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Europe's Energy-Intensive Industries Strategic Research Innovation and Deployment Agenda

From Innovation to Industrial Leadership



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Version of November 2026.
Content will evolve as the work progresses and may differ from the final SRIDA.

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1 Europe’s Energy-Intensive Industries SRIDA: From Innovation to Industrial Leadership

1.1 Innovate to Compete. Renew Europe’s EIIs Industrial Leadership

There can be no prosperous, sovereign and sustainable Europe without strong energy-intensive industries (EIIs) on its territory. EIIs are the backbone of nearly all European value chains, securing the supply of essential materials and products while supporting the economic and social vitality of Europe’s regions and communities. Their industrial operations sustain more than 20 million direct and indirect jobs across Europe and increasingly enable net-zero, circular value networks through industrial, urban and rural symbiosis, including waste-heat recovery, closed-loop water systems, waste valorisation and materials circularity.

But today, Europe’s energy-intensive industries base is under unprecedented pressure.

Europe is rapidly losing more than industrial production: it is losing capacity, investment and the know-how that underpin its strategic autonomy. Production has fallen significantly across most energy-intensive industries. A combination of structural challenges (such as energy cost, permitting time, fragmented and overly complex financial mechanisms) creates this competitive disadvantage.

It is time for industrial transformation and renewal at scale.

Restoring global competitiveness of the energy-intensive industries is therefore urgent, while strategic autonomy of their value chains has become an existential imperative. Europe cannot secure its industrial future by replacing one external dependency with another, and incremental improvements will not be sufficient.

Europe's strength in research and innovation is an asset. Our challenge is to turn innovation into industrial investments by scaling up, demonstrating and deploying innovations industrially in Europe, thereby rebuilding Europe’s industrial leadership.

Innovate in Europe. Scale in Europe. Deploy in Europe. This is the fundamental change in Europe’s industrial model needed to achieve industrial transformation at scale in our continent.

Powering global Process Industry leadership in high-value materials & products

Shaping a net-zero & circular future and Europe’s strategic autonomy for all generations

1.2 Moving Innovation Towards Industrial Deployment in Europe

Restored industrial global competitiveness, strategic autonomy of European value chains, and innovation-driven net-zero, circular and digital solutions, this is our shared destination for Europe's energy-intensive industries. This Strategic Research, Innovation and Deployment Agenda (SRIDA) sets out Investment Journeys towards the Energy Intensive Industries Partnership's ambitions.

This SRIDA is built on the A.SPIRE 2040 Innovation4Competitiveness Vision. Aiming to position the EIIs as "Global Champions Rooted in Europe", the Vision is a model of industrial leadership reconciling industrial prosperity with strategic autonomy and sustainability.

Innovate to compete. Compete to deploy. These are two guiding principles of the EII Partnership's SRIDA. In this spirit, the SRIDA prioritises cost-competitive innovations with the strongest and fastest contribution to the global competitiveness of the EIIs, while strengthening the strategic autonomy of European value chains.

The SRIDA also aims to help steer RI&D (research, innovation and deployment) funding towards innovations with strong potential for first industrial deployment in Europe. Connecting innovation with the industrial deployment potential.

Supporting industrial deployment requires more than a technological breakthrough. Alongside technological priorities, the SRIDA includes technological scale-up activities to support the integration of new technologies into existing industrial systems, and systemic activities to create the enabling conditions for the first industrial deployment in Europe.

The EIIs SRIDA sets out a coherent set of RI&D actions organised into Investment Journeys to support innovation scalability towards first industrial deployment in Europe.

1.3 A new industrial paradigm: Four Strategic Shifts for Integrated European EIIs Networks

European Energy Intensive Industries will evolve from predominantly individual production sites within separate, still mostly linear value chains towards becoming highly competitive, core industrial nodes within integrated European industrial value networks. These deeply interconnected ecosystems will span sectors and value chains, continuously optimising energy, materials, industrial data and water flows, closing loops and keeping resources in circulation.

Achieving this new industrial business model requires four fundamental, mutually reinforcing shifts:

Energy mix supply: integrated, competitive, low-carbon industrial energy systems, combining very high energy efficiency, security of supply, affordability and low-carbon energy sources.

Feedstock mix and water supply: secure, affordable and sustainable access to water and to a strategic mix of resources, from raw to secondary materials retaining waste and material streams in Europe and turning them into reliable industrial feedstocks.

Data for Production Systems: harnessing industrial AI and advanced digital technologies to manage increasing operational complexity and to enable intelligent, flexible and intensified production of high-value materials and products.

Industrial cooperation: integrated and resilient industrial value networks enabled by unprecedented levels of cooperation across sectors and companies, including closer collaboration with customers and end-users.

Together, these four shifts define the transformation towards a future-proof European industrial business model: integrated, competitive, autonomous, net-zero and circular.

2 State of Play

2.1 Cross-Sector: Shared Challenges, Shared Opportunities

Europe's EIIs are at a tipping point. Competitiveness enables the deployment of solutions that will deliver the transformation and will generate a positive impact for European citizens and the planet.

One of the continued strengths of the EIIs Partnership is our cross-sectorality, expanding the field of innovation opportunities. Cross-sector collaboration enables cascading use of energy and feedstock for the EIIs. This is at the very core of this SRIDA: accelerating change and amplifying impact by bringing together industrial sectors facing similar challenges, by fostering industrial symbiosis, and by considering innovation opportunities along and across value chains.

To move forward, the EIIs need:

- Technological and systemic innovation that can create viable business cases to unlock investment in Europe.
- Decisive action on two fronts: technologically, to reduce investment risk and operating costs and to validate, qualify, scale up and replicate solutions, and in terms of enabling conditions - continuous funding from development to deployment, addressing CAPEX and transitional OPEX gaps, timely infrastructure, faster permitting, coherent regulations, effective market-pull mechanisms, upskilled workforce and new talent.
- Affordable low-carbon energy and enabling infrastructure, which determine investment feasibility. This requires a strong political will.
- A reduction of the overall cost of net-zero technologies, including carbon management and conversion, circularity and other safe and sustainable solutions.
- Innovation that turns Europe's primary and secondary resources into globally competitive industrial feedstocks, processed at scale on European territory, supporting the future of European industrial value chains.
- Digital technologies, including AI-supported modelling and optimisation, that reach the maturity required for reliable industrial deployment. **A.SPIRE sees a clear opportunity for Europe to lead in industrial AI, building on its engineering expertise, technological capabilities and deep process knowledge.**
- Innovation that strengthens cross-sectoral capabilities for the development, qualification and industrial-scale production of high-value materials and products.
- A workforce ready for the challenge: sustained investment in talent attraction and workforce upskilling.

2.2 European Sectoral Perspectives: Shared Destination, Sector-specific priorities

The transformation will not look identical across all EIIs. Different sectors have different industrial configurations, resources, processes and value chains. The SRIDA will therefore combine a shared cross-sectoral direction with stronger sector-specific ownership of transformation pathways.

- **Cement Sector:** Innovation must address process emissions from limestone calcination through more cost-competitive carbon capture, supported by CO_2 transport and storage, while reducing capture-related energy demand and integrating heat recovery. Priorities also include reducing clinker content, expanding circular material use and developing reliable alternative cementitious materials, alongside further fossil fuel substitution.

- **Ceramics Sector:** Innovation must deliver affordable low-carbon drying and firing solutions adapted to different ceramic processes, including efficient kilns, heat recovery, electrification and alternative fuels. Priorities also include circularity, greater use of secondary materials, advanced refractories and technical ceramics, supported by testing and qualification facilities, digitalisation and collaboration with industrial users.

- **Chemical Sector:** Innovation must accelerate deployment of low-carbon technologies and circular feedstocks, including electrification, renewable and low-carbon hydrogen, recycling technologies, process efficiency improvements and Carbon Capture, Utilisation and Storage. Priorities also include greater use of biomass, recycled materials, waste-derived carbon and captured CO_2, improving recycling, promoting industrial symbiosis, developing new circular business models, and developing new materials, sustainable products and advanced chemical solutions.

- **Engineering Sector:** Information under development.

- **Minerals Sector:** Innovation must make European mineral extraction and processing more resource-efficient and competitive while reducing environmental impacts. Priorities include energy-efficient processing, mineral recovery, water management and by-product valorisation, alongside applied materials science, greater functionality and durability, product recyclability and applications for secondary mineral streams. For Lime specifically, innovation must deliver cost-competitive carbon capture, kiln upgrades and low-carbon fuel switching while maintaining lime quality. Further priorities include improving lime performance, enhanced carbonation, carbon-removal pathways and BECCS, supported by robust measurement and accounting of net CO_2 benefits and storage permanence.

- **Non-ferrous sector**: Innovation must advance competitive low-carbon primary production. In the case of aluminium, it must include inert-anode technologies, energy efficiency, electrification and application-specific hydrogen and carbon capture solutions. It must also enable high-quality recycling of complex aluminium scrap and recovery and valorisation of production residues.

- **Pulp & Paper Sector:** Further decarbonisation requires reducing energy demand and replacing remaining fossil fuels, including through more energy-efficient pulping and drying, electrification, low-carbon heat and digital process optimisation. Innovation must also expand value from sustainably sourced forest biomass and recycled fibres, contributing to Europe's circular economy.

- **Refining Sector:** Innovation must enable the transformation of refineries into integrated hubs producing renewable and low-carbon fuels, hydrogen and industrial feedstocks. Priorities include new conversion processes, replacing conventional hydrogen, electrification, heat integration and carbon capture, together with broader use of sustainable carbon feedstocks and low-carbon hydrogen.

- **Steel Sector:** Innovation must make hydrogen-based iron reduction and electric steelmaking competitive at an industrial scale, while carbon capture can complement the transition at existing integrated plants. Priorities also include expanding steel scrap use, improving scrap characterisation, sorting and processing, and advancing slag valorisation, heat recovery and digital process control.

- **Water Sector:** Innovation must strengthen industrial water resilience through lower demand, fit-for-purpose reuse, water recovery and recycling, monitoring and integrated water management. Water and wastewater facilities must also evolve into resource recovery hubs, recovering energy, nutrients and valuable materials while supporting decarbonisation and industrial symbiosis.

3 Investment Journeys: From Innovation to Bankable Opportunities

An Investment Journey integrates key technologies vital for strengthening the competitiveness of Europe's energy-intensive industries. It combines the technological and systemic actions needed to build a credible pathway towards first industrial deployment, ensuring a substantial and rapid impact in Europe.

Each of the nine investment journeys in this SRIDA aims to translate strategically relevant groups of technologies into viable business cases and bankable investment propositions for Europe's energy-intensive industries, by accelerating scalability, reducing investment risk and addressing the technological and systemic barriers to first industrial deployment in Europe.

The content of the SRIDA and this booklet is still under discussion. It may change in the final version of the SRIDA.

The IJs are still under discussion, and their scope is currently being finetuned. KPIs and milestones are currently being defined and will be shared at a later stage. The IJs may change in the final version of the SRIDA.

A.SPIRE
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Join A.SPIRE and be in the room where priorities are set. Contribute to shaping the innovation and investment priorities of the energy-intensive industries in Europe.

Through the Strategic Research, Innovation and Deployment Agenda, the Energy-Intensive Industries set out a shared direction for innovation and industrial investment in Europe, while considering your specific sector priorities.

Together, let's put net-zero, circular and industrial digital and AI innovation to work for the competitiveness of your industry and a strategically autonomous Europe.

Contact us to explore A.SPIRE membership and how your organisation can be part of the change:
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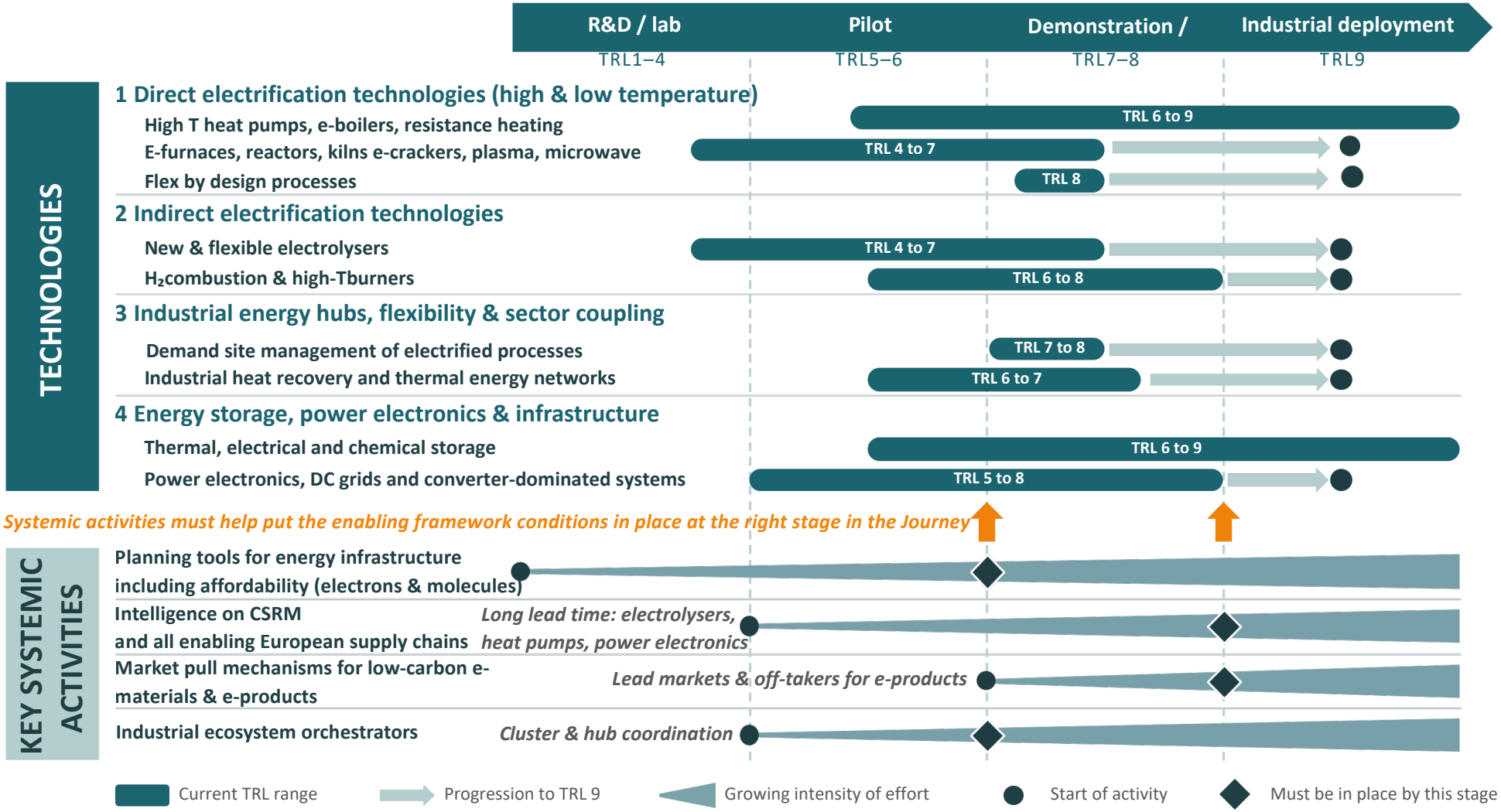
IJ1 Commercially Viable Direct & Indirect Electrification of Industrial Processes

MISSION

Integrate renewable energy and other low-carbon energy sources in a commercially viable way across EII through electrification (direct: electrons/ indirect: molecules).

SECTORS & VALUE CHAINS

Sectors: All Energy Intensive Industries
Enabling value chains: Energy suppliers and equipment suppliers



EXPECTED OUTPUTS

Efficient, sustainable, competitive and autonomous energy supply for European EII

Enabling the production of high quality and high-performance materials and products, including from variable feedstocks

IMPACTS

Industrial electrification rate: from 30% to

- ≥ 45% by 2030
  ≥ 65% by 2034

Levelized cost of useful heat vs fossil reference (€/MWh of useful heat)

Reduction indirect CO_2 emissions – target to be defined

Industrial flexibility load activated (% electricity load) – target to be defined

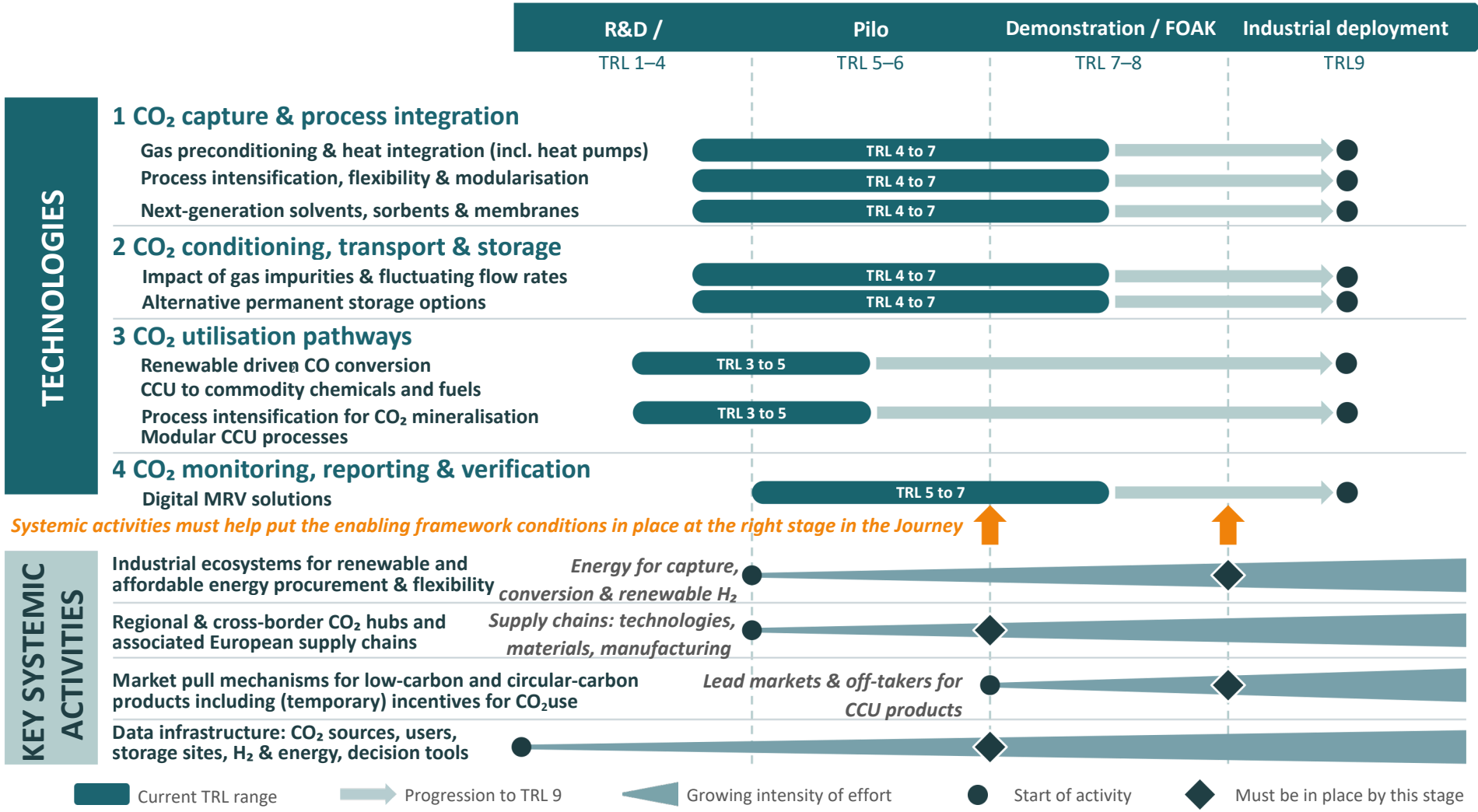
IJ2 Commercially Viable CCS and CCU for Industrial Decarbonisation and/or New Carbon-to-Products Value Chains

MISSION Deliver competitive, sustainable abatement solutions for residual emissions Establish CO_2 as a strategic industrial feedstock.

SECTORS & VALUE CHAINS

Sectors: EIIs with residual emissions and suitable for circular carbon feedstocks integration

Value chains: Integrated carbon management value chains



EXPECTED OUTPUTS

CCU: fuels, chemicals, building materials

CCS: permanently stored CO_2

IMPACTS

Triple the CO_2 used as a feedstock from carbon capture

Reduction of the total normalised CO_2 abatement cost (CAPEX + OPEX) >50%

Energy efficiency of CO_2 conversion ≥ 80%

Energy demand per tonne avoided CO_2: ≥ 20% reduction by 2034

Mt CO_2handled by full value chain CO_2 hubs – target to be defined

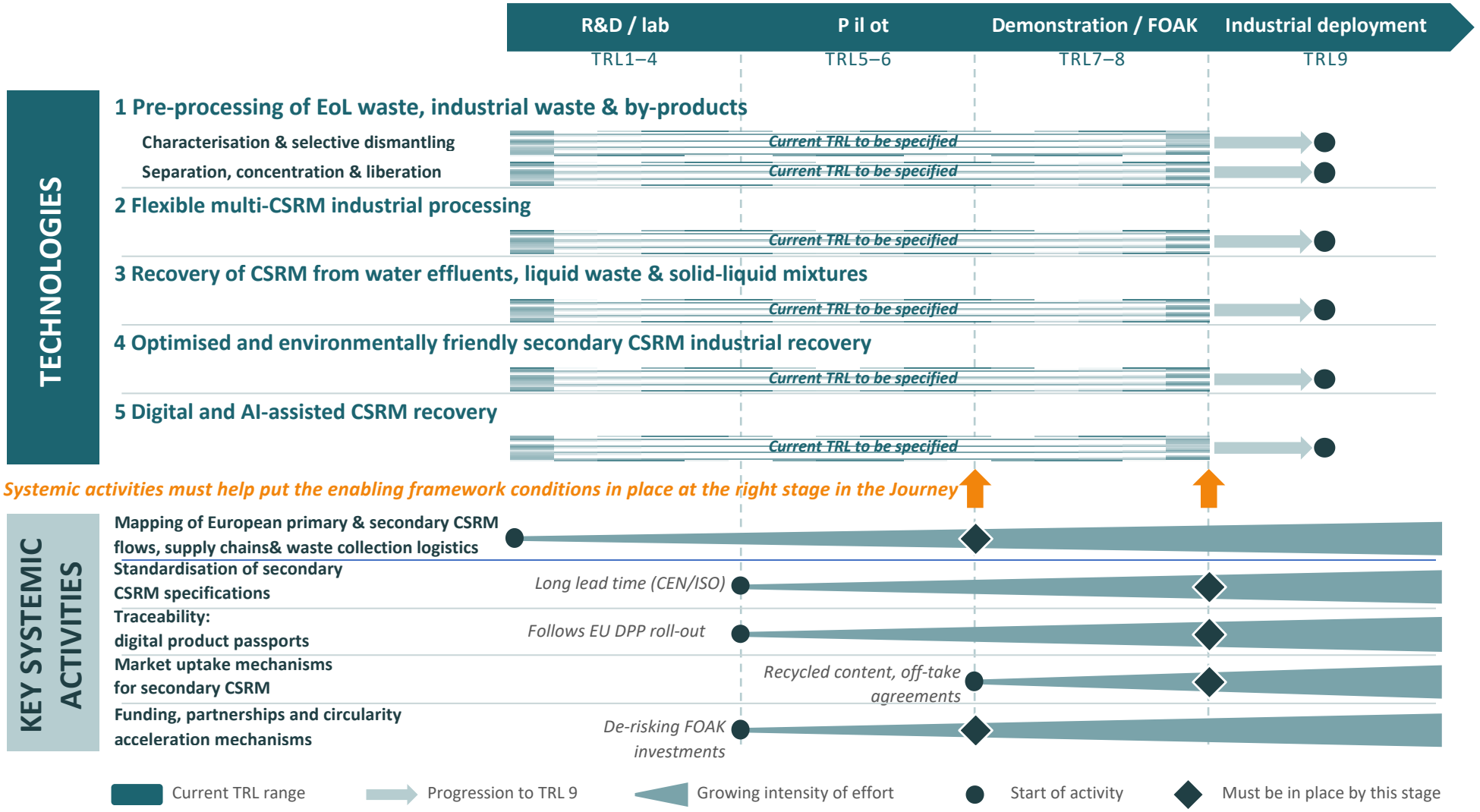
IJ3 Enhanced Supply of Secondary Critical and Strategic Raw Materials (CSRM)

MISSION Develop competitive capabilities and flexible technologies and infrastructures to increase the supply of secondary critical and strategic raw materials (CSRM) to the Energy Intensive Industries and their value chains.

SECTORS & VALUE CHAINS

Sectors: Ferrous, non-ferrous, chemistry, ceramics, engineering, water

Value chains: Electronics & semiconductors, permanent magnets, electric motors, electrical wiring & industry, electric vehicles & batteries, renewable energy, catalysis & chemicals, agriculture (fertilisers), etc..



EXPECTED OUTPUTS

Secondary CSRM meeting industrial- grade quality specifications

Examples: REE oxides and metals/cobalt, nickel and lithium salts/recovered gallium and germanium

IMPACTS

Decrease of imported volumes of selected CSRM: -25% by 2035

Increased recovery rate of targeted CSRM from waste streams : +40% by 2040
Number of large-scale demonstrators of CSRM recovery : 5 by 2035

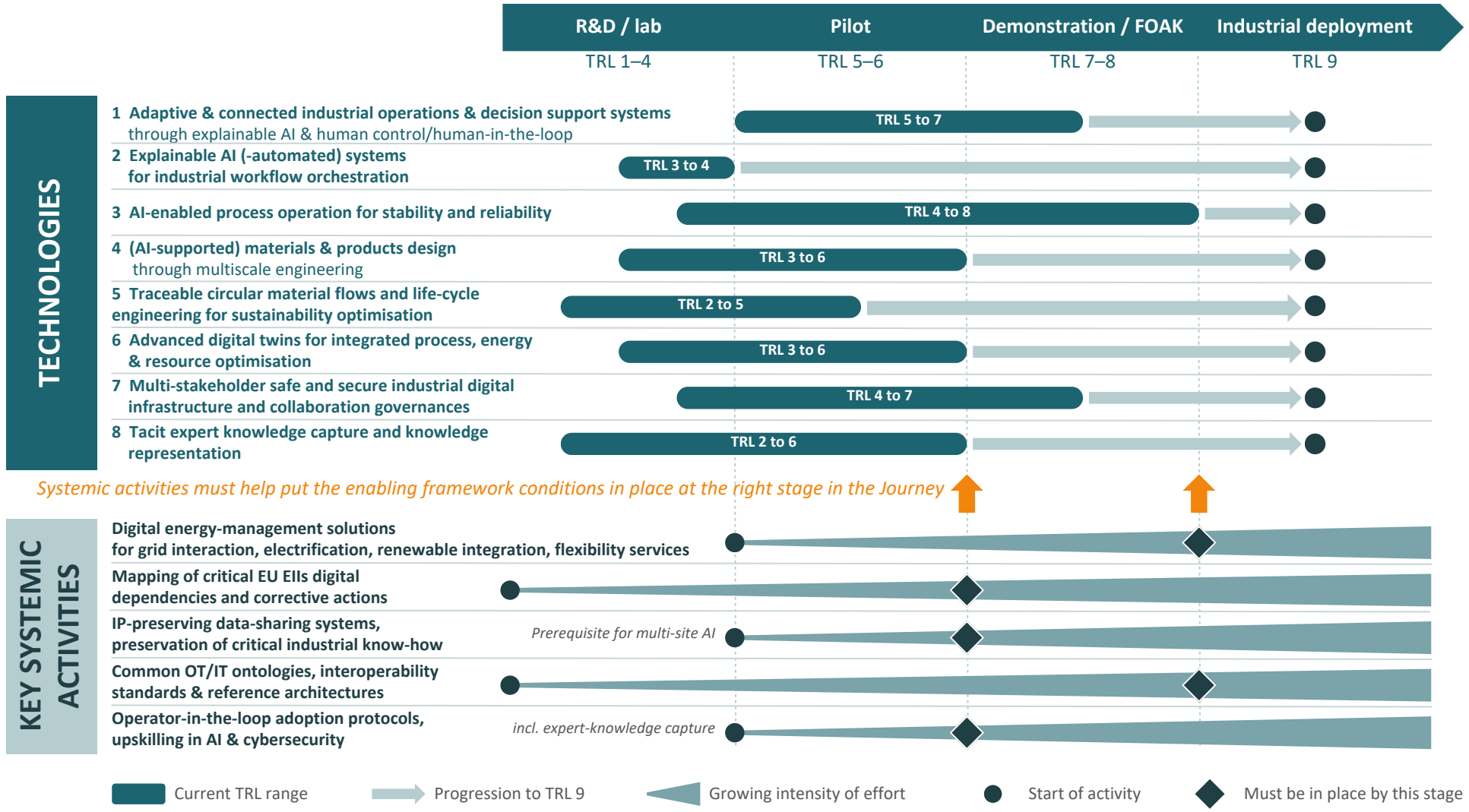
IJ4 Industrial AI and Digital Solutions for Process Excellence and Industrial Leadership

MISSION

Unlock the full potential of Industrial AI and digital technologies to deliver a step change in energy and material efficiency, flexibility and cost-competitiveness of industrial processes, and in the design, optimisation and validation of new-performance materials and products. **Establishing Europe as a global leader in Industrial AI & Digital technologies,** with EIIs as key drivers.

SECTORS & VALUE CHAINS

Sectors: All Energy Intensive Industries
Value chains: EII value networks, including energy suppliers, the public sector, technology providers, etc..



EXPECTED OUTPUTS

Industrial-ready, trustworthy, interoperable, cybersecure and reusable AI/digital solutions for predictive, adaptive and resource-efficient operations across plants and value chains, and for AI-enhanced materials & products

IMPACTS

Yield improvement, enhanced energy and material efficiency, reduction in off-spec production

Enhanced ability to deploy solutions across plants, sectors and legacy OT/IT environments

Extended operational lifetimes of Industrial AI and Digital Solutions

Enhanced reliability, traceability and explainability

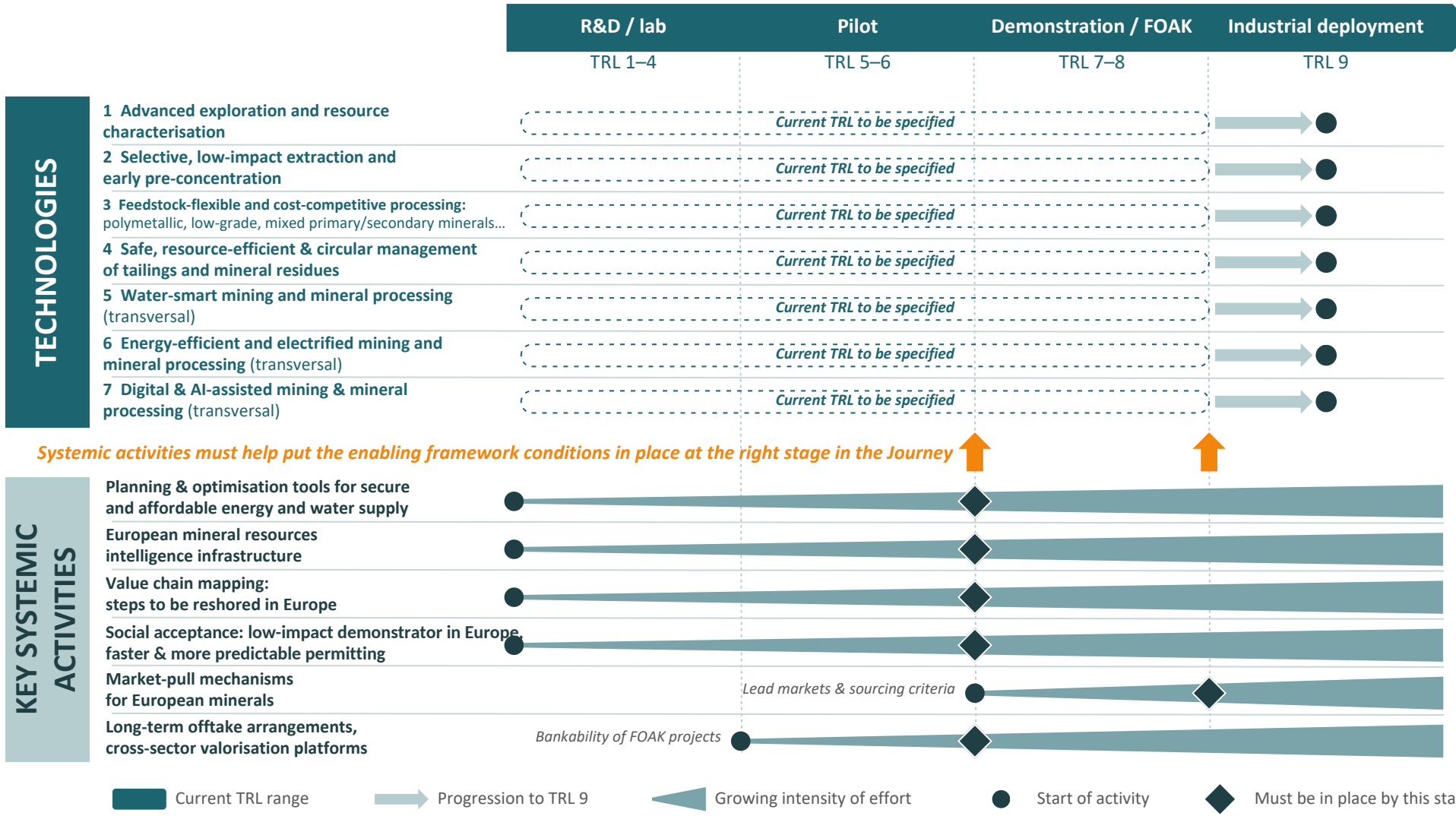
IJ5 Next-Generation Mining and Mineral Processing for Autonomous European Raw Material Supply

MISSION

Develop highly competitive, resource-efficient, low-impact and circular mining and mineral processing capabilities in Europe, through flexible processing technologies and infrastructure connected with downstream Energy Intensive Industries.

SECTORS & VALUE CHAINS

Sectors: Ferrous and non-ferrous metals, chemicals and fertilisers; cement, lime and other mineral industries; ceramics; equipment and technology providers
Value chains: Include batteries, permanent magnets, electronics, renewable-energy technologies, catalysts and construction materials



EXPECTED OUTPUTS

- Qualified raw materials and intermediates
- Valorised minerals
- Valuable compounds recovered from mine or process water
- Minimised environmental impacts (waste, emissions, water, biodiversity…)

IMPACTS

- Enhanced European extraction and processing capacities for priority minerals/materials
- Enhanced recovery yield from demonstrated mining & mineral processing routes
- Enhanced share of tailings/residues reprocessed or valorised
- Lower energy and fresh water consumption per tonne of qualified output

Current TRL range · Progression to TRL 9 · Growing intensity of effort · Start of activity · Must be in place by this stage · Current TRL to be specified

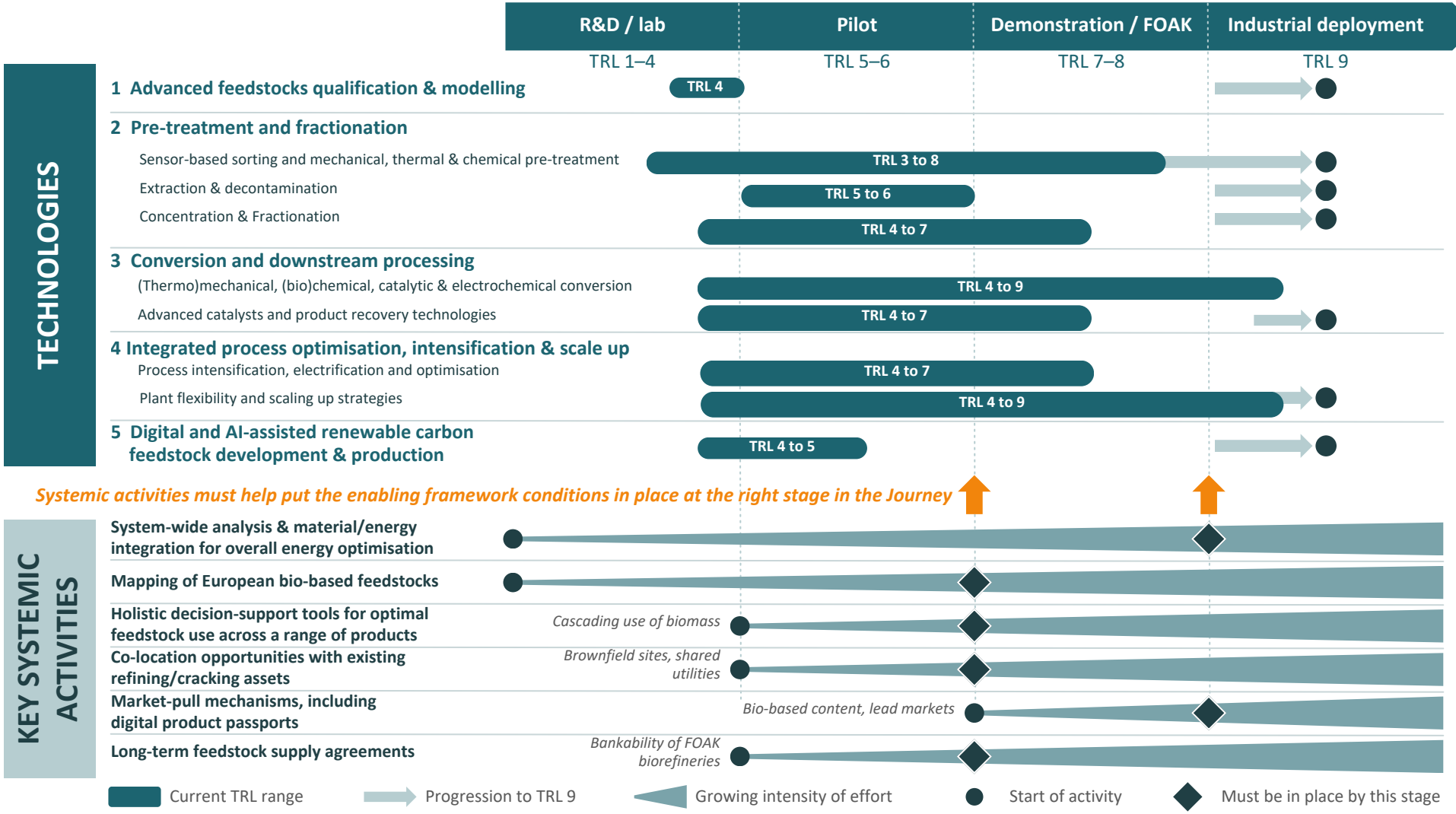
IJ6 Renewable & Circular Carbon Feedstocks for European Energy Intensive Industries

MISSION

Develop competitive and resource-efficient capabilities to produce high-quality renewable carbon feedstocks from sustainable biomass and waste-derived resources.

SECTORS & VALUE CHAINS

Sectors: Chemistry, refining, pulp & paper, steel
Value chains: Bio-based and recycled materials for construction, chemicals, paper and board, packaging, water treatment, fertilisers and nutrients, biofuel, etc..



EXPECTED OUTPUTS

Fractionable outputs, e.g.,, lignin, oils, proteins, biopolymers
Conversion intermediates: bio-oil, syngas, depolymerised fractions
Products, e.g., bio-based and specialty chemicals, biofuels, bioenergy, biomaterials…
Non-prioritised cascade outputs: fertilisers, biochar, peat substitutes, food and feed ingredients

IMPACTS

100% conversion rate of carbon feedstocks into marketable products or internal energy

All recycled carbon production sites fully supplied with renewable energy in 2045

10% reduction in specific energy consumption per product by 2030

Replacement of fossil-based feedstocks : 30% by 2040 – 50% by 2050

Biorefineries' energy consumption from waste/EOL products : 30% by 2030 – 100% by 2050
8 FOAK plants using variable feedstocks by 2035

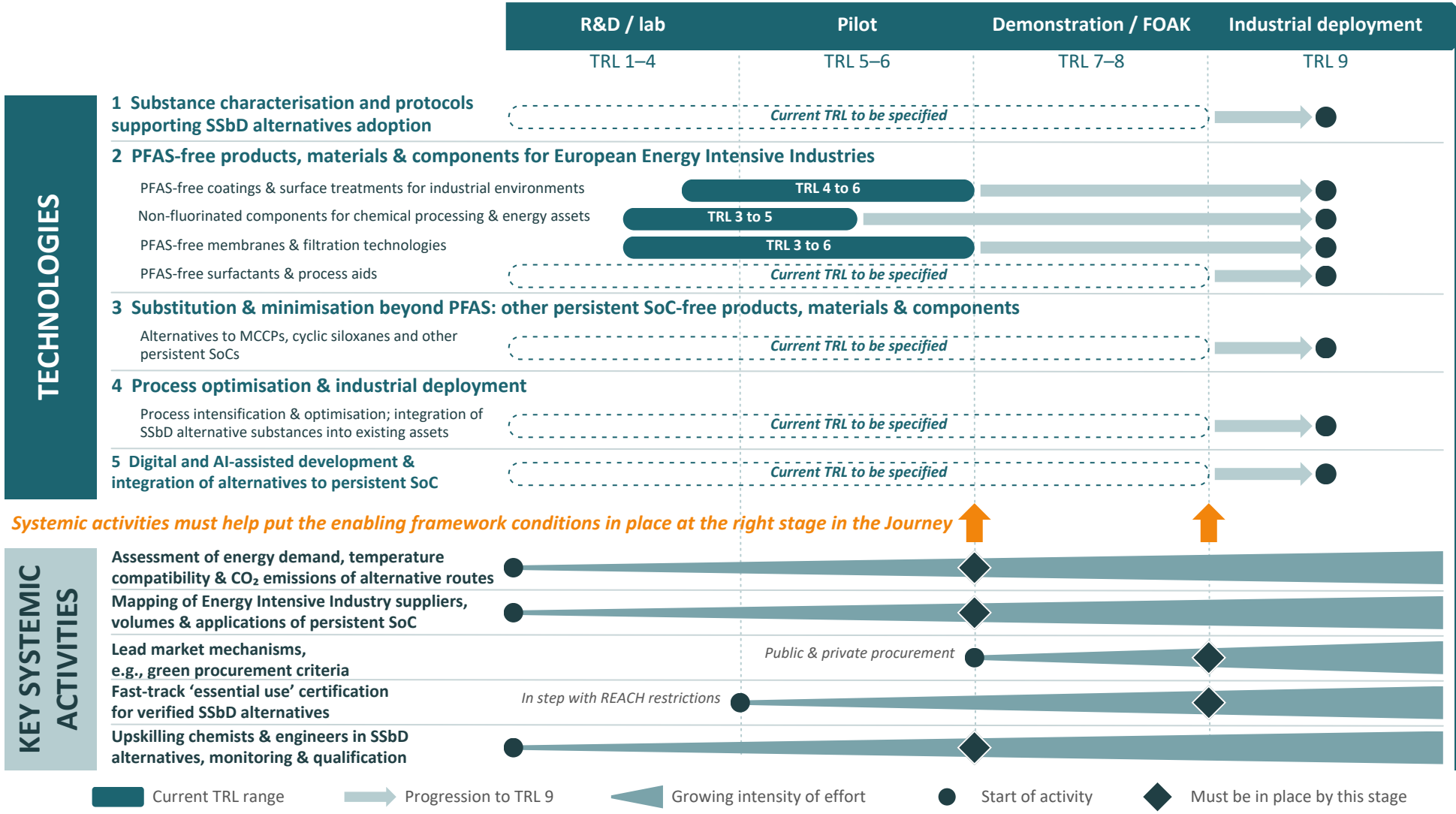
IJ7 Reformulating Materials & Products for Safe and Sustainable Functionalities

MISSION

Develop competitive technological solutions to substitute or minimise substances of concern used in EIIs production processes. Develop capabilities to design, produce, qualify and recycle SSbD materials and products, free from persistent substances of concern.

SECTORS & VALUE CHAINS

Sectors: All Energy Intensive Industries
Value chains: Electronics & energy-process components, automotive, aerospace, construction, protective materials, applications within EII



EXPECTED OUTPUTS

Alternative substances, materials and components free from, or with minimised content of substances of concern, with comparable or improved cost and performances

IMPACTS

At least 10 industrial functions validated at TRL 6–8, based on SSbD product, material or component alternatives by 2034

At least five bankable deployment cases by 2034

Drastically reduced (-80%) use of targeted persistent SoCs in EII

Drastically reduced (-80%) release into the environment of targeted persistent SoC

Current TRL range | Progression to TRL 9 | Growing intensity of effort | Start of activity | Must be in place by this stage | Current TRL to be specified

IJ8 Cross-Sectoral Development and Advanced Production of High-Value Materials and Products

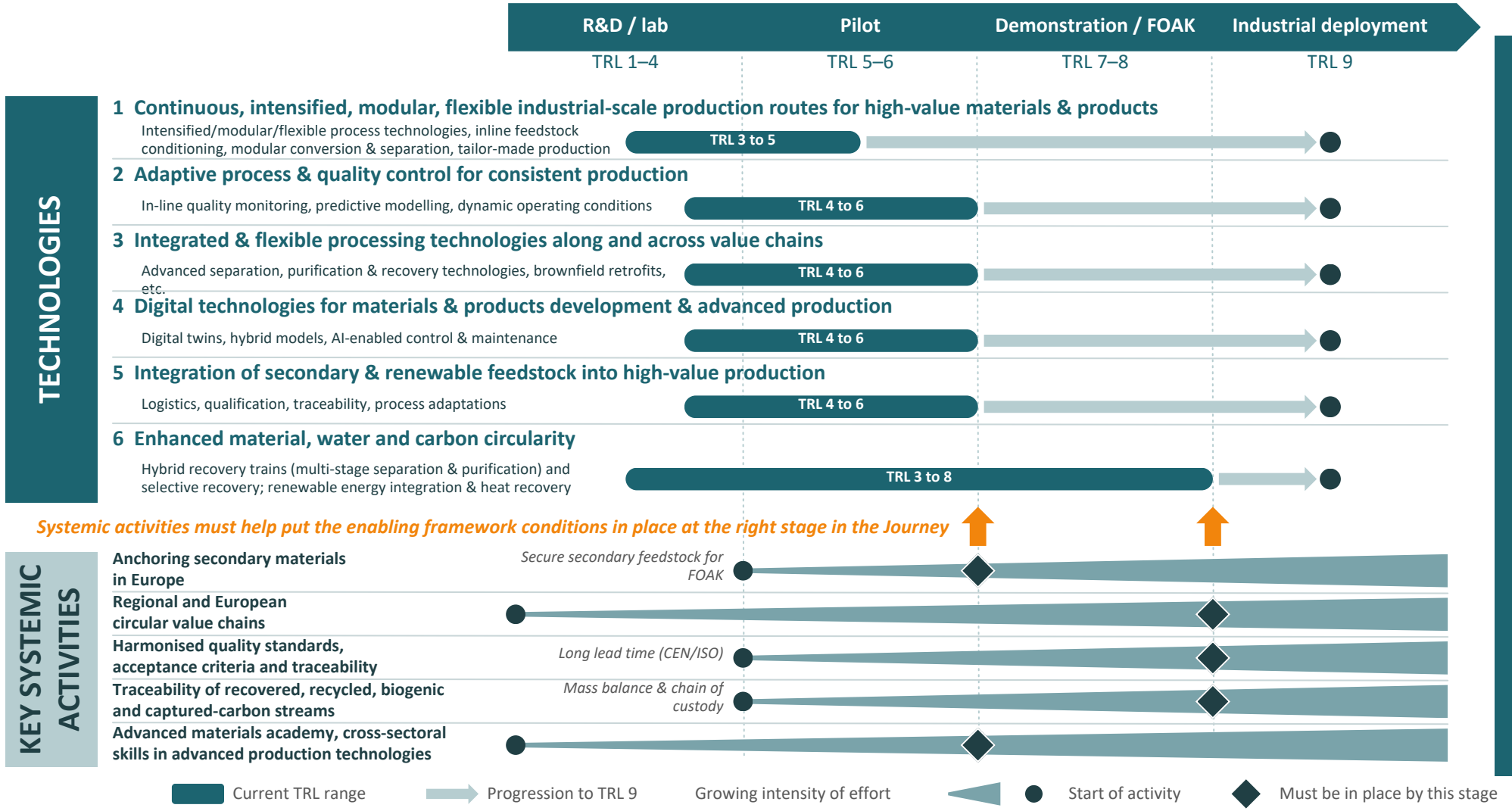
MISSION

Accelerate the development, scale-up and industrial production of innovative high-value materials and products through advanced cross-sectoral process capabilities.

SECTORS & VALUE CHAINS

Sectors: All Energy Intensive Industries

Value chains: All downstream value chains, including renewable energies, batteries, electronics, construction, aerospace, automotive



EXPECTED OUTPUTS

Qualified high-value materials and products, *including* recovered, circular, SSbD materials and products

IMPACTS

At least five priority solutions reaching TRL 7-8, across Energy Intensive Industries

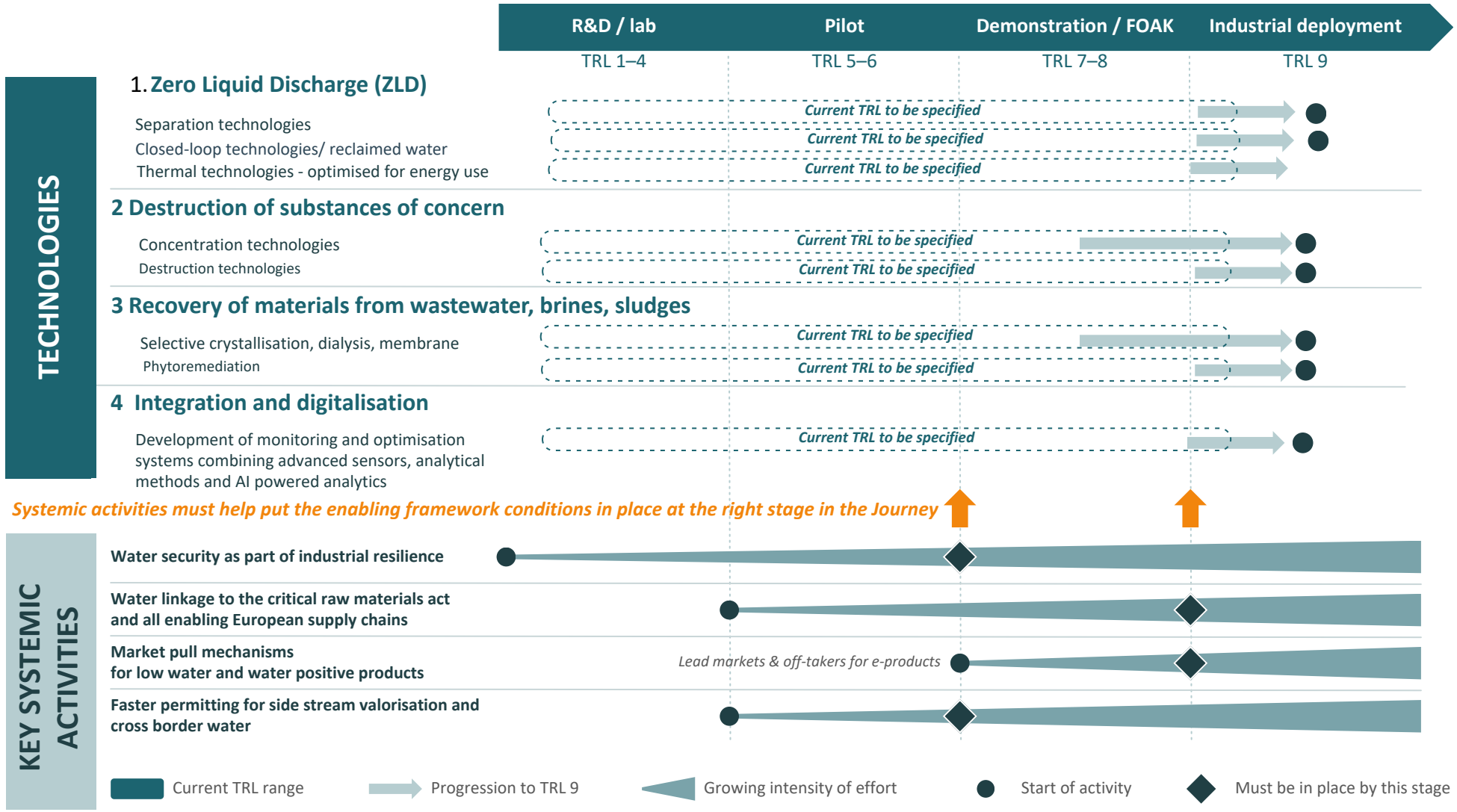
Bankable business cases for high-value materials and products (industrial investment pipeline)

IJ9 Water-Smart Energy Intensive Industries

MISSION Strengthen European industrial water resilience through zero liquid discharge, destruction of persistent pollutants and recovery of valuable materials from wastewater.

SECTORS & VALUE CHAINS

Sectors: All Energy Intensive Industries
Enabling value chains: Water sector and equipment suppliers



EXPECTED OUTPUTS

- Water resilient and competitive EIIs
- Water security supporting decarbonisation
- Reduced pressure on water bodies
- Elimination of persistent pollutants
- Circular water economy

IMPACTS

- Zero liquid discharge
- Destruction of persistent pollutants: 60% by 2034, 80% by 2040
- Share of salts, metals, acids and nutrients recovered – target to be defined
- Water reuse: 10% by 2034, 30% by 2040