Artificial intelligence

FORGING

INTRO

Responsibility of AI has recently been widely discussed in the scientific community. We see AI taking over at the moment in a quick pace that makes even keeping up with AI developments almost impossible for experts, and even more so for consumers.

Potentials:

•AI has the potential to transform many aspects of human lives, such as working life, consumption and learning. AI can make many mundane tasks easier.
•If used wisely, AI applications hold the power to aid in making better decisions, and navigating complexities of the modern world.
•AI might be able to share some ethical values with humans in the future.
•AI can interact with human intelligence in ways that enrich our capacities.
•AI is learning to create also culture and art, traditionally believed to be exclusive to humans.

Risks:

•AI might reduce need for human workforce in many areas, possibly leading to unemployment.
•If not understood and regulated well enough, AI might also hold the power to steer societal discussions and political realities in directions that might enforce divisions.
•Developments in AI and language generation that leaves invisible the original (human) sources of information hold risks for eradicating trust in society, as facts and fabrications become more difficult to differentiate.
•AI technologies might become so good at interaction that they will be impossible to differentiate from real humans. This might also have implications to how we treat our fellow humans.
•AI might contribute to creating technology-driven bubbles that can lead to increasing amounts of loneliness and isolation.

1: Research

•New capacities for AI are being researched all the time.
•In AI development, this phase includes basic research on technological capabilities and the limits of possibilities of artificial intelligence, increasing computing power and innovating new enabling hardware solutions.

Ecological considerations

•Developing more ecological hardware solutions: Exploring new, ecological materials or recycling solutions.
•Developing efficient software solutions: Developing solutions that require relatively less computing power. Is it possible to move towards use of representative data instead of large data masses?

Societal considerations

•Licensing and open-source: Purposefully balancing between open science and protecting intellectual property rights. Preventing potential misuse of data or technologies should be considered when making these decisions, as well as the use purposes that might require licensing.
•Inclusiveness of research practices: When research groups are diverse in composition, and different citizen groups are engaged in the research project whenever possible, the results are more likely to be usable and beneficial for larger groups of people.

2: Development of concepts and products

•AI develops at an unprecedented pace right now, new innovations and application areas appearing.
•With AI, this phase includes the translation of technological capabilities into concrete AI applications. In this phase, different application areas and opportunities of utilazing AI are considered.

Ecological considerations

•Environmental data for AI: when AI is applied to an area that can have ecological outcomes (e.g. industry), is adequate attention paid in using enough high quality environmental data in the AI modelling, optimizing the outcomes as ecologically as possible?
•AI working in a way that helps make processes more ecological: e.g. environmental modeling, AI aided optimization

Societal considerations

• Future considerations: Often the future implications of technologies that are developed now can seem irrelevant, but the first applications can be important in creating path dependencies that either preserve or harm human values in the future.
•Considering public perceptions of AI technologies: the research should be conducted in a societally acceptable and ethical way, taking into account and mapping public perceptions of AI use. When necessary, the decision to not develop AI applications for certain functions should be taken.
• Privacy: AI applications are often data intensive. When planning the data use, privacy of individuals should be taken seriously, considering the implications using their data in training AI can have.

3: Introduction and early implementation

•New AI applications are introduced to consumers all the time. As they are new and unlike anything before, they can receive high level of public interest on their release. For example, generative AI is discussed widely right now, and the opportunities offered by it are being actively explored by many users. On the other hand, novelty makes new applications hard to understand.
•Research on the application of AI for e.g. autonomous vehicles is right now aiming for commercialization in the coming years.

Ecological considerations

•Monitoring impacts: as new AI applications are taken up, is their environmental impact being monitored? Especially important this might be with environmentally sensitive application areas, e.g. in industry.

Societal considerations

• Target groups: Vulnerable groups, such as children and elderly, should be protected from harmful use of AI. They should have a chance of understanding that they are using AI (as opposed to e.g. chatting with a human) and what that means for them, e.g. through gathering data about them.
• Differentiation of humans and artificial intelligence: New AI applications can resemble human interaction and thought patterns in a believable manner. If we start treating artificial intelligence as we would humans, this can lead to deep issues and have implications to even human rights.
• Preventing biased decision making: AI models trained using data describing the existing society tend to omit human biases. When taking up new AI applications, it is therefore crucial to ensure the data used for training is unbiased or the biases are corrected as much as possible.

4: Scaling-up and fine-tuning established technologies

•As technologies become normalized part of our everyday practices, their basic premises are usually not questioned so much anymore. However, it remains important to stay aware of the ethical, ecological and societal impacts of technologies. For example, the algorithms used by all big social media sites at the moment use AI that shapes our perceptions of the world in a powerful way, even though they are often unnoticeable in everyday use.

Ecological considerations

•Energy use: AI can sometimes be energy intensive as opposed to e.g. using human decision making. The use of AI - compared to other technologies - should be considered, choosing the most efficient and purposeful technology that can be used.

Societal considerations

• Autonomy: AI should be applied in a way that allows users to preserve their autonomy. One part of this is that users can opt out from the use of AI applications that could potentially be harmful for them.
• Explainability: The AI systems that are widely used should be also publicly explained in a manner that allows users to understand their function and implications.
• Human connections: even when the use of AI applications is booming, it should be ensured they don't isolate people in technological bubbles but human connections remain.

The FORGING Consortium

INL · GAC GROUP · APRE · STAM MASTERING EXCELLENCE · VTT · i2cat

Stay in touch with FORGING

www.forging-hub.eu · @FORGING · info@forging-hub.eu

Funded by the European Union

Real-time based digital twins and simulation

FORGING

INTRO

Simulations, modelling and digital twins are taking huge leaps at the moment, both in early development and practical applications. Computing power and lack of good quality data form barries to what can be currently modelled, but quantum computing is expected to help solve these problems.

Potentials:

•Improved data use and new digital tools can produce better predictions and help in making better decisions.
•Virtual spaces can complement mobility, replace much of travelling and create new connections without place-dependency.
•Modelling of complex systems (even ecosystems and societies) with quantum computing can help in achieving environmental sustainability and social fairness.
•Digital avatars and working spaces might allow active life for people who can't move and be active in the physical world.• Visualisation of alternative futures through modelling holds potential for e.g. involving citizens in urban planning.

Risks:

•Living in digital worlds more and more can lead to physical loneliness, as people will likely still crave and need physical closeness.
•Care might become more digital, as it is too expensive to keep human workforce based system running, yet digital twins and virtual environments might not be as good in answering to human needs.
•As data use is amplified, taking care of individuals privacy might become challenging.
• There is a risk of big tech companies attaining monopoly of digital twin and simulation technologies
• The systemic implications of e.g. modeling human activities in industrial settings might ultimately be harmful to humans.

1: Research

•Simulations and digital twins are based on on-going vast research efforts, and the potential complexity of modelled entities gets greater all the time.
•Related to digital twins and simulations, research phase includes development of computing potential for ever more complex systems and researching on new immersive simulation technologies, for example, as well as sensor development to enable information collection and developing a digital twin of a physical system.

Ecological considerations

• Computing power and electricity use: digital twins and simulations use computing power intensively. Even in the basic research phase the question of energy use and needed computing power should be kept in mind, possibly developing solutions that are less intensive or not developing solutions that could replace more efficient practices.

Societal considerations

•Data privacy: at all points in the development of digital modelling solutions, individuals' right to privacy should be respected, even if this puts limitations to the research.
•Inclusion: as new immersive and interactive solutions are developed, usability and functionality to all groups should be ensured as well as possible.
• Purpose: There should be more consideration of the fundamental motivations behind technology development, and discussion in order to define shared visions for the society.

2: Development of concepts and products

•As new capabilities emerge, new application areas are developed all the time. At the moment, digital twin based solutions for industrial environments are visioned, for example.
•The challenge is how to bridge the gap between the virtual and real worlds, recognising the economic, social, political, psychological etc. constraints.

Ecological considerations

•Modelling environmental impacts: when developing models for application areas that have impact on the environment (e.g. industry), building in environmental optimization with high quality data and enough variables can lead to considerably more eco-friendly results.
•Energy use considerations: Sometimes using modelling and AI applications can be more energy intensive than using human labour. If this seems to be the case, the distribution of work between automation and human workforce is good to consider also from this perspective.

Societal considerations

•Licensing and openness: when developing new products based on modelling or digital twin technologies, it is good to consider the level of openness regarding the data used and the functioning of the application. Generally, openness is considered to lead to more democratic technology environment as consumers can get information about the technology they use.

3: Introduction and early implementation

•Digital twin and simulation technologies are currently entering many new fronts. They are tested e.g. in forerunner companies of manufacturing industry.
•There is a strong need for multidisciplinary foresight units in both business and the public sector to understand the implications of new technologies, using e.g. science fiction prototyping.

Ecological considerations

•Environmental data quality and comprehensiveness: as environmental modelling is taken up, it should be ensured that enough high quality environmental data covering all important environmental issues is used. If a system is optimised only for its carbon balance, for example, it may still end up producing other type of environmental damage.

Societal considerations

•Inclusivity: when testing new solutions with users and starting a scale up, it is important to remember that a solution that works well with some groups might be completely inaccesible for others. Therefore care should be taken to account for the needs of different citizen groups.
•Fairness in using test-phase technology: when new solutions are first introduced, they should be treated as experimental and older, alternative back-up systems should be kept up long enough. A complex modelling technology might reveal some unintended features only when used in large scale.
•Privacy and data security: as data intesive applications are taken up in new sectors and environments, the privacy of users should be carefully ensured.

4: Scaling-up and fine-tuning established technologies

•As new technologies become mainstream solutions, they reach more people and have more impacts than before. They can also become invisible and unnoticed, yet there are many important responsibility factors to consider.

Ecological considerations

•Replacing mobility: digital twin and simulation technology enables conducting many tasks without physical presence. As these established solutions emerge, many businesses can consider using them instead of travelling.

Societal considerations

•Physical needs: as virtual solutions are scaled up, it should be carefully ensured they don't replace important physical services and leave people lacking in their physical needs. In some domains it might be better to not have a virtual solution at all, and in other domains it might be good only as supplementing the physical work.
• Reality +: novel ways of being in the augmented world have broad based implications for societies.

The FORGING Consortium

INL · GAC GROUP · APRE · STAM MASTERING EXCELLENCE · VTT · i2cat

Stay in touch with FORGING

www.forging-hub.eu · @FORGING · info@forging-hub.eu

Funded by the European Union

Cyber safe data transmission, storage and analysis technologies

FORGING

INTRO

More and more data, including personal data about people, is generated and analyzed all the time. As the amount of data is increasing rapidly data security is becoming even more important. Responsible data processing protects people and their privacy. At the same time, it ensures responsible data use and utilization.

Potentials:

•Strong regulations about data safety and privacy are needed, as life moves more and more into the digital realm. Well justified, strong regulation is likely to be widely accepted.
•Data ownership could be decentralized to distribute it more widely. Potential for new, more distributed data economy where more people would benefit also exists.
•With adequate education, individuals could be more active in taking care of their own privacy and data security.
•Safe online environments ultimately enable digitalization and new, virtual realities that are emerging.

Risks:

•With data accumulation, huge power is centralizing to few big players. People might not realise what this means for them and possibly can't protect themselves.
•Societies are becoming dependent on a few critical virtual infrastructures, and cyber attacks to those systems could cause enormous harms. Cyber attacks can even be used as a weapon in warfare.
•If code efficiency is not carefully planned for, this could lead to excessive energy use.
•With increasing data available for powerful players, dissident voices may be more and more at risk.

1: Research

•Cyber security and data management form large research fields. As the pace of development is very high, even keeping up with criminals and hackers can sometimes be a challenge. As digital systems are vital to modern societies, cutting-edge research holds enormous importance.

Ecological considerations

• Code efficiency and energy use: cyber security as well as data management are often heavy processes that can use plenty of electricity. When developing the solutions, there is room to influence the amount of energy used by e.g. improving code efficiency.

Societal considerations

•Licensing and openness: Open science usually aids in taking up novel technologies in different sectors and can lead to faster development. However, openness needs to be balanced with security concerns in many cases.
• Safety: Security solutions should be based on the principle that the mechanism is so good that even if it is known to the other party, the counterparty still cannot violate it.

2: Development of concepts and products

•As new breakthroughs are made, they still need to be turned into practical products. Packaging the new solutions in a responsible manner can sometimes be a challenge when talking about data intensive products.

Ecological considerations

•Material reality of digital solutions: Even digital solutions always require a material basis that consists of computers, batteries, wires... As new digital software solutions are developed, their effect on the need for this material basis can be considered through e.g. capacity needed and suitability of software to existing (and old) hardware.

Societal considerations

•Data ownership models: many apps and companies collect data about individuals and sell it further. These models are likely to be restricted in the future as legislation evolves. Models for individual data ownership are still developing, and should be developed in a fair and inclusive way that offers opportunities for real agency for users.
•Anticipatory approach: Developers should move beyond identifying and fixing security vulnerabilities as they are discovered and embrace more proactively a risk modeling approach that identifies and address risks before they can be exploited.

3: Introduction and early implementation

•With digital services and products, the pace of development is fast, and there is always many new things entering the digital markets. Consumers can't always keep up on the newest trends in data management and digital solutions, even when they are directly affected.

Ecological considerations

•Environmental data: As new data intensive solutions are taken up the role and protection of environmental data should be considered along with more human-centric values. Data about the environment should be gathered carefully and the security and truthfulness always ensured.

Societal considerations

•Creating opportunities for autonomy: Data management can often be built in ways that offer people opportunities for agency regarding their own data. Note that asking for consent is often not enough, as this does not usually give users a real chance to choose.
•Privacy legislation: there is already a rather strict data privacy legislation in the EU. When launching anything new to users, it should be double checked the data handling follows these laws and rules, or even goes beyond the mandatory levels.

4: Scaling-up and fine-tuning established technologies

•Digital and data intensive solutions have become essential for daily lives in modern societies. As these solutions are scaled and more people are using them, they start also having different impacts.

Ecological considerations

•Energy use: Digitalization consumes a significant portion of all electricity used in current societies, and data handling is often quite intensive in terms of processing power needed. When making decisions of which solutions to take up, efficiency should be used as a criteria.

Societal considerations

•User education: Understanding data use and management is a complex and rapidly evolving field. Users of digital tools and services need easily accessible and understandable education to keep up with the ever-changing field and protect themselves online.
•Strongly protecting important digital infrastructures: Digital spaces often play very important role in satisfying the very basic human needs in daily basis. Important infrastructures need strong protection that is frequently updated and resilient against cyberwarfare threats.
• Understandability: People should have a real chance to give their consent for transferring data. Should be independent of literacy, internationally understandable, e.g. icon based solution that is easy to understand.

The FORGING Consortium

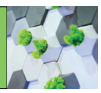
INL GAC.GROUP APRE STAM MASTERING EXCELLENCE VTT i2cat

Stay in touch with FORGING

www.forging-hub.eu @FORGING info@forging-hub.eu

Funded by the European Union

Bio-inspired technologies and smart materials



FORGING

INTRO

•The material world build by humans is evolving with advances in synthetic biology and material sciences. Sustainability can be a driving force in developing new materials, but new materials do not come without risks as well.

Potentials:

• Taking inspiration for innovation from natural ecosystems we can harness human resources for the good of the planet while simultaneously gaining better technologies for us.
• New materials with active (sensing, responding) and passive (antibacterial) functionalities can enhance the quality of life for many.
• With new materials, new solutions to persistent issues can be found, such as buildings functioning as batteries.
• New, emerging materials can play a role in replacing crude oil and moving towards use of recycled and reusable items.
• New materials and bio-sensing provide possibilities for health care.
• Utilising materials that are currently treated as waste or pollution might offer interesting business opportunities.

Risks:

• New materials require substantial investments to mature to usable solutions and to mitigate unintended consequences.
• Excessive use of raw materials needs to stop, and thus even new materials should not be excessively produced or used carelessly.
• New innovations lead to the surplus of the old, and old materials or technologies might end up as waste

1: Research

•This phase includes scientific explorations with different raw material possibilities, material structures and properties. Research does stretch the limits of possibility, even if the usability might not be tested outside of lab environments yet.

Ecological considerations

•Combining different materials: Often, to make new materials last and enhance their properties, artificial components are added. This can be a good solution, but the implications for e.g. recyclability or compostability should be carefully considered and communicated.
•Finding starting points from nature: Traditionally, research processes start from the needs of humans. When aiming for a better balance with natural ecosystems, starting points for research should also be found in the needs of nature. Waste materials or invasive species, for example, might offer interesting opportunities for material sciences.

Societal considerations

• Research funding: As researching new materials is often based on trial-and-error type of testing, it requires grand amount of funding and the results of any one experimental branch can not be guaranteed. To move forward with material sciences, adequate funding is necessary, but prioritization of different research areas might be necessary.
• Ecological costs: when considering the costs of new materials, not only their current monetary value should be given priority, but emphasis should always be put to their whole costs to ecosystems and the society.

2: Development of concepts and products

•As new materials emerge from the scientific field, their application areas and use properties still need to be refined. As they are turned into products, they at the same time become parts of whole products and production chains, and their recycling properties, among many other factors, need to be refined.

Ecological considerations

•Recycling and promoting circular economy: As new materials and production methods are developed, it is good to always consider adding elements that promote circular economy, such as using recycled raw materials or ensuring the recyclability of the materials or changeability of product parts.

Societal considerations

• Licensing and growth: With new solutions, the pros and cons of licensing should be carefully considered. Licensing might enable attaining funding or selling the idea to bigger companies and thus scaling the solution. On the other hand, it might limit the use of the new solution as grass-roots hobbyists, for example, might not be able to experiment with the new material anymore.
• Considering wider impact: At this stage, new innovations are still in very small scales and not widely used. However, it is necessary to already consider the consequences of the innovation scaling up: how could it change every-day practices, for better or for worse?

3: Introduction and early implementation

•As the new materials mature, they will eventually reach the consumers. As the consumers encounter the new materials, their safety and rights need to be considered in a new way.

Ecological considerations

•Multi-criteria evaluation: Materials that make it to user testing phase usually have positive effects to at least some sustainability values. When considering taking up new technologies, their sustainability should be assessed from multiple perspectives, considering many different environmental values, such as climate change, biodiversity and toxicity.
• Benefits of new materials or solutions: Changing for more sustainable materials is usually a good decision from environmental perspective. However, even more sustainable materials have their environmental footprint, and if the use can be avoided altogether, it can be an even better alternative.

Societal considerations

•User rights and knowledge sharing: when testing with smart materials that have functionalities affecting the users or their direct environment, the user rights and privacy should be carefully ensured. Users should also have enough knowledge available for them about the products they are using in simple enough language.
• Considering time scales of use: If a solution is perfect for 5 minutes of use but harmful for long periods of time before and after, the actual benefit of the product might be questioned. In such situations, careful consideration of whether to introduce the new product or not is needed.

4: Scaling-up and fine-tuning established technologies

•If a new material or solution proves to be useful, it might enter the scaling phase. In this phase, the solution gains popularity and becomes more common. With larger production amounts and wider user base, new responsibility considerations also become relevant.

Ecological considerations

•Resource use: As new solutions are scaled up more resources are used. Thus, it is important to ensure that the raw materials of solutions that will be taken up in large scale can truly be produced sustainably even at scale.
•Limiting overall consumption: Even as new materials might be less ecologically harmful than traditional materials, their use still consumes limited natural resources. Thus, even with new materials, the overall consumption of virgin raw materials should be decreasing to achieve true sustainability.

Societal considerations

•Inclusion and fairness: New materials can sometimes offer life-enhancing opportunities for people with disabilities, the elderly, or other special groups. From social fairness viewpoint, equally distributing the opportunity to benefit from these scientific advancements regardless of e.g. financial situation is important, especially in context of health care system.

The FORGING Consortium

INL GAC APRE STAM VTT i2cat

Stay in touch with FORGING

www.forging-hub.eu @FORGING info@forging-hub.eu

Funded by the European Union

Human-centric solutions and human-machine-interaction

FORGING

INTRO

Human-machine interaction and human centric solutions are not tied to a distinct line of technologies, but rather, should be present as a research area in all technology development. Humans' interaction with machines has dramatically increased over the past decades, and there is no end in sight to that development. Therefore, it is crucial to pay attention to building these interactions and interactive environments responsibly.

Potentials:

- New technologies hold significant potential in healthcare, from digital solutions improving efficiency to nanotechnology applied in human bodies.
- Technology and AI can help humans express their creativity with less effort and in a more accessible way.
- Multidisciplinary teams in technology development can lead to human-centric solutions.
- Technology and human enhancements can lead to completely new definitions of learning or education: there is no more need to know so many things by heart, and instead, understanding and interpretation become central in expertise.

Risks:

- Data should not be confused with knowledge, understanding or wisdom, even though it can lead to these outcomes.
- Unequal access to technology can deepen inequalities.
- Inserting technology to human bodies can leave people vulnerable to cyber attacks on themselves.
- Bodily enhancements can potentially become necessary for certain jobs or positions.

1: Research

- The research phase of technologies that humans will use a wide field with numerous different practices. As technology-focused research is done, the human and environmental aspects of technology should already be present, guiding the choice of new technologies to research and new capabilities to create.

Ecological considerations

- Re-use, repair, re-cycling: in the research phase the possibilities for environmentally wise behaviours, such as re-using old technology, repairing broken gadgets or re-cycling them part by part, can be created.

Societal considerations

- Multidisciplinary teams: As technologies for humans are developed, social scientists and experts familiar with human behavior should be included in the processes. This does not include only ease of use considerations, but also things like creating a healthy cognitive environment and avoiding harm to human minds.

2: Development of concepts and products

- When practical products and application of technology are developed, the human dimension becomes even more central. Technological capacities can be used in various manners to build products for the immediate use of humans.

Ecological considerations

- Environmental behavior: Technology can alienate humans from the nature, or it can bring more wisdom into the way we act with natural resources and protect the natural systems on our planet. When developing new technologies, their effects for human behavior towards nature or natural resources should be considered.

Societal considerations

- Complementing human intelligence: Technologies most often work alongside humans, complementing and not replacing human intelligence. When developing new digital solutions, ways of smoothly interacting with human cognition can be sought.
- Inclusion: As new products are produced, inclusion of different user groups should be considered. Often digital solutions can produce significant life-enhancing solutions for people with disabilities and the elderly, for example, if adequate efforts are made to adapt the solutions for their needs.

3: Introduction and early implementation

- As technologies are released and first used by real humans, data about their effects can be gathered. At the same time, the rights of people using the new technologies become more imminent.

Ecological considerations

- Considering resource use: New technologies are entering the market at a rapid pace. When adopting new technologies, ecological consequences should always be considered. If technology is clearly a more resource-intensive or environmentally harmful, the necessity of it should be carefully considered, aiming to find a more environmentally friendly alternative.

Societal considerations

- Intellectual property rights and authorship: Humans produce more and more content, including text, music and visual arts, in collaboration with computers and machines. As these solutions scale, there should be clear rules on IP rights and claiming authorship.
- User rights: As new solutions come to existence and humans come into contact with them, the users right to refuse the use of certain technologies or giving up their personal data should be always respected.

4: Scaling-up and fine-tuning established technologies

- As technologies become normalized, often also a dependency of them is created. Wide user groups bring a multitude of different users, and the diversity should be recognized.

Ecological considerations

- Nudging towards ecological behaviour: Technologies that reach large audiences also shape the behavior of masses. When humans' interaction with material reality is affected, ecological considerations should be concerned. This can mean encouraging people to fix their old technologies instead of buying new, or discouraging excessive online shopping of environmentally harmful products.

Societal considerations

- Cyber safety: individuals are increasingly dependent on technologies that hold their personal information, biometric identifiers and sometimes are even attached to their own body. This can leave individuals vulnerable to cyber attacks that are very personal, and the risks should always be minimized for individual users.
- Roles of data and understanding: Data intensity of modern societies has grown rapidly during the last decades. However, when scaling computer systems, data should not be confused with understanding, even though having enough good data can lead to new insights. Human considerations and wisdom can still not be outsourced.
- Possibility of opting out: Many technologies have already become practically a necessity in participating to the society. When technologies become more common, it should be carefully reflected whether we want them to become necessities, and for which technologies do we want to maintain the possibility of opting out.

The FORGING Consortium

INL · GAC GROUP · APRE · STAM MASTERING EXCELLENCE · VTT · i2cat

Stay in touch with FORGING

www.forging-hub.eu · @FORGING · info@forging-hub.eu

Funded by the European Union

Technologies for energy efficiency and trustworthy autonomy

FORGING

INTRO

Modern societies are dependent on consuming vast amounts of energy. At the same time, there are many huge problems related to our current energy infrastructures, all the way from ecological crisis to a pressing inequality of access. Developing better energy infrastructures and technologies is thus crucial.

Potentials:

- New, sustainable energy forms can revolutionise industry, leading to a zero-carbon path.
- Individuals can take a more active role in their energy use, e.g. by setting up energy communities.
- Technological solutions such as:
  - energy waste can be reduced e.g. by using excess heat that is currently mostly wasted
  - Smart energy grid and energy storages.
- Through financial incentives and taxes, energy use could be steered towards clean energy and lesser energy use in both industrial and individual levels. Carbon market or similar solutions can make clean energy even more profitable alternative

Risks:

- Increasing population most likely equals incresing energy demand.
- Energy scarcity leads to conflicts. Energy can also be weaponised.
- Uneuqal access to electrisity and energy is a persisting form in inequality.
- Some industrial sectors can be very hard to turn into sustainable in their energy use.

1: Research

- With energy technoloies, esearch phase consists of exploration of new potential energy sources and properties of different materials, for example. Ecological and societal considerations should be present already in this stage.

Ecological considerations

- Less harmfull end products and more efficiency: When deciding what to research, the ecological concerns should always be used as a guide. Looking for more ecological alternatives to current energy technologies can take many paths, and at the research state this multitude should be embrased.

Societal considerations

- Aiming for fair energy systems: even thought at this stage the research can seem detached from surrounding society, the seeds of fair and just energy systems are often already laid up.

2: Development of concepts and products

- After new potential energy solutions are recognised, they need to be turned into products that can be used by the public.
- At the moment, for example small scale nuclear power plants are beind conceptualised as potential power sources in many different areas.

Ecological considerations

- Use of rare minerals and materials: Many novel energy solutions demand the use of rare metals, minerals or other materials that can be environmentally harmful to produce. The use of such materials in new solutions should be considered carefully and minimised where possible.

Societal considerations

- Autonomy of users: When developing new energy solutions, it is often possible to give the users more power to choose and impact their own energy use. Empowering end users can be a good choice from both sustainability and marketing points of view.
- Openness of licensing: New, sustainable solutions have far more potential impact, of they can be picked up in different places without expensive licenses. As new solutions are developed, the possibility of open licensing and sharing of solutions should be pondered.

3: Introduction and early implementation

- New energy solutions introduced to the system usually have some sort of friction at first, as they are entering the energy grids. Many new solutions start off-grid in small scale.

Ecological considerations

- Often, as energy is used more efficiently the total energy use will not decrease but there will simply be more usage. When picking up new, more efficient technology, in order to achieve sustainability gains it is important to make sure the savings do not add to energy use elsewhere.

Societal considerations

- Equal access to electricity: as new electricity grids and solutions are built, it should be ensured that electrisity access has the potential of distributing equally, i.e. no areas are left behind.

4: Scaling-up and fine-tuning established technologies

- As new energy solutions turn from niches to important infrastructures, new types of possibilities and potential problems are faced. At the moment for example windmills and solar energy are fastly taking up a bigger role in the energy infrastructure.

Ecological considerations

- Multi-criteria decision making: as new energy technologies are scaled, their impact on multiple different environmental issues should be considered. Solutions that are good for carbon balance, such as the use of biomass, can be harmful for other matters, such as biodiversity, if they are scaled up too much.
- Problems possibly arising with volume: in small scale, many solutions can have no negative effects, but with scale their waste, burning product or some other part of the process might become problematic. For example, burning oil was not harmful before it was scaled accross the globe in bigger scale. These issues should be looked for and there should be an option not to scale a certain solution too much, if it is necessary.

Societal considerations

- Fairness for local communities: As new distributed energy solutions are build, it should be ensured the processes are fair for the local communities near the production sites. They should also be engaged in the planning phase.
- Security concers: As modern societies are very dependent on electricity, energy production is a potential target when seeking to disturb societies. Therefore, when speaking of nationally important energy forms, security threads need to be taken seriously and production secured accordingly.

The FORGING Consortium

INL GAC APRE STAM VTT i2cat

Stay in touch with FORGING

www.forging-hub.eu @FORGING info@forging-hub.eu

Funded by the European Union