the risks and implications involved in using AI?
- Does the AI application exclude me as a user?
- Do I know when I am interacting with a human, and when with an AI?
- What are the needs where AI best serves me?
- Do I feel I am a part of the process and practice of developing AI?
- Do I think of AI as a technology or as a being I have a relation to?

New questions?

FORGING

REGULATOR

QUESTIONS TO CONSIDER:
- How can I proactively collaborate with all stakeholders to implement effective regulation to target emerging societal issues?
- How can I protect vulnerable groups, such as children, from harmful use of AI?
- Should individuals have a chance of refusing the use of AI? How can I ensure it?
- How can I regulate for emerging technologies that could be harmful to society?
- How can I make sure there are enough intensives and deterrents for minimizing the energy usage of AI?
- How can I make sure markets have enough players to avoid concentration of power for too few actors?

New questions?

FORGING

INVESTOR

QUESTIONS TO CONSIDER:

- How do I identify and prioritize investment proposals that have a significant impact on the betterment of human lives, such as making better decisions or making mundane tasks easier?
- How do I purposefully balance between open science and protecting intellectual property rights, considering both potential misuse of data or technologies and the use purposes that might require licensing?
- How do I ensure that my investments contribute to societally acceptable, environmentally sustainable, and ethical development of AI?
- When do I need to decide to not develop AI applications for certain functions?
- How my investments support making a clear distinction between AI powered applications and human interaction?
- How can my investment decisions support the creation of a world where the users can opt out from the use of AI applications that could potentially be harmful for them.

New questions?

FORGING

MALICIOUS AGENT

QUESTIONS TO CONSIDER:

- How can I exploit emerging vulnerabilities for my own benefit?
- How can I manipulate individuals, publics and decision-makers through fake news, propaganda, and deepfakes?
- How can I use AI to develop autonomous weapons to promote my objectives?
- How can I use AI to gather data on individuals and use it to reach my goals?
- How can I use AI to launch sophisticated cyber-attacks?
- How can AI be used to manipulate markets, for instance though manipulating stock prices or engaging in high-frequency trading?

New questions?

FORGING

PERSPECTIVE CARDS

FORGING

DEVELOPER

QUESTIONS TO CONSIDER:

- How can I make sure the materials I develop do not promote the use of virgin natural resources?
- Can I turn waste or pollution into materials?
- How do I make sure that the materials I develop can be recycled and / or composted?
- How do I change the perspective of my development work from the aim to satisfy human needs to the aim to balance the natural ecosystems?
- Am I trying to understand the consequences of the innovations I develop from the perspective that they will be scaled up, and part of every-day practices?
- How can I take into account the whole production and life cycle of the innovations I am developing so that their sustainability can be ensured?

New questions?

CITIZEN

QUESTIONS TO CONSIDER:

- Can I trust that the sustainability of the novel materials has been assessed from multiple perspectives, and with consideration of different environmental values, such as climate change, biodiversity and toxicity?
- Am I able to experiment with new materials or is their use restricted by licences?
- Can I trust that there are processes in place that evaluate the costs of new materials primarily from their whole costs to ecosystems and the society?
- Is there an equal access to new materials with active (sensing, responding) and passive (antibacterial) functionalities that can enhance the quality of life?
- Are systems for recycling novel materials available and accessible to me?
- Can my community afford novel, more sustainable solutions and materials?

New questions?

USER

QUESTIONS TO CONSIDER:

- Do I have available products or services that have minimized the use of materials in their production?
- Can I select products that have been produced locally?
- When using smart materials that have functionalities affecting me or my direct environment, do I understand my rights and the implications to my privacy?
- Can the products that I have be repaired and are they reusable?
- Are health-care solutions based on new materials and bio-sensing based solutions available to me?
- Are the novel products/ services enhancing or extending my abilities in ways that I understand to be useful and beneficial?

New questions?

REGULATOR

QUESTIONS TO CONSIDER:

- How can I balance the need for innovative R&D with the mitigation of potential risks related to untested functionalities and unknown long-term impacts?
- How can I make sure, from a standards perspective, that bio-inspired technologies and smart materials effectively promote sustainability throughout their lifecycle at the levels of material sourcing, production processes, and end-of-life options?
- How can I ensure, from the perspective of regulations, the safety and privacy of users interacting with smart materials that have sensing and responding functionalities?
- How can I ensure that the benefits of bio-inspired technologies and smart materials are distributed fairly and equitably across user groups from the point of view of accessibility, affordability and bias limitation?
- How can I manage the burden on resource exploitation associated with the large-scale adoption of bio-inspired technologies and smart materials?
- How can I develop regulations and evaluation mechanisms that anticipate and evaluate the unforeseen long-term social and environmental impacts of bio-inspired technologies and smart materials?

New questions?

INVESTOR

QUESTIONS TO CONSIDER:

- How can I identify high impact of bio-inspired technologies and smart materials whilst mitigating potential risks related to untested functionalities and environmental impacts?
- How can I assess the long-term commercial viability of new materials from the perspective of user trust and adoption, production costs, regulatory compliance and competition from established industries?
- How can I ensure that my investment decisions in bio-inspired technologies and smart materials contribute to social inclusion and equity and address access disparities and potential job displacement challenges?
- How can I comprehensively evaluate the sustainability of new materials throughout their lifecycle from the perspectives of circularity, waste reduction and resource conservation?
- How can I anticipate the evolving ethical concerns and unforeseen potential disruptions to existing industries?
- How can I collaborate more pro-actively with other entrepreneurs, researchers and regulators to create an ecosystem for the responsible development and deployment of bio-inspired technologies and smart materials?

New questions?

FORGING

MALICIOUS AGENT

QUESTIONS TO CONSIDER:

- How can I disrupt the early-stage research of bio-inspired technologies and smart materials through introducing undetected vulnerabilities and harmful functionalities?
- How I exploit the properties of new materials with active or passive functionalities to create new weapons or tools for espionage or social manipulation?
- How can I exploit security gaps in smart materials that may be used to attack critical infrastructure?
- How can I exploit bias in AI-enabled material design to target specific groups and exacerbate social inequalities?
- How can I exploit the complexity of long-term material interactions and leverage the potential of delayed toxicity and ecological imbalances?
- How can I disrupt the public perception of new materials to create distrust and harm confident adoption?

New questions?

PERSPECTIVE CARDS

FORGING

DEVELOPER

QUESTIONS TO CONSIDER:

- How can I develop human-centric solutions that are intuitive, user-friendly, and ethical?
- How can I leverage the latest advancements in NLP, human augmentation, AR/VR, explainable AI, collaborative robotics, and ethical AI to create innovative solutions?
- How can I support individuals in the utilization of technologies, including AI, to enhance their capabilities and fully reach their creative potential?
- How can I develop human-centric solutions that improve healthcare outcomes, facilitate personalised medicine, and tailor treatments to individual patients' needs?
- How can I involve users in the design process to ensure that my solutions meet their needs and preferences?
- How can I make sure that critical solutions (e.g. when inserting technology to human bodies) cannot be attacked to harm the user?

New questions?

CITIZEN

QUESTIONS TO CONSIDER:

- How can human-centric solutions improve my quality of life and make my interactions with technology more seamless, intuitive and personalised?
- How can I ensure that human-machine interaction is safe, fair, and respectful of my privacy and autonomy?
- How can I be an active participant in shaping the development and use of human-centric solutions?
- How do I develop my own worldview when decision-making is strongly guided by technology?
- How can I identify and support companies that are developing and implementing sustainable human-centric technologies?
- How can I contribute towards a balance between open collaboration enabled by human-centric technologies and the safeguarding of individual creativity?

New questions?

USER

QUESTIONS TO CONSIDER:

- How can I benefit from the enhanced capabilities and personalised experiences that human-centric solutions offer?
- How can I understand and navigate the ethical implications of human-machine interaction in a digital immersive world?
- How can I protect my privacy and make informed decisions about the data I share with AI systems and other digital tools?
- Will I be able to opt out from technologies that I do not consider desirable?
- How can I be aware of the influences of the nudging techniques that are being used by the developers to shape my behaviour?
- How can I make informed decisions to avoid the use of products or services that may have a negative impact on the environment?

New questions?

REGULATOR

QUESTIONS TO CONSIDER:

- How can I establish clear guidelines and regulations to ensure the responsible development and use of human-centric solutions?
- How can I promote ethical practices and prevent the misuse of human-machine interaction for malicious purposes?
- How can I, in practical terms, balance the benefits of human-centric solutions with the need to protect individuals' rights and privacy?
- How do I ensure that citizens have an equal access to technology so that deepening inequalities and divides in access to knowledge can be avoided?
- How can I balance the economic benefits of technological advancements in human-centric solutions and human-machine interaction with the potential risks of job displacement and social disruption caused by the pursuit of an optimization rationality?
- How can I ensure that bodily enhancements that might become necessary for certain jobs or positions do not create cognitive or physical harm to users?

New questions?

INVESTOR

QUESTIONS TO CONSIDER:

- Taking forward my commitment to long-term value creation, how can I identify and support companies that are developing human-centric solutions that address pressing social and environmental challenges?
- How can I ensure that my investments in human-centric solutions are aligned with ethical considerations and promote responsible development and use of these technologies?
- How can I contribute to the democratization of access to human-centric solutions and ensure that these technologies benefit all people?
- How can I influence the companies I fund to shape their solutions to be more human-centric and ethically robust?
- How can I ensure that my investment decisions are focused on human-centric technologies that enhance and complement rather than replace human intelligence?
- How can I support start-ups that cater to the needs of diverse user groups, including minorities?

New questions?

MALICIOUS AGENT

QUESTIONS TO CONSIDER:

- Could I use human-centred design principles to create deceptive interfaces that trick users into giving up personal data or engaging in harmful behaviour?
- How can I exploit ethical concerns and biases in AI development to promote my own agenda or gain an advantage?
- Could I hack into human augmentation devices, such as brain-computer interfaces and wearables, to control or manipulate users?
- How do I identify the vulnerabilities in human-machine interfaces to deceive and manipulate the user?
- How can I use existing systems for spreading misinformation and manipulating public perception?
- How can I exploit social and psychological factors to promote intolerance, discrimination and undermine trust in institutions?

New questions?

PERSPECTIVE CARDS

DEVELOPER

QUESTIONS TO CONSIDER:

- Can I develop solutions that make use of energy waste, for instance excess heat?
- How can I balance between the aim for developing energy efficient systems and the need for clean energy solutions that may be less efficient?
- How do I balance between the need for novel efficient clean energy solutions and the environmental costs of their production?
- How can I contribute to introducing more sustainable energy solutions to very energy intensive industries?
- Can I develop solutions that do not require any energy use?
- How can I involve users and citizens in the development to better understand the impacts of my energy solutions?

New questions?

CITIZEN

QUESTIONS TO CONSIDER:

- Do I have access to electricity and energy regardless of my socio-economic status?
- Is my voice heard when energy systems are being planned in my living environment?
- Can I have influence on ensuring equal access to electricity in my community?
- Am I being treated fairly in the development of novel energy systems?
- Can I take a more active role in my energy usage, e.g. by setting up or joining a community focused on the production and distribution of energy?
- Where can I find information and help when looking to minimize my energy consumption?

New questions?

USER

QUESTIONS TO CONSIDER:

- Can I trust that I am being offered the most sustainable energy solutions?
- Am I supported to find ways to minimize my energy consumption?
- Do I have incentives to make investments to more sustainable energy solutions affecting my daily use of energy?
- Do I have enough information on the sustainability of different solutions to compare and choose between alternative options?
- Is the burden of minimizing the rebound effect (meaning that energy efficiency in one place often leads to more energy usage somewhere else) on my shoulders alone?
- Can I trust that the energy systems I depend upon are robust and resistant to external threats?

New questions?

REGULATOR

QUESTIONS TO CONSIDER:

- How can I incentivise the research and development of novel energy solutions that are sustainable throughout their life-cycle, from material sourcing through to production processes, and potential environmental impacts?
- How can I develop regulations that promote user control and decision-making within energy systems, ensuring equitable access and affordability?
- How can I enforce comprehensive life-cycle assessments and transparent risk management protocols for novel large-scale energy solutions?
- How can I contribute to the development of regulations for an ethical development and deployment of autonomous systems, whilst addressing concerns about data privacy, transparency and human oversight?
- How can I ensure that the design of regulations for the energy sector fully incorporates mechanisms for periodic participatory review and updates based on emerging technologies and societal needs?
- Considering the interconnectedness of energy systems, how might the development of common standards contribute to international collaboration to address global energy challenges?

New questions?

INVESTOR

QUESTIONS TO CONSIDER:

- How can I best identify high-impact, early-stage energy solutions considering both technological breakthroughs and behavioural changes?
- How can I assess the level of risk associated with investing in autonomous decision-making systems applied to critical infrastructure?
- How can I make sure that my investment decisions contribute to equitable access to clean energy and to the empowerment of marginalised communities?
- How can I best determine the potential for unintended consequences of novel energy technologies such as rebound effects, resource scarcity or environmental degradation?
- Have I considered the option to prioritise investing in adaptable solutions with modular designs and open-source elements, even if this means incurring in higher initial development costs?
- Do I participate sufficiently in collaborative initiatives that address specific societal challenges, even if the financial returns are less immediate or indirect?

New questions?

MALICIOUS AGENT

QUESTIONS TO CONSIDER:

- How can I exploit vulnerabilities in autonomous energy management systems to disrupt critical infrastructure, for instance through manipulating energy consumption or creating blackouts?
- Can I leverage the use of decentralised energy solutions such as microgrids for the manipulation of energy prices?
- Can I manipulate the algorithms used in energy distribution systems to impact specific communities or sensitive ecosystems?
- Can I exploit security vulnerabilities or potential environmental accidents to create distrust in novel energy solutions?
- How can I influence investors to prioritise short-term benefit over long-term sustainability goals?
- How can I exploit open-source technologies and collaborative research and development initiatives to obtain undue control over critical energy infrastructure?

New questions?

REAL TIME-BASED DIGITAL TWINS AND SIMULATION

PERSPECTIVE CARDS

DEVELOPER

QUESTIONS TO CONSIDER:

- How can my solutions support better quality decision-making based on high-quality data?
- Can I create solutions that reduce the need for physical travel?
- How are my solutions supporting environmental sustainability and social fairness?
- Am I making sure that I am developing solutions that are inclusive and create opportunities for everyone, e.g. for those who have restrictions in moving in the physical world?
- Are my solutions discouraging people from being active in the physical world?
- How do I ensure that my use of data preserves individuals' privacy?

New questions?

CITIZEN

QUESTIONS TO CONSIDER:

- Will I be able to maintain human contacts if I am hospitalized or placed in elderly care?
- Will some of the services I depend on be offered only in virtual spaces or will I have the possibility to select an option in the physical world?
- Will the use of digital twins and simulations offer me more opportunities to get involved in the development of my neighbourhood or city?
- Will the use of digital twins and simulations enhance my capabilities to participate in the working life?
- Can I trust that my privacy is always ensured even with the increased use of data?
- Are the services I am being offered optimized for economic rationality or human needs?

New questions?

USER

QUESTIONS TO CONSIDER:

- Is my job being threatened by my activities being modelled for simulations?
- Will someone notice and help if I get too involved in virtual spaces and start to suffer mentally because of it?
- What are the risks that I should be concerned about regarding the possible monopolization of digital twin and simulation technologies?
- Is the usability, functionality and affordability of the solutions I use ensured to all groups as well as possible?
- Is moving between the virtual and the real world seamless from all perspectives (economic, social, political, psychological etc.)?
- Do I understand enough about the solutions that I am using to make informed decisions about their use, for instance regarding their energy use or privacy related issues?

New questions?

FORGING

REGULATOR

QUESTIONS TO CONSIDER:

- How can I promote energy-efficient algorithms and infrastructure to mitigate the environmental impact of digital twins and simulation, while ensuring sufficient computational power for complex models?
- How can I ensure responsible data collection, storage, and utilisation in digital twin and simulation applications, especially through clear frameworks for data ownership, privacy, and transparency?
- How can I address potential negative societal impacts of digital twins and simulation, including social isolation, job displacement, and the influence of biased algorithms in decision-making processes?
- How can I champion the development of inclusive digital twin and simulation technology, ensuring affordability and usability for all social groups, regardless of income, disability, or technological literacy?
- How can I make use of foresight within regulatory bodies to anticipate the potential long-term social, economic, and environmental consequences of large-scale digital twin and simulation implementations?
- How can I develop regulations that establish ethical guidelines for the evolving relationship between the physical and virtual worlds facilitated by digital twins and simulations?

New questions?

FORGING

INVESTOR

QUESTIONS TO CONSIDER:

- How can I identify early-stage digital twin and simulation applications with disruptive potential, considering not only technological breakthroughs but also integration with existing infrastructure and workforce capabilities?
- How can I prepare for the potential disruption of quantum computing in the digital twin and simulation space?
- How can I balance the benefits of open-source data and simulation platforms with the need for intellectual property protection for proprietary algorithms and functionalities?
- How can I ensure that I prioritise companies with strong data privacy practices, accessibility considerations, and focus on solutions that address societal challenges beyond economic gains?
- How can I make sure that my investment decisions prioritise companies with robust methodologies for bias detection and mitigation, ensuring fair and equitable outcomes?
- How can I ensure my portfolio is adaptable and focused on modular and interoperable solutions that can be easily adapted to changing user needs and advancements in related fields such as AI and augmented reality?

New questions?

MALICIOUS AGENT

QUESTIONS TO CONSIDER:

- How can I exploit the complexity of real-time simulations to mask my activities and make it difficult to detect or attribute malicious actions?
- How can I manipulate real-time data streams within digital twin simulations to disrupt decision-making in critical infrastructure or financial markets?
- Am I able to weaponise personalised avatars and deepfakes within simulations to create discord, manipulate behaviour, or spread misinformation?
- Can I manipulate user perception or introduce delays to lead to critical errors in human-machine interface of real-time simulations?
- Can I use real-time social simulations to exacerbate societal tensions, polarise public opinion, or incite violence?
- Can I exploit potential blind spots in regulations or bypass ethical and security measures designed to prevent malicious manipulation of real-time simulations?

New questions?

FORGING