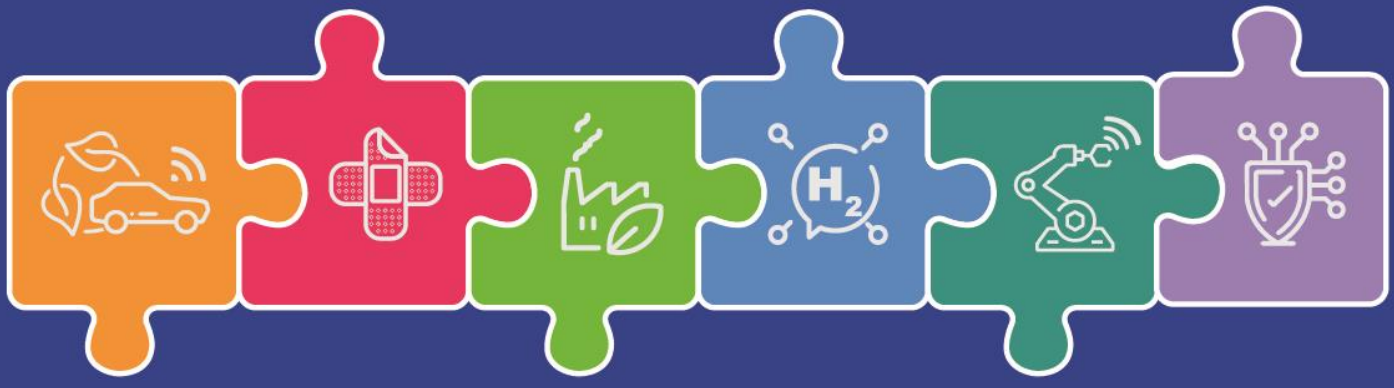
# Strengthening Strategic Value Chains for a future-ready EU Industry

## Report of the Strategic Forum for Important Projects of Common European Interest

# Annex II

## Key Strategic Value chains – detailed recommendations



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# Clean Connected and Autonomous Vehicles

## Vision and Levers

A common vision for the CCAV in Europe by 2030 was discussed and developed jointly during the first Workshop. This common vision can serve as a guide for formulating, prioritising and coordinating recommendations for actions. The various suggestions have been clustered in the following Vision points.

V1. Competitiveness → Strengthen global competitiveness of European CCAV value chain

- Increase competitiveness of EU players for CCAV products and services.

V2. Footprint → Reduce the health and environmental externalities of mobility in Europe

- Reducing air pollution (CO2, fine particles, other emissions), noise, visual pollution, utilisation of public space, of resources…
- Improve mobility safety related to "health" and mobility externalities
- Footprint is measured on a life-cycle basis

V3. Independence → Increase European strategic autonomy in CCAV

- Reduce critical dependence on foreign products, raw materials, technologies,
- Succeed in having strong EU suppliers in all important parts of the CCAV value chain,

- Ensure access to key raw materials,
- Data managed responsibly with EU interest in mind.

V4. Leadership → Achieve European leadership in key areas of CCAV

- Achieve leadership in key technologies

V5. User experience → Enhanced Mobility experience for all EU citizens

- Mobility is to become cheaper, safer, less time consuming, more enjoyable & comfortable, more accessible to all EU citizens and residents.
- Mobility as a service (MaaS) allows seamless, conformable, affordable, safe on demand point-to-point transport all over Europe
- High level of public acceptance for CCAV technologies

## SWOT

### Strengths (What is the EU good at?)

- S1. Strong basis/focus/know-how when it comes to optimizing the efficient use of batteries
- S2. Public and political support for sustainability and shifting towards new types of mobility
- S3. Comprehensive approach for combining navigation, radar and sensor or visual detection technologies

- S4. EU focuses on citizen centric approach and improvement of quality of life
- S5. Experience in clean and autonomous public transport
- S6. Good road, ICT and energy infrastructure favourable to innovation
- S7. Leading players in several sectors (OEM, suppliers, technology and research providers in several domains: automotive, trucks, motorbikes, bicycles, public transport, and vehicle electronics)
- S8. EU contributions to establishing global standards & regulations
- S9. Good reputation/image on high quality products
- S10. Good European FCEV technology position
- S11. Expertise and large number of players in the CCAV ecosystem
- S12. EU has state-of-the-art manufacturing capability
- S15. EU has a strong IP portfolio
- S16. Galileo
- S17. Strong investment acumen from the automotive industry (R&D, contribution to GDP)

## Weaknesses (What is the EU not good at?)

- W1. High dependency on critical materials (batteries, magnets, rubber, etc.) from outside the EU
- W2. Weak EU position in the field of electric buses relative to China
- W3. EU has limited real-life large scale testing facilities /areas
- W4. EU is not the best in navigation, radar or visual detection technologies separately
- W5. Charging infrastructure for electric vehicles is still being developed
- W6. Fragmentation: regulation, standards, markets, players
- W7. Relatively late start of the European FCEV launching compared to Asia
- W8. EU is not strong in AI and navigational data for automated Vehicles
- W9. Inadequate framework for funding and rapid deployment of new disruptive technologies
- W10. Restrictive legislation is hampering the development of the CCAV industry
- W11. Lack of true level playing field across EU-28 legislative measures

## Opportunities (What are the favourable external factors that could benefit the EU?)

- O1. Collaboration in autonomous and electric mobility development across industries
- O2. Connected, Clean and Autonomous vehicles are useful for the aging population
- O3. EU's has ample opportunities for renewable energy production
- O4. Cheaper freight transport
- O5. EU citizens could benefit from greater productivity due to autonomous vehicles
- O6. Opportunity for a sustainable and integrated transport sector that competes at global level with major players
- O7. Development of CCAV might improve overall sustainability of (digital) services
- O9. Development of a standardized and EU wide charging network
- O10. Improvement of funding
- O11. Increasing demand for autonomous public transports
- O12. Development of a domestic EU battery industry
- O13. Truck platooning for goods transport
- O14. Mobility as a Service (MaaS) and associated opportunities for Startups/SME's
- O15. Supporting legislation and technology
- O16. Implementation of 5G network
- O17. Development of domestic EU navigational and AI capabilities
- O18. Evolution of vehicle electronics architecture

- O19. Better integration of EV charging in the Smart Grid
- O20. Development of 5G Network

### Threats

- T1. Fragmented legislation and lacking regulatory framework for higher levels of automated driving
- T2. Mismatch in skills
- T3. Citizens acceptance and market uptake
- T4. Risks of delayed electrification and clean fuel charging infrastructure of the transport sector and lack of multimodal and sustainable solutions
- T5. Greater awareness of CCEV's actual externalities
- T6. Continued outsourcing leads to the creation of strong competitors
- T7. Lack of collaboration between EU players (member states, industrial or research organisations)
- T8. Vulnerability of infrastructure and AV to cybercrime
- T9. Massive job losses

## Specific recommendations

### High priority

| R3. | Develop common policy and instruments for connected & autonomous transport |
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| Short Description | Over the coming decades, all modes of transport will migrate to driverless operation.<br><br>This will require :<br><br>• digital infrastructure enabling “vehicle ↔ infrastructure” and ““vehicle ↔ vehicle” and “vehicle ↔ everything connectivity<br>• system integrator, at regional, national and/or EU level<br>• proper legal framework for circulation of AV and for such data transfer/storage<br>• Europe has to prepare for the integration and management of these new forms of mobility within an interoperable architecture of connected and shared mobility.<br>• Cellular connectivity |
| Concrete actions | • Define clear European policy objectives and targets for CCAV<br>• Develop and upgrade Intelligent Transport Systems (ITS) for CCAV (L5) |
| SWOT Items | S2, S5, S7, S11, S12, O1, O10, T7 |
| Related Recommendations | R26, R19 |

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| Related EU initiatives | • There is already a strategy at EU level on connected and automated mobility. Please see the communication on 17 May 2018. Link: https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf<br>• On data, in-vehicle data access is something that is being thoroughly discussed between the Commission and different stakeholders[1]. Competition concerns that should be taken into account when regulating the system of data access and sharing in vehicles. A recommendation on this will be issued soon. |

| R6 | Create a European scheme for financing Investments proposed to switch to CCAV (both for end users and for transportation authorities) |
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| Short Description | Replacing or upgrading current mobility equipment (infrastructure and vehicles) with CCAV ones will require massive investments in the coming decade. For each player considering such a change (municipalities, fleet or infrastructure operators, end users), such investments may be either impossible (lack of funds) or unattractive (ROI below their internal objectives).<br><br>Measures should be taken to encourage alternative financing solutions, such as leasing, which could combine public and private funds, taking advantage of abundant funds and very low interest rates in Europe today. |
| Concrete actions | EIB / EBRD and national funds/banks to create specific financial products to finance switch to CCAV investments for municipalities. |
| SWOT Items | W9, O10 |
| Related Recommendations | R39, R42, R1, R10, R15 |

| R7. | Develop new generation of clean powertrains |
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| Short Description | For European competitiveness, it is important to develop new generations of powertrains (including new generations of key components: battery, fuel cell system, electric motor, power electronics…) for performance improvement, cost reduction, reduction of CRM use, especially for mass transport (buses, coaches, ships, trains…) and Heavy Duty Vehicles (HDV). For this objective, it would be mandatory to include the |

[1] A framework for B2B data sharing was set up through a guidance from DG CONNECT + a dedicated Expert Group was launched on B2G data sharing. See here: https://ec.europa.eu/digital-single-market/en/guidance-private-sector-data-sharing + https://ec.europa.eu/digital-single-market/en/news/meetings-expert-group-business-government-data-sharing

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| | definition of sustainable processes along the whole value chain (including recycling) as well as Life Cycle Analysis (LCA) and eco-design.<br><br>According to McKinsey "Over the next 40 years, no single power-train satisfies all key criteria for economics, performance and the environment. The world is therefore likely to move from a single power-train (ICE) to a portfolio of power-trains in which BEVs and FCEVs play a complementary role: BEVs are ideally suited to smaller cars and shorter trips; FCEVs to medium/larger cars and longer trips; with PHEVs an attractive solution for short trips or where sustainably produced biofuels are available."[1]<br><br>The objective of this coordinated investment would be to allow the up-scaling and first deployment of such technologies for future mass market production of clean powertrains for electric vehicles with optimised performance for passenger car and heavy duty vehicles. For passenger car the following criteria could be used:<br><br>• high speed motor performance<br>• reduction of use in critical raw materials (e.g. rare earth)<br>• transmission optimisation including new materials and surface treatment<br>• life cycle analysis, waste reduction in production and recycling potential,<br>• regenerative breaking<br>• integrated power electronics and battery management systems<br>• improve simulation tools and production method for overall powertrain and individual component design<br><br>Expected benefits include:<br><br>• adapted powertrains efficiency and cost to targeted use of vehicles, 2nd use and recycling potential of the powertrain component and creation of new value chain<br>• by 2030, clean vehicles represents 33% of the total passenger car fleet in Europe |
| Concrete actions | • Support development and deployment of clean powertrain technologies into the European vehicle fleet<br>• Support investment of car manufacturer and supplier into the integration of most recent powertrain technologies such as those demonstrated in H2020 projects for mass production of clean vehicles. |
| KPI | • 10 new series of high-speed motor (above 20000 rpms),<br>• improved well-to-wheel powertrain,<br>• 50% critical raw materials and waste reduction,<br>• overall powertrain optimisation for expected drive use |
| SWOT Items | S12, O1 |
| Related EU | • This is linked to SVC on Batteries.<br>• There is an EU-wide initiative to support the creation of a battery industry in |

## Clean Connected and Autonomous Vehicles

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| initiatives | Europe for Electric Vehicles, as well as fuel cell systems. For batteries, this initiative is called the Battery Alliance, and it encourages coordination between stakeholders and has invested money on several projects. More info here: https://ec.europa.eu/growth/industry/policy/european-battery-alliance_en<br>• The focus of the alliance is to:<br>• Encourage investment in battery cell production<br>• Alternative fuels and raw materials<br>• Encourage recycling |

| R14. | Define common standards to increase interoperability and competition along each layer of the MaaS value chain in Europe |
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| Short Description | The long-term vision should be for a user to be able to book any available "shared" car anywhere in Europe from an app on his mobile phone, and be driven autonomously for short and mid-range distances, with the car stopping for automatic recharging as required along the way. To achieve this seamless level of interoperability, common European standard must be established for each aspect of the underlying solutions. E.g.:<br><br>Common standards should cover: communications, charging, booking, payment…<br><br>The EU CCAV ecosystem should allow interoperability and competition along each layer of the MaaS value chain: booking apps, fleet operators, infrastructure operators, energy provides (electricity, clean fuels), OEMs, Tiers 1…<br><br>Interoperable booking and payment platforms (as we have today for airplanes), allowing for multiple physical and virtual operators to compete<br><br>This could be something similar to the SWIFT banking transaction platform. SWIFT is a private organisation but following public rules. Another model for this could be the "National Access Point", where certain date need to be available for free to multiple users.<br><br>This common platform needs to be compliant with GDPR, common database with communication standards, security standards, and open access to all the players in a controlled manner. This database can be accessed by the booking apps, but also by other entities like municipalities for other needs such as managing traffic.<br><br>• Interoperability is key: interoperability among booking and payment platforms, vehicle fleet providers<br>• Standards for communication interfaces for customers, between vehicles and from infrastructures to vehicles could be added. Final customer interfaces could be added. This would create a governance structure for communication data flows. |

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| Concrete actions | • Develop standards for communication interface, data connection and storage between vehicles and users (infrastructure, customers) as a basis for governance of communication data flows (L1)<br>• Develop and open and interoperable booking and payment solution, based on standards (L4) |
| SWOT Items | W5, W6, O1, O5, O6, T1, T4, T7 |
| Related EU initiatives | • See the C-Roads initiative for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability. https://www.c-roads.eu/platform.html<br>• Moreover, the EU legislation already requires minimum standards for physical plugs (two types of plugs) and payment systems so that interoperability between operators is implemented. |

| R19. | Establish common regulatory framework for CCAV |
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| Short Description | To gain widespread acceptance, safety issues must be resolved to the full satisfaction of the public. Full transparency into safety regulations for autonomous and cooperative autonomous vehicles is needed to assuage public concerns and help governments encourage safe practices. To this end, a regulatory framework must be set to provide common standards for safe autonomous-vehicle operations. This would reassure both the public, about the hazard of AV, and industrial players, about their legal liabilities in case of accidents. |
| SWOT Items | S8, W3, W6, W10, O1, O15, T1, T5, T7 |
| Related Recommendations | R20, R26 |
| Related EU initiatives | • Safety in the automotive sector: https://ec.europa.eu/growth/sectors/automotive/safety<br>• The European Commission's work on motor vehicle safety deals with the safety of vehicle occupants (including children in child restraint systems) and vulnerable road users (pedestrians and cyclists). The work covers light-duty vehicles (passenger cars and vans) and heavy-duty vehicles (buses, coaches and trucks).<br>• Road Safety: new rules clear way for clean, connected and automated mobility on EU roads<br>• https://ec.europe.eu/transport/themes/its/news/2019-03-03-c-its<br>• Road Safety: new rules clear way for clean, connected and automated mobility on EU roads<br>• The European Commission has adopted new rules stepping up the deployment of Cooperative Intelligent Transport Systems (C-ITS) on Europe's roads. The new technology will allow vehicles to 'talk' to each other, to the road infrastructure, and to other road users – for instance |

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| | about dangerous situations, road works and the timing of traffic lights, making road transport safer, cleaner and more efficient. The new rules are in line with the proposals on clean mobility introduced by the Juncker Commission, are a further step for modernising the European mobility sector, preparing it for climate neutrality in the second half of the century and contributing to the EU's long-term goal of moving close to zero fatalities and serious injuries by 2050 ("Vision Zero").<br>• Vehicle automation technologies can already be approved under the EU vehicle approval framework. Moreover, for those technologies not foreseen by current EU rules, a number of guidelines were developed and approved by the Technical Committee on Motor Vehicles on 12 February 2019. See this link: https://ec.europa.eu/growth/content/guidelines-exemption-procedure-eu-approval-automated-vehicles_en<br>• In the EU, safety is part of the certification, so the framework on safety falls within that scope. There are also market surveillance activities foreseen. |

| R20. | Deploy vehicle-to-grid on a large-scale in Europe |
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| Short Description | **Summary**<br><br>Millions of vehicles with a > 70 kWh battery each represent an incredible asset for energy storage and flexibility for the power system. It is important to standardise the equipment allowing smart management of bi-directional exchange of energy between vehicle and surroundings (buildings and grids). If these storage capacities were made available to support grid operation, this could help manage the intermittency of renewable energy sources, and allow higher penetration of renewable energy in the European energy mix. Such standards would also allow to develop and build 1st pilot lines for Vehicle to Grid equipment, bringing the costs down while valorising storage assets.<br><br>**The problem**<br><br>Large scale development of intermittent renewable energy capacity (wind, solar), with penetration above 30% of the energy mix, is only possible with measures ensuring a cost-effective balancing between supply and demand. Balancing options are: flexible production, flexible management and storage. All three solutions are need. However, most flexible production sources are thermal (coal, gas). Phasing these out completely will require massive deployment of flexible demand and storage solutions. Although the cost of utility-scale stationary battery storage is falling fast, other storage solution are needed. The massive deployment of EV in the coming years is an opportunity to increase, possibly at a lower cost, the total available storage capacity of the system. |

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| | The opportunity<br><br>In the near future, average electric vehicle (EV) will be equipped with around 70 kWh battery to enable 400 km of real range (which is what EU households want on average). Such energy storage capacity could supply mobility needs for roughly 10 days. Assuming that most parking spaced are equipped with charging stations (see R53), connected EV offer a large potential reservoir of energy, which is not used 95% of the time. A 70 kWh battery enables to store the total energy consumed by other household use during roughly 5 days. 50 millions of EV by 2030 in Europe would represent 3.5 TWh storage capacity, which is 2 to 3 times more than the total capacity of hydraulic storage in Europe.<br><br>The challenge<br><br>Large scale deployment of V2G requires a number of challenges to be overcome :<br><br>• Technical: developing a common, effective, safe and easy to deploy solution,<br>• Economic: demonstrate that energy storage in EV is economically viable,<br>• Commercial: find the right business models to promote it, and energy companies to participate in the battery warranty cost.<br>• Social: ensure public acceptance.<br><br>The purpose of this project is, in phase 1, to deploy pilot programs to test and resolve all the challenges above, and in phase 2, to deploy V2G in a large scale<br><br>Proposal<br><br>Develop and build first pilot lines of equipment enabling smart management of bi-directional exchange of energy between the vehicle and energy systems : 1) based on DC based charging infrastructures, and 2) based on AC/DC chargers on board<br><br>This asset will be connected and flexible and could allow the consumer to better control its bills and environmental impacts of their consumption, by providing :<br><br>• a buffer for surplus of cheap carbon-free energy, including excess of local photovoltaic generation available at midday ;<br>• a complementary supply available when electricity coming from the grid is more expensive and CO2 intensive.<br><br>The aggregation of such assets through the electricity network could also allow the consumers to provide (and be paid for it) cost-effective services to system operators of grid and power infrastructures, in support of higher |

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| | penetration of renewable energy in Europe at lower cost.<br><br>Interactions and synergies between the mobility services infrastructures and energy systems (be it local or global) are multiplying when considering EVs, with expected benefits for Europe in terms of competitiveness, climate change and energy supply security. In France, a new study of RTE released the 15th of May 2019 estimated V2G could have a yearly benefit for the power system and customers of 200-700M€/year by 2035 (considering just the production system and not the network) and the optimal deployment level with adapted regulation would be about 3 Millions EVs. The effect of V2G would reduce peak demand compared to a scenario without any EV penetration by many GW, increase renewables integration (lower curtailment and thus lower subsidies) and lower Co2 emissions. At European level, the order of magnitude of V2G opportunity could therefore be estimated to few billions per year.<br><br>The project aims to develop and build first pilot lines of equipment enabling smart management of bi-directional exchange of energy between vehicle and surroundings, be it buildings (vehicle-to-home) or the grids (vehicle-to-grids)<br><br>It requires to alleviate private efforts in investments and collaboration to create a complete ecosystem setting the basis of a common forward looking framework enabling both sectors to benefit from the other.<br><br>Targeted market / applications: B2B between utility companies and fleet operators.<br><br>Expected benefits:<br><br>• Make the good deployment practices (regulatory, technological standards, market conditions) emerge in support of cost-efficient development in the mid-term across Europe.<br>• Validate expected benefits for Europe in terms of competitiveness, climate change and energy supply security. |
| Concrete actions | • Develop a vehicle to Grid regulatory framework (standard) including standards for equipment allowing smart management of bi-directional exchange of energy between vehicle and surroundings.<br>• Consolidate technical standards and create dedicated V2G certification program to control it.<br>• Regulation: drafting of EU Directive to push for regulation allowing to reveal the V2G economic value in all EU countries.<br>• Deploy program of vehicle-to-grid charging infrastructure<br>  o Deploy a large scale pilot program to deploy DC vehicle-to-grid charging systems equipped with off board bidirectional AC/DC chargers and ICT components to manage bi-directional exchange of energy between the vehicle's battery and energy networks infrastructures.<br>  o Deploy a large scale pilot program to deploy AC vehicle-to- |

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| | grid charging systems equipped with on board bidirectional AC/DC chargers and ICT components to manage bi-directional exchange of energy between the vehicle's battery and energy networks infrastructures.<br>• Business model:<br>  ○ test and develop pricing schemes to align interests and share the value creation between utility companies, infrastructure operators and fleet operators, vehicle owner/user<br>  ○ coordinated investments in large-scale manufacturing of bi-directional charging stations: ensure interoperability across EU, improve functionalities, and reduce costs<br>  ○ creation of EU financing schemes to help municipalities, transport authorities, fleet operator to equip in V2G charging stations<br>  ○ perform an evaluation of the lessons learnt from previous or ongoing smart charging and V2G projects before deploying a large scale pilot program of V2G charging infrastructure |
| KPI | • Targets for vehicle-to-grid charging systems<br>  ○ 2022 : 5 000 DC systems and 5 000 AC systems<br>  ○ 2025 : 20 000 DC systems and 50 000 AC systems<br>  ○ 2030 : 1 million systems over several EU countries<br><br>• Target available storage capacity by 2030 : ~80 GWh of potential storage capacity available |
| Investments proposed | • Investments by industrial players : nature/ destination, amount<br>• State aid support: destination, amount |
| Related Recommendations | R53 |
| Related EU initiatives | • Revision of the Energy Performance Buildings Directive, there is a provision for a charging spot for every building block.<br>• Workshop on the integration of Alternative Fuels Infrastructure and Electric Vehicles into the electricity system: focus on the smart charging (Brussels, 20/11/2018)<br>• Ongoing Evaluation of the Directive on the Deployment of Alternative Fuels Infrastructure (AFI) 2014/94/EU lead by DG MOVE, started in the beginning of 2019 and to be ended in 2020<br>• The report to be prepared by the Sustainable Transport Forum members and ad-hoc experts on key policy needs and options for actions which will support the work for the evaluation of the AFI Directive (based on questionnaires sent to stakeholders)<br>• There are already some pilot projects ongoing - e.g. list of 18 European V2G pilot projects: https://northsearegion.eu/media/4308/v2g-projects-in- |

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| R23 | Standardisation of high power charging for Electric Vehicles |
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| Short Description | Capacities of Electric Vehicles batteries will rapidly increase to ~100 kWh or more. Acceptable charging time for long distance trips will require so called ultra-high power charging. It is important to standardise asap ultra-high power charging equipment.<br><br>Recent examples of European projects funded by the European Commission aim at bringing together the considerable expertise of the European Automotive sector include projects such as AutoDrive, AI4DI, Brain, Achilles, and SYS2WHEEL. |
| Concrete actions | • Create a working group for the standardisation of high power charging for Electric Vehicles[2] |
| SWOT Items | S6, S8, O9, O15 |

| R25. | Create, expand and combine large area testing facilities (with specific emphasis on freight, people and both) |
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| Short Description | EU has leading players in several sectors (tyres, trucks, public transport and vehicle electronics). Thorough testing is critical to ensure the functionality of systems and technology and to ensure the required safety and reliability.<br><br>• Encouraging closer cooperation between companies, testing centres , research and the public sector to expand the test bed for connected, clean and autonomous multimodal transport and to ensure its international attraction<br><br>* accelerate and fund project specific testing, involving private and public players.<br><br>Need to clarify the concept of “testing facilities” (what do we mean exactly?), indicate them more precisely (living labs, test beds, etc.), explain why they are necessary.<br><br>We already have may testing fields (more than 20 in Germany alone), but to extra most value from such initiatives, it is important that we leverage them most. So what is needed is more than testing facilities, it is important to collect the data and have the resources to interpret it in order to develop |

[2] Entailing standardized equipment, charging power, payment modes, safe and cyber-secure as well as energy-efficient, aiming at greater deployment and connectivity throughout Europe

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| | autonomous driving AI capabilities. The data acquired and the knowledge developed in these various local initiatives needs to be shared and made available. |
| Concrete actions | • More focus on better coordination / collaboration among existing testing facilities, less on creating new ones.<br>• Take into consideration already existing actions and initiatives (Single Platform for open road testing and pre-deployment, etc.).<br>• Implement mobility-as-a-service as first use of self-driving cars thus concentrate on testing in urban (or geographically limited) areas<br>• Reduce timeline for self-driving cars to market for EU automotive companies |
| SWOT Items | S3, S8, S11, W3, W6, O7, O8, T3, T6, T8 |
| Related Recommendations | R49, R31 |
| Related EU initiatives | • https://ec.europa.eu/digital-single-market/en/cross-border-corridors-connected-and-automated-mobility-cam<br>• https://ec.europa.eu/transport/modes/road/news/2019-02-26-call-applications-single-platform_en<br>• "Autopilot"<br>• "CCAM Cooperative Connected Automotive Mobility Single Platform"<br>• FESTA: handbook on data sharing and data evaluation. |

| R26. | Enhance the certification process of CCAV |
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| Short Description | Through the certification process, and therefore the establishment of certification obligations, European Commission will oblige security and safety issues to be answered before CCAV will be available on European market. Further, this will oblige, any imported CCAV to have the same obligation as European vehicles.<br><br>Certification shall address not only conformance tests of protocols but also certification of service (ex. Communication performances rely not only in the protocols but also in the gateways which are never described in standards).<br><br>Definition of labels could be necessary in order to help the final user especially in case of an EV offers energy services to the Grid (market, TSO, DSO, flexibility operator or buildings), the labels should focus on the performance parameters in order to avoid any situation where the final user will expect a revenue that will not be possible to get due to bad technical performances due to any of the systems part of the service and the final user may ignore the source of limitations. |

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| | We need to have clear certification processes with good awareness and information for professionals and citizen on the safety and security requirements for CCAV on the market |
| Concrete actions | • Create a centralised information database on CCAV existing EU regulations and standards as well as certification process for industry (fair competition and safety of CCAV) and citizen (acceptance). This database should ideally also contain an overview of the applicable traffic rules and regulations in the EU-28 linked to the allowance of higher levels of automated vehicles. There is no such database available today (checked with DG MOVE and with UNECE WP.1)<br>• A collaborative framework may be given in order to gather FSR (Florence School of Regulation), JRC and other actors like research institute in order to accelerate this point |
| SWOT Items | S2, S4, S6, S7, S9, S11, W5, W6, 09, 019, T1, T3, T7, T8 |
| Related Recommendations | R19 |
| Related EU initiatives | • JRC is currently in discussion with GROW, different elements of certification are being discussed. Expected horizon is end of 2020.<br>• This topic is taken on board by DG GROW automotive unit and is part of the type approval process and its forthcoming delegated acts. Synchronisation with the work ongoing at GRVA/WP.29 of UNECE is also taken into the scope at DG GROW. |

| R27 | Create an European agency for CCAV and MaaS (Mobility as a Service) |
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| Short Description | The progress of each European country on the CCAV / EV will bring the need to harmonize the various technological bricks so that the systems remain compatible. This compatibility is essential to develop services that are accessible and interconnected between countries.<br><br>The agency could be involved, in different capacities as appropriate in:<br><br>• keeping up-to-date all information on services deployed in Europe concerning CCAV,<br>• disseminate knowledge, share good experiences, produce standards and develop MaaS both for passenger cars and commercial vehicles,<br>• provide/channel funding for infrastructure, fleets, industrial deployment,<br>• launch calls for projects<br>• list all past tests and build a data base with all criteria of experimentations (ex: IT and captors technologies, environment, social parameters, person or freight service...)<br>• build partnerships between industrials and research stakeholders from |

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| | different countries, in order to develop European value chain, for example improve the link between infrastructures and autonomous vehicles.<br>• manage and /or coordinate European funds to finance innovative autonomous services with transports of persons and freight (transit and last km).<br>• build protocols and follow Maas experimentations, in various territories, to get feed-back and deploy new sustainable services with a performant economical model for public finances.<br>• Contribute to the definition of new European standards, from the needs freight and persons services, in a framework of sustainable mobility, compatible with environmental constraints.<br>• Operate in synergy with already existing national agencies on the same topic<br><br>Examples:<br><br>• Maas CCAV: transports services and associated ticketing will change with shared and autonomous mobility. A European approach is essential from the beginning to allow good interconnections between countries.<br>• ISO 15118 PKI certificate governance: if the root certificates insuring the cybersecurity of the ISO 15118 could be offered by private companies, the governance should be defined at an European level in order to insure interoperability between countries and robustness + transparency of the certification process of these companies.<br><br>This European agency would be the main partner of companies and research organizations working in the field of CCAV / and MaaS, and also cities and regions. It could have branches in several member states / region, based on the presence of local industrial and technological players. |
| SWOT Items | S2, S4, S5, S6, S7,S8, S9, S10, S11, S12, W3, W6, W9, O1, O6, O7, O9, O10, O13, O14, O15, T1, T3, T4, T7, T9 |
| Related EU initiatives | • MOSART partnership |

| R31. | Big data for advanced AI for autonomous driving |
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| Short Description | Support coordinated investments to support European solutions in big data (navigational database) and in advanced AI, in order to accelerate development in autonomous driving in Europe<br><br>Instead of depending on foreign mapping data and AI technologies, or dispersing our effort in competing small-scale initiatives that may eventually be overtaken by those of foreign global giants, we should mutualise our efforts and create a European global technology player developing high definition mapping database, training advanced AI for autonomous driving, taking advantage of new sources of data coming from Galileo and lidar sensors. Depending on suppliers not subjected to EU rules or applying different ones also exposes EU to the risk of embargo or export restrictions. |

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| | Create the conditions for better coordination / collaboration between a large number of small and dispersed EU actors so that European citizen benefit from a highly-performing infrastructure and databases (mapping, autonomous driving…) under a common EU regulatory framework.<br><br>The use of Artificial Intelligence in autonomous driving includes other challenges such as the non-casual reasoning required for safety-critical systems, including certification of AI systems. Furthermore, access to EU training data, design and development of AI algorithms and techniques, fail-operational platforms to accommodate advanced AI based systems as well as and frameworks for verification and certification.<br><br>The real challenge to development of AI in autonomous driving is not the technology or the computing capacity, but it is really access to large sets of real data. Foreign competitors such as Google benefit large data pools. We need to consolidate data sets and build up capacity and create appropriate infrastructure. We need to create an ecosystem of companies that will support the OEMs in the development of AI with access to a large set of real data.<br><br>The use of AI is pivotal to move to L4 and L5. All aspects related to the use of advanced AI functions in autonomous car must be included. This is something that cannot be done at company or member state level, but it required a common initiative which is able to mobilize both resources and the relevant stakeholders. |

| R38. | Develop competitive industrial production of high pressure hydrogen storage for mobile applications |
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| Short Description | The European Union has identified Hydrogen and Fuel Cells as having the potential to help fight carbon dioxide emissions, to reduce dependence on hydrocarbons and to contribute to economic growth.<br><br>In Mobility, two of the main barriers to implementation of Fuel Cell are cost and safety. The Hydrogen tank is a key component of the fuel cell system that has direct impact on those parameters. Existing solutions for on-board high pressure Hydrogen storage are not compatible with mass production and too expensive.<br><br>The European Union, through FCH JU, should increase funding to existing projects and launch new projects aiming at developing and industrializing mass-produced, cost competitive high pressure hydrogen storage for mobile applications. The increased funding and/or new projects should be directed towards both the R&D effort required to develop such solutions, and the Capital expenditure required to up-scale towards mass production. |

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| Objectives | • Deployment of large-scale pilot of hydrogen fuel cell vehicle fleets, bringing in the benefit of economy of scale and a strong cost reduction of the fuel cell stack and of the hydrogen storage system on-board vehicles. Deployment of H2 fuel cell vehicles as energy-storage parts of micro-grid systems.<br>• Half the market price of the hydrogen system (Hydrogen storage system + Fuel cell system) thanks to product and process optimization, and scale effect.<br>• Upscale production capacity of Type IV 700 bar hydrogen storage system and stack system.<br>• Finance researches on materials to reduce the part production cost to allow zero emission with the same customer experience that a vehicle equipped with a combustion engine. |
| WOT Items | S2, S4, S5, S6, S7, S8, S10, S11, S12, W1, W7, W9, O1, O3, O4, T3, |

| R39 | Create a European scheme to support investment in clean mobility by mobility providers |
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| Description | In addition to, or as a coordination with, existing European and national incentives scheme, we need to have a strong and harmonised European-level scheme to encourage investment in clean infrastructure and vehicles, especially since these solutions often have higher investment costs that current technology.<br><br>• Eligibility to such schemes may take into account :<br>• Life cycle assessment of “cleanliness” (e.g.: 50% reduction in emissions)<br>• Made in Europe content (ego: minimum requirement of 60%)<br>• Incentives may be a combination of :<br>• Taxes,<br>• Subsidies,<br>• Long term loans,<br>• Regulatory requirements,<br>• Leasing schemes (for batteries, for infrastructure or for vehicles)<br><br>Such a scheme must be “user-friendly” and well communicated so that there is a high level of awareness. There must be a network of partners that help promote and implement it (regional authorities, private banks). |
| Related Recommendations | R6 |

| R42. | Introduce economic incentives for clean mobility and logistics for consumers/professionals + public procurement for heavy-duty vehicles |
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| Description | Added value of being clean should be monetized. Reward people that are not producing CO2, instead of punishing people that do produce Co2. Especially, try to make sure it is not a more expensive option. (For instance in the case of e-buses, make sure, through monetary rewards, that this is not more expensive than a regular bus.)<br><br>Example of logistics offering possibility to be delivered CO2-free when ordering online |
| Concrete actions | • Create a EU "bonus/subsidy" scheme for clean vehicles (for end user, and for transport authorities) |
| Related Recommendations | R6 |
| Related EU initiatives | • Clean Vehicles Directive: there is already a provision for "clean" obligations in public procurement by 2025 and 2030.<br>• One issue is how to help municipalities achieve these targets.<br><br>The other issue, is how to we incentivise private players to switch to "Clean". |

| R46. | Next generation of high-power inverters based on wide-band gap semiconductor technology |
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| Description | Technological improvement are emerging to enhance the electrical efficiency of inverters for electric drive trains. A 10% improvement of inverters efficiency would allow to increase by 10% the mileage for a same battery or to reduce by 10% the battery for a same mileage, therefore it can mitigate the issues associated with batteries (availability, disposal and cost) and increase the mileage autonomy of EVs, both being hurdles to the proliferation of EVs. The European industry should coordinate investments across the full value chain (substrates, components, inverters) with the support of Member States and EU institution, to deploy inverters based on compounded silicon components, maximize their electrical efficiency and ensure a competitive cost structure. The mainstream technology is Silicon Carbide (SiC), and a possible emerging technology is Gallium-Nitride (GaN).<br><br>Two major disruptions in the area of power electronics will lead to a significant improvement of the total cost of ownership of electric vehicles:<br><br>• Wide band gap materials (SiC and GaN)<br>• New packaging processes and materials<br><br>Wide band gap materials allow reducing the footprint of sub-modules due to inherent physical properties (higher temperature, higher operating frequencies). Efficiency can be significantly improved and size and weight of power modules can be reduced. On system level an improvement of efficiency will lead to less cooling effort resulting in less physical size of the system. The whole value is impacted by this new technology, including |

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| | additional components (like capacitors) or packaging processes and materials. Especially the latter is important for the future. In the past ten years, all packaging materials have changed and with the arrival of these new semiconductor components, it is expected, that this trend will continue. Temperature as well as frequencies will rise and require new EMC studies and filters. Materials for transformers need to cope with high frequencies, and higher frequencies will stress capacitors, which are today a large cost factor in EVs.<br><br>Voltage levels in cars will probably rise depending on the standards that the automotive industry will adopt. Semiconductor components will need further improvements in order to address these new needs. The introduction of these new materials will be relatively rapid and extensive knowledge about failure mechanisms and aging processes need to be regarded on an accelerated path. Modelling and simulation, new validation methods, new standards will be required. Functional safety will need specific scrutiny. Finally, the arrival of hydrogen based fuel cell vehicles will put additional challenges for the development of adequate power modules.<br><br>The European industry should therefore coordinate investments across the full value chain (substrates, components, power modules, appropriate driver devices and sensors) with the support of Member states and EU institutions, to deploy power modules based on compound semiconductor components, maximize their electrical efficiency and ensure a competitive cost structure. |
| Objectives | Develop a strong competitive industry supplying power modules and components to the worldwide industry for electric mobility, based on new wide gap semiconductors technology. |
| SWOT Items | Strong: SC industry. Weak: material, capacitors, inductances. Opportunities: change of technologies = change of suppliers. Threat: China accelerating |

| R47. | Develop a sustainable road transport ecosystem for heavy freight logistics |
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| Short Description | Long distance road transport is a main contributor to Green House Gas emissions for large-volumes industries such as paper, steel, beverages, etc. Moreover, the logistics service industry has a lot to gain from technology, both in terms of efficiencies and cost reduction.<br><br>In addition, advanced Automated Driving Systems could increase road safety of trucks significantly. Currently, the first publicly funded European multi-brand high density truck platooning projects are underway. However, only when systems are actually deployed in mixed traffic the potentially huge benefits will be validated and shown.<br><br>Deploying clean, connected, automated technology to long distance highway transports, will have a huge impact on Europe in terms of less accidents, reduced congestion, and higher efficiency (e.g. fuel consumption, reduce CO2 and NOx emissions). |

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| | Expected benefits:<br><br>• Reduced GHG, reduced transport costs, higher utilisation, higher transport effectiveness, reduced fuel costs; improved road circulation; reduced road accidents.<br>• Portfolio of virtual qualified tools to optimize and manage the innovative logistics solutions (by testing correlation with real-life scenarios) |
| Concrete actions | • Deploy cost effective clean (electric/hydrogen), connected, cooperative automated trucks for real logistics operational pilots.<br>• Develop further zero-emission powertrains (e.g. fuel-cell powered truck subsystem or battery-electric drivetrain) and interoperable H2 and electricity charging infrastructure solutions.<br>• Upgrade selected high-traffic corridors (e.g. Hamburg-Milan via Austria, Rhine-Barcelona via Rhone Alps; Rotterdam-Paris via Belgium; Sweden industry-port) with the necessary physical and digital infrastructure to support, for example, refuelling/charging, automated trucks, platooning integrated into logistics multi-stakeholder operation, and extended validation<br>• Supports the opening and EU-wide circulation of high-productivity trucks (longer and heavier transportation, aka EMS combinations).<br>• Support the implementation of standardized validation and testing frameworks for connected and automated vehicles, both in virtual and real environment, by means of regulatory<br>• Support the digitalization of all haulage operations (including docking, cargo loading and unloading, refuelling…) to enable automation in all phases of transport mission.<br>• Investigate new logistic business models to optimize the operational efficiency benefits related to platooning/automated vehicles.<br>• Investigate the interaction between the virtual co-pilot and the driver (for instance the driver in the first truck of a platoon)<br>• Evaluate efficiency and validate accuracy of the virtual modelling of these functions (cooperative platooning and low speed manoeuvres such as berthing at docks) by correlation with experiments run on safe and exhaustive city lab that reproduces real critical scenarios.<br>• Support a positive public opinion on both safety and occupational issues related to autonomous vehicles development.<br>• Coordinate connected platooning with similar projects concerning passenger cars (ex. Highway chauffeur systems).<br>• End-user acceptability and infrastructures requirements evaluation, development and validation<br>• Robustness strategy and “survival” modes implementation |
| KPI | • Number of clean trucks in circulation in Europe in 2030, in absolute numbers and in % of total trucks in circulation.<br>• Decisive contribution for reduction of $CO_2$ truck emission, as required by the 2019 EU institutional agreement which ensure that between 2025 and 2029, new trucks will emit on average 15% less CO2 compared to |

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| | 2019 emission levels. From 2030 onwards, they will be required to emit on average 30% less CO2.<br>• Communication standard for C-ITS |
| SWOT Items | S2, S7, S10 |
| Related Recommendations | Large scale cost effective fuel cell production – R50 |
| Related EU initiatives | • https://platooningensemble.eu/project<br>• www.eutruckplatooning.com<br>• https://www.acea.be/publications/article/infographic-eu-roadmap-for-truck-platooning<br>• EC funded project ENSEMBLE. Ensemble – Multiband platooning financed by H2020; Mobility Valley between Paris and Le Havre. A H2020 call will be published next year – April 2020 – on research and demonstration in the logistic area |

| R49. | Develop secure platforms for CCAV data sharing (storage and communication) |
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| Short Description | Develop a secure and cost-effective European cloud service CCAV will required and generate massive amounts of data.<br><br>We have strong data security and privacy requirements. We need a European cloud platform that EU players can use safely and cost-effectively. Anonymised access to this data could be the source of new business models and new start-up opportunities. |
| Concrete actions | to set up an infrastructure is a recognized need. For the deployment of CCAV a fundamental pre-condition is disposing of a European data base. Strategic investments are required in this field. There is the need to ensure financing in order to achieve scale economy (at present technologies are too expensive).<br><br>Need to punt a right emphasis on validation to demonstrate safety (e.g. how AI interacts with the reality). |
| Related EU initiatives | • ENISA has received broadened powers for cybersecurity schemes under the new Cybersecurity Act. Read here:<br>o http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2017)614643<br>o https://www.europeanfiles.eu/digital/revamped-enisa-eus-cybersecurity-agency |

| R50. | Develop a competitive industrial-scale hydrogen fuel cell |
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| Short Description | Europe has good Fuel Cell technology, but has been overtaken by Asia in term volumes and market adoption. In order for the EU to regain leadership in innovation, a coordinated industrial scaling-up initiative must been set up with support of key EU RTOs and industrial players, together with Members States and EU institutions. |
| Investments proposed | • Investments by industrial players : nature/ destination, amount<br>• State aid support: destination, amount |
| SWOT Items | S10, W7 |

| R51. | Create a European "CCAV Accelerator Network" for all interested CCAV players |
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| Description | It is important to encouraging vertical and horizontal collaboration and best-practice sharing in order to boost the European CCAV ecosystem. To this end, we should create a network of accelerators open to all European stakeholders and players in CCAV: national and regional technology clusters, industrial players, SME's, start-ups, Universities and RTOs, industry associations, private equity funds, incubators, industry experts…<br><br>This "Accelerator Network" will support centres focusing on entrepreneurial initiatives in CCAV. They could be located in several EU locations that are clusters of emerging CCAV industry, academic excellence and a conducive entrepreneurial culture.<br><br>Before considering to create a new structure it should be useful to analyse what networks or other types of initiatives already exist to support ecosystems in the mobility field, either at national and European level, in order to capitalize from that. A mapping exercise could be undertaken in this respect.<br><br>In the objectives listed here below the emphasis is mainly on entrepreneurship, also innovation should be considered as an important element.<br><br>IPCEI is not seen as an adequate instrument in this area, but coordinated investments between public and private players to support such networks could be beneficial to boost the whole CCAV ecosystem in Europe.<br><br>Objective:<br><br>• Identifying, attracting and supporting European entrepreneurship in CCAV, focusing on innovation beyond fundamental research<br>• Providing an environment for early-stage high-impact companies in CCAV to form and thrive<br>• Becoming the forum and network of choice for all players in the European CCAV eco-system<br>• Identifying and promoting best practices in CCAV technology entrepreneurship |

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| | across network locations<br>• Driving co-creation between research, entrepreneurs, industry, investors and governments<br><br>Potential services:<br><br>• Shared infrastructure, coaching/advisory, support services for early-stage high-impact companies<br>• Unique commercialization expertise through due diligence, market analysis and seed-stage funding<br>• Driving development of a shared European roadmap and vision with all relevant stake-holders to accelerate progress (similar to the roadmaps in the semiconductor industry)<br>• Conferences and workshops as condensation points for a European eco-system in CCAV<br><br>Funding options:<br><br>• Seed-funded by national or local governments and the EC, supported by established industry players.<br>• Providing paid-for services to startup investors and industry.<br>• In long-term, attracting private-sector funding by running a seed fund for CCAV ventures. |
| Expected benefits | • Greater vertical and horizontal collaboration between all players in the value chain<br>• More innovation, best-practice sharing, consolidation around best-in-class |
| SWOT Items | S5, S4, S2, W3, W4, W9, W10, W11, O2, O7, O8, O9, T3 |
| Related items | R61 |

| R52 | Deploy connected automated driving in “real” road conditions |
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| Short Description | Human error continues to be the main reason for road accidents. Perfectly aligned with the European initiative to reduce road deaths to almost zero by 2050, “Vision Zero”, Clean Connected and Automated Vehicles (CCAV) is a field of innovation of common European interest since it has significant potential to contribute to reduce the risk for human errors and improve the protection of vulnerable road users.<br><br>Furthermore, CCAV also contributes to the Europeans strategy of clean and energy efficient vehicles since it also has the potential of reducing emissions by avoiding traffic congestion through optimal traffic guidance and vehicle routing |

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| | as well as energy consuming search for parking slots.<br><br>Additionally, CCAV will provide new and better mobility services to citizens, increasing inclusiveness and improving rural mobility. CCAV will also enable increased freight transportation and improving the logistics sector to meet the increasing demand for goods transportation in Europe.<br><br>Finally, CCAV offers a huge potential to boost Europe's economic and innovative power and helps to maintain its technological and market leadership by defining technical standards, e.g. concerning data protection, implementing European technology roadmaps from R&D&I to production, sustain employment and increase key-enabling technology skills in education.<br><br>The industry, the Member states as well as the European Commission already made strong efforts to enable excellent research concerning Connected and Automated Driving through dedicated funding schemes. This support of the European industry is crucial in order to maintain its standing as innovation leader despite the strong international competition from especially China, Japan and the US, where large-scale funding of CCAV is already a reality.<br><br>Recent examples of European projects funded by the European Commission aim at bringing together the considerable expertise of the European Automotive sector include the testing and demonstration projects L3Pilot, ENABLE-S3 and ENSEMBLE.<br><br>However, the findings and deliverables from those and similar projects need to be actually deployed to establish and validate the economic and societal impact of higher level. Automated Driving functions in real road conditions with mixed traffic scenarios and real (prototype) vehicles for peoples and transport of goods. This is absolutely critical to ensure the functionality of systems and technologies as well as to guarantee their necessarily required safety and reliability.<br><br>A coordinated investment is necessary in order to leverage the huge costs for:<br><br>• a) R&D for crucial Automated Driving components and systems,<br>• b) novel fail-operational centralized computing platforms hosting the increasing number of autonomous driving and E/E functions in safe and secure manner,<br>• c) homologation, and<br>• d) the required digital infrastructure, both for traffic (e.g. infrastructure like specific traffic lights) and communication (e.g. roadside units, cloud and computing backbone)<br><br>Based on the experiences and results, common core systems, components and standards will be developed, tested, deployed and shared, allowing the European automotive industry to face the strong competition and remain globally competitive.<br><br>This topic is an absolute necessity for Europe: Future mobility needs to be |

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| | connected and automated while saving lives and reducing emissions.<br><br>Expected benefits include:<br><br>• Reduced accidents and generally improved road safety,<br>• Reduced traffic load in general,<br>• Reduced GHG/emissions,<br>• New, additional, integrated traffic & mobility modes and business models,<br>• Increase flexibility of design and development process to progress in the direction of "zero-fatalities" (in car computing platforms which are hardware agnostics),<br>• Maintaining strong European Automotive market share; adding highly-skilled jobs, leadership in key technological areas. |
| Concrete actions | • Large-scale verification, validation and deployment of advanced Automated Driving systems for vehicles and fleets for people and goods transport, embedded in mixed traffic scenarios in a selected number of countries, corridors or regions (potentially geo-fenced), e.g. Germany, France, Spain, Italy, Sweden<br>• Focus on deployment, from research demonstrators vehicles to large-scale customer pilots to speed-up deployment with thousands of automated vehicles to secure expected impact on the road system, drivers, users and society.<br>• Development and deployment of the required CAD communication, high performance computing and data infrastructures - deployment of direct communication (V2V, V2I, C-V2X) and long range communication via LTE and 5G.<br>• Development and application of a secure and cost-effective European digital infrastructure and back end, for example to tackle challenges such as the massive amounts of data generated by CCAV as well as common European interfaces for infrastructures like traffic lights, traffic and transport management |
| KPI | • Number of deployed Connected Automated Vehicles used by real customers/users in Europe.<br>• The use of highly automated systems in urban environments will depend largely on how they will prove themselves in complex situations in the city with their corresponding critical situations and borderline cases. The overall innovation area of automated driving in cities will keep all actors in the research field busy for decades to come. The question of which driving functions in which Operational Design Domains (ODD) or planned areas of application can be represented sufficiently reliable in the near future is of interest in the short term. More precise targeted implementation rates need to be discussed.<br>• Furthermore, the installation rates and number and sizes of cities equipped with e.g. traffic lights equipped to communicate safely and securely with automated vehicles needs to be determined. The example |

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| | cities or areas should be representative for many use cases. |
| SWOT Items | S2, S3, S4, S6, S7, S8, S9, S11, S15, W3, W8, W9, O2, O5, O6, O10, O11, O13, O17, T3, T7, T9 |
| Related Recommendations | R25, R47, R19, R3, R49 |
| Related EU initiatives | • EC funded project testing Automated Driving functions<br>• https://l3pilot.eu/index.php?id=15<br>• https://platooningensemble.eu/<br>• There already is a strategy at EU level on connected and automated mobility. https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf<br>• ERTRAC Strategic Research Agenda 2050;<br>• ERTRAC Roadmap on Connected & Automated Driving<br>• STRIA roadmap of DG RTD<br>• The New Single Platform for open road testing and pre-deployment of cooperative, connected, automated and autonomous mobility has been created with the abovementioned focus elements. See details here :<br>• https://ec.europa.eu/transport/modes/road/news/2019-02-26-call-applications-single-platform_en<br>• In the new multi-annual Financial Framework, the Commission has proposed a dedicated budget envelope for CCAM. The approach would be "European Partnership on Mobility and Safety through Automated Road Transport (MOSART), a new partnership that aims to provide a long-term framework for pooling resources and strategic planning in order to address the challenges that connected and automated driving brings to EU roads including, among others, systemic challenges, technical and non-technical enablers and societal impacts. |

| R53. | Large scale deployment of high power charging solution in collective buildings and public areas |
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| Short Description | Large-scale deployment of charging stations in collective buildings (private residence or office buildings), is a key requirement for large-scale deployment of electric vehicles in European. It will be an important complement to charging stations in public spaces (streets) and in private residences.<br><br>To maximize the convenience for the users and the benefits for the grid, the target ratio between the maximum number of electric vehicles using a building's parking space at any one time and a the number of charging stations in the building should be should be 1-to-1. This leads to an estimated of target of 10 million charging stations to be installed in |

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| | collective building by 2030.<br><br>This can be a challenge for existing building due to:<br><br>• Technical challenges: high-power access to the grid, integration in the buildings existing electrical network…<br>• Legal challenges: decision making process there are multiple owners in the building, liabilities in case of incident…<br>• Economic challenges: allocation of the installation cost, of the maintenance costs, of the energy consumption costs…<br><br>Such large scale deployment will require :<br><br>• a significant reduction in the cost of such charging station (from >300 € today to <200 €),<br>• a large European industrial base to drive this cost reduction,<br>• high level of functionalities in the charging stations (smart-charging, vehicle-to-grid, etc.),<br>• high level of quality with adequate certification and/or labelling schemes,<br><br>In parallel, a number of policy measures to encourage market adoption, which may include:<br><br>• direct subsidies and/or (soft-)loans programs to collective building owners/operator for installing charging stations,<br>• regulation to introducing requirements for charging stations in new collective buildings,<br>• development of standards to ensure :<br>  ○ interoperability across Europe,<br>  ○ minimum basing functionalities,<br>  ○ certification to ensure minimum quality, safety and (cyber-) security standards.<br><br>Such project required collaboration between:<br><br>• utility companies,<br>• vehicle OEM/suppliers,<br>• charging station manufacturers,<br>• EU and national institutions,<br>• construction companies<br><br>Animate a short term (1 to 2 years) European cooperative project in order to identify the best technical solutions to be deployed to existing collective housing with an incentive framework. Integrate the solution descriptions in a guide to be distributed in each European country.<br><br>Expected benefits include: |

## Clean Connected and Autonomous Vehicles

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| | • Accelerated adoption of electric cars thus accelerating their impact on climate change, sustainable mobility<br>• increased number of vehicles connected to a charging station, allowing large(r)-scale smart charging for grid support |
| Concrete actions | • Deploy a large scale pilot program (10 000 by 2022, and 100 000 stations by 2025) for charging stations in collective buildings,<br>• Standards: development of common technical standards.<br>• Regulation: drafting of EU Directive / National regulation,<br>• Certification: creating of a dedicated quality standard with certification & training programs,<br>• Deployment of a common regulatory framework<br>• Coordinated investments in large-scale charging stations manufacturing capabilities<br>• Creation of EU financing schemes to help building owners/operators to equip charging stations. |
| KPI | • Target : 10 million charging stations by 2030<br>• Target cost per charging station: today >300 €, target 2020 <200 €. |
| SWOT Items | S4, S8, 09, O10, O15 |
| Related Recommendations | R20 |

| R54. | Boost the adoption of clean and autonomous buses by municipalities |
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| Short Description | Clean Vehicle Regulations<br><br>The recently adopted (mid 2018) Clean Vehicles Directive (CVD) mandates that public authorities in the EU must purchase a proportion of "clean" vehicles by 2025 and 2030. However, "clean" must be understood as using an alternative fuel as defined in the Alternative Fuel Directive. Which means that biofuels, CNG, LNG are all covered. On the plus side, there is an incentive on buses as each zero emission bus (EV) would be counted twice in the quota. So there is a legally binding EU wide requirement to go for cleaner public road vehicles.<br><br>Clean (electric or hydrogen) municipal buses and refuse trucks will make a considerable contribution. There is a need to further simulate and speed-up deployment.<br><br>Market<br><br>Buses:<br><br>There are 900 000 buses & coaches in circulation in Europe, their average age is 12 |

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| | years[1]. The market is ~50 000/year new buses. There is now a number of EU manufacturers offering clean buses. The market situation is better that it used to be 4-5 years ago, but market deployment is still only starting with few large tenders (> 100 buses) being issued and awarded.<br><br>However, when you consider that the EU industrial landscape for buses is rather scattered, you end up with an industry which in terms of scale and costs is far, far behind the competition especially with China. The latter benefitted from a protected market with mandatory purchase of zero emission buses by large cities and significant subsidies from the central government. As a result Chinese bus manufacturers have a strong advantage over the EU ones<br><br>Trucks:<br><br>This action could also include fleets of urban trucks, such as refuse trucks.<br><br>Clean freight trucks (distribution) and refuse trucks now being made available to customers. Those vehicles can help address issues related to air quality and congestion as they allow noise-free out-of-hours deliveries and emit no local pollutants. The market is still at the very beginning. Like other clean vehicles, the upfront cost is higher but there are societal benefits. Here again, it would make sense to have a monetization method for the calculation of environmental costs over the lifetime of the concerned vehicles, like it was done before in the Clean Vehicles Directive (but removed in the recently adopted Directive). Need to develop and deploy charging infrastructure and related services for logistics and vehicle management.<br><br>The measure proposed for buses should also apply to other public vehicle fleets, such as refuse trucks. For the sake of simplicity, we focus on buses for the moment, however clean trucks should be part of the concrete actions proposed below.<br><br>Technology<br><br>There are number of different technological solution being studies or proposed for clean municipal buses and trucks. For electric, charging solutions are diverse: from overnight charging to opportunity charging at end-of-the-line bus stops. There is still substantial space for innovation and to explore alternatives: such as wireless charging. There is still work to do regarding opportunity charging to deal with long duty cycles and/or increase the battery capacity while reducing battery's weight. Different solutions are being proposed / tested and standardization of the interfaces is still ongoing.<br><br>Economics<br><br>Switching from traditional buses to clean buses requires significant investments, because of :<br><br>• the upfront cost of clean buses which is higher than for traditional buses, and<br>• the additional cost of the new charging infrastructure |

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| | The lower operating costs (maintenance, fuel) of clean buses can over time offset this higher investment cost, but :<br><br>• on the one hand, the Public Transport Authorities (PTA) may not have sufficient funding to cover the upfront costs, irrespective of future savings, and<br>• on the other hand, event with adequate funding and/or financing, the payback time (or NPV/IRR) may not be sufficiently attractive<br><br>While investing to reduce the GHG emissions has positive societal impacts, it has no immediate monetary benefit, which slows down considerably the pace of investments.<br><br>For large scale adoption of clean buses in Europe, beyond the (low) minimum requirements of the Clean Vehicles Directive (CVD), the switch to clean needs to an attractive value proposition for the PTA. To achieve this, we need a combination of:<br><br>• cost reduction,<br>• subsidy and/or financing schemes,<br>• regulatory requirements<br><br>Proposal<br><br>In order to develop the EU market and industry for clean buses on a large scale, we need, in parallel;<br><br>• To build up clean buses manufacturing capacity to serve a growing market and to reduce manufacturing costs.<br>• Provide funding & financing schemes for PTA, such as (soft-)loans guaranteed or provided, directly or indirectly, but the EIB<br>• Build pilot programs for innovative zero-emission technologies<br>• One should also find ways to ensure that the external costs of various technologies are reflected in their financial costs.<br><br>1: source https://www.acea.be/automobile-industry/buses |
| Concrete actions | • Introduce a transitional “smart” subsidy scheme to encourage early adoption and allow market to grow until it becomes economically attractive even without subsidies:<br>• Deploy medium scale procurement programs for deployment on the market (>100 buses per projects, 10 000 in total by 2025) for mature technologies<br>• Deploy a small scale pilot programs for research (>10 buses per projects, 1 000 in total by 2025) for innovative technologies (autonomous driving, wireless charging, other solutions…)<br>• Provide funding for new R&D programs for clean and autonomous buses.<br>• Regulation: drafting of EU Directive / National regulation to internalise the external costs in the procurement processes.<br>• Coordinated investments for first industrialisation of innovative clean and |

## Clean Connected and Autonomous Vehicles

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| | autonomous buses, with roadmap to reach EU manufacturing capabilities of 50 000/year by 2030<br>• Creation of EU financing schemes to help Public Transport Authorities switch to clean/autonomous buses |
| Expected benefits | • Cleaner public transport<br>• More affordable transport thanks to autonomous driving, especially in remote/low traffic areas |
| KPI | Need to establish clear EU targets. Examples:<br>• 20% clean buses in circulation by 2030 → 200 000<br>• 2/3 of new buses are clean by 2030 → 50 000/year |
| SWOT Items | S4, S8, 09, O10, O15 |
| Related EU initiatives | • DG MOVE had launched a Clean Bus Initiative but for various reasons it turned out to be difficult to finalize some of its deliverables (best practices, technology overview…)<br>• Clean Vehicles Directive (CVD) mandates that public authorities in the EU must purchase a proportion of "clean" vehicles by 2025 and 2030 |

| R55. | Creating a new generation of newly conceived tyres for CCAV |
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| Description | Future tyre of CCAV will have to be capable of meeting the outstanding challenges of electrical, connected and autonomous driven vehicles set by the technological evolution, which is taking place in the automotive industry.<br><br>Moreover, being the tyres the only element in contact with the ground, there is a lack of knowledge by vehicles' on-board systems (e.g. ADAS) of the actual forces exchanged between tyre and asphalt to be used as primary control input. Thus, tyres will be connected to vehicle and/or infrastructure to improve the mobility experience. Preventive safety of vehicle (and users) will greatly benefit from this new paradigm since current actuation based upon chassis kinematic features is just reactive-based and not preventive. Beyond the single vehicle, the objective should be to exploit the vehicle to vehicle communication as well as vehicle to infrastructure to allow the driver community to use those valuable information provided by the tyre to the benefit of other vehicles.<br><br>Moreover, the new tyres will have to be "clean" not only as far as reducing mobility emissions are concerned but along all the supply chain: from raw materials to manufacturing processes up to end-of-life disposal and recycling. |

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| | Expected benefits include:<br><br>• reduction of non-renewable resources impact<br>• lowering carbon footprint<br>• reducing batteries energy consumption<br>• Reducing noise emission<br>• Reduced weight - reduction in use of raw materials and lower impact on natural resources<br>• Improved mileage - longer tyre life and reduced exploitation of resources<br>• Improved vehicle and traffic safety including wet grip performance of worn tires<br>• Improved predictive maintenance<br>• Improved recyclability - introducing new thermoplastic materials that can be re-used, developing deconstruction processes that help sorting the materials for facilitating their use as secondary raw materials |
| Concrete actions | • Develop more "green" and clean tyres, that is will have to make more and more use of materials with low impact on non-renewable resources and on other key environmental impacts like end of life management.<br>• Manufacture tyres with digitalised low energy consumption processes<br>• Develop new tyre structure to be thoroughly re-conceived for electric vehicle (lighter tyres and suitable to bear higher loads - batteries are heavier than combustion engines - but have at the same time lower rolling resistance - which means they will last longer and consume less battery energy in real usage conditions - and lower noise pollution);<br>• Develop new tyres that are able to provide information to the vehicle system (full integration with ADAS) on the working conditions of tyres (vertical load, wear, etc.) and on the boundary condition (road condition / temperature, etc.) |

Medium Priority

| R5. | Create common standards, interfaces & architecture for vehicle electronics |
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| Short Description | Current vehicle electronics architecture dates back several decades and is not adequate for the arrival of smart vehicles. New vehicle electronics architectures and standards will appear and compete in the coming years. In order for a European solution to emerge and become tomorrow's standard, it is necessary to join forces and lead the efforts today.<br><br>In the same way as a dominant and open OS for PCs (Windows) or for mobile phones (Android) have both spurred innovation and the created a thriving diversified industry, tomorrow's smart vehicles will benefit from a common cost effective platform allowing plug-and-play integration of software and hardware. Such architecture must allow for centralised processing (CPUs and GPUs) and communication network/protocol, but |

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| | should also be modular, flexible and secure.<br><br>A consortium could be created to development a common standard, with the work financed by and accessible to all consortium members (RTOs, OEMS, suppliers), and potentially licensed out to external players. (i.e.: similar approach to ARM architecture, which is licensed to independent processor developers).<br><br>Need to clarify the description, what is possible, what is not. |
| Concrete actions | • Develop common EU interfaces for vehicle electronics based on standards<br>• Encourage collaboration, on a voluntary basis, between EU players to develop multilateral vehicle electronics architecture |

| R8. | Strengthen research and innovation funding for CCAV with greater coordination and "soft-financing" |
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| Short Description | Problems:<br><br>One the one hand, research and innovation funding in Europe for the CCAV value chain is done, mostly in the form of grants by EU funds or state aid, through multiple institutions and programs both at EU (e.g., H2020, Horizon Europe RIA programmes) and national level (such as IPCEI, ESF and purely national funding programs) which sometimes lack coordination and integration within an overall European strategy for CCAV.<br><br>On the other hand, private equity and debt financing is often only available for technologies that are already mature and close to commercialisation (or already commercialised, and requiring only scaling-up). Such "commercial" funding often comes with a lot of strings attached due to high levels of risks involved (equity will generally seek control and/or clear and high return on investment prospects, debt will generally seek guarantees).<br><br>This current situation leads to a number of problems:<br><br>• 1) lack of coordination and strategy:<br>  o some key technology developments may not receive sufficiently funding, while others may get excessive or poorly allocated funding,<br>• 2) intrinsic limitations of "research grants" and "state aid":<br>  o availability of such funding is limited by the budget that the EU and national/local government can allocate to supporting research;<br>  o cost of grants is supported by the taxpayers while generally benefiting individual private companies - and if research leads to profitable business, there is generally no pay-back for the state/taxpayer; |

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| | <ul><li>scope of grants is generally limited to the early phases of the research and innovation life-cycle (generally excludes first industrialisation and up-scaling)</li><li>These issues, which are well known, can become a limitation when required levels of funding for innovation and</li></ul><ul><li>3) "funding gap" between research and mass market:<ul><li>"public" funding (grants/state aid) generally stops (at early maturity stages) before "private" funding (equity/debt) takes over (at late maturity stages) - this leave a gap where a lot of technologies struggle to finance the proof-of-concept, first industrialisation[3] and scaling-up phases</li></ul></li></ul><br>Proposals:<br><br><ul><li>For a start, we need to establish stronger links between the various research funding programs, coordinate CCAV research funding at the European level and integrated it within an overall long term strategy for CCAV including all the maturity stages: research, innovation, first industrial deployment, scaling-up and mass market deployment.</li><li>Then we need to develop and deploy "soft-financing" tools and programs that can, on the one hand bridge the "funding-gap", and, on the other hand, be deployed on the scale required for massive transition to CCAV (i.e.: >>10's billion €):<ul><li>These "soft-financing" tools can be in the form of "soft-loans" (non-recourse, convertible, flexible principal repayment, low interest rates...), reimbursable grants, quasi-equity....</li><li>They could be provided mostly by public financial institutions (EIB, EFSI, national public investment banks/funds...) and be levered with private funding, possible with a tier systems (cash waterfall allocation according to risk/return appetite)</li></ul></li></ul> |
| Concrete actions | <ul><li>Develop comprehensive European CCAV research and innovation funding strategy</li><li>Coordinate research funding for CCAV between various funding institution/programs</li><li>Develop and deploy "soft-financing" tools and programs that can, bridge the "funding-gap" between research and large scale industrial deployment</li></ul> |
| SWOT Items | O15 |
| Related Recommendations | R6 |

[3] in case of an IPCEI, first industrial deployment may also be covered (if the project concerns the development of a new product or service with high research and innovation content or the deployment of a fundamentally innovative production process

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| Related EU initiatives | • Multiannual Framework (Horizon Europe) |

| R15. | Establish guidelines and incentives for innovative procurement by municipalities and transport authorities for deployment of CCAV solutions |
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| Short Description | With a growing number of municipalities launching bidding contests to deploy new CCAV solutions, some best- and worst- practices are being observed. A think-tank could be established to consolidate best practice recommendations for municipalities. Funding aids could be provided to those municipalities (or even to private players), that follow these guidelines.<br><br>Some examples of guidelines :<br><br>• Introduce some level of risk sharing between municipality, operators, technology provider, and end users,<br>• separate infrastructure operators, vehicle fleet operators and booking platforms, to ensure competition and specialisation at each level, and facilitate transition from one operator to another |
| SWOT Items | W5, W6, O1, O5, O6, T1, T4, T7, W9, O10 |
| Related EU initiatives | • ITS<br>• Smart Cities<br>• Trans-European Network for Transportation (TNT)<br>• INEA : Innovation and Network Agency<br><br>Tender recommendations written by UITP, in collaboration with customers and manufacturers |

| R32. | Support development of mobility-as-a-service with CCAV |
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| Short Description | Mobility models are changing to get transport as near to user needs as possible. A side positive effect of this shift has been the renovation of shared-property fleets towards less traditional, more digital, clean and autonomous vehicles. On the other side, no common framework is in place and all sharing services relies on different regulation and business models. If shared mobility is a reality for passenger cars, it is just starting for goods transportation, especially Heavy Duty Vehicles, which in turns will need a very strong MaaS model to be impacted on a larger scale. The model should be carefully steered from EU to ensure both technological progress (towards CCAV) and a common regulation framework to be proficient for all; end-users, carriers, shippers and OEMs in all parts of Europe. The model should also establish links with other forms of mass transportation |

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| | and ensure appropriate alignment and interoperability.<br><br>A task force[4] should be established to consolidate best practice recommendations and guidelines, with specific funding granted to those adopting the standards specified (i.e. new vehicles, minimum and maximum operation rates, etc. |
| SWOT Items | S8, S11, O4, O14 |
| Related Recommendations | R 27 |

| R37. | Support competitive industrial production of battery packs |
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| Short Description | A number of initiatives are already launched (or being launched) towards reducing the cost of batteries. These initiatives are focused on battery cells. However, the battery pack, excluding the cells, is also an area where substantial improvement could be obtained.<br><br>The pack (excluding the cells) accounts for 25% to 33% of the total battery system value, and c. 50% of the system's volume. It poses specific challenges in terms of weight, mechanical performance, thermal performance, safety, and vehicle integration. Breakthrough BEV performance could be achieved through new battery pack technology, parallel to cells technology.<br><br>Moreover, due to its volume the pack needs to be manufactured and assembled closed to the automotive assembly lines, which means local industrial jobs resulting from technology breakthrough.<br><br>To that effect, the European Union should launch a Joint Undertaking dedicated to Battery Pack, under a public private partnership format similar to FCH JU, with the objective to develop and industrialize breakthrough battery packs for Mobility applications |
| SWOT Items | S2, S4, S7, S8, W6, O1, O6, T4 |

| R60. | Human factors (motion sickness, sense of safety) in the operation of CCAVs |
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| Description | CCAVs provide new possibilities for mobility of citizens. Simultaneously they create new challenges for the user:<br><br>New motion patterns compared to conventional vehicles result, based on new seating positions, as well as the transformation of vehicle body and chassis. |

[4] See also MaaS alliance

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| | Therefore, accelerations and movements will be noticed differently as before. This leads to challenges and tensions concerning the acceptance of CCAVs.<br><br>The users Sense of Safety is going to be influenced negatively by this transformation. Furthermore the unknown accelerations and motions will influence the well-being of the user up to the point of Motion Sickness.<br><br>To counteract this process, we need a clear idea of the boundary conditions: Under which conditions do we expect an impact on the Sense of Safety and when respectively how does Motion Sickness evolve from vehicle/user motions. Furthermore we need to study actions to prevent and contain these senses. |
| Concrete actions | Analyse factors on sense of safety and motion sickness |
| Expected benefits | Increase User Acceptance of CCAVs |
| SWOT Items | S4, S5, S7, S9, W9, O1, O2, O5, O6, O11, O14, O15, T3 |
| Related Recommendations | R25, R31, R9 |

# Smart Health

## SWOT analysis

### Strengths

- S1: Commitment to ethical rules
- S2: Strong and standardised framework for data protection and privacy
- S3. A relatively stable regulatory environment
- S4. European expertise in collecting health data
- S5. High penetration of broadband and LTE internet connectivity
- S6. High levels of investment in technology
- S7. Strong medical technology sector in the EU, innovation in pharmaceuticals, innovative SMEs and start-up
- S8. Publicly funded health systems with universal coverage
- S9. Several pilot initiatives
- S10. Availability of data portals
- S11. High-level education and skilled labour force

### Weaknesses

- W1. Market fragmentation
- W2. Insufficient interoperability and data sharing
- W3. Limited scale-up of pilot initiatives
- W4. Risky clinical validation and longer time to market
- W5. Risk aversion of investors and funders for clinical validation
- W6. Lack of clarity on the development of digital therapeutics
- W7. Lack of an Evidence Standard Framework for Health Technology applications
- W8. Guidelines for interpreting regulations are missing
- W9. Lack of adaptability of the regulatory environment
- W10. No signal sent to companies by public national authorities (risk sharing) to support their investment into smart health
- W11. Value of outcomes from big data analytics and real-world evidence not yet clear
- W12. Low medical relevance of data collected (bad quality of data, of the context in which data are collected);
- W13. Insufficient adoption of standards for effective data generation, sharing and access at this stage.

### Opportunities

- O1. Personalised medicine
- O2. Remote healthcare
- O3. Emergence of the 'silver economy'
- O4. Technological opportunities in AI, robotics, blockchain 5G and high-speed internet
- O5. European Open Science Cloud
- O6. Increasing digital literacy
- O7. Chronic diseases prevalence

- O8. Growing market of medical technology and biomarkers
- O9. Digital therapeutics
- O10. Bio-based materials
- O11. Conversion of medicine and technology
- O12. Use of health data and applications for health maintenance and disease prevention

Threats

- T1. Lack of clarity around data ownership and data governance
- T2. Slow uptake by end-users/ lack of trust (concerns about reliability of technology and privacy, costs, etc.)
- T3. (Un)sustainability of universal health care systems
- T4. Pre-emption of the value chain by non-medical technology companies with subsequent lack of real innovation in health
- T5. Insufficient regulation of new types of healthcare companies
- T6. Consumerisation and commoditisation
- T7. Generation and analysis of huge volumes of data with no useful and valid medical output
- T8. Faster AI development in China, US/Canada
- T9. Lack of cybersecurity solutions
- T10. Possibility of losing track of the patient needs

# Compilation of all recommendations received

## Create a federated structure of health databases without „identification of individual data subjects "

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| R1 | Coordinate at the European level, a federated database of anonymised health and real-life data from "certified" sources |
| Short Description | Establish clear and coherent legal and ethical framework for collecting, sharing and accessing data that protects the rights of the individual and society<br><br>- In particular, collect/connect data from pilot initiatives at the end of the project to capitalize on the effort of integrating and cleaning up data for a specific application<br><br>- Educate and incentivize citizens/patients/health professionals/medtech & pharma industries to participate (for example, by giving them immediate access to services, creating communities, access to linked data). Use the know-how of the Medtech sector in providing these services to encourage participation. See health data as a common good that can foster innovation throughout the health sector. |
| SWOT Items referred to | Strengthening data infrastructure and cloud services<br><br>Market fragmentation |

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| R2 | Enable the use of big data in the full medicine lifecycle (from research to delivery to patient) |
| Short Description | Big Data and other technologies help enterprises leverage information to improve operational efficiency, meet the growing needs of patients, identify trends, and create new products and services.<br><br>The use of big data in the medicine lifecycle and the uptake of health data across Europe should be advanced. To achieve this, we recommend **the EU to work with Member States and healthcare system stakeholders on advancing structured data collection**, uptake of Electronic Health Records (EHRs) in national healthcare systems and investments in data infrastructure, while at European level the regulatory framework should be adapted. More specifically:<br><br>• **Adapt regulatory frameworks to fully leverage new technologies and reduce inefficiencies:**<br>• Big data medicines development will increasingly utilize new technologies and hence **new regulatory strategy approaches are required to determine when and how in the product life cycle evidence and services derived from these new technologies may be acceptable for regulatory decision making**. Digital technology has progressed such that regulatory documentation can reside in a single location, however be accessed and evaluated online, in real time, irrespective of geographic location. Outcomes, issues, and decisions could be debated, as they emerge, jointly by regulators rendering a consensus view. These aspects should be further considered to adapt to the dynamic reality of today's science, technology, and patient expectations. It brings overall efficiency by removing non-value-added steps, unnecessary duplications and by simplifying administration.<br>• All actors in the pharma sector should be allowed to take advantage of contemporary technologies and **make product and labelling information available through digital means**. This will increase product information utility and improve patient value-add.<br><br>**The uptake and use of Electronic Health Records (EHRs) should be advanced to benefit clinical trials efficiency and post-trial follow-up:**<br><br>• There is a relatively low uptake of EHRs in many countries with high degree of fragmentation across Europe and limited interoperability. There are opportunities to improve data accuracy and promote clinical trial efficiency when EHRs are used in clinical investigations. EHRs may enable clinical investigators and study personnel to have access to many types of data (e.g., clinical notes, physician orders, radiology, laboratory, and pharmacy records) that can be combined, aggregated, and analysed. EHRs may have the potential to provide clinical investigators and study personnel access to real-time data for review and can facilitate post-trial follow-up on patients to assess long-term safety and effectiveness of medical products. In addition, there are opportunities for long-term follow up of large numbers of patients, which may be of particular importance in studies where the outcome of interest occurs rarely, such as in prophylaxis studies |

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| | Systematic **investments in health data infrastructure at national levels should be made:**<br><br>• Standards which drive interoperability (e.g. the use of SNOMED CT ontologies) should be adopted and enforced. The eHealth network could be a good catalyst for this work.<br><br>**The use of EU Funds should be promoted:**<br><br>• Innovations that lead to more efficient data capture by clinicians and patients (e.g. voice to text technologies supported by standardized ontologies) should be supported. It is important to invest in available innovative medical technologies, coupled with electronic communication systems that connect existing often disparate healthcare infrastructure, to create integrated care solutions. |
| **SWOT Items referred to** | • Strengthening data infrastructure and cloud services<br>• Slow uptake by end-users (concerns about reliability of technology and privacy, costs, etc.)<br>• Market fragmentation<br>• European expertise in collecting health data<br>• High levels of investment in technology<br>• High penetration of broadband and LTE internet connectivity in EU |

| R3 | Leveraging federated models to accelerate data flows in the EU |
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| **Short Description** | Today there are difficulties in sharing healthcare records, lab tests, medical images and other important information for the development of innovative services, important research, and development of medicines and therapies. Obstacles include lack of interoperable formats, derogations in the GDPR to allow member states to localise and prohibit the free flow of sensitive data contrary to Art 1.3 (Art 23.1(e).<br><br>EU needs to accelerate its efforts to provide national health systems with expertise, evidence and treatments to improve health and empower patients. It also needs to address barriers that exist to accessing and creating high-quality data to enable these goals.<br><br>• Quality and completeness varies across countries<br>• Sample size is often limited<br>• Delays to accessing data prevent patient-focused action<br>• Limitations to access, research processes must be harmonized with patient privacy<br><br>DG CONNECT has developed a recommendation for the European Exchange of Electronic Health Records in February. It includes recommendations of standards (HL7/FHIR) for data sharing and a wide range of important data that is built to include |

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| | cybersecurity and GDPR requirements.<br><br>More efforts by Member States to develop strategies to implement these recommendations to be more ambitious in its goal for sharing health records across borders through federated models within the EU beyond health record summaries. The full ownership of health records by a European citizen to function as a digital passport that will travel with the individual everywhere will accelerate the benefits of patient-centric care. |
| SWOT Items referred to | Insufficient standardisation for effective data sharing and access |

| R4. | Personalised medicine and big data |
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| Short Description | Despite the promise of significant benefits, the potential of available healthcare data remains largely untapped, primarily due to the huge challenges associated with combining and analysing the vast range of different sources of real world data to provide meaningful information that will ultimately improve the lives of patients and citizens on a large scale. Real world data responds to the demand for real world evidence to enhance randomised controlled data.<br><br>Personalized medicine encompasses the development of different strategies and approaches to improved personalized diagnosis of disease, as well as treatment selection for particular patients, based on their individual characteristics. Such a molecular portrait of the patient can be defined, for instance, by integrating genomic information, like mutation profiles and gene expression, as well as other molecular markers. This information can then be used to predict the outcomes of different treatments using information about how other patients with similar characteristics responded to the given treatment. Such enterprise requires a coordinated effort to obtain, process and integrate very heterogeneous sources of information ranging from the sequencing and annotation of genomic variants to the mining of medical literature, as well as the construction of context-specific in-silico models.<br><br>The Coordination team of the Spanish National Bioinformatics Institute (INB) at Barcelona Supercomputing Centre looks after the activities of the INB groups across Spain as well as their participation in the ELIXIR projects, activities and communities. The team has also established and led TransBioNet, a network of bioinformatics groups at Health Research Institutions of Spain. In the context of TransNioNext, the Coordination team works to increase the translational impact of the INB in the Spanish National Health System by articulating interactions and collaborations between groups at clinical settings with others at research environments, fostering the adoption of best-practices and protocols, and the adoption of the latest analytical technologies. The Coordination team also leads technological works around security solutions and the use of software containers for diverse purposes.<br><br>In the context of European Projects, the INB Coordination team at BSC leads the ELIXIR benchmarking platform which aims to establish a knowledge hub where ends-users, |

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| | software developers, scientific communities and funding agencies can gather information about the technical and scientific performance of bioinformatics resources including analytical workflows. Moreover, this team participates actively at the RD-Connect project leading the security developments of the genomics platform as well as the activities regarding the RNASeq analysis pipelines and how to integrate those results with genomics data for a better understanding of the genetic bases of rare-diseases. |
| SWOT Items referred to | • European expertise in collecting health data<br>• High penetration of broadband and LTE internet connectivity in EU<br>• High levels of investment in technology<br>• Stringent regulations and data protection<br>• VC investment less strong for scaling up companies |

| R5. | Building a Health Data Ecosystem, based on a federated model, across Europe |
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| Short Description | For Europe to lead the way of digital transformation in healthcare, we need a more connected and sustainable health data ecosystem in Europe. Multi-stakeholder approaches should be used to build this ecosystem where individual, private and public data can meet to enable better and more personalized care while providing the highest protection to people's data.<br><br>Interoperability: A critical step is to adopt and contribute to the enhancement of existing standards ideally based on open technical and data (semantic) standards. The standard should be able to accommodate the comprehensive capture and interoperability of all health- related data such as clinical data but also high dimensional (e.g. omics) data or patient generated health data.<br><br>Federated model: This interoperability is best based on a federated model whereby the different sources of health data acts as nodes in a network. The virtual database created by data federation does not contain the data itself but allows for standardised analysis for different purposes. For example the analysis can be utilised to inform research, clinical treatment, and hospital planning and payment models. EU citizens and patients should remain in the centre of such a network and remain empowered, so no provider can prevent them from managing or accessing their data.<br><br>Examples: This increased interoperability is an unprecedented opportunity to connect different data ecosystems and dataset to implement services for the healthcare sector and the social welfare in alignment with the Helsinki Region example. Moreover, interoperability will also scale up the impact of clinical observational research in alignment within the IMI2 project EHDEN (European Health Data and Evidence Network, link) which aims to harmonise 100 million, anonymised health records across multiple data sources. These experiences should be scaled up and transferred to other settings. |

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| | Patient-centric: This interoperability should embrace a patient-centric approach. Under the General Data Protection Regulation (GDPR), citizens everywhere in the EU have the right to control the use of their personal data: patients can become a digital steward of their own medical data, managing and accessing them across borders, and share them as appropriate with other entities. To make this possible, a standardised system (e.g.: user-specific interface or conventional data sharing standards) is needed to promote the continuous improvement in the field of healthcare interoperability at EU and national level.<br><br>Recommendations:<br><br>• EU should support multi-stakeholder initiatives involving the value chain holistically (healthcare providers, authorities, industry, and patients) to explore through regulatory sandboxes the further development of federated models of data ecosystem for increased interoperability and connectivity, while meeting GDPR.<br>• These initiatives should take leverage as appropriate on existing initiatives such as the IMI2 projects on data (e.g. EHDEN).<br>• Future funding (Horizon Europe, Digital Europe, and CEF) should support those initiatives and make them transferable across Europe and health care settings.<br>• EC and MS should ensure harmonisation of data protection rules for the health data ecosystem, maintaining consistency in interpretation and implementation, and avoiding the application of derogations unless necessary. |
| SWOT Items referred to | Strengths<br><br>Multi-stakeholder approaches can truly generate the ecosystem where trust will be a cornerstone to enable interoperable data generation, sharing and access<br><br>Federated data model has the potential to be cost effective and efficient as one would not need to centralize all data. In addition, certain institutions that host data today do not have the required systems in place to analyses the data to its full potential – whereas with a federated model the weaknesses of the various data holders can be sidestepped thanks to the fact that the analysis would be taking place on a virtual database that would not be impeded by the main database shortcomings/limitations.<br><br>Prior pilot experiences have shown the potential of these models. The EU has the appropriate instruments to further develop the model, scale it up and transfer across the board.<br><br>Weaknesses<br><br>Insufficient adoption of standards for effective data generation, sharing and access at this stage.<br><br>Lack of harmonisation and adaptation of legal frameworks (including GDPR) for a |

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| | federated model of data sharing.<br><br>Lack of trust in models of data governance.<br><br>Threat<br><br>Some initiatives are specifically excluding industry from participating undermining a holistic view on the issue. |

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| R6 | To develop virtual integrated EU Data lake infrastructure based on national health data infrastructures |
| Short Description | As almost every EU country is working on development of national gene-health data infrastructure it is important not to duplicate these efforts on EU level but work on developing similar infrastructure but work on virtual EU infrastructure. To this end Latvia comments that: 1) They can offer infrastructure and national experts that are working on this topic already and developing and piloting first phases of genomic-health data infrastructure, 2) They made a good cooperation with International players in the area of VC investment and are ready to share experience and results, 3) It is important to show examples and positive results of digital health solutions for payors - pilots can help there, 4) In order to overcome the lack of high-level ownership of digital health solutions, we need to start with pilots – national and EU level, 5) Without appropriate infrastructure it is not possible to do personalised medicine and remote healthcare, 6) In the areas of AI, robotics, blockchain, data infrastructure and cloud services they can offer LV built infrastructure and national experts, 7) Their experience in strengthening interoperability and standardisation can be used and 8) In the export markets opportunity, they propose to use LV established international partnerships. |
| SWOT Items referred to | • STR: European expertise in collecting health data<br>• STR: High levels of investment in technology<br>• STR: Strong and standardised frameworks for data protection and privacy<br>• STR: Commitment to ethical rules<br><br>---<br><br>• W: Insufficient standardisation for effective data sharing and access<br>• W: Limited scale-up of pilot initiatives<br>• W: Limited VC investment compared to third countries<br>• W: Value of outcomes from big data analytics and real-world evidence not yet clear<br>• W: Limited acceptance of digital health solutions by payors<br>• W: Lack of high-level ownership of digital health solutions to enable large-scale roll-out<br><br>---<br><br>• OPR: Personalised medicine, remote healthcare<br>• OPR: Technological opportunities in AI, robotics, blockchain |

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| | • **OPR:** Strengthening data infrastructure and cloud services<br>• **OPR:** Strengthening interoperability and standardisation<br>• **OPR**: Export markets<br><br>---<br><br>• **THR:** Lack of clarity around data ownership<br>• **THR:** Lack of cybersecurity solutions<br>• **THR:** Slow uptake by end-users (concerns about reliability of technology and privacy, costs, etc.) |

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| R7. | **Fostering the development of a health innovation and maintenance ecosystem accelerating the adoption of advanced health technologies, realising preventive strategies and utilising life health footprints.** |
| Short Description | The paradigm shift of a responsive health care system towards proactive health care, where maintenance of good health is the prime focus instead of disease management. Fundamental to the paradigm shift is the availability of continuous health monitoring data from both clinical and citizen/patient generated sources as well as strategic and multidisciplinary collaboration between citizens/patients, researchers, healthcare and medical professionals and firms of different sizes. The current health ecosystem does not provide sufficient incentives for this paradigm shift, as reimbursement principles rarely include preventive care. The utilization of non-clinical sources - like wearables and other self-monitoring solutions - for health prevention and -care is not supported. A potentially vast body of valuable health related data as collected in MyData-like repositories may therefore remain unused. Furthermore, although several innovation ecosystem initiatives have been launched to accelerate the adoption of advanced health technologies, many initiatives remain as local/national pilots without systemic impact or a roadmap for scaling up business opportunities. There is a great need for large scale and long-term experiments with preventive health solutions to gather evidence for the approach and help transform healthcare towards health management as well as to provide financial support for European innovation partnerships pooling together the knowhow of local/national pilots aiming at accelerating the adoption of advanced health data and advanced technologies. Recent initiatives: Digital Health Revolution (http://www.digitalhealthrevolution.fi/) GE Health Innovation Village (https://www.ge.com/fi/company/health-innovation-village) Health Capital Helsinki (https://www.healthcapitalhelsinki.fi/en/) Clever Health Network (http://www.cleverhealth.fi), |
| SWOT Items referred to | Too strict regulation, lack of venture capital, limited scale-up of pilot initiatives, lack of high-level ownership of digital health solutions to enable large scale roll-out, 5G and high-speed internet, consumerization, commoditisation |

Support the development of smart health products and services

| R8 | Promote innovative solutions of European start-ups and SMEs in connected, smart health devices and digital health solutions |
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| Short Description | European SMEs and start-ups face a double bind situation: on one hand, digital health and smart health devices represent a clear opportunity to support their growth and access to investment, on the other hand the change in MD and IVD regulations is more demanding for market access and clinical validation. The level of exigence required by regulation authorities, for a safe translation from proof of concept to validation of Solution is much higher than in other industrial value chain, and this requires much more efforts than by the past.<br><br>Several industry associations (Medical Mountains in Germany, Healthtech Finland, SNITEM in France…) have already provided help services to medtech SMEs to manage this difficult transition but the step is high and financial support weak. EIT Health provides significant support to start-ups in incubation/creation phase but not so much in development phase.<br><br>Therefore, in order not to add further burden on these companies, the IPCEI should attract interest of SMEs and start-ups innovative solutions. Innovative procurement is a first instrument, but doesn't address the clinical validation phase. The member states and their regulatory agencies should organise their efforts in promoting innovative solutions from SMEs in clinical practice in a more cooperative way than by the past.<br><br>The real European Common Interest in smart health is the existence of robust start-ups and SMEs solutions. With real world evidence of benefits provided to healthcare systems, VC opportunities will be extended and not limited (see SWOT) |
| SWOT Items referred to | ***Additional Strength:*** *rich and dynamic landscape of innovative start-ups and SMEs in Europe*<br><br>**Weaknesses:** Value of outcomes and real world evidence<br><br>Stringent regulations and data protection *(that could be considered as well as a strength if protective, I.e. with a good understanding by regulators of SMEs challenges à see FDA)* |

| R9 | Biomarkers |
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| Short Description | Despite significant investments to increase the number of biomarker studies, only ~150 out of thousands of identified biomarkers have currently been implemented in clinical practice. This is mainly caused by the time-consuming process of reliably detecting biomarkers, the irreproducibility of studies that determine a biomarkers' clinical value, and by a mismatch in studies that are performed by academia and what is required for regulatory and market approval.<br><br>To increase the number of clinically validated biomarkers, rather than further increasing the number of biomarker discovery studies, we must improve the quality |

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| | and reproducibility of studies and establish a coherent biomarker development pipeline from discovery to market introduction. More attention should be paid by funding vehicles to initiatives that reinforce standardisation and reproducible science (e.g. multi-sites Proficiency Testing programmes).<br><br>• CliniMARK COST action: Development of Best biomarker practice guidelines<br>• EQIPD IMI-funded project: European Quality in Preclinical Data<br>• Panel session at BIO-USA Convention, June 2019: Novel Approaches to Improve Reproducibility in Academia-Industry Collaborations |
| SWOT Items referred to | Threats: Low medical relevance of data collected (bad quality of data, of the context in which data are collected); Generation and analysis of huge volumes of data with no useful and valid medical output. |

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| R10 | **Develop a roadmap for Europe that integrates the use of new technologies (AI, big data etc.) to enable Europe to become a centre of excellence in healthcare and medical research by 2030.** |
| Short Description | With new technologies having the potential to substantially benefit European scientific and medical research and delivery of care, this Roadmap should be in line with the ambitions of Horizon Europe and be an integral part of an industrial strategy for the EU.<br><br>There are a number of fundamental prerequisites for allowing new technologies to deliver the full potential of benefits for society: the creation of platforms to optimise the availability of health data from various sources, a clear and coherent EU framework for public and private stakeholders to enable increased access to and availability of data for research purposes. These should be based on criteria such as interoperability, connectivity and safety, with a clear data governance model at EU level, an alongside the development of analytical tools necessary to manage large volumes of data. The EU has a critical role to play to continue and further build on public-private collaborations in this field which can have a critical impact on the speed and accuracy with which data can be analysed and used. Activities should include the following:<br><br>• A roadmap or masterplan including plans for the development of regulations/ guidelines and policies for advancing the **standardization and interoperability of healthcare data across Europe** (European standards for HC Data and Health Data Exchange) to link data across multiple sources and to enable health data to be effectively collected, shared, used for learning and innovation at a large scale and a clear and coherent **legal framework for collecting, sharing and accessing health data** at EU level for research and public health purposes while protecting the rights of the individual and society and securing the appropriate levels of safety and security (complementary to GDPR and cybersecurity guidelines). Variations in interpretation of the GDPR leads to fragmentation and a lack of clarity on how to operate under this framework when it comes |

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| | to sharing health data. Further guidance is needed from the Commission and the European Data Protection Board together with a commitment to improve alignment between Member States.<br>• Addressing privacy and security concerns is necessary in order to fully leverage the benefits of new technologies in the healthcare and pharmaceutical industry. The **EU should foster and support significant investments in data encryption and cybersecurity,** in addition to adopting de-identification techniques and implementing clear rules on data use.<br>• Creating **an infrastructure where European Health Data networks can genuinely interact, with a public-private data governance model** and a platform where multiple data sources can converge. This is also in line with one of the priorities of Horizon Europe and builds on the results of EU wide R&I programmes, such as Horizon 2020.<br>• Enable **public private partnerships and investments** in the area of Biobanking and biomolecular resources research infrastructures, investments for Artificial Intelligence and data infrastructure. The **EU should also consider establishing an adequately resourced Health Data Institute** with a strong role in managing these actions and ensuring that health data is made available for secondary purposes. |
| SWOT Items referred to | • Strengthening interoperability and standardisation<br>• Creating data governance<br>• Market fragmentation<br>• High levels of investment in technology<br>• A relatively stable regulatory environment<br>• Strong and standardized frameworks for data protection and privacy<br>• Commitment to ethical rules |

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| R11 | Creating the conditions for the development of evidence based Digital Therapeutics #DTx |
| Short Description | Software is not only for diagnosis and monitoring, it may be the active ingredient of a new therapeutic class, Digital Therapeutics. Digital Therapeutics are evidence-based and prescribed by a physician To promote the development of Digital Therapeutics in Europe it is necessary: 1. to remove regulatory uncertainty for the development of medical software (see US 21 Century Cures Act) 2. To provide Evidence Standard Framework for Digital Health Technologies (see NICE, March 2019) 3. to involve users (patients and HCPs) in the development of this technology |
| SWOT Items referred to | S - increasing digital literacy<br>W - limited acceptance of digital solutions by payors<br>O - emergence of silver economy, personalized medicine, remote healthcare, export markets<br>T - Insufficient regulation of new types of healthcare companies |

| R12 | Smart Health Digital Services |
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| Short Description | Shifting healthcare delivery from the hospital to home / primary care settings is the solution that delivers cost savings and releases pressure on increasingly stretched hospital services. In addition, it has the potential to deliver higher quality and more personalised care to individuals and is the model of care generally preferred by patients and their families, thus delivering outcome based delivery of integrated (health and social) care.<br><br>Therefore, activities may be targeting the hospital and/or the community, to reduce the hospital burden through 1) decreasing the number of new patients admitted, 2) decrease the readmission 3) decrease the days in the hospital. Activities must use validated patient reported outcomes instruments.<br><br>a. Shortening stays for those patients where hospital or residential care is the only option<br>b. Ensuring effective transition from hospital to the primary/home care setting and maintaining effective services in that setting.<br>c. Installing new surveillance and support structures in the community, that provide access to health care professionals with a strong community link and rapid response time<br>d. Implementing infrastructure for monitoring social care<br>e. Demonstrating value for telemedicine for remote monitoring, and the use of 'virtual wards' (for multidisciplinary case management) in reducing hospital admissions (4).<br><br>Outcomes:<br><br>Activities run in this focus area need to demonstrate major contributions to achieving one or several of the outcomes below. Any proposed solution needs to be scalable in a sustainable manner.<br><br>Strong home-care structured services that, through technological innovation:<br><br>a. Integrate social and health services<br>b. Support delivering needed care<br>c. Impact positively on objective health parameters<br>d. Demonstrate efficiency<br>e. Contribute to patient independency |
| SWOT Items referred to | • Market fragmentation<br>• Limited scale-up of pilot initiatives<br>• Value of outcomes from big data analytics and real-world evidence not yet clear<br>• Limited acceptance of digital health solutions by payors<br>• Lack of high-level ownership of digital health solutions to enable large-scale roll-out |

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| R13 | SMART HEALTH BASED ON INDUSTRY 4.0 : BioFABrication for tailored ADVANCED therapies by 2030 |
| Short Description | The goal is to exploit the potential of innovative technologies in regenerative medicine and biofabrication, for the future of healthcare sciences. Bridging personalized medicine and these new technologies is fundamental to achieve a rational roadmap to deliver the dream of long-lasting advanced therapies.<br><br>Expected Impact:<br><br>□ Developing manufactured functional tissues and organs, thus eliminating transplantation waiting lists<br><br>□ Developing advanced 3D in vitro models to better understand pathological mechanisms and Advanced therapies for rare and life-threatening diseases<br><br>□ Developing new drugs and enable repurposing of existing off-the-shelf medicines through 3D in vitro models, identifying the most effective therapies for patients<br><br>□ Produce tissues and organs generating less immune reaction than donor tissues<br><br>□ Stimulating new regenerative medicine and biofabrication industries<br><br>□ Transforming traditional surgical practice by personalized in-situ robotic bioprinting of advanced therapies<br><br>□ Creating a hub between partners that will guarantee professional knowledge diffusion and democratic access to new regenerative medicine therapies through biofabrication and organ-on-chip technologies<br><br>How does success look like?<br><br>Timely advancement of these technologies requires cooperation amongst a range of disciplines, close collaboration between academia and industry, which will be boosted by combining these proposals. Moreover, such an integrated approach will in our view deliver:<br><br>□ The first integrated artificial organ biofabrication line as a prototype clinical printing room;<br><br>Good manufacturing practice (GMP) Robotic 3D bioprinters for use in the operating theatre;<br><br>□ Human 3D mini-tissues and -organs for bioreactor-based high throughput automated screening and analysis for toxicity assays, drug development and other relevant industries, working towards personalized drug treatment and testing; |

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| | An open access database with digital information including models of human 3D tissues and organs to improve strategies and approaches developed for new therapies.<br><br>European network for basic research, GLP safety testing of biomaterials, GMP production guidelines and facilities, required standardization and quality control strategies for advanced therapies validation and translation;<br><br>Achieve a common regulatory hallmark to facilitate clinical and manufacturing development on a mid-long-term future, utilizing current actions in the field, such a as the EMA Guidelines on human cell-based medicinal products (EMEA/CHMP/410869/2006).<br><br>Automation of procedures and workflows necessary to lower the barrier to market entry for advanced therapies. Underlying challenge Scientific and commercial competition from the United States and<br><br>Asian countries in advanced therapies, in vitro models and biofabrication, requires that Europe not only provides resources to maintain technological competitiveness but also to strategically invest in this quickly developing area. The clustering would build on Europe's track record of stem cell biology, biofabrication, engineering, advanced material science, and GMP manufacturing of medical therapies. Europe is already in a dominant position in stem cell biology, biofabrication, engineering and advanced material science and is home to many of its pioneers. Our initiative will capitalize on the ongoing success and demonstrate European technological superiority and leadership. Advanced therapies are expected to develop into a 5 billion Euro industry in 2017, with a yearly growth rate of 13.0% over the next 10 years, with biofabrication playing a pivotal role in this growth. The global market for bioprinting reached $263.8 million in 2015. The market should reach $295 million in 2016 and $1.8 billion by 2021, growing at a compound annual growth rate (CAGR) of 43.9% from 2016 to 2021. Despite some promising regenerative medicine strategies already clinically used, in most cases their development is still a "black box" of complex information. We aim at tackling this information gap while improving biofabrication technologies that have a pivotal role in most of the stages of these novel strategies.<br><br>This will allow large-scale articulation of information between the EU partners promoting a faster and efficient development of functional advanced functional therapies. In addition, organ-on-chip technology is in its infancy but is also developing extremely rapid. Organ-on-a-chip and micro tissues have been identified by the European Pharma-Industry as an essential requirement to reduce animal testing in the drug development cycle and improve early stage rejection of unsatisfactory compounds. This has the potential of reducing drug development costs by 1B Euros each new molecule.<br><br>These technologies have been already identified as an important future industry, exemplified by recent significant investments in countries like the U.S., Japan, Canada, and China. Hence, the proposed strategic axe will directly:<br><br>1. Improve European healthcare and the lives of ageing European citizens. |

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| | 2. Guarantee citizens access to the new personalized medicine therapies.<br><br>3. Activate structural exploitation of research result dynamics in order to maximize the impact of scientific activities and stimulate the growth of resulting innovative value chains.<br><br>4. Standardize academic research and commercial production of fabricated therapies.<br><br>5. Lead the development and convergence of digitalized strategies with biofabrication, organ-on-chip and regenerative medicine.<br><br>6. Create a strong relationship with existing European infrastructures (BBMRI, ECRIN, EATRIS) and Flagships (HBP and Graphene)<br><br>7. Create coherence within the rapidly emerging biofabrication industry;<br><br>8. Stimulate the cosmetic, pharmaceutical, agriculture, food and robotic industries by testing and reducing molecule toxicities. |
| SWOT Items referred to | • High levels of investment in technology<br>• Strong medical technology sector in the EU, innovation in pharmaceuticals, innovative SMEs and start-up<br>• Pilot initiatives as EIT-Health<br>• Growing market of medical technology and biomarkers for SMEs<br>• Facilitate market access and individualized therapies<br>• Precisions medicine for ageing management<br>• Chronic diseases prevalence<br>• Know-how related to bio-based materials and other new technologies relevant for health and medical services |

| R14 | Investment schemes for the smart health value chain |
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| Short Description | According to the Forum findings thus far, investment recommendations are about to be a fundamental pillar of the smart health value chain development. As such, two main stream policies are required: The first one has to focus on big data issues concerning public infrastructure as well as collection, use, distribution and utilization of data by public and private entities, including any possible aspects of national health systems. The second one has to focus on the activation and support of, primarily small and medium, enterprises as integrated parts of the smart health value chain for the development and supply of multiple biomedical and bioengineering devices, procedures and services. Within this framework, specialized funds can be created as well as targeted initiatives either on common European ground or integrated in national investment programs. |
| SWOT Items referred to | |

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| R15 | Using smart health solutions to mobilise the potential of active ageing by ensuring quality healthcare in response to the social and demographic changes |
| Short Description | Support national, regional and European programmes that stimulate innovation and entrepreneurship. Particularly programmes that construct public-private partnerships through the use of information and communication technology that aim to extend independent living for old people, and in promoting internal tourism and economic activity of seniors.<br><br>Smart health technologies can also help tackle the issue of adherence especially with chronic conditions such as multiple sclerosis, diabetes, and rheumatoid arthritis, where adherence to prescribed medications is more critical than ever. |
| SWOT Items referred to | Silver economy |

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| R16 | Provide targeted support to facilitate market access for SMEs and other technology developers |
| Short Description | Make optimal use of available, or new, financial instruments to support Health-tech SMEs and other technology developers to bring new products and services to the market.<br><br>Supporting argument: The health sector is highly regulated, the market access time is longer, and there are special risks associated with life sciences in the development. Due to risk aversion of investors and banks, funds are scarce for medical technology SMEs that represent ca. 90% of the companies in this sector.<br><br>Ongoing initiatives:<br><br>Investment Plan for Europe (Juncker Plan); European Structural and Investment Funds; EIB; Horizon 2020 European Innovation Council Pilot. |
| SWOT Items referred to | Weakness and opportunities |

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| R18 | Personalized Medicine |
| Short Description | Focus of this project is the development of a global strategy of therapeutic intervention based on: a) cancer vaccines against tumour antigens which play a role in tumour development and maintenance, b) adoptive immunotherapy (mainly by BiTEs: Bispecific T-Cell Engager monoclonal antibodies, viral vectors, and CAR-T cells), and c) nanomedicines. Scope of the project will be to bring the lead candidates through |

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| | complete clinical development up to the First Industrial Deployment.<br><br>Final objective will be to build **GMP facilities able to produce personalized cancer vaccines, BiTEs, viral vectors for cell therapy,** and **nanoparticles targeting clinical phase 3** and the **commercial phase**. This objective is clearly beyond the current state of art in Europe, specifically in the sense of an integrated large scale industrial consortium for the production of innovative medicines in oncology. |
| SWOT Items | List SWOT items referred to<br><br>• **Strengths**:<br>  o we propose an integrated strategy to tackle cancer based on **personalized medicine, nanomedicine, and adoptive immunotherapy,** including **the production of viral vectors for** the generation of **CAR-T**;<br>  o we have the **technology and scientific know-how** to get the project to industrial scale<br>• **Weaknesses**: the First Industrial Deployment infrastructure has to be completely created<br>• **Opportunities**: we propose to integrate the genetic vaccines that represent the frontier of the biotechnology, with the most innovative immunotherapy products on the ground<br>• **Threats**: the project is highly ambitious but needs substantial financial support |

| R19 | Advanced Technologies for Precision Diagnostic in Oncology |
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| Description | Europe, and Italy in particular own specific technology that is today considered in clinical research the “gold standard” for isolation and manipulation of pure, single cells from heterogeneous samples. This offers unique opportunities to develop new diagnostic and therapeutic strategies to improve patient outcomes and address unmet medical needs, including established scenarios such as personalized medicine for cancer based on liquid and small tissue biopsy and innovative application fields such as forensic medicine, pre-natal analysis and immunology.<br><br>In order to leverage on this scientific/technical advantage and realize its market potential in the medium term, this technology needs to be translated from clinical research to diagnostic, demonstrating in measurable terms (by means of the concrete actions identified below) positive impact for the patient on the course of the disease and feasibility in terms of health economics. Such *demonstration of clinical utility* is indispensable to obtain reimbursement from private and public sanitary system, thus deploying the expected benefits (see below) to all potential users |
| SWOT Items | STRENGTH: Gold standard technology for single cell isolation and manipulation. Reference workflow for liquid biopsy. |

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| | WEAKNESS: Need proof of clinical utility. Cell recovery and analysis throughput can be improved, workflow cost can be mitigated in order to be suited to massive diagnostic use<br><br>OPPORTUNITIES: Opening of innovative application and market fields for the technology, such as pre-natal analysis, forensic medicine and immunology<br><br>THREATS: Several competitors have entered the field of liquid biopsy with alternative approaches, in particular the detection of "cell free circulating tumoural DNA" (ctDNA) from blood, developed mainly by well-funded US-based competitors. |

## Adapt regulations and standards

| R20 | Elaborate guidelines and implement standards (Standard Operating Procedures, formats) to measure and collect high quality, interoperable data |
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| Short Description | Elaborate regulations/strict guidelines for the standardization and interoperability of data (input from European medical associations on what and how to collect) so as to link data across sources and for health data to be effectively used. This includes establishing protocols to standardize measurement conditions before data is acquired/measured (sample preparation, patient/citizen environment and activity…).<br><br>Create a certification to guarantee quality and conformity of data/data sources.<br><br>Ensure these guidelines are implemented at the 27+ national levels |
| SWOT Items referred to | Insufficient regulation of new types of healthcare companies |

| R21 | Accelerating the innovation in the creation and market access of software as a or used in medical devices |
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| Short Description | Market entry criteria for software as used in medical devices is not clearly defined in the medical devices regulation. A higher risk classification may occur causing long waiting periods for products to reach the market. Such delays will prevent important data to be generated for innovation in products and services. The advancement of the technical state of the art should also be reflected in guidance answering which types of software should be regulated. We believe the mentioned exemption criteria that are being established in Canada, and that are already established in the United States of America should also be taken into account in the European regulatory framework.<br><br>This includes:<br><br>Software which is intended to communicate, store, archive, and provides mechanism to retrieve selected or all data, including search functions for identifying the dataset to be retrieved should not fall under the indicated regulations. The state of the art in technology does not justify requiring the CE mark on such software. In addition, software should not be considered fulfilling a medical intended purpose if |

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| | it is intended to display data.<br><br>With these exemptions drawn up, it should be evident that modification of such data for the purposes mentioned should also be exempt from the regulation. Rationale: The technical TCP/IP network protocol is based on fragmentation of an item into transmission unit and re-assembled at the recipients point. Fragmentation can, in this case, be considered as modification of data for purposes of transportation.<br><br>Software fulfilling the definition of an in vitro medical device<br><br>Software should be considered as in vitro medical device, in cases it is driving or influencing the use of an in vitro medical device. With this, the implementing rule 3.3 (MDR) and 1.4 (IVDR) would be applied not only to classification, but also to qualification of software.<br><br>In addition, the intended purpose of a software should be the decisive factor in order to make a decision, which regulation is to be applied. This would require specific guidance asking for a precise formulation of the intended purpose in the technical documentation of the medical software.<br><br>Suggestion would be taking the definitions of the medical device and in vitro medical device into account and building guidance around these principles. |
| SWOT Items referred to | |

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| R22 | To develop an European Evidence Standard Framework for Digital Health Applications |
| Short Description | Without evidence of benefit and safety, it is difficult to adopt these technologies and the consequent transformative effect on healthcare delivery |
| SWOT Items referred to | S - increasing digital literacy W - limited acceptance of digital solutions by payors O - emergence of silver economy, personalized medicine, remote healthcare, export markets T - Insufficient regulation of new types of healthcare companies |

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| R23 | Support shift towards smart value-based healthcare systems |

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| Short Description | One of the key objectives to create a connected and sustainable health data eco-system in Europe should be to ensure a shift towards value-based healthcare systems which incentivize outcome-based interventions and solutions and reduce healthcare inefficiencies.<br><br>The EU should support, through the European Semester, a regular and structured comparison of EU Member States healthcare systems to support effective reforms and track progress towards value-based healthcare. This could build on the ongoing OECD initiatives in this field.<br><br>The EU should continue to provide guidance (such as EMA) and scale up current projects to support the use of Real World Evidence (RWE) and connected databases to inform:<br><br>• Research, e.g. through synthetic clinical trials<br>• Treatments,<br>• Outcome-based payment models.<br><br>The EU should also support a shift towards patient and populations-based registries across borders. |
| SWOT Items referred to | Strengths<br><br>Comparison of reforms and readiness for smart healthcare systems has the potential to trigger needed reforms at Member States level.<br><br>Weakness<br><br>Co-creation of Member States is key in achieving the expected outcomes.<br><br>Limited acceptability of synthetic clinical trials by payors and regulators.<br><br>Opportunity<br><br>Technologies such as blockchain can generate opportunities to build trustworthy outcome-based payment models. |

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| R24 | Create more notified bodies in Europe/ increased Notified Body capacity in Europe |

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| Short Description | With the new set-up under MDR the approval times for digital health solutions are very likely to increase. This is due to a number of factors:<br><br>• the stricter requirements for recertification of Notified Bodies(NB) under the MDR lower the numbers of NBs in Europe (less NBs have reapplied)<br>• there is a risk that not all NBs will have been recertified when MDR enters into force in May 2020 the medical devices already on the market need to be recertified which also takes up NB resources<br>• New products need to be certified by NBs:<br>• Software as Medical Device (SaMD) will need to be certified by a NB under MDR. This has not been the case under MDD where most SaMD is risk class 1. Under MDR it seems that most SaMD will be risk class IIa as a minimum (MDR article 2 + annex VIII, section 6.3. rule 11).<br><br>For these reasons there will be a lack of capacity among NBs which risks creating bottlenecks and slow down the approval times for and hence access to digital health solution in Europe. |
| SWOT Items referred to | Weaknesses/market fragmentation/Liability, demonstration and testing + weaknesses/Regulations and data protection |

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| R25 | Don't create new standards. |
| Short Description | The problem in digital health interoperability is not a lack of standards, but the lack of adoption of those that exist.<br><br>Many of the most relevant are referenced in the European EHR Exchange Format of February 2019 (HL7 CDA, IHE, and DICOM).<br>For smart medical devices consider IEEE 11073, ITU-T H.810, HL7 FHIR: all open, international standards. |
| SWOT Items referred to | Insufficient standardisation for effective data sharing and access |

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| R26 | Interoperability requires action from the demand-side |

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| Short Description | If buyers and procurers of technology do not want to perpetuate data silos, they need to<br><br>• Develop and communicate digital health strategies, action plans, digital health architectures with stakeholders and experts,<br>• Define standards and specifications based on international, open standards,<br>• Communicate these specifications stakeholders and vendors (including SMEs) with advance notice, and<br>• Eventually require compliance with these specifications in their tenders and procurements. |
| SWOT Items referred to | Insufficient standardisation for effective data sharing and access |

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| R27 | Ethics, regulations and standards as foundation of a human-centric smart health |
| Short Description | Collection mechanisms, quality issues, standardization and norms, homogenous literacy, and, analysis and utilization of data must conform to the dual concerns of Smart Health: a) technical / technological prerequisites as a new "language" of common understanding, exchange of information and development of products, procedures and services, and b) ethical, legal and societal boundaries and specifications safeguarding the human-centric development of any achievement within the smart health value chain. It follows that several considerations such as cybersecurity, data portals, health platforms, networks etc. must conform to the aforementioned dimensions. |
| SWOT Items referred to | |

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| R28 | Empowering Personalised Medicine through better access and utilization of "smart data" guidelines |
| Short Description | There is enormous need to develop new, scalable and expandable big data infrastructures and analytical methods that can enable healthcare providers' access knowledge for patients. Developing common guidelines through co-operative actions between national authorities and the European Commission will ensure that they form the basis of future national legislation or provide a minimum level of alignment. This way the so called "smart data" can offer actionable information to yield better decision for personalized medicine, minimizing drug adverse events, and lead to more effective clinical decision-making and manage healthcare costs. |
| SWOT Items referred to | Personalised medicine |

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| R29 | Removing obstacles of development and usage of artificial intelligence in healthcare |
| Short Description | Artificial intelligence (AI) would enable holistic and proactive analysis of health and, consequently, early detection of health problems, and design of clinical practices and health services. Such analysis is rarely applied due to strict interpretation of the GDPR. Furthermore, the Medical Device Regulation does not provide clear guidance for certifying AI-based products, especially those which are based on continuous learning. Europe should introduce common guidelines for: (1) applying AI-based products in healthcare and (2) certifying AI-based products. This is of particular importance considering competition in the global markets. For example, the privacy legislation is less stringent in US and China. Ongoing initiatives: High-Level Expert Group on Artificial Intelligence, Clever Health Network (http://www.cleverhealth.fi), EU/BigMedilytics-project (https://www.bigmedilytics.eu). |
| SWOT Items referred to | Strong and standardized frameworks for data protection and privacy (strength) Limited scale-up of pilot initiatives (weakness) Faster AI development in US and China (proposed new threat) |

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| R30 | Enabling the use of real-world data in the development of new therapies and health products. |
| Short Description | Real-world data (RWD) is playing an increasingly important role in several phases of drug development. Additionally, RWD has a high potential in the development of medical devices, personalised food products and applications providing decision support for patients and healthcare professionals. The usage of RWD should be accelerated by: (1) providing European level guidance, (2) ensuring that emerging national legislation on secondary use of data and biobanks are aligned at European level, (3) promoting interoperability of health data at European level, (4) promoting technologies needed to anonymize data or to create synthetic data for AI algorithm training. On-going initiatives: IMI/GetReal (https://www.imi-getreal.eu/), EIT/EHR2EDC (https://www.eithealth.eu/ehr2edc), EU/MIDAS ( http://www.midasproject.eu/), new legislation on secondary use of health and social services data (Finland). |
| SWOT Items referred to | European expertise in collecting health data (strength) Insufficient standardization for effective data sharing and access (weakness). |

Promote skills for the development, uptake and effective use of smart health products and services

| R31 | Digital literacy for eHealth data tools for citizen empowerment and person-centred care |
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| Short Description | Preparing the right curricula for tomorrow's engineers and technology developers requires a solid base of evidence and well-developed predictions to inform and guide decisions and implementation. Foresight can help improve education and training systems, solve current educational challenges, offer projections of the future trends in employment, and analyse the current and future skills base. Digital transformation for health and care impacts the labour market not only by increased demand for skills, but also through significant changes in job profiles – new professions related to cloud computing, big data, AI, machine learning, etc., will emerge. As the traditional taxonomy of professions changes, the skills forecast must adapt to the nuances of the digital workforce. These includes clinical and non-clinical providers. While the Digital Education Action Plan, Cedefop's Skills Panorama or Victory Project – analysing vacancies in a few EU countries – are steps in the right direction, more should be done. To reduce shortages caused by lack of information or information mismatches, we call upon European leaders to:<br><br>• Enhance digital skills forecasts at national and regional levels.<br>• Invest in deeper analysis of the digital skills needed for working with modern technology tools such as: AI, cloud or IoT.<br>• Support the idea of an EU-wide educational campaign on the benefits of and mechanisms for health data sharing to break down misconceptions and support the actions put forward by the Communication. |

| R32 | HUMAN CAPITAL – Capacity-building for Academics and SMEs to overcome innovation hurdles |
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| Short Description | From our experience as a research infrastructure dealing with both academia and SME users, there is still very often a lack of knowledge and understanding of the critical early product development path that eventually leads to commercialisation. Aspects related to unmet medical need, regulatory requirements, intellectual property ("freedom to operate") are usually overlooked, underestimated or planned too late in the research development process. Most academics and SMEs lack the awareness, in-house expertise, or funding to address those key innovation factors properly. This type of human capital building is also particularly key in EU member states with lower R&I performance.<br><br>• Codex4SMEs INTERREG North West project: Companion diagnostics expedited for SMEs<br>• TMex (Translational Medicine explained) for early-career scientists: Yearly course on medicines development for the next generation of innovation leaders<br>• EMA Regulatory Science to 2025, a strategic reflection – (see Goal 5: Enabling and leveraging research and innovation in regulatory science) |

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| SWOT Items referred to | Weaknesses: Lack of regulatory guidance and expertise (not listed in current SWOT) |

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| R33 | **Foster a culture of uptake and sharing of health data generated through new technologies by strengthening digital literacy and better understanding of new data sources and skills.** |
| Short Description | A range of stakeholders already use evidence and insights from Real-world data (RWD), as they recognise that data from Randomised Clinical Trials (RCTs) alone cannot address all their questions. Healthcare organisations, regulators, HTA bodies, payors, clinicians, patients and industry all use evidence and insights from RWD. There is however a great potential to do more as digital and Artificial Intelligence technology and methodologies advance and enable data collection at a much larger scale.<br><br>Further benefits will be driven by digitalisation, linkage and use of more of the data collected by the healthcare system, including "omics"; from the use of data collected directly from patients through smart devices; and by approaches incorporating patients' non-health data and broader environmental data.<br><br>These fast-paced changes in Artificial Intelligence, digitalisation and big data will substantially impact the ability to assess and benchmark care interventions using patient-relevant outcomes, with the support of digital solutions and a European Harmonised distributed health data network.<br><br>These developments will also impact a future European clinical assessment system, in line with the European Commission's HTA proposal, that accelerates the process through harmonization of clinical data requirements and removal of duplicative assessments.<br><br>Hence there is a need to foster a culture of data-sharing and understanding of these new data sources and how they can be used in healthcare decision-making and build the appropriate knowledge and skills. Incentives are needed for patients, healthcare providers, payors, regulators, and other data collectors and users, about the benefits and value of data sharing such as:<br><br>• To identify unmet healthcare needs;<br>• To better understand patient and disease heterogeneity;<br>• To advance research, disease prevention, treatment and personalised health;<br>• To enhance life-sciences interoperability between diagnostics, medicines, devices and e-health;<br>• To support a move towards value-based healthcare.<br><br>Key areas of action include:<br><br>• **Structured data collection:** Clinicians and patients are the "front line" of data capture and need to be motivated / incentivised to record key data accurately |

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| | over a period of time. However, the multiple formats and methods for capturing and the lack of standards are a disincentive to provide high quality, complete, longitudinal source data. Clinicians and patients might see no direct, immediate benefit for themselves in recording detailed information if there is no positive feedback loop.<br>• **Capability building and skills:** Healthcare systems/governments should invest in EHR systems and patient portals as a basic part of a modern healthcare system; adopting standard outcome measures wherever possible.<br>• **Users of data for decision-making purposes:** they need to have good knowledge, skills and understanding of data drawing from multiple novel sources including digital technologies. The role for the European Commission could be to issue guidance on education and training of stakeholders for Member States to implement them.<br>• **Promoting best practice in methodology**: Professional societies, regulatory and HTA agencies, academics and industry should continue to refine best practice guidelines for conducting and reporting RWE studies and other RWD analyses; including the latest big data analytical approaches.<br>• **Improving trust and acceptability of Real World Evidence (RWE):** Options for using evidence and insights from RWD should be raised and discussed during scientific consultation meetings at early and late development stages. A plan should be developed with regulatory and HTA bodies to create clear and transparent guidelines on the acceptability of RWE and big data analytics to support post launch commitments, assessments of new indications, inclusion of RWE results in the label, and for the pro-active promotion of RWE results. Where possible the guidelines should be harmonised across Europe and ultimately with those of Japan and US.<br>• Numerous studies have pointed to the **importance of public understanding of the use of data.** The EU should support stakeholder efforts to build trust through public education and debate regarding the use of health data in research. |
| SWOT Items referred to | • Increasing digital literacy<br>• Need for training of regulators and assessors.<br>• Lack of guidance on how to adhere and cope with the different regulatory prerequisites. |

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| R34 | Cross-border training, skills and culture enrichment for optimal employment of biomedical devices, procedures and services digitalisation |
| Short Description | Aspects such as skills mapping, trust in technology, culture enrichment, digital skills as tailored to biomedical needs and specifications for both public and private domain, increasing awareness and smart health education cover a holistic approach, briefly described in the recommendation title. If such a perspective is adapted, multiplying benefits and significant cost reductions are expected. In terms of investment policies, the opportunity to organize and implement complementary schemes is apparent. |

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| SWOT Items referred to | |

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| R35 | Encourage the integration and uptake of digital skills transformation in educational and training curricula that can be replicated throughout Member States |
| Short Description | Smart Health innovation typically is generated from highly skilled personnel but also requires adequately trained personnel and technology specialists to know how to use the resulting smart health solutions. For example hospital staff should be adequately trained to be tech-savvy to operate such solutions.<br><br>There are many opportunities for companies to develop Smart Health Technology solutions that will support the healthcare sector, e.g. within telemedicine and early detection. However, as aforementioned the obvious barrier is the competencies needed for daily operations. Guidance for companies/end-users/patients/public health providers and professionals is necessary. Not all education and training systems across Europe take account of aspects of digital transformation of healthcare by including it as a core component in the education of student doctors, or in the continuous professional development programmes offered to healthcare professionals.<br><br>Currently such educational and training curricula for health professionals, providers vary from one country to another, making updates and reform even more complex to implement. That is why it is important that digital literacy training is provided throughout the value chain of healthcare systems based on a harmonized and mutually-recognized set of guidelines. |
| SWOT Items referred to | • Increasing digital literacy<br>• Slow uptake by end-users (concerns about reliability of technology and privacy, costs etc.) |

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| R36 | Patients and treatment focus absent |
| Short Description | Patients must be at the centre of the analysis. Paramount to ensure that perspectives regarding technology uptake, interplay between different treatments (many patients have several diagnoses), and regulation will be reflected in the action plan. Otherwise we risk ending up with a technology focused action plan of little relevance to the clinical work and thus the market to which the industry must sell its products. |
| SWOT Items referred to | Threats: uptake |

Stimulate the demand-side and the uptake of smart health products and services

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| R38 | Update regulatory bodies to enable them to assess digital health solutions |
| Short Description | Training/new expertise<br><br>Regulatory bodies need to be clearer on what evidence needs to be provided to evaluate benefits of digital solutions. |
| SWOT Items referred to | Threats: uptake |
| R39 | Building the "Hospital of the future" |
| Short Description | Hospitals are the central piece of health care systems, serving as an ecosystem where the whole value chain can be found. Clinical and non-clinical stakeholders, patients, industry or payors have a role. Depending on the country or the region, whether it is public or private, linked to a university or not, there are multiple models of hospital management. But they all have in common the need to find new approaches to integrate their digital transformation.<br><br>Future hospitals could become digital innovation hubs and platforms, where the entire health ecosystem would meet and enhance collaboration generating new ideas, allowing the use of new technologies (such as artificial intelligence) and improving the standard of care across the board.<br><br>Under Horizon 2020, it was foreseen an action on “The smart hospital of the future (DT-ICT-12-2020)” without an execution so far.<br><br>The EU should launch calls under future funding to research, develop and design the hospital of the future, taking into account different models. These “hospitals of the future” would integrate data, software, hardware and people, enabling universal patient data to be created, stored, used and transferred for the benefit of the patient (i.e. fast access to critical data on demand throughout the entire patient pathway). These approaches will make data-driven solutions a cornerstone of hospital functioning, enabling more evidence-based care and better empowerment of healthcare providers and patients<br><br>Projects should address issues such as: data generation and sharing, internal and external interoperability, cybersecurity, artificial intelligence, new management models, new approaches in treatment (e.g. digital surgery), skills and training.<br><br>Projects should consider local circumstances and types of hospital, identifying a limited number of transferable models to be used throughout the EU. |
| SWOT Items referred to | Weaknesses<br><br>• Limited acceptance of digital health solutions by payors |

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| | • Limited scale-up of pilot initiatives<br><br>Threats<br><br>• Slow uptake by end-users (concerns about reliability of technology and privacy, costs, etc.)<br>• Skills of the healthcare management and workforce<br><br>Opportunities<br><br>• Strengthening data infrastructure and cloud services<br>• Strengthening interoperability and standardisation |

| R40 | Digital health needs incentives |
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| Short Description | Digital health products and services need to enter the regular care system including the public funding and reimbursement schemes in the health systems of Europe's Member States and regions. Without regular funding you get pilots: shiny solutions that whither when funding is withdrawn. |
| SWOT Items referred to | Limited acceptance of digital health solutions by payors<br><br>Limited scale-up of pilot initiatives |

| R41 | Stimulate the demand-side and the uptake of smart health solutions : Smart Health (Cross –Border and Field) Demonstration projects |
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| Short Description | Design, funding and implementation of Cross –Border and Cross – Field Smart Health demonstration projects aiming to inspire trust, support demand (both public and private) and stimulate supply of products, services and procedures.<br><br>Demonstration projects can focus on, either big data and other digital technology issues and their applications including any possible interactions / aspects of national health systems, or the development and provision of multiple biomedical and bioengineering devices, procedures and services. Mixed aim projects can also be pursued.<br><br>As the final deliverable(s) of each project are demonstrations of services, products or procedures to be, each project can have an integrated, holistic approach, associating multiple sub-elements of different Technological Readiness Levels as well as different technological fields.<br><br>The "Smart Health (Cross –Border and Field) Demonstration projects" can also pull |

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| | elements and capitalize upon basic Smart recommendations such as database (s) of health data without „individual identifiers“, the development of smart healthcare products and applications and skills development at authorities, regulators, payors and citizens in order to understand technologies and their advantages. |
| SWOT Items referred to | |

| R42 | European Challenges for novel data driven solutions in Smart Health |
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| Short Description | High quality datasets could be provided to technology developers (SMEs, startups, industry) in the context of defining specific challenges focused on solving (complex) problems of high value to and selected by the clinical users and organizations that provide the data or by the public health organizations. Participants in the challenges would have the benefit of access to high quality data and to clinical requirements, and of connecting with potential customers. In this model, the data providers may get access to advanced and innovative solutions for relevant problems. |
| SWOT Items referred to | Weaknesses<br>• Limited scale-up of pilot initiatives<br>• Value of outcomes from big data analytics and real-world evidence not yet clear<br>• Limited acceptance of digital health solutions by payors<br><br>Threats<br>• Lack of clarity around data ownership<br>• Lack of cybersecurity solutions<br>• Low medical relevance of data collected (bad quality of data, of the context in which data are collected)<br>• Generation and analysis of huge volumes of data with no useful and valid medical output<br>• Pre-emption of the value chain by non-medical technology companies with subsequent lack of real innovation in health |

## Create a pan-European operational network as a governance mechanism (a European Smart Health Innovation Hub) that can assess and promote Smart Health initiatives

| R43 | Capitalise on and scale-up smart health pilot and demonstration projects to accelerate learning curves |
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| Short Description | Local experimentation using connected devices and digital health solutions have been and are currently implemented in several countries in Europe (Netherlands, Finland, Germany, Estonia, France…). Some member states also recently launched health data initiatives (France: Health Data Hub). There are also pilot projects funded or to be funded in the framework of H2020, Interreg or innovative procurement programmes. Map these initiatives, put them in perspective, give them visibility and coherence, should be the starting point.<br><br>Capitalisation among countries, regions, cities, cross border collaboration has not yet been organised. This would be useful given the high fragmentation of market in Europe.<br><br>What are the key findings, evidence-based results and value for payors and patients of these initiatives? Which are the different ways to tackle the challenges of acceptability and appropriateness of data collection?<br><br>Feedback on stakeholders organisation along the value chain of care is also critical.<br><br>Scale-up: deployment of new economic models will be of interest for companies if they can be reproduced in other countries as a clear opportunity to invest. Current initiatives are either too small in size compared to the complexity of stakeholders involved or too specific to the national context. Scale up of different pilots in a coordinated approach would be of great value and common interest. |
| SWOT Items referred to | Weaknesses<br><br>• Limited acceptance of digital health solutions by payors<br>• Value and real world evidence not yet clear<br>• Limited scale-up of pilot initiatives |

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| R44 | Create a task-force for coordination, education and skill development regarding digital health (public/private framework) |
| Short Description | Transforming healthcare with digital and smart health solutions is a huge challenge for European healthcare systems, and not only for the care providers. A whole added-value chain will have to transform its model from an acute-based paradigm to a more preventive and reactive health service. New comers might accelerate this transformation, but they will not fill the gap in 3 years on behalf of historical stakeholders.<br><br>Health industry (pharma, biotech, medtech) has already invested significant efforts in R&D for several decades, but economic and social benefits will not be realised without strong efforts from public sector at the national level: coordination of initiatives (based on above recommendation “capitalise and scale-up”) and educational actions of all stakeholders (payors, regulators, healthcare professionals, care providers, |

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| | patient empowerment…)<br><br>Living labs should be developed and supported to assess the relevance of smart health solutions before a ground implementation, as well as all initiatives aiming at collecting real world data and feedback from professionals, payors and patients. RTOs and research institutes can provide these living labs in cooperation with clinical centres see for instance IHU Strasbourg/IRCAD in France. |
| SWOT Items referred to | **Threat:** Slow uptake by end-users<br><br>***Additional Weakness***<br><br>*No signal sent to companies by public national authorities (risk sharing) to support their investment into smart health* |

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| R45 | **FUNDING & INFRASTRUCTURE** – The importance of exploiting current capabilities of European research infrastructures to bridge gaps towards implementation |
| Short Description | Health European Research Infrastructures, funded by European member states, such as BBMRI (biobanking), EATRIS (translational research), and ECRIN (clinical research) provide access to high quality services serving academia and industry. They share the same commitment to increasing knowledge and awareness about good research practice and ensuring greater access to common resources (e.g. quality standards, training courses). Their end goal is to make it easier for the broader research and innovation community to achieve the highest possible standards and to deliver high-quality and reproducible science. The digital revolution and the new regulatory framework of patient-centred research results in complex and multidisciplinary research programmes, requires tight cooperation between infrastructures supporting translational research, biobanking and clinical research to provide joint services for cross border transfer of data and bio samples, cohort integration, multimodal data management, machine learning, and multinational trials.<br><br>• EFPIA/BIOMED Alliance (March 2019): Bold vision needed to translate basic health research in to new ways of delivering healthcare and new treatments for patients<br>• H2020 Scientific Panel for Health (May 2018): Building the future of health research (see p.12; 28; 29)<br>• Global Collaboration Initiative, Translation Together: Putting Translational Science onto a Global Stage (2017), Nature Review Drug Discovery<br>• Medical Research Infrastructures (BBMRI, EATRIS, ECRIN) joint statement (September 2018): Solid foundations for Horizon Europe (Four success factors for Health) |

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| SWOT Items referred to | Opportunities: Further exploitation of the expertise and services of existing European medical research infrastructures (BBMRI for biobanking; EATRIS for translational research; ECRIN for clinical research) |

| R46 | Data governance model (DGM) including usage of data |
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| Short Description | Create a model (-s) covering organizational, process, technical, technological, legal, ethical aspects and pilot it (them) for end-to-end data collection. Different type of data should be collected within DGM:<br><br>• samples (biological);<br>• "*biological*" data (also sequenced);<br>• health data (from different sources GPs, Hospitals, Specialists);<br>• socioeconomic data;<br><br>DGM also should include the system/solution how all the data is matched, stored and analysed.<br><br>To this end Latvia comments that: 1) It is more about local (national) and not across EU, but can be expanded also to EU dimension, 2) They offer infrastructure and national experts that are working on this topic already and developing and piloting first phases of DG model, 3) They made a good cooperation with International players in the area of VC investment and are ready to share experience and results, 4) End-to-end data governance model (including data usage) is important to overcome the weakness of value of outcomes from big data analytics and real-world evidence not yet being clear, 5) Without end-to-end data, personalised medicine and remote healthcare are not possible, 6) They offer infrastructure and national experts that are working already on creating data governance, 7) In the areas of data infrastructure and cloud services they propose to use LV built infrastructure and national experts, 8) Their experience in strengthening interoperability and standardisation can be used and 9) In the export markets opportunity, they propose to use LV established international partnerships. |
| SWOT Items referred to | • STR: European expertise in collecting health data<br>• STR: Strong and standardised frameworks for data protection and privacy<br>• STR: Commitment to ethical rules<br><br>----------<br><br>• W: Insufficient standardisation for effective data sharing and access<br>• W: Limited scale-up of pilot initiative<br>• W: Limited VC investment compared to third countries<br>• W: Value of outcomes from big data analytics and real-world evidence not yet clear<br><br>----------<br><br>• OPR: Personalised medicine, remote healthcare<br>• OPR: Creating data governance |

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| | • OPR: Strengthening data infrastructure and cloud services<br>• OPR: Strengthening interoperability and standardisation<br>• OPR: Export markets<br><br>---<br><br>• THR: Lack of clarity around data ownership |

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| R47 | Explore and facilitate synergies between public actions at EU, Member State and regional levels |
| Short Description | Identify public actions and create a coordination platform.<br><br>Supporting argument: The value chain is divided between various specialized actors and distributed in different places. In addition, public action comes from various institutions and programs that are not, or insufficiently, coordinated. |
| SWOT Items referred to | |

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| R48 | Support and facilitate multidisciplinary cross-sectoral cooperation |
| Short Description | Make optimal use of available, or new, means to facilitate cooperation between all actors involved along Health-technology development and deployment.<br><br>Supporting argument: The health sector is highly multidisciplinary. It needs the cooperation of actors in various disciplines and business domains (biomedical, engineering, digital, healthcare provision, etc.).<br><br>Ongoing initiatives: European Structural and Investment Funds; Horizon 2020; national programmes. |
| SWOT Items referred to | |

# Low $CO_2$ emissions Industry

## SWOT Analysis

### Strengths (What is the EU good at?)

- S1. Being at the forefront of low-carbon solutions at world level
- S2. Having a highly skilled and well-trained workforce with a huge multiplier effect creating millions of indirect jobs
- S3. High performing, innovative steel, cement and chemical industry and products
- S4. Strong R&D-efforts on EU-and member state level.
- S5. High & growing share of low emission power (renewable & nuclear)
- S6. Existing high-performing research institutions, initiatives and networks
- S7. Substantial internal market demand for steel, chemicals and cement

### Weaknesses (What is the EU not good at?)

- W1. Lack of a long-term and coordinated EU Industrial Policy Strategy, which is coordinated with the Climate, Resource and Energy Policy Strategies
- W2. Upscaling of low-$CO_2$-technologies still on learning curve/lack of common European electricity market
- W3. Infrastructure for $CO_2$ and H2 transport (Pipelines) and (seasonal) storage as well as waste not existing
- W4. ETS may prove insufficient to support investments, needed for long-term transformation
- W5. No common understanding of how to evaluate the impact of the utilization of $CO_2$ as alternative carbon source
- W6. Absence of a common methodology for assessing the CO2 emissions reduction

### Opportunities (What are the favourable external factors that could benefit the EU?)

- O1. Creating new markets and business opportunities for innovative and sustainable products
- O2. More sustainable, resilient SVC; first mover advantage for the EU
- O3. Enhancement of cross-industries industrial symbiosis through circular economy and $CO_2$-valorisation
- O4. Shared H2 and $C0_2$ -transport & storage infrastructure for industry, including opportunities for municipalities and SMEs which can connect to new infrastructures
- O5. Innovation, growth and skills/job creation
- O6. Develop (climate neutral) energy import partners, resulting in secure supply and more stable prices
- O7. A flexible industry can better provide auxiliary services, thus contributing to a renewable and secure electricity network and industry.
- O8. Develop a common methodology for assessing the $CO_2$ emissions reduction

### Threats (What are unfavourable external factors that could harm the EU?)

- T1. Risk of implementation of low-carbon technologies is high (unpredictable factors e.g. increasing global
- competition and challenging access to materials for the deployment of low-carbon energy)
- T2. Increased demand in case of restricted supply of green electricity and H2, produced internally or imported, will lead to rising prices; risk of lack of low-$C0_2$ electricity (overlapping growing needs in different sectors)

- T3. International competitors not subject to similar $CO_2$ cost constraints (risk of carbon and investment leakage); strong price competition in the EIIs
- T4. Risk of carbon and investment leakage to countries outside the EU
- T5. Low $CO_2$ emissions Technologies may be developed and deployed outside the EU (e.g. China, USA).
- T6. No consensus on the role of carbon capture; lack of public support for carbon storage sites
- T7. Most options to abate GHG emissions strongly linked to availability of climate-neutral and affordable electricity and recycled materials
- T8. Lack of public acceptance for energy infrastructure (grid, pipelines, storage as well as large scale renewable energy generation such as wind parks) projects
- T9. Import of cheap, high GHG products from outside the EU competing with more expensive low carbon products from the EU

## Recommendations and actions

| Recommendation Title | Identify potential areas for coordinated investment among key technological pathways for GHG abatement |
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| Short Description:<br><br>Projects and major technological pathways for GHG abatement in steel, chemicals and cement sectors are outlined in the recommendations and the Annex. The Strategic Forum on Important Projects of Common European Interest (IPCEIs) aim to identify among those technological pathways areas for coordinated investment via IPCEIs to scale projects in the "Low-$CO_2$ Industry Value-Chain" by approximately 2030. Both policies and industrial strategies should enable coordinated investment between regions and countries to create new interregional value chains. The proposed areas for coordinated investment entail technological pathways with a potential to achieve for each or in combination of several pathways at least 80 to 95% of $CO_2$ emission reductions, including through their handprint. Importantly, the proposed list should not exclude other technological solutions with potential to achieve significant GHG emission savings. Technological neutrality and flexibility in future developments of other low-carbon solutions are key factors for the overall | Main technological pathways for GHG abatement in steel, chemicals and cement:<br><br>• $CO_2$ Valorisation<br>• Process Integration in steelmaking<br>• Carbon Direct Avoidance in steel: Hydrogen-based metallurgy<br>• Carbon Direct Avoidance in steel: Electricity-based metallurgy<br>• Chemical Valorisation of waste (including chemical recycling of plastics)<br>• Electrification of chemical processes (e.g. electrification of crackers, Power-to-Heat)<br>• Electrification of cement manufacture<br>• Alternative raw materials and fuels including hydrogen<br>• Development of new chemical production plants based on non-fossil feedstocks<br>• Development of alternative cement products (low $CO_2$ binders)<br>• Eco-design and resource efficiency, including recycling<br>• Energy efficiency: Innovative grinding technologies for cement manufacturing<br>• Artificial Photosynthesis<br>• Carbon Capture Storage, and Permanent Capture Technologies (ex : cement recarbonation) |

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| success of the transition towards a Low-$CO_2$ Industry. | Identified areas for coordinated investment via IPCEIs:<br>• $CO_2$ Valorisation in chemical, steel and cement sectors (in combination with Process Integration in steelmaking and Carbon Capture and Storage)<br>• Carbon Direct Avoidance in steel sector<br>• Chemical recycling of waste in chemical sector |
| SWOT Items referred to | S3, S4, O2 |
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| Recommendation Title | **Scaling up projects to demonstrate low-$CO_2$ technologies and prepare for future roll-out** |
| Short Description: Transformation of existing value chains to new, low-$CO_2$ value-chains will require substantial investment by public and private actors. High investments are particularly necessary to prove low-$CO_2$ technologies by 2030 approximately. This is a necessary prerequisite before roll-out of new low-$CO_2$ technologies can start. Contribution to the achievement of 2050 climate targets will highly depend on the demonstration phase. | Concrete Actions:<br>• Bring multiple technologies to first-of-a-kind full scale size to allow for experimentations with design improvements on an industrial scale, which is necessary to achieve cost optimization of new low-$CO_2$ technologies and facilitate market uptake.<br>• Support deployment of first-of-a-kind projects with coordinated revision of state aid guidelines and regulations to address first-mover disadvantages<br>• Combine ETS Innovation Fund with support provided by other EU programmes and by the Member States (e.g. through an IPCEI).<br>• Support financing of infrastructure elements of the projects (e.g. via coordinated investments in Connecting Europe Facility and European Structural and Investment Funds, or under IPCEI rules)<br>• Provide additional investment support in the form of loans and guarantees (e.g. InvestEU Fund)<br>• Ensure that sustainable finance regulation will attract investments in energy intensive industries and does not penalize competitiveness of the EU<br>• Adapt and improve IPCEI framework: e.g. by allowing operational costs incurred by the use of low-carbon production processes to be eligible for support, which would require an extension of its scope to mass production, including |

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| | continued operation in the transformed configuration; by simplify administrative procedure<br>• Allow integration of projects at different TRL level under one or more IPCEIs where synergies are an indispensable element for the success of the overall project<br>• Consider support via IPCEI of technologies that are currently still at a low TRL level, yet entail significant potential for a very high impact in the long term, and of complementary technologies necessary for intermediate steps of technology demonstration |
| SWOT Items referred to | S1, W2, T1 |
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| Recommendation Title | **Continue support and close the R&D gap** |
| Short Description: Sustained support to development of low $CO_2$ emissions technologies in the energy intensive industries through Research and Innovation at EU and National levels will remain fundamental. Many technologies must be supported in the next decade in order to bring them to TRL 6-8 by 2030 and be ready for industrial deployment to deliver impact by mid-century. | Concrete Actions:<br>• Ensure that, disruptive technologies with high potential impact in the long term are supported by R&I funding instruments (including Horizon Europe); in specific cases by IPCEIs<br>• Adopt a new Mission dedicated to low $CO_2$ emissions industry under Horizon Europe, promote efficient risk sharing instruments (including for the incubation phase of new products) and complement with other EU funding instruments (i.e. EU Invest)<br>• Continue the successful cross-sectoral contractual Public Private Partnerships of SPIRE, Bio-based Industries Public Private Partnership and the institutional Public Private Partnership of Fuel Cell & Hydrogen under Horizon Europe to enable the collaboration of industry, Member States and research organisations for the faster deployment of innovation in resource and energy efficiency and the production and utilization of hydrogen in industrial processes<br>• Expedite new co-programmed Partnership Clean Steel |
| SWOT Items referred to | S1, S3, S4, W2 |
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| Recommendation Title | **Develop guidelines and assessment methodologies for** |

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| | low $CO_2$ emissions technologies |
| Short Description:<br><br>The complex structure of EIIs value chains, which are interlinked, entails that a product $CO_2$ footprint needs to be assessed over the production, use and end-of-life phases. | Concrete Actions:<br><br>• Ensure common and harmonized guidelines and assessment methodologies for the evaluation of the impact of low $CO_2$ emissions technologies in the energy intensive industries and value-chains<br>• Harmonized guidelines and calculation methodologies should be developed in particular for $CO_2$ (and CO) valorisation and waste as carbon feedstock or CCU-fuel<br>• Consideration robust carbon accounting in the full supply chain for these calculations, i.e. considering also monitoring emissions from upstream and downstream processes, |
| SWOT Items referred to | W5, 6, O8 |
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| Recommendation Title | Create an appropriate EU regulatory framework |
| Short Description:<br><br>New, low-$C0_2$ technologies will require an enabling regulatory framework both at EU and national level. Revising the State Aid Framework to sustain the transition of industry towards a new, low-$CO_2$ Industry Value-Chain will prove fundamental, in particular to reflect high CAPEX and increased OPEX for at least a certain period of time before and during roll-out. In spite of R&D efforts to lower OPEX and to provide competitively priced energy vectors, some residual additional OPEX may remain for which neutralizing measures need to be found and implemented. New low-$CO_2$ technologies should be properly accounted and recognized under the legislative framework to allow business cases to emerge. | Concrete Actions:<br><br>• Establish a supporting EU policy framework for deployment of low $CO_2$ emissions technologies, including securing the supply of materials for the energy transition and the low $CO_2$ emissions industry: e.g. *European Council Conclusions on an "industrial transformation masterplan*".<br>• Revise State Aid rules to reflect higher energy use in low-$CO_2$ technologies and production modes; e.g. expand the existing EEAG-Guidelines in a way that allows for exemptions for energy-intensive users from environmental levies to other areas (such as use of, hydrogen production or its use) and provides for the support of investments in climate neutral energy sources (such as the use of hydrogen production). Facilitate cross-border transport of $CO_2$ and the redesign and conversion of existing installations, including permitting procedures. The EU framework for state aid on low-$CO_2$ technologies should allow overcoming existing market failures and foster the EU competitiveness (also in relation to third countries).<br>• Recognition in ETS/MRR of greenhouse emissions reduction, such as use of CCU, CCS, electric boilers and of $CO_2$ emissions avoidance resulting from the utilisation of $CO_2$ as |

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| | a carbon source for the products of value (e.g. chemicals or fuels)<br>• Create lead markets, which will allow innovative low-$CO_2$ and circular products gain access to the market (via e.g. creating awareness and willingness to pay more for low carbon products, product standards and public procurement, once a critical mass of the new low $CO_2$ products is available)<br>• Promote recycled carbon fuels in the implementation of RED II at national level<br>• Promote free and fair international trade for industry; e.g. continue improving its Trade Defence Instruments (TDI) and their application against dumping and governmental subsidisation and other support schemes for industry in third countries. |
| SWOT Items referred to | W1, W4, O1, T1, T2 |
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| Recommendation Title | **Ensure support for the transition to Circular Economy** |
| Short Description:<br><br>Almost all energy intensive industries already depend highly on recycled materials as raw materials input, while security of raw materials supply (especially critical raw materials) is indispensable for others.<br><br>Enhanced circularity will become more important over the next decades as a strategy to reduce emissions, reduce raw material use, maintain security of supply (in some cases), and enhance production and growth while reducing costs. Collection and sorting of waste represent an important challenge, for example some value-chains this will prove crucial for maintaining the quality of basic materials in recycled product streams. | Concrete Actions:<br><br>• Improve the circularity of materials by requiring the design of products that are reusable and recyclable in the first place and support the waste hierarchy.<br>• Improve the traceability of materials and chemicals in the supply chain to enhance recyclability.<br>• Facilitate transfer and valorisation of waste, $CO_2$ /CO. Support /facilitate industrial symbiosis<br>• Optimization of pre-treatments for reducing production costs<br>• Improve existing sorting technologies and facilitate the deployment of new and more efficient technologies for the treatment of end-of-life material streams (e.g. copper removal from ferrous scrap)<br>• Facilitate /organize access to waste streams. Facilitate chemical, cement and steel recycling<br>• Establish a level-playing field for environmental requirements between European installations and installations located in third countries that use ferrous scrap (i.e. full application of the waste shipment regulation)<br>• Ensure regulation on waste recycling that supports material circularity and prioritises |

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| | recycling and re-manufacturing over waste incineration<br>• Reduce contamination of end of life materials streams<br>• Harmonisation across MS of End of life and -Waste criteria, definition of by-products, hazardous waste<br>• The simplification of the permitting process. |
| SWOT Items referred to | O3, W5, |
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| Recommendation Title | **Ensure access to competitively priced low-$CO_2$ energy supply for Low-$CO_2$ technologies** |
| Short Description:<br><br>Securing adequate and competitively priced low-$CO_2$ energy supply for Low-$CO_2$ technologies will be a key factor of success for the transition to a "Low-$CO_2$ Industry Value Chain". Development of low $CO_2$ energy system to secure growing energy demand for transition to Low-$CO_2$ technologies needs to be urgently planned and undertaken. The EU need to recognize that transition in EIIs to Low-$C0_2$ will entail a significant increase in energy demand in the EU. High and rising electricity prices as a consequence of EU and national regulations could close off the road to several technological solutions. | Concrete Actions:<br><br>• Ensure access to competitively priced, low-carbon and climate neutral energy and adapt industrial processes to the switch towards alternatives<br>• Develop an EU Energy Masterplan for EIIs, including a mapping, aligning energy supply to EIIs transitioning to low-$CO_2$ technologies and addressing challenges such as infrastructure, variability and storage<br>• Adapt existing EU regulatory framework to transition of EIIs towards low-$CO_2$ technologies and provide consistency within the EU energy and climate policy framework (e.g. Energy-Efficiency Directive, indirect costs under EU ETS, recognition of CCU-fuels as source stream in ETS etc.)<br>• Lower regulatory costs related to electricity consumption by EIIs on a level playing field basis across the EU and also vis-à-vis international competitors (e.g. PPAs) |
| SWOT Items referred to | S5, W1, T1, T2, T7 |
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| Recommendation Title | **Plan and develop infrastructure for a Low-$CO_2$ Industry** |
| Short Description: Low-$CO_2$ technologies will require either a completely new infrastructure, or retrofitting and adapting the existing infrastructure. There is an urgent need to start planning and investing in infrastructure needed for new, low-$CO_2$ technologies in order to guarantee the sufficient and | Concrete actions:<br><br>• Align with measures of the Energy Union, plan necessary infrastructure for low-$CO_2$ technologies (waste, H2, gas, electricity grids, pipelines for $CO_2$and for other gasses and by-products to be valorised in a circular system, |

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| continuous supply of industry e.g. with hydrogen and climate neutral energy. No single company or sector will be able to provide the capital for these infrastructure investments on their own, hence public policy and financial support is a necessary prerequisite. | (seasonal) H2 and CCS storage) by developing an EU mapping<br>• Facilitate system integration, adaptation and market regulation of (new) cross-border infrastructure involved with the climate neutral economy, such as the cross-border transport of $CO_2$.<br>• Promote investments and implementation of infrastructure for low-$CO_2$ technologies (e.g. Connecting Europe Facility, IPCEIs, or environmental State aid etc.)<br>• Minimise permitting procedure time requirements |
| SWOT Items referred to | W1, W3, O4, T6, T8 |
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| Recommendation Title | **Ensuring International Competitiveness throughout the transition and beyond** |
| Short Description:<br><br>The industrial transition will have to happen in a highly competitive and dynamic international environment. Given that the transition to low-$CO_2$ technologies will be a high-risk operation, it is essential that this process is accompanied with a continuous monitoring of the adequacy of measures against carbon leakage in EIIs. In addition to carbon pricing policies, product and market related policies need to be part of the proper mix of pull and push measures to promote the transition to a low carbon economy. | Concrete Actions:<br><br>• Ensure carbon leakage protection measures from both direct and indirect costs of the EU ETS during transition, for example by avoiding that unilateral direct or indirect carbon costs are borne at the level of the best installation<br>• In lack of global-level playing field, explore the need for complementary measures to maintain competitiveness of EU industry in the short-medium term during transition and to encourage international action: "*examine the economic feasibility of different carbon inclusion mechanisms which are aiming at establishing a level playing field at global scale*[5]"<br>• Research the adequacy of EU ETS measures to provide sufficient incentives for EIIs to invest in low-$CO_2$ technologies and explore complementary measures for medium/long-term framework not only for $CO_2$ compliance, but also for $CO_2$ cost<br>• Modernize the WTO rulebook to tackle more effectively trade distorting practises. |
| SWOT Items referred to | T3, T4, T5 |

[5] Joint Statement, Friends of Industry Group, December 2018 https://www.gouvernement.fr/en/6th-ministerial-conference-friends-of-industry

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| Recommendation Title | **Develop a Highly skilled workforce** |
| Short Description: The deployment of these technologies at large scale and at European level will require a large number of highly skilled scientists, engineers and workers. | Concrete Actions:<br>• Develop and strengthen a highly skilled workforce for the whole Low $CO_2$ Industrial value chain<br>• Promote education and skills and anticipate future skills to prevent shortages and mismatches at Member States level for e.g. chemical and material science engineers, engineers for the development of e.g. electricity and renewable energy infrastructure, specialists in industrial innovation, environmental engineers and designers for eco-design of products and the development of sustainable industry in Europe etc.<br>• Support reskilling and upskilling: e.g. via Life-long learning programmes |
| SWOT Items referred to | S2, O5 |
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| Recommendation Title | **Raise awareness of EU citizens for low $CO_2$ technologies and products** |
| Short Description: Public acceptance for Low-$CO_2$ technologies, including for transport of $CO_2$, which is also a precondition for a successful deployment of CCS, will require cooperation between industrial sectors and Member States. | Concrete Actions:<br>• Raise the awareness on Low $CO_2$ technologies and the acceptance of negative externalities of their deployment. Design and promote information campaigns especially when it comes to end-user markets is needed for a broader diffusion<br>• Develop initiatives that promote market deployment of low $CO_2$ emissions (considering their whole life cycle) products and technologies |
| SWOT Items referred to | T6, T8 |

# Background and Policy Context

At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. The EU's nationally determined contribution (NDC) under the Paris Agreement is to reduce greenhouse gas emissions by at least 40% by 2030 compared to 1990, under

its wider 2030 climate and energy framework. All key legislation for implementing this target has been adopted by the end of 2018[6].

The EU-long-term strategy towards 2050, which was published in 2018[7] states, that for the industry significant modernisation of existing installations or replacement will be required. In this view, a combination of electrification, increased use of hydrogen, renewable synthetic gas, biomass, waste and the introduction of a stronger circularity of resources will reduce energy related emissions[8]. Furthermore, the strategy stresses the need for the transformation of the energy system to a carbon free system. But the strategy also mentions that some process-related emissions in the industry will be difficult to eliminate and that therefore solutions like Carbon Capture should be considered. The EU-long-term strategy 2050 focuses also on the development of a more circular economy, with significant less use of primary raw materials and stresses the importance of recovery and recycling to reduce GHG emissions and in parallel reduce the EU's reliance on critical raw materials. The importance of circular economy for a transition towards a low-carbon economy is recognized and also supported by the EU Strategy for Plastics in a Circular Economy, which was published in 2018[9].

Deep abatement of GHG emissions of energy-intensive industrial processes will have a major impact on the energy system and electricity consumption will go up significantly and energy efficiency might decrease. The transition in the power and industrial sectors should thus go hand in hand with the envisaged transformation of industrial value chains.

The implementation of a combination of technology options for $CO_2$-emission reduction and avoidance will be key to achieve the targets of the Paris Climate Agreement[10]. Continuous or incremental improvements of existing technologies will not be sufficient, but so-called *breakthrough* low-carbon technologies must be endeavoured and applied.

As first step to implement the Renewed EU Industrial Policy Strategy, the Commission has established a Strategic Forum on Important Projects of Common European Interest (IPCEI), which identified six key value chains, which should be strategically strengthened. One of them is the Strategic Value Chain on low carbon-industrial technologies and measures, for which key stakeholders from the Member State are asked to recommend value-chain specific actions and agreements for new joint investments, including possible IPCEIs.

# Presentation of the Strategic Value Chain of low-$CO_2$-Industry

The energy intensive industries (EIIs) will have to make a strong transition through a change of basic production processes and business models to create new value chains applying low-$CO_2$-industrial

[6] communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 2011 A roadmap for moving to a competitive low carbon economy in 2050: /* com/2011/0112 final */

[7] European Commission 2018 A Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy: COM (2018) 773 final

[8] European Commission 2018 In-Depth Analysis in Support of the Commission Communication Com (2018) 773 - A Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy.

[9] Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions A European Strategy for Plastics in a Circular Economy: /* COM/2018/028 final */

[10] United Nations The Paris Agreement https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed 07.03.19)

processes and technologies. Low $CO_2$-technologies can be defined as specific technologies aimed at reducing $CO_2$-emissions in industrial production processes and along the entire value chain or to avoid them significantly.

In 2015 the EIIs represented 15% of total direct[11] greenhouse gas emissions (GHG) in the EU[12]. 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[13]. EIIs reduced their greenhouse gas emissions by 36% between 1990 and 2015 (-375 Million Tons) and accounted for 28% of the total economy-wide emission reductions by the EU. However, significantly abating emissions of these sectors is difficult because 45%of $CO_2$-emissions that result from the feedstocks cannot be reduced by just changing fuels, but by a change in processes. In a highly competitive environment, companies that change their processes and technologies will have a price disadvantage in the first moment. Therefore, there is a need of technical break-through technologies and the transformation of the value chains towards new pathways.

EIIs have been working on solutions towards the deep reduction of greenhouse gas emissions, but the most promising low-$CO_2$ technologies must to be proven at industrial scale. Due to the very long investment cycles in the EIIs this shall happen as early as possible, if significant progress on the climate targets is to be achieved by 2050. However, there are fundamental framework conditions and challenges, which will determine the pace of technologies' deployment in steel, chemicals and cement, such as:

- The rising demand for $CO_2$-free, ample and competitively priced energy through the climate policies and the deployment of low-$CO_2$ technologies
- The need of suitable infrastructure for H2 transport, CCU and CCS
- The CAPEX[11] for industrial low-$CO_2$ transition will be significantly above current investment levels of EIIs and investment decisions will depend on competitive OPEX[12]
- New low-$CO_2$ process plants will likely be constructed and existing installations will have to be replaced or updated, leading to additional costs (CAPEX+OPEX) for producers.

Most EIIs operate in a highly competitive and dynamic international context. Continued protection of competitiveness is essential to ensure high levels of investment in the EU. The lack of a level playing field at global scale in terms of costs and regulatory constraints related to carbon emissions might hinder the transition of EIIs, in particular where markets for climate-neutral, circular economy products are missing.

Concerning the different possible technological options, the focus in this report will be on the technological pathways that are currently the most explored and have a high potential for industrial deployment in the timeframe until 2030 and beyond. Main technological pathways for GHG abatement in steel, chemicals and cement are:

[11] Direct Greenhouse gas emissions arise directly in the production process of these sectors, while additional GHG emissions are embodied in the raw materials production chain (e.g. emissions from the production of electricity, fuels, chemicals, equipment etc...)
[12] Wyns T, Khandekar G and Robson I 2018 Industrial Value Chain. A Bridge towards a Carbon Neutral Europe. (Vrije Universiteit Brussel (VUB) - Institute for European Studies)
[13] Pee A de, Pinner D, Roelofsen O, Somers K, Speelman E and Witteveen M 2018 How industry can move toward a low-carbon future: Cutting industry's carbon emissions will require significant investment and coordinated effort among businesses, governments and other stakeholders (Sustainability & Resource Productivity) (McKinsey&Company)

- $CO_2$ Valorisation
- Process Integration in steelmaking
- Carbon Direct Avoidance in steel: Hydrogen-based metallurgy
- Carbon Direct Avoidance in steel: Electricity-based metallurgy
- Chemical Valorisation of waste (including chemical recycling of plastics)
- Electrification of chemical processes (e.g. electrification of crackers, Power-to-Heat)
- Electrification of cement manufacture
- Alternative raw materials and fuels including hydrogen
- Development of new chemical production plants based on non-fossil feedstocks
- Development of alternative cement products (low $CO_2$ binders)
- Eco-design and resource efficiency, including recycling
- Energy efficiency: Innovative grinding technologies for cement manufacturing
- Artificial Photosynthesis
- Carbon Capture Storage, and Permanent Capture Technologies (ex : cement recarbonation)

## The Sub-Value-Chain of low $CO_2$ steel making

Steel production is a major source of global $CO_2$ emissions. The iron and steel industry accounts for approximately 6.7% of global anthropogenic – and 31% of industrial – $CO_2$ emissions[13]. With respect to carbon emissions, global steel production still generates almost 6-7% of annual emissions. Since the 1960s, energy use and $CO_2$-emissions in the European steel industry have been significantly reduced by almost 50%.

The typical value chain for steel products involves raw materials production and energy supply, iron- and steelmaking, purification and refinement, forming, shaping and coating and further processing for various applications in different sectors such as automotive, construction, industrial equipment and metal products, including by-products and on-site energy systems. At their end-of-life, most of the steel products are recycled and the steel scrap is used to produce new steel.

In Europe, steel is generally produced through two production routes. The first is the Blast Furnace and Basic Oxygen Furnace route (BF-BOF), which is also called the 'primary' route. Primary production accounts for about 60% of the market. The second is the Electric Arc Furnace route (EAF), also called the 'secondary' route. EAF production has a market share of around 40%.

Blast furnaces produce hot metal from iron ore. This is usually done using carbon in the form of carbon monoxide (CO), which is used to remove the oxygen from the iron ore in a chemical process known as 'reduction'. $CO_2$ is an inescapable product of this reaction. In the second step, the Basic Oxygen Furnace turns the hot metal, with the addition of some scrap, which is used to control the temperature, into steel.

By contrast, Electric Arc Furnaces produce steel by melting steel scrap using electricity. Both the primary and secondary production routes generate $CO_2$ emissions. However, the secondary route (EAF) produces only a about third less $CO_2$ compared to the primary route because using recycled iron or steel scrap saves energy as the iron ore reduction process is not required. The $CO_2$ emissions from the secondary route are essentially due to the melting of steel scrap through the use of electricity, though this is already partly decarbonized (grid $CO_2$ emission factor).

The process of primary steelmaking by blast furnace reduction is now approaching the technically feasible maximum of efficiency, close to the thermodynamic limits ][14]. In order to further decrease

the environmental impact of steelmaking and of $CO_2$-emissions, new reduction techniques need to be developed and implemented. Simultaneously, more and more metal-scrap is recycled especially for steel used in the construction sector globally[15]. However, iron ore-based steelmaking route (primary route) will still form an important part of the steel production due to quality requirements of the material.

The technologies with the biggest potential for low-carbon steel-making are Carbon Direct Avoidance (CDA) through direct reduction processes with hydrogen or electrolysis of iron ores, Process Integration, Carbon Capture and Usage (CCU)/$CO_2$-Valorisation and Carbon Capture and Storage (CCS)-technologies[16]. Heat and mechanical electrification are already applied in the industry, especially for steelmaking out of steel-scrap.

Steel is a mitigation enabler, as with its strength and durability it enables energy, material an emission savings in other industries. $CO_2$ savings in other industries outweigh the emissions created by the production of the necessary steel at a ratio of 6 to 1. Steel is contributing and underpinning the development of the green economy. Renewable energy (wind mills), resource- and energy-efficient buildings, low carbon and clean energy vehicles, as well as recycling facilities depend on steel applications.

The access to steel is a strategic requirement for the EU-economy - for transport, construction, manufacture, space, defence and especially energy. Renewable energy technologies are based on steel, Solar and Wind using the highest amount of steel. Low carbon steel will thus also be crucial for ensuring the energy supply security and the energy networks (e.g. steel as key component for gas supply pipeline networks).
As steel is a critical material for innovation in many sectors, the value chain is crucially linked to the development of Key Enabling Technologies (KETs) such as advanced manufacturing, digitalization, advanced materials and nanotechnology, industrial biotechnology as well as to areas such as metal organic frameworks, Nano sponges and hybrid membranes.

## Technology development for the Sub-value Chain of low-carbon steel:

Low-$CO_2$ innovation projects within the EU steel industry can be grouped into two main pathways. Each project, in combination, potentially offers significant synergy effects in the transition to the low-carbon economy and beyond. One approach continues with fossil fuel based metallurgy, the other marks a shift to non-fossil fuel based metallurgy. The two pathways are respectively called **Smart Carbon Usage (SCU)** and **Carbon Direct Avoidance (CDA)**. These are flanked by overarching **circularity projects**, such as enhancing energy efficiency, the recycling of steel and its by-products, to help tapping further $CO_2$ mitigation and energy savings.

The first pathway with scope for considerable $CO_2$ emissions reduction is **Smart Carbon usage (SCU)**. SCU consists in making further use of existing steelmaking routes using fossil fuels (coal, natural gas, etc.) while at the same time cutting the quantities of $CO_2$ they produce. This pathway includes two groups, respectively called **Process Integration** and **$CO_2$**

**Valorisation/Carbon Capture and Usage (CCU)** - which, for a meaningful evaluation, require Life Cycle Assessment (LCA) since the implementation of SCU will require a considerable amount of $CO_2$ free electricity.

The **Process Integration** group is dedicated to all modifications of existing ironmaking/steelmaking processes based on fossil fuels that would help reduce the use of carbon in, and thus the $CO_2$

emissions of, a state-of-the-art EU plant. It covers options such as the recycling or better internal use of steel plant gases, the partial replacement of coal by either natural gas or biomass, an increase of the scrap/hot metal ratio in an energy efficient way, and the replacement of ore with Direct Reduced Iron (DRI) or Hot Briquetted Iron (HBI), etc. Furthermore, it covers all alternative iron/steelmaking processes making use of fossil fuels as the main reducing agent (e.g. all coal or natural-gas based smelting or direct reduction processes). This group also addresses $CO_2$ capture processes which have to be integrated in steel plants.

The **$CO_2$ Valorisation/Carbon Capture and Usage (CCU)** group includes all the options for using the Hydrogen, CO and $CO_2$ in steel plant gases or fumes as raw materials for the production of, or integration into, valuable products. Indeed, CO and hydrogen are often the materials needed for first step in the production of chemicals, such as by cracking naphtha or natural gas. Process waste gas from steel and refineries can potentially be reused for chemical synthesis with lower energy consumption over the life time of the (chemical) product. Green hydrogen, which will become gradually more available during periods of oversupply of renewable power, can also be used in a flexible way by some of the Carbon Valorisation/CCU technologies. This group of technologies will therefore require significant efforts in LCA studies (for real assessment of $CO_2$ mitigation effects) and cost/market analyses to effectively compare processes and target products.

These technologies can also be combined with the Carbon Capture and Storage (CCS) technology as purified $CO_2$ is often a by-product of those processes. This leads to low cost capturing projects which can be linked with transport/storage infrastructure when this eventually becomes available.

A drastic reduction of $CO_2$-emissions can be achieved through the second pathway, called **Carbon Direct Avoidance (CDA).** This pathway leads towards the further development of (new) processes that would produce steel mainly from virgin iron ore and/or suitable scrap using renewable electricity and/or hydrogen produced from renewables. The purpose is the large-scale replacement of the current fossil fuel (coal and/or natural gas) mix, using such means as the direct reduction process, the plasma smelting reduction process or electrolysis processes for iron ores, among others. It also addresses the processes that allow for the production of these two energy vectors in steel plants with no, or limited, $CO_2$-emissions. Hence, this pathway includes two groups of technologies: hydrogen-based metallurgy and electricity-based metallurgy. There are several **projects on Carbon Direct Avoidance** in the steel industry**.**

Another way to assure steel supply without producing new CO2-emissions is the recycling of steel scrap in the DRI-EAF-process with electric energy out of renewable energy sources. This would not only be promising, because steel is 100 % recyclable. The rate of recycling of steel depends on the end-use, but at present on average around 85% of steel, at the end of its first useful life, is recycled; over 99% of steel scrap from cars is recycled today.

A non-exhaustive list of projects of the steel sector in the above technological pathways is included below in the Annex.

## The Sub-Value-Chain of low $CO_2$ cement production

Cement is a binding agent used in concrete and as it is needed for construction, its demand is closely correlated to economic development[17]. The basic value chain for cement production starts with the quarrying of the principal raw materials, such as limestone and clay. The rocks are crushed in different steps and then combined with other ingredients and heated to very high temperatures in the cement

kiln (calcination process). There certain elements are driven off in the form of gases and the rest remains as clinker. After the clinker is cooled, it is grounded into a fine powder and mixed with other ingredients (gypsum, limestone, granulated blast furnace slag …), which is then resulting in cement [18]. The vast majority of cement goes into concrete that is a mixture of cement (10-15%), water (15%-20%) and aggregates (65%-75%). Therefore, concrete is a low-carbon product that through its properties such as thermal mass, its longevity (lasts for 100 years), recycling and recarbonation potential, is a key enabler for the low carbon transition. Indeed, concrete is an essential material of choice for power generation plants, wind turbine structures, sustainable office buildings and housing and key infrastructure such as dams, bridges, tunnels, roads and highways.

The process step consuming the most energy is the production of clinker by sintering limestone and clay. As cement is the third most used substance in the world, its production also accounts for 5% of the global human-made $CO_2$-emissions. The calcination of limestone (CaCO3 dissociated to CaO and $CO_2$) is an inevitable step of cement production. 60% of total $CO_2$-emissions of the cement manufacturing process the from the processing of carbonates (natural limestone or waste carbonates). The remaining 40% emissions comes from burning fuels in order to reach the high temperatures for clinker mineral formation. Over 90% of all cement plants in Europe are already equipped with more energy-efficient dry kilns[19].

According to the vision of CEMBUREAU, the European association of the cement industry, the cement sector can reduce its carbon footprint by 32% using conventional technologies and up to 80% when successfully implementing carbon capture and use/storage until 2050 compared with 1990 levels [20]. The cement sector wants to invest in resource and energy efficiency, carbon sequestration and reuse, the development of low carbon concrete and in smart buildings & infrastructure, recycling concrete and the possibilities of recarbonation as well as in sustainable construction.

The most promising low $CO_2$-technologies for the cement production are the use of biomass and waste for heat and feedstock/biofuels, energy efficient technologies, , developing low-clinker cements and innovative binders and optimizing mix constituents in concrete, the use of waste streams as alternative raw material as well as CCU and CCS [20] .

As in other process-emissions industries, a complete avoidance of $CO_2$-emissions is not possible in the cement industry, as the calcination of limestone to calcium oxide releases previously chemically bound carbon dioxide. Although a reduction of the amount of used calcium oxide in cement is feasible, a complete replacement is currently not possible technically. Hence, in the following, we will discuss possibilities to reduce $CO_2$-emissions and capture the unavoidable $CO_2$. In addition, significant $CO_2$ savings can be achieved through the use of concrete in sustainable buildings.

According to International Energy Agency (IEA) cement industry should contribute to the largest $CO_2$ emission reduction through CCS in Europe, in order to meet the target of 2°C of global temperature increase (IEA '2DS scenario')[21].

## Technology development for the Sub-value Chain of low-$CO_2$ cement

There are several possibilities available to reduce $CO_2$-emissions in the cement industry that can be categorized in four groups: implementation of improved processes to reduce the energy consumption, alternative raw materials and improved cement blends to reduce $CO_2$-emssions from calcination of limestone, the use of alternative heating sources, and carbon capture technologies. In addition, $CO_2$ in off-gases from cement kilns can be used as a raw material in the chemical industry. A

combination of all of these technologies will be necessary to achieve a significant reduction of $CO_2$-emissions.

$CO_2$ reduction can also be achieved down the value chain thanks to the thermal mass of concrete (which reduces the need for heating/air conditioning and therewith reduces $CO_2$), the construction of sustainable public transport systems such as trams and monorails, concrete recyclability and recarbonation of cement in concrete over the lifetime and at end-of-life of a built structure.

The industry, through the European Cement Research Academy (ECRA), is working on advanced grinding technologies that could decrease the electricity intensity of cement production beyond current best practice levels and provide means to manage electricity demand more flexibly. They include contact-free grinding systems, ultrasonic-comminution, high voltage power pulse fragmentation, and low temperature comminution.

The change from wet kilns to dry kiln technology in Europe and a constant focus on improving energy efficiency resulted in an improvement of the energy efficiency in the cement industry already. Further improvements are expected to have a limited potential, e.g. the new IEA CSI roadmap estimates that a 10% improvement can be made by 2050 in the best case scenario at the global level [22].

One way of reducing $CO_2$-emissions in the cement manufacturing process, consists in modifying the input in two ways. First, by substituting raw materials such as clay, shale and limestone by waste and by-products from other industrial processes such as calcium, silica, alumina, iron and crushed concrete. By this substitution, a reduction of $CO_2$-emissions during the clinker-making process can be achieved. In Europe, 3-4% of raw materials used in the production of clinker consists of alternative raw materials and ash from fuel (14.5 million tonnes per year).

Second, by partially substituting the clinker with alternative raw materials such as fly ash (from the power sector), granulated blast furnace slag (from the steel sector), natural pozzolana (volcanic ash), artificial pozzolana (calcined clay) or limestone (natural or waste concrete). In this way, less clinker is needed to make the cement, which in turn reduces the energy consumption[23]. The required mechanical properties of the concrete requires a special attention to its formulation depending on its final usage and the composition of the considered low carbon cement

In both cases, availability of these alternative materials is problematic and the supply of fly ash and blast furnace slag will diminish with the decarbonisation of the power and steel sectors.

Alternative fuels: Instead of using coal as fuel in the calcination process, various other alternative fuels are feasible to use, such as e.g. industrial waste, tyres, or biomass [24]. In this context, the cement industry is engaged in the EPOS Project[24], which seeks to identify, through a digital platform, alternative fuel sourcing opportunities for plants in different industrial sectors (steel, chemicals, cement) in an industrial symbiosis approach.

Studies carried out by Ecofys [25][26] have demonstrated that there are no technical barriers to increase the use of alternative fuels to 90-95%. Obviously, the use of alternative fuels will anyway lead to $CO_2$-emissions and are limited by the availability of the alternative fuels. Furthermore, regulatory barriers exist. The refuse-derived fuel (RDF) production in France should increase to more than 2 million tons due to a higher share of sorting residues used for RDF. But this growth in RDF is accompanied by new renewable energy auctions dedicated to RDF power plants. In total, RDF combustion plants with a thermal capacity of 100 MW are to be supported until 2025. In order to take

benefit of their evenly distribution and their multiple-grid connections, the cement plants must have to be integrated into the national waste to energy programs.

**Electric heating:** In order to reduce the $CO_2$-emissions more significantly, attempts to replace the fuel-based heating with electric heating have been made. Results from Ceralink Inc. indicated that a microwave-based heating (Microwave Assist Technology MAT) decreased energy consumption of limestone calcination by 36% compared to conventional heating. [27]Although the technological readiness might be not high enough for immediate and large-scale implementation, the potential to electrify the heating in the cement industry is in principle existent.

Finally, the technology that will allow the cement sector to reduce its $CO_2$ emissions to 80% by 2050 is the carbon capture technology. The cement sector is exploring a wide range of capture technologies through different projects, such as the *Oxyfuel technology* (ECRA Project) using pure oxygen instead of air in combination with flue gas recirculation in order to provide a high $CO_2$ concentration exhaust gas stream for further capture; two plot plants are ready to implement the technology, one in Retznei (Austria) and one in Collefero (Italy); *Post-combustion technology* (Norcem Brevik project), which focuses on tailed separation of $CO_2$ from flue gas; *Calcium looping* (CaL) *technology* (Cleanker project), which is one of the most promising technologies for $CO_2$ capture in cement plants; *Direct separation technology* (LEILAC Project), which enables pure $CO_2$ to be captured through a re-engineering of the process flows of the calciners. In addition, the cement industry prepares the ground for a large scale implementation of $CO_2$ capture in the industry through the CEMCAP project, funded by Horizon 2020.

All these techniques aim to remove $CO_2$ from the cement production process. The captured $CO_2$ can then be either stored (CCS), or utilized (CCU) and chemically bound.

An efficient way to store $CO_2$ chemically is to bind it to cement, hence $CO_2$ can be used to produce concrete from recycled aggregates. Aggregates are exposed to very high levels of $CO_2$ in a controlled curing chamber triggering a chemical transformation that locks the $CO_2$ in the concrete. These are called carbonatable binders which harden with $CO_2$ from flue gases (instead of water) and at a much faster rate. Additionally, concrete itself exhibits a **recarbonation** potential: during the lifetime of a concrete structure (building or road), hydrated cement contained within the concrete reacts with $CO_2$ in the air. Studies show that up to 25% of the process emissions related to the production of cement can be reabsorbed along the life cycle and up to 50% at end of life through forced recarbonation (Fastcarb project).

The technology FutureCem, which is a combination of lime clay calcination and an improvement in the efficient usage of cement from Cementir (Denmark), has a reduction potential of up to -32% and if CCU/CCS is combined it would be possible to get up to -80% target.

A non-exhaustive list of projects of the cement industry in the above technological pathways is included below in the Annex.

## The Sub-Value-Chain of low $CO_2$ chemical production

The chemical industry is the main industrial energy consumer (19% of total industrial consumption) and the third largest industrial emitter in the EU. Only the production and incineration of plastics produce every year 400 million of tons of $CO_2$[28].

The chemical industry enables many downstream value chains. The production processes are highly energy intensive and carbon is a prominent feedstock for the chemical industry. Additionally to the reduction of GHG-emissions, the chemical industry can achieve energy-savings in other value chains through the development of special materials with potential for $CO_2$-emission reduction.

Since 1990 the European chemical industry reduced its GHG emissions by 59%[29]. New low carbon processes such as energy efficiency measures, alternative carbon sources (bio based raw materials, captured $CO_2$, waste) and Electrification could enable the reduction of $CO_2$-emissions. In the study of DECHEMA (2017) promising measures to reduce emissions are further efficiency and plant retrofits, the transition to power-based heat and steam generation and the recuperation of waste heat. Additional savings can be enabled by the use of climate-neutral produced hydrogen for ammonia or methanol production or using carbon dioxide for the production of methanol, olefins and BTX. Electrolysis based processes will benefit from a progressive decarburization of the power sector[30].

Advanced process technologies for the chemical valorisation of $CO_2$ can provide means to store climate neutral energy in products. The Chemical industry can recycle Carbon from $CO_2$ in a wide range of applications, such as Chemicals and polymers, alternative fuels for transport, construction materials, biomass or the storage of climate neutral electricity and can consequently contribute to a more circular economy[30]. All the recycling options need to be part of a European strategy towards $CO_2$ emission reduction in a future economy.

Key options for $CO_2$ emission avoidance in the chemical industry are the fostering of Circular economy through the utilisation of $CO_2$ as alternative carbon source or the chemical recycling of waste and biomass, as well as the switch to alternative, renewable energy sources through electrification of production processes (CEFIC 2019).

In general, process efficiency can be enhanced through recycling of chemical materials and products, and feedstocks can be substituted by sustainable biomass. The emerging bio-economy is trying to substitute conventional carbon sources by bio-based alternatives.

## Technology development for the Sub-value Chain of low-carbon chemicals

Fossil fuels are the largest source of $CO_2$ in the chemical industry, as high quantities of energy are needed to perform chemical reactions (e.g. to break down naphtha into olefins and aromatics a temperature of 850 °C is needed in the steam cracker).

To lower the $CO_2$-emissions and fossil carbon use in the production of chemicals, there are three major options besides the use of alternatives feedstocks. These are Electrification, $CO_2$ (and CO)-valorisation, as well as the chemical recycling of waste.

At the stage of the inputs, the use of **alternative feedstocks** from biomass, recycled plastics or other wastes, methanol or captured $CO_2$ and other materials is key to the reduction of $CO_2$-emissions for the chemical industry and especially the reduced usage of fossil carbon sources for petrochemicals.

The Zambezi-technology of the company Avantium is being demonstrated in a pilot bio refinery in the Netherlands, where climate neutral carbon sources are used instead of fossil resources. In the developed process plant-based non-food feedstocks are converted to high purity fermentation processes to produce a range of durable materials, while lignin is used in energy generation[31].

As the chemical industry uses large quantities of hydrogen as a reactant, e.g. in ammonia synthesis, it is very important to use $CO_2$-neutral hydrogen for these reactions (in the conventional production of hydrogen significant volumes of $CO_2$ are released). To do this, a new process technology is currently developed by BASF and partners to produce hydrogen from natural gas, by splitting it directly into its components hydrogen and carbon (methane pyrolysis). This process requires comparatively little energy and could be brought at industrial scale with the by-product of solid carbon that could be used in the steel or aluminium production[32]. The potential of Methane pyrolysis to reduce $CO_2$-emissions is

-50% (assuming the 2030 electricity grid) and even -90% or more (with only climate neutral electricity).

### Electrification

At the stage of the production process alternative hydrogen-based processes and the electrification the production process are the main technological options.

Regarding electrification and new processes, such as Power-to-Heat, Power-to-molecules, Power-to-Fuels and Power-to-X several businesses have announced that they want to realize large scale electrolysis installations for the production of green hydrogen.

Nouryon and Gasunie are currently investigating the possible conversion of sustainable electricity into green hydrogen using a 20-megawatt water electrolysis unit. BioMCN will combine hydrogen from the intended facility with $CO_2$ from other processes to produce renewable methanol, a raw material for bio-fuels and a variety of chemical feedstocks. Compared to fossil-based methanol this will reduce emissions by up to 27,000 tons of $CO_2$ per year[33].

VoltaChem is an ambitious open innovation research program initiated by TNO and ECN with industrial and academic partners, which focuses on the indirect and direct use of sustainable electricity in the chemical industry. Activities exist e.g. in the field of power-to-heat, for the use of electricity to generate or upgrade heat for chemical production processes. But research is also going on about Power-to-chemicals[34] and Power-to-hydrogen[35]. The project aims also at the connection and optimal integration of the electricity market and the chemical industry.

The project, *MAPSYN*, aims to bring selected innovative energy efficient chemical reaction processes, assisted with novel microwave, ultrasonic and plasma systems, up to the manufacturing scale.

The MAPSYN project has been granted funding from the 7th EU-Framework Program to investigate highly efficient chemical syntheses using alternative energy forms[36].

The $CO_2$-reduction potential of Electrification of chemical process is very high, especially when entirely based on the use of renewable electricity. For instance the E-Furnace Technology (electrical heating for stream crackers) developed by BASF[37] has a reduction potential of -30% (with the 2030 electricity grid) and -90% or more ( with only renewable electricity).

### $CO_2$ (and CO) valorisation

$CO_2$ valorisation can contribute to a more sustainable production of chemicals, materials, fuels, biomass with significant $CO_2$ emission avoidance compared to current production and can provide

means to store excess energy. Energy intensive industries (e.g. chemicals, cement, steel, electricity) provide large sources of concentrated $CO_2$ or CO.

Advanced process technologies and advanced materials are essential to the valorisation of $CO_2$. Key technologies include catalysis, advanced process technologies for electrochemical, electro catalytic, photocatalytic processes, biotechnological processes and biological pathways for the conversion of $CO_2$ into chemicals, polymers and fuels. These advanced process technologies for the chemical valorisation of $CO_2$ can also provide means to store excess energy and production of sustainable alternative fuels.

Separation and purification technologies are required for the valorisation of $CO_2$ from industrial streams (and from air). The level of purification needed depends on the input stream and the $CO_2$ valorisation route. The utilisation of $CO_2$ as carbon source in place of fossil resource requires disruptive innovation based on the design, development and scale-up of specific advanced process technologies.

In the chemical sector $CO_2$ can be used as an alternative source of carbon for the production of a wide range of chemicals from basic chemicals to fine chemicals and polymers.

The direct air $CO_2$-capturing pilot system implemented in a geothermal plant in cooperation with Climeworks in Iceland captures 50 metric tons of $CO_2$ per year from the air, mixes the $CO_2$ with water and injects it into stone layers[39].

In the H2020 project Mef$CO_2$, a synthesis of methanol from captured carbon dioxide using surplus electricity was developed[40].

In a similar approach, in the H2020 project FReSMe, residual steel gases from ($CO_2$ from blast furnace gasses) are transformed to methanol and are used as liquid energy storage or fuel (e.g. for ships)[41].

Carbon Recycling International developed the Emissions-to-Liquids technology (ETL), which recycles $CO_2$ into alcohols (methanol) and liquid hydrocarbons. This process needs water and electricity and can use $CO_2$ from industrial point sources or from ambient air. A facility of CRI in Iceland produces renewable methanol from $CO_2$ and $H_2$ alone. This technology could replace hundreds of millions of tons of fossil fuel and reduce $CO_2$-emissions by billions of tons per year[42].

There are further CCU-research and development projects such as by Air Liquide, the I3upgrade project, the VALORCO project and the VITESSE2 project.

For plastics, e.g. polyurethanes the first demonstration plant by Covestro in Germany with 5,000 t/a production of $CO_2$-based polyols (20% $CO_2$ content and ~20 % $CO_2$-emission reduction as compared to pure fossil based compound). This was the first demonstration of the direct utilisation of $CO_2$ as a replacement for propylene oxides in polyurethane precursors. Reactions of this kind are called “Dream reactions” in chemistry as they would provide a previously unknown direct pathway into a molecule or molecule class. Therefore, the development of the $CO_2$-based plastic foams was a technological breakthrough and it paved the way for further research and applications in different plastic materials. For the polyurethanes, $CO_2$ emission reduction stems not only from the direct replacement but also indirectly from the replacement of fossil based and energy intensive precursor molecules such as propylene oxide.

In a biotechnical approach, the Algafarm project of Secil in Portugal , $CO_2$ resulting from the cement production process is used for growing microalgae and last tests with various species of microalgae should be completed in 2019[43].

In complement to the utilisation of $CO_2$ as alternative carbon feedstock in $CO_2$-valorisation, in some cases the captured CO2 is transported and stored; e.g. in rock stratums of the sea bed (Carbon Capture and Storage = CCS).

### Chemical recycling of waste

As for the Output-Stage, the chemical recycling of waste and the general reduction of waste, the implementation of circular economy models and the valorisation of $CO_2$ from own production processes or from flue gases in other industrial sectors can create the beginning of new value chains in the chemical industry.

In the field of waste-to-chemicals, a consortium of companies (Air Liquide, AkzoNobel Specialty Chemicals, Enerkem and the Port of Rotterdam Authority) agreed to invest in an advanced waste-to-chemistry plant in Rotterdam. The aim is that this will be the first plant of this type in Europe to offer a sustainable alternative for waste incineration, by converting plastic and mixed waste into new raw materials for industry[44].

Further reduction of the footprint of the chemical industry and its wide variety of products can be achieved through other measures such as the better utilisation of other alternative carbon sources. These can be biomass including biogeneous waste streams and other waste materials (incl. plastics/chemical recycling). In addition, the direct and indirect utilization of climate neutral electricity and alternative energy forms (carbon neutral hydrogen, which can also be combined with $CO_2$ as a feedstock) is of high importance for the abatement of $CO_2$ for the chemical industry. The higher conversion efficiency of chemical production processes and the better the energy and water management, the less $CO_2$ emissions and the more sustainable can become the value chain.

For all of these technologies and measures to implement effectively and efficiently it will be crucial also to optimize the (re-)design of processes, plants and production through the intensified use of digital technologies.

# List of technologies and concrete projects of low $CO_2$ emission technologies

In addition to the specific priority recommendations listed above, this annex shows a non-exhaustive list of technologies and concrete projects of low $CO_2$ emission technologies that could accelerate the overall energy-intensive industry to speed up the process towards climate neutrality by 2050, meaning $CO_2$ emissions reductions of at least 80% and up to 95%. These low $CO_2$ emission technologies could be considered for potential IPCEIs. The following tables include consequently three lists of low $CO_2$ emission technologies from the chemical, steel and cement sector.

## List of Low $CO_2$ emission Technologies from the Chemical sector

| Technological pathway | Project name/Description | Abatement Potential | TRL | MS |
|---|---|---|---|---|
| $CO_2$ valorisation | List of $CO_2$ valorisation projects funded under the funding measures: "Chemical Processes and Use of $CO_2$" and "CO2Plus - Broadening the Raw Materials Base by $CO_2$ utilization"/BMBF | | | Germany |
| | Other projects involving chemical | | | |

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| | companies include:<br><br>**Kopernikus Power-2-X**[14] and **carbon2chem**[15] | | | |
| **$CO_2$ valorisation** | **$CO_2$ to polyols**[16]<br><br>**Dream Production project – Covestro (lead)**<br><br>The objective of "Dream Production" was the technical development and implementation of a polymer production from $CO_2$ on pilot scale. This was based on a previous project "Dream Reaction" in which the catalyst for this reaction was developed. Polyether carbonates (PECs)-based polyols, a precursor of polyurethane foams, could be synthesized with an optimum of | above 20% | TRL 7-8<br><br>TRL 8 | Germany<br><br>Funding measure: Chemical Processes and Use of |

[14] https://www.kopernikus-projekte.de/projekte/power-to-x
[15] http://www.chemieundco2.de/en/

https://www.thyssenkrupp.com/en/carbon2chem/
[16] DECHEMA, p.83

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| | 20% $CO_2$-content.<br><br>Based on the results, Covestro[17] and partners further developed the technology into demonstration scale, (5.000 t/a) to produce the product "cardyon™" in Dormagen in June 2016.<br><br>Furthermore, further research and innovation activities are ongoing to extend this innovative technology to other polymers for other applications (including hard foams for insulation, elastomers and surfactants) for partial replacement of fossil-based raw materials with $CO_2$.<br><br>Related projects include https://www.carbon4pur.eu/<br><br>**NEOSPOL project – REPSOL[18]**<br><br>**Repsol has** developed a new technology to synthesize a new type of polyol with $CO_2$ | | | $CO_2$"/BMBF<br><br>Spain |
| **$CO_2$ valorisation** | **$CO_2$/CO to polymers (cross-sectorial)**<br><br>Tata Steel[19] and Dow Benelux are | High | TRL 6-7 | The Netherlands |

[17] https://www.co2-dreams.covestro.com/en
[18] https://www.repsol.com/en/energy-and-innovation/a-better-world/transforming-co2/index.cshtml

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| | planning to realize installations to utilize carbon oxides from production gasses to make naphtha and polymers. This way a $CO_2$ valorisation demonstration facility could be built after 2025 (on a scale of 4-5 mtonne $CO_2$).<br><br>tbc: project between Dow and ArcelorMittal to be added | | | |
| **$CO_2$ valorisation** | **$CO_2$ to formic acid, oxalic acid and other chemicals**<br><br>Avantium[20], a leading technology development company and forerunner in renewable chemistry has been developing technologies for electrochemical valorisation of $CO_2$ into various chemicals<br><br>Example of projects include<br><br>https://www.spire2030.eu/ocean | n.a. | TRL 5-6 | The Netherlands |
| **$CO_2$ valorisation** | **Steel2Chemicals**<br><br>Separation of Carbon Monoxide (CO) and $CO_2$ streams from steel waste gas from the blast furnace. Valorisation of CO gas stream | 2.3 tons of $CO_2$ avoided per ton of chemicals product produced from CO in the syngas. Further potential of avoiding ~7 tons of $CO_2$ per ton of chemical produced via process optimization. | TRL 4-6 | Belgium, The Netherlands |

[19] https://www.tatasteeleurope.com/static_files/Downloads/Corporate/About%20us/hisarna%20factsheet.pdf
[20] https://www.avantium.com

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| | through catalytic Fischer-Tropsch conversion into synthetic naphtha for the production of polymers. (see also project Everest and Carbon2Value) | | | |
| | | | | |
| $CO_2$ valorisation | $CO_2$-to-methanol<br><br>examples include:<br><br>Carbon Recycling International (CRI)[21]<br><br>CRI was founded in 2006 in Reykjavik, Iceland.<br><br>CRI developed and operates the first-of-its-kind power-to-methanol manufacturing facility in Svartsengi, Iceland using its proprietary Emission-to-Liquids (ETL) process. The plant produces renewable methanol by capturing carbon dioxide from an emission stream and reacting it with hydrogen produced from hydroelectric and geothermal power. The plant has been in operation since 2012 and was expanded in 2015 to a production capacity of 4000 | The production of low carbon intensity or renewable methanol with CRI's ETL technology has the potential to decrease life-cycle carbon emissions by more than 90% compared to fossil fuels<br>-<br>-<br>-<br>-<br>-<br>-<br>-<br>-<br>The $CO_2$ abatement potential amounts to 1,4t $CO_2$ per t Methanol. | -<br>-<br>-<br>-<br>-<br>- | *Iceland*<br><br>Belgium |

[21] www.carbonrecycling.is

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| | tons/year.<br><br>Other projects have been launched in Europe (e. g. . http://www.mefco2.eu)<br><br>**Port of Antwerp**[22]<br><br>Brings different players together to produce sustainable methanol from $_{CO2}$ and low-carbon hydrogen. The consortium was formed Q4 2018, and the pilot project aims for 4,000 to 8,000 tonnes of methanol per year<br><br>**Fos sur Mer area (Port of Marseille) :**<br><br>50kt synthetic methanol production from co-produced H2 (Kemone chlorine plant) +20MW electrolyser<br><br>$CO_2$ captured in the port area (per default KemOne plant)<br><br>Waste heat from industry | For the project (50kt) the total abatement is 70kt$CO_2$/a and for a 20 year project 1400kt<br><br>(For an estimated capex of 50-70M€, the $CO_2$ abatement cost is 35-50€/t) | TRLL 7-8<br><br>-<br><br>-<br><br>-<br><br>-<br><br>-<br><br>-<br><br>N/A<br><br>Feasibility study will give information<br><br>35 000 ton/p.a. | France<br><br>Sweden |

[22] https://www.portofantwerp.com/en/news/port-antwerp-brings-different-players-together-produce-sustainable-methanol

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| | **Production of methanol from carbon dioxide and waste streams**<br><br>In this feasibility study, Perstorp AB will explore the possibilities to annually produce 100 -200 thousand tonnes of methanol from carbon dioxide and other waste streams available at the plant. The hydrogen should be produced by electrolysis. The feasibility study will define technology and requirements for the equipment and its size. The study will be used for investment calculation, project plan and basis for permit applications, and investigate how the product can be classified from a sustainability perspective and its impact on the value chain of downstream products | | | |
| **$CO_2$ valorisation** | **$CO_2$-to-olefins**<br><br>Low-carbon ethylene and propylene can be produced via MTO (Methanol to Olefins), if methanol is made using H2 and $CO_2$ as previously described. The MTO reaction is strongly exothermic and the process follows a two-step dehydration of methanol to dimethyl ether and water, to control the heat of reaction and the adiabatic | Approx. -249% (in the MTO process -1.13 t $CO_2$/t olefin, compared to the naphtha route 0.76 t$CO_2$/t olefin) | TRL 7 (Although MTO technology is well known, the TRL is limited by the TRL of methanol production from $CO_2$ and low- carbon H2) | |

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| | temperature increase, followed by the conversion to olefins. | | | |
| $CO_2$ valorisation | **Olefins can be created from H2 and $CO_2$ in a single system**, for example in a single-stage electro-catalytic process, which omits the need for intermediate products (e.g. methane and methanol as feedstock for olefin synthesis).<br><br>- | n.a. | TRL 3-4 | |
| $CO_2$ valorisation | **Dimethyl ether (DME)** can be produced through direct synthesis from $CO_2$, and used as a fuel additive or a LPG substitute. | | TRL 1-3 | |
| $CO_2$ valorisation | **Sodium acrylate from ethylene and $CO_2$** is currently investigated in lab scale. | n.a. | TRL 1-3 | |
| $CO_2$ valorisation | **Conversion of $CO_2$ to ethylene through an electro-catalytic process** is currently investigated in lab scale. | n.a. | TRL 1-3 | |
| $CO_2$ valorisation | **$CO_2$-to-methane**<br><br>**Jupiter1000**[23] | | | France |
| $CO_2$ valorisation | **Direct utilization of sunlight-REPSOL**[24] | n.a | TRL 3-4 | Spain |

[23] https://www.jupiter1000.eu/projet
[24] https://www.repsol.com/en/energy-and-innovation/a-better-world/transforming-co2/index.cshtml

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| | Solar fuels production using a photo electrochemical process. Thus, using $CO_2$ and water—and direct sun light as the main energy source— more complex molecules such as formic acid, methane, and methanol, among others can be obtained. | | | |
| Chemical Valorisation of waste (including chemical recycling of plastics) | **Chemical recycling of plastic**[25]<br><br>Plastic waste transformed into a raw material using thermochemical processes.<br><br>**Waste to chemicals**[26]<br><br>A consortium of companies comprising Air Liquide, AkzoNobel Specialty Chemicals, Enerkem and the Port of Rotterdam Authority has signed a development agreement for the initial investments in an advanced waste-to-chemistry plant in Rotterdam. The aim is that this will be the first plant of this type in Europe to offer a sustainable alternative for waste incineration, by converting plastic and mixed waste into new raw materials for industry. | n.a. | TRL 5-8 | The Netherlands |

[25] https://www.ce.nl/publicaties/2168/verkenning-chemische-recycling
[26] https://www.portofrotterdam.com/en/news-and-press-releases/partners-start-financing-waste-to-chemistry-project-in-rotterdam

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|---|---|---|---|---|
| Electrification of Chemical Processes | VoltaChem[27] is a business-driven Shared Innovation Program that connects the electricity sector to the chemical industry. New technologies are developed and implemented that focus on the conversion of renewable energy to heat, hydrogen and chemicals. | n.a. | | The Netherlands |
| Alternative raw materials and fuels including hydrogen | Methane or other lower hydrocarbons are decomposed in a high temperature pyrolysis process generating hydrogen and solid carbon. | | TRL 4-5 | |
| Alternative raw materials and fuels including hydrogen | Several businesses want to realize large scale electrolysis installation for the production of green hydrogen[28]. Among these businesses are: Nouryon and Gasunie, Tata Steel, the port of Amsterdam and Nouryon, Engie and Gasunion and Tennet, Gasunie, Tennet and Thyssengas. These hydrogen projects could improve GHG emission reductions in industrial sectors, and further elaboration on these projects is done via the SVC Hydrogen. | | TRL 2-4 | The Netherlands |

## List of Low $CO_2$ emission Technologies from the Steel sector

| Technological pathway | Project name/Description | TRL | Abatement potential | MS involvement |
|---|---|---|---|---|
| Carbon Direct Avoidance: hydrogen-based metallurgy | Hybrit[29] - Hydrogen based metallurgy: HYBRIT is based on direct reduction of fossil free iron ore pellets using hydrogen and renewable energy, which generates water as a by-product instead of carbon dioxide, followed by a fossil free EAF-based crude steel production. A pre-feasibility study has been successfully completed, lab scale study and construction of a pilot plant, representing the complete fossil free process chain from ore to crude steel, are ongoing. | TRL 5-7 | 95% | Sweden |

[27] https://www.voltachem.com/
[28] https://www.deingenieur.nl/artikel/dutch-industry-explores-possibilities-of-major-hydrogen-factory
[29] http://www.hybritdevelopment.com/

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| **Carbon Direct Avoidance: hydrogen-based metallurgy** | Main Project **SALCOS**[30]; building blocks **GrInHy** and **Wind-H2** - Hydrogen based metallurgy:<br><br>SALCOS is based on the industrial direct reduction process using in addition to natural gas flexible amounts of hydrogen, produced by renewable energy to significantly reduce the $CO_2$ emissions short term for the steel production, because of the used industrial processes. The project is based on a modular concept allowing a stepwise transformation of the steelmaking process, potentially starting mid-2020.<br><br>The GrInHy-project[31] operated the by then biggest high temperature electrolyser (HTE) in an industrial application. The successor project GrInHy 2.0 has started in 2019 setting up a mega-watt scale steam electrolyzes system. The HTE enables the production of hydrogen with the highest electrical efficiency by using waste heat.<br><br>The aim of the "Wind-H2"[32] sector-interconnection project is to generate hydrogen in Salzgitter through PEM electrolysis and electricity from wind power (seven wind turbines with an output of 30 MW). | GrInHy:<br>TRL 5-6<br>SALCOS:<br>TRL 7-9<br>Wind-H2:<br>TRL 8 | SALCOS: up to 95% depending on the amount used of electrolytic produced hydrogen (-60% $CO_2$ if operated with 100% natural gas; -85% $CO_2$ if operated with 55% H2; -95% $CO_2$ if operated with 100% H2) | Germany |
| **Carbon Direct Avoidance: hydrogen-based metallurgy**[33] | **H2Steel**, consisting of CCU and CDA projects. The CDA part of H2Steel covers the aspects of H2 production, integration of renewables with H2 production and industrial operation, Hydrogen-plasma iron ore reduction, raw materials adaption to H2 based metallurgy, metallurgy of steel making in transition as well as slag metallurgy and by-product generation. In terms of projects, it currently includes **SuSteel** and **H2Future**.[34] The SuSteel technology is based on the idea of using hydrogen-plasma to combine the hitherto separated process steps of iron ore reduction and steel making into one single process (Hydrogen Plasma Smelting Reduction: HPSR). H2 Future aims at full scale demonstration of hydrogen production through PEM-H2-electrolysis and integration of renewable electricity, Hydrogen production and integrated steel making.<br><br>The currently running H2Future and SuSteel projects shall be followed-up and expanded. In addition, a large scale project on steel metallurgy and related slag | Follow-up of H2 Future: TRL 7-8, follow-up of SuSteel: TRL 6, slag and steel metallurgy: TRL 8-9, raw materials beneficiation TRL 2-4 | At least - 80% | Austria |

[30] https://salcos.salzgitter-ag.com
[31] https://www.green-industrial-hydrogen.com/
[32] https://www.windh2.de
[33] www.voestalpine.com/blog/en/innovationen/the-three-pillars-of-decarbonization
[34] www.h2future-project.eu/

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| | metallurgy and by-product making is being sought to be established. In parallel, there is intention to develop projects on related raw materials beneficiation. | | | |
| **Carbon Direct Avoidance: hydrogen-based metallurgy** | In a first step, $CO_2$ avoidance by converting the blast furnace operation to hydrogen, i.e. instead of carbon (CO) in the form of injection coal, hydrogen (H2) is used as a reducing agent in the existing blast furnace process and water vapour instead of $CO_2$ is released;<br><br>Subsequently, the blast furnace route is gradually converted to so-called direct reduction plants (DR plants) by 2050. These do not produce liquid pig iron, but sponge iron ("Direct Reduced Iron", DRI), which is further processed into crude steel in electric arc furnaces.<br><br>The direct reduction is to be achieved by gradually increasing the input of hydrogen for a sustainable carbon neutral steel production[35]. | n.a. | Step 1: Reduction of approx. 20 % of the $CO_2$ produced and thus significant modification of the blast furnace process<br><br>Subsequently: Significant $CO_2$ reduction in line with the Paris climate targets | Germany |
| **Carbon Direct Avoidance: electricity-based metallurgy** | **SIDERWIN**[36]: Development of new methodologieS[37] for InDustrial $CO_2$-freE steel pRoduction by electroWINning. SIDERWIN [38](previously ULCOWIN) is based on $CO_2$-free steelmaking through electrolysis, transforming iron oxide (e.g. hematite) into a steel plate (at the cathode) and oxygen (anode) | After SIDERWIN, TRL 6 | 87% (Reduction by 87% of direct $CO_2$ emissions) | France |
| **$CO_2$ valorisation** | **Carbon2Chem**. Aiming at using emissions from steel production as raw material for base chemicals (e.g. synthetic fuels, fertilizers and polymers) in a cross-industrial | TRL 7-8 | Utilization of approx. 60% of the top gases without | Germany |

[35] https://www.thyssenkrupp-steel.com/de/unternehmen/nachhaltigkeit/klimastrategie/
[36] https://www.siderwin-spire.eu/
[37] Siderwin Work Packages (2018). Work packages. Available at: https://www.siderwinspire.eu/content/work-packages
[38] CORDIS – SIDERWIN (2017). Development of new methodologies for industrial CO2-free steel production by electrowinning. Available at: https://cordis.europa.eu/project/rcn/211930_en.html

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| | network<br><br>www.thyssenkrupp.com/en/carbon2chem/#420627<br><br>https://onlinelibrary.wiley.com/toc/15222640/2018/90/10<br><br>www.thebiojournal.com/60-million-euros-forcarbon2chem-project/ | | necessary changes to the steel production assets; Potential of > 90% top gas utilization in the long-term | |
| $CO_2$ valorisation | **H2Steel**, consisting of CCU and CDA projects. The CCU part of H2Steel currently can be clustered into two planned project groups. These are called "**Power-to-Hydrocarbons Demonstration**" and "**BIO ABC**".<br><br>"Power-to-Hydrocarbons Demonstration" covers the use of electrolytically produced Hydrogen for the production of alcohol and methane and the "geomethanisation" which aims to convert in geological underground formations electrolytically produced H2 and $CO_2$ via bacteria into methane.<br><br>"BIO ABC aims to apply a 2-step bioprocessing solution to convert high amounts of industrial $CO_2$ into the biofuel butanol. | Production of alcohol and methane: TRL 5-7,<br><br>Geomethanisation: TRL 5-7,<br><br>Buthanol production by bioprocessing: TRL 3 | Depends on choice of system boundary for $CO_2$-emission calculation - harmonised methodology needed | Austria |
| $CO_2$ valorisation | **Everest** – Enhancing Value by Emissions Re-use and Emissions Storage. The Everest project is designed in combination with the Athos project<br><br>Using Works Arising Gases from steelmaking for the production of hydrocarbons (CCU), combined with Carbon Capture and Storage (CCS). Production of hydrocarbons is achieved through catalytic Fischer-Tropsch conversion of syngas from which the $CO_2$ has been removed[39]. | TRL: 6-8 | | Netherlands |
| $CO_2$ valorisation | **CARBON2VALUE**[40]: Development and demonstration of low CARBON technologies to transform $CO_2$ and CO streams from the steel industry into new VALUE chains | TRL 6 | | Belgium, Netherlands |

[39] Progress for Dutch carbon capture - CO2 - CATO;_20190114_144131_2019.1.14_Carbon_Capture_Journal_CATO_article.pdf
[40] https://www.carbon2value.be/en

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| $CO_2$ valorisation | **GENESIS**[41]: High performance membranes to capture $CO_2$ | TRL 5 | | Belgium, Netherlands, Latvia, France |
| $CO_2$ valorisation | **STEELANOL**[42]: Steelanol recycles carbon into sustainable, advanced bio-ethanol[43][44] | TRL 9 | Reduced direct emissions and<br><br>65% secondary reduction.<br><br>($CO_2$ emissions from Steelanol-biofuels are 50-70% lower than petroleum-based fuels, and around 35%<br><br>Compared to when steel plant off-gases are converted into electricity. If fully deployed,<br><br>emission reductions of 65% could be achieved | Belgium |

[41] https://www.genesis-h2020.eu/
[42] http://www.steelanol.eu/en
[43] Vlaamseklimattop (2015). Project "Steelanol" - First commercial project for advanced bio-fuel production from waste gas. Available at: http://www.vlaamseklimaattop.be/sites/default/files/ atoms/files/ArcelorMittal%20- %20project%20Steelanol.pdf
[44] INEA (2017). Horizon 2020 – Energy and Transport. Compendium of projects implemented by INEA. Available at: https://ec.europa.eu/inea/sites/inea/files/h2020-compendium_20sider17_web.pdf

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| | | | through EU<br><br>bioethanol production | |
| $CO_2$ valorisation | TORRERO[45]: TORrefying wood with Ethanol as a Renewable Output: large-scale demonstration | TRL 8 | | Belgium, Netherlands |
| $CO_2$ valorisation | BIOCON-$CO_2$[46]: BIOtechnological processes based on microbial platforms for the CONversion of $CO_2$ from the iron and steel industry into commodities for chemicals and plastics | TRL 4 | | Spain, France, Belgium, Germany |
| $CO_2$ valorisation | eForFuel[47]: eForFuel develops an industrial biotechnology solution that uses electricity and microorganisms to convert $CO_2$ into hydrocarbon fuels, thus providing a sustainable replacement of fossil carbons. | TRL 4 | | Belgium |
| $CO_2$ valorisation | CARBON4PUR[48] - see Covestro | TRL 5 (pilot plant TRL 7 at Dormagen on clean $CO_2$) | 20% $CO_2$ in Polyol | France, Germany |
| $CO_2$ valorisation | STEEL2CHEMICALS | | | Belgium, Netherlands |
| $CO_2$ valorisation | BOF2UREA[49]: The project objective is to contribute towards the reduction of the impact on the climate of industrial activity through the production of urea from the energy and carbon in residual gases in integrated steel plants, using process- and cost-efficient technologies, while simultaneously delivering storage ready $CO_2$ at no extra costs. | TRL 5 (SEWGS is being tested at SSAB). The ammonia and urea reactors ARE at TRL 9 | 24 % $CO_2$ per ton of urea | Belgium, Netherlands |
| Carbon Capture and Storage (CCS) | ATHOS - $CO_2$ transport and storage on the Dutch Continental part of the North Sea. The Athos project is to be seen in combination with the Everest project[50] | TRL 8-9 | Infrastructure project by consortium of | Netherlands |

[45] http://www.torero.eu/
[46] https://biocon-co2.eu/
[47] https://www.eforfuel.eu/project-ambition/
[48] https://www.carbon4pur.eu/
[49] https://projecten.topsectorenergie.nl/projecten/basic-oxygen-furnace-gas-to-urea-00031352
[50] Progress for Dutch carbon capture - CO2 - CATO;_20190114_144131_2019.1.14_Carbon_Capture_Journal_CATO_article.pdf

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| | | | Gasunie, EBN, Port of Amsterdam and Tata Steel. Aim: Transport and storage of 95% $CO_2$ enriched flow | |
| **Carbon Capture and Storage (CCS)** | **3D DMX**: carbon capture project[51] | TRL 6 | | France |
| **Process Integration** | **Hisarna**[52] - process integration (with CCS) - HIsarna is a new type of furnace in which iron ore is directly injected, and liquefied in a high-temperature cyclone so that it drips to the bottom of the reactor where powder coal is injected. The two react into liquid iron. | TRL 7 | Min 20% emission mitigation;<br><br>35% (with high scrap use);<br><br>80% (with CCS) | Netherlands |
| **Process Integration** | **IGAR**: upgrading of blast furnace gas. Based on process-integrated $CO_2$-capture through top-gas recycling in a blast furnace. Use of plasma torch and reactor to heat and reform gases, enabling less coke/coal consumption. | n.a. | n.a.<br><br>(Potential $CO_2$ savings of 0,1 - 0,3 ton $CO_2$/ton of crude steel) | France |
| **Process Integration** | **BAMBOO**[53]: waste heat recovery | TRL 5 | | Spain, Italy |
| **Eco-design and resource efficiency, including recycling** | **RESLAG**[54]: Turning waste from steel industry into valuable low cost feedstock for energy intensive industry | TRL 6 | | Spain |
| **Eco-design and resource efficiency,** | **URBCON**[55]: By-products for sustainable concrete in the urban environment | Aim to build buildings | 25% $CO_2$ capture | Belgium, |

[51] https://az659834.vo.msecnd.net/eventsairwesteuprod/production-ieaghg-public/99281ccc0213400fb834be0b073de482
[52] HIsarna Factsheet (2018) - www.tatasteeleurope.com
Eurofer (2017). EU ETS REVISION: Unlocking low carbon investments in the steel sector. Presentation 18.01.2017 (Strasbourg)
Birat, Jean-Pierre. (2017). Low-carbon alternative technologies in iron & steel. Presented at IEA 20.11.2017 (Paris). www.iea.org
[53] http://bambooproject.eu/project/
[54] http://www.reslag.eu/
[55] http://www.nweurope.eu/projects/project-search/urbcon-by-products-for-sustainable-concrete-in-the-urban-environment/

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| including recycling/Carbon Capture Storage, and Permanent Capture Technologies | | from carbonated BOF slag | per ton of slag | Netherlands, Germany |
| Chemical Valorisation of waste/Alternative raw materials and fuels including hydrogen | OSMet [56] proposes innovative methods to upgrade and utilize pulp&paper mill organic sludge (valuable elements of C and CaO) for various metallurgical applications as<br>1. Recipes will be designed to produce bio-briquettes for use in BF and CF<br>2. lime containing sludge from pulp&paper mills can be used in EAF and AOD | n.a.<br><br>30% reduction of direct $CO_2$ emissions in stainless avoiding lime and dolomite burning | TRL 4-6 | Sweden, Finland |

## List of Low $CO_2$ emission Technologies from the Cement sector

| Technological pathway | Project name/Description | Abatement potential | TRL | MS involvement |
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| Electrification of cement manufacture | CemZero[57] Electrification of cement manufacture | CemZero is only a desktop study stage and is not expected to reach TRL6 before 2030 | TRL 2-4 | -<br><br>Sweden |
| Electrification of cement manufacture | SolPart 2[58] - Solar calciner reactor technology able to reduce $CO_2$ generated during calcination process | Up to 40% of $CO_2$ emissions ($CO_2$ from fuels) | TRL 5 - 6 | Pan Europe |

[56] https://www.swerea.se/en/collaboration/member-programmes/welcome-to-prisma/updates
https://www.slu.se/en/departments/forest-biomaterials-technology/research/ongoing-projects/osmet-s2/
[57] https://bioenergyinternational.com/heat-power/cementa-vattenfall-launch-cemzero
[58] https://www.solpart-project.eu/

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| Alternative raw materials and fuels including hydrogen | **FISSAC project –** This involves stakeholders at all levels of the construction and demolition value chain to develop a methodology and software platform, to facilitate information exchange, that can support industrial symbiosis networks and replicate pilot schemes at local and regional levels. | Enabling the production of low-clinker cements. | TRL 6-7 | *Turkey* |
| Development of alternative cement products (low $CO_2$ binders) | **Alternative low carbon clinker - L**ower $CO_2$ clinkers based on calcium sulfoaluminate belite clinkers for applications with extended features and benefits. The aim is to provide a product with improved performance at lower specific $CO_2$ intensity using standard equipment. | Up to 20% $CO_2$ reduction vs Ordinary Portland Cement clinker | TRL 5 - 6 | Spain |
| Development of alternative cement products (low $CO_2$ binders) | **Futurecem - Limestone Calcined Clay Cement**[59] Alternative binder based on calcinated clay and limestone. Reduced clinker content up to 50%. Strength largely dependent on calcinated kaolinite content. | 30% $CO_2$ reduction compared to Portland cement | TRL 7 | Denmark |
| Development of alternative cement products (low $CO_2$ binders) | **Clay Calcination** - General purpose cement with reduced clinker content of approx. 50% by combining calcined clays and ground limestone. The aim is to provide options for the increasing scarcity of industrial by-products used as clinker replacement materials. | 30% $CO_2$ reduction potential vs Ordinary Portland Cement | TRL 5 - 6 | France |
| Development of alternative cement products (low $CO_2$ binders) | **Perfcon Prediction Tool** The project will deliver reliable data to assess the performance of concrete using e. g. new $CO_2$ efficient cements and recycled materials for the production of concrete under laboratory as well as field conditions taking into | As an example, with the implementation of CEM II/C-M cements for concretes of the exposure classes XC1-XC4 and XF1 (indoor and "normal" outdoor concrete), the $CO_2$ intensity of these concretes could be reduced by approx. 25% | TRL 5 - 8 | Pan Europe Project |

[59] http://www.aalborgportland.com.cn/en/innovation/534e3f323261b164.html

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| | account conditions on site and real exposure. | compared to the current average values. | | |
| Development of alternative cement products (low $CO_2$ binders) | **Ternocem** A new type of cement using waste slag from the aluminium industry | $CO_2$ reduction of 200kt/annum for this project, scalable across the EU where AL slag is available. | TRL 7 | |
| Electrical Efficiency: Innovative grinding technologies for cement manufacturing | **Advanced grinding technologies**[60] Decrease the electricity intensity of cement production beyond current best practice levels and provide means to manage more flexibly electricity demand. E.g. contact-free grinding systems, ultrasonic-comminution, high voltage power pulse fragmentation, low temperature comminution. | Targeting up to 30% in electrical energy for grinding. Related $CO_2$ reductions would be dependent on the $CO_2$ intensity of different electricity grids | A number of higher efficiency grinding technologies are currently at TRL 6 while others are in earlier stages of development | Germany R&D<br>Pan Europe<br>Project |
| Carbon Capture Storage, and Permanent Capture Technologies | **Norcem, Post Combustion CCS Project**[61] Tail-end separation of $CO_2$ from flue gas by e.g. chemical absorption, adsorption, membranes or Calcium Looping. A world-first project for CC within the cement industry has been underway at Norcem's plant in Brevik, since 2013. | $CO_2$ reduction of 400 ktons/annum for this specific project. The potential capture of 95% of total $CO_2$ emissions including process and fuels) at cement sites applying this technology | TRL 7 | *Norway* |
| Carbon Capture Storage, and Permanent Capture | **ECRA Oxyfuel CCS Project**[62] Using pure oxygen instead of air in combination with flue gas recirculation in order to provide a high $CO_2$ concentration exhaust gas stream for further capture; | Capture about 95% of total emissions (including process and fuel $CO_2$ emissions). | TRL 7 | Austria, Italy |

[60] https://ecra-online.org/fileadmin/redaktion/files/pdf/CSI_ECRA_Technology_Papers_2017.pdf
[61] NORCEM Breivik Project.
[62] ECRA Oxyfuel project

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| **Technologies** | two plot plants are ready to implement the technology, one in Retznei (Austria) and one in Collefero (Italy); | | | |
| **Carbon Capture Storage, and Permanent Capture Technologies** | **Leilac[63] Direct Separation Technology CCS Project** Enables pure $CO_2$ to be captured through re-engineering of the process flows of the calciners. This innovation requires minimal changes to the conventional processes for cement, replacing the calciner in the Preheater-Calciner Tower. | $CO_2$ reduction of 80kt/annum for pilot scale increasing to 600-1000kt/annum for demonstration phase of this project. Capture over 95% of process emissions or 60% reduction of total emissions | TRL 6-7 | Belgium |
| **Carbon Capture Storage, and Permanent Capture Technologies** | **Cleanker[64] Calcium Looping CCS Project** Advancing the integrated calcium-looping process for $CO_2$ capture in cement plants | Capture about 95% of total emissions (including process and fuel $CO_2$ emissions). | TRL 7 | Italy |
| **Carbon Capture Storage, and Permanent Capture Technologies** | **Methanation of $CO_2$ captured from kiln exhaust gases**. The aim is to make use of captured $CO_2$ and hydrogen and convert them into a synthetic fuel for multi-purpose use. | 100% of the $CO_2$ from the clinker line can be used at the final stage of the project | TRL 3 – 5 | tbc |
| **Carbon Capture Storage, and Permanent Capture Technologies** | **RECODE[65]** is to enable a circular-economy approach in the valorisation of carbon dioxide ($CO_2$) emitted during cement production. Novel carbon capture and conversion technologies will be tested under actual industrial conditions in a cement plant of TITAN Cement S.A., aiming to achieve at least 20% reduction in $CO_2$ emissions. The captured $CO_2$ will be used to | >20% reduction in $CO_2$ emissions during industrial trial. | TRL 6 | Greece |

[63] Leilac project.
[64] Cleanker Project
[65] https://www.recodeh2020.eu

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| | manufacture value-added chemicals and materials, which in turn will be used in cement production. | | | |
| **Carbon Capture Storage, and Permanent Capture Technologies** | **Fast Carb Recarbonation Project**[66] Accelerated carbonation technics to enable recycled aggregates from construction waste to absorb up to 50% $CO_2$. This results in an aggregate with reduced porosity which improves its quality as an aggregate for the use in concrete or road foundations. | Absorb up to 50% $CO_2$ | TRL 7 | France |

[11] CAPEX: Capital Expenditures
[12] OPEX: Operational Expenditures
[13] Worldsteel, 2015; IEA, 2014
[14] Croon, D., & Peters, K. 2018 European Steel. The Wind of Change.
[15] Allwood J 2016 A bright future for UK Steel. A strategy for innovation and leadership through up-cycling and integration. (University of Cambridge)
[16] Wyns T, Khandekar G and Robson I 2018 Industrial Value Chain. A Bridge towards a Carbon Neutral Europe. (Vrije Universiteit Brussel (VUB) - Institute for European Studies)
[17] Industrial Efficiency Technology Database Cement http://ietd.iipnetwork.org/content/cement (accessed 18.02.19)
[18] Portland Cement Association 2019 How Cement is made https://www.cement.org/cement-concrete-applications/how-cement-is-made (accessed 15.02.19)
[19] CEMBUREAU-The European Cement Association 2013 The role of cement in the 2050 Low Carbon Economy: Executive Summary
[20] Industrial Efficiency Technology Database Cement http://ietd.iipnetwork.org/content/cement (accessed 18.02.19)
[21] CLEANKER project http://www.cleanker.eu/the-project/project-contents (accessed 07.03.19)
[22] Aurélie Favier, Catherine De Wolf, Karen Scrivener, Guillaume Habert a Sustainable Future for the European Cement and Concrete Industry: Technology assessment for full decarbonisation of the industry by 2050
[23] Michael Taylor, Cecilia Tam, Dolf Gielen Energy Efficiency and $CO_2$ Emissions from the Global Cement Industry (International Energy Agency)
[24] EPOS project https://www.spire2030.eu/epos (accessed 13 Mar 2019)
[25] CEMBUREAU 2017 Status and prospects of co-processing of waste in EU cement plants.
[26] ECOFYS 2016 Market opportunities for use of alternative fuels in cement plants across the EU (ECOFYS)
[27] Morgana Fall, Vadim Yakovlev, Catherine Sahi, Inessa Baranova, Johnney Bowers, Gibran Esquenazi 2012 Energy Efficient Microwave Hybrid Processing of Lime for Cement, Steel, and Glass Industries - Final Technical Report (Ceralink Inc.)
[28] European Commission 2018 In-Depth Analysis in Support of the Commission Communication Com (2018) 773 - A Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy.

[66] https://fastcarb.fr/en/home/

[29] Bazzanella A M and Ausfelder F 2017 Low carbon energy and feedstock for the European chemical industry: Technology Study (DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.)
[30] PHOENIX Initiative A European Integrated Approach to $CO_2$ Valorisation http://www.phoenix-co2-valorisation.eu/) http://www.phoenix-co2-http://www.phoenix-co2-valorisation.eu/lw_resource/datapool/systemfiles/cbox/56/live/lw_datei/flyer-phoenix_180215_v6.pdf (accessed 6 Mar 2019)
[31]https://www.avantium.com/in-the-media/avantium-to-open-pilot-biorefinery-sights-already-set-on-commercial-scale-up/
[32] https://www.basf.com/global/en/media/news-releases/2019/01/p-19-103.html
[33] https://www.gasunie.nl/en/news/biomcn-to-produce-renewable-methanol-with-green-hydrogen
[34] Power-to-chemicals means the use of electricity for direct chemical transformations via direct electro-conversion.
[35] Power-to-hydrogen means the use of electricity for direct chemical transformations via hydrogen.
[36] http://www.mapsyn.eu/
[37]https://www.icis.com/explore/resources/news/2019/01/10/10304937/basf-aims-to-develop-electric-furnaces-for-steam-cracking-to-cut-co2-emissions/
[38] https://dechema.de/en/Low_carbon_chemical_industry-path-123212,124930.html
[39] https://qz.com/1100221/the-worlds-first-negative-emissions-plant-has-opened-in-iceland-turning-carbon-dioxide-into-stone/

[40] http://www.mefco2.eu/

[41] http://www.fresme.eu/

[42] http://www.carbonrecycling.is/news/2018/11/23/achieving-a-transition-to-a-low-carbon-energy-system

[43] SECIL 2016 Inauguration of Microalgae Production Unit http://www.secil-group.com/2016/10/28/inauguration-of-microalgae-production-unit/?lang=en (accessed 12.03.19)

[44] https://www.portofrotterdam.com/en/news-and-press-releases/partners-start-financing-waste-to-chemistry-project-in-rotterdam

# Hydrogen Technologies and systems

## SWOT analysis

### Strengths

- S1: EU strategy to keep up with decarbonisation
- S2: Strong R&D and skills across EU
- S3: Strong EU industrial base
- S4: Existing wide (stakeholder) ecosystem
- S5: Strong emphasis on demonstration (TRL --> MRL)

### Weaknesses

- W1: Uncertainties on concrete decarbonisation strategies
- W2: No real regulatory incentives
- W3: primary materials partly from outside EU
- W4: Industry and supply chain needs to be optimized
- W5: Over standardization or slow development of standards (depending on use case)
- W6: low (roundtrip) efficiency
- W7: R&D needed for innovative technologies (eff., costs), full SVC
- W8: Scale-up needed (MRL)
- W9: Asian players rapidly moving ahead
- W10: Lack of technology-, market-, business- strategies
- W11: Lack of clear, transparent, updated LCA comparison

### Opportunities

- O1: Climate and energy policy drivers (decarbonisation)
- O2: New regulatory framework
- O3: push for circular economy
- O4: Basis for future strong industrial H2 ecosystem
- O5: First mover advantage for additional standards
- O6: Local interest & invest basis for coordinated actions
- O7: ensure public acceptance
- O8: Sector coupling and sectoral integration
- O9: Job & growth creation (skills, businesses)
- O10: new end uses & businesses with H2 infrastructure
- O11. Momentum to develop clean hydrogen
- O12: Access to multiple sources of low carbon H2

### Threats

- T1: Lack of regulation, tariffs, certificates and GOs, etc.
- T2: Technology alternatives (are being developed or will reach readiness earlier)
- T3: Industrialization may not bring costs down
- T4: Chicken and egg problem for H2 ecosystem
- T5: development and deployment outside EU

- T6: missing public acceptance
- T7: Ambition too limited and/or lack of sufficient visibility

## Recommendations

### Hydrogen strategy (Develop an EU wide vision, roadmap, decision base)

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| R1 | Develop a joint **European wide vision and (integrated, concerted) masterplan/roadmap** for a future European Hydrogen Economy and ensure a **coordinated approach of the EU, national and regional** support to the H2 technologies. To do so, also create and agree on a joint **decision base.** |
| Short Description<br><br>(and concrete actions) | **(1) Vision:** Several countries have committed to and announced to build up a hydrogen economy (e.g. Japan, Korea) essentially as a way to decarbonize energy import. A clear vision on the different technologies, needs, actors to involve along the timeframe from 2020 to 2050 is needed.<br><br>**(2) Roadmap:** Also, a coordinated (cross-border) energy policy is needed. Based on a joint vision a coordinated/ commonly agreed roadmap should be prepared taking into account the following elements across regions and actors: compatibility, additivity, no dependency or inter-dependency.<br><br>**(3) Decision Base:** Analytical understanding (simulations, studies) together with a decision process are needed to decide on selected technologies, systems, utilization cases and their scale-up within the selected timeline for action. For any concerted roadmap and action plan the decision base should be founded on a transparent and fact based approach in order to ensure that the decision base is founded on realistic assessments of the needed RES capacity and thus market potential for H2 and its applications. At the same time it is essential taking into account strategies industrial players are ready to support (It is key to avoid "desk studies/roadmaps" as well as techno-push not backed by industrial players that are ready to invest). |
| SWOT Items referred to | |
| Timeline for action (implementation) | 2019-2022 (urgent |
| Actors:<br>Who needs to implement the action? | Member states under the umbrella of the EC (EU driven “Mission like” organised) |
| Prioritisation (from 1 to 10): | 10<br><br>It is very urgent, because with no vision and roadmap the other recommendations won’t be practicable. This first recommendation should therefore have the highest priority and should be implemented most quickly. |

### RDI (Ensure EU innovation leadership through continuous strong support to EU RDI)

| R2 | RDI along full value chain: Improve Round Trip Efficiency (continuous and integrated improvement of existing solutions) |
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| Short Description<br><br>(and concrete actions) | The efficiency of the "round trip" (P2H2 - H22P, including transport, storage, etc.) has to be improved<br><br>SoA >30-40% towards >40-60% . Improvements are expected in electrolysers and fuel cells, industry and heat sector, etc. that can meet these expectations specially when using waste heat as efficiency booster for Solid Oxide technology, however low temperature electrolysers are mature and hurting thermodynamic limitation. On top of that, in case hydrogen has to be transported over long distance and/or stored a significant loss of efficiency will have to be incurred. In practice, large scale G2P may remain reliant on CCGT in the mid-term despite the expected increase in SoA efficiency of Electrolysers and Fuel Cells.<br><br>Another unexplored opportunity is the coupling of H2 production with district heating. E.g. placing an electrolysis plant with a thermal plant (DHP) will increase energy efficiency as the electrolyser typically will require heat during start-up and produce surplus heat during the process. An integration will therefore minimise the heat loss. |
| SWOT Items referred to | |
| Timeline for action | 2020 towards 2030 |
| Actors:<br>Who needs to implement the action? | Public and private funding<br><br>Joint projects |

| R3a | Develop next generation key components |
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| Short Description<br><br>(and concrete actions) | Develop next generation key components and technologies for a future industrialized hydrogen value chain.<br><br>E.g. direct PV-to-Hydrogen (including photocatalysis), concentrated solar-to-hydrogen, direct Wind-to-Hydrogen, direct Power-to-hydrogen carrier, direct Hydrogen-carrier-to-Fuel cell |
| SWOT Items referred to | |
| Timeline for action | 2020 for industrialization until 2030 |

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| Actors:<br>Who needs to implement the action? | Public and private funding |

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| R3b | Development of PtX technologies (hydrogen derivatives) |
| Short Description<br><br>(and concrete actions) | Numerous studies have highlighted the problems inherent in the logistics of hydrogen as vector due to its ultra-low boiling point. These problems can be overcome by use of a hydrogen carrier, being renewable carbon or nitrogen. The strategies and thus support should therefore also include conversation technologies such as methanation, methanolisation, ammonia etc. in order to present cost effective solutions to sustainable power, mobility and materials.<br><br>Solely focusing on direct utilization may result in EU losing out on technologies where some MS are progressing rapidly and may result in a technology lock-in. |
| SWOT Items referred to | |
| Timeline for action | 2020-2030 |
| Actors:<br>Who needs to implement the action? | EU and MS |

H2 industrial ecosystem (strengthen a skilled workforce as backbone, industrialize key components, create a more mature supply chain, scale-up technologies for multiple-businesses, and create a circular economy)

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| R4 | Develop and strengthen highly skilled workforce in all parts of the value chain (as enabler and basis for a future H2 ecosystem) |
| Short Description<br><br>(and concrete actions) | Support integration of hydrogen technologies and systems (such as electrolysers and fuel cells) as main subjects in university and professional schools' engineering courses, in particular the latter. Ensure the conversion of HR currently dedicated to ICE towards electric appliances, electrolysers and fuel cells. |
| SWOT Items referred to | |
| Timeline for action | Beginning 2020 |
| Actors:<br>Who needs to implement the | |

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| action? | |
| R5 | Industrialisation of key components (e.g. high pressure tanks, stacks) - pilot manufacturing |
| Short Description<br><br>(and concrete actions) | Industrialize key components, e.g.<br><br>• High pressure tanks: In order to be cost effective, support the set-up of pilot manufacturing means to industrialize innovating composite 350b and 700b high pressure tank enabling highest H2 storage ratio at affordable cost compatible with mobile application. Containment systems should also consider any other green and hydrogen-based fuels which may be viable and commercially requested by use cases.<br>• Evaluate the viability of liquid organic hydrogen carriers<br>• Stacks: In order to be cost effective, support the set-up of pilot manufacturing means to industrialize PEM FC stacks based on innovating bipolar plates enabling power density and durability compatible with mobile application |
| SWOT Items referred to | |
| Timeline for action | Towards 2025 |
| Actors:<br>Who needs to implement the action? | |
| R6 | Support & create a more mature industrial structure/ supply chain (H2 ecosystem): coordinated growth, EU innovation leadership, JV & partnerships, SME integration, SME support |
| Short Description<br><br>(and concrete actions) | • Growth: encourage the growth of a competitive market<br>• EU innovation leadership: Develop an EU supply chain of at least 2 suppliers per critical components; In a global competitive market, it is important for the EU to support the creation of EU players, fit to compete with players from other parts of the world.<br>• Joint ventures: build joint ventures to ensure critical mass and thus create the "EU players" concept to include business/commercial partnerships and partnerships between several independent smaller companies that can compete together for the global market.<br>• SME integration: encourage a more specialized cooperation with increased added value for largely integrated innovative SMEs to favour strong supply chains. This opens opportunities for spill-over effects for new entrants + consolidates the sector.<br>• Study financing needs in particular for SMEs that develop/supply critical components and propose specific measures to address them. |
| SWOT Items | |

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| referred to | |
| Timeline for action | 2030 |
| Actors: Who needs to implement the action? | |
| R7 | Scale-up renewable and low carbon hydrogen technologies through an ecosystem approach (multi-usage approach) |
| Short Description<br><br>(and concrete actions) | Scaling-up renewable and low carbon hydrogen technologies and bringing costs down through mass-market effect requires to favour local ecosystemic approaches and adding up H2, or other green and hydrogen-based fuels, local uses.<br>Development pathways and corresponding support measures should incentivise multi usages approaches (for which there is a climate and economic rationale for Hydrogen), mainly industry, electricity, heat sector & heavy transport, instead of promoting application silos. |
| SWOT Items referred to | |
| Timeline for action | 2020+ --> |
| Actors: Who needs to implement the action? | |
| R8 | Create new business opportunities and markets and hydrogen derivatives as energy carriers for applying Hydrogen (experimentation capacities, use cases) |
| Short Description<br><br>(and concrete actions) | Experimentation capacities need to be generated (e.g. compared to leading non-EU countries like Japan, Korea, China, US, Canada). For this, use cases are needed to be identified (e.g. train sector, aviation, ports, airports, logistic centres, industry, heating, etc.) and supported.<br><br>Identify and address the existing barriers for adequately monetising positive externalities stemming from the usage of renewable and/or low carbon hydrogen and hydrogen derivatives in the several different applications and business sectors. |
| SWOT Items referred to | |
| Timeline for action | 2020-2030 |
| Actors: Who needs to implement the action? | |
| R9 | Circular economy: Create a highly integrated and seamless electrolyser and FC |

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| | system development, production and recycling |
| Short Description<br><br>(and concrete actions) | Creation of a holistic environment to cover all industrialization aspects of electrolyser and FC systems for mobile applications from cradle-to-grave<br><br>• Fostering low TRL research and linking it to higher TRL development enhancing innovation<br>• Establishment of development environments for continuous electrolyser and FC system product development<br>• Establishment of most advanced production environments for electrolyser and FC system products<br>• Establishment of recycling environment for electrolyser and FC systems to create closed material cycles ab initio. |
| Timeline for action | 2020 |

Public awareness, acceptance, and safety

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| R10 | **Ensure public awareness and acceptance:** inform on safety, inform market players and consumers on positive potentials, demonstrate feasibility (technical, economic, environmental, societal) |
| Short Description<br><br>(and concrete actions) | • **Inform on safety:** Prepare and publish a very comprehensive "booklet" on hydrogen safety meant for citizens with very clear, easy accessible information and examples. And all information needed to convince people about how the safety issues are solved by hydrogen experts. At one hand, the safety issue is a producer and developer responsibility. At the other hand the information campaign should be balanced also w.r.t. the level of resources spent on such an information campaign.<br>• **Inform (potential) market players and consumers about the positive potentials:** inform about the positive contribution of renewable and/or low carbon hydrogen to the environment. (In)form SMEs and ensure large public acceptance [if there is no information, no market and value chain could be formed]. Inform about the potentials and effectiveness of hydrogen (supply chain, economy, and ecosystem). It is important that support mechanisms take into account the overall benefit of the H2 value chain, including jobs and EU added-value. Information (campaigns) especially when it comes to end-user markets (e.g. FCEV) and trust in hydrogen use is needed for a broader diffusion.<br>• **Demonstrate that a hydrogen economy will be technically, economically, environmentally, societally feasible:** conduct and make visible demo-projects and business cases along the whole hydrogen value chain (production, storage & distribution, utilization) and demonstrate the safety along the hydrogen value chain. Identify the most feasible and fast way to develop production capacity and distribution network to support the transformation of use cases. |
| Timeline for action | 2025 |

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| R11 | **Ensure maximum safety for European citizens and create competitive advantage through standardization** |
| **Short Description**<br><br>**(and concrete actions)** | Ensured safety of technologies is needed (also to ensure awareness and acceptance of the citizens).<br><br>Additionally further Standardization work is needed for technical verification, deployment, usability, acceptance, etc. with a particular focus on<br><br>- Hydrogen metering<br><br>- Certification of transportable high pressure storage tanks for road vehicles<br><br>- Safety infrastructure of Hydrogen refuelling stations<br><br>- Testing and certification methods for hydrogen based power trains on inland water vehicles |
| **SWOT Items referred to** | W3, W10, O2, O5 |
| **Timeline for action** | Urgent (2019) |

Rregulative measures

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| R12 | **Adopt low carbon hydrogen and hydrogen based derivatives as the reference (based on CertifHy): develop a harmonized EU framework for certification, introduce guarantees of origin** |

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| Short Description<br><br>(and concrete actions) | **Definition:** Renewable and/or low carbon hydrogen and hydrogen based derivatives is needed to reduce EU GHG emissions in a cost-effective way. Much confusion remains on the definition of renewable and/or low-carbon hydrogen which should simply correspond to hydrogen whose production process has a carbon footprint lower than a given threshold, expressed in gCO2 per unit. As an example, green hydrogen produced with biomass as an energy source doesn't show a zero CO2 content. Referring to electrolysis, low-carbon hydrogen should be considered as hydrogen produced with low carbon electricity, including non-renewables electricity. Any definition should build on the approach developed in the European project CertifHy that defines 1. Renewable and low carbon hydrogen, 2.Low carbon hydrogen and has developed a full framework for guarantees of origin (https://www.certifhy.eu).<br><br>**Introduce Guarantees of Origin: GOs are necessary to trace the production of renewable and/or low carbon hydrogen and to allow end consumer to value it. GOs should also be created for "off-grid" projects, which do not feed into the gas grid (in particular in the industrial and mobility sectors). A harmonized European framework shall be developed based on the outcome of the European CertifHy project.**<br><br>**RED II implementation should provide revenue visibility (mandates mechanism usually not very effective): It is important to have a clear, unified definition for the different "types" of hydrogen. The discussions on this subject, e.g. within the framework of RED II, should be taken into account (e.g. concrete proposals (f.e. quotes) for the implementation of RED II (Art. 25) would be helpful)**<br><br>It is essential to act on both demand and offer to solve the chicken and egg problem. On demand, specific targets should be defined, and penalties or incentives set-up to make sure that these targets are met.<br><br>• Create a demand market for hydrogen, through a CO2 price mechanism<br>• RED II sets an objective in the transportation sector only, but we don't know how Member States will implement it, with or without penalties |
| SWOT Items referred to | O1, O2 |
| Timeline for action | Urgent, RED II related, 2020 |
| Actors: Who needs to implement the action? | CertifHy Project, Member States, EC |

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| Short Description<br><br>(and concrete actions) | **Implementation of EU regulation (REDII, Clean Vehicle Directive, CO2 emission performance standard, AFID, ETS etc.) should provide revenue visibility:** It is essential to act on both demand and offer to solve the chicken and egg problem. On demand, it should be ensured that the various EU legislative frameworks provide a sufficient market-signal prompting a shift to renewable and low-carbon H2.<br><br>• Producers of black hydrogen at the moment receive free ETS allowances (hydrogen through steam reforming is an activity included under Annex I of the ETS Directive). However, hydrogen production through electrolysis is not part of Annex I, and thus doesn't receive ETS allowances (that could then be traded with, as electrolysis doesn't generate emissions). This widens the cost gap between black and green hydrogen, and disregards the decarbonisation value of green hydrogen. We believe same product should equal to same free allowances under ETS.<br>• There is a Delegated Act pending under Article 27 of REDII that should clarify when H2 can be considered as 100% renewable if taken from the grid. In that regard it is important that the requirements of additionality and documentation e.g. through green PPA/GOs are established in a way that does result in rigid rules that sets up unnecessary barriers to prove that the electricity I renewable while at the same time ensures that the production of renewable H2 is not based on old hydroplants and or lead to increased fossil electricity generation. |
| SWOT Items referred to | - |
| Timeline for action | Urgent, related to the implementation of above mentioned regulation. |
| Actors: Who needs to implement the action? | EU and MS |

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| R13 | Set up **regulatory measures** (positive legislative and regulatory framework) for a hydrogen economy to evolve |
| Short Description<br><br>(and concrete actions) | Long positive, lasting & stable legal, tax, and regulatory framework: As for every investment-intensive industrial sector, H2 needs a coherent and stable long lasting legislative framework to allow investors to take decisions. Simplify legislation and administrative procedures (in particular for permitting)<br><br>• Develop relevant regulatory framework to provide a value to zero-emission products, especially in end-use segments where hydrogen is required and where build-out of infrastructure requires clear and stable long term policy framework such as transport (persons, goods : distribution/logistics fleets, regional and long haul trucks) where policies shall be designed to |

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| | promote/incentivize/force a share of zero-emission vehicles<br>• apply incentivising **tax regime** for renewable and low carbon hydrogen<br>  ○ E.g. taxation regime for electrolysis: water electrolysis is currently out of the scope of the directive which defines common European framework for the taxation of energy products and electricity. This should be maintained, not to burden the cost of efficient decarbonisation technologies. Tax exemption should apply to low carbon hydrogen if used as a fuel for transport or other energy/industrial uses.<br>  ○ e.g. apply incentive tax regime for distributed fuel cells CHP systems running on hydrogen (factoring in the advantages of using highly efficient FC CHP systems while addressing its cost premium disadvantage at an early market stage)<br>• ensure that services electrolysers and fuel cells offer to the power grid can be captured by hydrogen stakeholders to reduce the cost related to electricity, which is an important component of the renewable and/or low carbon hydrogen price to the final user<br>• **Harmonize EU regulations** on H2 generation, storage & distribution (gaseous and liquid), refuelling, utilization to facilitate installation and operation – clarify permitting process<br>• **A CO2 price coherent with the decarbonisation target:** Reaching the long-term climate goal for EU may require to fine-**tune or complement the already existing ETS** system so as to reach an incentivizing CO2 price, together with a series of additional measures (standards, targeted support). Set an adequate mechanism at EU level to increase competitiveness of renewable and low carbon hydrogen and enable their deployment.<br>• **Requirements and rules** for Hydrogen generation, storage and distribution: Define the rules and responsibilities of market players in relation to P2G (ownership, unbundling, rules); Requirements for development of joint gas and electricity network plans (P2G); Agree on admissible concentration of H2 admixtures in the existing gas grid<br>• **Incentivise/ value storage & conversion technologies:** In a fully decarbonised electricity generation scenario, large quantities of renewable electricity will need to be curtailed at peak times. The use of P2G and seasonal storage should be enabled via the market design on a level playing field with the other storage source, thus avoiding curtailment. Storage and release from storage must not be treated as consumption and generation of electricity. As an example, H2 energy storage could be favoured through the reduction of transport taxes vs other energy sources. |
| SWOT Items | |
| Timeline for action | |
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| R14 | Access to finance and innovative financing tools |

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| Short Description<br><br>(and concrete actions) | **Access to institutional instruments:** Renewable and/or low carbon hydrogen solutions should be eligible to financing instruments designed to support the energy transition, such as the European Fund for Strategic Investment or InnovFin operated by EIB, or National / Regional partnering financial institutions. Renewable and/or low carbon H2 shall benefit from existing institutional instruments which lead to lower risk investments for private investors.<br><br>**State aid guidelines:** Hydrogen production, storage, transmission and distribution shall be made eligible to public financial support under the Energy and Environmental Guidelines (EEAG), as market only mechanisms does not foster the emergence of renewable and low carbon hydrogen.<br><br>**Develop new instruments:** In addition to the existing portfolio of instruments, new instruments should be developed to mitigate the risk in the early phase of market scale-up, such as guarantee schemes to de-risk investment in refuelling infrastructure for FCEV (e.g. Guarantee mitigating the risk of low utilization due to lack of sufficiently ambitious mandatory targets for zero-emission vehicles). |
| SWOT Items referred to | |
| Timeline for action | 2019/2020 to review/adapt existing tools to H2 markets scale-up and develop innovative tools such as guarantees (e.g. COM has already started a process in terms of reviewing state aid rules post 2020[67]) |
| Actors:<br>Who needs to implement the action? | Members state, industrial investors, finance sector, EC, public/para-public banks, commercial banks |

Hydrogen Production

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| R15 | **Level playing field for renewable and low carbon H2 production** |
| Short Description<br><br>(and concrete actions) | The production of conventional hydrogen is on the carbon leakage list up to 2030. The CO2 price will not drive decarbonisation. Thus, there is a need to eliminate the competitive disadvantage for renewable and low carbon hydrogen, i.e. via certificates (carbon import tax) or additional support. Thus, set-up, on a temporary basis, a support mechanism to compensate the lack of economic competitiveness of renewable and low carbon hydrogen compared to grey imported hydrogen. (also related to regulatory measures). It shall be set –up through guarantee of origin (GO) system to allow the markets players to differentiate the low carbon option from the |

[67] The validity of the current version of the EEAG has been prolonged until 2022 – see press release: https://europa.eu/rapid/press-release_IP-19-182_en.htm

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| | not low carbon. |
| SWOT Items referred to | |
| Timeline for action | 2020 - 2025 |
| Actors: Who needs to implement the action? | EU + MS |

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| R16 | Hydrogen Production: Identify "no regrets" options and development of large scale (>1 GW) electrolyser plants |
| Short Description<br><br>(and concrete actions) | Larger scale, central production, flexible electrolysers to produce at scale hydrogen while providing services back to the power grid. E.g. if assets are not well seated there may be a risk of stranded assets.<br><br>• Provide infrastructure to supply the power<br>• Guarantee of power supply at competitive price and in required quantities<br><br>Large scale electrolysis and hydrogen derivatives plants can be constructed at sites of stranded renewable energy resources such as Northern Germany or the North Sea, where exploitation of abundant wind resources is limited by lack of transmission infrastructure.<br><br>Governments and public actors should enable and incentivise exploiting those resources for producing hydrogen derivatives. |
| SWOT Items referred to | |
| Timeline for action | 2025 |
| Actors: Who needs to implement the action? | Industry, EU (It is up to the commission to create a 'no-regret' option, once it is demonstrated the industry can start investing.) |

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| R17 | Push forward alternative (to electrolysis) hydrogen production technologies,<br><br>develop energy-efficient technologies and scale-up production |
| Short Description<br><br>(and concrete actions) | Investment in scale-up of renewable and low carbon hydrogen production needs to be incentivised. Development work which leads to large-scale hydrogen production via alternative routes using renewable energy sources (e.g. photocatalysis, concentrated solar splitting) and large-scale seasonal storage technologies needs to be undertaken. Funding programmes and funding of implementation projects need to be continued, e.g.<br><br>• short-mid-term: renewable hydrogen (electrolysis) and low carbon hydrogen (SMR+CCS, as bridge technology) and<br>• long-term renewable hydrogen beyond electrolysis (e.g. photocatalysis, concentrated solar splitting)<br><br>Investment in optimization of biomass-to-H2 and waste-to-H2 processes following a circular economy approach. Funding projects for scaling up the technology to TRL>6 aiming at increasing efficiency and reducing costs. |
| SWOT Items referred to | |
| Timeline for action | 2020 : develop plans for low carbon production and implement first projects<br><br>to 2025 (short-mid), --> 2030+ for long-term alternatives |
| Actors:<br>Who needs to implement the action? | Industry + R&D, continuous improvement,<br><br>support by funding (MS, EU)<br><br>SME |

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| R18 | Develop/create renewable and low carbon hydrogen production bases |
| Short Description<br><br>(and concrete actions) | Development of production bases for renewable and low-carbon hydrogen, close to existing hydrogen demand centres to be linked with locations/hubs (e.g. airports, ports, railways stations) where demand develops, esp. through IPCEI) |
| SWOT Items referred to | |
| Timeline for action | 2025 |

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| Actors:<br>Who needs to implement the action? | Industry |

Hydrogen Storage & Distribution

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| R19 | Push forward large scale hydrogen-energy storage and hydrogen based energy carriers for sustainable energy resilience and security |
| Short Description<br><br>(and concrete actions) | In view of its flexibility as an energy carrier (from renewables integration to gas usage for power, heat, industry and mobility needs) support the development of large scale hydrogen-energy storage and hydrogen based energy carrier facilities. To enable the monetisation of its energy security role, include hydrogen and derivatives as part of the minimum energy stock obligations of Member States. |
| SWOT Items referred to | |
| Timeline for action | 2030 |
| Actors:<br>Who needs to implement the action? | Industry<br><br>MS, TSO |

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| R20 | Hydrogen Distribution: Build on existing grids/ pipelines |
| Short Description<br><br>(and concrete actions) | Create the backbone of hydrogen infrastructure to decarbonise today's oil and gas usages. E.g.:<br><br>• Hydrogen Refuelling Stations for all main mobility potential users, e.g. heavy duty road vehicles (core and comprehensive networks under the TEN-T corridors), railway (main train stations), ports, airports, logistic centres, etc.<br>• Enable the blending of larger percentages of hydrogen into the natural gas (NG) grid in a harmonised way throughout Europe (this will depend a lot on the end-use of the NG grid)<br>• Potentiate the upgrading/retrofitting of NG grid for full flexibility and compatibility with larger share of H2 blending<br>• Evaluate and test the hydrogen transport via oil pipelines or supply gas stations by truck with hydrogen carriers like LOHC or ammonia |
| SWOT Items referred to | |
| Timeline for action | 2030 |

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| Actors:<br>Who needs to implement the action? | Industry, Grid operators |

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| R21 | Develop airports/railroad stations/ports as hubs for hydrogen logistics |
| Short Description<br><br>(and concrete actions) | Airports/ports/railway stations/etc. Have the potential to combine many heavy users of hydrogen and liquid fuels processed from hydrogen: aviation, road transport, railways, heat and stationary power for buildings…<br><br>Enable those as hydrogen hubs:<br><br>• Develop regulations facilitating the installation of hydrogen storage on or near airports/ports/railway stations, , especially for LH2<br>• Incentivize the development of large-scale hydrogen storage and transport infrastructure at airports/ports/railway stations.<br>• Incite gradually increasing use of CO2-neutral fuels in aviation/port/.. activities.<br>• trial different H2 transport and storage technologies for different hubs to have the best possible understanding of logistics aspects |
| SWOT Items referred to | |
| Timeline for action | 2020: set up first hubs, understand the characteristics of H2 transport options (cost, operation), technologies are further matured, define applicable regulations for deployment of further hubs<br><br>2025: develop several hubs (e.g. ~10)<br><br>2030 |
| Actors:<br>Who needs to implement the action? | Industry, airport and port managers, standardisation organisations, aviation authorities, fire authorities |

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| R22 | Develop technologies for large-scale use of liquid hydrogen and liquid hydrogen derivatives like ammonia in order to create a liquid hydrogen supply chain |

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| Short Description<br><br>(and concrete actions) | Liquid hydrogen and derivatives will be necessary to support large-scale use of hydrogen. The development and growth of European capabilities, leveraging existing operational and technology expertise, on the liquid hydrogen pathways is needed including:<br><br>• Develop innovative and affordable (energy-efficient) technologies for hydrogen liquefaction and storage, including related components and systems<br>• Develop affordable liquid hydrogen transportation with minimum losses.<br>• Develop advanced refuelling stations to optimize LH2 use for LDV and HDV hydrogen mobility (process, materials, components) and their industrialization<br>• In parallel, develop/adapt the relevant standards, associated regulation |
| SWOT Items referred to | T6, W5 |
| Timeline for action | 2020 (adapt standards), develop/test, 2025 (start-up first LH2 stations) |
| Actors:<br>Who needs to implement the action? | Industry (industrial gas regulators), component suppliers (valves, pumps, materials) |

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| R23 | Develop further technologies for alternative hydrogen storage and transportation |
| Short Description<br><br>(and concrete actions) | Various technologies will ease the logistics of large amounts of hydrogen: LOHC, metal hydrides, ammonia.<br><br>Research should be promoted in these fields to enable the re-use of existing oil infrastructure for hydrogen transport and storage. (fuel pipelines and trucking of liquid fuel). |
| SWOT Items referred to | |
| Timeline for action | 2025 |
| Actors:<br>Who needs to implement the action? | R&D + industry |

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| R24 | Deploy and test alternative technologies for hydrogen storage and transportation in large scale |
| Short Description<br><br>(and concrete actions) | Various technologies ease the logistics of large amounts of hydrogen and are already fully developed but not yet deployed in large scale hydrogen storage and transport: LOHC.<br><br>Development and incentives in these areas should also prioritise scalable energy carriers (electro-fuels) like ammonia, methanol, DME etc. in heavy duty sectors like marine and power generation.<br><br>Support the deployment of these alternative technologies in large scale. , in particular addressing the important issue of fuel density when compared with more traditional ones. |
| SWOT Items referred to | |
| Timeline for action | 2025: clarify what would be the use cases and how these carriers would fit in an hydrogen economy (with focus on the need to have systemic approach) |
| Actors:<br>Who needs to implement the action? | R&D + industry |

Hydrogen Utilization: Industrial Use

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| R25 | Foster the use of renewable and/or low carbon hydrogen and hydrogen derivatives where it is the most cost effective |
| Short Description<br><br>(and concrete actions) | In order to be cost effective and provide the highest value, renewable and/or low carbon hydrogen should be directed primarily towards usages which are difficult to decarbonize, namely as raw material for industrial use or as a fuel for heavy and long haul transportation, aviation and shipping (provided they can afford the price). In particular maritime shipping which actually accounts for 20% of CO2 emissions of transport modality with further increase in long term forecasts. |
| SWOT Items referred to | tbc |
| Timeline for action | 2020 (2025) |
| Actors:<br>Who needs to implement the action? | Utilities, regions, EPC, integrators, supply chain, local authorities |

| R26 | Industrial use |
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| Short Description<br><br>(and concrete actions) | Usage of low carbon or renewable hydrogen either as a fuel for energy intensive industries or as feedstock to decarbonise the footprint of European industry. |
| SWOT Items referred to | |
| Timeline for action | 2020-2025<br><br>(If intermediate products in REDII are to be interpreted as H2 used for cleansing purposes in refineries this will already go into effect no later than 2021) |
| Actors:<br>Who needs to implement the action? | Refineries, steel, EPC, utilities (gas grid), regions, fertiliser and chemical producers |

Hydrogen Utilization: Mobility

| R27 | Level playing field for transport application |
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| Short Description<br><br>(and concrete actions) | Support mechanisms to alternative fuels for transport should ensure a level playing field so as to let the most competitive and efficient solutions emerge. This is particularly key for the different infrastructure support/subsidy that may be given to different zero emission technologies. (including to recharging infrastructure and grid upgrade that shall be quantified with H2 beenfiting from similar level of support). |
| SWOT Items referred to | tbc |
| Timeline for action | 2020 |
| Actors:<br>Who needs to implement the action? | EU + MS |

| R28 | Push forward the penetration of hydrogen into Road Mobility |
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| Short Description<br><br>(and concrete actions) | Focus support on heavy duty vehicles (HDV) with long range and intensive usage profiles (double shifters, etc.), including captive fleets (and their related infrastructure at the depo) |

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| SWOT Items referred to | |
| Timeline for action | 2020, 2022 |
| Actors: Who needs to implement the action? | EU, MS |

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| R29 | Development of **zero emission MD/HD vehicles** to achieve European GHG targets (mobility package) |
| Short Description<br><br>(and concrete actions) | Support the development of an European offer for technologies for MD (buses, ..) and HD (trucks, …) mobility, covering the whole value chain:<br><br>• Industrialisation of key components and their integration in vehicles<br>• Development of H2 fuel cell trucks and development of manufacturing<br>• Development of sources (low carbon or renewable), of supply chain, with focus on innovative supply chains (very HP, Liquid H2) and of refuelling stations<br><br>The pre-commercial deployment of trucks in real-life conditions in captive fleets of sufficient size to have a valuable REX and feed-back to product development |
| SWOT Items referred to | |
| Timeline for action | 2020: initiate the roll-out in the early 2020s<br><br>2025: have an offer by a set of OEM for MD/HD vehicles on the European market |
| Actors: Who needs to implement the action? | Truck manufacturer, logistic companies, infrastructure and fuel supplier, public authorities |

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| R30 | Enable acceleration of zero emission public transport by developing value chain of **hydrogen buses - -> done** |
| Short Description<br><br>(and concrete actions) | In order to reach procurement targets as indicated in the Clean **Mobility Package**, hydrogen buses will be a good complement to electric battery buses to accelerate deployment of zero emission public transport. As Hydrogen buses are not at the same Manufacturing readiness level as battery buses, it is important to spur the different players of the value chain (from infrastructure to components) in order to be as competitive as the other alternative powertrain initiatives. |

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| SWOT Items referred to | W11 |
| Timeline for action | Now (2020) |
| Actors: Who needs to implement the action? | EU + MS |

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| R31 | Development and deployment of a Hydrogen based propulsion system for regional/local trains operating on non-electrified routes or segments |
| Short Description<br><br>(and concrete actions) | The development work for hydrogen trains (including their related infrastructure at the depot) is a viable alternative to diesel power and cost intensive overhead line electrification<br><br>- Set-up support mechanisms for the development and deployment of hydrogen trains<br><br>- Set-up support mechanisms for the development of infrastructure (HRS)<br><br>- Define a European certification framework for trains at European level (European Rail Agency)<br><br>- -LCCA analysis in order to do appropriate comparison with electrification<br><br>In addition, due to the volume of H2 to be stored for railway use, such projects can accelerate the availability of H2 storage for other mobility applications in the same area (e.g: buses, LDVs…).<br><br>- This deployment could be accelerated through the inclusion of rail in the scope of the Alternative Fuels Infrastructure Directive. |
| SWOT Items referred to | |
| Timeline for action | 2020: launch in different countries the development of adapted train platform<br><br>2025: first deployments made |
| Actors: Who needs to implement the action? | National PTOs with regional authorities, H2 supply companies, infrastructure companies, train OEM |

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| R32 | Push forward the Hydrogen based **in-land or coastal ships** as an alternative to highly pollutant diesel engines |
| Short Description<br><br>(and concrete actions) | Support replacement of current power trains on existing small vessels and barges with enough commercial life time and their related infrastructure in the river harbours and coastal areas<br><br>- Support the development of new hydrogen inland ships or costal vessels<br><br>- Support the related infrastructure (HRS)<br><br>- Develop positive, stable legislative and regulatory framework for hydrogen in-land ships and coastal vessels primarily at IMO level, then at any other relevant regulatory level.<br><br>Maritime and inland navigation have synergies:<br><br>(1) the application will be the same;<br><br>(2) synergies exist on technologies on board (and to a certain extent also at port)<br><br>(3) The same WATERBORNE Technology Platform is now addressing maritime AND inland navigation as the same ecosystem. |
| SWOT Items referred to | |
| Timeline for action | 2022 |
| Actors:<br>Who needs to implement the action? | River management, ship builders, ship operators, inland port authorities |

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| R33 | **Maritime vessels** Hydrogenisation/hydrogen derivatives: on-board integration of alternative fuels, of innovative technologies and of electrical distribution architecture, while ensuring the same ship's operational performances. |
| Short Description<br><br>(and concrete actions) | 1) Support the development and deployment of power trains for small to midsized and large vessels based on existing technologies and maritime clean alternative fuels, with particular reference to maritime constraints such as weight and volume of the system, or such as vibration, inclination and salinity of the operative environment; this development may also represent the springboard for scaling up for higher MW applications. |

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| | 2) Support the on-board integration of clean hydrogen based fuels and fuel cells and/or combustion engines that can burn for example green ammonia, including a complete reconfiguration of on-board Power Generation systems and electrical architecture. This may also include the heat generation.<br><br>3) Considering the SMR process for Hydrogen production as a possible and short/medium term technology for reducing the environmental footprint of ships.<br><br>3) Further refine technologies for Hydrogen or clean hydrogen based fuels storage on mid-size to large sea going vessels to increase the possible autonomy of these ships either for propulsion and/or for heavy hotel load<br><br>4) support and drive rules and regulations at IMO to remove obstacles to vessels powered by alternative fuels, namely clean hydrogen based fuels<br><br>5) Set up the infrastructure at sea ports for high capacity clean hydrogen based fuels refuelling and storage based on the efficient storage technologies |
| SWOT Items referred to | S1,S2,S4,S5,W2,W4,W7,W8,O1,O5,O6,O9,O11,T1,T4 |
| Timeline for action | 2025-2030 |
| Actors: Who needs to implement the action? | Shipbuilders, ship operators, classification societies, equipment suppliers (e.g. fuel cell technology providers, power distribution suppliers), ports and logistic for fuel infrastructure, academia. |

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| R34 | Utilization in **Air transport**: support the development of a <100 seater commercial passenger airplane |

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| Short Description<br><br>(and concrete actions) | While Hydrogen-based air-transport has only been demonstrated for small private planes so far, the technology exists also to enable short to mid-range commercial airplanes based on Hydrogen as the energy source. Development of related technologies should be pushed in particular relating to<br><br>- Hydrogen-burning jet engines for propulsion<br><br>- Efficient airworthy fuel cells for electricity production<br><br>- Light-weight liquid hydrogen tanks<br><br>- and airport mass LH2 storage methods,<br><br>so that the development of first demonstrations models can be launched. This should put the European aviation industry in the forefront of technology development for sustainable aviation.<br><br>Carry out demonstration projects with jet fuel blending of CO2-neutral fuels processed from electrolyser hydrogen and carbon from biomass, e.g. gasified biomass. For example combine with biochar (to be added to soils) to achieve negative emissions. |
| SWOT Items referred to | |
| Timeline for action | 2020: start adapting standard for H2 in planes and in airport (including LH2 storage and on-road transport)<br><br>2025: first design? First pilot? |
| Actors:<br>Who needs to implement the action? | Aircraft manufacturers, aviation authorities, hydrogen producers and transporters/infrastructure companies, airport operators and airlines. |

Hydrogen Mobility Utilization: Stationary/ Grid

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| R35 | Grid services |
| Short Description<br><br>(and concrete actions) | Enable the usage of the flexibility provided by hydrogen produced through electrolysis from renewable electricity for balancing the power grid, enhance demand side management and enable the integration of distributed FC CHP generation, aggregated in virtual power plants (VPP), to operate in the market. |
| SWOT Items referred to | |
| Timeline for action | 2030 |

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| Actors:<br>Who needs to implement the action? | TSO + Research organisation |

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| R36 | Use electrolysis flexibility to support the electricity system |
| Short Description<br><br>(and concrete actions) | Because of its capabilities to vary its power demand, electrolysis shall be made eligible and given access to flexibility revenue streams, ensuring a level-playing field in the electricity market |
| SWOT Items referred to | |
| Timeline for action | 2030 |
| Actors:<br>Who needs to implement the action? | Utilities, TSO |

# Industrial Internet of Things

## Scope and architectural layers

The value chain of IIoT is progressing and evolving rapidly. The value chain of IIoT can be structured along the way **data gets captured, transferred, processed and analysed** (in a centralized data centre or cloud)[68]. More recently, several trends and challenges have impacted this linear visualisation and demanded a more decentralised approach. More specifically, the following challenges are transforming this value chain:

- Latency issues. Latency refers to the time it takes for a given amount of data to be transferred across the network. Within IIoT settings, the number of connected devices and objects is increasing significantly and at the same time speed and fast data are becoming more crucial for many industrial processes (especially for time-critical processes where split-second reactions may be essential, e.g. asset management, critical power issues, process optimization, predictive analytics, and real-time needs of supply chain management). As such IIoT networks are increasingly requiring networks with extremely low latency.
- Network bandwidth issues. Bandwidth refers to the maximum amount of information or data that can be transmitted across a network channel in a certain period. As more and more data is transferred across IIoT networks, there is an increasingly strong pressure on bandwidth capacity. At the same time, this substantial increase of data makes that storage costs, energy costs and IT integration costs are surging.
- Reliability issues. The growing number of (inter)connected devices and objects also increases the risk of data losses or operational failures in the event of limited internet connectivity (this is especially the case when more remote assets get connected or when more assets in regions with unreliable internet connectivity get involved in IIoT networks).
- Security issues. As more and more data get transferred within IIoT networks, security concerns on transmitting sensitive business data across these networks are rising. Traditional IIoT settings where data gets stored and analysed in a centralized cloud or data centre are also vulnerable to well-coordinated cyberattacks and power outages.

These challenges strongly impact the IIoT value chain and more specifically, there is a trend towards edge computing. In edge computing, sensors, controllers, and other connected devices or objects capture and analyse IIoT data directly (or transmit it to a nearby computing device) rather than transferring the data to a centralized cloud (cloud-based computing) or data centre where the data get processed and analysed. When this data processing and analysis occurs at the edge of a network - as opposed to a centralized data centre or cloud - the data can be immediately analysed and put into action[6970]. Accordingly, one could state that in a more traditional IIoT setting, data is first captured,

[68] The European H2020 project "CREATE-IoT" referred to the IoT Data value chain, which includes the following processes: data acquisition, data transmission/ingestion, data processing, data storage, data filtering, data analysis/analytics, data integration, data discovery, data usage, data exposure (openness), and data monetization.

[69] https://business.sprint.com/blog/four-advantages-edge-computing/

[70] Gartner defines edge computing as “solutions that facilitate data processing at or near the source of data generation. For example, in the context of the Internet of Things (IoT), the sources of data generation are usually things with sensors or embedded devices. Edge computing serves as the decentralized extension of the campus networks, cellular networks, data centre networks or the cloud.” See:

transferred and then processed and analysed at a centralized location (most often the cloud). Edge computing however is based on a distributed computing environment, in which data is collected, processed, and analysed locally[71].

Edge computing has several advantages [72],[73],[74]:

- Faster response time and real-time analysis: As data is processed closer to the source, and not in a centralized data centre or cloud, this reduces latency and empowers faster responses. With lower latency levels, applications can also operate more efficiently and at faster speed.
- Reliable operations when intermittent connectivity: The local storage and processing of the data ensures there is no data loss or operational failure in the event of limited internet connectivity.
- Security and compliance: A lot of data transfer between devices and the centralized cloud or data centre is avoidable. Edge computing enables to filter sensitive information locally and only transmit important data to the centralized data centre or cloud. This allows users to build an adequate security and compliance framework that is essential for corporate network security.
- Cost-effective solutions: Edge computing can locally perform a lot of data computations, which allows businesses to decide which services to run locally and which ones to send to the centralized cloud or data centre, which reduces the final costs of an overall IoT solution.

The trend towards edge computing has a strong impact on the IIoT value chain. It is however important to note that edge computing will mainly complement and extend the traditional IIoT value chain (and its main building blocks). Not all data will be processed and analysed in the edge. Processing and analysing data in the cloud (or in a centralized data centre) still has its specific advantages such as computing power (especially needed to analyse large data sets, for machine learning and for developing artificial intelligence algorithms) and maintenance. As such, both systems (edge computing and centralized cloud computing) tend to work in conjunction in recent IIoT systems. The IIoT value chain as depicted in Figure 1 contains the following segments:

- Capturing data
- Pre-processing & (pre)analysing data
- Transferring data
- Processing data
- Analysing data

Several feedback loops exist between the various value chain segments (data for instance will not be transferred only from left to right but can also be send back in the process). The future IIoT solutions will evolve from a linear centralised value chain model to a decentralised and distributed value networks model across the different IIoT architectural layers (see graph in the main report).

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https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders/

[71] https://www.alibabacloud.com/knowledge/what-is-edge-computing

[72] https://iiot-world.com/smart-manufacturing/edge-computing-key-drivers-and-benefits-for-smart-manufacturing/

[73] https://www.rtinsights.com/edge-computing-unlocking-the-business-value-of-the-iot/

[74] https://internetofbusiness.com/shift-from-cloud-to-edge-computing/

## SWOT analysis

**Strengths**

- S1. A particular strength of the EU is the increasing abundance of institutionalized cooperation platforms at both regional and European level. These platforms not only stimulate collaboration across firms, but also between firms and public organisations and more recently across regions and countries. Some examples:
    - Regional level (clusters): Silicon Saxony (Germany), High Tech NL (the Netherlands), Silicon Alps (Austria), DSP Valley (Belgium), M4 corridor (UK), SCS cluster (France)
    - National and regional level (policy initiatives): In the individual Member States, policies and initiatives to support IoT have been launched as part of larger programs such as Plattform Industrie 4.0 (Germany) and Impresa 4.0 (Italy). Moreover, several European Regions include IIoT, Big Data and AI in their Smart Specialization Strategies[75]. Specific national plans have been launched on Artificial Intelligence[76].
    - European level (mainly with support of Horizon2020 funding): Silicon Europe, IoT European Research Cluster (IERC), the Alliance of Internet of Things Innovation (AIOTI), the Internet of Things European Platforms Initiative (IoT-EPI), H2020 IoT European Large-Scale Pilots Programme, H2020 8 IoT security and privacy projects, Smart Specialisation priorities related to IIoT/Big Data/Artificial Intelligence that make use of Structural Funds, Next Generation Internet (under the next EU Research and Innovation Framework Programme), , the IoT action plan for Europe, the European Artificial Intelligence Strategy, the European AI Alliance. A number of PPPs are also active in the Industrial data field (EFFRA, BDVA, SPIRE, … ). Additionally, the Key Enabling Technology (KET) Strategy has recently included AI, security and connectivity.
    - Global level with a strong European presence: 5G Automotive Association[77] (5GAA, with a large European member base, including founding members: AUDI AG, BMW Group, Daimler AG, Ericsson, and Nokia), 5G Alliance for Connected Industries and Automation[78] (5G-ACIA, forum for collaboration between automation, engineering and process industries on the one hand, and telecom operators, vendors and suppliers on the other hand).
- S2. Europe holds a strong position in network equipment technologies[79]. Examples of European leaders in this segment include Nokia, Swisscom, Vodafone, Ericsson and Siemens Networks. These companies are driving the development and deployment of LTE,

[75] Basque Smart Specialization Strategy 2020, Auvergne-Rhone-Alpes: Industries 2020 First, Lombardy' RIS3, Catalonia, Smart Puglia, Arctic Smartness, Austria RIS3,

[76] Austria (developing), Denmark, Estonia (developing bill), France, Germany, Italy (taskforce), Sweden, UK, the Netherlands

[77] http://5gaa.org/

[78] https://www.5g-acia.org/

[79] ATKearney (2016). Rebooting Europe's High-Tech Industry.

LTE-A, LTE-M and NB-IoT. Europe also has strong telecom operators (e.g. Orange), but these are mainly involved in software technologies while they do not own important hardware technologies. This stands in contrast to major Asian players such as Huawei that are active (and strong) in all segments of telecommunication technologies.

- S3. Europe holds a strong position on innovative advanced manufacturing technologies[80]. Additive Manufacturing is a notable example of that. As documented by industry reports, Europe is a leader in the development of Additive Manufacturing technologies[81].S4. Recently, the European Commission has undertaken multiple initiatives as part of the Digital Single Market Strategy (e.g. Digitising European Industry & European Data Economy with emphasis on Digital platforms and Digital Innovation Hubs)[82]. These initiatives should further stimulate the development of the European IIoT ecosystem.
- S5. As elaborated by the Task Force on Cybersecurity, the EU has a strong position in cybersecurity fields relating to security components, hardware security modules and security software. These market segments offer the EU a strong market position. Cybersecurity is considered an important enabling technology of the (industrial) internet of things[83], and the EU's strong position in this value chain segment is important in improving its industrial competitiveness in IIoT.
- S6. The Digital Transformation Scoreboard (2018) shows that the adoption rate of (Industrial) IoT technologies is rising rapidly. On top of this, it is shown that 65% of firms that implement IoT systems use it to be more competitive.
- S7. Europe had a strong position in microsystems and micro controller parts[84]. Leading companies in this field are Bosch, Infineon, STMicroelectronics and NXP.
- S8. Europe has a strong position in the areas of component and module manufacturing, especially in the field of semiconductors. Flanking EU policy measures have been taken to keep semiconductor production in Europe, such as ECSEL-JU[85]. Europe is however losing ground to North America, but especially to East Asia which has outpaced the rest of the world regarding the share of internationally filed patents in semiconductor technologies[86].
- S9. The surge of data captured by IIoT systems brings along issues related to (personal) privacy and the confidentiality and integrity of organization data. To derive the full benefits from IIoT, not only security risks, but also privacy risks need to be addressed. Within the context of data privacy, Europe has a strong position.

[80] http://europa.eu/rapid/press-release_MEMO-12-484_en.htm?locale=FR
[81] Wohlers Report 2018
[82] https://ec.europa.eu/digital-single-market/en/policies/shaping-digital-single-market
[83] E.g. Good Practices for Security of Internet of Things in the context of Smart Manufacturing (2018). A study by the European Union Agency for Network and Information Security. Available at: https://www.enisa.europa.eu/publications/good-practices-for-security-of-iot
[84] This was agreed by experts attending the first IIoT workshop in April 2019.
[85] https://www.ecsel.eu/
[86] Fraunhofer IMW (2018). Global competition in microelectronics industry from a European perspective: Technology, markets and implications for industrial policy. Available at: https://www.imw.fraunhofer.de/content/dam/moez/de/documents/Working_Paper/180301_021_Microelectronics%20from%20a%20European%20perspective_Dornbusch_%C3%B6ffentlich.pdf

Weaknesses

- W1. There is a strong concentration of European frontrunners in only a few West-European countries, namely the United Kingdom, Germany, and France. As such IIoT developments and adoption rates might be not that widespread across the European Union, leading to an unbalanced uptake of IIoT technologies across EU Member States.
- W2. There is a lack of transparency and clarity in terms of data ownership in Europe which might hamper the further development and deployment of IIoT technologies. It can be argued that data ownership in the EU is still not clearly defined or covered in contracts. However, in order to unleash the full potential of IIoT systems, a thorough understanding is required of the rights when data is produced by various connected devices/nodes. There is also a need for more clarity on data ownership in integrated IIoT systems crossing multiple companies and providers, taking the end-user into account[87]. Data ownership is however not always the issue, but rather access to the data and the associated regulation. Hence, there is a need to harmonize data regulations among EU Member States.
- W3. There is still a lack of standards and interoperability in Europe. This hampers the widespread breakthrough for IIoT systems and effective data sharing and access. as the "availability of ICT standards and technical specifications, in particular to provide for interoperability between products, services and devices, is critical to achieve all the benefits that the Digital Single Market can deliver" [88]. There is especially a lack of standardized communication protocols and intercloud operability.
- W4. Ubiquitous and high-speed connectivity is not available yet in the EU, especially in less populated regions. Furthermore, the penetration of high-bandwidth wireless technologies, needed to transmit large amounts of data, is still limited (reliable Wi-Fi networks are still missing in large parts of Europe for instance. Furthermore, 5G technology still has to be launched in Europe).
- W5. There are still important obstacles that hamper the further development of cybersecurity technologies in the EU[89]. Major weaknesses include the limited public and private investments and their highly fragmented nature in the EU, which weaken both the cybersecurity value chain as well as the IIoT value chain.
- W6. Currently, many applications are technically solvable, and the costs of setting up a working and effective platform based on IIoT, Big Data analytics and Artificial Intelligence and the costs related hardware components such as sensor nodes, actuators and suitable computer power are rapidly decreasing. However, the multitude of existing platforms with

[87] As stated by experts attending the first IIoT workshop in April 2019.

[88] European Commission (2018). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. The annual Union work programme for European standardisation for 2019. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0686&from=EN

[89] As pinpointed by the other Task force dealing with cybersecurity

different procedures and standards make it risky for companies to engage with such platforms as there is the danger to get locked-in by adopting the wrong platform[90]. .

- W7. The rapid growth of Big Data and Artificial Intelligence in the EU make that the demand for high performance computing (HPC) is expected to increase considerably in the coming years. However, a key challenge is to close the investment gap with other regions (especially the United States) to ensure that businesses, public sector authorities and researchers have sufficient and equal access to supercomputing facilities and services[91]. Currently only 5% of the HPC capabilities are being provided by European HPC centres, while a third of the global demand for HPC capabilities comes from the European industry [92]. In addition, the supply of IIoT infrastructure is scattered across Europe. In order to close the investment gap, significant investments in infrastructure, access to Big Data, the development of tailor-made complex software solutions, as well as investment in new business development are needed.
- W8. The venture capital market for IIoT in the EU is still less developed compared to the United States[93] which might have a negative impact on the number of start-ups and scaleups in the sector in the EU.
- W9. The IIoT value chain requires unique know how and skills. These profiles and skills are however increasingly difficult to find in the EU, especially as they require a higher level of multi-disciplinary knowledge entailing both traditional competences on advanced manufacturing processes as well as new software-driven competences. Moreover, given that the IIoT industry is growing rapidly in the EU, this skill shortage might increase substantially in the coming years and many firms that are embarking on IIoT projects will have problems finding sufficient people with the necessary IIoT skills to further develop their businesses.
- W10. The integration of new production technologies into existing production chains or industrial processes is progressing slow in the EU[94]. As a result, Europe is currently not tapping its full potential in terms of usage of new technologies.
- W11. Although the adoption rates of IoT technologies by firms is increasing in the EU, these technologies are still mainly adopted by larger firms according to the Digital Transformation index 2018. Furthermore, most manufacturers are not aware of the potential solutions that are available to digitize their company.
- W12. Europe lags behind in the field of connectivity technologies as this field of technology is increasingly dominated by non-European players such as Huawei and Qualcomm[95].

[90] Experts on the first IIoT workshop argued that IIoT platforms should be made more horizontal and should be able to serve different application domains.
[91] European Commission and European Investment Bank (2018). Innovation Finance Advisory Studies – Financing the further of supercomputing – how to increase investments in high performance computing in Europe.
[92] COM (2016) European Cloud Initiative- Building a competitive data and knowledge economy in Europe 178 final: page 5
[93] See for instance the CBinsights reports on VCs in the Internet of Things
[94] EC (2018). Digital Transformation Scoreboard 2018 from: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf

- W13. EU investments in ICT-related products and R&D are still limited. Investments in ICT-related products are for instance about three times as high in the US compared to the EU (between 2000-2014). R&D expenditures in ICT-related products are about twice as high in the US compared to the EU[96].
- W14. Europe is lagging behind in terms of satellite-based network technologies and its current network of satellites is rather limited. In the hyper-connected world of Industrial IoT, satellites can however add vital redundancy to territorial networks and enhance the resilience of the overall 5G network[97].
- W15. There is a risk of disputes over licensing and enforcement of key standard, essential patents on enabling IIOT telecommunication technologies. This may require EU IIoT implementers (including SMEs) to negotiate and take licenses or face the risk of patent infringement.
- W16. The European Digital Single Market is still not yet fully functioning, leading to fragmented European regional markets[98].

Opportunities

- O1. The report has argued that interoperability and standardization is critical to maximize the value of IIoT. A widespread breakthrough for IIoT systems for instance requires fully connected global ecosystem, which is only possible through interoperability across systems and regions. The development and adoption of global IoT standards is pivotal to support IIoT products and services in scaling-up and to ensure the advancement of the IIoT technology. Currently, initiatives have been taken to coordinate standardisation activities at the EU level[99]. Nevertheless, more activities could be undertaken to advance these developments[100].
- O2. The surge of data captured by IIoT systems brings along issues related to (personal) privacy and the confidentiality and integrity of organization data. According to an IDC survey of technology decision makers, these concerns are a very important hindrances for the acceptance and growth of IoT applications in general and the main cause of low levels of trust in these kinds of solutions. Accordingly, when one addresses these privacy and security risks, substantially more benefits from IIoT could be derived.
- O3. The EU Digital Single Market, as well as the Digital Innovation Hubs, create

[95] https://www.reuters.com/article/us-qualcomm-tech/qualcomm-launches-new-chip-to-power-5g-smart-phones-idUSKCN1Q81GE
[96] https://ec.europa.eu/jrc/en/news/latest-statistics-ict-sector-and-its-rd-investment-available
[97] https://www.newtec.eu/article/article/the-role-of-satellite-in-5g
[98] As argued by experts attending the first IIoT workshop on April 2019.
[99] For instance as part of the EU's ongoing IoT Large-scale Pilots and Existing PPPs in IoT.
[100] EU initiatives addressing standards could also include the development of FRAND (fair, reasonable and non-discriminatory) conditions for standard essential patents in enabling technologies. See also "Standard Essential Patents and the Internet of Things. Legal Affairs (2019). Policy Department for Citizens' Rights and Constitutional Affairs. DG for Internal Policies of the Union.
http://www.europarl.europa.eu/RegData/etudes/IDAN/2019/608854/IPOL_IDA(2019)608854_EN.pdf

opportunities for new IIoT start-ups and allow existing companies to reach a market of over 500 million people, which furthers boosts the competitiveness and scale of IIoT firms.

- O4. As regulations concerning data ownership are not clearly defined in Europe, it would be worthwhile to invest in initiatives that make data ownership in integrated IIoT systems crossing multiple companies and providers, more transparent. Additional value will be created when data is shared across organisations, allowing access to complementary data. In this respect, the creation of a pan-European data exchange platform that enables data sharing and data access to a wide variety of value chain actors offers opportunities.
- O5. Although several initiatives were recently launched to support IIoT adoption in EU, a common vision and coordination across these initiatives is lacking. Hence, an interesting opportunity lies in the improved coordination of existing initiatives and programmes across EU Members States to foster IIoT adoption.
- O6. 5G is crucial to run many IIoT applications. Hence, it will be important to speed up the roll out of 5G within Europe[101][102]. The way spectrum for 5G is allocated to different actors in the value chain (by auctions) however differs across EU Member states[103]. This spectrum allocation however should not make other industry players too dependent on others for their infrastructure[104].
- O7. Europe has a diverse mix of value chain actors spread across the different value chain segments of IIoT which enables a good understanding of the lifecycle and evolution of data within IIoT systems.
- O8. European players should focus more on the monetisation of data assets and flows as enormous opportunities arise when value chain actors share their data. Due to a lack of valuation, most European players are currently afraid or unwilling to share data. There is a need of new business models focusing on data sharing.
- O9. Europe holds a competitive position regarding services and platform aggregators. The European Union is particularly well placed in the field of embedded software & systems[105]. As these are crucial components of most IIoT systems, many European enterprises are strategically well placed in the IIoT value chain[106].
- O10. IIoT ecosystems and value chains include many types of stakeholders with different competences and needs, often spread across multiple regions. As such it remains important to stimulate cross-regional and cross-sectoral collaborations. It is also important to create more synergies among different funding schemes (H2020, Interreg, ESIF, structural funds, social funds, etc.).
- O11. Several relevant initiatives to boost Europe's position on IIoT, Big Data and artificial

[101] https://www.iotworldtoday.com/2019/03/18/how-5g-could-help-fuel-the-next-generation-of-iot-projects/
[102] https://www.networkworld.com/article/3268668/5g-to-become-the-catalyst-for-innovation-in-iot.html
[103] Most often the available spectrum is allocated to telecom operators.
[104] Here it is worth noting that the identification of spectrum for 5G and spectrum requirements are being discussed in Europe among the European Commission and EU Member States. Some harmonization rules on this aspect have already been agreed upon. See also: https://ec.europa.eu/digital-single-market/en/5G-international-cooperation

intelligence software are currently on-going, but most of these initiatives are oriented towards research organisations and are technology push-driven. One could focus more on the deployment barriers closer towards market commercialisation. Important synergies arise when living labs and test beds in different regions are better linked to each other. It can also be important to scale up the existing living labs.

- O12. The transition from centralized and cloud-based IIoT architectures toward edge-oriented IoT architectures, with intelligence moving toward endpoints, gateways and intelligent devices offers opportunities. Europe has an opportunity based on its adoption rate of (Industrial) IoT technologies to adapt intelligent edge and distributed intelligent dynamic flexible mesh. This will have a major impact on IIoT and intelligent connectivity infrastructure, skills and sourcing.
- O13. The acceleration of the deployment of intelligent connectivity infrastructure based on novel wireless networking technologies and techniques/slicing (e.g. 5G, low earth orbit (LEO) satellites, backscatter networking, etc.) balancing a set of different requirements, such as endpoint cost, power consumption/battery life, bandwidth, latency, connection density, operating cost, quality of service, range, operational conditions, etc. entails opportunities.

Threats

- T1. In the EU, there are large disparities in digitisation between regions and there is still a Digital Divide in several EU Member States[107]. Especially in newer Member States broadband penetration still remains low (in many rural areas, broadband penetration is virtually non-existing), which holds back development of IIoT systems and exacerbates the need for support. There is also a strong digital divide in terms of IIoT adoption rates.
- T2. Although Europe represents a very large potential market, it is composed mainly by SMEs and midcaps who are typically slower at adopting new technologies due to financial, skills and awareness constraints[108]. An excessive focus on the needs of large organisations only may hamper the further deployment of IIoT technologies in the EU.
- T3. The EU is increasingly investing in ICT-related products and R&D, but nevertheless other regions are investing substantially more[109]. Investments in ICT-related products are about three times as high in the US compared to the EU (between 2000-14). Additionally, R&D expenditures in ICT-related products are about two times as high in the US compared to the EU.
- T4. Although the EU is increasingly investing in artificial intelligence, it lacks behind the United States and China in terms of investments and strategic initiatives[110]. It is however

[107] https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry
[108] Guide To IoT Innovation (SME focus) – Achieving Innovation Performance – September 2017. Available at: https://iot-analytics.com/9-ways-smes-embrace-iot-innovation/
[109] https://ec.europa.eu/jrc/en/news/latest-statistics-ict-sector-and-its-rd-investment-available
[110] Digital Transformation Monitor (2018). USA-China-EU plans for AI: where do we stand?

claimed that artificial intelligence is one of the technologies within the IIoT value chain with the highest impact on competitiveness[111].

- T5. Many firms active in the IIoT value chain are currently struggling with finding employees with relevant skillsets. This shortage of skilled people will however continue to grow in the coming years.
- T6. There is currently a lack of awareness creation programmes focused on the adoption of IIoT, especially for SMEs[112].
- T7. There is an increasing market dominance of non-European players in the field of software, AI and data analytics. The market dominance of non-European players (such as Google) in some IIoT value chain segments is becoming alarmingly strong and is increasingly threatening the position of European players, especially given the observation that these firms are progressively insourcing related IIoT value chain activities.
- T8. The market for (management) software is nascent, but most frontrunners in this segment are still located in the United States and the EU threatens to lag behind in this important IIoT segment. Currently, there is also a strong dependence on software infrastructure from outside Europe.

[111] A report by PWC claimed that AI could contribute up to EUR 13.33 trillion to the global economy in 2030, with China and United States seeing the biggest impact (close to 70% of global economic impact).
[112] See for instance the Horizon2020 programme "IoT4Inustry". www.iot4industry.eu

# Cybersecurity

## Vision: “Cybersecurity Europe by 2030”

A common vision for the cybersecurity in Europe by 2030 was discussed and developed jointly during the first Workshop. This common vision can serve as a guide for formulating, prioritising and coordinating recommendations for actions. The various suggestions have been clustered in the following Vision points.

V1. Market share → EU is to be more competitive in the field of of cybersecurity solutions

- The EU, as a whole, imports 5.3% of its Cybersecurity products and services from non-EU sources. However, if one combines Cybersecurity imports from outside the EU with Cybersecurity sales made by International companies from operational bases established within the EU, the ‘effective’ imports from international companies headquartered outside the EU are between 26-30% of demand in 2016.
- Aim to be more competitive in the field of cybersecurity solutions by 2030 for cybersecurity products, services and infrastructure solutions.
- This corresponds to a market share growth of 1.5%~2%/year over 2020→2030.
- For meeting above targets: EU should have a real-time cybersecurity market data available for agile decision-making in order to meet KPIs

V2. Protection → EU is to increase levels of protection with appropriate cybersecurity solutions

- Many EU consumers, politicians and organisations are not aware of cybersecurity risks, and users not adequately protected.
- EU enterprises have high risk to lose their valuable IPRs (particularly, trade secrets and confidential business information) due to insufficient cybersecurity preparedness
- Our aim should be to raise awareness and ensure adequate solutions are deployed for all users in the EU.
- The EU should promote general awareness with a shared cybersecurity taxonomy and ontology, also multi-language (EU official supported languages). We need to make sure that progress in this matter can be measured, with KPIs captured by an observatory.
- We need to increase resilience: detect and respond more jointly, with high level of detection points in networks at EU-level (for states, companies, etc.).
- Cybersecurity does not exist and cannot be trusted by default. We need to consider cybersecurity and resilience by design to mitigate risk.
- The European Cybersecurity Certification Framework, due to enter into force by mid-2019, will create increased awareness and will help raise levels of cybersecurity for ICT products and services in the market, while at the same time reducing fragmentation of cybersecurity certification schemes at national level. We need to ensure its success.

V3. Independence → EU to increase its autonomy and digital sovereignty in cybersecurity

- We need competitive and state of the art, and “Made in Europe” solutions, for products and services across the cybersecurity value chain.
- Increasing the competitiveness both of the European market and industry, also means including the local and regional levels through a variety of measures to ensure they can adopt and profit from the use and development of standards, compliance programmes, certification, procurement rules and investments.
- For acceleration of growth, EU need to make full use of public procurement programmes to boost growth and market share
- Create a trusting environment to encourage pre-competitive collaboration between EU players.
- Stimulate the growth of SMEs and create incentives for existing players to collaborate/consolidate.
- It is essential to involve European operators and final users for the identification of needs and requirements. European Cybersecurity suppliers (especially SW companies) need to gain more traction accelerate in scale, and grow faster.

V4. Leadership → EU to achieve global leadership in key areas of cybersecurity

- Fragmentation and internal competition can be a source of weakness when facing foreign global giants. Pay special emphasis of deployment of H2020 and future MFF projects to stimulate market uptake. Europe has to become a global player that brings solutions to the market.
- We need to coordinate our efforts, especially efforts of various SME, research organisations, and governments, and to encourage collaboration and in some cases consolidation (individual SMEs are sometimes too small to compete with foreign players). A European cybersecurity industry should talk with a united voice and take common actions proactively.
- This could lead to the emergence of European global leaders in innovation that will be world leaders in their respective fields. This will require focusing investment on competitive advantages for the market uptake of European demand-oriented solutions.
- There should be selected leading edge cybersecurity research areas for showing European cybersecurity leadership in the technology. Each research organization should nominate their specific strategic focus areas for the cybersecurity and research organizations should be encouraged to collaborate with each other.
- Similarly, European solutions, standards, technologies and certifications should become global standards.
- As a global leader, Europe should attract, develop and retain top talent, especially in the public sector.

# SWOT Analysis

The following SWOT is the outcome of task force members’ contributions to the desk-research based SWOT analysis. These items serve as a basis for the recommendations. For ease of reference each item was assigned a unique number.

### Strengths (What is the EU good at?)

- S1. Common regulatory framework → regulation is useful for creating a single market and needs to be effectively implemented across EU. The NIS Directive, the Cybersecurity Act, the Radio Equipment Directive (RED) and in the future the European Competence Centre proposal have laid out the regulatory framework for the area of cybersecurity.
- S2. Wide research base
- S3. Services → EU is strong in cybersecurity service offerings (downstream part of value chain)
- S4. Large internal market → The EU's internal market has proven to be the strongest one worldwide and currently is the strongest market for cybersecurity products and services
- S5. Cybersecurity ecosystem: many players, local clusters of expertise. Collaboration among players much better than in the US and APAC
- S6. Very strong in Network and Information System Security (NIS), embedded security, cryptography, block chain, formal methods, privacy and some other areas. Large presence of European players in international top conferences and journals, start-ups, sectors
- S7. Certification and standardization → EU has tremendous knowledge to support global certification and standardization schemes, and these should be (or should become) global standards. For Cybersecurity, however, we are behind other continents. High standards of certification and standardization are strengths in terms of raising user protection levels, but they are a barrier to SMEs. There need to be accompanying measures to help EU start-ups and SMEs overcome these barriers.
- S8. Cybersecurity associations → the organisation of the sector in order to be able to speak and act with one voice through the existence of cybersecurity associations…
- S9. High expectations of security and privacy
- S10. Education → EU has high level of education
- S11. Strong industrial base → Industry in the EU has a core competence in the development on industrial security and embedded security

## Weaknesses (What is the EU not good at?)

- W1. Lack of Global leaders → the EU lacks large innovating global market players
- W2. Underinvestment → underinvestment in developing and deploying cybersecurity solutions, misallocation of funds, lack of strategy and focus. Investment gap in the proof of concept (POC) and early stage industrialisation/commercialisation.
- W3. Fragmentation → the EU Digital Single Market in this area is not yet developed; different countries have for example developed different cybersecurity certification policies. The Cybersecurity Act hopes to counter this. Regulatory differences between EU countries, compliance wields differences in export possibilities.
- W4. R&D Gaps → lack of research efforts in some cybersecurity sub-domains. Research institutes are working EU widely within generic topics with limited resources, instead of focusing on some selected technologies to become global leaders within selected cybersecurity areas.
- W5. Dependency for Hardware/Software → EU is weak in cybersecurity hardware and software (upstream part of value chain). We rely heavily on foreign players. Local players often lag behind other region-based competitors. In some areas, EU totally lacks local solutions.
- W6. Patenting → difficult to patent software in EU, this gives unfair competitive advantage to US and Chinese players.

- W7. Openness → EU gives open and unguarded access to foreigner to its IP, research, technologies, start-ups and SME. Our best assets are being acquired by foreign players. This strengthens them and weakens our local players. We are missing a vision about protecting EU technology. We are being too naive.
- W8. Illiteracy → lack of awareness (public, politicians, organisations) about cybersecurity threats (including theft of trade secrets through cyber-attacks/intrusions) and solutions, lack of skills
- W9. Dispersion → Many different, uncoordinated initiatives, institutions, efforts. Lack of structures to build collaboration or consolidation within small and medium size cybersecurity companies of European origin
- W10. Lack of reliable cybersecurity data related to EU and Member States
- W11. No common vision for European Cybersecurity industry
- W12. Lack of public administrations support for EU cybersecurity products in public procurement procedures
- W13. Lack of cybersecurity professionals

### Opportunities (What are the favourable external factors that could benefit the EU?)

- O1. Digitalisation → Overall digitalisation, Internet of Things
- O2. Single Market → the EU Digital Single Market
- O3. Labour → Labour market growth
- O4. Unique assets → leveraging unique assets from across the EU
- O5. Differentiation → developing advanced and certified cybersecurity solutions, giving specific advantage to EU solution, especially in procurement criteria
- O6. Training → developing skills and creating cybersecurity ecosystem
- O7. Cooperation → greater cross-border cooperation, notably between research organization and universities networks
- O8. Innovation → promising new cybersecurity start-ups with creative business ideas
- O9. EU has possibilities to test and pilot in different types of regional markets with different types of conditions and languages, if a pilot can be scaled across EU, it is possible to scale globally.
- O10. Strong industrial base (automotive, machine tools, energy, industrial control systems …) that could help develop a strongly specialized industrial cybersecurity offer for the international market.
- O11. Strong position in High Performance Computing (HPC) and Cryptography.

### Threats (What are unfavourable external factors that could harm the EU?)

- T1. Rapid rise of non-EU markets and large-scale investments: fast growth of non-EU competitors, penetration in critical components in the supply chain.
- T2. Dependency on microelectronics
- T3. Skills competition
- T4. Legal and market barriers
- T5. Espionage → growing global espionage where governments might also be involved

## Detailed recommendation descriptions

## High priority

These actions are clear, detailed, with concrete actions, and have received support from several participants. Some of these actions could be part of a coordinated investment.

| R12. | Use 5G for cybersecurity innovation and services |
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| Description | 5G provides a secure and capable platform, moving beyond today's consumer oriented mobile broadband towards a more enterprise-oriented network where automation, critical systems and cyber physical systems represents new constituents. According to GSMAi 5G alone is forecast to create $2.2 trillion of economic value by 2034. A telecommunications generation lasts approximately 10 years and as such this investment has a future proofed market. 5G is the first generation of mobile telecommunications that allows: Network exposure functions (allowing more services to make use of the mobile network), Cloud services and Secured by design practices to be managed between networks. The 5G standards, defined by 3GPP, outline what will be secured but not how, this is being defined at present and will result in numerous opportunities that could be exploited within Europe. This is a potential strategic benefit to European value chain for cybersecurity as this rollout will result in new technologies being defined for the network and supporting services. These include the Internet of Things (IoT), Network Function Virtualisation, Mobile Edge Computing, Artificial Intelligence, Augmented Reality and Industrial Automation. All of which will require a new generation of security controls. Each will require research, design, implementation, testing of supporting technology. This value chain doesn't stop when the network is live based on the nature of the telecommunications industry. Value is still being made from securing 2G and 3G networks several generations later. A specific target could be enabling the secure use of 5G services by vertical industries like Health, Transport, Manufacturing, Utilities. Each of these critical services are developing embedded systems to improve their end user services. Pair these embedded services with Europe's strengths in the telecommunications industry and the result is a powerful foundation for tomorrows connected era. Each aspect of the supply chain for these services will require technical and procedural protection throughout the lifecycle of the service. Europe can use its current foundations as a springboard to overcome its cybersecurity weaknesses and create a future competitive position in the era of digital enterprises and society. |
| Objectives | Take full advantage of the possibilities offered by 5G in terms of security by developing and deploying new cybersecurity applications on 5G. |
| Concrete actions | • Create favourable conditions for 5G networks and for its usage in the end points through various embedded systems like for vehicles, utilities, healthcare, and manufacturing.<br>• Support start-ups and research that has a focus on securing strategic 5G services.<br>• Identify key technologies and service requirements for secure-5G and provide funding to accelerate these deliverables.<br>• Support software development that relates to new technology identified for 5G networks, such as secured APIs for service interaction between the 5G |

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| | network and strategic verticals.<br>• Support hardware development for securing 5G technology, such as embedded systems and new appliances introduced in the standards. |
| Expected benefits | • Become a leader in technology and services to protect 5G enabled services<br>• Leverage new 5G services faster as they are more secure and therefore available to use by a wider range of services (such as health)<br>• Ensure that all the innovation and services made possible thanks to 5G will be secure (which they will not be without adequate cybersecurity applications)<br>• Become a leader in technology and services to protect 5G enabled services |
| KPIs | • Target Investment amounts to develop solution<br>• Number / % of services/applications that are adequately secured / not secured<br>• Value of 5G cybersecurity solutions market in Europe, value of exports |
| SWOT Items | S4 , S5, S6, O1, O2, W1, T1 |
| Related items | R18, R36, R41, R34 |
| Related EU initiatives | • 5G PPP and 5G Industrial Association<br>• EU Council conclusions 21 and 22 March<br>• Commission Recommendation of 26 March 2019 on Cybersecurity of 5G networks C(2019) 2335 (press release http://europa.eu/rapid/press-release_IP-19-1832_en.htm) |

| R18. | Secure highly critical applications and essential services: electricity, gas, water, vehicles… |
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| Description | Essential services, such as energy infrastructure (including electricity, oil and gas, water and nuclear) are very complex, as other sectors depend on them. We need :<br>• To improve the cyber resilience in the essential services to avoid as much as possible the unavailability of their supply system.<br>• To provide Europe with a network of critical infrastructures with a high degree of resilience that are supported by a network of European suppliers that meet the highest security requirements established by international standards and norms.<br>• To build and set-up a European-level cybersecurity regulation for critical |

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| | infrastructures that allows the provision of essential services for the EU.<br><br>The project will enhance the activities under the NIS Directive in three directions:<br><br>• Increasing the protection level of the infrastructure assets against cyberattacks.<br>• Developing advanced mechanism of early cyberattacks detecting and prevention systems.<br>• Restoring the system in fastest way when a cyberattack has succeeded.<br><br>Example: Car industry<br><br>Among the different verticals, EU car industry is a strong asset with world leaders located in the EU. This industry is facing multiple security challenges related to new car functions: connectivity, driverless cars, electrification and connection to smart grids. Cybersecurity could be showstopper. Another challenge is to address the certification of the car and its critical functions and not only the subcomponent (HW/SW). Competition is still open in that field as it is really an emerging domain. The EU has strong research base and cybersecurity ecosystem with world leaders in the EU. Automotive is driving the innovation market for new security technologies (HW/SW) for embedded systems. The proposal is to set up security of clean connected autonomous car as a European priority, and to fund coordinated projects both on security solutions development and security certification in that field. The electric vehicles charging sector also comprises many actors with divergent interests leading to heterogeneous security solutions for charging. Manufacturers, users and charging station operators need a confidence model for interconnection and an agreement for charging on the electric grid. |
| Concrete actions | • To set up an alliance integrating stakeholders of highly critical infrastructure sector (network operators, technology suppliers, cybersecurity solution providers, standard and certification bodies, etc.) for defining cybersecurity standards and test procedures.<br>• To foster the development of specific cybersecurity solutions that satisfy functional and performance requirements coming from critical sectors.<br>• To support investment in R&D, since new technology could be needed, and R&D projects can help in the development and validation of new solutions.<br>• Encourage cooperation of Computer Emergency Response Teams (CERTs) for high critical infrastructure through the NIS Directive Framework.<br>• Support hardware development for securing embedded systems and automation architectures.<br>• Support development of Scada systems secured by design.<br>• Support development of detection system adapted to industrial protocols and fieldbus.<br>• Identify key technologies and service requirements for automation and provide funding to accelerate these deliverables<br>• Support the establishment of relevant partnerships between automation actors and cybersecurity firms to enhance protection of installations<br>• Develop new equipment to prepare Industry 4.0 to be resilient using inter |

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| | alia certification and approval systems.<br>• Launch a European coordinated action to develop security, governance and security certification for sector specific applications. |
| Expected benefits | • Securing the whole energy distribution infrastructure and power distribution in the utility domain as well as in the consumer / prosumer domain, which are sectors already covered by the NIS Directive.<br>• Enhancement of the security level of highly critical infrastructure, including, energy (electricity, gas, oil), water distribution, telecommunications, etc., which are sectors already covered by the NIS Directive.<br>• Build European leadership on strong innovative global players to position the European cybersecurity and critical sectors' secure equipment providers as international leaders.<br>• To increase confidence in the functioning of a critical sector, based on the development of more robust and secure products.<br>• To ensure that new devices have and will maintain a level of cybersecurity appropriate to highly critical infrastructures, reducing cybersecurity costs based on a common framework that enable the selection of the best provider.<br>• To improve the reaction to cyber incidents, sharing information among the relevant stakeholders involved in critical infrastructure management and operation. |
| KPI | • 100% availability of Essential services<br>• Cybersecurity Incidents & Responses, the mean time to detect and mean time to respond are good indicators to check the resilience of an installation.<br>• Propagation effect (number of entities affected).<br>• Number of systems that comply with cybersecurity standards and norms.<br>• Adherence to the Security Policies & Compliance: adherence to the appropriate compliance and regulatory policies prevents legal penalties, public fallouts, and loss of the company’s reputation<br>• Cost and availability : the cost of cyber investigation, staff and resources employed in locating the incidents, data restoring, and malware removal are other key performance evaluators. |
| Rationale for coordinated investment | • Critical services and infrastructure can’t be exposed to cybercrime or cyber-terrorism, European vital infrastructures and installations need a high level of protection for the competition to flourish<br>• These infrastructures are more and more the target of leakage attempt or ransomware abuse; intrusion protection system should permit to reduce the risk of a massive attack<br>• Enhance the level of cooperation within the CSIRT Group under the NIS Directive (established in 2017, gathering CERTs in MS and EU CERT in one coordination body). To do that, Europe need skills in this domain and this |

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| | should be enhanced through the establishment of relevant partnerships. |
| Type of investment envisaged | • Critical Infrastructure awareness and modernization: training and awareness programs oriented to obtain the right skills to manage cybersecurity; update of systems with higher levels of security; improve management of crisis (protection and recovery plans).<br>• Certification and Testing labs: to ensure the compliance to cybersecurity standards and norms.<br>• Manufacturing capacity: critical infrastructure equipment providers to supply more secured products.<br>• Software & HW development: to provide cybersecurity solutions specific for highly critical infrastructure sector.<br>• Specialized research network: to develop new technologies related to cybersecurity in critical infrastructures. The network of national coordination centres, proposed to be created along with a European cybersecurity competence centre, should play this role. |
| SWOT Items | S1, S2, S3, S4, S5, S7, W1, W2, W4,W5, W12,T1, O17, O22 |
| Related items | R19, R16 |
| Related EU initiatives | • Under the Cybersecurity Act: ENISA and the Commission will create expert groups to provide input to develop certification for specific sectors<br>• NIS Directive: covers already critical infrastructure, such as operators of critical infrastructure, such as notification of incidents. Some actions are voluntary, but could become mandatory.<br>• JRC Pilot Project on IACS<br>• H2020 Pilot Projects for a European Cybersecurity Competence Network: CONCORDIA, CyberSec4Europe, ECHO and SPARTA. |

| R61. | European Cyber Security Fund & Private Investment Portal |
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| Description | Europe is lacking venture capitalist market with similar scale as exists in US or China. EU should be actively creating industry specific investment funds which would be collaborated with private investors. There should be investment funds available for scaling cybersecurity industrial companies for cross border expansion inside EU and also for growing globally. Investment funds should have similar “best-practices of success” considered as Israel is using for Cybersecurity or South Korea is using for telecom and consumer electronics + cyber range applications. As an example of Israel cybersecurity-fund collects initial investment back with some pre-agreed returning-rate, allowing governmental fund to increase its value allowing more funds for investments in the future, once financial liabilities are fulfilled for the government, entrepreneurs have liberty to operate freely. For the start Israeli government, provide |

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| | some innovative procurement programs to help funded companies to get their first customer references and market testing. The discussion on the design of a dedicated Investment Fund in cybersecurity has been initiated by ECSO in cooperation with international private investors already in 2018. According to the preliminary analysis, the first fund should have the size of minimum 120 M€ with a focus on Series A and Series B investment and targeting 4 transactions per year, with tickets of 4M€ investment per company which have 1M€ of revenue as minimum. In addition, the Fund aims to ease the private investors community: in 2017-2018 ECSO organised 4 events designed to cover the different investment phases, ranging from seeding to strategic investment and M&A, as well as to support companies positioned on the entire cybersecurity value chain. |
| Concrete actions | • Create a dedicated fund and the related managing structure for Cybersecurity within the European Fund for Strategic Investments<br>• Design and implement a specific platform aiming to facilitate the meeting between cybersecurity companies and private investors<br>• Establish a Permanent Selection Committee with the double mission:<br>• 1) To evaluate and select the companies looking for investments according to an agreed selection criteria. Liaise the selected companies with the investor community (IC).<br>• 2) To educate and facilitate the understanding of cybersecurity technologies (technical issues) for generic VCs. In parallel, educate and support start-ups and scale-ups in improve their marketing capabilities (à link to inter-regional accelerator programme).<br>• Finance and organise a European Investor Roadshow like the one organised by ECSO (see the 2017-2018 report) |
| Expected benefits | Support the consolidation of the market and the whole EU catch up gap of global cybersecurity industrial and turn the future development become more competitive instead from the losing global market share to the steady +1% annual growth. |
| KPI | • Fund size : 500 M€ ~ 1 billion €<br>• Number of transactions / deals : 50~100 per year<br>• Average transaction size : > 1M€<br>• Number to stakeholders in the Fund ecosystem (investors, experts, targets, associations) |
| SWOT Items | S3, S4, S8, W1, W2, O1, O2, O7, T1 |
| Related Items | R22, R39, R35, R31, R50, R53 |
| Related EU initiatives | • EIB, EIC, MFF<br>• Venture EU : http://europa.eu/rapid/press-release_IP-18-2763_en.htm<br>• European Fund for Strategic Investments (EFSI).<br>• DEP proposal (Digital Europe Programme) under the next Multiannual Financial Framework (MFF): http://europa.eu/rapid/press-release_IP-18-4043_en.htm |

| R50. | Create a “Cybersecurity Accelerator” network of industry players and regional ecosystems specialised in cybersecurity |
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| Description | A network of regional ecosystems specialised in cybersecurity managed by a central acceleration structure to facilitate the rise of pure players able to compete on the global market. The network is made of regional excellence hubs providing scale-ups (and not limited to early stage start-ups) with key expertise and services on the commercialisation phase of their solutions. The accelerator structure is a network supporting centres focusing on entrepreneurial initiatives in cybersecurity. They could be located in several EU locations that are ecosystems of emerging cybersecurity industry, academic excellence and a conducive entrepreneurial culture.<br><br>Objective:<br><br>• Identifying, attracting and supporting European entrepreneurship in cybersecurity, focusing on innovation beyond fundamental research<br>• Providing an environment for early-stage high-impact companies in cybersecurity to form and thrive<br>• Becoming the forum and network of choice for all players in the European cybersecurity eco-system<br>• Identifying and promoting best practices in cybersecurity technology entrepreneurship across network locations<br>• Driving co-creation between research, entrepreneurs, industry, SMEs, end-users, investors and regional authorities and governments<br>• Thanks to a network of regional ecosystems, this initiative will stimulate better technologies<br>• Ensuring fast-track market access to SMEs.<br><br>4 key European services completing the existing local acceleration layer:<br><br>Potential services:<br><br>• Local immersion & regulatory support: coaching/advisory, support services for growth-stage high-impact companies to better understand the local business environments (e.g. application of the NIS directive, GDPR,)<br>• Shared infrastructure, coaching/advisory, support services for early-stage high-impact companies<br>• Unique commercialization expertise through due diligence, market analysis and seed-stage funding<br>• Network of sales and resellers at regional level (link to the DIHs)<br>• Business- design service driving development of a shared European roadmap and vision with all relevant stake-holders to accelerate progress in order to collectively design the best solution<br>• Driving development of a shared European roadmap and vision with all relevant stake-holders to accelerate progress (similar to the roadmaps in the semiconductor industry) |

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| | • European Industry Roadshow: a series of competition day at regional level to give best EU scaleups visibility to international investors. Investors deck preparation and readiness coaching is part of this service.<br>• Conferences and workshops as condensation points for a European eco-system in cyber security<br><br>Funding options:<br><br>• Seed-funded by regional authorities and the EC, supported by established industry players (including VC and family offices)<br>• Providing paid-for services to startup investors and industry<br>• In long-term, attracting private-sector funding by running a seed fund for cybersecurity ventures |
| Concrete actions | • Create a "Cybersecurity Accelerator" network of regional ecosystems specialised in cybersecurity ("Cybersecurity Valleys") |
| Expected benefits | • Greater vertical and horizontal collaboration between all players in the value chain<br>• More innovation, best-practice sharing, consolidation around best-in-class<br>• Emergence of European competitive and high level SMEs and companies on cybersecurity |
| SWOT Items | S5, S4, S2, W3, W4, W9, W10, W11, O2, O7, O8, T3 |
| Related items | R61, R69 |
| Related EU initiatives | • Commission initiative on Digital Innovation Hubs in the framework of the Digital Europe Program<br>• Commission proposal for a Cybersecurity Competence Centre.<br>• EIB, EIC |

| R34. | European Data Space: create a framework and infrastructure for secure data communication, storage and handling |
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| Description | We already have a dedicated European-wide communication framework and infrastructure for secure data sharing in some sectors (banking, personal identification, health, social security and pension data → CEF: connected European facilitation network).We also have such infrastructure at national levels, and are currently trying to develop new ones for dedicated sectors (energy, transport).As more and more sectors become digital and connected, secure communication will become more and more important in new sectors: connected cars, intelligent |

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| | houses, and health data. Europe needs to develop a harmonised communication framework for such infrastructure, and a coordinated approach to develop, finance and operate them. Here the inherent capabilities (e.g. latency, slicing) and security functionality of 5G provides a foundation for such secure infrastructures. The aim is notably to facilitate communication within industries and knowledge sharing and trust between key EU players |
| Concrete actions | • Develop cloud framework with high level of authentication and secure data lake.<br>• Enable secure and privacy enhancing End-to-End communication between devices, individuals and legal entities for pan-national and pan-sector specific use<br>• Create a dedicated European-wide harmonised communication framework and infrastructure for secure data sharing<br>• Support the cybersecurity analysis of emerging technologies (Artificial intelligence , quantum, cognitive technologies…) and their use in innovative protection products, services and processes |
| Expected benefits | • Support European strategic autonomy for industry and citizens' privacy |
| KPI | • Information confidentiality for citizens and companies should be enforced with those type of framework, ensuring a privacy high level.<br>• All data vulnerabilities, including internal and external, along with their aging, can help the security professionals validate the effectiveness of the imposed security structure |
| Expected investment amount | • ~100 M€ |
| Type of investment envisaged | • Creation of the European Data Space Platform for connecting Data Providers and Data Users.<br>• Definition of the Governance rules of the Platform<br>• Standardisation and certification frameworks for a secure data exchange with the possibility of certifiable software, systems and services part of the European Data Space Platform (EDSP) or users of the EDSP.<br>• R&D for new components of the EDSP using AI, cognitive technologies, …<br>• Deployment of the European Data Space Platform in specific verticals (banking, automotive, energy, cybersecurity …) as well as cross-sectorial domains.<br>• Deployment of the European Data Space Platform at national and regional levels. |
| Rationale for coordinated investment: | • Depending on the US cloud infrastructure, such as Amazon, Azure, or other Google platforms is a weakness for information and data security in Europe, affecting confidentiality and privacy of European citizens and firms. |

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| | Moreover, industrial systems are increasingly dependent on cloud services. Having a European sovereign solution is a key point to protect this critical infrastructure and for intellectual protection in all the domains. |
| Related items | R21, R6 |
| Related EU initiatives | • German “Industrial Data Space”<br>• Industrial Data Organisation (IDS)<br>• The EU Certification Framework has been established by the Cybersecurity Act<br>• REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ENISA, the "EU Cybersecurity Agency", and repealing Regulation (EU) 526/2013, and on Information and Communication Technology cybersecurity certification (''Cybersecurity Act'') |

| R66. | Create the next generation EU framework for PKI infrastructure and European DNS management for critical infrastructure |
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| Description | Public Key Infrastructures (PKI) and the Domain Name System are two extremely relevant enabling elements to create and maintain a trustworthy and reliable European Digital Society. PKIs play a key role in establishing trust over the Internet as they allow on the one hand to mutually authenticate parties (human or machines) and on the other, if used correctly, to secure communication channels and data. Today however, many PKI (Public Key Infrastructure) applications are not accepted on the long end, due to the lack of access to open, trustworthy, affordable and well-recognized PKI infrastructure, (i.e. cross-border applications for eHealth, eID, intelligent transport systems, e-government services etc.). This is a clear obstacle to the development of a more interoperable and secure digital space. The DNS is instead part of the backbone on which every digital service is built on today. Even if the Internet has no central coordination point, its addressing structure is centrally coordinated through its DNS, roughly speaking a set of hierarchical phonebooks, where names of “online services” are associated with IP numbers. For example, the DNS ensures the mapping between www.nature.com and its IP address, 151.101.240.95. Without DNS, the majority of the Internet Services would not be accessible, including those services which are typically considered “critical”. In other words, its operation is today essential for the European Digital Society. This consideration let emerge two major issues:1) DNS was believed to be extremely robust, however, cyberattacks that happened in the recent years (e.g. Mirai attack), demonstrated how its infrastructure is today potentially vulnerable. 2) The governance of DNS, since its creation, has been in the hands of ICANN, a private organisation under the US law. The fact that ICANN in practice “sets the rules for the Internet addressing systems making Internet based services available” implies that its decisions have a global impact on online services and on citizens. These two points |

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| | highlight how it is in the interest of Europe to ensure (1) that DNS is adequately protected and fit to answer to the challenge of the full digitalisation of the European Society, and (2) the alignment of its governance with the European interests. |
| Concrete actions | • EU common harmonisation and standardisation action (potentially supported by the JRC and ENISA). This action would imply to place a new work item by a European Standardisation Organization (ESO) to create a harmonised PKI standard. It would aim at the definition of a common trustworthy Authentication Framework.<br>• Enable the secure and privacy enhancing End-to-End communication between devices, individuals and legal entities for pan-national and pan-sector specific use through the implementation of the identified PKI standard across all the digital sectors. The future European Cybersecurity Competence Centre could tackle this point based on the above referenced Authentication Framework by including MSP, JRC and ENISA inputs with the involvement of stakeholders.<br>• Establishment of an international debate and negotiation on the governance of the DNS with the involvement of ICANN, ITU, the Member States and the technical support of JRC and ENISA, aiming at guaranteeing the protection of European interests, security and autonomy in the governance of the DNS<br>• Ensure the establishment of a DNS fit for the challenges of the full EU digitalisation: a common EU effort is needed to ensure the DNS ability to address the reliability and security requirements to satisfy the needs of a fully digitalised Europe. This action implies on a side a harmonisation action for what concerns security requirements for the existing DNS infrastructure and on the other the opening of an R&D and standardisation effort with the relevant stakeholders and MS to plan the design of an European DNS fit for the next Internet generation (with the technical support of JRC and ENISA).<br>• Establish an additional infrastructural layer of DNS targeting more specifically ICT critical access (i.e. Smart-Grids, intelligent transport systems, eID solutions, eHealth, e-government…) |
| Expected Benefits | Support European digital space security and strategic autonomy: A framework providing in one hand PKI infrastructure, and on the other hand trustworthy European DNS, would contribute to several market segments using critical technologies (Digital identities – biometrics, IoT security). A European DNS would make internet exchanges more reliable: ICT-internet and Private Network should be understood as solutions within the presented value-chain. These two approaches will impact many sectors and more precisely the critical ones as defined by NIS directive (Energy, Transport, Financial Services, Health, Water, Digital Infrastructure) |
| KPI | • Successful harmonisation of European PKI infrastructures<br>• Definition of a European PKI standard<br>• Successful EU engagement in the international debate on DNS governance<br>• Establishment of a European Secure DNS infrastructure |

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| Expected investment amount | • 100 M€ - 500M€ |
| Type of investment envisaged | • Standardisation, manufacturing capacity, software development and infrastructure. |
| SWOT Items referred to | S3, S4, S5, S6; W1, W5; O1, O2, O4, O5; T1 |
| Related items | R9. |

| R29. | Leverage public procurement in order to increase the overall levels of cybersecurity |
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| Description | Public procurement guidelines designed for contracting authorities/entities or targeted private entities would include minimal security requirements in terms of cybersecurity. This guidelines could be recommended for any public procurement project and/or be mandatory for EU financed projects. When procurement is done or co-funded by EC, guidelines including requirements for a European reference in procurement should exist. Referring to EU certification scheme in public procurement would trigger companies to comply with EU standards. The EU should focus those procurement frameworks on the most vital parts of the value chain first and build upon existing frameworks whenever EU ones are missing. It should be avoided that certain procurement criteria can only be met by non-EU companies. It is important to highlight that the best cybersecurity solutions should be a priority and mechanisms are needed to ensure that European players can reach in time appropriate levels of security. Such a procurement framework could potentially also be applied in the private sector. The extent to which this is possible should be explored. There could be a specific consideration given to EU start-ups and SMEs. Example: most health players are public, and most develop their own systems, and most systems are not secure. Public procurement can be a tool to push for development of state-of-the art, competitive, providers of secure IT services in Europe, by providing them with clear market opportunities. Guidance may be introduced to encourage (or force) minimal security requirements (which will require specialised external providers, and which may exclude low-cost low-quality providers). |
| Concrete actions | • Promote the uptake of the cybersecurity certification framework (a standard) criteria into public sector procurement. |
| Expected benefits | • Higher level of protection for all public institutions and infrastructure in the EU.<br>• More advanced and higher quality produced developed thanks to a “market-pull” effect.<br>• A more dynamic, innovative and expanding European cybersecurity industry serving a growing local market. |

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| KPI | • Public expenditure on Cybersecurity at EU, national, regional and local levels<br>• Level of protection at public institutions/infrastructure (firewalls, antivirus, incident detection…)<br>• % of such expenditure awarded to EU players<br>• % of innovative solutions (i.e.: that did not exist 3, 5, 10 years before) |
| SWOT Items | S1, O2, T4 |
| Related items | R51, R52, R17, R54 |
| Related EU initiatives | The Defence and Security Procurement Directive (2009/81) |

| R6. | Promote greater sharing of cyber threats, vulnerability and incident information |
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| Description | Cybersecurity incidents are a reality and attacks are becoming more and more sophisticated. It is difficult for the industrial sector to maintain a permanent up-to-date protection level. An expertise and legitimate authority at EU level able to keep track of security incidents will help to understand better the threats, impacts and vulnerabilities. A centralised data collection point, where information is stored in a standard/normalized way, will lead to better and faster reaction for the community to provide appropriate counter- measures. This body will act as advisor and could help in certain circumstances to offer complete advisory information and/or services for investigations. European policymakers have acknowledged the value of voluntary information sharing to understand threats, protection, information and networks, and how to prevent cyber-attacks. Under the NIS Directive and GDPR, it is now mandatory for Operators of Essential Services and Digital Service Providers (controllers, processors) to inform relevant authorities of a Data Breach and/ or incident. However, this is considered after the fact, after an incident and/or breach. This points to two main issues when it comes to cybersecurity information sharing in Europe:<br><br>• Lack of harmonisation or automatized mechanisms as regards data breach notification and / or incident reporting requirements. NIS and GDPR are only two of the current reporting requirements (applied across sectors) but when looking at specific sectors, there are several other regulations to consider. I.e. in finance, in addition to NIS and GDPR, one must also consider eIDAS, Target2, PSD2, and ECB reporting requirements, each of which different taxonomies and ontologies, timeframes and templates for reporting have. There is a huge fragmentation of approaches here which leads to lost time that should be used for response.<br>• Information sharing on cybersecurity as it currently stands, whether through entities such as ISACs or open source platforms, is usually performed ex-post which means its purpose serves mainly for statistics or adapting behaviour for |

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| | future mitigation. Moreover, information sharing tends to include users/operators, solution providers, and consultancies alike, meaning that intelligence sharing on trends and threats and trust-building is impeded. The introduction of tools and solutions that facilitate trust, a simple and anonymous exchange of information and a simple and understandable re-use of information exchanged would be beneficial for all stakeholders, but this should be considered in a tiered approach to allow for users/operators to gather in a trusted environment for sharing of information and intelligence.<br><br>The EU should embrace a similar system to Coordinated Vulnerability Disclosure (CVD) that will allow European digital entities to share potential threats, backdoors, and overall weaknesses in systems and designs before any data breach of incident may occur. In addition, an EU-wide approach is essential to prevent a scattering of national approaches to vulnerability disclosure. An EU coordination body or steering group that defines a standard for intelligence and information sharing and helps to keep things federated and synchronised could be envisaged, fitting in more easily with existing domestic sharing structures, and with ENISA, Europol/EC3 and the NISD CSIRT Network. Make sure that more organisations introduce policies in the field of coordinated vulnerability disclosure (so that hackers that find vulnerabilities report this to a designated organisation so that they can be solved). More insight into vulnerabilities means that the products and services will get better. Once a climate starts to exist in Europe where reporting these vulnerabilities becomes the norm quality security automatically improves. This will also safeguard a better quality of the information being shared, meaning that preventive and responsive measures will improve. Governments can play an important stimulating role. Cyber Security information harmonization means the development of dedicated Ontology and Taxonomy on a specific language or also cross languages. The derived semantic interoperability is the fact of sharing standard terminologies between stakeholders/end-users on their communications, chats or exchanged reports. If they communicate using a common semantics, it means the understanding of a message is easier and smarter. This can lead, after a common reasoning about a specific theme, the decision makers to operate quickly, so saving time on reaction and moving immediately to operational activities. Setup a policy ensuring access to detected vulnerabilities to stakeholders. Provide security researchers clear guidelines to coordinate disclosure of vulnerabilities. |
| Objectives | • Improve the collection, structuring (through standardisation), sharing and usage of threats, vulnerability and incident information<br>• Improve cyber threat detection and hunting, coordination of vulnerability disclosure, including using with AI<br>• Improve EX-ANTE analysis by means of advanced behavioural algorithms such us Emotions and Computational Stylometric analysis; so understanding the Human Factor side inside natural language contents<br>• Improve EX-POST analysis by using AI/Cognitive algorithms on occurred events and case histories |
| Concrete actions | • Implement and optimize existing rules, guidelines and framework for disclosure and information sharing on incidents/breach reporting and for vulnerabilities |

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| | detection.<br>• Make the most out of initiatives around "Cybersecurity Information Sharing Sector-Based Networks" where parties can join on a voluntary basis, and adhere to specific information sharing rules.<br>• Create a Cyber Security Ontology and Taxonomy on a specific language and cross languages. So, putting human/domain expert know-how into a cognitive computing engine (based on either Semantics or Machine learning)<br>• Create (manually or automatically) the semantic rules in order to apply categorization, entities/relations extraction and consequent terms normalization automatic activities<br>• Build a horizontal network (instead of vertical from organization, to decentral, to national, to EU institution). Such a flat network stimulates sharing information and collaboration, without imposing fines. This creates trust and more transparency about who experienced, what, when, why. Creating a feedback loop between those who report and the regulator/entity receiving notifications is crucial.<br>• Strengthen the role of trusted intermediary parties (as in the case of the MISP).<br>• Promote a culture of (in-house) ethical hacking.<br>• Define an ISAC standard (guidelines, requirements) paper in cooperation with CEN CENELEC JTC13 (cybersecurity TC) covering the ISAC information management, processes etc. Thus establishing a harmonized environment which will facilitate collaboration among all European Standards, as well as information sharing among regional/national/sectorial ISACs themselves throughout the EU |
| Expected benefits | • Sharing relevant data is vital for the single market to function.<br>• Reduced fragmentation of approaches<br>• Coordinated measures and platforms for information sharing, intelligence sharing and crisis management.<br>• Improved 24/7 automatic analysis with no human subjectivity<br>• Reduced time from the Request for Information to the specific concrete action on the field<br>• Interoperability and exchange of data<br>• Improved understanding and response to threats and incidents, so reducing time to operational tasks<br>• Improved understanding of behaviour of (potential) cyber attackers<br>• Improved understanding of citizen perception about digital innovation (web campaign) |
| KPI | • Number of incidents/threats/vulnerabilities reported, intercepted<br>• Number of categories and hierarchy levels in the taxonomy<br>• Number of concepts included in the ontology<br>• Number of European languages considered<br>• Number of semantic behavioural attributes extract from analysed contents (Human factor attributes) |

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| SWOT Items | S2, S5, S8 |
| Related items | R7, R10, R4, R21 |
| Related EU initiatives | • ECCC, ENISA, NIS directive, Cybersecurity Act<br>• Must take account of the status quo – provisions of the NIS Directive and in particular the cooperation in the CSIRT Network, Cybersecurity Act. Make recommendations on that basis.<br>• YesWeHack present ZeroDisclo.com. This non-profit platform provides the technical means and the required environment for all to adopt the coordinated reporting of vulnerabilities commonly known as "Coordinated Vulnerability Disclosure". https://zerodisclo.com/header/01_how_it_works/ |

| R54. | Increase innovative public procurement |
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| Description | European cybersecurity products and solutions that manage to cross the "Valley of Death", *i.e.* from research to market, are not widely deployed across European and global markets. European cybersecurity industry has developed largely on the basis of national governmental demand, including the defence sector. In parallel a multitude of innovative SMEs has also emerged both in specialty and niche markets (e.g. crypto systems) and in well-established markets with new business models (e.g. antivirus software). Despite this evolving market structure companies still have difficulties growing outside their national market. While European companies tend to be strong and innovative, their size and capacity (mostly SMEs) are smaller in comparison to their global competitors. European Union should develop a new program from innovative cybersecurity procurement scheme. Program should start from EU own procurement and to scale all the member states. Innovative procurement should be based on describing the problem or challenge, not solely strictly defined technical specifications. Public procurement plays also a crucial role in providing public references to European companies and especially SMEs and start-ups entering the market. Whether offering consists SME based products or services, it should be more favoured. EU should sponsor Member State with providing for example 10-20% support for MS (out of purchase value) if they follow EU recommendation. There should be also encouragement to find European cybersecurity solutions from other Member State. If offering consists cybersecurity products or solutions from other Member State, there should be some additional funding provided by EU. |
| Concrete actions | • Develop a new decisive program for innovative cybersecurity procurement scheme.<br>• Develop a scheme for ICT vendors' screening evaluating their trustworthiness.<br>• Create incentives to find European cybersecurity solutions from other Member States for national procurements. |

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| Expected benefits | More EU cybersecurity SME based innovations finds a way to market, with real customer reference, and practical feedback from the market. Cross border, collaboration encouragement dismounts practical trade barriers inside European Digital Single market. |
| SWOT Items | S1, S3, S5, W1, W2, O4, O5, T3 |
| Related items | R29 |

| R39. | Clarify and raise awareness of the role of the various European bodies involved in Cybersecurity: ENISA, ECSO, ECCC, regions… |
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| Description | Fragmentation is a key weakness of the EU, notably in Cybersecurity. This fragmentation is seen at all levels, not just between countries but also between various EU institutions. This results in an inefficient environment for regulation, funding R&D, strategic infrastructure, public procurement, standardisation, and certification. Europe must have **coordinated actions for Cybersecurity** (along the same model as the US Federal Aviation Administration, or the European Space Agency) and seek strategic autonomy. Responsibilities need to take account of the European political landscape and include ENISA, ECCC, ECSO and the various DGs of the EU Commissions, the national agencies (ANSSI in France, BSI in Germany…) and regional authorities. The scope of ENISA has recently been reinforced with the "Cybersecurity Certification Framework", and its role could be further expanded in the future, excluding the creation of standards (which should come from standardisation bodies and driven by market demand).The following responsibilities need to be allocated to one or several agencies, as appropriate:<br><br>• act as the **European Authority** on all matters related Cybersecurity (such as to produce certification schemes, standards, propose draft regulation),<br>• Set **procurement guidelines** or rules, for public / private organizations, and sharing among Member States.<br>• establish innovate **procurement** program for cybersecurity to speed up global regaining market share,<br>• disseminate knowledge, share good experiences,<br>• provide/channel **funding** for hardware, software, services, infrastructure, industrial deployment,<br>• launch calls for projects,<br>• build partnerships between industrials and research stakeholders from different countries, and work closely with already structured **regional cybersecurity ecosystems,** in order to develop European Cybersecurity value chain,<br>• manage European funds to finance Cybersecurity research,<br>• **Monitoring market data** for agile decision making (see V1)<br><br>Ideally, we should have a "**one-stop-shop**" European body that would be the main |

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| | partner of companies and research organizations working in the field of Cybersecurity. It could have branches in several member states / regions, based on the presence of local industrial and technological players. |
| Concrete actions | Create a European optimised NIST-like framework |
| Expected benefits | • Vital to preserve sustainability of digital society and economy.<br>• Hard to do by Member States themselves. |
| SWOT Items | • S1, S5, S7, W2, W3, W4, O7, T4 |
| Related items | R35 |
| Related EU initiatives | • The Commission proposed for a European Cybersecurity Competence Centre (ECCC) and network.<br>• Cybersecurity Act |

| R35. | Develop a comprehensive EU strategy to support EU players in cybersecurity value chain |
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| Description | To focus investment on competitive advantages for the market uptake of European demand-oriented solutions it is essential to involve European operators and final users for the identification of needs and requirements. European Cybersecurity suppliers (especially SW companies) need to gain more support to accelerate in scale, and grow faster. Therefore the EC should promote the inception of a Master Plan to deploy an EU Cybersecurity Investment program funded by all EU financial instruments available (Horizon Europe, Digital Europe, InvestEU, European Investment Bank, etc...).Indeed, public funding is essential to stimulate and catalyse public & private operators (financial services, transport, energy, utilities, etc...) long-term investments through European collaborative projects in specific verticals within an Investment program... This is in the essence of the EC as regards SVCs and IPCEIs. One of the problems of the European Union is that there is little or no public procurement at the EU level (there are many national initiatives, but often with insufficient scale to compete with similar Chinese or US initiatives).The future EU centre of competence shall be key for its conception and implementation. |
| Concrete actions | Create a large funding platform and program to support high-potential cybersecurity players, or to invest in critical/sensitive areas (energy, transport, health). |
| Related items | R39, R61 |

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| Related EU initiatives | Horizon Europe, Digital Europe, InvestEU, European Investment Bank, European Strategic Fund, national Public Investment Banks, Sovereign Investment Funds, |

| R58. | Fast-track Research to the access on the markets |
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| Description | Often cybersecurity solutions and products are aging fast and market access for SMEs is particularly difficult. Industry is dynamic, and often baseline research takes a long time. One challenge is to getting industry involved or collaborating with research, and then commercialise the developed solutions. Majority of cybersecurity industry is relatively small and incapable to sacrifice key resources for time consuming collaboration with slow progressing research, not paying off in the next months. Cybersecurity research and cybersecurity ecosystems need a new type of market test-bed-model, and fast track market access to commercialise these solutions. That would allow researchers to test market innovation already in the early stage with the market, if there are some critical, revolutionary ideas or finding which have real interest of market and if those are really having some opportunities to survive in the future. It could allow "research team" to cooperate also with some SMEs more closely. In case there are no SMEs, researchers could be creating "test-bed company" for measuring market reaction for the idea. If "test-bed" is passed with base evaluation requirements, it could be introduced to private investors already in the early stage, and parallel research team may still continue research work with higher motivation, expecting to better meet real-market demand. |
| Concrete actions | • Dynamic cybersecurity research model<br>• Designing an interregional acceleration program to create a market place with reduced costs for local SMEs to commercialize their solutions. |
| Expected benefit | European cybersecurity research would become more agile. It could be more collaborating with the industry, which in cybersecurity contains mainly SMEs. Research investments and focus would be better coordinated, with less failures expected. |
| SWOT Items | S3, S5, W3, W4, W6, O4, O6, O7, T3 |
| Related EU initiatives | FP9 |

| R21. | Shared Database for AI development in cyber security |
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| Description | The adoption of AI and machine learning for security use are slowed down because it is |

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| | difficult to access real data and attack data for sensibility reasons. It would be helpful to have a shared database at the European level of attacks and legitimate data (facts, events, network flows, etc.).The shared database could also be composed by different remote databases as in a network of federated databases. The important fact is to have a normalized terminology stored into databases so to improve, to maximize the comprehension and inter communications between final users. Terminologies in multiple languages can be managed by means of a specific semantic layer for normalization and correlation tasks either in the storing phase or in the retrieval one. Furthermore, having a powerful and federated cognitive search engine, based on deep semantic analysis, is a must so that end-users and stakeholders can access remotely and in an easy way also using natural language questions, so not only Boolean operators as in the standard search engines. The same end-users can browse the databases using the extracted semantic attributes, so allowing them to be guided and transforming a normal search activity into a discovery one. |
| Concrete actions | Definition of a Cyber Security data model based on a dedicated taxonomy and ontology also in a multi-language mode.<br><br>Developing an avant-garde cognitive engine capable to accept natural language questions also by different languages (e.g. European official languages).<br><br>Developing an avant-garde discovering engine. |
| Expected benefits | Smarter and easier access to stored information.<br><br>Enhanced capabilities to discover (not only searching) targeted contents by using extracted semantic attributes/tags other than metadata. |
| SWOT Items | S2, W12 |
| Related items | R20, R6, R7 |
| Related EU initiatives | • EU strategy on AI.<br>• Project AI4EU<br>• EU programs : FP9, DEP |

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| R36. | Assess the necessity for mandatory cybersecurity certification or general cybersecurity legislation for all IoT products |

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| Description | Anything 'smart' can also be vulnerable. Even if devices are smart and connected, they are not always upgradeable, and eventually they will become vulnerable to attacks. The EU should promote the security of B2C IoT devices and consumer products. The Cybersecurity Act establishes a framework for the establishment of European cybersecurity certification schemes for ICT products and services and defining these along the lines of ICT products and services that require high, substantial and basic assurance levels. As a function of their criticality, mandatory certification for certain industrial IoT devices (consumer, industrial, medical…) could be introduced through a specific sectorial legislation. Alternatively, horizontal legislation could include cyber security as part of product safety requirements and CE-marking. |
| Concrete actions | • Explore the necessity and feasibility of horizontal legislation such as the Review of the Radio Equipment Directive to include cyber security as part of product safety requirements and CE-marking.<br>• Develop basic level cyber security standards (e.g. with ETSI, CEN CENELEC). |
| Expected Benefits | Increase cyber security awareness of consumers and wider public.<br>Protect European consumers of B2C IoT and smart devices.<br>Possibility of leading in developing global standards. |
| SWOT Items referred to | S1, S4, S7, O1, O2. |
| Related items | R4 |
| Related EU initiatives | Cybersecurity Act |

| R22. | Support emergence of a European cloud service that can provide the highest levels of security and functionalities, and can compete internationally |
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| Description | Depending on the US cloud infrastructure, such as Amazon, Azure, or other Google platforms is a weakness for information and data security in Europe, affecting confidentiality and privacy of European citizens and firms. Moreover, industrial systems are increasingly dependent on cloud services. Having a European sovereign solution is a key point to protect this critical infrastructure and for intellectual protection in all the domains. Several European start-ups have tried to create a local solution, sometimes with the support of local governments, and sometimes with much better security and functionalities than the solutions of global leaders (Google Cloud services, Microsoft Azure, Amazon AWS…), but most have failed to reach sufficient scale to become viable. The automotive industry has its own cloud service called "BNX", where all the OEMs (Renault, BMW…) and Tier1 suppliers share data on a very high security platform. All the big European players (Siemens, Schneider…) have their own in-house system. In Germany, there is even a dedicated secure cloud service for SMEs. In all these examples, successful cloud service benefits from the support of strong backers (either public authorities, or key users). |

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| Concrete actions | • Public investment funds (EFSI, national sovereign funds) to invest in the development of a promising existing European cloud service and boost it to global scale<br>• Public administrations to use European cloud services for data storage (i.e.: procurement legislation)<br>• This cloud service should incorporate some new value-added technology, to justify dedicated funding and procurement requirements.<br>• Develop and use a competitive European cloud based on open solution such as *OpenCloud* will allow development of autonomous and protected services (see *Orange* or *Numergy* in France). |
| Expected benefits | • Independent, secure, competitive and high-performance cloud storage and other cloud services for all EU players<br>• Strategic autonomy, user data confidentiality and privacy, hardware and software security. |
| SWOT Items | S3, S4, S5, W10, W11, W15O18, O19, T25 |
| Related items | R61, R29, R54 |

| R16. | Develop and strengthen a highly skilled workforce in all parts of the cybersecurity value chain |
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| Description | Foster a greater education and awareness system for cybersecurity solutions within Europe – focusing on all parts of the cybersecurity value chain (from research to service). In an ever-increasingly digitalised world, developing digital skillsets is now more important than ever. There are not enough professionals with the knowledge and skills to protect, data systems and networks from cyberattacks. A true cybersecurity skill shortage persists in Europe. Moreover, general understanding of cybersecurity knowledge and certifications is missing. In addition, it is critical to note that many cyber-attacks/ incidents occur through human error that is entirely preventable. As many studies have shown, even just considering that regardless of educational efforts 4% of people will click on any given phishing campaign means that 100% security in hardware will not prevent cyber-attacks. Therefore, a skilled workforce is missing in EU and competition is strong. EU should map out the skills needed along the value chain, identifying also means to fill the gap and relevant timeframe for implementation alongside looking to retain cybersecurity specialists. EU could help universities and other education/ training institutions to build new degree courses in cooperation with industry and built on excellence of European academic research, operation education and training for cybersecurity specialists, both in the research, development of products and solutions and in operating cyber secure systems, with a strong knowledge of EU products. This action would also benefit from a larger availability of test facilities for cyberattack simulations, subsidized penetration tests of business systems and |

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| | Training Facilities like Cyber Ranges. The creation and coordination of a network of interoperable, federated cyber ranges to train in cybersecurity, staff coming from start-ups, SMEs and large companies, critical infrastructures, as well as students at different educational levels (primary and secondary school, university, professional training) would be of interest. Special attention could be devoted to sectorial cyber ranges for industries like energy, automotive, transport, finance, health… |
| Concrete actions | • Help universities and other education/ training institutions to build new degree courses in cooperation with industry for cybersecurity specialists. Cybersecurity is an area where experience and relevant certification may be more valuable than formal degrees. In order to develop new courses, teachers must be trained themselves, via knowledge transfer from technology experts to teachers.<br>• Establish cybersecurity apprenticeships: In the mid-term, develop a dedicated civil service fast track apprenticeship scheme that focuses on cybersecurity. Graduates will gain valuable cybersecurity experience as part of the broad curriculum and will be able to support governments' overall digital transformation efforts through their specialization. It is important to ensure that the focus of these schemes should not only be on technical cybersecurity skills, but on risk management and other organization aspects of cybersecurity. The EU could develop an apprenticeship scheme/toolbox that can be used by companies to set up their own apprenticeships at different levels and in different sectors.<br>• Map skills demand and Launch an Erasmus+ sector skills alliance that will implement the Blueprint in Cybersecurity (including the mapping of skills demand and supply)<br>• Look into the new initiative under Erasmus 2021-2027 on Centres of Vocational excellence aiming at developing comprehensive skills ecosystems<br>• Create an interoperable network of cyber ranges starting with the identification of gaps to be covered in the cyber range area at EU level from the analysis of the cyber ranges being identified in ECSO and the ones that are part of the 4 pilot actions (SPARTA, CONCORDIA, CyberSec4Europe, ECHO), following with the creation of specific cyber ranges in sectors or areas of interest not covered by the existing ones and the connection among them. |
| Expected Benefits | • With a substantial increase in European expertise, who are at the forefront of cybersecurity solutions, this will not only ensure that Europe has the global experts, researchers into cybersecurity solutions, but also that the likely outcome of cybersecurity innovative solutions will derive from and flourish in Europe.<br>• Training people from a young age, allows for retaining cybersecurity talent in Europe.<br>• EU certification for instance young college students, explaining common risks and solutions would promote the cybersecurity profession, which ensures cybersecurity hygiene and improves solutions' quality in the long-term.<br>• Improve awareness of citizens and companies on cybersecurity matters.<br>• Creation of a new generation of cybersecurity professionals taught in learning |

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| | by doing.<br>• Possibility of executing cyber exercises at different scales depending on specific needs.<br>• Higher competitiveness of European cybersecurity industry.<br>• Improve the core cybersecurity digital skills and understanding in Europe. |
| KPI | • Increase the number of European citizens who receive (some form of) cybersecurity education certification.<br>• Raise the overall understanding and knowledge of EU citizens in relation to cybersecurity.<br>• Successfully (re) train 30% of workforce on cybersecurity skills by 2025.<br>• Increase the number of cybersecurity professionals by 2022 (currently 350,000 in Europe) |
| SWOT Items | S2, S3, S5, S9, O3, O6, T3 |
| Related items | R28 |
| Related EU initiatives | • There is a methodology, proposed in the Skills Agenda for Europe, for strategic sectoral cooperation for skills.<br>• Cybersecurity is one of the eligible sectors for Erasmus+ Sector Skills Alliances implementing the Blueprint. Erasmus+ call for proposals expected in October 2019. |

| R7. | Develop and maintain European excellence in cyber threat understanding and hunting |
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| Description | European policymakers have acknowledged the value of voluntary cyber threat information sharing in understanding the threats, protection of information and networks, and how to prevent cyber threats and attacks.<br><br>EU has strong research base and cybersecurity ecosystem. EU should maintain its excellence in threat mastering through R&D in attacks, ethical hacking, bug bounty, market survey, and vulnerabilities sharing. Security analysis of emerging technologies (AI) is also a key subject that the Commission will tackle with increased international collaboration between national cybersecurity competence centres. The future European Cybersecurity Competence Centre (ECCC) and stakeholder community should help in this process. The EU could encourage alliances between companies involved in cyber threat detection / hunting to get a volume effect in analysis and machine learning and develop an EU threat intelligence capacity. Different European technologies should be put together to improve EU Cyber Threats intelligence capability, such as understanding events in advance (EX-ANTE) and studying them after they've occurred (EX-POST). A particular focus is to invest in biometrics technologies as for example the following ones applied on content coming from the web or any other |

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| | source:<br><br>• Emotions analysis that is able to extract anxiety, stress, fear, so not only the capacity to extract sentiment (positive, negative or neutral) but going in depth analysing the specific mood referred to a specific people, organization, infrastructures, ..This enables end-user to understand future potential actions on dedicated targets<br>• Stylometric analysis (Writeprint) that is able to extract conjunctions, verbs, adjectives, vocabulary richness and complexity, lexical differentiation and usage of specific jargon, slangs, etc. strictly related to specific human factors and behaviour. As an example, the target is to understand if a writer has a style of writing which can be related to criminal groups or if published content on the web using different accounts/nicknames are actually related to the same person. This can contribute to report malicious profiles on social network that may be involved, at various level, in "cyber security threats"<br><br>Larger emerging ethical hacking platforms (comparable to US Hackathon 150K members) might also help the EU. The establishment of an EU community of ethical hackers and cybersecurity professionals would not only create a culture of trust and provide a mechanism for stakeholders to obtain advice on threats & trends, but it could also facilitate the emergence of EU players in cybersecurity. Intelligence sharing as regards threats, trends and lessons learned among different verticals, governments and other key actors such as national CERTs and law enforcement should be fostered. Links with the users and operators should be developed and the discussion around CvD amongst cybersecurity stakeholders and vendors should be raised. |
| Concrete actions | • Develop rules, guidelines and framework for disclosure and information sharing on incidents/breach reporting and for vulnerabilities detection.<br>• Create a Cyber Security Ontology and Taxonomy on a specific language and cross languages. So, putting human/domain expert know-how into a cognitive computing engine (based on either Semantics or Machine learning). Create (manually or automatically) the semantic rules in order to apply categorization, entities/relations extraction and consequent terms normalization automatic activities<br>• Create a "Cybersecurity Information Sharing Network" where parties can join on a voluntary basis, and adhere to specific information sharing rules<br>• Support research in attacks and vulnerability analysis<br>• Support cyber threat intelligence sharing and analysis platforms for different verticals, governments, and national CERTs and law enforcement<br>• Concerning worldwide private actors, support the idea to split Worldwide Cyberthreats Intelligence platforms (receiving all cyberthreats data from customers) by creating European CyberThreat Intelligence platform restricted to data coming from European customers |
| Expected benefits | • Enhance EX-ANTE analysis capabilities<br>• Enhance EX-POST analysis capabilities, so improving understanding and |

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| | reasoning about lesson learned |
| KPI | Number of semantic behavioural attributes extracted from analysed contents (Human factor attributes) |
| SWOT Items | S2, S5, W2, W4,W5,T1 |
| Related items | R6, R10, R4 |
| Related EU initiatives | Same as the ones described in R6 |

| R8. | Develop and deploy end-to-end data protection solutions using advanced cryptography |
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| Description | Launch a European coordinated action to develop advanced cryptographic functions and protocols (fundamental research, and operational Proof-of-concept). EU has strong research base and cybersecurity ecosystem, but cybersecurity solutions must often rely and work with out-of-EU enablers (such as cloud) or components (antivirus). Technical challenge is to build global secure solutions with untrusted/unsecured components. Cryptography is the key technology to secure digital applications. Europe has a strong background in theoretical mathematics that are the basis of cryptography, and innovative schemes development should be encouraged, supported and pushed to proof of concept and standardization. Homomorphic encryption enabling the use of untrusted cloud services, as well as Identity and Attribute based encryption (IBE, ABE) enabling global secure solutions with massively interconnected objects are technologies to support. European Commission could, in collaboration with Member States, make available, research and innovation funds (H2020) for breakthrough and patenting on advanced cryptography. This should comprise also innovative cybersecurity deployment projects, including pilot lines via launching calls for proposals (for an amount to be defined). DARPA is currently financing such procurement projects. |
| Concrete actions | • Develop ad-hoc advanced encryption algorithm to support European regulation (GDPR, NIS, eIDAS, …), and deploy these solutions to allow safe transmission, storage and exploitation of this data in unsecure environments<br>• Develop algorithms in following domains : ABE attribute-based encryption, IBE identification-based encryption, homomorphic encryption, anonymization, zero knowledge, block chain, quantum safe cryptography<br>• Develop adequate architecture to support this.<br>• Support technology from fundamental research to operational proof of concept in advanced cryptographic solutions.<br>• Define EU policy and guidelines on cryptography (there is no such thing for the moment)<br>• Provide funding to encourage the 6~7 EU start-up companies that have developed specific niche solutions to team up to develop more |

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| | comprehensive solutions for cryptography |
| Expected benefits | support European strategic autonomy |
| KPI | number of international or European standards published |
| Type of investments | Hardware, embedded software, application, HSM (hardware security modules) |
| SWOT Items | S2, S5, W2, W4,W5,T1 |
| Related items | R64. |
| Related EU initiatives | • European Cybersecurity Competence Centre : should select this issue as priority<br>• Horizon Europe, Blockchain Observatory, Quantum Flagship Initiative |

| R64. | Develop homomorphic encryption |
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| Description | Cryptography is the key technology to secure digital applications. Homomorphic encryption is a form of encryption that allows correct computation using ciphertexts only without revealing the plaintext. Therefore, homomorphic algorithms can protect the privacy of data in hostile environments (e.g. in a foreign cloud), out of reach of laws like American Cloud Act of March 2018. Need for standardised use within Europe regarding cloud applications to protect sensitive data. To this end, working with ESOs is essential, in order to introduce such a proposal in the annual rolling plan for ICT Standardisation. Efficient algorithms are needed. At present time, performances provided by R&D labs are too weak to meet operational requirements. More investments are needed to improve these performances, and also to look for specific hardware accelerations. Specific research funding could be allocated through Horizon Europe Program in parallel with ESOs activities. |
| Concrete actions | • Support R&D in homomorphic encryption to allow data privacy in hostile environments by introducing dedicated R&D budget in the new “Horizon Europe” research budget (continuation of “Horizon 2020”)<br>• Make proof of concept for homomorphic encryption:<br>• Server development<br>• Client encryption/decryption<br>• Real-life use cases<br>• Support implementation of the newly designed algorithms on hardware acceleration platforms (FPGA, etc.) |

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| Expected Benefits | Data is an additional layer of solutions to be considered in the presented value chain. Homomorphic encryption is one of the critical technologies and processes that Europe should master as a forefront protection of data privacy. This technology will have a strong impact on many verticals and especially for the most critical ones. |
| SWOT Items referred to | S2, S5, S6, S7, W2, W5, O2, O4, O5, T3 |
| Related items | R8. |
| Related EU initiatives | H2020-ICT32-2014-RIA: HEAT (Homomorphic Encryption Applications and Technology, https://heat-project.eu/): KU Leuven, UBristol, UL, UPMC, CRX, NXP and Thales UK |

| R31. | Cyber security SME Hub: a unique platform supporting the "Cyber security Made in Europe" |
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| Description | Cybersecurity technology is changing rapidly and only the SMEs, due to their agility, can provide the cutting-edge solutions needed to remain competitive. While the US has the largest market, specific regulatory framework (e.g. the Small Business Act) and Silicon Valley ecosystem, Israel has a strong military-academic-industry partnership and China has a protectionism strategy, EU is still looking for an appropriate business model on SMEs. SMEs are generally more reactive and able of fast innovation. They are therefore critical in EU to prove the viability and the efficiency of new cybersecurity tools. However, with a domestic market valued at EUR 25 billion and a very diverse industry landscape, made of 12 000 companies of which 74 % are micro companies and SMEs (source: 2018 ECSO Estimation), the European offering is not yet consolidated partly due to a difficult access to the market for young companies specialised in cyber security.<br><br>The SME Hub is intended as a market support and networking tool for European Cyber SMEs. It shall help SMEs to create **more market transparency and to reach out far beyond their traditional home markets**, which are usually nationally or regionally limited.<br><br>The Hub consists of three main functionalities aiming to give more visibility to European SMEs:<br><br>• **The Registry.** The SME hub shall be a publicly accessible platform where SMEs can register their company and define the services or products they offer in a predefined market segmentation structure which is based on the ECSO Taxonomy. Accordingly, this platform can be searched by interested companies who require services or products, based on type, quality and delivery capability of the registered SMEs. The provided market segmentation |

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| | and categorisation can also be used to build consortia of different SMEs over larger parts of the value chain, e.g. when required for a project or large RfP.<br>• The “Cybersecurity Made in EU” label. The label is a private marketing tool fostering the claim of quality and security of European companies and NOT a certification. The label would target companies and NOT Products / Services, is based on self-declaration and NOT technical audit, is aimed mainly at SMEs but NOT excluding large companies. The operational model is based on a multiscale approach NOT competing with existing (similar) national label but rather aiming for synergetic co-existence with existing national/regional initiatives. The criteria are:<br>o 1)The company is a registered entity located in Europe, with headquarters in Europe (if part of a group, then group headquarters in Europe)<br>o 2) European ownership: company provides reasonable assurance that there is no majority ownership/control from outside Europe (declaring ownership structure / majority stakes)<br>o 3) The company has >50% of cybersecurity R&D activities located in EU and >50% of staff (FTE)<br>o 4) The company offers trustworthy cybersecurity (ICT) products / solutions: The company declares to comply with the basic requirements defined by the ENISA Essential Security requirements for ICT including No-spy declaration: No offered product or solution contains backdoors (non-declared functionality)<br>• The Quadrant. The Hub shall give the possibility to serve as a market differentiator between SMEs based on their broadness of service, quality and capability to deliver. This shall be achieved by deriving various “European Cyber Quadrants” for the different market sectors, where cyber SMEs will be ranked according to clear and unambiguous criteria regarding quality and capabilities. The platform shall be open to all European Cyber SMEs, neutral and unbiased. It shall be provided via a web platform which is easily accessible by potential customers. The governance of structure, contents and criteria shall be done by a neutral governance body consisting of industry participants. ECSO, and in particular its Working Group focusing on SMEs, is currently finalising the business and operating model. A test is expected to be launched in Q4. |
| Concrete actions | • Create a pan-European incubator for SMES to ensure short time market access.<br>• Provide funding to help cybersecurity SMEs to obtain certification<br>• Support SMEs and start-ups with getting certification and EU funding<br>• Reinforce and promote the use of the European “Small Business Act”<br>• Support the ECSO initiative to design and implement a SME Hub and the related functionalities: Directory, Label, Quadrant |
| Expected benefits | • bring products sooner to the market |

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| | • avoiding SME leaving the EU |
| SWOT Items | S1, S3, S5, W1, W2, O4, O5, T3 |
| Related items | R50 (European accelerator network), R61 (to facilitate SME to access to finance). The conjunction of R31, R50, R61, will foster the consolidation of the EU market. R42 |
| Related EU initiatives | To some extent, the European Enterprise Network carries out some of these activities. |

| R42. | Speed up the use of the EU Cybersecurity Certification Framework and support the SMEs to receive certification |
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| Description | The cybersecurity act has been recently adopted. It creates a cybersecurity certification framework to certify products, services and processes. Certification is based on schemes specifying the type of product, service or process that can be certified, the security requirements for certified items and how to certify them. Schemes are proposed by the European Commission in the Union Rolling Work program for Cybersecurity Certification. The recommendation is to speed up and enforce the use of the European security certification by initiating the definition of schemes in critical areas (IoT, medical devices, automotive, industrial systems), helping companies (specifically SMEs) to certify their products and promoting the use of certified products (requirements in call for tenders), on the basis of international IEC/ISO and market-adopted standards. Ensure that the certifications are cross sectorial, to avoid creating silos or internal barriers between different cybersecurity sectors.<br><br>• Certification is complex and expensive creating delays in their uptake.<br>• Support SMEs and start-ups with getting certification and EU funding.<br>• This will help to bring products sooner to the market (and avoiding SME leaving the EU).<br>• SME support solutions could be linked to national and regional competence centres, brokers, clusters, and coordination centres that are aware of new EU programmes and funding opportunities.<br><br>In particular with regards to the role of regions, Wallonia (BE) launched in 2018 “KIS: Keep It Secure”, a recent mechanism to raise awareness and enhance maturity about cybersecurity among SMEs in Wallonia (BE). The regional authority acts as the facilitator to raise the level of maturity of SME end-users willing to implement audit and IT security analysis. In particular, Wallonia regional authorities aim to liaise end users with a list of validated and authorised security audit providers through a dedicated funding support “cheque enterprise”. The end-users using the regional mechanism will get funded 75% of the costs of IT security solutions. |
| Concrete | • Fill in Union Rolling Work program for Cybersecurity Certification with critical |

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| actions | products, services and processes (IoT, medical devices, automotive, process/secure development life-cycle, industrial systems) → Norms<br>• Help industry in using European certification (information, training, dedicated funding) → SMEs<br>• Promote and/or incentivise the use of certified products (in call for tenders, in future sectorial regulations) → Procurement<br>• Have mandatory certification in energy<br>• Initiate the process with some critical verticals where Europe has a leadership position (autonomous electric vehicle for example). |
| Expected Benefits | • To enhance the security level of systems by using secure components<br>• To maintain a control on non-European and untrusted components (evaluated and certified in Europe)<br>• To give a label to quality secured European components. |
| SWOT Items | S1, S4, S7, O2,W3, T1, T4 |

| R24. | Support European cybersecurity hardware suppliers |
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| Description | Recent attacks show that hardware is a new entry point for attackers. The vulnerabilities exploiting hardware are hard to detect since they rely on proprietary specifications. The hardware founders could even add back doors (e.g. Hardware Trojan) without being detected by final users. Having an industry of electronic components in Europe would help to maintain strategic autonomy on these technologies. Examples: to build a washing machine, you have 270 suppliers (both hardware, software, etc…). Today, there are no guidelines on the sourcing requirement regarding cybersecurity. The washing machines could be hacked to have 1 million washing machines starting at once. It is a real cybersecurity threat and there are no security measures or framework in place for the moment. Rationale:<br>• Current dependency of non-EU suppliers<br>• Hardware is a hard segment to invest in<br>• IPCEI already exists in microelectronics<br>• We can develop specialized EU chips for cybersecurity applications |
| Concrete actions | Coordinated investments between cybersecurity hardware manufacturers to compete with non-EU actors |
| SWOT Items | S4, S5, W10, W11 |
| Related items | R31, R61, R38, R65 |

| R53. | Review and adjust EU innovation funding instruments to make them competitive and relevant for the fast evolving cyber security industry. |
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| Description | European funding mechanisms are not competitive enough, compared to the way some of EU's biggest competitors support cyber security industry and innovations (peer review). In the EU instruments application, implementation and reporting processes and time frames are long and cumbersome to be relevant for companies competing in the fast evolving global cyber security market. Assess the feasibility to use cascade funding as part of larger research projects. Increase understanding what kind of innovations and solutions are needed in the market. Support the SMEs and start-ups in participating in the EU funded projects. Make a study on different public funding models on cyber security industry and innovation (EU vs main competitors). Assess the requirements in the EU financial instruments and interview CTOs of European cyber security companies to identify the main bottlenecks hindering participation in the EU projects. Make recommendations to address identified shortcomings and problems. |
| Concrete actions | Introduce specific rules/tools to support a simplified participation of SMEs in EU-funded projects |
| Expected Benefits | Increased investments in the innovation and growth in the European cyber security industry.<br><br>Stronger and bigger European cyber security ecosystem and solutions.<br><br>Increased global market share in cyber security supply. |
| SWOT Items | W2, W3, T1 |
| Related items | R61 |

| R55. | Enable and encourage cross border collaboration on cybersecurity products and services |
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| Description | Mainly Member States have local cybersecurity service and product suppliers. Those may be well-established in one MS market, but growth cross border inside EU, is not happening. Often trade-barriers are invisible: business-culture, language, mistrust and others. SMEs find it often easier to grow to non-EU markets than inside EU. EU should build program where existing SMEs have opportunities to find new partners, distributors and solution integrators from the other MS. EU should finance business-workshops for Cybersecurity companies where companies are driven, "even forced", to work together towards building joint-offerings. The program could be financed by EU and it should include travelling costs for those company participants. Example: If three companies are able to make pilot-proposal to EU for build joint-offering, EU would provide financing for that to test it. Financing would be conditional until, offering could be proven in practice. |
| Concrete | Create dedicated strategic funding programs in support of SME collaboration |

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| actions | |
| Expected benefits | More local or regional European cybersecurity companies are able to find partners inside EU to build joint-offering. If offering is match, it increases odds to have more industry related consolidation inside EU instead of having non-European cybersecurity giants conducting acquisition from EU, buying out promising SMEs in the early stages. At the same time, this practically lowers trade barriers inside European Digital Single market. |
| SWOT Items | S5, S8, W1, W2, W4, O1, O2, O9, T1 |

| R56. | Support industrial buyout and investments inside EU |
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| Description | Europe is lacking of venture capitalist for scaling up investment rounds. Cybersecurity markets are globally ruled by large cybersecurity industrial giants, where exists non-European based companies. Often global markets are having unfair competitive activities provided by some countries allowing some business advantages to companies originating from the same country; competition is not always played by “fair-play” market-economy, with international trade rules. Europe must have a scheme providing more visibility of cybersecurity industry existence inside EU with providing more opportunities for venture capitalist and industrial investments to find potential companies inside EU. There should be new encouragement for buyout of EU origin cybersecurity companies happening within EU. Enablers could be as an example:<br>• tax deduction,<br>• easy loans from public institutions (national or EU banks),<br>• Industry specific investment funds, with dedicated facilities to help mergers and growth. |
| Concrete actions | Create dedicated strategic funding programs in support of market consolidation |
| Expected benefits | More globally competing European based cybersecurity companies born and industry origins remains more often inside EU. |
| SWOT Items | S4, S5, W1, W2, W3, O7, O9, T1, T2 |

| R57. | Accessing Global market |
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| Description | There should be support for industrial access to the global markets. EU has extensive network of EU embassies all around world. Those organizations should have a special scheme to support European based SMEs to find market information of partners, re-sellers and customers. US, China and many other countries have trade counsellors located in their embassies to enabling industry to access new markets (EU do not allow |

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| | it).EU could also establish industry related scheme to have trade counsellors focused in the industry specific sectors. Those trade counsellors could be co-financed with industry itself, coordinated with some industry clusters or association to maintain "fair-equal treatment" for all companies interested to penetrate those markets. |
| Concrete actions | Introduce advisory services for European Business within the EU delegations network |
| Expected benefits | Increasing new business growth opportunities for cybersecurity industry and research to get access to the new markets and lowering business risks for early stage failures. This is equalizing global trade opportunities between EU and competing countries. |
| SWOT Items | S5, W1, W2, W3, W9, O4, O7, T1, T3 |

| R60. | Integrate existing expertise into to the EU decision making processes |
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| Description | One of the biggest weakness in EU is lacking industrial voice from decision-making. Dynamic and critical business sectors, such as cybersecurity requires continuous visibility to real economy and business. Today's framework of EU conducts surveys and studies, and decision bases on those outputs. In practice, the non-European ICT sector is well-represented in Brussels with lobbyists. On the other hand EU own industry has no chance to contribute or to be heard. EU needs a new industrial advisory framework, with a well-built structure throughout the whole EU. There should be reasonable number of European Cybersecurity companies present, covering different size and types of companies with balance of geography. Besides the industry, there should be also a similar researcher network across the EU. The framework should call an advisory board to meet quarterly to provide advice, generate some new ideas, consultancy and help adequately to build real-time SWOT, updated KPIs etc. for EU. Industrial specific clusters should be used in a more efficient manner for selecting Advisors. |
| Concrete actions | • EU Advisory board for supporting continuous decision making helping Cybersecurity related Commission DGs<br>• We need to have a clear voice from the EU cybersecurity industry. ECSO could enlarge its membership and play that role. |
| Expected benefits | Helps the whole EU base decision making process to interact between industry and research across-EU more efficiently and balance out lobbyist influence. |
| SWOT Items | S1, S4, W7, W8, W11, O1, O2, O7,T1, T4 |
| Related EU initiatives | Contractual public-private Partnership with ECSO and the Commission proposal for a Competence Centre and network. |

| R65. | Certifiable secure firmware on open hardware for Europe |
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| Description | Secure hardware components, e.g. secure chips or secure hardware building blocks are more and more being incorporated into larger system on chips (SoC). Main SoC players and developers are residing outside of the EU. They are therefore in a good position to also provide secure software on top their proprietary hardware. Therefore it is important to promote the development of open source security hardware that can be used to both create stand-alone security chips and that can be integrated into larger systems on chip. In addition a framework is required to allow for development of a secure and security certifiable firmware / software on top of such open source hardware. Open Hardware can also provide protection from in–built trojan horses. Yet a successful certification is difficult to achieve because developers as well as hackers have the same information level. |
| Concrete actions | • Need of certifiable hardware-based firmware and applications which can be trusted by users. This work could be conducted under the responsibility of the future European Cybersecurity Competence Centre<br>• Need of scalable solutions according to the environment and the level of potential attack. This topic could be tackled by the European Commission's annual workplan for certification with proposals to work on an EU candidate scheme in parallel to the need of EU standards addressed by the MSP for standardisation.<br>• Provide funding for and set up an EU driven community for open source security hardware. |
| Expected Benefits | Facilitate access to (EU) certification and increase the consumer's confidence level by placing on the market secure and reliable ICT solutions. Increase the robustness of European ICT solutions, taking advantage of the European Certification Framework and enabling European manufacturers and solution providers to compete on the world stage. Security certification (dynamic), besides Safety requirements for placing a product on the European market, is also a stage that should be integrated in the presented value chain. Create an open platform for security software and applications on top of openly defined hardware and enable EU based companies to provide security solutions independently. |
| SWOT Items referred to | S5, S7, W1, W4, W5, W6, O2, O4, O8, T1, T2, T4 |
| Related items | R4. R66 |

| R59. | Market data availability and awareness |
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| Description | Cybersecurity related market data, "the correct data" is not easily available. Detail market studies are continuously updated and especially for small companies, it is almost impossible to have access for relevant cybersecurity market data. European Union should have continuous production of relevant indicators of cybersecurity market data. There should be information about different Member States and also similar data from non-European markets. At the same time, there should be an updated directory of all significant organizations operating inside EU in the field of Cybersecurity. This mapping also needs to include competences. The S3 Pilot Action on Cybersecurity led by Brittany Region has started the process, as explained in ECSO's position paper, using the ECSO taxonomy on the cybersecurity market. The Pilot Action is using the CRAFT tool, developed by Bureau Développement Innovation of the Brittany region. The Pilot Action is fully willing to share its experience if considered useful. |
| Concrete actions | • Create a **mapping** of the European cyber-industry value chain or industry, which includes SMEs and end-users, to complement the one already developed by the JRC, based on a **common taxonomy**.<br>• EU provides itself or throughout other third parties real-time cybersecurity statistics to be available for public sector, industry (including end-users, providers and SMEs) and research (for bench marking and support for decision making) |
| Expected benefits | Helps the whole EU base its decisions on more relevant data. It applies to EU itself, Member States, private industry and research. Updated correct data is one of the most important ways to build Situational Awareness of Cybersecurity, all over EU. At same time all stakeholders in EU have the similar starting-point to build their baseline for their decision-making processes. This mapping exercise is the first step to create a comprehensive European value chain that includes all actors. It will be a useful tool to further identify strengths and weakness of the European cybersecurity industrial base, to connect actors together across Europe, to create synergies and complementarities, based on a common "language" and understanding of the moving landscape. |
| SWOT Items | S3, W7, W8, W9, W11, O4, O7, T3, T4 |

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| **R71.** | **Risk Information Sharing Platform: Collaboration in risk management towards informed governance** |
| Description | Many regulations and laws ask stakeholders to take a risk-based approach; risk management is finally becoming a board topic. This evolution has been sped up by GDPR and the NIS directive. However, there is only a framework available for risk management, namely the ISO/IEC 27005. What scope stakeholders should analyse in their risk management approach is completely unclear. There is no guidance on what scenarios to include, what probabilities of threats to apply and what ease of exploitation of vulnerabilities or what efficiency of risk mitigation measures. This situation is most unsatisfactory, as it is sheer impossible to compare risk assessments |

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| | done buy different stakeholders. This makes cross-stakeholder risk management impossible. The risk lying in long interdependency schemes cannot be qualified or analysed, which makes regulation as well as governance impossible. By taking this approach, stakeholders will work on a comparable model and produce comparable results. This would lead to more objectivity and to more board level involvement. Risk assessments can be linked and combined to create larger overview of a corporate or even a sector. |
| Concrete actions | For this reason, it is proposed to start a 2 phased informed governance project, which brings together actors with the aim to define a common taxonomy for risk management: The first phase will focus on basic risk management scenarios:<br><br>• Definition of minimum set of risk scenarios (asset – vulnerability – threat). The CERT community as well as the Security Operations Centres have extensive knowledge what are the most common scenarios leading to incidents; these should be identified and qualified.<br>• Definition of metrics for threat probabilities, ease of exploitation of vulnerabilities and efficiency of risk mitigation measures by the same community (related to R21, R6, R7)<br><br>In a second phase regulators should step in and help to address the remaining governance aspects like minimum scope, minimum impact qualification (in case of NIS and GDPR), and of course an acceptable risk acceptance matrix. This approach will lead to a better risk management, a better governance and an increased level of security in Europe. The same approach would be chosen for advanced, more sector specific risk management. For each NIS sector, stakeholders meet in ISAC setups and discuss sector specific risk scenarios as well as threat probabilities, ease of exploitation of vulnerabilities and efficiency of risk mitigation. Upon these risk scenario models, standard as well as advanced certification schemes will be created. |
| Expected benefits | • The project will lead to an information sharing platform for risk management.<br>• Individual time spent in risk management would be reduced due to the availability of scenarios and metrics.<br>• Stakeholders will work on a comparable model and produce comparable results. This would lead to more objectivity and to more board level involvement. Risk assessments can be linked and combined to create larger overview of a corporate or even a sector.<br>• This approach will be supported by the private sector as it will lead to harmonisation of regulatory requirements in cybersecurity and thus reduce the regulatory burden and increase the attractiveness of the European Union.<br>• This approach would lead to more security, as risk management gets much more objective and comparable. Regulators as well as corporates can implement better governance models. |
| SWOT Items | S1, S3, S5, S6, S7, O2, O5, W3, W5 |
| Related items | R21, R6, R7 |

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| Related EU initiatives | • Risk management approach of the legal frameworks<br>• Certification frameworks |

| R69. | Create a network of experts to provide assistance and training to public procurement agencies for their cybersecurity procurement needs |
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| Description | Contracting authorities need access to cybersecurity expertise when planning their IT infrastructure and procuring IT equipment. As building in-house cybersecurity capacity is not feasible in the majority of cases, on-demand access to expertise should be available in competence centres. Already existing networks of competence centres may develop this additional expertise, .e.g. Digital Innovation Hubs, national/regional innovation agencies, or newly established structures may be envisaged. |
| Concrete actions | Define cybersecurity expertise in public procurement competency; Identify suitable existing competence centres to develop cybersecurity consultancy capacity; Envisage funding programme; |
| Expected benefits | Increase of cybersecurity awareness of contracting authorities; Increase of cybersecurity level of public IT systems; Increase of chances for innovative and possibly EU made solutions to be purchased in public procurement. |
| KPI | Cybersecurity competence centre network creation; |
| SWOT Items | S1, S3, S4, S5, S6, S7, S9, W1, W2, W5, W8, W9, W10, O1, O2, O6, O7,O8, O9, T3, T5 |
| Related items | R50 |
| Related EU initiatives | Digital Innovation Hubs (CNECT), Procure2Innovate (CNECT) |

| R25. | Coordinated EU cybersecurity strategy and governance for the smart grid |
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| Description | From electrical distribution to power, to advanced distribution management systems, EV charging infrastructure and up to electrical panels we should guarantee interoperability and seamless security along the propagation of energy and metering. This can be applied to smart grids, micro grids, smart cities, distributed energy resources integration (PV, storage, genset …) where orchestration will happen. It will require local intelligence (edge), rule based engines as well as orchestration from the cloud (weather prediction data plus tariff management plus power availability, demand response state etc.). Challenges of the Smart Grid sector in the field of cybersecurity |

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| | • Lack of a common European regulation and certification framework in cybersecurity<br>• Lack of governance for Authentication of third parties during the all vehicle lifecycle<br>• Product life cycle management<br>• Resilience of the ecosystem<br>• Integration of multi-energy and connection to a grid (electric, gas, etc.)<br><br>Among the different verticals, EU car industry is a strong asset with world leaders in EU. This industry is facing multiple security challenge related to new car functions: connectivity, driverless, electrification and connection to smart grids or different gas providers. Cybersecurity could be a showstopper. Competition is still open in that field as it is really an emerging domain. EU has strong research base and cybersecurity ecosystem with world leading companies. Automotive is driving the innovation market for new security technologies (HW/SW) for embedded systems. The proposal is to set up security of clean connected car as a European priority, and to fund coordinated projects both on security solutions development and security certification in that field. Charging vehicles sector (electric, hydrogen, LNG, natural gas for vehicles) comprises many actors with divergent interests leading to heterogeneous security solutions for charging. Manufacturers, users and charging station operators need a confidence model for interconnection and an agreement for charging on the electric grid or other fuel.<br><br>Regulation & Certification Framework:<br><br>• Although some specific standards have been defined regarding cybersecurity issues for industrial and automotive systems, there still a lack of a unified regulation and certification framework at European level for energy providers and technology suppliers. (*Utilities don't know what to require; manufacturers don't know what to develop).*<br>• ENISA is working at the definition of a unified regulation for the electric sector and this should concern smart charging.<br>• Definition of the cybersecurity ecosystem should facilitate in order to speed up the harmonisation at EU level (need of trust).<br><br>Smart charging for electrical vehicle :<br><br>• Smart Grid provides electrical supply to many other critical infrastructures (hospitals, defence, transport, telecommunications, public institutions etc.).<br>• Smart Grids and Telecommunication Networks should be strongly integrated. Cybersecurity of networks, authentication and authorisation for charging on the grid at the good/authorized moment will be mandatory.<br>• Cryptography, Public Key Infrastructure and secure database are tools of success, while also having issues<br><br>Product Life Cycle Management: |

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| | • Cybersecurity innovative solutions created in R&D projects should be deployed in an old and geographically disperse infrastructure with thousands of legacy devices.<br>• We have to think in life cycle products of 20-30 years with continuous vulnerability revision (*defence that works now may not work tomorrow*) that will affect the manufacturing, upgrading and certification process.<br><br>Resilience:<br><br>• Disaster response should be improved.<br>• Greater coordination with other stakeholders and with other cybersecurity organisations<br>• The volume of electronic (IoT) devices to be integrated or connected to the smart grid will grow exponentially in the coming years with extreme actualisation costs:<br>• Electric vehicles will require specific equipment to be integrated in the infrastructure (recharging posts and stations).<br>• Distributed Generation (domestic PV panels, wind generation etc.)<br>• Future threats will come from IoT devices connected to the Smart Grid (How can security be assured?).<br>• How to detect massive attacks from IoT devices (for example, HVAC systems, domestic appliances etc.).<br>• People awareness:<br>• As in many other sector, infrastructure is only a part of the whole system. People continue to be one of the main sources of vulnerabilities.<br>• There are more and more external personnel in the Smart Grid facilities. It is necessary to raise awareness of the staff.<br>• Greater participation of the final user, for example in energy demand-response scenarios.<br><br>Integration of smart devices and IoT: |
| Concrete actions | • Fund coordinated projects to reach a secure, clean, and connected car both on security solutions development and security certification. Develop an ecosystem based on trust model for interconnection and agreement for charging, for instance on the electric grid, but also for gas solutions.<br>• Smart Grid is considered one critical sector and could be one of the first verticals for R42, which proposes to “initiate this process with some critical verticals where Europe has a leadership position (autonomous electric vehicle for example)”.<br>• To set up an alliance integrating stakeholders of the smart charging (network operators, technology suppliers, cybersecurity solution providers, standard and certification bodies, etc.) for defining cybersecurity standards and test procedures.<br>• To foster the development of specific cybersecurity solutions that satisfy functional and performance requirements.<br>• Investment in R&D: new technology could be needed, R&D projects to |

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| | validate the solutions<br>• Telecommunication and energy sector coordination to jointly define security aspects.<br>• Creation of a specific CERT for the sector at EU level.<br>• From 61850 as a communication protocol to last mile technology (Power Line Carrier, 5G, LoRA, Zigbee etc.) for the sake of securing Distributed Energy resources, demand response, advanced metering, sharing energy (maybe enabled by blockchain), this in accordance with country regulation and orchestration of utilities and keeping the consumer becoming a prosumer in the loop. This can be derived to home automation starting from industrial use cases from power critical and power intensive customers (Oil & Gas, Healthcare, Data centres etc.). Enabling 62443 certifications or other standards, guarantying as well GDPR rules conformity. |
| Expected benefits | • Build European players in vehicle charging, whether it's gas or electricity, with secure networks and cybersecurity for charging solutions<br>• Enhancement of the security level of the Smart Charging<br>• To position the European cybersecurity and smart charging sectors as an international leader.<br>• To share a common framework will make interoperability easier, select the trust provider, and globally reducing cybersecurity costs.<br>• Development of more robust and secure products, increasing trust in the new technology and charging systems.<br>• Increase the sharing of information among the relevant stakeholders: for instance, provide a better and faster response to cyber incidents.<br>• Ensure that new devices, including IoT devices, have and will maintain a level of cybersecurity appropriate to the Smart Grid. |
| SWOT Items | S1, S3, S4, S7, W12 |
| Other potential interested parties | • EC: promotion of a common regulation for the whole EU regarding cybersecurity requirements for design, implementation, operation and maintenance of smart charging platform.<br>• Standardisation and certification bodies: definition of and compliance with specific cybersecurity standards for the smart charging. This should include standards and certification process for the different actors involved in the implementation, operation and maintenance of equipment and infrastructure (see IEC, ETSI, ENISA, etc.).<br>• Utilities: deployment of standards (operation, management, maintenance); employees training and awareness on cybersecurity issues; cyber incident response;<br>• Vehicle equipment providers: provision of certifiable secure systems; new procedures for up-to-date secure systems (lifecycle management of secure equipment).<br>• Equipment providers: such as electric vehicles and charging stations, IoT plug & play devices etc., to provide compatible cybersecure systems.<br>• Engineering & Integration companies: |

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| | • Cybersecurity solution providers: development of technologies and solutions for cyber-attack and anomalies detection, security level monitoring and control in the smart ecosystem.<br>• Hardware providers: development of certifiable cybersecure HW components that meet the high-performance requirements of the smart grid.<br>• Cybersecurity services/consultancy companies (CERT, SOCs etc.): support and development in the application and deployment of policies, standards, etc.<br>• R&D technology entities: research on new technologies - such as AI - to support the development of new solutions for cyber incident prevention, detection, identification and/or response. |
| Related items | R42, R18 |
| Related EU initiatives | • JRC Pilot Project on IACS |

| R10. | Support to the development of European breakthrough technologies applied to cybersecurity |
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| Description | The exploitation of emerging technologies (Artificial intelligence, quantum, cognitive technologies, DLTs…) in the cybersecurity field can help to develop a new range of products and services. Cognitive/AI technologies can support also the analysis of citizen perception about Security from social networks, as it leads to an erosion of citizens' trust and confidence in digital trust. Examples:<br>• new detect function, preventive analysis of potential cyber threats on social networks (either Surface or Deep/Dark web), analysis of the behaviour of "potential hackers" (Emotions and Style of Writing) on nodes exposed to simulate a critical infrastructure, the creation of a "cyber" taxonomy for categorisation,<br>• The creation of a "cyber" ontology for the normalization of terms exchanged by stakeholders at European level and the extraction of personal information as related to the GDPR issue.<br>• the understanding of the Human Factor side of social network contents; so extracting behavioural attributes expressed by writes and giving the possibility by end-users/practitioners/phycologists to understand how messages are spread into the web, if they are pro or counter messages, the methods of approaching people, who is the boss of a group in a forum,<br>• the understanding of specific slangs, dialects and misspellings typical of social networks languages such as talkative languages |
| Concrete | • Support of emerging technologies (Artificial intelligence , quantum, cognitive |

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| actions | technologies…) and their use in innovative protection products, services and processes<br>• Developing of advanced behavioural AI algorithms in order to understand the "Human Factor" from unstructured contents and into multiple languages. |
| Expected benefits | • Enhanced comprehension of the style of approaching of cyber attackers<br>• Advanced prevention capabilities<br>• Understanding the human factor side into web contents<br>• Improving finalization of targeted web campaign<br>• Understanding social network targeted slangs<br>• Understanding fake vs real news |
| KPI | • Number of semantic behavioural attributes extract from analysed contents (Human factor attributes) |
| SWOT Items | S2, W4, W5, O5, O7 |
| Related items | R7 |

| R32. | Development of Industrial cybersecurity building on Europe's strong industrial base |
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| Description | Europe has core competences in the development of industrial security and embedded security and is able to compete globally. Robust cybersecurity for the whole range of IoT and IIoT products, services and processes is a longer-term and strategic perspective to cybersecurity. Consequently, to spur industry-wide uptake of integrating cybersecurity solutions into products, including the development of products, and after-sales, establishing cybersecurity development processes (e.g. IEC 62443-1-4) factually increases cybersecurity in the long-term, in particular stimulating innovation and investments into cybersecurity solutions.<br><br>• Industrial cybersecurity leaves room for further improvements.<br>• Certification and standards covering the entire life cycle would be valuable.<br>• This would establish a cybersecurity by design approach.<br>• A focus on full life cycle development may also unfold opportunities for new service offerings: companies or shared service centres focusing on delivering industrial cybersecurity solutions. |
| Concrete actions | • Build policies on existing industry security measures, including investments towards industrial cybersecurity solutions.<br>• Draft a cybersecurity life cycle management methodology to train software, hardware and infrastructure developers. |

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| Expected benefits | • Boost Europe's cybersecurity capacities, in particular for its industrial infrastructure<br>• Setting the global standard on cybersecurity<br>• Building trust in the Single Market |
| SWOT Items | S7, S4, S11 |

| R23. | Implementing a secure European Operating System for critical applications |
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| Description | There is no Operating System being developed and maintained in Europe. In addition, its development is fundamental for all the services that rely on it. Academic research with a strong involvement of European industry and European Union Agency for Network and Information Security (ENISA) should help such an implementation. Within many architectures hardware is a new entry point for attackers. Vulnerabilities inside hardware are hard to detect since the latter relies on proprietary specifications. Hardware founders could even add back doors (e.g. Hardware Trojan) without being detected by final users. Having an industry of electronic components in Europe would help to obtain strong strategic autonomy on these technologies. |
| Concrete actions | • Created a public/private consortium to develop an EU OS<br>• Investing in research to secure hardware and OS is one of the necessary means to defend European industry and strategic autonomy |
| Expected benefits | • Strategic autonomy, user data confidentiality and privacy, hardware and software security. |
| SWOT Items | S4, S5, W10, W11 |
| Related items | R21 |

| R41. | Set up a special training program and professional certification in the cybersecurity |
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| Description | Private background in skills and academics should be leveraged to create a centre of excellence in cybersecurity of IoT devices and driverless cars to complete the state of the art gaps. Starting from the European e-Competence Framework (e-CF) - part of ISO 11506 and receive the EN 16234 from European Committee for Standardization – a special training program and professional certification in the cybersecurity IoT lifecycle should be setup, in order to improve the skills, knowledge and proficiency levels. Industrial players as well as training and certification providers could sign an MoU with ENISA and NIST (National Institute of Standards and Technology) to export and trust the framework around the world (i.e.: accreditation or certification accredited by ...). First training could be on:<br>• IoT awareness and knowledge base;<br>• IoT cyber security issues;<br>• IoT security lifecycle. |
| Expected benefits | Increase the human value for the entire cybersecurity lifecycle.<br>Increase the value of "The EU cybersecurity IoT Certification".<br>Growth, employment for businesses. |
| SWOT Items | S7, W3, O3, T3 |
| Related items | R16, R28 |

## Medium Priority

These recommendations are clear with concrete actions, but have received only limited or mixed support from participants (apart from the party submitting the proposal).

| R43. | Fund European research, development, demonstration and deployment in Cybersecurity |
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| Description | Dedicate significant part of European R&D funding (H2020, …) to the R&D covering all the chain of security technologies and their integration in critical systems:<br>• Cryptography<br>• Threat intelligence and vulnerability detection on hardware, software and systems<br>• Security of emerging technologies (AI)<br>• Developments, analysis and validation tools<br>• Large scale demonstrators and proofs of concepts<br>• Create a DARPA-style process to fund R&D with clear applications and a clear client already in mind. The projects are proposed with a short 4-page document.<br>• Key areas :<br>  o cyber range applications and services,<br>  o cybersecurity assessment tools for digital systems, |

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| | ○ physical & cybersecurity supervision systems,<br>○ Secure AI components. |
| Concrete actions | • Boost European research funding for cybersecurity<br>• Create dedicated strategic funding programs to fund large scale demonstrators and proofs of concepts |
| Expected benefits | • Maintain and enforce the European expertise in security technologies<br>• Help in generating "Made in EU" cybersecurity solutions<br>• Help in developing technological bricks for industry (start-ups, SMEs, large groups) to build offer on. |
| SWOT Items | S2, S5, O5, O6, O7, W2, W4, T3 |

| R38. | Create European world-class player for Firewall and Antivirus |
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| Description | Bringing together important knowledge and innovation subjects could help: next generation firewalls (how to prevent from becoming dependent on solutions from the US, Russia and Israel). |
| Related items | R24 |

| R44. | EU strategy for research focusing on excellence |
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| Description | Review and selection process needs to be substantially improved: more emphasis on excellence in record of accomplishment (both for reviewers and for participants) – too much average and "me too" research is funded and some of the top teams do not even participate. Strategic choices on what to research (which topics and in which phase) needs to be improved substantially. For most projects, there is a misalignment between goals (market impact) and timescales (80-90% of EU projects in cybersecurity has zero market impact). Funding should go to strategic basic research with a time horizon of 4-5 years that has the potential to make an impact, rather than "applied" research that should be done over 2 years, but takes 5 years from conception to result and subsequently has 0 impact. Solution: develop strategy on which areas and research to fund and focus on excellence<br><br>• strategic basic research with horizon of 5 years<br>• fund DARPA-style research (clear goals)<br>• Close follow-up by experts on a quarterly basis and demand prototype that satisfy customer after 2-4 years (rather than reviewers and the Commission). This requires overhead and top technical/business expertise at |

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| | the side of the funding agency.<br>• Fund R&D of innovative SMEs<br><br>Some areas of research are not strong enough: e.g. system and network security, malware. For example, a platform to foster and harness Coordinated Vulnerability Disclosures (CVD) amongst cybersecurity stakeholders and vendors. |
| SWOT Items | W2 |
| Related items | R3 |

| R28. | Skills insights |
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| Description | • It is unclear what specific skills professionals need.<br>• It should be easier to find people with specific skill sets (at universities, employers).<br>• A tool could help to understand what skills are currently present in the workforce and what capacity is needed in the future.<br>• This would help for instance universities to train certain professionals and close the skills gap more accurately. |
| Concrete actions | • Develop a platform that provides insights into the current and needed skills capacity, per Member State.<br>• Develop a cognitive algorithm in order to extract attributes linked to a specific skill from natural language contents either online (web, social network, email) or offline (such as surveys) |
| SWOT Items | O3, T3 |
| Related items | R16 |
| Related EU initiatives | • ECSO is already working on getting such an overview (comparable with Cyberseek).<br>• European e-Competence Framework |

| R27. | Ensure that European security interests, high cyber security requirements and diversity of providers are part of the public procurement. |
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| R9. | Define an EU Digital Trusted Attestation model |
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| Description | The question in Cyber security protection level is about Digital Trust. The EU could create its own certificate signature under a relevant certificate Authority name. Any |

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| Description | Establish a single market for public procurement and EU-wide publication of tenders. Ensure quality and security at all stages of the process. Security aspects should be an integral part of public procurement in cyber security. Price should not be the main consideration, rather priority should be given to the high level of cyber security. Build public procurement around finding a solution to a problem or challenge and not only on pre-determined specifications. It is important to ensure diversity of solution and service providers, as cyber security is provided in layers of products and solutions. Not all those layers should come from one provider or even one country. To support the emergence of global innovative players in Europe at critical levels of the cybersecurity and ICT value chain, regulation should be introduced to incentivise and/or oblige EU players, especially public players, to use European solutions whenever a credible offer exists. |
| Concrete actions | Review EU public procurement regulation (identifying whether a change is needed) and prepare guidelines on public procurement in cyber security. Train and educate public procurement officials in procuring cyber security solutions. Require and advice EU institutions to ensure diversity of cyber security products and solutions. |
| Expected Benefits | Growth in European cyber security industry. European cyber security product and solution providers will get an important access point to the market and relevant references. |
| SWOT Items | S3,S4,S5, O1, O2, O5, W1, W3, T1 |

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| | validated contributor will have the possibility to link its Digital PKI to this trustworthy EU certificate authority as a delegated trustworthy authority. With an appropriate delegation model setup, “actors/contributors/members” in the EU would have the possibility to offer, in their respective products and services, a trusted digital certificate to build a strong Digital Trust for their own customer. This concept will be the opposite of the current many self-generated certificates present in products on the EU market. The delivery of the service should be free. |
| Concrete actions | Create an EU certificate signature under a relevant certificate Authority name |
| SWOT Items | S7,S3,W1,T1 |
| Related items | R66 |

| R13. | Promote Secure Systems Life Cycle through the whole Supply Chain (Cybersecurity by Design) |
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| Description | Current cyberattacks are exploiting existing vulnerabilities in operating systems, products and communications that were designed and developed without cybersecurity requirements. If cybersecurity by design does not start to be used, then we will face the same problem in the future. Developing vulnerabilities free software for complex systems is still a challenge. Promote the knowledge and use of secure systems (software, hardware and communications) development methodologies, tools and standards, through the Life Cycle and Supply Chain. Help developers build systems with the appropriate level of cybersecurity and ready for assessment and certification when needed. On the other hand, recently a DARPA project demonstrated conclusively that certain pathways for attackers have all been shut down in a way that is mathematically proven not hackable for those pathways. The EU has strong research base and cybersecurity ecosystem in secure software and formal methods. European Commission could, in collaboration with Member States, make available, research and innovation funds (H2020) for the availability of new tools for SW development and security analysis. |
| Concrete actions | • Create an agency, i.e. Cybersecure Systems Engineering Organisation in charge of creating, testing and applying tools, technologies and practices to acquire, develop, operate and maintain innovative and trustworthy systems.<br>• Create awareness around secure systems life cycle among companies.<br>• Research & Innovation funds for the availability of new methodologies and tools for secure systems Life Cycle through the Supply Chain. |

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| Expected benefits | • Facilitating cybersecurity by design.<br>• More secure systems.<br>• Developers and integrators with cybersecurity knowledge.<br>• More cybersecure European Industry.<br>• Easily certifiable systems.<br>• Public and private procurement asking for “Made in Europe” secure systems Life Cycle use. |
| SWOT Items | S2, S3, S4, S5, S6, S7, W1, W2, W5, O4, O5 |
| Related items | R7, R11 |
| Related EU initiatives | • SDLC : software development lifecycle – a framework and methodology to ensure safety of software<br>• OWASP: “Organization for Web Applications Security Project” international framework to test application. |

| R17. | Setup a pan-European campaign to educate and raise awareness about cybercrime |
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| Description | EU awareness is rather strong, but there is still room for better awareness for citizens, who might not be too aware about the threat scenario, ongoing cybercrime or that the police do not have resources/capacity to prioritize the crimes. EU should be at the forefront to develop a toolkit that gives companies the opportunity to secure their systems and encrypt data to secure valuable information, including trade secrets (technical/commercial) and confidential business information. This toolkit could be key to maintain competitiveness. A pan-European campaign to educate and raise security awareness could also be valuable. |
| Related items | R29, R15 |

| R19. | Improve the level of security of the enterprises and strengthen industrial leadership in secure infrastructure through certification, ecosystem creation and stepped-up EU research and innovation |
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| Description | The increasing use of industrial automation systems in Europe entails risks linked not only to information security, but also to the physical security of citizens. Consider the potential impact of cyberattacks on critical infrastructures and automated industrial plants. World leaders in secure infrastructure are in the EU. Identify and promote good |

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| | practices for the adoption of cost-effective models aimed at the development of high-level skills and advanced technological solutions for the security of critical infrastructures and Cyber Physical Systems at both national and European level. Leverage the development of 5G by exploiting the inherent security capabilities of 5G to provide such secure infrastructures. It could be worth creating a full European cybersecurity ecosystem from training, to products and services to address the protection of the European infrastructure. This ecosystem should encompass the adoption of **unified Cyber Security standards** (like ISO 27001 and IEC 62443) across Europe but also a European **certification scheme for products, systems and service providers** |
| Concrete actions | Identify and promote good practices for the adoption of cost-effective models aimed at the development of high-level skills and advanced technological solutions for the security of critical infrastructures and by assuring the full life cycle of Cyber Physical Systems |
| SWOT Items | S1, S2, S6, S7, W1, T1 , S4,W2,W5,O1,O4 |

| R20. | Enhance the use of AI (Artificial Intelligence) for cybersecurity |
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| Description | AI is a promising technology that could be used to enhance attack detection and implement new counter measures. Several initiatives exist but a European approach of the topic would increase the impact of the underlying technology. This could power resilient and self-healing systems. |
| Concrete actions | • Create specific open sources libraries with AI algorithms addressing different cybersecurity needs |
| SWOT Items | S2, W12 |
| Vision | V4. Leadership |
| Related items | R21 |

| R52. | Align cybersecurity strategies of public institutions within EU |
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| Description | In order to allow for good procurement of cybersecurity solutions, public institutions should have a clear view of their needs, level of protection, interoperability of their equipment etc. The aim of this action is to make sure that national and regional strategies exist and that these strategies are well coordinated at the EU level to optimise their performance. Having said that, any industrial EU strategy should not seek to simply replicate existing mature ecosystems (e.g. Silicon Valley in the US or Beersheba in Israel). It should instead recognise and take advantage of our own |

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| | European distinctive strengths and values, which are the basis to help cybersecurity ecosystems to emerge. The EU should play as a geographic constellation of "Cyber valleys". In this scenario, each regional ecosystem contributes to a common programme and facilitate a quick access of local cyber security SMEs to the European market. In this framework, Smart Specialisation in cyber security and inter-regional cooperation should become a permanent feature of the post-2020 European cyber security ecosystem. |
| Concrete actions | • Open dialogue with the national cybersecurity authorities to:<br>  ○ Review the existing strategies<br>  ○ Prepare new coordinated strategies<br>• Rank public institutions into categories according to sensitivity and provide them with adequate assistance (competence centres)<br>• Develop a common methodology to measure the cybersecurity readiness for public institutions, unified and applicable across sectors.<br>• Define the activities of competence centres, their funding, status, etc.<br>• Reinforce the need to come up with a strategy, while keeping national sovereignty. |
| Expected benefits | • Aligned strategies could strengthen the economic impact of actions.<br>• Full coverage of highest standards across the EU could avoid the weakest link to be attacked.<br>• A common methodology for measuring cybersecurity readiness allows for transparent comparison.<br>• Coherent approach to cybersecurity issues, based on national, regional specificities, among public institutions.<br>• Setting good strategic goals may drive the market to bring more advanced solutions.<br>• Ranking of public institutions will help them in defining their procurement needs.<br>• Ranking of public institutions will help the markets to adapt/standardise their product. |
| SWOT Items | S1, S5, S7, S8, S9, W3, O1, O2, O6, O7 |
| Related items | R29, R22, R39, R27, R51 |
| Related EU initiatives | • NIS Directive obliges national authorities to have a national strategy. |

| R11. | Setup an R&D and methodology to certify complex systems, complex solutions and services |
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| Description | The EU has strong research base and cybersecurity ecosystem. The EU has also strong |

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| | competences in certification and standardization. Cybersecurity solutions are generally composed of various subcomponents. Certifying them is necessary. Certifying the overall solutions is more challenging with no method and approach yet available. EU could ease and encourage alliances between European companies involved in the field to work on process and tools for certification of complex systems or cybersecurity solutions. |
| Concrete actions | • Make available, research and innovation funds (H2020) for the availability of new methodology to certify complex systems, complex solutions and services.<br>• Integrate the UNI 11506 and $(ISC)^2$ framework, furthermore encourage the alliance with product vendor certification (e.g. Cisco, CheckPoint, etc.) |
| Expected benefits | The benefit is to reduce the cost of certification process |
| SWOT Items | S9 |
| Related items | R7, R13 |

| R4. | Labelling of cybersecurity solutions in sensitive digital domains |
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| Description | Over the years, there has been an erosion of citizens' trust and confidence in digital trust. EU could promote the use of cybersecurity certification in critical products and services for the safety and the privacy of European citizens. EU could support and encourage the development of sectorial certification schemes in the European cybersecurity certification framework (IoT, consumer electronics, medical devices, wearable, etc.). Alternatively, for less sensitive areas EU could also promote labels. Use this new cybersecurity certification framework to promote schemes for products, services and services. Voluntary approach that should come from the industry. By default, developing the certification scheme should be a voluntary approach by industry players with compulsory implementation once the scheme has been developed and approved by the Commission, and the relevant standardisation organisations. If needed, such scheme development could be made compulsory by regulation. |
| Concrete actions | • Support and encourage the development of sectorial certification schemes in the European cybersecurity certification framework (IoT, consumer electronics, medical devices, wearable, etc.)<br>• Create associate labels<br>• Launch communication/awareness campaign on such labels<br>• Encourage the alliance with ITU, ISO, NIST organization to evolve the schema in emerging technology (i.e. IoT) |
| SWOT Items | S1, S2, S7,S9, O1, 05 |
| Related | R36 |

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| Related EU initiatives | • In the Cybersecurity Security Act there is already the possibility to have a label for each certificate<br>• There is already an international rating system for each specific application. "Magic Quadrant of Gartner", but this really targets experts |

| R68. | Develop cyber-insurance in Europe |
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| Description | Introduce incentives for cyber insurance, to force institutions to implement certain cybersecurity measures. Let the market drive it for the insurance companies to shape the insurances. Cybersecurity insurance exists in the US. |
| Concrete action | • Create a European insurance |
| Expected benefits | This approach could significantly stimulate the compliance with EU standards and principles. The development of a cyber-insurance market is expected to be economically viable and to make a substantial economic impact. Insurance companies can take up the role of informal regulators to strengthen cybersecurity levels. |

| R3. | Standardization of cybersecurity protocols and languages for better interoperability, ergonomics and secure cybersecurity solutions |
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| Description | Usability and ergonomics of secure products can be complex for non-cybersecurity experts. Lack of interoperability is also an issue. The EU should enable and promote interoperability and increased ergonomics of cybersecurity products and services. This innovation will lead to a set of new security functions (like discovery and automated association), standardized commands and instructions to offer structured and secure communication streams between trusted IP connected products and services. |
| SWOT Items | S7, W6 |

| R5. | Maintain high security and privacy standards for better user protection and support for EU players |
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| Description | As of May 2018, with the entry into application of the General Data Protection Regulation, there is one set of data protection rules for all companies operating in the EU, wherever they are based. Stronger rules on data protection mean that people have more control over their personal data and that businesses benefit from a level playing field. This privacy regulation is challenged by foreign rules (like the US Cloud Act for example) but the EU should continue integrating high privacy and IP requirements in certification schemes in the European cybersecurity certification framework. |
| SWOT Items | S1, S2, S4,S5, W1 |

| R73. | Develop cybersecurity solutions for connected and autonomous vehicles (V2X) and related infrastructure |
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| Description | EU automotive industry is a strong one with world leaders and the autonomous connected vehicles race is a worldwide one that the EU must not lose. But cybersecurity can be a handicap and at the same time a promoter of this kind of vehicles. For this reason cybersecurity of the vehicle as well as of the communications V2X must be assured, not forgetting the charging of the vehicles either electric or by other means. In this direction, the EU is already working on elaborating the regulatory measures and enabling a framework where cybersecurity will be essential to guarantee vehicle safety. In the same way that in 2011 the ISO 26262 functional safety standard established a clear engineering process, cybersecurity needs to be designed and built into automotive systems throughout the development lifecycle to provide defence in depth by providing an engineering process as specified in the [J3061] recommended practice. Both standards aim at minimising risks coming from unwanted electronic/electrical malfunctions and cybersecurity attacks respectively. It is worth noting how the aforementioned J3061 guidelines are already on its way to turn into a standard under the *ISO/SAE CD 21424 Road Vehicles -- Cybersecurity engineering* name. ISO 21424 is supposed to be released in the latest 2019 or beginning of 2020.Among others, one of the key steps during that process is the security testing, which is particularly important to ensure that no vulnerabilities can lead to safety hazards or privacy issues. |
| Concrete actions | • Build an automotive cybersecurity testing laboratory, where full vehicle cybersecurity assessments can be performed in an independent manner<br>• Make cars' safety and security transparent and comparable for customers, so that they can include this information in their purchase decision<br>• Provide consumer information on vehicle´s cybersecurity robustness<br>• Delivery of security and safety information to the automotive sector<br>• Establish a rating in terms of cybersecurity<br>• Define a coherent governance for secure electric vehicle charging. |
| Expected benefits | • More secure vehicles and transport infrastructures.<br>• Better knowledge of the level of cybersecurity of autonomous and connected |

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| | vehicles.<br>• Improve the competitive position of the European automotive industry as well as the creation of specialised cybersecurity automotive industry |
| SWOT Items | S2, S3, S4, S5, S7, W1, W2, W4, W5, T1, T2 |
| Related items | R18, R25 |

| R51. | Build cybersecurity functionalities within existing Public Procurement Competence Centres |
|---|---|
| Description | As public buyers cannot be specialists in all areas, competence centres need to be established to build-up expert knowledge that is available on demand to them. Since various types of competence centres already exist, the objective of this action would be to identify the existing ones and to develop their cybersecurity function. Public buyers drive 14% of GDP and administer many sensitive IT systems. Their competence in cybersecurity needs to be strengthened. |
| Concrete actions | • Identify existing structures, competence centres or similar organisations that could develop a new cybersecurity public procurement consultancy-like activity, e.g.<br>o Digital Innovation Hubs (some 270 organisations, managed by CNECT, GROW is in contact for this idea already);<br>o Big Buyers Initiative (a starting GROW project among big institutions to cooperate on selected themes);<br>o InnoBroker type institutions – ensure that the top-edge innovative technologies are known public buyers;<br>o Other similar type of organisations networks (innovation agencies).<br>• Develop a set of minimum actions, common methodology, etc.<br>o Needs identification;<br>o Preliminary market consultation;<br>• Technical specifications and tenders certification, etc.<br>• Ensure cooperation within the competence centres and focus on sharing best practices. |
| Expected Benefits | • Increase cybersecurity competence within the public buyers community<br>• Increase the dialogue with the cybersecurity industry to match the best solutions with the identified needs. |
| SWOT Items | S5, O1, O6, O7 |
| Related items | R29 |

| R2. | Proactively identify and respond to violation of trade rules by foreign countries |
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| Description | The EU cybersecurity industry has the level to become a good player on the world market. Some countries are trying to set legal and trade barriers to protect their internal ecosystem. The EU should monitor and tackle unfair practices in third countries, for example through the application of the EU Trade Defence Instruments measures. If the legal conditions are fulfilled, the Commission may launch investigations with a view to determining whether the adoption of trade defence measures would be warranted. The European "International Procurement Instrument" (IPI) process, when adopted, would allow to apply measures restricting the access to the European procurement market for companies, goods and services from the third country that do not allow equal access and reciprocity in public procurement to their own markets. Potentially powerful, it is important that this process delivers effective leverage to negotiate the opening of third country procurement markets. Sufficient resources need to be allocated to ensure proper identification, investigation and response. The rules of the Internal Market should also be applied to cybersecurity products and applications. |
| Concrete actions | • Accelerate the adoption of the "International Procurement Instrument".<br>• Envisage IPI also for Cybersecurity, to ensure identification and response to non-reciprocity in public procurement by foreign countries.<br>• Dedicate sufficient resources and ensure an agile organization setup. |
| SWOT Items | W6,O5 |

| R30. | Create an EU training facility centre |
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| Description | • Create an EU network of associate experts that train professionals and students<br>• This training facility could link to national training facilities.<br>• Apart from training, this centre could also be responsible for testing, piloting, and realising commercial deployment.<br>• Such a facility could be a potential coordinated investment and is distinct from the EU competence centre. |
| Concrete actions | Create an EU training facility centre. |
| SWOT Items | O3, T3 |
| Related items | R18 |
| Related EU initiatives | Builds upon EU Cybersecurity Competence Centre. |

| R45. | Law Regulation and Compliance for the IoT devices and Driverless Car |
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| Description | Using the support of academics, institutions and private contribution we can create *the EU research academy* focusing on law regulation and compliance for IoT devices and driverless car. GDPR is good starting point to produce practical documents and case studies. We can use the SAE publications and/or California Consumer Privacy Act connected devices document to start our program, in this way we can create a law base knowledge to introduce the practical documents to explain what the steps in case of start a civil or penal action are and export the framework. First guide/document:<br>• IoT devices in Civil and penal action;<br>• Driverless car in EU;<br>• US law and compliance vs EU |
| Expected benefits | • Better EU reputation in the world. EU driving the compliance and law regulation in the world. Business growth: consulting and technology. |
| SWOT Items referred to | S1, S2, S6, S7, W4, O1 |

| R40. | Cyber Security and Forensics in IoT devices and connected mobility |
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| Description | Using both experience of the academic research specialized in the cybersecurity IoT and driverless car and the private Companies specialized in big projects in military area, we can create a consortium, and/or research valley, and/or innovation environments/platforms, specialized in cybersecurity or in connected mobility to write scientific papers, set up innovative case studies and patents, as well as to provide with support for the actors of the connected mobility sector to ensure cybersecurity safety of mobility solutions to customers and users. |
| Concrete actions | Export our knowledge outside EU and become attractive for the worldwide venture capital, in this way we can cover the unexplored and innovative areas. First research projects:<br>• vulnerability assessment and penetration test on the IoT devices and driverless car<br>• prevention and prediction cyber-attacks on the IoT devices and driverless car;<br>Forensics acquisition for the IoT devices. Creation of innovation platforms in partnerships with territories recognised for their expertise on connected mobility or digital in general, that could : |

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| | • support mobility actors with methodological and operational guidance/expertise to allow them to ensure maximum cybersecurity of their products and services to their customers/users<br>• to provide with cybersecurity analyses of connected mobility solutions<br>• to offer proof-of-concept tests for their products, services, applications etc. |
| Expected benefits | EU attractive for the venture capital, export the patents and the business growth. |
| SWOT Items | S2, S6, W4, O1 |

| R26. | Develop and promote appropriate tools for funding industrial deployment of new technologies |
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| Description | Europe has adequate tools for financing research, primarily through the Commission and Member States, in the form of subsidies, for which there is no expectation of return on investment (ROI). However, it lacks adequate tools for financing the subsequent phases of industrial deployment (prototypes, demonstrators, and large-scale rollout). These investments are often not eligible for subsidies, and struggle to raise capital due to uncertainty on ROI. This threshold effect (no ROI expectation for research, high ROI expectation for industrialisation) is one of the reasons that some good technologies fail to be deployed. In some cases, the stakes involved go well beyond pure ROI considerations: environmental or societal benefits, sovereignty, security etc. Failing to deploy the technology simply because ROI cannot be demonstrated for an early stage deployment is a key weakness for Europe compared to China (where state funding is massively available with no ROI considerations) and the USA (where private investors are willing to take large bets).This problem is especially acute for Cybersecurity, where the benefits for society will be significant, but will require massive investments in the coming decades to renew infrastructure, and for which the business models are not easy to see today (ex: competitiveness will depend on scale, so small scale deployment will not be competitive).<br>The European Investment Bank (EIB) is seen as a natural provider of funds for industrial deployment (Investor Portal), but its solutions may not be sufficiently well known or may not be suitable (i.e.: strict ROI requirements for equity, strict Debt Service Coverage Ratio (DSCR) for debt). |
| Concrete actions | A collaboration should be initiated between the Commission, Member States, public financial institutions (EIB, EBRC, Sovereign investment funds, national development banks) and private investors (banks, private equity, corporate) to develop and promote appropriate European financing tools, with appropriate levels of funding (hundreds of billion € overall), dedicated to financing large scale technology deployments. These tools should promote appropriate risk sharing and alignment of interest between all participants involved in a project. |
| SWOT Items | W2, W3, T1 |

| R14 | Generalizing the cybersecurity risk management in safety analysis frameworks. |
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| Description | Most of the safety critical applications use safety analysis and certification through dedicated standards and norms. Merging safety and cybersecurity analysis in the same framework is a way to improve efficiency both in terms of security of the citizen and cost and time to market. |
| Concrete actions | Support and encourage merging safety and cybersecurity analysis in the same framework through R&D and standardization |
| SWOT Items | S1,S7, O1,O4,O5,T3 |
| **R72** | **Enhance cybersecurity for the industrial domain and for the automation and communication systems that ensure safety, availability and process integrity.** |
| Description | Protection of critical and essential infrastructure is essential for the sovereignty and security of European nations. In accordance with Network and Information Security Directive, development of new secure technologies in detection, protection and reaction systems is a major opportunity for defence and cybersecurity of European industry. Collaboration within this domain between suppliers and operators for new and legacy systems should strengthen system security. European companies are not sufficiently present on this market to compete with the rapid rise of non-EU markets and large-scale investments. Identification of Advance Persistence Threats with monitoring and detection solutions is a response to massive and distributed attacks on industrial sector and IOT architecture. New technologies have to be promoted and developed. |
| Concrete actions | Develop complete intrusion detection systems for “essential” industry in Europe. Connection with SOC and development of AI to identify complex incident and advance attack is becoming a necessity. |
| Expected benefits | Invest in a market where non-EU players are present, develop solution for Europe in a NIS domain. Make Europe independent |
| SWOT Items | S4, S5, S6, S7, W4, W5, O5, O6, O7, T1 |

| R15 | To promote a top-down culture of safety and risk-management through the conscious adoption of policies and procedures appropriate to each industrial reality |
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| Description | To support the internal capabilities or to develop services devoted to helping the enterprises to tackle the goal of developing new solutions including security and privacy by design models. To promote a top-down culture of safety and risk-management through the conscious adoption of policies and procedures appropriate to each industrial reality. |
| Concrete | Support the internal capabilities and develop services devoted to helping the |

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| actions | enterprises to tackle the goal of developing new solutions including security and privacy by design models. |
| SWOT Items | S1, S7, O1,O4,O5,T3 |
| Related items | R17 |

| R67 | Set test labs using critical infrastructure as a platform for testing innovative solutions |
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| Concrete actions | Create thematic cyber labs, give examples of existing platforms. |

| R33 | Create a code of ethics/conduct to guide the use of cybersecurity |
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| Description | Cybersecurity solutions can be used for both good and bad purposes. In the light of cybercrime, it is important to highlight the ethical dimension of cybersecurity. There is large debate recently about the report of the Commission's group of High Level experts on AI. This report discusses the ethical dimension and red lines for the development of AI solutions. Ethics is a wide term although it is often mistaken as purely moral principles. However, ethics is about values and the axiology base of societies. We are talking about concepts that have to do with right or wrong and ultimately justice. At the very end ethics have always been the determining factor of social rules, namely law. Both the Cybersecurity Act and the GDPR regulation promote ethics and norms on information security. The Cybersecurity Act introduced the Cybersecurity Certification Framework, which promotes the principles of "security by design" and "privacy by design", whereas the GDPR promotes "privacy by design". Both are expected to become global standards (GDPR already is). The goal of these legislations is to promote trust and confidence to the digital environment and facilitate the success of the Digital Single Market. On the other hand the security and privacy features that developers must embed to their products by design, are helping businesses and citizens to get better protection from cybercrime, which is hitting hard the European economy. |
| Concrete actions | • Create a code of ethics to guide the use of cybersecurity |
| SWOT Items | S7, O6 |
| Related EU initiatives | • Cybersecurity Act, GDPR, Cybersecurity Certification Framework, Digital Single Market |

| R62 | Focus funding on areas of specific EU excellence or critical needs |
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| Description | Areas must be selected from security and business points of view. Policy should not be based on usual suspect-philosophy, by selecting the most popular sectors. It should be based on the real European skills analysis, where EU could and should have strengths, where windows of opportunities exist or/and where EU has to have some critical capabilities of its own for security reasons. |
| Expected benefits | Better coordination of resources and ability to focus on selected must-win battles instead of trying to be good in everything – but being below average in everywhere |
| SWOT Items | S1, S5, S7, W1, W2, W3, W11, O1, O2, O3, O4, O5, O6, O7, O8, O9, T1, T2, T3, T4, T5 |

| R63 | European must get maximum out its geography on the cybersecurity research |
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| Description | Europe has research and education scattered around EU widely. A huge number of research institutes and universities exists in the EU, but most of the cybersecurity research in these organisations is focused on the same research areas, with very limited resources. Instead in order to scatter every research resource around, there should be more encouragement for selections of key success research areas for each organisation. There should be a foundation on what each research institute should "and choose" to focus. There should be some evaluation of track-record, skills & resources in specific fields of cybersecurity, for an organisation to qualify for EU funding. When focused is selected, the organisation may qualify for EU funding only in those chosen areas, not in other areas. With better focus and more coordinated resources, there will be significantly improved outcomes and EU based innovations would be gaining back some key areas of cybersecurity. It should be noted that the EU would need just for the sector of cybersecurity 350000 new professionals. |
| Expected benefits | Limited research and training resources should better coordinate inside Single European Digital Market in order to catch up the global market gap. |
| SWOT Items | S2, S7, W4, W6, O3, O6, T1, T3 |
| Related items | R62, R60 |