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Recommendations to improve or create cross-border networks of ATI technology centres

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Section 1

1. Introduction

This report presents the recommendations to improve or create cross-border networks of ATI technology centres. These recommendations are based on desk-research and the outcome of three workshops that focused on how cross-border networks of ATI technology centres can be promoted by focusing on three specific application areas and their associated value chains:

- IoT precision farming
- Low carbon industrial processes
- Smart health

The workshops took place between December 2020 and March 2021. They were organised within the Advanced Technologies for Industry (ATI) project commissioned by EISMEA and DG GROW. This project aims at aligning the monitoring activities of the KETs Observatory, the mapping of KETs centres, the Digital Transformation Monitor and other related monitors with the goal of ensuring better coherence and comparability.

This report has three main sections:

- The first section presents the **concept of value chain-based networks** and its implications for the functioning and development of networks of ATI technology centres. It presents the rationale for the selection of the three application areas covered in the report and the main dimensions of analysis. This section concludes with the presentation of the **general recommendations for future networks of technology centres**. These recommendations can be considered as a blueprint for other application areas in which a value chain-based approach could be applied.
- The second section zooms in on each of the three **application areas** covered in this report. It first presents the background notes of each of the application areas, detailing their **current situation and most pressing challenges**.
- The third section presents the **area-specific recommendations** to improve or create cross-border networks of ATI technology centres in each of three specific application areas and their associated value chains.

Definitions

Advanced Technologies (AT) comprise several technologies that are key for the European industry to maintain and increase their levels of innovation and competitiveness. It includes key enabling technologies such as Advanced Materials, Advanced Manufacturing Technology, Industrial Biotechnology, Nanotechnology, Micro- and Nanoelectronics, Photonics, as well as several of the most promising digital technologies (Artificial Intelligence, Security, Connectivity, AR/VR, Big Data, Blockchain, Cloud Computing, IoT, IT for Mobility and Robotics).

ATI Technology Centres are defined as public or private organisations carrying out applied research and close-to-market innovation (Technology Readiness Levels TRL 3 to 8, not necessarily the whole range but including at least one TRL >5) in Advanced Technologies.

Networks of technology centres refer to networks providing technology facilities, services and expertise to SMEs in the field of ATI. The network acts as a single-entry point ('one-stop shop') for SMEs willing to get access to the technology services and facilities available from the technology centres in the network.

Section 2

2. The future of cross-border networks of ATI technology centres

2.1 Applying a value chain-based approach to networks of technology centres

There are various networks operating in Europe in the domain of research, development and innovation (R&D&I). Among them we can distinguish those networks that are focused on novel technologies to connect researchers from various organisations and streamline their efforts towards investigating fundamental research related questions. ATI related networks are different as they rather focus on technologies with a higher technology readiness level, e.g. TRL 5-8, and hence foster the deployment and market uptake of new technologies. As noted in the recommendations included in the 'Study on SME access to KETs technology centres'[1], these ATI related networks currently offer high quality cooperation activities and industry-relevant services. The landscape, however, is fragmented: ATI related networks are often only known and accessible to a narrow community (e.g. the local ecosystem of a pilot line), but not to geographically or thematically more distant organisations. These networks also tend to have a narrow technology focus, often addressing only one aspect of innovativeness at one single point of a value chain, but not providing solutions on other aspects of the value chain (like financing, business development or regulation).

A transition towards application, value creation and the promotion of technology exploitation in economic terms is therefore needed. The abovementioned study suggested that this transition can be achieved by applying a value chain-based approach to cross-border networks of technology centres (TCs). This approach entails that one of the main aims of these networks should be the provision of support on all steps of innovation. By linking different TCs and competences, the scope and function of the future networks should go beyond those of the individual TCs and the existing networks. They should be able to address demands from technology to manufacturing to product, and hence take into account the entire associated value chain.

By introducing a value chain-based approach to networks of technology centres, these networks could benefit from several advantages:

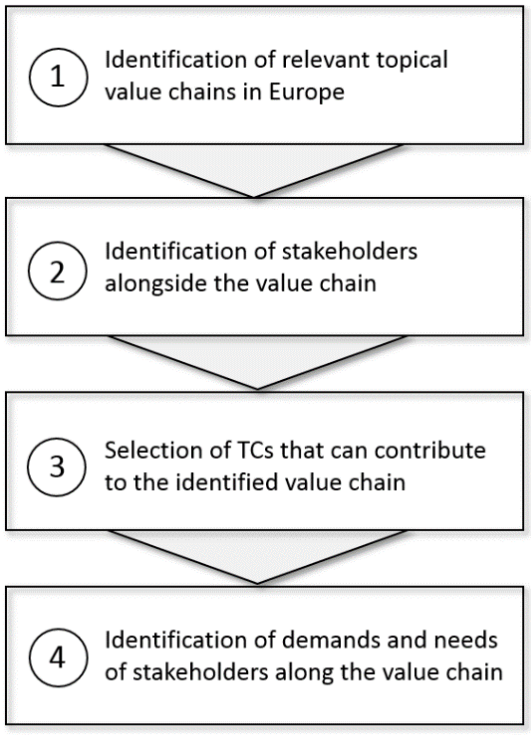
- They would be in a better position to address the demands from industry from technology development to manufacturing to product. This would foster the success of innovation and the uptake of new solutions by industry by facilitating the access to technological solutions.
- These value chain-based networks would also tend to be more flexible, hence having a greater capacity to adapt to evolving demands from the market.

The study also pointed out that transforming existing networks of TCs, which are primarily focused on technology, into value chain-based networks, is a challenge. Technology would no longer be an end in itself since the focus of a value chain-based network would be determined by market demands and industrial needs. Contrary to technology-based networks, characterised by long-term R&D&I agendas and commitment to specific technologies, value chain-based networks require a high degree of agility and flexibility to be able to adapt swiftly to market demands.

Figure 1 shows the main elements that would be required for the development of value chain-based networks. This roadmap, as described in the 'Study on SME access to KETs technology centres', indicates that the process would start with the identification of relevant value chains (1) in which the future network would operate, followed by the identification of relevant stakeholders across the value chain (2). On this basis, it would become easier to determine which TCs could participate in the network (3). The services to be offered would be defined on the basis of the needs and demands of the stakeholders along the value chain (4).

[1] https://ati.ec.europa.eu/reports/eu-reports/study-access-smes-kets-technological-centres

Figure 1: Roadmap towards value chain-focussed networks



Source: Van de Velde, E. et al. (2018) 'Study on SME access to KETs technology centres'[2]

2.2 Analysed application areas

Three workshops were organised by the Advanced Technologies for Industry (ATI) project between December 2020 and March 2021 with the objective of making this roadmap more concrete, to come to value chain-focussed networks in three application areas:

- IoT precision farming
- Low carbon industrial processes
- Smart health

These areas have been chosen because of their prominent link with societal challenges (see, for instance, the missions of Horizon Europe[3]), as well as their links to strategic value chains where the EU can have an outstanding position[4]. The Strategic Forum on Important Projects of Common European Interest (IPCEI) has identified several key strategic value chains based on their potential impact on Europe's industrial competitiveness, climate ambitions, strategic autonomy and security as well as the willingness of Member States and industry to develop joint coordinated actions in each area[5]. The six identified key strategic value chains are:

- Connected, clean and autonomous vehicles
- Hydrogen technologies and systems
- Smart health
- Industrial Internet of Things (IIoT)
- Low- CO_2 emission industry

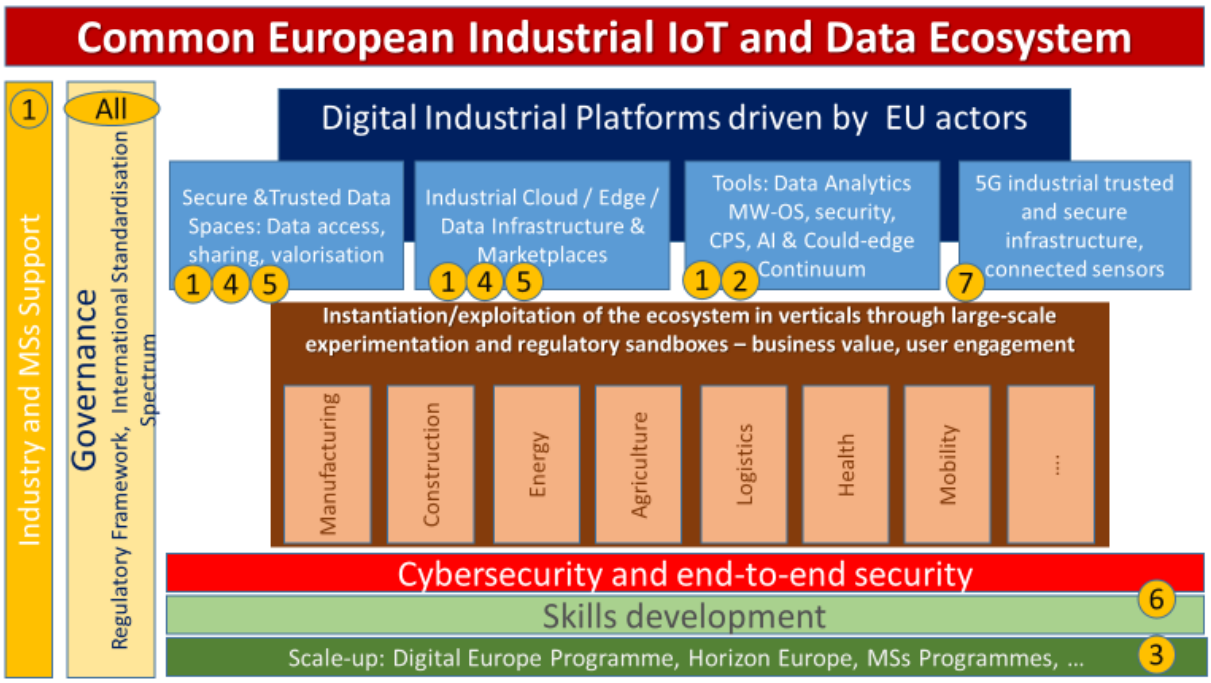
[2] https://ati.ec.europa.eu/reports/eu-reports/study-access-smes-kets-technological-centres
[3] In Horizon Europe, each mission is « a mandate to solve a pressing challenge in society within a certain timeframe and budget ».The missions are the following: cancer; adaptation to climate change including societal transformation; healthy oceans, seas coastal and inland waters; climate-neutral and smart cities; and soil health and food. More information is available at: https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/missions-horizon-europe_en
[4]https://ec.europa.eu/growth/content/industrial-policy-recommendations-support-europe%E2%80%99s-leadership-6-strategic-business-areas_nn
[5] Strengthening strategic value chains for a future-ready EU Industry, Report of the Strategic Forum for Important Projects of Common European Interest

- Cybersecurity

As Figure 1 shows, the first step towards value chain-focused networks is to identify relevant topical value chains in Europe. Seen the importance of the six identified key strategic value chains for Europe's industrial future, it was decided to select three particular key strategic value chains namely smart health, industrial Internet of Things and low- CO_2 emission industry. As part of this ATI project, several activities related to these key strategic value chains have taken place including several workshops to discuss the current state of play in Europe, a SWOT analyses and the formulation of concrete recommendations. These activities supported step 2 namely the identification of stakeholders alongside the value chain.

Figure 2 provides an overview of the Strategic Value Chain of Industrial Internet of Things. For the Strategic Value Chain of Industrial Internet of Things, a mapping of global and EU value chain players has been compiled. As IIoT technologies are used across several industries such as manufacturing, agriculture, logistics, oil and gas, transportation, energy/utilities, mining and metals, healthcare, aviation and other industrial sectors, a focus on IoT precision farming was applied for this report as smart farming and food security is one of the 5 main areas where IoT European large-scale pilots projects are co-funded[6].

Figure 2: Graphical representation of the Strategic Value Chain of Industrial Internet of Things



Source: Main report Strategic Value Chain of Industrial Internet of Things (IIoT), the figures refer to the 7 recommendations and corresponding actions that were formulated[7]

Low carbon industrial processes were selected seen the enormous challenge Europe is facing with regard to decarbonisation in order to reach the European Climate Goals. This field is very broad with many heterogeneous actors, product and process segments potentially involved, and no value chain network in this area is yet institutionalised.

[6] https://european-iot-pilots.eu/

[7] The 7 recommendations and corresponding actions are: 1. Development and piloting of a common European data space in industrial value ecosystems by defining tested and verified rules and practicalities for scalable data sharing, taking into account technical, legal, ethic and business aspects; 2. Support the deployment of a fundamentally innovative device / software technology for in-situ, real-time process monitoring for additive manufacturing; 3. Scale-up digital technologies integration along the whole value chain; 4. Secure data ownership, security and access; 5. Address measure to support data economy implementation in EU industries; 6. Support technical skills modifications for new entries and workers in order to enlarge the possibilities of qualified jobs and mitigate the risks of losing jobs; and 7. Develop a shared 5G network across Europe with appropriate infrastructure and a forward-looking regulatory framework that tackle the existing market failure due to the fragmentation of European markets.

Smart health was selected as it is recognised as one of the most promising remedies to the rising healthcare expenditure per capita associated with active and healthy ageing. Innovations in the smart health area allow healthcare providers to cure diseases more effectively, to ensure patient centred care and to prevent illnesses more frequently.

2.3 Dimensions of analysis and models of collaboration

The analysis and recommendations presented in this report are developed based on the following assumptions and definitions:

- ATI related networks focus on technologies with a medium-to-high technology readiness level, e.g. TRL 5-8, and hence foster the deployment and market uptake of new technologies.
- A transition towards application, value creation and the promotion of technology exploitation in economic terms is needed. This approach entails that one of the main aims of these networks should be the provision of support in all steps of the innovation process. By linking different TCs and competences, the scope and function of future networks should go beyond those of the individual TCs and the existing networks. They should be able to address demands from technology to manufacturing to product, and hence consider the entire associated value chain.
- The introduction of a value chain-based approach to networks of technology centres.

Three models of collaboration were discussed to analyse the pertinence of future networks. The rationale behind these models of collaboration is based on the structure and purpose of future networks of technology centres, depending on the needs they aim to address. The models are suggested for analytical purposes: they serve to highlight the main objectives of the networks and the translation of such objectives into their internal functioning and service offer. The models are understood as tools to reflect upon how well networks fulfil each purpose, to detect gaps and to facilitate decision making regarding the composition of future networks. Future networks of technology centres should contain elements of the different models depending on the needs that they aim to address. Box 1 presents the three models of collaboration.

Box 1: Models of collaboration between advanced technology centres in the provision of cross border services and support to SMEs

Joint-service model: The primary target of this type of networks are SMEs that have a previous understanding of their technological needs. This includes supplier SMEs, start-ups and some downstream SMEs if they have the knowledge on the type of technological solution they need. These TC networks are best placed to provide support in the provision of joint services to companies, hence increasing their offer to companies by complementing it with that of other centres in the network. In so doing, these networks also facilitate the access to services required when these are located in another country. In addition to this, these networks can assure the streamlining of the innovation process across different TCs or other service providers as the project moves up the TRL ladder. This diminishes the costs for the SME and lowers the barriers of access as it is clear from the beginning of the project which technology centre can develop or work on which part of the project, requested by the SME.

Awareness-based model: Like the previous model, these networks target primarily SMEs that are looking for a certain technological solution. The main difference with the former model is that this kind of networks mainly focus on making the available offer visible. It is up to the companies to find the service providers that are more suited to their needs. There is hence no streamlining of the services along the innovation chain across different technology centres (e.g. no joint services).

Coaching-based model: These networks are characterised by their focus on downstream SMEs, that is, those SMEs that require support in 1) identifying the challenges that could be addressed through technology development or uptake; 2) determining the priorities in terms of development or investments. These networks are best placed to provide support in coaching the SMEs to start the

innovation process by helping them identify and prioritise their needs and directing them to the most appropriate 'joint-service' or 'awareness-based' network.

Source: IDEA Consult

The three collaboration models presented above offer complementary ways to address the challenges faced to foster the uptake of IoT precision farming, low carbon industrial processes or smart health. The extent to which these models are suited to the IoT precision farming field, low carbon industrial processes or smart health area were discussed during the workshops.

Joint-service networks are essential to carry out testing, demonstration and validation processes of solutions maximising the expertise and infrastructure already existing in Europe. By offering joint support services across different technology centres, strengths and expertise of each of them are linked and can, hence, unveil important synergies. This joint service offer can allow, among other, for the customisation of already existing solutions to specific environments. In addition, each of the technology centres is embedded in its own regional and national ecosystem. This is important, for instance, when the service is provided to advanced technology suppliers or start-ups aiming at the introduction of their product in another country or legislative setting.

Awareness-based networks can be useful vectors of information and good practices. As mentioned in the previous sections, the IoT precision farming, low carbon industrial processes and smart health area context are very fragmented due to a combination of a high number of stakeholders along the value chain, as well as the different regulatory environments across countries. A holistic and complete overview of the solutions and infrastructure available in this field across Europe can reach a key objective: it can shed light on the solutions that are already available elsewhere in Europe as well as on the organisations that can help the development and testing of these solutions in a different context (country, circumstances, environment, etc.). This would not only improve the knowledge on the benefits of digital technologies in the field and the available offer but could also avoid duplication of efforts and maximise synergies between actors.

Coaching-based networks can support SMEs in identifying their needs and establishing concrete plans for action: small and medium-sized SMEs often do not have the necessary in-house skills to know which technological solutions might help them. Setting up networks focusing on the development of methodologies to support these companies might be beneficial. These methodologies can help SMEs to identify the challenges that could be addressed through technology development or uptake; determining the priorities in terms of development or investments; and finding the best partners to develop their projects (from technology centres to technology providers or other types of relevant actors). These networks are best placed to provide support in coaching the SME to start the innovation process by helping them identify and prioritise their needs and directing them to the most appropriate 'joint-service' or 'awareness-based' network.

The pertinence of each model of collaboration (see Box 1) has been assessed in the context of each specific application area and its associated value chain, along the following dimensions:

- **Openness to relevant contributors:** this dimension covers the thematic scope of the network as well as the types of members needed to meet market demands.
- **Comprehensiveness:** this dimension focuses on the degree in which the actors in the network operate in a coordinated manner towards SMEs (e.g. common strategy or governance structure).
- **Service portfolio:** this dimension covers the kind of services that these value chain-based networks should offer to address the needs of SMEs (e.g. feasibility studies, demonstrators, pilot production, experiments, technology scouting, innovation management scouting, trainings), as well as the interaction between SMEs and the networks.
- **Pan-European scope:** this dimension refers to the embeddedness of future networks into broader ecosystems at EU level and whether there would be a need for a pan-European value chain-based network of technology centres.

A workshop was organised for each of three selected areas to identify the key elements required for the creation of a value chain-based networks of TCs. The objective of the three workshops was:

1) To discuss the need to set up cross-border value chain-based network of technology centres in each of the three selected application areas, including an analysis of the areas in which these networks would be needed and the models of collaboration that would be more pertinent.
2) To shed light on several dimensions related to the creation and/or development of these networks (openness to relevant contributors, comprehensiveness, service portfolio, pan-European scope).

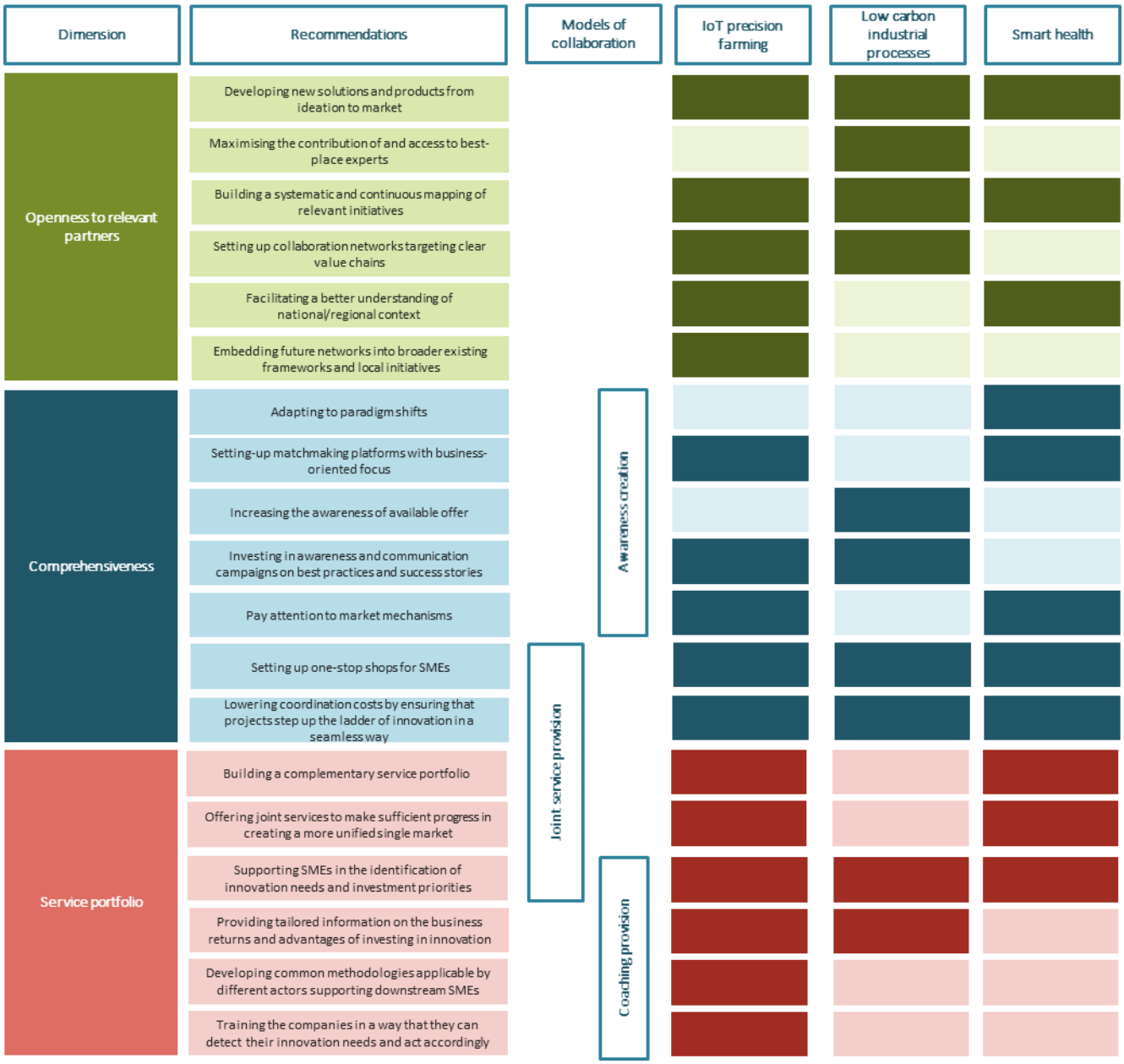
2.4 Recommendations to improve and/or create networks of technology centres: a framework of analysis

The figure below summarises the main recommendations for each of the dimensions covered in this report with regards to the improvement and/or creation of future networks of technology centres: the openness to relevant partners, their level of comprehensiveness and their service portfolio. This figure can serve as **a blueprint for the application of a value chain-based approach to future networks of technology centres in other application areas** beyond the ones covered in this report. The recommendations build upon previous work of EARTO[8] and the European Commission[9] that highlight the role of technology centres as the backbone of dynamic R&D&I ecosystems and stable innovation-driven value chains.

The figure also shows which recommendations are relevant in each of the areas under the scope of this report: IoT precision farming, low carbon industrial processes and smart health. A similar exercise could be carried out for other application areas in order to identify their action priorities. When a recommendation is not highlighted as relevant, this does not entail that the recommendation is not applicable to that specific area, but rather that it should not be regarded as a top priority at this moment. The figure also depicts which recommendations are more closely related to the models of collaboration that we discuss in this report, namely the joint-service model, the awareness-based model and the coaching-based model.

[8] EARTO "Setting-up a European Strategy for Technology Infrastructures" (https://www.earto.eu/8056-2)
[9] https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2019)158&lang=en

Figure 3: Recommendations and priorities for actions



Source: IDEA Consult

Note: Darker colours in the columns below each of the three application areas indicate a higher relevance.

OPENNESS TO RELEVANT PARTNERS

Developing new solutions and products from ideation to market/ Maximising the contribution of and access to best-placed experts.

Future networks need to be open to new partners and to partner up with different types of organisations in order to: 1) develop new solutions and products from ideation to market and 2) maximise the contribution of and access to best-placed experts. Developing new solutions and products from ideation to market constitutes a top priority for the three application areas covered in this report as the fragmentation of actors and initiatives leads to a suboptimal exploitation of the potential available in Europe.

Building a systematic and continuous mapping of relevant initiatives

In order to address this, a systematic mapping of relevant initiatives has been identified as one of the most pressing needs across the three application fields. Such a systematic mapping would allow to:

- Detect synergies and gaps;
- Explore new collaboration avenues;
- Foster the identification of relevant actors and the collaboration between them;
- Facilitate the connection between the available initiatives and the end-users (e.g. SMEs, farmers, patients, healthcare professionals).

Setting up collaboration networks targeting clear value chains

Once a clear picture of the landscape is available, a collaboration network of technology centres targeting clear value chains can be set up. Current networks in the three areas tend to focus exclusively on technology and this makes it difficult for companies to move from ideation stage up to commercialisation. This process can be facilitated by embracing the combination of technology and application areas within new networks or among existing networks. This will facilitate the access of companies to networks as it will become easier for them to find the network providing the services that they need. It will also allow for the development of solutions where different technologies play a role. This is especially relevant in those areas where it is not yet clear which technologies will be the best solution to address certain challenges (e.g. decarbonisation processes).

Facilitating a better understanding of the national and regional contexts

Some application areas are more affected by local legislation than others in the sense that local regulations might to some extent determine the range of technology options (for instance the existence of certain regulations limiting farmers' activities). This implies that the local contexts need to be taken into account when developing value chain-based networks in order to better adapt to the needs of the end-users. This need to understand the local contexts also refers to the availability of funding options or the existence of economies of scale that might make the deployment of certain solutions more feasible or attractive in certain regions. This would be the case, for instance, of IoT precision farming solutions that become more viable when they can be applied to large surfaces of land like the example of the LoRaWAN coverage installed in Northern Greece.

Embedding future networks into broader networks and connecting with local initiatives

Finally, it is important that future networks are embedded into broader existing frameworks and local initiatives. This is especially the case in the area of smart health where coordination within the Innovative Healthcare Initiative is recommended as well as a strong synchronisation with other initiatives such as the Digital Innovation Hubs or networks supported under the Interreg Europe programme. The main objective is to avoid duplication of initiatives and strengthen the coordination between the existing ones.

COMPREHENSIVENESS

Adapting to paradigm shifts

In some fields, a change of paradigm goes hand in hand with the development of certain technology solutions. Cross-border networks of TCs can contribute to such a paradigm shift. This is the case of networks operating in the smart health area. The move towards value chain-based healthcare and a more prevention-oriented paradigm (supporting, for instance, wearables and other self-monitoring solutions for prevention) can be further supported by value chain-based networks as they can accompany the new solutions from ideation to market in a more seamless way.

Setting up matchmaking platforms with business-oriented focus

Matchmaking tools are required to foster cooperation. In the case of low carbon industrial processes, there is a need to strengthen collaboration between industrial actors and technology centres to cooperate in a certain field (for example exchange in material flows, energy). This matchmaking is seen as one of the ways to address the fact that multiple sectors will be potentially affected by technology solutions in these areas. This type of matchmaking mechanism would need to focus on a specific value chain in order to be useful for all actors involved and it would not only include typical R&D&I-actors (technology centres, research infrastructures, projects) but also actors from the value chain ecosystem around the respective thematic field (e.g. suppliers of solutions). For example, Hydrogen Europe is a valuable partner for matchmaking in a cross-border-network of low carbon industrial processes.

Increasing the awareness of the available offer

Closely related to the systematic mapping of ongoing initiatives and to the availability of matchmaking tools, there is a need to increase the visibility of the available technology solutions and providers as well as the technology centres that can help companies to explore the potential of such solutions in a tailor-made approach. This visibility is currently being promoted by ongoing initiatives such as the mapping of the ATI technology centres[10] and other initiatives with a narrower technology focus (e.g. the smart AKIS initiative offers an inventory of applicable solutions in the field of IoT precision farming). While the value added of these initiatives is remarkable, the advantage of a value chain approach for future networks is that the link between the end-user and the technology solutions, providers and centres becomes clearer. In other words, such a network becomes more visible for the companies and actors that are more closely related to it.

Investing in awareness and communication campaigns on best practices and success stories

One of the common aspects that has been highlighted across the three application areas is the need to invest in communication campaigns that can make visible best practices and success stories. In order to be coherent with the idea of value chain-based networks, these communication efforts should be structured along the business needs that are targeted and the business returns of implementing the technology and innovation that address such needs. Up to now, most communication campaigns have been focused on the technology, it would be time to move to a solutions-oriented communication style.

Paying attention to market mechanisms

Value chain-based networks are by definition more closely associated to business than those networks that have a narrower technology focus. This entails that market mechanisms operating in the business targeted by the network need to be taken into account when designing such networks. For instance, in the area of smart health, solutions would need to be more often demonstrated at a European scale in order to prove the potential outcomes, lower the risk and speed up its commercialisation. In the IoT precision farming, market mechanisms are also important: a key element to be considered by future networks is the need to offer R&D&I services that connect new technologies to various applications across different legislative settings.

Setting up one-stop shops for SMEs

Across the three application areas, the multiplicity of initiatives across Europe and the difficulty to assess which initiatives are more interesting for individual SMEs is pointed out as a barrier for access of these companies. A systematic mapping of initiatives would improve the access to this information, yet future value chain-based networks need to pay attention to the ways through which SMEs can access the network. These mechanisms will depend on the purpose and mission of the network (awareness-based, coaching-based, joint-service), but they all have in common the need to create clear pathways for SMEs to have access to these initiatives and to the technology centres that are part of them.

Lowering coordination costs by ensuring that projects step up the ladder of innovation in a seamless way

In a simplified way, most current networks provide services to SMEs following a bilateral approach: technology centre *X* provides services to company *Y*. If in the development of its innovation project, this company would need the service of another technology centre (*Z*), a new bilateral approach is initiated between the company and the technology centre Z. The succession of these bilateral steps has several disadvantages: it increases the coordination costs and the complexity of the projects. In many cases, the output of the first technology centre might not necessarily be completely streamlined or be compatible with the needs in the following step of the process with the second technology centre. In addition, SMEs do not always have the necessary technical expertise in-house to coordinate this process. As a result, it becomes evident that one of the most important advantages of networks of technology centres is to offer a streamlined approach for the whole innovation process (i.e. that the outcomes of each step are compatible with the inputs required in the following step). The need for this streamlining has been highlighted in the smart health area but can be an important aspect for many other applications areas as well.

[10] https://ati.ec.europa.eu/technology-centre/mapping

SERVICE PORTFOLIO

Building a complementary service portfolio

The systematic mapping of ongoing initiatives will allow, among others, to assess the degree of overlap and complementarity of ongoing initiatives. This will allow not only to provide better information to end-users on the initiatives that are better tailored for their needs but will also help the initiatives themselves to better adapt their service portfolio in function of what is already available. Future networks will hence have a better understanding of how to design their service portfolio in a way that they can have a greater added value.

Offering joint services to make sufficient progress in creating a more unified single market

The multiplicity of regulatory contexts in some application areas is often a significant barrier for innovation. This problem becomes even more prominent in value chains of strategic importance for Europe. One way to address this barrier would be fostering the provision of joint services by technology centres located in more than one country. This entails that the knowledge on the national or regional regulatory contexts can be embedded in the project since the start and this barrier can hence be addressed more successfully. This is the case in areas that are very much affected by local regulations such as health or farming.

Supporting SMEs in the identification of innovation needs and investment priorities

A key aspect of the uptake of innovation is the provision of support to those companies that do not have the required expertise in-house to assess their innovation needs. These companies, referred to as downstream companies in this report, are usually reluctant to innovate as they do not know which technologies can address their challenges. Support in the identification and prioritisation of the challenges and the required solutions is considered as crucial element to support the uptake of new technologies. An example of this can be found in the IoT precision farming area where farmers are not usually aware of the ways through which they can benefit from available technologies. The smart health area is also an interesting example as hospitals, healthcare staff or patients are not always aware of the technological options that can address their daily challenges.

Providing tailored information on the business returns and advantages of investing in innovation

Knowledge of the solution does not always go hand by hand with the willingness to invest in it. Technological solutions and innovation are often seen as expensive, and it is important to analyse and showcase to the end-users the business returns of investing in technology and innovation. It is important that the information on the business returns (turnover, creation of employment, etc.) is as close as possible to the daily work of the companies in order to be inspiring for them.

Developing common methodologies applicable by different actors supporting downstream SMEs

The development of methodologies to provide support, advice and coaching for SMEs is seen as a useful approach for downstream SMEs – those with limited R&D&I human and financial resources. This methodology would be applied by those organisations that are already supporting SMEs (clusters, trade associations, etc.) and would constitute a proven and solid approach to help the SMEs prioritise the investments and the innovation efforts to maintain and strengthen their competitiveness and resilience.

Training the companies in a way that they can detect their innovation needs and act accordingly

SMEs often face a situation in which they have limited skills in house to innovate or digitalise their daily work. Future networks of technology centres can play a role in this aspect as they have the equipment, skills and knowledge necessary to provide training for companies on two main aspects: 1) technological options (which solutions exist and how they can benefit from them); 2) the implementation of the technology itself (how to use it once it is implemented). IoT precision farming is a good example of an area where such training is likely to have a strong impact.

Section 3

3. Background notes for developing cross-border networks of ATI technology centres

3.1 Background note on IoT precision farming

Industry 4.0 is increasingly affecting the agri-food value chain by introducing the use of IoT and sensors in farms, allowing farmers to make informed decisions about their crops or livestock. IoT and sensors allow for the monitoring of real time parameters, setting up and being an integral part of smart systems and smart data management, enabling connectivity and information flow across agri-food value chains. Many farmers, however, have not yet adopted these digital technologies or tend to invest only in consolidated technologies. There are several reasons why these technologies are not being applied more extensively:

- Scepticism about the benefits of digital technologies, the lack of proof of concepts that demonstrate these benefits, the lack of knowledge on the various technological options or the high costs of these solutions is partially hindering the uptake of technologies by farmers.
- The application of digital technologies often requires customised approaches to address the specific contexts. This customisation is likely to increase the cost for farmers and, hence, their reluctance to apply these technologies in their farms.
- The European agricultural value chain is complex and more fragmented compared to the United States. The uptake of new technologies becomes more difficult in settings with many actors (crop farms, livestock farms, veterinarians, transporters, slaughterhouses, retailers and consumers) being involved in different stages of the process across different countries and legislative spaces. An optimal application of IoT for precision farming would require ensuring that data are interoperable across all value chain segments, countries and legislatives spaces.
- The legislative fragmentation entails that it is difficult and costly to develop products that can be successful across legislative contexts. Many companies, and particularly SMEs, hesitate to demonstrate their technology beyond their own national context due to this fragmentation. The financial benefit of doing so is not easy to demonstrate.

The combination of these factors entails that further public support is needed to encourage the uptake of technological solutions in this domain. Cross-border and/or cross-regional platforms are part of the solution to tackle these challenges as they can bring the relevant actors together and facilitate the process from technology development to manufacturing to product beyond national borders. This is likely to speed up innovation as well as the uptake of technologies by farmers.

There are multiple examples of cross-border initiatives operating in this field. For instance, many Horizon 2020 and other Framework Programme projects have addressed the topic of sensors for agri-food. Examples are:

- **IOF2020**[11] (Internet of Food & Farm 2020): The project explores the potential of IoT-technologies for the European food and farming industry. It aims to develop an ecosystem that consists of farmers, food companies, policymakers, technology providers and end-users. The consortium led by the Wageningen University and Research consists of more than 120 members. They focus on 5 trails (arable crops, dairy, fruits, vegetables and meat), IoT technology and established 33 use cases.
- **SMARTAGRIHUBS**[12] (digital innovation hubs in agriculture) is a pan-European network to speed up the development and uptake of digital innovations. SmartAgriHubs relies on an

[11] https://www.iof2020.eu/
[12] https://www.smartagrihubs.eu/

existing network of 140 DIH's operating in five different sectors and geographically categorised within nine regional clusters (Central Europe, France, Iberia, Ireland & UK, Italy & Malta, North-East Europe, North-West Europe, Scandinavia, South-East Europe). The aim of the project is to fund flagship innovation experiments and supporting DIHs. They aim to become a sustainable network that delivers a one-stop shop service to actors in the field.

- **ATLAS**[13] (Agricultural Interoperability and Analysis System): the goal of ATLAS is to achieve a new level of interoperability of agricultural machines, sensors and data services and enable farmers to have full control over their data and decide which data is shared with whom in which place. The technology developed in ATLAS will be tested and evaluated within pilot studies on a multitude of real agricultural operations across Europe along 4 relevant use cases: 1) precision agriculture tasks, 2) sensor-driven irrigation management, 3) data-based soil management, and 4) behavioural analysis of livestock.
- **DEMETER**[14] (Building an Interoperable, Data-Driven, Innovative and Sustainable European Agri-food Sector) is a large-scale deployment of farmer-driven, interoperable smart farming-IoT (Internet of Things) based platforms, delivered through a series of 20 pilots across 18 countries (15 EU countries). Involving 60 partners, DEMETER adopts a multi-actor approach across the value chain (demand and supply), with 25 deployment sites, 6 000 farmers and over 38 000 devices and sensors being deployed.
- The **Nefertiti network**[15] is a demonstration network where research institutes are linked directly to farmers. The network is used to showcase digital solutions and other innovations in agriculture, for peer-to-peer learning among learners and to increase awareness and innovation uptake.
- The **agROBOfood**[16] network is a growing network of various partners. The ambition of the project is to build a pan-European network of innovation hubs and competence centres to stimulate the development and implementation of robotic concepts and to develop solutions more easily. The DIH (Digital Innovation Hubs) will become a one-stop shop where people can find all the information needed and be linked to the right partners, thanks to the close collaboration of the triple helix.
- The objective of the **S3 High-tech farming partnership**[17] is to improve the impact of R&D&I projects, to reduce funding and knowledge gaps by clustering the information and improving access, allowing better management and marketing of new technologies and enabling farmers to use and master the new technologies. The regional ecosystem is often not aware of what is happening at national level or in other regions. There is a strong demand to better align the interconnections at EU level.
- The **ICT-AGRI-FOOD**[18] was established in 2009, as a result of a working group among Member States. The vision of the network is to bring actors together and to have an overview of what is going on in various Member States across the EU regarding a sustainable and resilient agri-food system.

The following sections present various elements for the design of future value chain-based networks of technology centres operating in IoT precision farming.

3.1.1 Openness to relevant contributors

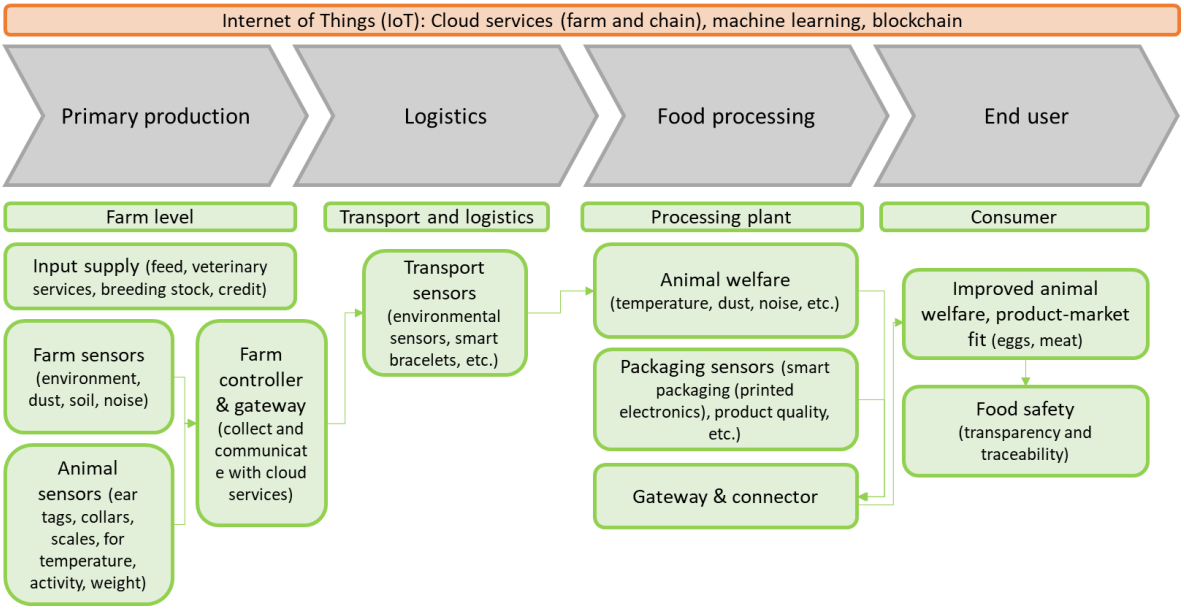
The IoT precision farming value chain entails multiple actors and technologies such as cloud services, machine learning and blockchain technologies that connect the sensors and data systems with one another (see Figure 4). These technologies are key for the digitalisation of the agri-food sector as they enable the collection of sensor-based data throughout the value chain. This enables transparency and traceability, but also entails that an optimal application of the technology requires the involvement of various stakeholders across the value chain. In this context, reaching an optimal level of openness to

[13] https://www.atlas-h2020.eu/
[14] https://h2020-demeter.eu/
[15] https://nefertiti-h2020.eu/
[16] https://agrobofood.eu/project/
[17] https://s3platform.jrc.ec.europa.eu/high-tech-farming
[18] https://www.ictagrifood.eu/

relevant contributors in future cross-border networks of technology centres working on IoT precision farming would require several elements:

- **Identifying active technology centres across the value chain**: Future cross-border networks of technology centres working on IoT precision farming would need to identify the concrete value chains they will focus on (see roadmap included in Figure 1): e.g. livestock value chain, fruit and vegetables value chain. Identifying concrete value chains is needed to reveal the technology centres that are active in them and their potential role within the network.
- **Identifying other relevant actors across the value chain**: The following step focuses on the identification of other actors along the value chain that could play a role in the cross-border network. Depending on the concrete value chains that are selected, a series of key actors might be essential to identify the needs and the barriers to foster the application of technological solutions: e.g. farms, cooperatives, veterinarians, sensor manufacturers, IoT service providers, logistics companies, processing plants and even end-users. Other actors could also be relevant. This is the case, for instance, of intellectual property rights and data protection experts or even regulatory authorities (who could help speed up the adoption of more streamlined regulation across borders). Intermediaries (e.g. regional development agencies) can also play an important role, especially through cross-regional platforms, such as the Thematic Smart Specialisation Platform. The High-Tech Farming partnership, for example, aims to create an ecosystem for testing, disseminating and commercialising European technological solutions and to connect regional platforms consisting of regional authorities, demonstration farms and technology providers.
- **Adapting the governance structure for a seamless provision of services across TCs**: The selection of TCs for a future cross-border network would have to consider the need to ensure that the expertise of the different technology centres allows for new technologies to move up the TRL ladder in a unified way.

Figure 4: Sensors for farm management of livestock value chain



Source: IDEA Consult based on IOF 2019a; IOF 2019b; Ovo-vision 2016

3.1.2 Comprehensiveness

Comprehensiveness refers to the degree in which the actors in a cross-border network operate in a coordinated manner towards SMEs. In general, the focus of a value chain-based network would be determined by market demands and industrial needs. This is particularly important in case of networks operating in the field of IoT precision farming. In this area, it is of crucial importance to bridge the valley

of death and to foster the application of technological solutions and make them more easily available to farmers (i.e. by lowering the costs). One of the key elements is the offering of R&D&I services that connect new technologies to various applications across different legislative settings. In this context, future cross-border networks would need to make a choice on how to organise themselves. There are two main options:

- 'Closed' networks where technology centres and other partners share communication, networking, monitoring and management costs. This option has the advantage that it can ensure more efficiently the streamlining of the process (e.g. that projects can make use of the services provided by different partners in a streamlined manner, quicker and without loss of information or increased costs). This type of network, however, requires the implementation of clear and transparent guidelines and rules to ensure that all partners work in alignment with the network´s strategy.
- 'Open' networks that only share communication and networking costs. These networks need less stringent rules or guidelines as they are characterised by loose interaction between members. This type of network allows to identify a broader set of actors involved in a certain value chain but might not facilitate the streamlining of the services provided.

3.1.3 Service portfolio

One of the most important objectives of future value chain-based networks operating in IoT precision farming should be to foster the uptake of these technologies by different actors throughout the production system. In order to do so, it is key that that these networks focus on translating the offer of their members into solutions for concrete business challenges. A value chain-based network in the IoT precision farming field would therefore need to offer those services that are needed for a successful uptake of the technology by farmers and other actors throughout the production system.

The added value of technology implementation for each step of the value chain as well as the potential barriers for technology diffusion and exploitation need to be identified. These networks would hence need to define the service offer accordingly, as well as the extent to which these services would need to be offered in a coordinated manner across different actors (even when located in different countries).

Some technological solutions in the IoT field are already available in the farming sector. However, farmers still lack information on how and what to digitalise and the necessary resources to do so (economic or human resources, availability of certain skills, etc). Future networks in the sector would need to consider involving actors that are able to provide support to farmers in this process. Scouting services for farmers could prove useful in order to fully develop IoT solutions in this area.

IoT precision farming solutions are highly dependent on the availability of a critical mass of data. The actors that are currently more likely to have access to these data are in most cases large players like John Deere and Bosch. This entails that future networks might need to liaise to some extent with these players in order to find ways for SMEs to work with these large companies to have a broad access to data and improve their solutions. Some type of mentoring or coaching role could be considered.

3.1.4 Pan-European scope

The abovementioned limitations related to the fragmented nature of the European market and legislative frameworks entail that responses might be more effective if they are articulated from a cross-border perspective. There is already a number of cross-border initiatives that are operating in this area like the High Tech Farming partnership. The objective would be that future value chain-based networks operating in the field build on the experience and trust that has been generated in the existing initiatives and not to replace them. The precise mechanisms through which these initiatives could be connected in the future depend on the (value chain) focus they have and the complementarities between them. At the same time, enough flexibility and openness to new partners would need to be maintained to be able to react swiftly to market developments.

3.2 Background note on low carbon industrial processes

The European industry sector faces the technological and economic challenge to advance decarbonisation the fastest possible in order to reach the European Climate Goals and abating greenhouse gases. 30% of energy end-use in the EU is consumed by the production sector.

Generally, we can speak of two types of CO_2 emissions from industrial processes: those from combustion facilities deriving from energy use in the production processes and those inherent in the (chemical)

production processes (among others the examples of the calcination of limestone CO_2 in cement manufacturing).

The emissions from energy use in the production processes can be reduced significantly or even completely, by applying strategies of energy- and materials efficiency, technologies of Advanced Manufacturing and the switch to zero-carbon electricity from renewables. However, the abatement of emissions inherent in the production processes, such as in many raw materials and energy intensive industries, is much more difficult and can only be realised when developing disruptive low CO_2 technologies.

In 2015, the Energy Intensive Industries (EIIs) represented 15% of total direct greenhouse gas emissions (GHG) in the EU. This is why we will focus here on the application of low carbon industrial processes in the value chains of energy intensive industries. 90% of industry's direct GHG emissions consist of CO_2 and globally half of the industry's emissions result from the manufacture of the four industrial commodities: ammonia, cement, ethylene and steel. Especially in the energy intensive industries, it is of crucial importance to change industrial production processes to become less CO_2-intensive or even CO_2-neutral, by developing and deploying low CO_2 technologies. Main CO_2-emissions reduction pathways applicable to most industries include energy efficiency and process integration, the use of alternative feedstocks and fuels (captured CO_2, hydrogen, biomass and waste), electrification, hydrogen-based-processes (e.g. in steel production), Carbon Capture and Utilisation (CCU), Carbon Capture and Storage (CCS), recycling, materials efficiency and circular economy[19] as well as higher valorisation of waste streams and materials efficiency.

In the energy intensive and raw materials industries, switching to zero-carbon electricity, if technically feasible, requires significant changes to the design of the furnaces or kilns, which normally have long lifetimes and are a major component in a complete integrated process. There is a need for technical breakthrough technologies and the transformation of value chains towards new pathways. For this existing initiatives and networks, e.g. technological or industrial clusters in the Member States have to work together, in order to scale-up, test and find the best solutions in a short time frame.

The **main challenges** ahead for the development of low-carbon-industrial processes in the EU are[20]:

- needed investments in new process plants or other long-term investments and high operational costs, especially for renewable electricity;
- need of suitable infrastructure and strategies for better supply of renewable electricity, biomass, H2, recycling but potentially also for CCU (carbon capture and use);
- need of further research and development of low-carbon industrial processes and pathways;
- risk of losing competitiveness towards other world regions and
- a variety of technological options and measures to avoid carbon emissions in different industries, where different solutions have to be adopted and to be scaled-up.

The latter challenge can be addressed through a value chain-based approach of developing networks of technology centres in the EU. In the heterogeneous landscape of different technological solutions, approaches and research and technology providers, industrial companies need support from the appropriate technology centres with the expertise they need. In an overarching network for different industries forces can be joined to create synergies to lower the CO_2-footprint of the industry.

On the EU-level, there are various examples of cross-border initiatives, research and innovation programmes and projects, technology centres, as well as transnational networks and platforms with the objective of significantly reducing CO_2- and other greenhouse gas emissions in the energy intensive industries.

- **SPIRE:** A first initiative is SPIRE, which is a contractual public-private partnership for 'Sustainable Process Industry through Resource and Energy Efficiency' between the European Commission and eight process industries, including the steel industry. Projects under the umbrella of SPIRE are co-funded under H2020 and address topics such as energy and resource

[19] The circular economy may boost repair, reuse and recycling, which generally (although not always) saves GHG emissions. It may also boost activities such as refurbishment (a product's manufacturer updates the product's appearance to expand the product's life), remanufacturing (the manufacturer uses parts of an old product in a new product) and eco-design (more efficient products with longer life and easier to recycle).
[20] As identified in the Stakeholder Task Force 'low-carbon industry' initiated by the Strategic Forum.

flexibility, efficient integrated downstream processes as well as recycling. The project DISIRE for example, aims to improve the measuring of the properties of raw materials or product flows, evolving processes and overall resource and energy efficiency by technological breakthroughs and concepts in the field of Industrial Process Control.[21]

- **ECCSEL:** The European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL)[22] is a project funded under the European Union's Horizon 2020. It is a permanent pan-European distributed research infrastructure with five operations centres in France, Italy, the Netherlands, UK and Norway. Its mission is to enable low to zero CO_2-emissions from industry and power generation to combat climate change.
- **SUNRISE**[23] and **ENERGY-X**[24]. These are pan-European academia-industry initiatives aiming at providing new technologies to be ready by 2030, in the area of sustainable fuels and chemicals. While ENERGY-X focuses on the use of renewable electricity and point sources of CO_2, SUNRISE also advocates the efficient use of solar energy and Direct Air Capture as ultimate goal. They both promote the storage of energy in chemical bonds as an efficient, dense and scalable solution to the energy storage problem. SUNRISE and ENERGY-X are supported by hundreds of major European players in the field of chemistry, materials (cement and steel) and energy.
- **PHOENIX:** The PHOENIX Initiative is a collaborative effort supported by the EU Member States, France, Germany, the Netherlands, and the European Chemical Industry Council (Cefic).[25] PHOENIX will function as an umbrella initiative linking national and European R&D&I activities with respect to CO_2 valorisation to ensure an optimal use of public funding and private investment. PHOENIX will interact with all relevant stakeholders from industry through research institutions to national governments and the European Commission.
- **BBI JU:** In the field of bio-based products, the Bio-based Industry Joint Undertaking is a public-private partnership that aims to foster innovation and to support the creation of new value chains for biomass-based products and services.
- **BAMBOO[26]:** a relatively new R&D|I-project in the field of energy and resource efficiency challenges, funded under Horizon 2020, with a focus on steel, petrochemical, minerals and pulp & paper industry. The objective is to scale up promising technologies under real production conditions on three main innovation pillars: waste heat recovery, electrical flexibility and waste streams valorisation.
- **KET4CleanProduction** is a Coordination and Support Action (CSA) funded by Horizon 2020, which connects 13 technology centres (TCs) and 7 members of the Enterprise Europe Network. The objective of the project is to help SMEs to overcome challenges related to clean production. It will enable the enterprises to achieve sustainability, innovation and to become more competitive. To achieve a higher innovation capacity, SMEs need to integrate key enabling technologies (KETs). This will result in higher productivity, less waste and a better pollution management. The project is divided into three phases: pilot phase, large scale demonstrator phase and sustainability phase. The KET4Clean Production network also offers a one-stop access platform for cross-border innovation services for manufacturing SMEs through a network of superior 'KETs technology centres' (KET TCs) and Enterprise Europe Network (EEN) partners. Also, it fosters SMEs connectivity to KET TCs through joint project proposals for micro grants.

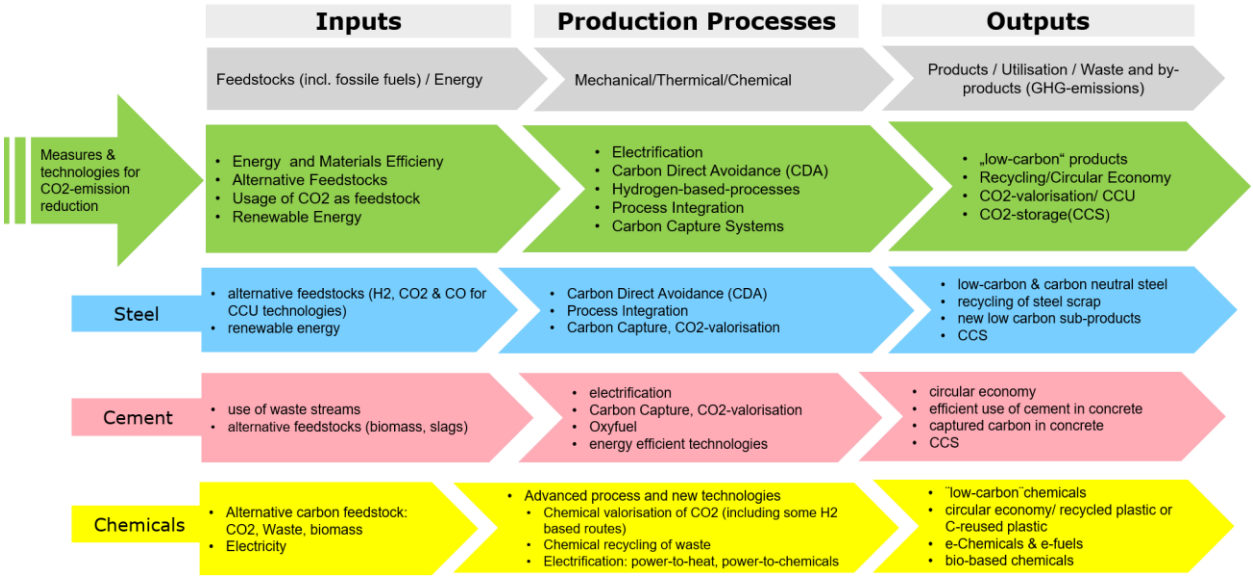
As stated above, the field of low CO_2 industrial processes is very broad with many heterogeneous actors and product and process segments potentially involved. Hence, the assessment of 'landscape of networks' can be done at the moment mainly on the assessment of the identified networks (see above) in combination with the workshop (see below).

[21] https://www.spire2030.eu/disire
[22] https://www.eccsel.org/about/eccsel-eric/about-eccsel/
[23] www.sunriseaction.eu
[24] www.energy-x.eu
[25] http://www.phoenix-co2-valorisation.eu/phoenix
[26] https://cordis.europa.eu/project/rcn/218188/factsheet/en

3.2.1 Openness to relevant contributors

A trans-European value chain network on low carbon industrial processes is not yet institutionalised and can potentially be open to a broad range of all industrial sectors, especially the manufacturing sectors and the energy intensive sectors, but also to actors in the field of renewable energy, energy and materials efficiency, bioeconomy and hydrogen. While there are several measures and adaptations such as implementing energy and materials efficiency, using renewable electricity for the production processes and contribute to better recycling of industrial products, there is no 'one-fits-all-approach' for all the different targeted industrial sectors. The following graph shows the different technologies and measures along the value chain of a typical industrial company (detailed for the steel, cement and chemical sector), which could be implemented to lower the carbon footprint. Around these different solutions, several initiatives and projects - in some cases also specific TCs - are already existent and in some areas (e.g. carbon capture technologies) they begin to form networks between each other (see also existing initiatives above).

Figure 5: Graphical representation of the Strategic Value Chain of low CO_2 industry



Source: Analytical Report: Strategic Value Chain of low CO_2 emissions Industry

3.2.2 Comprehensiveness

As part of the Strategic Forum on Important projects of common European Interest (IPCEI), considerable efforts were taken to build up a value chain centred cross-border network. In the beginning of 2019, a Task Force with relevant actors from the energy intensive industries was set up to bring together stakeholders along this emerging value chain across EU Member States in two stakeholder workshops and various virtual meetings. Several challenges and opportunities around this emerging strategic value chain were discussed, including the formulation of recommendations for a better uptake of low carbon technologies. One of the challenges is that these industries work separately from each other and there is a strong competition between the actors belonging to the same industry as steel. There is a lack of culture of cooperation in networks. An opportunity for actors of different industries to work together to share cross-sectoral technological solutions for CO_2-low-processes, is to join forces in a 'cross-border', 'industry-neutral' network around the emerging value chain. In addition, there are many interrelations among actors along the Strategic Value Chain (e.g. the chemical industry could use the captured CO_2 or other residuals as input for new products).

This field of actors is very heterogeneous, also because it is a kind of a 'meta' value chain with the challenge of decarbonisation that must be addressed by potentially all industrial sectors. Even from the first analysis, the workshop and the work of the Task Force on the Strategic Value Chain of low CO_2 industry it seems that there are not so many TCs specialised on decarbonisation of industrial processes in the EU. The TCs and initiatives identified in section 3.2, however, seem to be very comprehensive and some of them already constitute networks, as they unify already broad range of actors in their structures (e.g. SPIRE with research and technology institutes, companies, clusters). These TCs and initiatives also seem to offer different degrees of comprehensiveness in their network - from formal

membership and strong commitments to loose attachment through partially implemented common projects.

On the other hand, there are multiple actors, initiatives and projects fragmented along the value chain which are working on the topic. The multiple industries that have to work on the decarbonisation of their processes with different technologies, measures and services will need support from research and technology centres along their value chain.

Some relevant segments for low carbon industry, such as the bio-based economy have made progress with the creation of a significant number of projects covering the whole value chain across European countries. However, when entering higher TRL phases, there is only a scattered number of projects addressing the value chain.

3.2.3 Service portfolio

For now, the services offered by TC or initiatives and networks in the field of low carbon industrial processes offer a wide range of different activities, mainly in research and development, upscaling of technologies, project and funding coordination. The initiatives represented in the workshop also had a broad portfolio, but with a focus on giving access to research infrastructures and the participation in research and innovation projects. Some of them could also imagine offering coaching and consulting related services as well.

However, it seems that the different activities are fragmented and often a specific company only knows the TCs in its own region, which may be not the most appropriate when it comes to the search for the best available service or technology for low CO_2 industrial processes. Through collaborations between initiatives and projects, the different actors can take advantage from important synergies but also create learning effects among each other for even better support of their target groups.

3.2.4 Pan-European scope

While some efforts to build-up cross-border networks exist, the switch to low-carbon alternatives often implies, at least partly, a disruption for existing pan-European value chains. A focus on a value chain for a low CO_2 industry includes bringing in new technology providers and/or feedstock chains. Hence, additional initiatives or at least a significant reconfiguration of existing ones appear necessary to realise a low carbon economy.

This also creates the need for a pan-European cooperation across industries along the value chain, working together on the best solutions to decarbonise industrial solutions in thematic networks, that could be created through an initiative of cross-border networks of TCs. Regarding low carbon industrial processes, SMEs from all over Europe will face similar challenges to their production process depending on their type of product and industrial sector. As there is little knowledge about the effectiveness and sustainable upscaling of low CO_2 technologies, there is a need for sharing good-practices between them.

3.3 Background note on smart health

The EU boasts a solid innovative medical technology sector where medical devices are currently further shaped by emerging trends such as artificial intelligence or blockchain. Despite these strengths, the EU is still relatively weak in translating research into tangible health products and services[27] and needs to bolster its actions in nurturing a stronger digitally enabled health care delivery. An important barrier to overcome is the limited collaboration between the various health related industrial sectors due to competition, diverging business models and different development timelines, despite the prerequisite to integrate technologies and health innovations along the healthcare pathway[28].

Rolling out and scaling up novel, smart health technologies is still hindered by a lack of proper digital infrastructure and the lack of standardisation across the EU. MedTech SMEs developing smart healthcare products and services need a better functioning value ecosystem and access to infrastructure via technology centres, however, they face several challenges (among others)[29]:

- First of all, they need **access to good quality datasets**. Data is essential and requires a large infrastructure. The availability and accessibility of data is key for the development of new products. Other issues arise related to data security, data standardisation, quality control and

[27] European Commission (2020). Draft proposal for a European Partnership under Horizon Europe European Partnership for Health Innovation
[28] Inception Impact Assessment, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12663-Digital-health-data-and-services-the-European-health-data-space_en
[29] https://ati.ec.europa.eu/reports/product-watch/artificial-intelligence-based-software-medical-device

data interoperability. The establishment of coordinated data sharing across the Member States is still an important challenge in the area of health data and data analytics in Europe, despite the many ongoing initiatives[30].

- They **need market demand** that underpins the success of scaling up for instance through more innovative procurement and more awareness about the positive features of digital healthcare solutions. Start-ups need to be close to the end-user such as hospitals and patients in order to understand their needs and develop tailored solutions. Nevertheless, it is not enough to prove the value to the final customer, but new digital healthcare products and services require a change of the whole healthcare system. Existing models should be transformed from an acute-based paradigm to a preventive, personalised and responsive health service. Health insurance, reimbursements, clinical practices, investment schemes need to be adapted in order to embrace the potential of such innovations.

- SMEs need **support to go through the various procedures, regulatory approvals** and need support in testing and validating their products and services throughout the clinical workflow.

3.3.1 General landscape of networks of ATI technology centres in the field of smart health

Technology centres play a critical role in the smart health ecosystem. They support the development of digital healthcare solutions and medical devices by providing access to technology, support to validation and prototyping, testing (in vitro and in vivo), safety and clinical testing[31]. They can be key to support start-ups in the field of smart health in terms of providing access to data, access to digital knowledge (such as cybersecurity), access to support in clinical trials or going through regulation procedures, reaching to the market.

More specifically they help:

- Developing smart health prototypes;
- Providing access to technological infrastructures and pooling resources in data, expertise, computing processing and storage capacities;
- Connecting medtech and digital firms;
- Networking between SMEs and key healthcare actors such as health professionals, clinical centres or large companies;
- Co-working spaces and mentoring and
- Support in regulatory competence, IP law, procurement rules.

Pan-European collaboration among technology centres has been instrumental for SMEs to raise the quality and access to technology support services across Europe. There are multiple examples of cross-border initiatives, both voluntary ones as well as networks supported by EU programmes that support SMEs in access to knowledge in the field of smart health.

Some examples of **pan-European organisations** relevant for technology centres in the field of digital health include:

- **EARTO** (the European Association of Research and Technology Organisations) promotes the interests of RTOs in Europe by reinforcing their profile and position as a key player and runs a specific working group in emerging technologies for healthcare. It aims at creating a European research and innovation ecosystem, where RTOs can work together underpinning a competitive European economy and ensuring high quality and healthy life.

- The **European Clinical Research Infrastructure Network** (ECRIN) is a not-for-profit intergovernmental organisation that supports the conduct of multinational clinical trials in Europe. As of 2013, ECRIN has the legal status of a European Research Infrastructure Consortium (ERIC).

- The **European Institute for Biomedical Imaging Research** aims to improve cooperation between research institutes, academic departments and industry that form the European

[30] See also https://www.healthparliament.eu/mediacoverage/big-data-healthcare-role-eu/
[31] EARTO (2019). Accelerating the Digitization and Market Access of Emerging Technologies for Healthcare - The Pivotal Role of RTOs

biomedical imaging community with the goal of improving the diagnosis, treatment and prevention of diseases. It actively supports research networking activities and common initiatives and interoperability in the field of biomedical imaging research.

Under **Horizon 2020**, the EU provided targeted research and innovation funding to support the use of digital technologies in health and long-term care services. The latest Horizon Europe framework programme aims to ensure the sustainability of healthcare systems, focusing among others on tools, technologies and digital solutions for healthcare.

The **Innovative Medicines Initiative** (IMI) (co-financed by the Horizon 2020 programme) facilitates the collaboration between key players such as universities, research centres, industry, SMEs, patient organisations and medicines regulators and it fosters the competitiveness of European SMEs by channelling funding to SMEs through research projects and also indirectly. There are various Horizon2020/Innovative Medicines Initiative 2[32] projects that provide a framework for creating better cross-border linkages among technology centres and SMEs in the field of smart health:

- **EHDEN** (European Health Data & Evidence Network) was launched to address the challenge of generating evidence from real-world clinical data at scale. The project aims to do this by building a federated data network allowing access to the data of 100 million EU citizens standardised to a common data model.

  More specifically, the EHDEN project is training and officially certifying SMEs for the task of mapping observational data to the observational medical outcomes partnership (OMOP) common data model[33]. These calls for proposals are relevant for stimulating the creation of emerging, new markets for data sciences and help SMEs to expand their data analysis services.

- **PULSE** (Participatory Urban Living for Sustainable Environments) will leverage diverse data sources and big data analytics to transform public health from a reactive to a predictive system, and from a system focused on surveillance to an inclusive and collaborative system supporting health equity. All the geospatial data collected or generated within PULSE have been made accessible through the WebGIS tool, a web-based platform that allows the visualisation of the data, to monitor different kinds of public health phenomena and to explore their location-related dynamics.

- **BigMedilytics** (Big Data for Medical Analytics) is an EU-funded initiative to transform the healthcare sector by using state-of-the-art big data technologies to achieve breakthrough productivity in the sector by reducing cost, improving patient outcomes and delivering better access to healthcare facilities simultaneously. The project is composed of 12 pilots that address three themes with the greatest impact on the sector - population health and chronic disease management, oncology and industrialisation of healthcare services - and covers the entire healthcare continuum from prevention to diagnosis, treatment and home care.

In the new programming period, the European Commission aims to increase the competitiveness of European health related industries and to pilot and deploy healthcare technologies on a large scale, partly through the establishment of ambitious European Partnerships.

Innovative Health Initiative (IHI) is the successor of IMI and IMI2. Innovative health is one of the fields that the European Commission identified as an upcoming institutionalised partnership. IHI will support joint research between industry, academics and SMEs, expanding beyond pharmaceuticals, to include medical technology, biotech, digital health and vaccines.

The **Digital Europe Programme** is another key pillar of smart health supporting the creation of a digital infrastructure needed for digital health tools. The three priorities of the digital transformation of health and care are to ensure citizens' access to their health data, foster personalised medicine through shared European data infrastructure and empower citizens with digital tools for user feedback and person-centred care[34].

[32] The IMI2 programme builds on the successes of IMI1 and focuses on the needs of patients and society, and on delivering tools and resources to speed up the development of urgently-needed treatments. In addition, a greater emphasis is placed on accelerating patient access to new treatments (https://www.imi.europa.eu/about-imi/history-imi-story-so-far).

[33] https://www.imi.europa.eu/news-events/newsroom/screening-certification-and-technology-scans-how-imis-projects-can-help-smes

[34] European Commission (2018). Communication on enabling the digital transformation of health and care

The Digital Innovation Hubs operating in the health sector help companies improve their processes, products and services through the use of digital technologies. They provide innovation services, such as financing advice, training and skills development that are needed for a successful digital transformation. The European Digital Innovation Hubs (EDIHs) in health will continue under the most recent programme and will allow for a broad uptake of Artificial Intelligence, high-performance computing and cybersecurity[35].

Various networks support cross-border collaboration and access of SMEs to digital innovation hubs:

- The **DIH-HERO Digital Innovation Hub Healthcare Robotics** is building an independent platform which connects DIHs across Europe to create a sustainable network for the benefit of small and medium-sized enterprises.
- **AI-DIH Network** is a preparatory action to create a European Network of Digital Innovation Hubs with focus on AI. Medical technologies are one area that the network targets.
- The **European Innovation Partnership on Active and Healthy Ageing** (EIP on AHA) brings together government authorities, care professionals, industry and users across borders to scale-up and bridge the gap between seller and buyer, producer and user. The mission of the Partnership follows the Digital Single Market strategy and its Communication[36] notably "to build a healthier society that can cope with demographic change, address inequalities, maintain resilient healthcare systems, and provide quality care services to citizens across the EU".
- The **eHealth Hub Platform** has mapped the ecosystem of IT companies, investors and other stakeholders like experts, corporates and business supporters active in the European digital health landscape. eHealth Hub's goal is to provide high-quality, vertically focused and business-oriented services tailored to the needs of European eHealth SMEs and stakeholders and to secure their continuation after the project end via a sustainable support structure.

Relevant for all cross-border networks of smart health is the **European Health Data Space** - one of the priorities of the European Commission 2019-2025 - that is expected to promote better exchange and access to different types of health data (electronic health records, genomics data, data from patient registries etc.).

A further programme that supports innovative medical products and greener manufacturing is the recently launched **EU4Health[37]**. The programme is a European response to COVID-19 and invests €5.1 billion. Funding opens for applications in 2021.

EU4Health will boost EU's preparedness for major cross border health threats by creating reserves of medical supplies and also healthcare staff and experts including increased surveillance of health threats. It will also support digital transformation of health systems and make medicines and medical devices available and affordable, advocate the prudent and efficient use of antimicrobials as well as promote medical and pharmaceutical innovation and greener manufacturing.

At regional level, the Thematic Smart Specialisation Platform for Industrial Modernisation has been launched including various thematic areas in order to build regional coalitions to support the creation of new European value chains, in areas associated with strategic growth. In particular, the MedTech 4.0[38] has been a pilot project developed under the MedTech partnership, which developed an open platform for accessing and analysing health-related data. The MedTech4Europe Interreg[39] project connects public authorities at regional level with the objective to strengthen the Research, Development and Innovation (RDI) ecosystem in favour of innovative medical technology industry in generating economic growth, creating jobs and providing solutions for patients and healthcare systems in the regions.

[35] https://ec.europa.eu/digital-single-market/en/news/future-digital-innovation-hubs-and-reference-sites-digital-transformation-health-and-care-eu
[36] European Commission (2018). Commission Staff Working Document Progress of the European Innovation Partnership on Active and Healthy Ageing
[37] https://eu4health.eu/
[38] https://s3platform.jrc.ec.europa.eu/medical-technology
[39] https://www.interregeurope.eu/medtech4europe/

DESIGN OF FUTURE VALUE CHAIN-BASED NETWORKS OF TECHNOLOGY CENTRES

The following sections present various elements for the design of future, cross-border value chain-based networks of technology centres in the field of smart health.

Policy gaps and need for more action

It is important to identify existing policy gaps and scope for building more synergies among existing European level initiatives and cross-border networks. There are several areas where policy actions need to be further reinforced.

- There is a lot of innovation and entrepreneurship going on in the field of digital health, but it requires a big jump to **introduce innovation to the market**. The future Digital Europe programme is expected to help bridging the gap between research and innovation, commercialise innovation and offer solutions for scale up, nevertheless more policy attention is needed across all other policy programmes relevant for smart health.
- Another issue is a **fragmented market,** not only in terms of resources, but also in terms of locality, procurement and value. While indeed, digital health can grow and go across borders, there are still further difficulties in truly scaling up at a European scale. Most adoption still happens through public procurement and more cross-border procurement initiatives are necessary.
- In digital health, **access to data** is vital to build solutions, especially in terms of validation of the data. A lot of data are held within silos in research institutions and hospitals or in the hand of citizens. There is no mechanism in place to make the exchange of data accessible. There should be a stronger focus on data and how to deal with access to large scale datasets.
- Policies need to reflect more about the **acceptance of patients and citizens to support the adoption of digital health**. One solution is more uniformity in the assessment frameworks, as well as in reimbursement pathways. In terms of value chain-based healthcare to increase the care and reduce the cost, the focus should be placed on the perspective of the patient and defined by patient groups. AI and other technologies can play an essential role to facilitate the adoption of digital health solutions.
- There is a fragmentation in the **legal landscape due to General Data Protection Regulation (GDPR)** and the restrictions in using and re-using data. New technology will help including privacy enhancement technologies and synthetic datasets. However, GDPR remains an obstacle for secondary use and sharing of sensitive data. There is a need for better integrating electronic health records not only to provide a seamless experience for the patient but also to improve communication between health professionals and research.
- There are fragmentations in terms of support. At national and regional levels, very often two different directorates deal with SMEs within the economic and the healthcare fields which need to be bridged. Pan-European networks can address this policy gap.
- Access to cross-border technology infrastructure for SMEs in the context of a **value chain-based healthcare and more prevention-oriented** paradigm shift – supporting, e.g. wearables and other self-monitoring solutions for prevention.
- Stimulating the **networking between smart health start-ups and large firms** across EU borders and between start-ups and clinical professionals

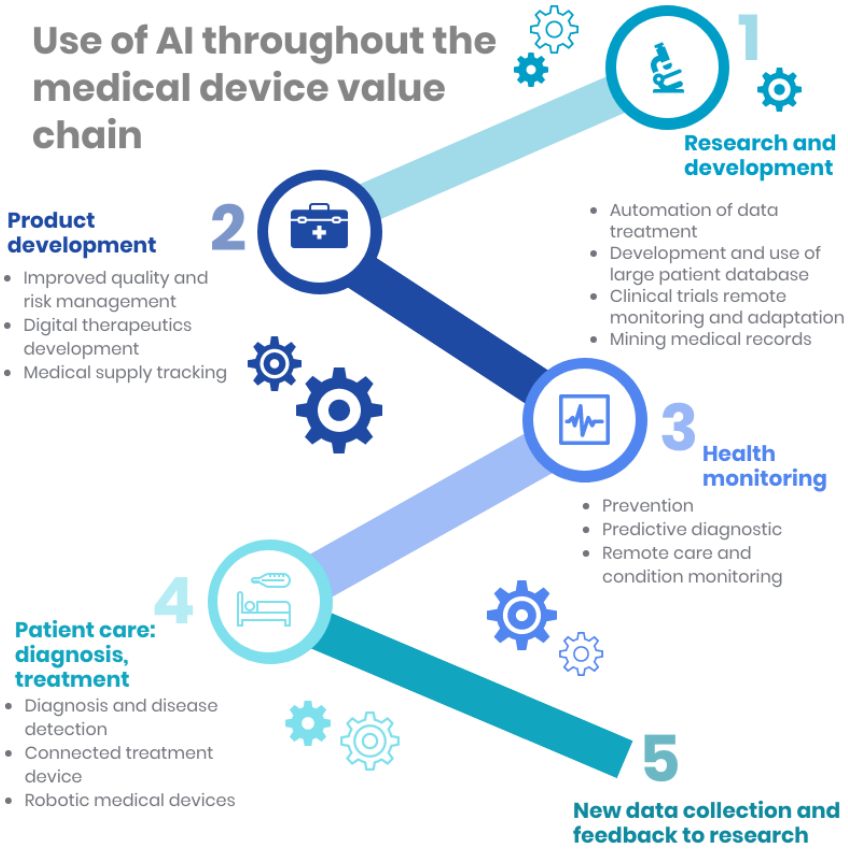
3.3.2 Openness to relevant contributors

In this context, reaching an optimal level of openness to relevant contributors in future cross-border networks of technology centres working on smart health would require several elements:

- **Identifying active technology centres across the value chain**: Future cross-border networks of technology centres would need to identify the concrete value chains they will focus on such as AI software as a medical device, clinical wearables, digital therapeutics, healthcare robotics, telemedicine, other smart medical devices. Identifying concrete value chains is needed to reveal the technology centres that are active in them and their potential role within the network. Further types of technology centres might be also critical to support with data security, access to knowledge in IoT, robotics, advanced manufacturing, AR/VR etc.

- **Identifying other relevant actors across the value chain**: The following step focuses on the identification of other actors along the value chain that could play a role in the cross-border network including regulators, insurance companies, payers, healthcare institutions, patient's forums etc. Intermediaries (e.g. regional development agencies) can also play an important role, especially through cross-regional platforms, such as the Thematic Smart Specialisation Platform.
- **Adapting the governance structure for a seamless provision of services across TCs**: The selection of TCs for a future cross-border network would have to consider the need to ensure that the expertise of the different technology centres allows for new technologies to move up the TRL ladder in a unified way.

Figure 6: Examples of AI/ML-based software utility along the healthcare value chain



Source: Technopolis Group, 2020

3.3.3 Comprehensiveness

Comprehensiveness refers to the degree in which the actors in a cross-border network operate in a coordinated manner towards SMEs. In general, the focus of a value chain-based network would be determined by market demands and industrial needs. In this context, future cross-border networks would need to make a choice on how to organise themselves. There are two main options as explained in section 3.1.2.

3.3.4 Service portfolio

One of the most important objectives of future value chain-based networks operating in smart health should be to foster the safe and fast validation and uptake of advanced technologies by the healthcare ecosystem.

The service portfolio offered by a future cross-border network of ATI technology centres in the field of smart health should take into account the unmet needs of SMEs identified and focus on the potential for more synergies across existing networks.

Section 4

4. Area-specific recommendations to improve or create cross-border networks of ATI technology centres

This section presents specific recommendations for each selected application area and provides detailed information about best practices to follow and the priorities in each dimension.

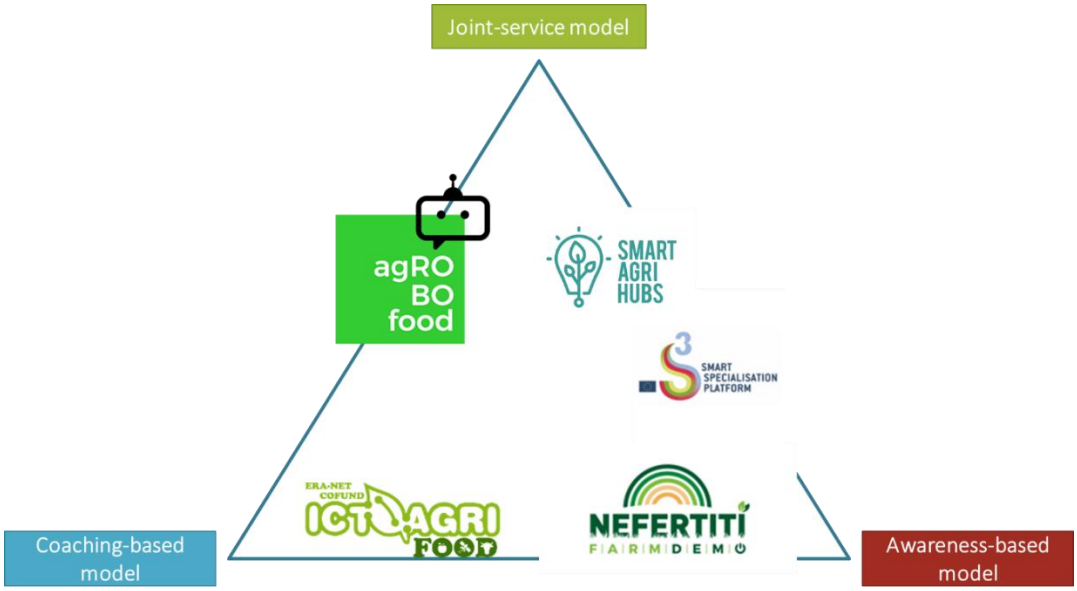
4.1 Recommendations to improve or create cross-border networks of ATI technology centres in the field of IoT precision farming

The following sections present various recommendations for the design of future value chain-based networks of technology centres operating in IoT precision farming.

The five initiatives presented during the IoT precision farming workshop, namely NEFERTITI, agROBOfood, S3 High Tech Farming partnership, ICT-AGRI-FOOD, SmartAgriHubs, have been positioned across the three models of collaboration. The three models of collaboration were displayed in a pyramidal shape showing that current models of collaboration tend to be closer to one or two models. It was stressed that even though the networks might be closer to one or the other model, they often integrate elements from another model.

- The Nefertiti network was positioned between the coaching-based model and the awareness-based model, with the reasoning awareness-based for tech providers and certain farmers (80%) and coaching-based for other kind of farmers (20%).
- The agROBOfood network was positioned between the joint-service model and the coaching-based model.
- The S3 High-tech farming partnership positioned itself between the joint-services model and the awareness-based model.
- The ICT-AGRI-FOOD positions itself between the coaching-based model and awareness-based model, but closer to the first one.
- The SmartAgriHubs project was positioned between the joint-services model and the awareness-based model.

Figure 7: Location of the presented initiatives across the three models of collaboration

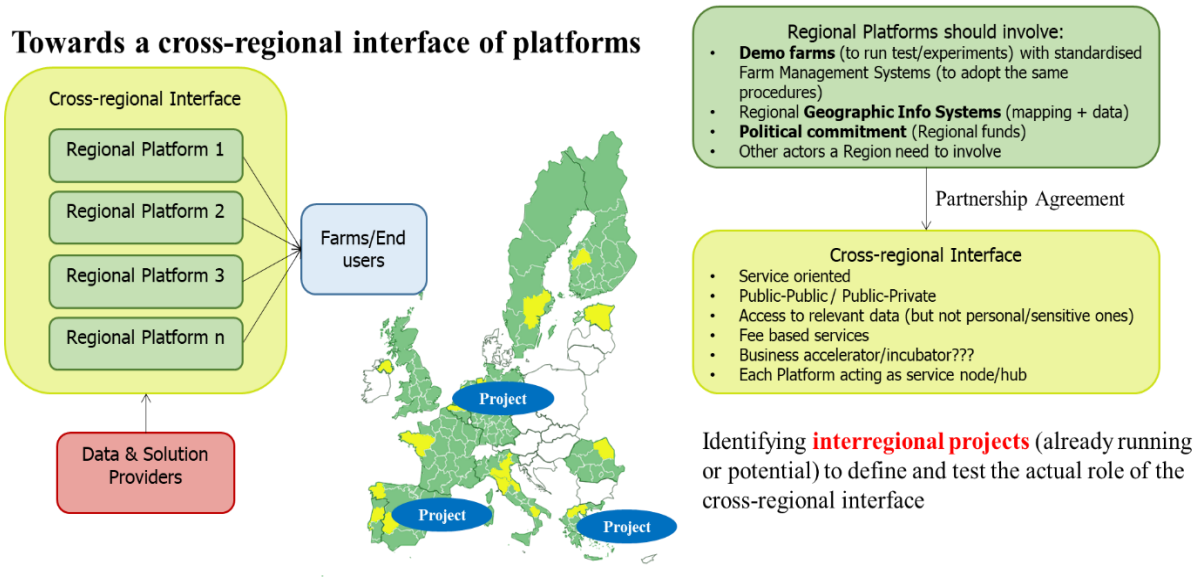


Source: IDEA Consult

4.1.1 Openness to relevant contributors

An important question for setting up value chain-based networks in IoT precision farming is: Which kind of actors should be involved and how can an alignment on interests of the various actors be realised? The 'openness' dimension refers to the thematic scope of the network as well as the types of members needed to meet market demands. As shown in Figure 4, several stakeholders are involved like farms, IoT service providers, sensor manufacturers, innovation intermediaries, etc. The High-Tech Farming partnership, for example, aims to create an ecosystem for testing, disseminating and commercialising European technological solutions and to connect regional platforms consisting of regional authorities, demonstration farms, and technology providers as shown in Figure 8. ATI technology centres are at the core of the data and solution providers (red box in Figure 8).

Figure 8: Towards a cross-regional interface of platforms for high tech farming



Source: High Tech Farming partnership

A technology push for data and solution providers often does not work in the context of IoT precision farming as farmers often lack the knowledge to make educated choices on which digital technology to adopt in their farm. Hence, innovation intermediaries and cooperatives often play a key role to combine the diverse needs of several farmers and select the best solution providers. Hence, in setting up valuechain-based networks in IoT precision farming, innovation intermediaries and cooperatives should play a key role, next to technology centres, to facilitate an effective transfer and deployment of technology to the end-user.

Some of the most pressing challenges and market failures in this field are[40]:

- Lack of information about existing technologies, the lack of digital skills;
- Limited availability of reliable cost/benefit analyses of the new technologies;
- Research and innovation projects that are still required to develop new solutions and
- Lack of basic infrastructure, such as broadband or access to other high-speed internet connections

In the area of IoT precision farming, several initiatives already exist to address the challenges associated with introducing digital technologies in farms. Each of these initiatives has its own focus. For instance, the SmartAgriHubs project works on three different levels to involve DIHs and technology centres for various countries and stimulates them to work complementary. The S3 High-tech farmer partnership focuses on attracting and involving farmers in demo case projects in order to close the gap between innovators on a local level and the innovation systems at European level.

[40] 'A smart and sustainable digital future for European agriculture and rural areas', Declaration signed on the Digital Day 9 April 2019.

When creating cross-border networks of TCs in the area of IoT farming, it is important not to focus on a particular sector, e.g. farming, or on a specific technology, e.g. IoT, but rather to combine the application of a specific technology in a particular sector. There are already a multitude of networks focusing on farming, such as the EIP-AGRI network at EU level, several farmers associations at national and regional level, cooperatives at regional and local level. This makes it difficult for farmers to identify the relevant partners. Cross-border networks of TCs with a clear focus on a few specific technologies in a particular sector that can act as a one-stop shop would offer a true benefit for farmers to digitalise their farms.

The ICT-AGRI-FOOD network would be very interested to align the existing agri-food networks by assisting other networks and partnerships to create a link with at the level of Member States and ministries. The S3 High-tech farmer partnership could complement the work of the ICT-AGRI-FOOD by creating a link at the regional level. The agROBOfood network, the SmartAgriHubs network and the Nefertiti network could identify relevant TCs to become part of this value chain-based network, based on the current activities and networks.

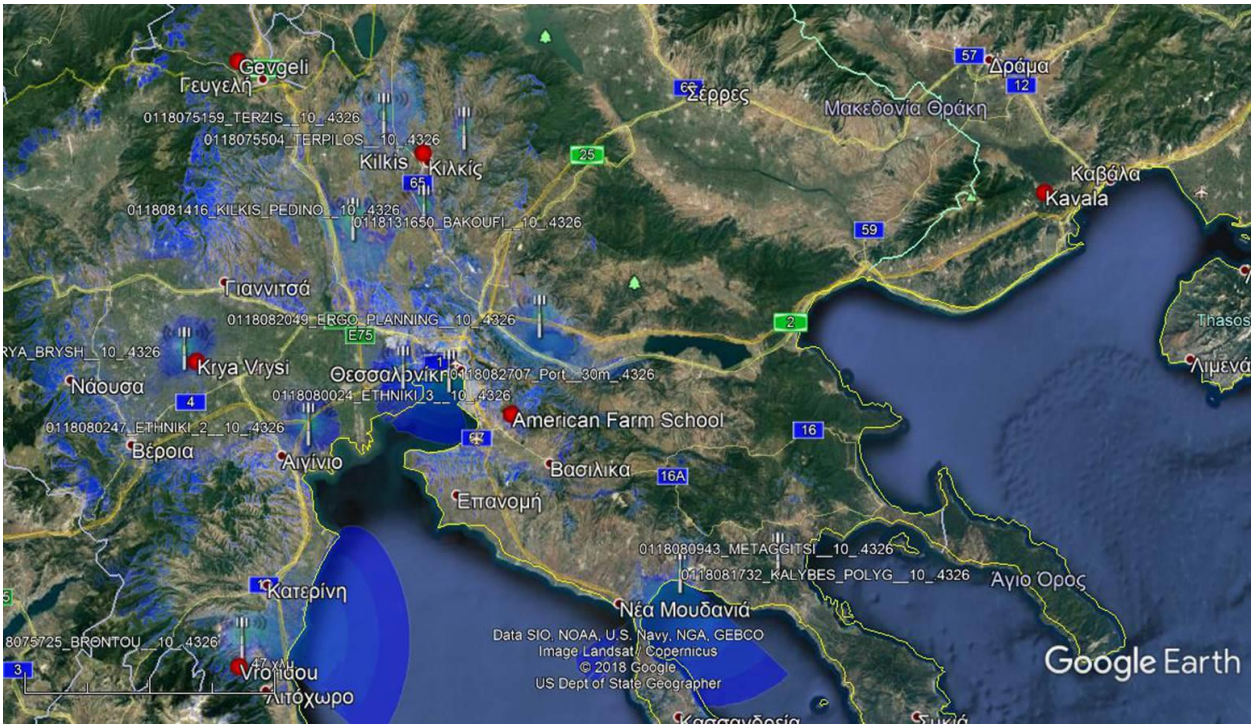
In order to attract new TCs to this value chain-based network, it is important to demonstrate the value of becoming a member. Hence, innovation intermediaries and cooperatives can play a role to connect the diverse needs of several farmers toward the offering of services by TCs and solution providers. The one-stop shop could be further linked to relevant partners, which are part of the triple helix in the various ecosystems.

4.1.2 Comprehensiveness

This dimension focuses on the degree in which the actors in the value chain-based networks should operate in a coordinated manner towards SMEs, e.g. the internal functioning and structure of the network. The ways through which this coordination is set up depend on the main objectives to be pursued by such a value chain-based network:

- **Coaching-based model:** Establishing local connections to farmers is very important, as it opens a larger market when commercialising the product or service in a cross-border setting. Through coaching, services and trials, barriers to entry for farmers and small agri-food companies can be lowered as much as possible to get into touch with new technologies. Delivering demonstration services on-site is relevant for them as this implies that there is no need to invest in research projects, but they can try out specific applications at a low price. Local contacts of DIH and technology centres play an important role in transferring the technologies to the farmers. A value chain-based network in IoT farming should align the internal functioning of several TCs as a low entry level for farmers is needed. Also, training should be offered so that the skills of local contacts can be improved.
  A coaching-based model might be best suited to address the needs of farmers regarding IoT precision farming. Farmers are aware of the needs they have, but they often do not know which actor can offer a customised solution to address their particular needs. In addition, they often do not have the knowledge to choose among the offering of several technological solution providers that promise to solve the need. It might also be beneficial if neighbouring farms are installing the same IoT technologies as advantages of scale can be achieved. For example, Northern Greece has installed a LoRaWAN coverage (Figure 9). This LoRa network can technically cover up to 20 000 devices in Northern Greece and this number can triple if the network is expanded throughout mainland Greece. It is a common ultra-short-wave telecom protocol, free for all farmers and technology solution providers to adopt, and therefore easily expandable. Hence, it ensures interoperability as it provides a basis on which sensors can be developed and it ensures connectivity as transport and logistics can be followed using the same system.

Figure 9: The LoRa coverage of Northern Greece



Source: American Farm School

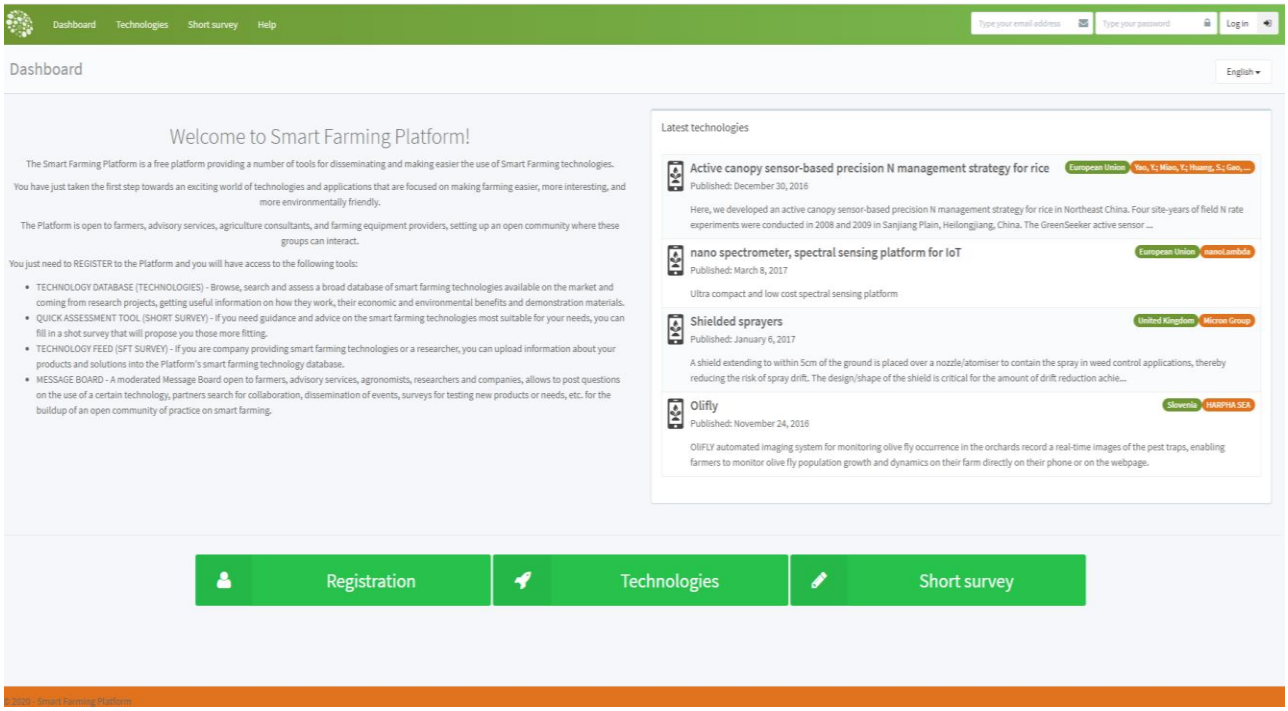
- **Joint-service model:** A value chain-based network in IoT farming should not focus on the hardware too much, but rather focus on offering services related to data analyses and identifying SMEs that can provide these kinds of services to farmers so that a regional ecosystem can be created. It should also take care of aspects such as farm management systems and interoperability, as these are key to improve the uptake of innovations. Standards are needed to facilitate the exchange and interpretation of data. Well-functioning farming systems are needed so farmers can find the information coming from the various systems in one central place. A value chain-based network in IoT farming should align the internal functioning of several TCs as a low entry level for farmers is needed.
- **Awareness-based model**: Although most farmers are aware of the needs they have, they are still actors that can benefit from additional awareness creation, especially with regard to sharing best practices and success stories.

4.1.3 Service portfolio

This dimension covers the kind of services that future value chain-based networks should offer to address the needs of SMEs and farmers as well as the interaction between SMEs and farmers, and the networks. Ideally, value chain-based networks can offer their services in a coordinated manner across different actors and countries.

- **Awareness-based model:** Smart AKIS is organising the offering of services by creating an inventory of direct applicable solutions from a large stock of research results and commercial applications (Figure 10).

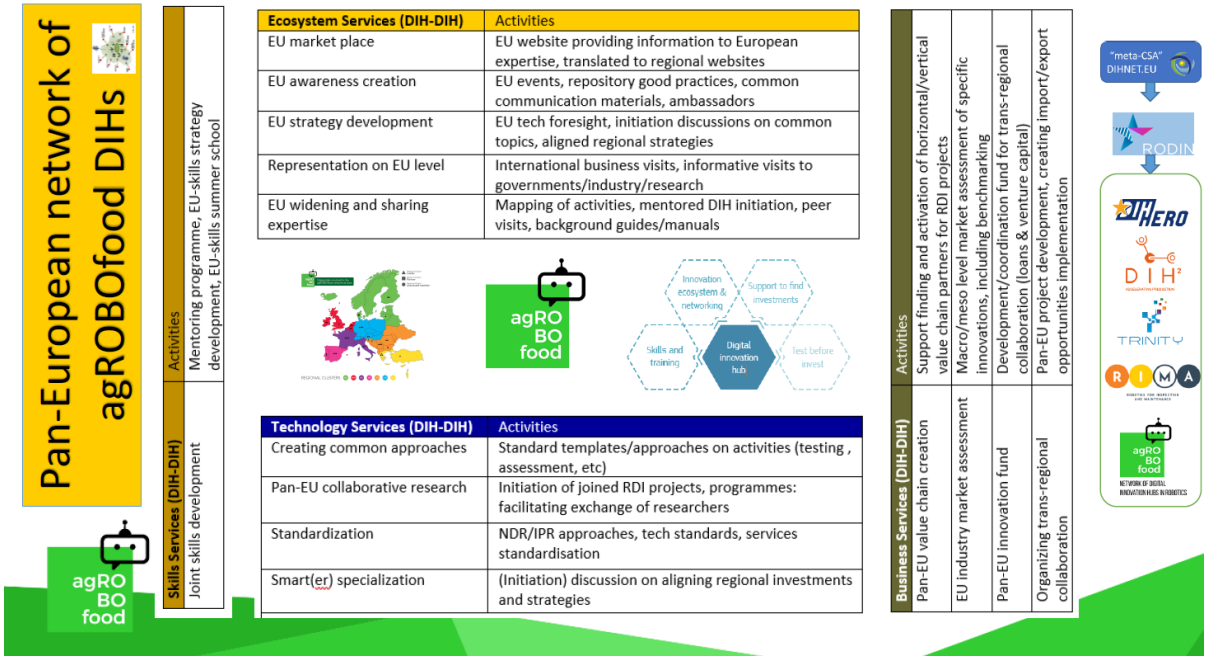
Figure 10: Smart-AKIS – Smart Farming Platform



Source: https://smart-akis.com/SFCPPortal/#/app-h/dashboard

- **Joint-service model:** As a pan-European network, the agROBOfood network offers a full coverage of services which could be further professionalised (see Figure 11). The idea of offering customers access to a one-stop shop is very important as this one-stop shop guides customer in getting answers to their questions and provides support in formulating their needs. In order to create good contacts between farmers and SMEs, trust is needed. In the agROBOfood network, open calls are launched to create the opportunity for SMEs and farmers to get in contact with regional clusters and DIHs.

Figure 11: Services offered by agROBOfood



Source: agROBOfood presentation 4 December 2020

- **Coaching-based model:** The Smart Agri Hubs project for example, is creating an ecosystem of 140 Digital Innovation Hubs embedded within 9 regional clusters to foster an agricultural value chain network. It consists of 2 000 competence centres and 28 Flagship Innovation Experiments where digital ideas and prototypes are developed and introduced into the agri-food market. In this project, DIHs and technology centres in the network are well placed to perform coaching tasks as they receive funding to coach SMEs. Depending on the maturity of the DIH, the level of support differs. DIHs that are not yet very mature, tend to link companies to other DIHs who can offer the required services. The less mature DIHs are coached by the SmartAgriHubs team to gain maturity via training and workshops on business, ecology and technology related topics. Toward the future, the SmartAgriHubs project will focus on coaching as one of the main activities.

4.1.4 Pan-European scope

This dimension refers to the embeddedness of future value chain-based networks into broader ecosystems at EU level.

There are many networks active in the area of IoT farming which makes it difficult to obtain a good overview. The ICT-AGRI-FOOD network has tried to establish a comprehensive overview as most partnerships focus on particular aspects, so knowing what other partnerships are doing is very valuable and needed. By linking partnerships and creating a value chain-based network, the knowledge and innovation transfer towards end-users can be improved.

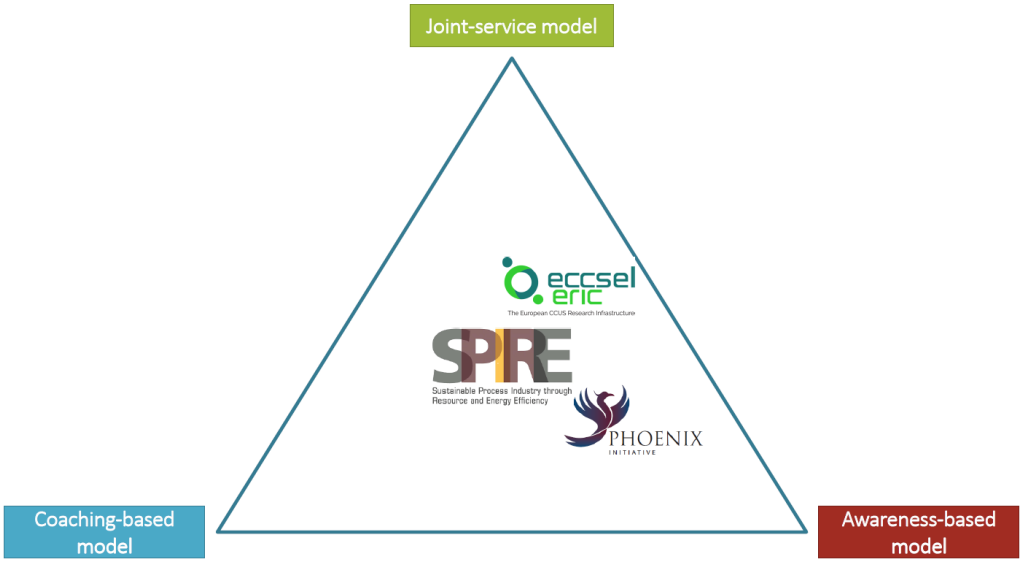
In addition, several networks offer similar services, so coherence between them would be welcomed. Moreover, as agri-food projects and initiatives are funded at various levels - European, national and regional level - it is very complicated to see the difference between these projects, especially from the point of view of the end-user. Bringing the information and funding opportunities together on the level of DIH or a value chain-based network, can help to improve the overview. This statement was reinforced by the S3 High tech farming partnership that stressed the need for interregional activities. While the S3 High tech farming partnership starts from a regional perspective, the SmartAgriHubs and agROBOfood network rather apply a pan-European scope with several DIHs at the core, creating a network of DIHs between countries.

It is essential that regional and national projects aim at creating synergies, to be part of a larger landscape and to become a node that is connected to other projects and partnerships. Current efforts such as the technology centres mapping of the current catalogue of DIHs, might act as a good starting point as other technology centres and DIH can connect to these initiatives.

4.2 Recommendations to improve or create cross-border networks of ATI technology centres in the field of low carbon industrial processes

The following sections discuss the possibilities and challenges linked to developing value chain-based networks of technology centres in Europe working in the field of low CO_2 industrial processes. Three initiatives - ECCSEL, PHOENIX and SPIRE- presented themselves in the workshop as examples for cross-border networks in the respective field. They positioned themselves between the three models of collaboration for cross-border-networks of TCs and discussed about their potential role in such future networks with the participants. The three initiatives positioned themselves mainly between the joint-service and awareness-based model but emphasised that they have very **hybrid approaches and integrate different functions** in their networks. Following the presentation of the different initiatives and networks, it became clear that all collaboration models seemed to be of high relevance.

Figure 12: Positioning of the presented initiatives across the three models of collaboration



To our knowledge, a sufficient future-oriented and value chain-based cross-border dimension and cooperation of existing TCs and initiatives in the field of low-carbon industrial processes, which would be needed to start building up a value chain-based network of actors along the value chain, is lacking to date. However, there are many industrial sectoral clusters and initiatives existing at regional, national and European level today. They are primarily focused on innovation in their respective sectoral technologies (e.g. optimising energy efficiency of their processes), but not so often on overarching, cross-cutting topics such as the decarbonisation of industrial processes or low- CO_2-technologies, which would rather require a value chain-based approach. As low carbon industrial processes have to be adapted to every sector and individual production processes of companies, there is still a lot of R&D&I going on and companies still have to be motivated to participate in projects around the shift and scale-up of clean, low-carbon production processes. The high heterogeneity and variety of different solutions to decarbonisation in industry also makes it hard for SMEs and other industrial companies to identify the best approaches for them and find the right experts to support them. To ensure better embeddedness and guidance for such actors, networks of TCs, initiatives and cross-cluster-collaborations across the EU have to be developed in an open and transversal approach along the value chain of low CO_2 industrial processes.

The relevant actors, who are already very active in this field across the EU, have to be brought together in order to facilitate the process from technology development and the transformation of whole industrial processes beyond national borders. This alone, however, will not be sufficient. It is important to create opportunities of awareness-building for those industrial companies which are until today rather passive concerning the restructuring and change of their production process. They should get the possibility to exchange with other companies regarded as 'best practices' in the field and technology developers or service providers which could help to reorganise and change their processes. As in the raw materials industry, there are a lot of possibilities of interchanging inputs/outputs and materials, e.g. CO_2 'harvested' from the cement production could be used as an input in the chemical industry for other products.

Regional and national networks, often in the form of technology networks or industrial clusters, should be activated in order to take part in broader transnational networks, where they can exchange with the relevant TCs, Horizon Projects, Technology Platforms, European Pilot production networks and Open Innovation Test Beds. The coordination and support action (CSA)-project KET4CleanProduction could enlarge its network not only to the manufacturing SMEs, but also to the field of energy intensive industries. The three collaboration models presented above could present complementary ways to address the challenges faced in order to decarbonise industrial processes. The extent to which these models are best suited and may have to be adapted to this field were discussed during the workshop.

For the field of low-carbon industrial processes, it would be a good approach to first develop further the existing cross-border initiatives and networks of TCs, but also to connect them to each other in order to find synergies and new ways of working together. In a next step, the introduction of the **awareness-based model for such a network of TCs** seems to be the most appropriate**,** as the most important barrier for industry to decarbonise is the lack of knowledge about the technological offer, the potential measures and the relevant actors, which would be there to offer support. Furthermore, this could initially be used to organise awareness-raising events regarding the challenge of decarbonisation for industry. Through the implementation of this model, the transformation of the already existing networks into value chain-based networks could be pushed forward by fostering transnational **multiple cross-cluster collaborations** (e.g. between regional clusters in different energy intensive and manufacturing industries, technology networks of renewable energy, TCs for Advanced Manufacturing and energy efficiency, bioeconomy clusters, hydrogen associations) and the exchange of good practices.

In a second step, the model could be widened to the **joint-service model** approach with the advantage of creating a kind of a one-stop shop including the offering of different TCs, networks, projects and initiatives in the field of low-CO_2-industrial processes. In the field of low carbon industrial processes, both SMEs and large companies are present. In the raw materials industry, there are mainly larger companies active, while the manufacturing industry sector entails many SMEs. Both downstream SMEs and large companies, but also technology providers and start-ups, can support the industry to switch to low CO_2 production processes. This implies that the models should be adapted, following a detailed identification of relevant stakeholders.

4.2.1 Openness to relevant contributors

Overall, it has to be considered that most initiatives have different ways of integrating stakeholders. Besides formal membership, many actors, in particular SMEs, are active in ATI technology centres via projects with the members, through the clusters they are active in, and/or inside the initiative.

As explained in the previous section, there is a variety of different industries and actors potentially relevant along the value chain of low carbon industrial processes. In general, it is important to highlight that investing in low-carbon technologies and activities is currently not attractive for several existing sectors. Hence, general conditions setting incentives (e.g. emission regulations) would be more important compared to broader cross-industrial commitments towards the different stakeholder groups of the low-carbon industry.

Assuming enhancements in this direction, cross-border networks could be developed along this emerging value chain of low carbon industrial processes, which could be seen as a transversal value chain including different types of industry sectors and company types. One overarching solution to all industry is not realistic and thus the creation of cross-border networks is even more important in order to enable matchmaking of companies that face similar challenges with technology developers and suppliers, which are working on relevant solutions. The European Cluster Collaboration Platform could support this process and it promotes the creation of cross-border networks between various cluster organisations located in different European countries.

A first requirement would be the identification of all relevant stakeholders. A mapping of different initiatives, clusters, TCs and projects in the field of clean production has to be elaborated further[41]. The mapping of ATI technology centres provides a first overview of technology centres that could be further expanded.

Such a network should be open not only for the typical R&D&I-actors (technology centres, research infrastructures, projects) but also to actors from the value chain ecosystem around the respective thematic field. The cross-border network should not only be open to different industries in need of applying low carbon industrial processes, but also for suppliers of solutions of input and output. For instance, a network such as Hydrogen Europe would be a valuable partner for matchmaking in a cross-border-network of low carbon industrial processes. Such a cross-border-network with a transversal topic such as decarbonisation should remain open for new entrants and could even profit from multiple-cross-clustering and exchange among different industries. Low carbon solutions for production processes working in one industry could be analysed, adopted and tested in other industries.

[41] For a mapping of the clusters active in the field of clean production, the European Cluster Collaboration Platform can be consulted.

4.2.2 Comprehensiveness

In the workshop, it became clear that the specific features of the value chain of low CO_2 industrial processes makes it very complex to discuss the potential of future value chain-based networks of ATI technology centres, as one has to take into account the diversity of cases and the reality of different types of collaborations between stakeholders. As different kinds of companies (SMEs and large enterprises) are looking for innovative processes and technologies to lower their carbon emissions, they could be given the possibility through value chain-based networks to see the available offer of technological solutions or to find a suitable cooperation partner or service provider, which could fit their specific needs. Such an approach should serve to streamline different services and technological solutions of different TCs along the needs of the industry. A joint-service network could also cooperate with the European pilot production networks in order to test, demonstrate and validate low-CO_2-technologies and processes together with the participating companies. Expertise and infrastructure could be shared across borders and industrial sectors and could unveil synergies.

For the development of a value chain-based network focusing on low carbon industrial processes, it would be key to first create a higher awareness and willingness of European companies to commit to the change of their processes and facilities towards clean production. Therefore, not only technological development, e.g. in pilot lines, but also a common work on solutions for financing and regulatory issues (e.g. standard-setting for the requirements of low carbon industrial processes) is needed to be carried out by potential cross-border value chain-based networks of ATI technology centres. When entering higher TRL phases, there is only a scattered number of projects addressing the value chain.

Value chain-based networks of ATI technology centres should be developed in a way that technological infrastructures would open up for SMEs, that means setting up a network that offers a kind of 'one-stop shop' for SMEs. In a network of TCs and SMEs, the access for SMEs should be as easy as possible, but the efforts for RTOs and TCs should not be too demanding (it should be manageable for the service provider that steers this network). It was stressed in the workshop that SMEs have varying needs with respect to support. Whereas established SMEs (which may be non-technical in nature) typically need help to access new technologies or knowledge, start-ups may need help in commercialisation and gaining access to new markets.

The companies interested or participating in the value chain-based network should be given transparent information about the services of the different participating TCs. They should be guaranteed to receive the best available service and cooperation partners, in order to offer the best value for money for SMEs. Further it was noted from the audience in the workshop that such a value chain-based network of TCs could be linked with KICs (Knowledge and Innovation Communities) supported by European Institute of Innovation & Technology (EIT).

4.2.3 Service portfolio

The different services and competences of TCs in the field of low carbon industrial processes should be brought together. In building up a cross-border value chain-based network between them, they could organise a common access via a 'one-stop shop' for companies and SMEs willing to take the path to clean production. Services that can be offered by such a future value chain-based network operating in low CO_2 emissions value chains are:

- Continuous update of a database of the most relevant actors low carbon industry in the EU (e.g. also technological infrastructures), specified by technology providers and potential users;
- Network coordination (e.g. coordination of working groups for cross-border standard setting activities, coordination of project portfolios);
- Awareness-raising through public information and communication about the decarbonisation of industry and the different possibilities;
- Showcasing of best practices (benchmarking, etc.);
- Organising of cross-industry events;
- Coordination of funding and research activities, creating cross-border R&D&I- and pilot projects to upscale CO_2-technologies and
- Matchmaking between industrial actors to cooperate in a certain field (e.g. exchange in material flows, energy) or matchmaking of technology providers and companies wanting to decarbonise.

However, these are only preliminary suggestions for elements of a service portfolio. Following discussions in the workshop, a mapping of different needs for services according to the phases of technology development, upscaling and commercialisation would be needed. As the field of technologies is extremely broad in the case of low CO_2 industrial processes, the field would have to be structured first also to help SMEs to get through the type of technology centre they could support them best.

In a value chain-based network, SMEs offering technological solutions and SMEs looking for solutions should be connected with each other as an additional service (matchmaking of technology providers and companies wanting to decarbonise). For most SMEs the **awareness-based model of collaboration** would be best suited and therefore the model could build the bottom-layer for further activities. Also, for the different TCs and initiatives this would be an important first step, as they can get a better overview of the activities of other TCs through the inclusion in such an awareness-based collaboration network. Another recommendation from the workshop was to start with the awareness-based model and then to structure different actors in different working groups by industry areas, which could initiate R&D&I projects (for example Horizon Europe, Eureka, Eurostars). Then in a next phase, it would be possible to evolve the network to the joint-service model of collaboration.

4.2.4 Pan-European scope

When the global challenges associated with climate change are faced, the exchange of best practices and knowledge and the reciprocal support between the European regions and their industry are crucial. Cooperation with different INTERREG-programmes such as the RESINDUSTRY (Policies for Renewable Energy Sources in Industry[42]) or DeCarb (Supporting the clean energy transition of coal-intensive regions[43]) could be initiated in order to broaden the pan-European scope of the network and create synergies with interregional networks, trying to push forward the transitions of European industries towards energy efficiency, green energy consumption and clean production pathways.

Existing ATI technology centres and initiatives in the field of low-carbon industrial processes could be combined with regional and national industrial clusters (which are organised in associations or loose networks). Often regional industrial clusters (e.g. a cluster on smart production) already deal with common challenges of their member companies such as the abatement of greenhouse gas emissions, but they often have not enough possibilities and resources to support their members sufficiently. In other cases, particular European networks (e.g. in hydrogen production and distribution) could effectively connect to other industrial clusters (such as the steel producing companies) in order to find new solutions for production processes without CO_2-emissions and coal use.

This implies the creation of a pan-European network of different regional, national, European TCs, initiatives, network associations of clusters in order to join forces. Also, to identify common strategies, an analysis of needs and challenges of the related industrial companies and SMEs needs to be done. Then, thematic sub-networks with a pan-European perspective could be created (e.g. one on the use of biomass as a feedstock in manufacturing with different members from Germany, France, Slovenia and Portugal facing similar challenges).

A mapping on where more networking is needed in the landscape of low CO_2 industrial processes would be important to get an overview of the entire landscape. For such a mapping of actors, their roles and needs, leading questions could be: Who are other players and actors nationally and regionally that can provide services in the field of low- CO_2-industrial processes? How are they related to other actors in the industrial landscape and what do these actors need to decarbonise their processes? Analysing these questions could show the gap of what is not covered by already existing networks and initiatives. One way of structuring such mapping would be to use the value chain approach and the TRL phases, which is a key difference between various initiatives.

The gap identified through the mapping could show, whether a value chain-based network of TCs would be needed for better coordination and the improvement the access for SMEs and industrial companies. It could also show how such a network should look like and what role it could take to integrate actors from all over the EU in a pan-European effort.

With regards to the geographical dimension of such a network and its anchoring on the ground, it was stressed during the workshops with regards to this dimension, local satellites such as regional innovation agencies and clusters were seen as important elements of a pan-European network.

[42] https://www.interregeurope.eu/resindustry/
[43] https://www.interregeurope.eu/decarb/

4.3 Recommendations to improve or create cross-border networks of ATI technology centres in the field of smart health

The following sections discuss the possibilities and challenges linked to developing value chain-based networks of technology centres in Europe working in the field of smart health.

Following the workshop, it has been concluded that there is an **untapped value in establishing more synergies among existing networks but also in creating new networks of technology centres in the area of smart health** with the objective to support more innovation and bringing solutions closer to the market (and eventually to patients). These networks can support technology development and help building connections within the ecosystem such as between start-ups and large corporates or become 'go-betweens' for SMEs, hospitals and health care professionals. There is a clear need to build a cross-sectoral and cross-stakeholder consortium to address ambitious research and innovation projects. Networks in the area of smart health shall consider not only the application of digital technologies in healthcare but move beyond the realm of digital smart health and enable the better use of other advanced technologies in particular life sciences but also advanced manufacturing or nanotechnology.

4.3.1 Openness to relevant contributors

There is a number of existing networks (both voluntary initiatives and supported under various European programmes) that connect a segment of the value chain relevant for smart health. They provide a community also for companies and SMEs to be part of and aim at addressing existing issues of fragmentation. Some of these networks have been presented in the section 3.3.1.

Despite the existing efforts, sustainability of these initiatives and projects is an issue, which is closely linked to the operational model of existing funding mechanisms. Most publicly funded projects last two or three years. The lack of continuity puts long-term goals at risk. There is a need to provide a framework which creates more certainty and ensures that solutions can be brought to the market.

In order to build upon existing linkages and knowledge and also with a view to creating more synergies, first of all a systematic mapping of pan-European initiatives, clusters and projects in the field of smart health would be beneficial. As it has been specifically suggested during the workshop, SMEs still require a better rulebook that helps them understand the current ecosystem. SMEs have limited experiences to propose research priorities and agendas for cross-technology innovation, especially when interacting with the European Commission and other funding entities.

Future **value chain-based networks of technology centres can assist and facilitate better understanding of national/regional contexts**, where clusters are relevant stakeholders to inform SMEs about the local rules. There should be better coordination between technology providers (RTOs), clusters who know their SMEs and the industry associations to offer a joint service. There is added value if the network of technology centres and the nodes can become the link between these stakeholders. Living labs have also important role in any future networks of technology centres.

4.3.2 Comprehensiveness

There is a number of guiding principles that future network of technology centres in the field of smart health should follow. **Networks of technology centres should pay more attention to market mechanisms** even at the stage of technology development or technology transfer. Smart health solutions shall be more often demonstrated at a European scale, where healthcare providers can test the technology in practice and start-ups can prove the potential outcomes. This can remove barriers and risks. It can also help create mutual understanding between the technology provider and innovators on one side, and healthcare professionals on the other side, by really understanding each other's worlds and identify real needs. Pilot trials are unique opportunities for SMEs to test their technology in the field of smart health. Innovation trials, not only clinical trials, should be more easily accessible for SMEs, since it is difficult to test the technology in hospitals. These initiatives should be linked to projects and programmes at the national level.

Value chain-based healthcare should be placed in the centre. Even though the context of value chain-based healthcare has been implemented in some local or regional experimentations, it is not widely adopted and implemented. It is a critical priority to implement more value chain-based approaches and procurement. Within cross-border collaborations, companies have to follow the local or regional rules.

Digital solutions have to be tangible and clear, and the focus should be on well-functioning integration into the workflow so that health care professionals actually start using the solution. Additionally, trust and awareness among healthcare professionals and patients is important and can be achieved with the

integration of their feedback via clear feedback loops. Integrated care groups can be used for modelling the needs of patients. These groups can be set up as virtual personas built upon actual patient use cases to find healthcare solutions and the connection with the ecosystems with the health care professionals and patients.

EU funding programmes are the true 'compass needle' of the ecosystem. The network should ensure that they can get mentoring about how to innovate. Funding should also allow that any consortium can implement emergency projects for the development of specific technology, such as in the current situation of the pandemic. The programmes should be accessible for all companies at a competitive basis. However, duplicates should be avoided.

4.3.3 Service portfolio

Future value chain-based networks of technology centres should build up complementary service portfolios. Dedicated services can be put in place that connect various healthcare actors and provide an opportunity for SMEs and start-ups in the field of smart health in a cross-border setting. Awareness-raising is a first step, but joint services are necessary to make sufficient progress in creating a more unified single market in this field.

Joint services have to be differentiated for different kinds of companies and their specific needs should be addressed. Access to structured information, the visibility of infrastructures and services are particularly important.

Another important aspect is the capacity building of companies that are trying to scale up at a European level. Any future network of technology centres should be built around national contact points which can link companies and find opportunities. There is a need for mentorship, in particular for traditional medical technology or unexperienced companies.

Patients and citizens should be in the centre of technology innovation and development. A way for networks of technology centres to provide support is to co-design the smart health offer and technology with SMEs, patients and healthcare providers. The various levels such as RTOs, academics, SMEs need to be connected, firstly, by listening to the final users and secondly, listening to large firms and using them as a compass.

It is important to be pragmatic and **embed any future value chain-based network into national and regional ecosystems and clusters** that constitute a natural platform and link technology, start-ups and traditional SMEs locally. There is a role to be assigned to the RTOs and technical universities in terms of the maturation of the technology and access to start-ups in the field of smart health.

More specifically, the establishment of a library of accomplished initiatives and good practices would be useful to help SMEs. Introducing such a library should come from a top-down approach and provide a one-stop shop landing page for SMEs where they can get assistance for their technology projects and information where to get funding.

SMEs that want to internationalise must understand the healthcare innovation landscape in each region and country. The service offer of the network of technology centres should address this need in particular.

4.3.4 Pan-European scope

There is a need for future value chain-based networks of technology centres to provide general direction and oversight in reducing fragmentation and existing barriers to the wider development of smart health applications. Duplication however should be avoided. It is suggested to embed any new network in the Innovative Healthcare Initiative and ensure a strong synchronisation with other initiatives such as the Digital Innovation Hubs or networks supported under the Interreg Europe programme.

Section 5

5 Annex

5.1 Agenda of the workshop on IoT precision farming

9.00 – 9:05	Welcome, Evangelos Meles, European Commission DG GROW
9:05 – 9:30	Introduction to the concept of value chain-based networks. Recommendations from the 'Study on Access of SMEs to ATI technological centres', Els Van de Velde, IDEA Consult
9:30 – 10:45	Presentation of various cross-border networks of ATI technology centres • Adrien Guichaqua, NEFERTITI • Kees Lokhorst, agROBOfood • Fabio Boscaleri, S3 High Tech Farming partnership • Niels Gotke, ICT-AGRI-FOOD • Anneleen De Visscher, SmartAgriHubs
10:45 – 12:20	Discussion, moderated by Els Van de Velde, IDEA Consult
12:20 – 12:30	Conclusions and Next Steps

5.2 Agenda of the workshop on low carbon industrial processes

9.00 – 9:05	Welcome and introduction by Evangelos Meles, European Commission DG GROW
9:05 – 9:30	Introduction to the concept of value chain-based networks. Recommendations from the 'Study on Access of SMEs to ATI technological centres', Els Van de Velde, IDEA Consult
9:30 – 10:45	Presentation of various cross-border networks of ATI technology centres • Sverre Quale, Norwegian University of Science and Technology for ECCSEL • Sophie Wilmet, CEFIC for PHOENIX • Evelina Paunksnyte, A.SPIRE
10:45 – 12:25	Discussion, moderated by Sven Wydra (Fraunhofer ISI)
12:25 – 12:30	Conclusions and Next Steps

5.3 Agenda of the workshop on smart health

9.00 – 9:05	Welcome, Evangelos Meles, European Commission DG GROW
9:05 – 9:30	Introduction to the concept of value chain-based networks. Recommendations from the 'Study on Access of SMEs to ATI technological centres', Els Van de Velde, IDEA Consult and Kincsö Izsak, Technopolis Group
9:30 – 10:40	Presentation of cross-border networks in the area of smart health • Françoise Charbit, European Affairs Senior Adviser CEA, EARTO, coordinator of the WG Emerging Technologies for Healthcare • Françoise Siepel, Assistant Professor, University of Twente, Operational coordinator, DIH-HERO project • Manuel Ottaviano, Senior Researcher, Technical University Madrid, Horizon 2020 project PULSE • Patrick Boisseau, Director General, MedTech Europe, Innovative Healthcare Initiative (potential JU to be set up) • Furio Gramatica, HealthTech4EU
10:40 – 12:15	Virtual roundtable discussion, moderated by Kincsö Izsak, Technopolis Group • Jacques Demotes, Director General, ECRIN • Danny Van Roijen, Digital Health Director, COCIR • Speakers & Participants
12:15 – 12:30	Conclusions and Next Steps

About the 'Advanced Technologies for Industry' project

The EU's industrial policy strategy promotes the creation of a competitive European industry. In order to properly support the implementation of policies and initiatives, a systematic monitoring of technological trends and reliable, up-to-date data on advanced technologies is needed. To this end, the Advanced Technologies for Industry (ATI) project has been set up. It provides policymakers, industry representatives and academia with:

- Statistical data on the production and use of advanced technologies including enabling conditions such as skills, investment or entrepreneurship;
- Analytical reports such as on technological trends, sectoral insights and products;
- Analyses of policy measures and policy tools related to the uptake of advanced technologies;
- Analysis of technological trends in competing economies such as in the US, China or Japan;
- Access to technology centres and innovation hubs across EU countries.

You may find more information about the 16 technologies here: https://ati.ec.europa.eu.

The project is undertaken on behalf of the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA) by IDC, Technopolis Group, Capgemini, Fraunhofer, IDEA Consult and NESTA.

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