

TNO Onderzoeksplannen 2027 - Overzicht Vraaggestuurde Programma's

MIB Thema	Vraaggestuurde Programma's (VPs)
Klimaat en Energie	P325 System Transition P307 Geo-energy P321 Renewable Electricity P340 Sustainable Industry P341 Energy and Infrastructure
Water, Klimaatadaptatie en Maritiem	P310 Karakterisering Grondwater P502 Duurzaam bouwen P407 Smart and Sustainable Mobility
Circulaire Economie	P510 Luchtkwaliteit P515 Circulaire Economie
Gezondheid en Zorg	P204 Future of Work P203 Biomedical Health
Veiligheid	P104 Defense Technology Industrial Base P102 Veilige maatschappij P108 Weerbaarheid
Sleuteltechnologie	P607 Space & Scientific instrument. P612 Semicon & Quantum P615 Flexible and Freeform Products P617 Smart Industry
Digitalisering	P706 ICT P707 Digital Systems (ESI)
Maatschappelijk verdienvermogen	P901 Transitions & Transformations
Kennisbasis	Exploratory Research Programma's
Uitvoering Wettelijke Taken en Overig	Defensie, Geologische Dienst en Overig

Titel	VP System Transition (P325)
MIB-thema	Klimaat en Energie
Contactpersonen TNO	Marijke Menkveld (VPM), Erlend Deckers (DM)
Programma jaar 2027 - Samenvatting	
In het Klimaatakkoord van Parijs (2015) is afgesproken dat de temperatuur door de uitstoot van broeikasgassen niet meer dan 2 graden mag stijgen. In maart 2026 heeft de EU met een wijziging van de Europese klimaatwet een klimaatdoel van 90% emissiereductie in 2040 ten opzichte van 1990 vastgesteld. Deze sterke vermindering van de CO₂-uitstoot is nodig op weg naar een nagenoeg CO₂-neutraal energiesysteem in 2050. Daarnaast is de energietransitie ook noodzakelijk voor een beter concurrerend en meer strategisch onafhankelijk Europa. In het onderzoeksprogramma System Transition ontwikkelt TNO in multidisciplinaire teams de kennis om die energietransitie mogelijk te maken. Met die kennis ondersteunt TNO overheden, bedrijven en organisaties bij goed onderbouwde (beleids)keuzes en helpt de energietransitie te versnellen. Het programma System Transition bestaat uit 3 proposities: behavioural and societal transition (BST), net zero energy systems (NZES) en sustainability & circularity transition pathways (SCTP). Propositionen vormen ons hoogwaardige aanbod aan de markt: de verbinding tussen onze klanten en stakeholders enerzijds, en onze kennis en faciliteiten anderzijds. De propositie BST levert daarbij de sociaal- wetenschappelijke kennis over gedrag, de propositie NZES ontwikkelt kennis over de transitie naar een elektriciteit- en warmtevoorziening zonder emissies en de propositie SCTP levert kennis over de transitie naar duurzame energie en brandstoffen voor mobiliteit en industrie en de integratie in het energiesysteem. In november 2024 werd een intentieverklaring getekend tussen TNO en de kennispartners CPB, PBL, RVO en CBS om hun samenwerking te versterken in de 'Kenniscoalitie Energietransitie (KCET)'. Een eerste programma binnen KCET is het EIK programma dat in 2025 tot stand is gekomen: 'Energietransitie Integraal Kostenbeeld'. De kennispartners werken met financiële ondersteuning van het ministerie Economische Zaken en Klimaat aan een betere kennisbasis voor de te verwachte kosten van de energietransitie, de betaalbaarheid en de effecten op overheidsfinanciën en macro-economie. Vanuit het programma zijn in 2026 al diverse publieke rapportages uitgebracht en bouwen we in 2027 de samenwerking verder uit. In Q4 2026 en eerste helft 2027 werken we aan beleidsvragen over de effecten van energie- en klimaatbeleid op de energierekening van huishoudens en bedrijven en beleidsknoppen om de energierekening betaalbaar te houden. Er is ook de wens om breder naar de maatschappelijke baten van de energietransitie te kijken. Daarnaast verkennen de kennispartners een mogelijk nieuw programma over Clean Competitive Industry. In adviezen van de SER en WKR wordt gepleit voor meer aandacht voor gedrag in energie- en klimaatbeleid. Om de effectiviteit van beleid te vergroten gaat TNO in de propositie behavioural and societal transition in 2027 gedragskennis gebruiken voor de kwantificering van gedragseffecten van beleid. Ook werken we in verschillende EU en NWO-projecten samen met universiteiten en andere kennisinstituten om kennis te ontwikkelen over alternatieve economische paradigma's in het beyond growth debat, het operationaliseren van rechtvaardigheid, methoden voor burgerparticipatie, de rol van energiegemeenschappen en marktcreatie. Rechtvaardigheid is een belangrijk thema. De minister roept: "iedereen moet mee kunnen doen met de energietransitie". Maar hoe doen we dat dan? Er is behoefte aan methoden, tools en kaders. De energietransitie wordt in toenemende mate begrensd door netcongestie, de stagnerende warmtetransitie en de groeiende druk op ruimte, infrastructuur en investeringscapaciteit. Oplossingen vragen daarom om een integrale systeembenadering waarin elektriciteit, warmte, mobiliteit, industrie, ruimtegebruik, beleid en gedrag in samenhang worden beschouwd. TNO wil in de propositie Net Zero Energy Systems (NZES) in 2027 de huidige modellen portfolio verbeteren om samen met stakeholders die integrale systeembenadering te onderzoeken op lokaal, regionaal en nationaal niveau. In de propositie sustainability & circularity transition pathways wil TNO in 2027 nieuwe scenario's voor de Nederlandse energietransitie ontwikkelen. Daarbij nemen we onzekerheden, de materialentransitie en inzichten rond systeemkosten en economische effecten uit EIK mee. We onderzoeken hoe Europese strategieën rond strategische autonomie en klimaatambitie doorwerken in het Nederlandse energiesysteem. In Europa worden komend jaar voorstellen besproken voor klimaatbeleid	

tot en met 2040. Tegelijkertijd hebben de EU-leiders in maart 2026 overeenstemming bereikt over een agenda met concrete maatregelen om het concurrentievermogen, de veerkracht en de strategische autonomie van de EU te versterken.

In dezelfde propositie werken we ook aan een database en optimalisatietool met informatie over de businesscase van hernieuwbare brandstoffen voor mobiliteit en industrie. We focussen daarbij eerst op methanol en Sustainable Aviation Fuel (SAF). Methanol is een veelgebruikte grondstof in industriële processen. SAF speelt een grote rol vanwege Europese regels over verduurzaming van luchtvaartbrandstoffen in de ReFuelEU Aviation-verordening, maar wordt nu nog weinig gebruikt. Verder analyseren we beleidskaders voor koolstofverwijdering en integratie daarvan in het ETS1 als onderdeel van de herziening van dit Europese emissiehandelssysteem.

Titel	VP Geo-energie (P307)
MIB Thema	Klimaat en Energie / MMIP4: Duurzame warmte en koude in de gebouwde omgeving (individueel en collectief), MMIP 6,7 (Verduurzaming warmtevraag Industrie, CO2 opslag, grootschalige energieopslag)
Contactpersonen TNO	Maurice Hanegraaf (VPM), Tirza van Daalen (DM)
Programma jaar 2027 - Samenvatting	
Geo-Energy develops the validated knowledge, data, models and technologies needed for safe, affordable and scalable use of the Dutch subsurface in the energy transition. The program supports the Geological Survey of the Netherlands in providing trusted information products, independent advice and applied R&D for government, regulators, public authorities and industry. Its scope covers sustainable heat and cooling, CO₂ transport and storage, underground hydrogen storage, well technology, induced seismicity, geological disposal of radioactive waste and subsidence. These themes are connected by one central challenge: the subsurface is becoming increasingly important for the energy transition, climate adaptation and strategic autonomy, while the risks, uncertainties and spatial constraints must be managed transparently. The 2027 plan responds to a set of urgent external developments. Electricity-grid congestion is increasingly constraining the electrification and the heat transition, making underground heat and cold storage, flexible heating and cooling and integrated energy-system planning more relevant. At the same time, the deployment of geothermal energy and large-scale heat networks is progressing more slowly than anticipated, which increases the need for better derisking, bankable business cases and practical decision support. CCS is moving from preparation to operation through Porthos, Aramis and future North Sea hubs, while underground hydrogen storage is becoming essential for seasonal balancing and security of supply. Renewed policy attention for nuclear energy increases the need for credible knowledge on long-term geological disposal of radioactive waste. Climate change, groundwater management, building-damage risks and mining effects require stronger national information on subsidence and deformation. Across all market teams, VP307 will use SMO funding to address capability gaps that are not sufficiently covered by ongoing externally funded projects. The emphasis in 2027 is therefore not on developing isolated tools, but on integrating, validating and translating existing knowledge into usable workflows, evidence packages and decision-support products. Heat activities will connect AI-based subsurface property modelling with underground heat and cold options, grid-congestion use cases, business-case calculations and AI-supported network modelling. CCS activities will focus on WIND4CCS, CO₂ quality and corrosion, and flow-loop based CO₂ flow assurance, while broader monitoring and liability work continues through POSEIMON and Porthos-related activities. Well Technology will mature the Design–Validate–Deploy chain through Radial Jet Drilling, CCS well-barrier testing and iWells. Induced Seismicity and Underground Hydrogen Storage will jointly strengthen salt-cavern monitoring, risk management. Geological disposal of nuclear waste will build experimental competence for deep-borehole disposal, and Subsidence will prepare the first public model-chain release and national-scale testing. The expected outcome is a coherent VP307 portfolio that strengthens GDN's role as a trusted, evidence-based partner for policy, permitting, investment and operational decisions on the Dutch subsurface.	

Titel	VP Renewable Electricity (P321)
MIB Thema	Klimaat en Energie, MMIP1, MMIP2, MMIP 13
Contactpersonen TNO	Mark Overwijk (Division Director Energy Supply), Jan Willem Wagenaar (VP-manager Wind Energy), Kahya Engler (Program Manager Solar Energy)

Programma jaar 2027 - Samenvatting

We have a vision of a clean, competitive and energy resilient Europe, where homegrown renewable energy and electrification safeguard affordability and energy security. We foresee that renewable energy supply will be the backbone of our future independent energy system. Consequently, it is our mission to develop impactful innovations that assure competitiveness of renewable energy technology, affordability of renewable energy assets and flexibility in the energy system. With our track record in solution driven research and together with our partners, we make the energy system work in practice for industry and citizens. Beyond clean energy and a competitive EU, societal developments are such that we require the renewable energy generation to be both circular and in perfect harmony with nature. Also, geopolitical developments in recent years have put more and more emphasis on energy independence and physical and cyber resilience. With these external drivers in mind, the long-term goals of this VP are:

1. Support the NL and EU manufacturing of renewable energy technology.
2. Improve the reliability and affordability of renewable energy systems.
3. Make renewable energy generation nature-inclusive and circular.
4. Increase flexibility and stability in the energy system and boost storage and conversion methods.

Having these long-term goals in mind, we define specific goals for 2027.

Manufacturing

Supporting the NL and EU manufacturing, TNO develops and industrializes flexible perovskite solar foils through automated roll-to-roll manufacturing technology. The programme integrates perovskite materials and device architectures with coatings, laser interconnections, encapsulations, inline characterizations and module finishing. In this way, it supports PV manufacturers, equipment suppliers and product integrators in bringing lightweight, efficient and locally produced solar products to market. As such, TNO has successfully applied a perovskite solar module on foil to a roof tile. Despite its curved shape, the solar roof tile module achieves an energy efficiency of 12.4%. In 2027, the main focus will be to specify, upgrade and order the new roll-to-roll perovskite infrastructure within SolarNL.

Mass-Customisation

Further on manufacturing, TNO and partners develop concepts for PV products that can be tailored to specific applications while retaining scalable production benefits, i.e. mass-customisation. The value proposition is driven by demand for products beyond standard module formats, for integration into buildings, vehicles, infrastructure, lightweight structures and high-end energy applications. Here, TNO combines expertise in materials, packaging, module design, interconnection, reliability testing and automated manufacturing. In 2027, key activities include reducing cell-to-module losses, improving packaging and materials, validating mass customization line manufacturing concepts, and connecting closely to the roll-to-roll perovskite programme.

Reliability

To strengthen the renewable energy sector as a whole and specifically to de-risk asset operation, TNO has launched the concept of the data sharing platform. The logic of the concept is that by sharing data, the entire sector gets stronger. TNO has aligned with external stakeholders from industry, government, academia, etc. in offshore wind for setting up such a data sharing platform and all stakeholders welcome the concept. Throughout 2026, TNO has developed a first demo version of the platform incorporating Eneco's Princess Amalia Wind Farm SCADA data. Following, we aim to develop it further and extend the use cases in 2027. As such, TNO profiles itself as independent data supplier.

Circularity

In order to make renewable energy generation circular, we research and investigate circular design, end-of-life scenarios, repurposing strategies, and advanced recycling routes. TNO and partners have demonstrated various methods for reclaiming valuable materials from renewable energy technologies, such as glass fibres from wind turbine blades and glass, silver and

silicon from PV panels. For 2027, the goal is to demonstrate that new products can be made of these reclaimed materials, such as commercial plastic products of the glass fibres and silicone-based chips of the PV waste. Alongside, we aim to do the same for the magnets in wind turbine generators.

Further research focuses on circular design, such as reversible resins in wind turbine blades and reduction of critical raw materials solar cell manufacturing. This, without sacrificing performance and while maintaining reliability. Finally, we aim to develop end-of-life logistics planning capabilities for ports and inland transport networks for decommissioned offshore wind farms.

Storage

To increase the flexibility of the Dutch electricity system and make better use of renewable electricity, TNO and partners are investigating the co-location of renewable generation, electricity consumers and energy storage. TNO and partners are developing and validating offshore storage solutions, including batteries, compressed air storage, underground pumped hydro and flexible electrolyzers integrated with offshore wind farms, with the objective of maximizing renewable electricity utilization and reducing curtailment. Preliminary results show that optimal offshore storage sizing strongly depends on the storage technology, cost structure and intended flexibility service. The analyses further indicate that capturing all curtailed offshore wind generation is not economically optimal, with cost-effective solutions targeting only the most valuable, curtailed energy. These findings highlight the importance of technology-specific sizing and dispatch strategies to maximize system value and minimize overall investment costs. In 2027, TNO aims to establish and validate at least three representative storage concepts through laboratory and field demonstrations, providing quantitative evidence of their contribution to congestion mitigation, renewable energy integration and system cost reduction.

Resilience

To better protect future energy infrastructure against operational disturbances and cyber threats, TNO continues to develop the SWITCH laboratory as an open innovation facility for integrated energy systems. Over recent years, SWITCH has evolved into a hybrid energy system comprising renewable generation, storage technologies and advanced control systems that can be tested under realistic operating conditions. Previous research has demonstrated how cyber-attacks and equipment failures can be detected through monitoring and anomaly-detection techniques, providing valuable insights into the resilience of future energy systems. In 2027, the laboratory will be further expanded and energized to enable testing of grid faults, restoration scenarios and cybersecurity threats in a realistic environment. With the support of the Ministry of the Interior and Kingdom Relations and together with the TNO Defense teams, this will provide industry, grid operators and policy makers with a unique platform to evaluate new technologies and strengthen the resilience of critical energy infrastructure.

Titel	VP Sustainable Industry: Feedstock Conversion and Sustainable Materials (P340)
MIB Thema	Klimaat en Energie / Sleuteltechnologie, Mission C, MMIP 6 and 8, KIA CE MMIP 1, 2 and 3
Contactpersonen TNO	Esther van den Beuken, Richard Braal

Programma jaar 2027 - Samenvatting

The demand driven program “Sustainable Industry: Feedstock Conversion and Sustainable Materials” articulates TNO’s comprehensive strategy to support the transition of the Dutch industrial sector towards circular and sustainable materials, aiming at climate neutrality (net zero emissions) and 100% circularity by 2050 – fully in line with the Dutch Climate Agreement (DCA) and the National Program Circular Economy (NPCE), respectively. This plan is structured around two propositions: “Feedstock Conversion” and “Sustainable Materials”. Within these propositions, six targeted sub-propositions serve as focal points for collaboration, innovation, and development. The figure below provides an overview of these (sub)propositions.

Feedstock



Plastic recycling technologies & system solutions
Sustainable fuels & chemicals
Industrial carbon capture

Materials



Circularity by design
Energy saving materials
Alternatives for toxic and critical materials

Overview of relevant propositions (Feedstock & Materials) and their respective sub-propositions.

Feedstock Conversion

Our main objective for the proposition ‘Feedstock Conversion’ is the development of sustainable & efficient processes for the following topics:

- **Plastics recycling technologies and system solutions (PRT&SS):** We provide technologies and system solutions to accelerate the transition towards Circular Plastics by developing new recycling technologies, such as thermal cracking, dissolution, depolymerization and advanced feedstock preparation, a.o. using physics informed ML / AI and applicable to various (complex) plastic waste streams. In addition, we develop a system view on the plastic value chain using our TNO system models (a.o. CITS, PRISM) and provide circular system solutions (R-strategy impact, technology scenario’s etc.) towards a circular plastics chain in 2050 to guide authorities, industry and other stakeholder to make the right decisions for the circular transition;
- **Sustainable fuels & chemicals (SF&C):** We develop innovative biomass and CO₂ conversion technologies, like thermochemical processes to convert biobased waste streams into syngas and high value chemicals, or catalytic processes to convert biomass into functionalized chemicals, or separation-enhanced technologies to convert CO₂ into syngas and fuels (e.g. for shipping and aviation) and a portfolio of novel technologies using NH₃ as an H₂ carrier, including separation-enhanced NH₃ production, NH₃ cracking, and NH₃ conversion into syngas and chemicals;
- **Industrial Carbon Capture (ICC):** We develop new process-integrated precombustion capture technologies, including our proprietary sorption-enhanced water-gas shift (SEWGS) capture technology for e.g. the steel industry. We enable the industrial implementation of post-combustion ICC using absorption technology by performing pilot campaigns at industrial sites with real flue gases, and by developing proprietary technologies to decrease solvent degradation and emissions, and lower overall levelized cost of carbon capture. Finally, we develop new cost-effective technologies for CO₂-purification.

To arrive at these long-term goals, the following key results are intended for 2027:

Plastic Recycling Technologies & System Solutions:

- Industrially demonstrate solvent-based recycling technology at TRL6 through integration in a circular plastics value chain;
- Increase market applicability of solvolysis technology through validation of suitable polymer use-cases such as thermoset composites;
- Demonstrate dissolution-based pretreatment of difficult waste at TRL3,
- Complete LCA & TEA for thermochemical recycling of textile waste;

Sustainable Fuels & Chemicals:

- Advance TNO's Digitalization & AI frameworks for complex process chains through strategic priority Flagship projects (first digital twin of thermochemical conversion) to accelerate R&D, enhance testing and predictive capabilities, and de-risk scale-up of TNO's strategic technologies.
- Establish a SAF Powerhouse in the Netherlands, leveraging TNO and Dutch technology leadership to accelerate sustainable aviation fuel innovation, demonstration, and deployment, positioning the Netherlands as a European frontrunner in SAF.
- Demonstration of next-generation bio-based polyol platform in first-of-a-kind bio-polyester applications for high-value markets including adhesives, coatings, textiles, and sustainable packaging.
- Demonstrate TNO's proprietary SEDMES (Separation Enhanced DME Synthesis) for integrated biomass-to-DME conversion, validating continuous production of high-purity dimethyl ether and accelerating scale-up towards commercial deployment (TRL6/7), as well as TNO's proprietary COMAX (a sorption-enhanced reverse water gas shift technology) for tailored synthesis gas production from diverse producer gas feedstocks and captured CO₂, enabling application across multiple industrial value chains (TRL5).
- Strengthen TNO's portfolio of carbon capture and utilization (CCU) technologies for the selective production of olefins and other high-value chemical building blocks from CO₂ (TRL3).
- Establish a leading knowledge position in flexible ammonia cracking technologies, including full design of multitubular membrane reactor for ammonia cracking (MEMA), patent filing for direct utilization of ammonia for CO₂ conversion (DUET), and performance evaluation of advanced functional materials.

Industrial Carbon Capture:

- Demonstrate DORA (Dissolved Oxygen Removal Apparatus) technology at TRL6-8 in three pilots with performance on solvent lifetime extension and improved CO₂ purity demonstrated.
- Demonstrate the electrified regeneration of CO₂ capture solvent at a cement plant (TRL5-6).
- Demonstrate CYPRESS (novel technology for NO_x removal from CO₂) at TRL4
- Demonstrate CO₂ capture using amines at an Aluminum production site using TNO's mobile pilot unit (TRL6).

Sustainable Materials

Our main objective for "Sustainable Materials" in the period 2027 – 2030 is the development and validation of novel sustainable materials within the scope of following sub-propositions:

Energy Saving Materials:

Within Energy Saving Materials, we develop and demonstrate novel sustainable materials that facilitate energy saving in the built environment and in mobility applications. For the built environment, we develop and validate innovative optical materials for sustainable buildings. These materials are either coatings or polymer films with specific solar control functionalities, which are applied in windows and building-integrated photovoltaics. Additionally, from 2024 we focus on re-use of old flat glass from windows and solar panels. For mobility applications, we develop and implement circular and lightweight, structural thermoplastic composite (TPC) materials in automotive and other mobility applications. The ability to use these materials in a wide range of products and components will enable accelerating the energy transition by lowering fuel consumption and extending range of electric vehicles, resulting in reduction of CO₂ emissions. In addition, development of recycled TPC (reTPC) supports the industry in meeting recently updated end-of-life vehicle (ELV) legislation. These activities are part of Brightlands Materials Center's programs for Sustainable Buildings and Sustainable Mobility. Based on the expertise and infrastructure built up in this sub-proposition in the fields of functional coatings, functional films and continuous fiber additive manufacturing (CFAM), we will start developing materials for defense, safety & security applications in 2027, in close alignment with TNO's Defense,

Safety & Security unit and Brightlands Chemelot Campus. Examples of applications for which materials will be developed are signature management, on site repair, lightweight structural components, and capture and decomposition of volatile substances.

Alternatives for Toxic & Critical Materials:

Within Alternatives for Toxic & Critical (ATC) Materials, we focus on the development of safe, sustainable, and economically viable alternatives to critical and toxic materials. Furthermore, we aim at increasing supply chain robustness for materials of high economic and strategic value via novel recycling processes, establishing alternative sources, and developing sustainable production processes. At the core of the ATC sub-proposition is the development of materials for a PFAS-free, CRM-lean PEM electrolyser, for which new membranes, anti-corrosion coatings and recovery/recycling solutions for CRM containing catalysts are developed. Adjacent to PFAS-free coatings, novel testing capabilities for PFAS-free polymers and new processes to establish waste streams as feedstock for CRM-containing advanced materials are being developed for various application areas.

Circularity by Design:

Within Circularity by Design, we enable industries to transition to a circular economy, with higher material reuse and recovery rates, cleaner recycling streams, and circular business models. We do this by (1) development of safe and sustainable products with improved circularity, including recyclability and reuse, (2) microplastic and environment system analyses, mitigating microplastics through process design, product design and exposure reduction, and (3) experimental understanding of polymer quality in the life cycle of design, production, use and recycling by implementing artificial intelligence (AI) solutions for process control and product optimization.

To arrive at this long-term goal, the following main results are intended for 2027:

Energy Saving Materials:

- *Thermochromic coatings and laminates for smart windows:* Monitoring functional performance of thermochromic windows in test buildings, office buildings and residential buildings. Study the switching behavior in test buildings, assess the impact of lower temperature, and improved thermal comfort by the thermochromic window on health of occupants.
- *Thermochromic retrofit window film for smart windows:* Develop thermochromic coating on PET film on lab scale and validate its functional performance and durability.
- *Towards a 100% circular window:* Develop and demonstrate coatings and polymer interlayers that facilitate reuse of old window glass for production of new windows.
- *Demonstration of consistent quality reTPC from mixed production waste streams* at an industrially relevant scale, together with industry partners, and business case for recycling post-industrial waste TPC.
- *Demonstration of TPC products manufactured by CFAM and/or by fused granulate fabrication* using recycled materials, meeting the mechanical requirements for selected e-mobility applications.
- *Materials for defense:* Develop and validate at least 2 materials for defense, safety and security applications on lab scale. Examples of applications for which materials will be developed are signature management, on site repair, and capture and decomposition of volatile substances.

Alternatives for Toxic & Critical Materials:

- *Optimize the functional properties of a PFAS-free membrane* and validate its performance in a PEM electrolyser.
- *Optimize the conductivity and corrosion resistance of a PGM-free anti-corrosion coating* on titanium substrates and validate its performance on flow field plates of a PEM electrolyser.
- *Develop and validate the performance of a PFAS-free hydrophobic coating* in semicon applications.
- *Establish new testing protocols for PFAS-free sealants, O-rings and lubricants* for CO₂ storage infrastructure.
- *Optimize and scale up to 15 liter scale of vanadium recovery process* from spent catalyst waste and process optimization for use of recovered feedstock in synthesis of thermochromic materials.

Circularity by Design:

- Development of a prototype film containing post-consumer recycle for use in contact-sensitive applications (e.g., food, cosmetics, hygiene).
- Demonstration of the first prototype of an AI-supported method for the measurement of the composition and quality of sorted plastics in a recycling facility, intended as an exit control to enhance its value.
- Unlock a mechanistic understanding of microplastic formation and emission pathways in PP, HDPE, and PET recycling to enable mitigation strategies that simultaneously reduce environmental impact, improve process performance, and increase the market value and profitability of recycled plastic products.

- Development of prototype high-temperature reversible adhesive system or composite material + evaluation and validation of recycling principle with industry partners (TRL 3-5).

This plan is heavily supported by strategic collaborations with industry leaders, academic institutions, and government bodies, ensuring that the Dutch industrial sector not only meets its climate and circularity targets but also remains a competitive and sustainable force in the global market.

Titel	VP Energy and Infrastructure (P341)		
MIB Thema	Klimaat en Energie / Sleuteltechnologie, MISSION C; MMIP 6, 7 & 8		
Contactpersonen TNO	Stephan Janbroers		
Programma jaar 2027 - Samenvatting			
The demand-driven programme “Energy & Infrastructure” sets out TNO’s strategy to support Dutch and international industry achieve carbon neutrality by 2050, in line with the Dutch National Climate Agreement and the EU Clean Industrial Deal. By driving innovation and strengthening the international position of Dutch technology suppliers and asset owners, the programme supports both economic value creation, resilience, and global impact for the Netherlands. It is built around two pillars: the research lines ‘Power to Industry’ and ‘Infrastructure’, each designed to enable the efficient roll-out of clean energy, to accelerate electrification, and to reduce the dependence on fossil fuels. Six focus areas provide the focus for innovation. Sustainable Industrial Heat, Power-to-X Technologies, and Process Efficiency and Flexibility within Power to Industry; and Safe and Reliable Infrastructure Development, Flexible Energy Systems, and North West European Energy Infrastructure within Infrastructure. By 2027, TNO aims to create measurable impact by piloting and licensing renewable-driven industrial technologies. We aim to strengthen the international market position of Dutch technology suppliers, and support resilient, future-proof energy infrastructure. This will accelerate decarbonisation and improve resilience while increasing earning power for the Netherlands. In response to recent offshore energy developments, the programme will place greater emphasis on ports and the import of renewable molecules and the resilience of energy infrastructure, while maintaining the knowledge position the Netherlands has built in offshore hydrogen production. The plan is underpinned by strategic collaboration with industry, academia and government, helping Dutch industry meet climate targets while remaining competitive and sustainable in global markets. An example of intended results for 2027 is the development and start of projects regarding the value of a coordinated multi-commodity energy hub on the Rotterdam port area, including validation via hardware and software demonstration, with a focus on alleviating grid congestion via technical, regulatory and market innovations. Another example is that the Community of Practice Electrolysis (COPE) will be consolidated into a self-sustaining platform for harmonization and standardization in electrolysis to produce green hydrogen. The research lines will also see the results on dedicated investments on AI and digitalization that focus on ‘Machine learning for integrity monitoring of energy infrastructure’ and on ‘Autonomous Testing for Accelerated R&D’.			
Power to Industry		Sustainable Industrial Heat	
		Power-to-X Technologies	
		Process Efficiency and Flexibility	
Infrastructure		Safe and reliable infrastructure development	
		Flexible energy systems	
		North West European energy infrastructure	

Titel	VP Karakterisering en Dynamiek Samenstelling Grondwater (P310)
MIB Thema	Water, Klimaatadaptatie en Maritiem. IKIA B,E
Contactpersonen TNO	Maurice Hanegraaf (VP Manager) Tirza van Daalen (Division Director, Geological Survey of the Netherlands)
Programma jaar 2027 - Samenvatting	
Groundwater is essential to the Dutch economy, environment, and society. It supplies drinking water, agriculture, industry, and nature, and increasingly serves as a source of underground energy storage. At the same time, it faces growing pressure from climate change, urbanisation, pollution, and rising competition between different uses of groundwater and the subsurface.	
Addressing these pressures calls for groundwater stewardship: the socially just, sustainable, and economically responsible management of groundwater, a shared responsibility of government, knowledge institutions, society, and industry. TNO's Geological Survey of the Netherlands (GDN) is uniquely positioned to support this, connecting government, science, and industry while acting as custodian of the data and knowledge that underpin sustainable use of the Dutch subsurface. As set out in TNO's Groundwater Stewardship plan for 2026–2029, GDN supports different sectors in making climate-resilient, sustainable, and economically responsible decisions on groundwater use.	
By 2030, TNO aims to provide a trusted national groundwater information platform, a deeper understanding of the Dutch subsurface and groundwater quality, decision-support tools for climate resilience and multiple subsurface use, and a shared digital twin capability — strengthening TNO's role as an independent knowledge partner and orchestrator of groundwater stewardship, nationally and internationally.	
This programme supports several national and European policy goals. It contributes to Water en Bodem Sturend by ensuring groundwater and subsurface conditions inform spatial planning, and to the National Delta Programme by strengthening freshwater availability and resilience to drought, flooding, and salinization. A joint programme by the Ministries of I&W and EZK on the sustainable use of the subsurface addresses conflicts such as between drinking water protection and thermal energy storage. It also supports the groundwater quality and quantity objectives of the European Water Framework Directive, and the integrated subsurface governance being developed through the Nationaal Programma Bodem, Ondergrond en Grondwater. Through its focus on climate-resilient water and soil systems, the programme also contributes to Mission 3 (“Vitaal landelijk gebied in een klimaatbestendig Nederland”) of the KIA Landbouw, Water en Voedsel. Separately, research on thermal energy storage, geothermal energy, and other subsurface energy technologies supports the energy transition under the Dutch Climate Agreement.	
In 2027, this translates into concrete progress across connected themes, building directly on the methods, models, and first tools developed in 2025 and 2026. Grondwatertools will grow into a more complete national platform for groundwater information, adding new climate projections and reporting features. Continued research will deepen understanding of how contaminants such as PFAS behave in the subsurface. New climate-resilience tools will help manage drought, salinization, and subsidence, while governance approaches for combining different uses of the subsurface will be tested in real municipal cases. TNO will also begin building a shared digital twin capability for groundwater management.	
Reflecting these priorities, the P310 Groundwater VP-plan sets out TNO's 2027 research priorities across six themes: Groundwater Resources, Advanced Groundwater Information Products, Subsurface Characterisation and Parameterisation, Climate Resilience, Multipurpose Potential, and Digital Twins for Groundwater Stewardship.	

Titel	VP Duurzaam Bouwen (P502)
MIB Thema	Klimaat en Energie
Contactpersonen TNO	Arjen Adriaanse (DM) en IJsbrand van Straalen (VPM)
Programma jaar 2027 - Samenvatting	
VP Duurzaam Bouwen richt zich op het optimaal verduurzamen van de gebouwde omgeving en van maritieme en offshore constructies. Dit betreft met name gebouwen, droge en natte kunstwerken, lijninfrastructuur, offshore en schepen. Maatschappelijk relevante thema's zijn daarbij CO₂-reductie, opschalen woningbouw, verminderen van de gasafhankelijkheid, betaalbaarheid, circulariteit, veiligheid, (voorspelbaarheid van) onderhoud en vervanging, en digitalisering. VP Duurzaam Bouwen bestaat uit vijf deelprogramma's: <u>Infrastructuur</u>, <u>Bouwinnovatie</u>, <u>Versnelling energietransitie gebouwde omgeving</u>, <u>Maritieme en offshore constructies</u> en <u>Klimaatadaptatie</u>.	
<u>Infrastructuur</u>	
Het deelprogramma <i>Infrastructuur</i> richt zich op het optimaliseren van het beheer en duurzaam vernieuwen van verouderende infrastructuur. Dit wordt bereikt door middel van levenscyclus-gericht beheer en levensduurverlenging, beheersing en reductie van risico's voor veiligheid en bruikbaarheid op zowel object- als portfolioniveau, en het stimuleren van duurzaam materiaalgebruik. De impact komt tot uiting in een beter beheersbare en betaalbare vervangings- en renovatieopgave, een effectievere planning en prioritering van ingrepen met minimale hinder voor bereikbaarheid, een versnelling van de transitie naar circulaire en klimaatneutrale infrastructuur, en een hogere productiviteit in de hele keten — zowel technisch als organisatorisch.	
De kennis die TNO hiervoor ontwikkelt, zorgt ervoor dat assetmanagers de beschikking krijgen over beslissingsondersteuningsmodellen, technieken en kaders voor het ontwerpen, inspecteren, beoordelen en beheer van diverse constructies - nieuw en bestaand; wegbouwkundig, droog en nat; van beton en staal- en voor de toepassing van circulaire en milieuvriendelijke materialen. Op het gebied van bewegingswerken wordt in 2027 het achtergronddocument opgesteld dat kan worden gebruikt voor een eventuele richtlijn voor de beoordeling van bestaande bewegingswerken, waarin alle kennis die afgelopen jaren is ontwikkeld, wordt meegenomen. Daarnaast worden ontwerp- en beoordelingsrichtlijnen ontwikkeld voor de toepassing van nieuwe betonsoorten op basis van alternatieve bindmiddelen, zoals geopolymerbeton. Voor asfalt wordt in 2027 ingezet op een groot Europees samenwerkingsproject (HorizonEurope MATTERS) waarin de focus ligt op betere voorspellingsmodellen voor duurzame bio-based asfaltverhardingen. Tot slot wordt ingezet op de ontwikkeling van beslissingsondersteuningsmodellen waarin gebruik wordt gemaakt van de gegevens uit de vele verschillende datasystemen (InfraScan) en op een methodiek waarmee eenvoudiger kan worden bepaald welke (betonnen) bruggen op een geïndustrialiseerde wijze kunnen worden vervangen (ProInfra). In 2027 wordt in samenwerking met stakeholders voor beide een pilot ontwikkeld.	
<u>Bouwinnovatie</u>	
Het deelprogramma <i>Bouwinnovatie</i> versnelt de transitie naar een circulaire bouweconomie, bevordert industrialisatie en garandeert veiligheid door innovaties te ontwikkelen voor bouwproducten, bouwelementen en gebouwen. Duurzaamheid, betaalbaarheid en grootschalige toepassing binnen de woning- en utiliteitsbouw staan daarbij centraal.	
In 2027 wordt onderzocht hoe hergebruik van bouwproducten en toepassing in bouwwerken beter kan worden opgenomen in regelgeving en praktijk. Binnen houtbouw en toepassing van biobased materialen ligt de focus op het verwijderen van metaal uit secundair hout en het bepalen van de reststerkte, het vaststellen van de levensduur van biobased isolatiemateriaal en de ontwikkeling van hennepsplanken. Ook wordt gewerkt aan optimalere ontwerp- en rekenmethoden, zoals het vastleggen van de invloed van vocht op de prestaties van biobased composieten en het ontwikkelen van geavanceerde rekenmethode om de constructieve veiligheid van kantoorgebouwen te beoordelen. Voor conceptuele en industriële bouw worden in 2027 bouwstenen voor digitale werkprocessen, procesmonitoring, automatische regelcontrole, simulatiemodellen, robotica en AI verder ontwikkeld en getest. Dit moet helpen om woningen en gebouwen sneller, slimmer en met minder verspilling te realiseren. Voor de verduurzaming van zorggebouwen richt het onderzoek zich op gezonde en duurzame gebouwen, met aandacht voor ontwerpqualiteit, ventilatie, warmtapwater, energiegebruik en netcongestie. Voor de veiligheid van gebouwen wordt gewerkt aan een risicomodel om de reactie van gebouwen op veranderingen van het grondwater- en bodemniveau vast te stellen. Daarnaast wordt een model ontwikkeld voor het berekenen van trillingen in	

hoogbouwhoutconstructies en de beoordeling van bestaande hoogbouwconstructies. Tevens worden voorstellen ontwikkeld voor het aanpassen van bestaande rekenregels om hergebruikte constructieve elementen en demontabele gebouwen veilig toe te kunnen passen.

Versnelling energietransitie gebouwde omgeving

Doel van het deelprogramma *Versnelling energietransitie gebouwde omgeving* is het versnellen van de verduurzaming van bestaande gebouwen door middel van integrale datagedreven oplossingen waarin installatie-, gebouw- en wijkniveau worden gekoppeld. Kwaliteit, betaalbaarheid en de behoeften van de gebruiker staan hierbij centraal. Op het gebied van *datagedreven diensten* worden in 2027 de resultaten verwacht van de praktijkvalidatie van de contingentenaanpak¹, wordt de contingentenaanpak ingezet om energiearmoede gericht aan te pakken en wordt gestart met het opzetten van een open dataplatform voor woningdata. Ten aanzien van *optimalisatie gebouwverduurzaming* wordt in 2027 de modelomgeving doorontwikkeld voor een breed scala aan verduurzamingsmaatregelen en uitgebreid met vochtmodellering en kwantificering van het flexibiliteitspotentieel in woningen. Tot slot wordt in 2027 op het gebied van *slimme warmtepompen* ingezet op het toepassen van het Autodoms model² voor verschillende praktijksituaties en wordt de meerwaarde van een grey-box model voor een lucht-water warmtepomp vastgesteld.

Maritieme en offshore constructies

Het deelprogramma *Maritieme en offshore constructies* draagt bij aan de ontwikkeling van veilige, betrouwbare en kostenefficiënte scheeps- en offshore constructies voor zowel bestaande als nieuwe assets. Dit vereist unieke kennisontwikkeling op het gebied van constructies onderhevig aan nieuwe belastingen (bijvoorbeeld cryogeen, corrosie, hitte), maar ook op het gebied van levensduurvoorspelling, monitoring en hergebruik van constructies en materialen. Dit om daarbij een circulaire economie mogelijk te maken en de strategische autonomie van de sector te borgen. TNO combineert laboratoriumonderzoek, praktijkmetingen en rekenmodellen om de veiligheid en kosteneffectiviteit van nieuwe oplossingen voor de groeiende maritieme en binnenvaart vloot op alternatieve brandstoffen aan te tonen. In 2027 ligt de focus op FastTrack2Approval, gericht op het verkorten van doorlooptijd en kosten voor het aantonen van de haalbaarheid en toepasbaarheid van alternatieve energiedragers. Data uit analyses, meetcampagnes voor veiligheid en regelgevingsstudies rond LNG, methanol, waterstof en nucleaire energie worden samengebracht in een dashboard. Daarnaast ontwikkelt TNO in 2027 een methodiek om monitoring en hergebruik van bestaande constructies te integreren in de ontwerp-, productie-, gebruiks- en recyclingfase van offshore constructies en schepen, gericht op optimaal asset value management. Met een contingentenaanpak worden de componenten met de grootste economische en circulaire meerwaarde geïdentificeerd. Verder ontwikkelt TNO samen met de offshore-windsector een eerste minimum viable concept om de impact van het stopzetten van windturbines (curtailment) en dynamische belasting van stroomkabels te verminderen door rekenefficiënte modellen te combineren met grootschalige validatietests.

Klimaatadaptatie

Het deelprogramma Klimaatadaptatie richt zich op een klimaatadaptieve gebouwde omgeving. Methoden en oplossingen worden ontwikkeld om de effecten van klimaatverandering op onze leefomgeving te beoordelen en zorg te dragen dat gebouwen, infrastructuur en de gebruikers ervan bestand zijn tegen extreme omstandigheden in de toekomst. Door TNO wordt ingezet op een klimaatrobuuste kritieke infrastructuur, een bebouwde omgeving waarin gebouwen bestand zijn tegen schade als gevolg van veranderingen in grondwater en ondergrond en aan het voorkomen van een ongezond binnenmilieu als gevolg van veranderingen in het klimaat. In 2027 wordt een geïntegreerde modelleringsworkflow ontwikkeld en geïmplementeerd voor het evalueren van de veerkracht van de bestaande transportinfrastructuur en het beoordelen van de effectiviteit van geselecteerde mobiliteits- en infrastructuuradaptatiemaatregelen. Daarnaast wordt een geteste en op onderdelen gevalideerde versie van het risicobeoordelingsgereedschap voor de effecten van grondwater en ondergrond ontwikkeld, mede gefinancierd uit externe programmafinanciering. Een demonstratie van geïntegreerde oplossingen en beslisondersteuning wordt uitgewerkt om hitte-, vocht- en schimmelrisico's in woningen en zorggebouwen meetbaar, voorspelbaar en beheersbaar te maken, als stap naar grootschalige toepassing en verankering in beleid en standaarden.

¹ <https://www.tno.nl/nl/newsroom/insights/2024/11/contingentenaanpak-bewijst-effectiviteit/>

² <https://ventures.tno.nl/portfolio/autodoms/>

Titel	VP Smart and Sustainable Mobility (P407)
MIB Thema	Water Klimaatadaptatie en Maritiem / Missie D+ (MMIP 9 & 10; deel-KIA Toekomstbestendige Mobiliteitssystemen)
Contactpersonen TNO (DS en VPM)	Arjen Adriaanse (Director of Science & Technology); Marika Hoedemaeker (VP-manager)
Programma jaar 2027 - Samenvatting	
The demand driven programme (VP) Smart and Sustainable Mobility is dedicated to advance innovation and knowledge in smart technology and policy solutions. Its primary goal is to enhance the safety, sustainability, and efficiency of the mobility and logistics sector. This involves significant challenges in improving road safety and enhancing efficiency of mobility and logistics, while simultaneously innovating for a sustainable and climate neutral mobility system with very low to zero emissions in traffic and transport, powered by renewable energy. We do this by dividing our work into four focus areas: 1) Liveable and Resilient Cities and Regions, 2) Safe and Efficient Mobility, 3) Sustainable Mobility and 4) Green Maritime Performance. In 2027 strategic portfolio management will remain a key focus, with decisions being taken on both the discontinuation of activities and the development of new initiatives. For example, we will stop investing in the Charge Planning Tool, since it is ready to be licensed to logistics service providers and carriers. At the same time extra investments will go to emissions of tyre and brake wear and emissions from inland and maritime shipping. Another example is the discontinuation of the research into the impact of electrification of mobility on grid congestion, which has resulted in tooling that is ready to be used but which currently has low market traction for addressing this from the wider mobility system perspective.	
The focus area of Liveable and Resilient Cities and Regions carries out research aimed at providing tools and methods for better and faster decision and policy making for more sustainable, resilient, safe and accessible cities and regions for all, where residents, visitors and businesses function optimally. Cities and regions today face a complex set of interrelated challenges, and to address their challenges our research focuses on three main technology and method lines. In the first line, <i>Understanding and interpreting the mobility and spatial system</i>, we use systems thinking, a broad prosperity perspective and mental model knowledge to address barriers in policy and decision-making. Research in 2027 will investigate how combined interventions such as mobility hubs, shared mobility, car-low neighbourhoods and automated driving contribute to mobility transition goals. This helps governments identify effective intervention packages and understand their systemic impacts before implementation. In spatial research, knowledge graphs are developed, linking spatial interventions, impacts and suitability criteria. This enables policymakers to identify synergies and trade-offs, and to select locations where interventions such as mobility hubs, water storage or public amenities deliver the greatest value. In the second line, <i>Modelling (Predictive Digital Twins)</i>, our Large-scale Agent-Based Simulator (LABS) research advances detailed simulation capabilities that represent the combined effects of multiple mobility and spatial interventions. This improves understanding of complex system dynamics and supports governments and businesses in making more robust mobility and spatial planning decisions. In 2027, we will demonstrate the added value of LABS as compared to traditional transport models. In the third line, <i>AI-based design and optimisation incl. scenario generation (prescriptive Digital Twins)</i>, we work towards generating optimised urban designs to increase the pace and quality of transformations. In 2027, we will develop AI methods that extract and structure knowledge from policy documents, linking interventions to policy ambitions to identify synergies, co-benefits and cross-domain opportunities. In parallel, optimisation methods are developed that translate stakeholder preferences into decision criteria and incorporate equity considerations. This supports balanced decisions that improve mobility and spatial outcomes while explicitly considering equity, sustainability and system-wide impacts.	
The Safe and Efficient Mobility focus area develops technologies, methodologies, and governance concepts for safer, smarter, more efficient passenger and freight transport. The research combines advances in self-organising logistics, safety assurance of emerging transport innovations, and automated vehicle technologies.	
For the Self-Organizing Logistics topic, we develop decentralized planning concepts, secure data-sharing solutions, and trusted business models that enable asset sharing across organizations. By validating and extending these solutions next year in container transport, defence -, agricultural -, and city/construction logistics, we aim to improve efficiency, resilience, and sustainability while addressing challenges related to emissions, supply chain security, and scarce resources.	

For the Safe Introduction of New Transport Innovations topic, we develop efficient safety assessment methods for increasingly AI-driven transport systems. In 2027, a key focus is the assessment of end-to-end AI-based automated driving systems through the combination of AI and interpretable safety guardrails. We also explore AI-supported identification and generation of traffic scenarios to strengthen safety validation and testing for both industry and governments.

For the Development of Solutions for Automated Vehicles topic, we develop the core technologies required for safe, trustworthy, and scalable automation. Central to this work is, coming year, a Safety Shell for Software-Defined Vehicles, providing monitoring, redundancy, and safe fallback mechanisms for AI-driven driving functions. Research focuses on connected perception, context-aware driving, resilient system architectures, and methodologies that support the large-scale deployment of Connected Automated Transport in logistics.

Together, these activities contribute to future mobility systems in which logistics networks become more collaborative, automated vehicles operate safely and reliably in complex environments, and transport innovations can be deployed responsibly at scale.

For the area of **Sustainable Mobility**, there is a clear urgency for action. In the EU, transport accounts for around a quarter of total greenhouse gas emissions, with road transport responsible for the largest share. Achieving both international and national climate change objectives requires a fundamental transition of the mobility system. We provide in-depth knowledge, technological solutions, model-based development tools, advanced monitoring and testing facilities to support society, governments and industry to accelerate the transition towards a climate neutral and ultra-low polluting mobility system.

Towards 2030, we support a) industry in developing competitive low-emission technologies with a focus on battery electric propulsion and sustainable fuel engines, b) governments by providing evidence-based policy support with techno-economic assessments and real-world emission and energy performance data offering insights that lead to well informed decisions. As an example, in 2027 we aim to apply a TNO developed framework for agent-based models to assess strategies for future-proof charging infrastructure roll-out. Given the scarcity of capacity on the electricity grid and increasing demand for electricity, it is essential to develop future-proof charging infrastructure roll-out strategies and agent-based models to forecast future demand. In 2027, we will also calibrate and demonstrate with various project partners in CIMBATT our extended battery Remaining-Useful-Life estimation algorithms for maritime, truck and non-road mobile machinery applications.

In the area of **Green Maritime Performance**, we aim to remove technical and policy barriers that hold back the maritime energy transition by creating and validating sustainable solutions. To enable the national and global IMO ambition towards climate neutral shipping by 2050, towards 2030 we focus on four key areas: a) development of a validated emission model for Europe wide implementation and scenario building; b) co-development of hybrid methanol ICE powertrain, including energy management approach to optimize the use of batteries onboard based upon maritime energy operational profile; c) development of a full scale carbon capture pilot system towards a first real life permanent installation on board; and d) the development of qualitative and quantitative transition monitor to assess the impact of technology and policy development.

In 2027 we focus on a) measurement of emissions on current vessels (e.g., NOx emissions on diesel fuelled ships and methane slip (CH₄) on LNG ships) and development of standards for measuring emissions from alternative fuels while co-developing regulation (e.g. formaldehyde in methanol engines). b) applying full scale engine tests for pre-commissioning methanol ICE powertrains up to 1.4MW, and up to 800KW battery power including shore power and charging. c) maturing our carbon capture towards a licensable carbon capture control approach. Finally, d) we will develop a maritime energy transition monitor with the ministry of Infrastructure and water management, with a central focus on electrification for 2027 (both shore power and charging).

Titel	VP Luchtkwaliteit (P510)
MIB Thema	Klimaat en Energie
Contactpersonen TNO (SD en VPM)	Bas Henzing (VPM), Kemo Agovic (Division Director EMT Systems Solutions & Environment)
Programma jaar 2027 - Samenvatting	
Anyone following the news will recognize that the Netherlands continues to face significant challenges related to air pollution, climate change, nitrogen emissions, and biodiversity loss. Governments, businesses, and society need reliable information to understand emission sources, how they affect people and nature, and how environmental goals can be balanced with societal and economic development. This is the basis for informed decisions, effective policy design, permitting processes, and responsible economic activities within environmental boundaries. In the VP Air Quality, innovative measurement, modelling, and data-analysis capabilities are developed to support evidence-based decision-making on these important topics. Working closely with ministries, regional authorities, knowledge institutes, and European partners, TNO integrates a broad range of technologies into practical solutions. By 2030, the program aims to provide a knowledge infrastructure that enables independent verification of emissions, health-oriented air quality management, effective nitrogen reduction strategies, and integrated monitoring of biodiversity and ecosystem recovery. Intended key results for 2027: – Tooling to support the implementation of the revised Ambient Air Quality Directive (AAQD) by national ministries, provinces, environmental agencies and municipalities, with a focus on local scale, source specific monitoring and an upgrade of source attribution capabilities. – Robust attribution of health-relevant air quality indicators, such as ultrafine particles (UFP), oxidative potential (OP) and chemical composition to source-specific emissions, enabling a source-oriented assessment of health impacts and supporting targeted mitigation strategies, for example for essential industries with high emission risks (e.g. recycling, steel). – Enhanced independent verification of greenhouse gas emissions by combining atmospheric measurements, emission inventories and modelling, strengthening evidence-based evaluation of climate policies and emission reduction measures. – Hydrogen emission monitoring and source-attribution capabilities, with initial focus on industrial clusters and hydrogen production sites, but also agriculture. – Improved quantification and monitoring of nitrogen emissions, concentrations and deposition, supporting regional and local nitrogen reduction strategies and enabling effective progress towards resolving the nitrogen crisis. – Demonstration of airborne eDNA-based biodiversity monitoring to assess ecosystem recovery and nature restoration impacts. – Demonstration of AI-driven workflows that reduce analysis and modelling effort, improve source attribution accuracy, and accelerate policy assessments. Success will be demonstrated through at least three applied use cases in air quality, greenhouse gases, nitrogen or biodiversity monitoring.	

Titel	VP Circulaire Economie (P515)
MIB Thema	Circulaire Economie
Contactpersonen TNO (DM/SD en VPM)	Erlend Deckers (VPM), Kemo Agovic (Division Director EMT Systems Solutions & Environment)
Programma jaar 2027 - Samenvatting	
Growing demand, concentrated supply chains and geopolitical dependencies are increasing vulnerability of Dutch and European industry, particularly for critical raw materials needed for the energy transition and other strategic technologies. A circular economy can reduce both vulnerabilities and associated environmental impacts by limiting primary raw material use, retaining the value of products and components, and recovering materials for high value applications. Circularity can thereby strengthen value chain resilience, strategic autonomy and industrial competitiveness while reducing material-related environmental pressures. Realizing this potential requires an integrated understanding of material use and value chains, because the effectiveness of circular strategies depends on product and material characteristics, supply and demand developments, (inter)national value chain configurations and technical and economic feasibility. The knowledge and innovation challenge is to evaluate these strategies, translate them into practicable value chain interventions, and develop technologies for sustainable (critical raw) material recovery. An integrated approach helps prevent improvements in one part of the value chain from creating environmental impacts or material dependencies elsewhere. It also reveals the technical, economic and institutional barriers that must be addressed and provides evidence for targeted interventions and policy advice. Within VP515, the Circular Strategies & Critical Raw Materials (CS&CRM) program addresses this challenge through three reinforcing research lines. Line 1, Integrated Assessment Methods (IAM) combines material flow analysis, socio-environmental impacts, criticality, and economic performance, to evaluate circular strategies across full value chains and to improve the feasibility, enhance the performance, and de-risk circular strategies across full value chains, covering all R-strategies. Line 2, Circular Value Chains (CVC) translates such insights into viable end-of-life strategies by modelling material flows and recycling operations, and by assessing consumer behavior, economic incentives and policy interventions. Line 3, Sustainable Recycling Technologies (SRT) develops and scales sustainable and resource-efficient recycling processes for recovering critical raw materials from complex waste streams at a quality suitable for renewed use in high-end applications. Together, these research lines determine which circular strategies are environmentally effective and economically viable, how the required value chains can be organized, and which technologies are needed for implementation. This integrated approach provides governments and industry with concrete strategies, decision support tools and recycling technologies for more resilient and circular critical raw material value chains. VP515 contributes to the National Program for a Circular Economy (NPCE 2025), the National Raw Materials Strategy (Grondstoffenstrategie 2022) and the EU Critical Raw Materials Act (EU CRMA), and supports the KIA Circular Economy (KIA CE) and KIA Key Enabling Technologies (KIA ST). The program provides integrated assessment methods, value chain strategies and recycling technologies for priority product groups (ICER 2023), including the manufacturing industry, energy technologies and the built environment, and supports implementation of the associated product group roadmaps. In 2027, we will operationalize and finetune MIST (Materials Intelligence for Sustainable Transitions) and FIESTA (Fast and Insightful Environmental Sensitivity Technology Analysis) as integrated assessment and CRM decision-support frameworks to the actual needs of the Dutch/European market. We will apply of state-of-the-art AI techniques to enhance and multiply our portfolio of innovative decision-support tools, while using these techniques responsibly and proportionately to their added value. Within CVC, we will deliver the first operational version of the Delphi tool (recycling strategy tool) that will include physical process and cost modelling, and we will extend our prospective analysis of recycling value chains in the Netherlands beyond the use case of lithium-ion batteries. Within SRT, we will demonstrate our patented electro-leaching process for Li-ion battery recycling and circular PV recycling process at TRL 4-5, and develop a rare earth magnet recycling process step at TRL 3.	

Titel	VP Future of Work (P204)
MIB Thema	Gezondheid en Zorg
Contactpersonen TNO	Seth van den Bossche (DM a.i.), Jeremy

Programma jaar 2027 - Samenvatting

VP Future of Work addresses the pressing challenges of slowing productivity growth and structural labour-market mismatches and shortages across Europe and the Netherlands. The programme focuses on innovations that can strengthen sustainable labour productivity, accelerate the adoption of innovation—particularly human-centric AI—and improve labour-market adaptability. It also aims to support healthy, safe and high-quality working environments. A productive, resilient and adaptable labour market, offering high-quality jobs, is essential to strengthening competitiveness and prosperity while enabling the major societal transitions facing the Netherlands and the European Union.

The programme serves the current and potential workforce, employers, government bodies, and HR and occupational safety and health professionals. Its work is organised around four interconnected knowledge lines: adaptive and productive organisations; labour-market innovation; healthy and sustainable work; and Safe and Sustainable by Design, including safe chemical innovation.

For the 2026–2029 period, VP Future of Work will accelerate the adoption of human-centric AI and digital technologies that support productivity, learning, sustainable employability and responsible innovation. It will contribute to a skills-based labour market through skills intelligence, matching, validation and data-driven labour-market innovation. The programme will also improve labour productivity, organisational adaptability and innovation uptake through ecosystem-based approaches, workplace innovation and robust productivity assessment methods. In parallel, it will advance healthy, safe and sustainable work through data-driven monitoring, integrated risk assessment and the responsible implementation of AI and digital technologies. A dedicated focus will further strengthen Safe and Sustainable by Design methodologies, Next Generation Risk Assessment approaches and AI-assisted assessment capabilities for responsible chemical and material innovation.

In 2027, VP Future of Work will build on the 2026 KIP-projects, research and partnerships to deliver validated methods, demonstrators and practical tools across its four programme lines. The results will be prepared for implementation, scaling and valorisation with industry, government and societal partners.

The VP Future of Work directly addresses the following societal transitions, key technologies and strategic agenda's:

Major Societal Transitions	Key Technologies ³
Digital Transition Energy Transition Health Transition	Digital and information technologies: • AI • Data science, data analytics and dataspace • Digital Twinning and Immersive technologies Engineering and fabrication technologies: • Sensor and actuator technologies • Robotics • Digital Manufacturing technologies
National Technology Strategy ⁴	Thematic KIA
Artificial Intelligence and Data Productivity enhancement	Health and Care & Public Earning Capacity Digitalization Climate and Energy Safety and security
(Inter)national Agendas and Roadmaps	Strategic Program Plans

³ https://www.tno.nl/publish/pages/8843/tno_herijking_sleuteltechnologie_2023_v4.pdf

⁴ [De Nationale Technologiestrategie | Titel uitgave \(overheid.nl\)](#)

[European Commission-The future of European competitiveness](#)
[EU Quality Jobs Roadmap](#)
[European Commission-European Skills Agenda](#)
[Strategic knowledge Agenda SZW](#)
[Mission Health & Care](#) / Strategic knowledge agenda VWS / [AZWA](#)
[Productivity agenda NL](#)
[Human Capital Agenda Top sectors](#)
[Action plan green & digital jobs](#)

LSH
HTSM
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Titel	VP Biomedical and Digital Health: Future of Health (P203)
MIB Thema	Gezondheid en Zorg
Contactpersonen TNO	Jasper Kieboom (VPM), Marc Zegveld (MD a.i.)

Programma jaar 2027 - Samenvatting

The Future of Health research programme supports the mission-driven innovation policy of the Dutch Ministry of Health, Welfare and Sport (VWS). It contributes to the central mission of increasing healthy life expectancy and reducing health inequalities. The programme advances prevention, healthy living environments and participation of people with chronic conditions or disabilities in society. In addition, TNO contributes to enabling care closer to people's daily lives through self-management, home-based and digital solutions, improving quality of life for people with dementia, and strengthening resilience against health threats. Across all missions, reducing pressure on the healthcare workforce through technological and social innovation is a key goal, creating synergies with TNO's Future of Work research programme.

We do this by reducing the risk of disease development (prevention) and by helping to manage disease by developing ground-breaking technologies and approaches such as lifestyle interventions, digital health technologies and drug development. The research program Future of Health significantly contributes to the three moonshots of TNO illustrated below:



To help achieve the moonshots, newly developed technologies and knowledge will be implemented in the context of the quadruple helix that includes collaborations with other research programs, academic and industrial partners, health professionals in field labs, healthcare insurance companies, governmental and local policy makers, and citizens to provide systems solutions. The research is conducted in public-private consortia and used in projects with industry (e.g. in services for industry and growth fund projects).

To contribute to above missions and moonshots the Future of Health Program is organised in three propositions Efficient Drug Discovery, Health & Lifestyle and Youth Health. The main short-term results for 2027 are:

for the proposition **Efficient Drug Development**:

1. Establishment and commercialisation of an integrated gut-liver platform that improves prediction of oral drug absorption, metabolism and tissue exposure in humans using TNO's multi-organ assay plate.
2. Further development of integrated metabolic flux and systems biology approaches in preclinical and clinical studies that offer predictive insight into drug responses and support data-driven decision making for pharmaceutical and biotech industry.
3. Extending our cardiometabolic kidney disease model with pulmonary hypertension readouts to better capture the complex interplay between metabolic, renal and pulmonary vascular disease demanded for development of therapeutic intervention.

for the proposition **Health and Lifestyle**:

4. Validated biomarkers, predictive models and mechanistic insights that improve understanding of health and disease trajectories and enable earlier identification of risk and intervention opportunities.
5. New and improved lifestyle, digital and AI-supported interventions co-developed with stakeholders and showed to support health, resilience, participation and prevention in relevant target populations.

6. Demonstrated real-world applicability of digital health and AI innovations, including evidence of effectiveness, safety, user acceptance and potential to support healthcare professionals and preventive care delivery

for the proposition **Youth Health**:

7. Development and implementation of new or improved evidence-based integrated health prevention and care approaches that give every child the best possible start in life, with a specific focus on the first 1000 days, healthy weight, mental health and reducing health inequalities via tailoring strategies
8. Valorisation, implementation and scaling of proven innovations, including the D-score, the I-JGZ platform and methodologies such as the LISO and IDEAS framework, enabling professionals, municipalities and care organisations to make better use of evidence-based prevention and support and optimize the quality of adoption and usage of innovations.
9. Strengthening collaboration between research, policy and practice through public-private partnerships, knowledge workplaces and the TNO Open Lab, accelerating societal impact and implementation

Titel	VP Defence Technology Industrial Base (P104)				
MIB Thema	Veiligheid				
Contactpersonen TNO	Marcel van der Graaf (VPM), Christa Hooijer (Director S&T)				
Programma jaar 2027 - Samenvatting					
The geopolitical and security landscape continues to change fundamentally. Rising geopolitical tensions, increasing strategic competition, the growing importance of technological sovereignty, and the commitment of European nations to substantially increase defence investments create both an urgent security imperative and a significant economic opportunity for the Netherlands. In this context, a strong and innovative Dutch Defence Technological and Industrial Base (NLDTIB) is essential to safeguard national security, strengthen European resilience, and create sustainable earning capacity. P104 ‘Defence Technologies Industrial Base’ contributes to these objectives by developing, maturing and valorising strategically relevant technologies that support both operational defence capabilities as well as the long-term competitiveness of Dutch industry. The programme focuses on technology domains in which the Netherlands can establish or maintain a distinctive position through a combination of scientific excellence, industrial relevance and effective public-private cooperation. Activities are selected based on their contribution to national strategic interests, the availability of a clear right-to-play for TNO and the Netherlands, and their potential to generate societal, operational and economic impact.					
Societal					
Enablers					
Capabilities					
Knowledge base					
<i>The propositions of TNO DSS towards the ministry of Defence and defence industry</i> The programme contributes directly to the TNO Defence, Safety & Security propositions Integrated Air and Missile Defence, Sustained Firepower, Effective Autonomous Capabilities, Military Use of Space, Maritime Security & Defence, Surviving on the Battlefield of the Future, and Warfighting Capable. In 2027 P104 will develop, technologies, critical building blocks, experimental facilities, and demonstrators for advanced sensors, weapon systems, command and control (C2), resilient manufacturing, autonomy of systems, and protection. These developments support applications across the land, maritime, air, and space domains. For example, a Closed-loop radar test facility, a Quantum based Positioning Navigation and Timing solution, and a Mobile production unit for energetic materials.					

Titel	VP Veilige Maatschappij (P102)
MIB Thema	Veiligheid
Contactpersonen TNO	Gwen Jansen-Ferdinandus en Lili Bannenberg (VPM), Christa Hooijer (Director S&T)
Programma jaar 2027 - Samenvatting	
Nederland staat voor complexere veiligheidsvraagstukken die worden gekenmerkt door toenemende maatschappelijke druk, snelle technologische ontwikkelingen, groeiende informatievolumes en aanhoudende capaciteitsuitdagingen. Het Vraaggestuurd Programma Veilige Maatschappij (VPVM) ontwikkelt kennis, methoden en technologieën die organisaties binnen het justitie- en veiligheidsdomein ondersteunen bij het versterken van een veilige, weerbare en toekomstbestendige samenleving.	
Voor de periode 2027-2030 richt het VPVM zich op drie samenhangende doelstellingen:	
1. <i>Doorbraak in capaciteitsvraagstukken: systeemgerichte innovaties voor toekomstbestendige operationele slagkracht</i> Veiligheidsorganisaties staan voor een groeiende druk op personeel, middelen, infrastructuur en ketencapaciteit. Capaciteitsvraagstukken vragen daarom om meer dan oplossingen voor alleen personele schaarste. VPVM ontwikkelt kennis over hoe mensen, middelen, processen, informatie en technologie in samenhang kunnen worden georganiseerd om de operationele slagkracht duurzaam te vergroten. Daarbij wordt nadrukkelijk gekeken naar arbeidsextensivering, strategische capaciteitssturing, nieuwe samenwerkingsvormen, ketenoptimalisatie en technologie als capaciteitsversterker.	
2. <i>Effectieve besluitvorming onder druk: slimme sturing in complexe veiligheidsvraagstukken</i> Besluitvormers moeten steeds vaker besluiten nemen onder tijdsdruk, met onvolledige informatie en in complexe bestuurlijke netwerken. VPVM ontwikkelt beslissondersteunende methoden en instrumenten die besluitvormers zowel op operationeel als strategisch niveau ondersteunen.	
3. <i>Technologie onder controle: strategisch omgaan met kansen en dreigingen van geavanceerde systemen</i> Nieuwe technologieën bieden kansen voor het veiligheidsdomein, maar creëren tegelijkertijd nieuwe kwetsbaarheden, afhankelijkheden en dreigingen. VPVM helpt veiligheidsorganisaties om geavanceerde technologieën verantwoord te benutten én zich te beschermen tegen ongewenste toepassingen daarvan door kwaadwillenden	
Deze strategische doelstellingen worden de komende jaren gerealiseerd door middel van vier kennis- en technologieënlijnen:	
1. <i>General Purpose Artificial Intelligence (GPAI) voor het justitie- en veiligheidsdomein</i> VPVM bouwt aan een JenV-brede kennisbasis voor de veilige en verantwoorde inzet van generatieve en agentie AI. In 2030 beschikken veiligheidspartners over een gezamenlijke test- en ontwikkelomgeving, gedeelde AI-bouwblokken en interoperable AI-agents die professionals ondersteunen bij analyse, informatieverwerking en besluitvorming. Hiermee wordt kennisdeling tussen ketenpartners versneld en kan de meerwaarde van AI sneller worden vertaald naar de operationele praktijk. Om dit te bereiken wordt in 2027 gewerkt aan een generieke experimenteermilieu voor AI-agents en de doorontwikkeling van toepassingen voor concrete veiligheidsvraagstukken binnen het JenV-domein.	
2. <i>Countertechnologie</i> Richt zich op het herkennen, begrijpen en tegengaan van dreigingen die voortkomen uit nieuwe technologieën, hierbij ligt voor nu de focus op drones maar er is ruimte om in de toekomst andere technologieën te verkennen. In 2030 beschikken veiligheidspartners over handelingsperspectieven, technologieën en organisatorische werkwijzen om dergelijke dreigingen effectief te beheersen. In 2027 wordt er een stap in deze richting gezet door de nadruk te leggen op de verdere ontwikkeling en beproefing van counterdroneconcepten voor operationele inzet in complexe en verstedelijkte omgevingen.	
3. <i>Systeemanalyse</i> Ontwikkelt methodieken, modellen en simulaties waarmee complexe veiligheidsvraagstukken beter kunnen worden begrepen en beleidskeuzes beter kunnen worden onderbouwd. Het doel voor 2030 is dat systeemdynamisch denken en werken een vast onderdeel vormt van beleidsontwikkeling en strategische besluitvorming binnen het veiligheidsdomein. Om systeemanalyse duurzaam te verankeren binnen beleidsontwikkeling en strategische besluitvorming wordt in 2027 geïnvesteerd in de verdere ontwikkeling van systeemanalytische methodieken, de integratie van AI en	

de ontwikkeling van simulatiemodellen. Hierbij worden onder andere use cases opgepakt m.b.t. National Risk Assessments en een simulatiemodel als beslisondersteunende tool voor strategische besluitvorming over capaciteit in het gevangeniswezen.

4. *Geavanceerde technologie voor opsporing*

Ontwikkelt innovatieve gegevens-, sensor- en analysetechnologieën waarmee menselijke expertise en data beter kunnen worden gecombineerd ter ondersteuning van opsporing, toezicht en interventies. In 2030 wordt beoogd dat deze technologieën aantoonbaar bijdragen aan effectievere en efficiëntere veiligheidsprocessen. Om deze ambitie te realiseren worden in 2027 geavanceerde sensoren en analysetechnologieën verder ontwikkeld en beproefd om de informatiepositie en operationele slagkracht van veiligheidsorganisaties te versterken.

De vier kennis- en technologielijnen versterken elkaar en vormen gezamenlijk het instrumentarium waarmee het VPVM invulling geeft aan de drie strategische doelstellingen. GPAI, systeemanalyse en geavanceerde technologie voor opsporing ondersteunen veiligheidsorganisaties bij het vergroten van hun operationele slagkracht en besluitvormingsvermogen, terwijl GPAI en countertechnologie bijdragen aan het verantwoord benutten en beheersen van geavanceerde technologieën.

Titel	VP Weerbaarheid (P108)
MIB Thema	Veiligheid
Contactpersonen TNO	Gwen Jansen-Ferdinandus (VPM), Christa Hooijer (DS&T)
Programma jaar 2027 - Samenvatting	
De Nederlandse samenleving staat voor een nieuwe veiligheidsrealiteit. Hybride dreigingen, sabotage, online beïnvloeding, economische ontwrichting en militaire spanningen raken niet alleen Defensie en de overheid, maar ook bedrijven, vitale infrastructuur en burgers. Dit vraagt om een weerbare samenleving die voorbereid is op grootschalige verstoringen. De <i>Rijksbrede Weerbaarheidsopgave</i>⁵, de wet Weerbaarheid kritieke entiteiten en de Cyberbeveiligingswet markeren de eerste stappen in het duiden van de opgave die Nederland hierin heeft. Met het Vraaggestuurde Programma (VP) Weerbaarheid draagt TNO bij aan de transitie naar een weerbare samenleving. Op basis van de prioriteiten uit de Rijksbrede Weerbaarheidsopgave en de expertise van TNO is gekozen voor een focus op drie samenhangende doelstellingen: 1) het versterken van de weerbaarheid van kritieke infrastructuur, 2) het herkennen en tegengaan van <i>foreign information manipulation and interference</i> (FIMI) en 3) het strategisch omgaan met schaarste in tijden van crisis en conflict. Hiermee draagt het VP Weerbaarheid bij aan de TNO-propositie <i>Comprehensive Societal Resilience</i>. <i>1. Versterken van de weerbaarheid van kritieke infrastructuur</i> Het VP Weerbaarheid versterkt de weerbaarheid van kritieke infrastructuur door kritieke entiteiten beter in staat te stellen dreigingen en verstoringen vroegtijdig te herkennen, onderbouwd te handelen en sneller te herstellen. Richting 2030 ontwikkelt TNO hiervoor samen met de overheid en kritieke entiteiten schaalbare detectie-, analyse- en interventieconcepten. De focus ligt op bescherming tegen ongewenste drones, het versterken van operational technology (OT) en het beter begrijpen van ketenafhankelijkheden, onder meer in energie- en infrastructuursystemen. In 2027 levert het programma concrete bouwstenen op voor een landelijk stelsel voor counter-drone bescherming van geselecteerde infrastructuur, inclusief inzicht in benodigde technologie, informatie-uitwisseling, rollen en randvoorwaarden. Daarnaast wordt een innovatie-ecosysteem voor OT-weerbaarheid ingericht waarbij oplossingsrichtingen voor verschillende use cases in kort-cyclische innovatiesprints worden beproefd. <i>2. Herkennen en tegengaan van foreign information manipulation and interference</i> In het VP Weerbaarheid wordt gewerkt aan het ontwikkelen van (A) analyse-capaciteit m.b.t. beïnvloeding in de online informatieomgeving in het kader van strategische veiligheidsstukken en (B) effectieve weerbaarheidsinterventies tegen beïnvloedingscampagnes. In 2027 ontwikkelen we een gestandaardiseerde onderzoeksmethode voor systematische en AI-gedreven detectie en analyse van beïnvloedingscampagnes in de online informatieomgeving. We tonen aan waar simulatiemodellen meerwaarde bieden voor het verdiepen van ons begrip van beïnvloedingscampagnes, voor opleidings- en trainingsdoeleinden en voor het vooraf inschatten van de effectiviteit van weerbaarheidsinterventies. Tot slot werken we verder aan het ontwikkelen van interventies gericht op het versterken van de weerbaarheid tegen beïnvloedingscampagnes, en tonen we de effectiviteit van deze interventies in praktijktoepassingen aan. <i>3. Strategisch omgaan met schaarste</i> Het VP Weerbaarheid helpt Nederland om beter voorbereid te zijn op schaarste aan mensen, middelen en capaciteit die kan ontstaan in (aanloop naar) crises en conflicten. Richting 2030 ontwikkelt TNO samen met overheid, bedrijven en kritieke sectoren methoden om proactief zicht te krijgen op potentiële knelpunten én inzicht in de mogelijke interventies en hun gevolgen. Daarvoor modelleren we keteneffecten en control-points binnen deze ketens om de effecten van keuzes	

⁵ [Weerbaarheidsopgave | Publicatie | Nationaal Coördinator Terrorismebestrijding en Veiligheid](#) - Publicatie opgesteld door de Rijksoverheid. Onder coördinatie van de Nationaal Coördinator Terrorismebestrijding en Veiligheid (NCTV) en het ministerie van Defensie

inzichtelijk te maken. Zo stelt het VP beleids- en besluitvormers in staat om onderbouwde keuzes te maken over de verdeling en prioritering van mensen en middelen, zowel in de koude als de warme fase van crisis. In 2027 wordt de ontwikkelde methode voor het verkennen van toekomstige schaarste gevalideerd in minimaal twee praktijkcasussen. Ook worden inzichten uit afwegingskaders vertaald naar toepasbare handvatten voor organisaties die hun continuïteit onder druk moeten waarborgen.

Titel	VP Space & Scientific Instrumentation (P607)
MIB Thema	Sleuteltechnologieën
Contactpersonen TNO	Kees Buijsrogge, Ton Marée
Programma jaar 2027 - Samenvatting	
Our multi-annual R&D program 2027 - 2030 supports our ambition to contribute to preventing climate change and air pollution, enable secure broadband connectivity, help understanding the Universe, and stimulate economic growth in the Netherlands and Europe, making this all happen in a sustainable way. Therefore, we organize the VP along program lines directly connected to this ambition; Instruments for Earth Observation and related Space Data Utilization, technologies for Satellite Communication, and Scientific Instrumentation focusing on instruments for Ground Based Astronomy, Space Based Astronomy, Big Science and Diagnostics for Fusion Energy, and system development for Space Safety and Sustainability including In-Orbit-Servicing to extend the lifetime of satellites and their payloads. Our main objective in the area of Earth Observation and Space Data Utilization is to maintain and strengthen the Dutch position with regard to monitoring the composition of the Earth's atmosphere. We want to contribute to help monitor the Paris agreement and give detailed insight in emissions and spread of air pollutants and greenhouse gases. We have the long-term goal for in-orbit-demonstration of a small and very accurate instrument with related downstream models, specifically focused on measurement of greenhouse gases and air pollution. In addition to the instrument, given the focus in the commercial EO market on information products, we will work on the development of data processing methods that can enable global information services that provide actionable information to decision makers in governments. Our goal for 2027 and beyond is a next (after TANGO) Dutch small satellite instrument that will measure emissions (like NO₂, CH₄, CO, SO₂, aerosols) with a very high accuracy. Long-term development will focus on the measurement in Thermal Infrared (TIR) (NH₃, N₂O) and on Volatile Organic Compounds (VOC's). We will work on improving our LOTOS-EUROS and TOPAS models by including more air quality trace gases and CH₄. In the domain of Satellite Communication our aim is to develop state-of-the-art optical terminals for ground, air, drone and space usage for the value chain of global satcom providers. We follow four main use cases: Secure & Robust Comms for worldwide Mobile Security Operations; Cyber Proof/Quantum Resilient Comms over Ground Networks for Secure Connectivity; Ultra-High-Speed Global Secure Connectivity Network (constellations); Data Relay for Earth & Space Sciences from (deep) Space. Furthermore, TNO started in 2024 to intensify investments in quantum communication (QKD networks) and internet enabled by space nodes. Each of these use cases have their own timeline of development, where the first laser satcom constellations are in industrial development right now, but deep Space data relay using laser satcom is foreseen to be further away in the future. We will work on our four main drivers; fast, secure, multi-point and far communication. For fast communication the long-term goal is ultra-high data throughput of 10 Tbit/s feeder link to a GEO- or MEO-satellite. Secure communication focusses on links with ultimate protection, suitable for the quantum era with a long-term target of a Quantum Key Distribution service with satellite nodes, which is resilient to hacking attacks. Multi-point communication facilitates simultaneous communication with multiple senders and receivers with a long-term target of a multi-beam optical space terminal in orbit, receiving data from various nodes (space, aerial, naval) and transmitting towards multiple users. With far communication TNO looks at data links over very long distances with a long-term target of a link to a deep space science mission, such as a planetary or asteroid mission. These various use cases provide a very promising opportunity for Dutch industry to extend its space-related activities into a commercial market: in this development we will position Dutch high-tech companies as potential suppliers for the terminals and their subsystems based on user requirements from this market. We intend to strengthen our position with regard to developing high-grade instruments to perform world-class science, both in space and on ground. For this, we work together with universities and scientific institutes. In the realization of the instrumentation we involve industry where possible. For each subdomain (Ground Based Astronomy, Space Based Astronomy, Scientific Instrumentation), we have a specific focus. Our long-term goal for Ground Based Astronomy is to contribute to the development of the KECK telescope optics with a 1,4 m secondary deformable mirror expected to be achieved in the coming four to five years from now, and a segmented 15 m adaptive primary mirror expected to be achieved in about 10 years. Steps towards that goal are deformable mirrors of increasing size, better support structures and laser guide stars for the big telescopes in the world (UH88, EST, ELT, GMT, MAORY, GEMINI, KECK). After successful demonstration in 2024 of the deformable mirror of 24cm on the NASA IRTF, for 2026 the goal	

is to test a deformable mirror of 60cm diameter on the UH-88 telescope and extend our on-sky-heritage, for 2027 start the developments for KECK.

In the Space Based Astronomy domain we use ESA's long-term planning for space science missions, the Voyage 2050 Senior Committee advice 'Voyage 2050', as a guideline in combination with the Dutch science community (SRON, NOVA, TU Delft) ambitions and priorities. The coming years we will work on the Point Ahead Angle Mechanism (PAAM) for the LISA (detection of gravitational waves) mission. TNO's PAAM design is in the baseline design of the optical bench. Given LISA mission adoption by ESA beginning 2024 and a successful Preliminary Design Review summer 2026 we aim to lead the further PAAM development until flight in close co-operation with the Albert Einstein Institute and ESA.

Within the domain of Scientific Instrumentation we started contributing to the development of silicon mirror technology and the metrology system of the Einstein Telescope, in co-operation with Dutch scientific institutes, universities and companies. In addition, we aim to contribute to nuclear fusion technology by applying our optical systems design expertise to develop technologies for diagnostic instrumentation in the extremely challenging environment of the nuclear fusion chamber. Within NL we co-operate on this with DIFFER and ITER-NL. Potentially we will use this technology for the Dutch ambitions on nuclear fission (SMR's).

In the domain of Space Safety and Sustainability including In-Orbit-Servicing TNO's ambition is to contribute to a long-term space sustainability with its expertise in the field of Optics, Optomechatronics, Radar and Space System Engineering, enabling the required space systems for GNC, rendezvous proximity operations, inspection and docking. Both for civil and military applications. As a first step TNO is involved in the EU pilot mission for In-Space Operations and Services (ISOS), starting with first preparatory activities in summer 2026.

Titel	VP Semicon & Quantum (P612)
MIB Thema	Sleuteltechnologieën
Contactpersonen TNO	Rogier Verberk (DM), Laura de Kort (VPM)
Programma jaar 2027 - Samenvatting	
The goal of TNO's Semicon & Quantum program is to support with groundbreaking innovations the establishment of Dutch or European sustainable control points in the semiconductor-, quantum-, and medical devices value chains. TNO's technological leadership helps companies to innovate faster than their competitors and forms a strong foundation for new startups. Utilizing TNO's extensive knowledge position across multiple science and engineering disciplines, as well as its test and pilot line facilities, we bridge the gap from fundamental knowledge to commercialization, also known as 'from lab-to-fab'. Relative to the first edition, the European Chips Act 2 explicitly broadens the perspective from chip fabrication to the entire semiconductor value chain, including manufacturing equipment and advanced material development, as well as future compute paradigms like quantum computing. While most European Research & Technology Organizations target their pilot lines to chip development, TNO is specialized in semiconductor equipment and materials. In fact, TNO is the only RTO with a pilot line for equipment development and has extended infrastructure for materials testing and qualification. TNO will continue to support established (like ASML, ASM) and emerging (like Nearfield Instruments, Orange Quantum Systems) control points, to help them innovate faster and stand the fierce competition from other regions in the world. Simultaneously, this experience and expertise created a unique position to build the foundations for new spin-off companies with similar potential. The focus on the semiconductor industry and quantum technologies is because of the high geo-economic value, the significant economic impact (high export value), as well as the technological leadership of these sectors with subsequent spillover to other sectors. The European Council states in its Strategic Agenda 2024-2029 that Quantum Technologies & Semiconductors are key topics. The topics are also identified in the 10 priorities of the Dutch National Technology Strategy, and the Wennink report. The focus on medical devices for non-invasive diagnostics and monitoring is motivated by the ambition to fight the congestion in the (Dutch) medical system. This portfolio contributes directly to the sovereignty of Europe while these 'beyond state-of-the-art' technologies generate significant spillovers to other sectors as well. TNO supports ASML by developing new technologies to continuously improve the performance of DUV and EUV lithography systems, e.g., by more accurate sensors, and better performing optics and materials. Typical activities for 2027 include TNO's work together with partners to find replacements for PFAS containing materials and investigate ways to reduce costs and energy consumption for chemical conditioning and exhaust gas recycling of EUV systems. Also the demonstration of in-chip cooling (demonstrator based on AMD chips ready by the end of 2025) aims at sustainability improvements in this sector, and possibly the start of a new spin-off company. The 2027 focus of the continuous innovation on new metrology concepts for the semiconductor industry will be on acoustic metrology, dedicated metrology for heterogeneous integration (the most advanced chip manufacturing strategy for high-end AI chips), and AI based defect detection. The activities on quantum computing and quantum sensing have been prioritized over quantum communications. In 2027 the program will have completed its transition from primarily technology development and ecosystem development, to primarily innovation and industrialization in collaboration with companies. This transition reflects the maturing, or at least emerging, industrialization of this new domain. TNO works together with more and more companies; either dedicated quantum companies or companies with a high-tech or semicon background now stepping in to 'quantum', as we have first seen in 2026. Some new collaborations with such high-tech industrialization companies on quantum computing are foreseen for 2027. While quantum sensing projects are foreseen on both application development and technology industrialization. A new 3-year European project on standardization shall support the commercialization of quantum technologies in general. While performing clinical validation studies of multiple of our Medical Devices (including wearable optical devices and deep-tech ophthalmic instrumentation, running during 2025-2027), TNO will continue the development of its extremely sensitive IPUT acoustic sensor and explore their application in photoacoustic wearables. From a technology point of view, one of the priorities for 2027 is a systematically larger role for AI in our innovations, such as AI supported optical design, designing a new semicon metrology sensor by model-based AI, software code development supported by AI, neural-network based defect detection by optical sensors, and even AI based discovery of new materials. After successful pilots in 2025 and 2026, the HTI Startup Challenge will be an integral part of the 2027 program. It has been demonstrated to be an effective new instrument to identify new innovations, to qualify industrial/commercial feasibility of new ideas earlier in the technology development process, and to be an effective training method for TNO personnel.	

Most of the activities mentioned will be executed in close collaboration with companies from the Netherlands, rest of Europe, South Korea, Japan, or the USA.

Titel	VP Flexible and Freeform Products (P615)
MIB Thema	Sleuteltechnologieën
Contactpersonen TNO	Ton van Mol
Programma jaar 2027 - Samenvatting	
In VP 'Flexible and Freeform Products/Holst Centre' it is our ambition to strengthen Dutch industry by creating innovations based on our capabilities in thin film electronics and hybrid printed electronics combined with our strong position in Brainport to link up to local industry. Our innovations combine economic impact with a contribution to a healthy, sustainable and digital society. Through our unique business model of shared innovation and industrial residents we actively transfer our innovations to our industrial partners as well as the establishment of new start-up companies. Our technology portfolio enables technological solutions to important societal challenges such as energy storage, sustainable electronics, affordable healthcare and a digital society. They can also unlock significant new economic activity. However, progressing from the laboratory bench to the point where it provides the basis of a commercially successful business or product has become increasingly challenging due to increasing complexity of the technology as well as the environment where the product will be implemented. New approaches to innovation are needed such as a serial spinout model, focused programmatic initiatives and pilot lines that involve the relevant value chain players and stakeholders. Our unique approach to innovation is applied to 5 growth platforms: • New manufacturing technologies for electronics production, with a focus on creating high-performance, scalable additive and laser-based manufacturing technologies for electronic products and further leveraging printing and assembly technologies in markets such as advanced packaging, integrated photonics, and 3D printed microelectronics. The key deliverable for 2027 is to develop and validate, through a spin-off to be founded, a tool concept for laser transfer of integrated photonics components, enabling high-throughput placement at submicron accuracy. • Health focuses on platforms for wearables for remote patient monitoring and smart wound care, personalized medication for improved patient care, and X-on-chip for advanced diagnostics and accelerated development of new drugs, partially executed in collaboration with TNO Unit Healthy Living and Work and the University of Twente. For 2027, the key deliverables are to launch a new platform for ultrasound wearables and a spin-off based on this platform for defense applications. Personalized medicine will focus on scaling 3D pharma printing by building the commercialization ecosystem, production solutions and AI-driven design tools needed for broader clinical and industrial adoption. For X-on-chip, the aim is to further establish and validate the Multi-Organ-Multiwellplate platform and spin off a turnkey manufacturing start-up. • Energy storage aims to enable a Dutch battery technology ecosystem and, concurrently, a high-tech hydrogen electrolyzer ecosystem, focusing on next-generation device concepts and the equipment and production technology required for such devices. For batteries, the focus will remain on realizing the OBIC pilot line in Helmond and, concurrently, developing propositions together with MBE/Powertrains around this innovation hub. Technologically, developments will revolve around material selection, dry coating process development, and equipment realization for dry coating of electrodes and electrolytes for high-performance battery cells. These developments coexist with continuous support for the current scale-up ecosystem in the Netherlands, both technologically and through ecosystem building together with BCC-NL. We aim to further connect the emerging needs of the Ministry of Defense to the ecosystem as a follow-up to the feasibility study for a Dutch battery cell factory for high-performance and defense-related applications. Because of the lower industry forecasts in the hydrogen domain, we are considering redirecting our high-tech electrolysis activities more towards generic equipment building around advanced electroplating technology (eSurfPlate TM). We aim to establish customer traction in broader market segments, starting with the energy market as a beachhead, such as the remaining electrolysis market (PTL suppliers) and the energy storage market (Ore Energy project). • Advanced packaging focuses on creating unique technological platforms and solutions for next generation of power and RF electronics. This roadmap is branded under CITC. For 2027, the key deliverables are to mature the reliability of a fully additively manufactured MOSFET package and to expand technological scope towards more complex chips and components (e.g. low IO count microcontrollers). In addition, we aim to expand on our thin film FO-PLP platform and to create a functional prototype of a fan-out package with 3D antenna integration.	

- **Integrated photonics** with a focus on (i) upscaling InP and SiN production in NL, (ii) creating solutions to heterogeneously integrate InP, SiN and its electronic driving chips in one package using panel level fabrication processes. This roadmap is executed as part of the Photonics Integration Technology Centre (PITC), a collaboration between TNO and University of Twente, Eindhoven University of Technology and PhotoDelta. The key deliverables for 2027 are to demonstrate functional PIC building blocks such as InP-SiN using LIFT, panel level optical interconnect technology using polymer waveguides, and ScAlN phase modulators technology on 4-inch wafers. In 2027 the technology and building blocks will be directed towards three strategic application areas: datacenters, optical wireless communication and ultra-sensitive PIC-based sensing of pathogens.

Titel	VP Smart Industry (P617)
MIB Thema	Sleuteltechnologieën
Contactpersonen TNO	Mark Courage (DM)
Programma jaar 2027 - Samenvatting	
Dutch manufacturing faces a structural productivity challenge driven by labor shortages, increasing product complexity, geo-political uncertainty and growing international competition. VP617 Smart Industry addresses this challenge by accelerating the development and adoption of autonomous manufacturing, AI-driven productivity solutions and digitally connected value chains, while strengthening Dutch strategic autonomy in critical industrial sectors. The program contributes to the national ambition of expanding the adoption of Smart Industry technologies from approximately 600 companies today to several thousand companies by 2030. TNO's innovation agenda focuses on three strategic objectives: • Scale-up: hyper-efficient, zero-defect, first-time-right manufacturing. • Productivity: flexible high-mix, low-volume, high-complexity production. • Strategic Autonomy: resilient, digitally integrated value chains and industrial control points. By combining innovations in AI & Data, Mechatronics & Robotics, Optical Systems, Intelligent Imaging and Cybersecurity in line with the National Technology (NTS) Strategy, VP617 contributes to higher productivity, faster industrial scale-up and stronger European technological sovereignty. 2027 is a transition year for Smart Industry within TNO. Following more than half a decade of public investments and the emergence of large-scale programs such as NXTGEN Hightech, Luchtvaart in Transitie and regional innovation ecosystems, Smart Industry knowledge development activities are expected to conclude after 2027. From the beginning of 2028 onwards, the focus shifts from technology development towards industrial deployment, valorization and the transfer of proven technologies into sustainable commercial and ecosystem structures. The emphasis is therefore on scaling, adoption and embedding previously developed technologies, platforms and methods in industry. The intended outcomes described in this VP Plan for 2030 should be interpreted as the longer-term societal and economic impact resulting from these activities, including productivity growth, competitiveness and strategic autonomy. These impacts extend beyond the direct control and funding horizon of VP617 and therefore represent expected downstream effects rather than program deliverables. In 2027 we will maximise leverage on national and European programs while positioning the Netherlands in emerging technology domains such as Physical AI, Smart Robotics and Humanoids. Emerging technologies in these domains are expected to become key enablers of future productivity growth and autonomous production systems. VP617 establishes the sensing, data and operational knowledge infrastructure required for future Physical AI systems. Through technologies such as IPP, autonomous inspection and sensing solutions (including DVM-NDI, 3D vision, anomaly detection and FOS), and interoperable data ecosystems such as Smart Connected Supplier Network (SCSN) and Digital Product Passports (DPP), the program captures, structures and contextualises the manufacturing data needed to train, deploy and scale autonomous manufacturing systems. As such, VP617 provides the foundation for future Physical AI, Smart Robotics and Humanoid applications in industry.	

Titel	VP ICT (P706)
MIB Thema	Sleuteltechnologieën
Contactpersonen TNO	Björn Håkansson (VPM), Berry Vetjens (DM),
Programma jaar 2027 - Samenvatting	
TNO co-creates digital innovations together with industrial and societal stakeholders. We do this by integrating the enabling technologies identified in national and European ICT agendas into first-time engineering solutions. These industrial and societal stakeholders have common needs: To overcome their challenges in operating in digital ecosystems. In VP ICT we address these common needs through four propositions: Intelligent Application Fabric, Data sharing, Fast open digital infrastructures and Trusted ICT solutions. The propositions address different layers of the digital stack and aim to generate impact through the defined impact pathways. The goals along these pathways are for each proposition defined as follows:	
<u>Intelligent Application Fabric</u> Innovations centered around digital applications are becoming increasingly important and TNO has formed a new application-centric proposition: Intelligent Application Fabric, which aims to strengthen Dutch and European competitiveness by translating advances in AI, quantum computing and immersive technologies into trustworthy applications that solve concrete industrial and societal challenges. Within Trustworthy Augmented Intelligence we aim to augment the intelligence of the user <i>and</i> the AI system to increase productivity and improve decision making. In 2027 GPT-NL, the Dutch sovereign LLM fully trained on lawfully acquired data and ethically aligned, will be assessed for adoption in real-world situations. Quantum focusses on hybrid specialistic solutions to optimise quantum workflows and accelerate implementation. With AI also becoming increasingly important in this domain, we will design quantum machine learning solvers for computational problems. For immersive applications we will focus on validation, e.g. on VR trainings for complex areas with a specific focus on AI enhanced media processing.	
<u>Data sharing</u> With the completion of the Data Spaces Blueprint v3.0 in 2026 we aim in 2027 at replicable data space approaches, stronger evidence for viable business and governance models, tooling for onboarding, agreements, compliance and automated data management, and a clearer role for IT providers in scalable and commercially sustainable deployment. We will design an open architecture for compliance proof sharing, realise a Trust Solutions Sandbox to test and validate data collaborations in practice, we will deliver reference architectures and interoperability patterns for privacy-preserving data collaboration. To create impact in the physical world, digital twin platforms are an effective concept; we will have pilots on the delivery of a cross-domain digital twin platform for real-time collaboration and predictive analytics, with expansions into European initiatives.	
<u>Fast open digital infrastructures</u> In Fast and Open Digital Infrastructures, we develop sovereign, resilient and high-performance digital infrastructure solutions across the technology stack. At the network layer, we develop 6G technologies and sector-specific digital service platforms that address the resilience of connectivity infrastructures and unlock the value of connectivity for businesses across the value chain. At the cloud layer, we develop federated sovereign cloud platforms, interoperability services and reference architectures that enable open and sovereign cloud ecosystems. Building on our established strengths in networking and cloud, we are expanding our activities towards the compute layer through hybrid AI computing infrastructure solutions for distributed and heterogeneous AI workloads. Through valorisation, standardisation, ecosystem orchestration and field validation, we translate these technologies into deployable solutions, services and new business opportunities that strengthen Dutch and European digital sovereignty, resilience and competitiveness.	
<u>Trusted ICT</u> Trusted ICT strengthens the cyber-resilient, trusted and competitive position of Dutch society. Growing interconnectivity, software dependencies, AI-enabled attacks and geopolitical tensions increase cyber risks, while adoption of advanced cyber-security technologies remains too slow. TNO develops and validates capabilities for secure-by-design products and software, trusted data and communications, and resilient IT/OT infrastructures. In realistic environments, we validate automated vulnerability discovery and security testing, crypto-agile and quantum-safe solutions, formally verified hardware and software, and automated detection, response and recovery. These capabilities strengthen digital sovereignty, reduce strategic dependencies and help industry, government and critical-infrastructure operators innovate securely and maintain continuity under cyber threat.	

Titel	VP Digital Systems (ESI) (P707)
MIB Thema	Sleuteltechnologieën
Contactpersonen TNO	Wouter Leibbrandt (DM), Bas Huijbrechts (VPM)
Programma jaar 2027 - Samenvatting	
Over the past decades, physical systems have been increasingly subject to digitalization. The rationale for digitalization is simple: it unlocks enormous potential in terms of functionality, performance, variability, flexibility, etc. Digitalization is now a fact across almost all physical systems as new digital developments, such as AI, are introduced. VP Digital Systems has the goal to strengthen Dutch society and economy in view of these digital transitions with methodologies where systems engineering is used in a broad sense 1. to manage the complexity of advanced digital systems and 2. to leverage the full potential of applying digital technologies in physical systems. In view of the complexity inherent to digital systems, the growing international competition, and the shortage of skilled technical experts, the VP wants to deliver methodologies to realize the following vision on future systems engineering: <i>By 2035, Dutch competitiveness will be secured by leadership in managing digital system complexity across high-value industries and critical infrastructures.</i> The VP addresses both digitalization of engineering and engineering of digitalization. The initial focus of VP Digital Systems is to develop, validate, and embed such methodologies in two domains. In the high-tech systems domain, the VP has established a strategic role for itself in the strong eco-system. In the energy domain, the VP is establishing a similar role. To achieve its goal / realize its vision, VP Digital Systems supports the following actions: Agenda Setting and Programming: VP Digital Systems collaborates closely in research programs with eco-systems in the high-tech systems industry and in the energy domain, linked to the relevant innovation agendas and the national technology strategy. In 2027 the high-tech industry portfolio will be positioned around productivity-driven engineering, multi-speed development and delivery, and closed-loop lifecycle engineering. The 2027 priority in the energy domain will be the establishment of joint Innovation center for Digitalization of the Energy system (IDE). Research: VP Digital Systems does research projects based on strategic research questions from the respective domains with a close cooperation with industry, market, government agencies, and academic groups. The approach for VP Digital Systems is demand-driven, rather than technology driven. The 2027 focus will be AI-augmented engineering systems, adaptive engineering for multi-speed systems, lifecycle intelligence and system evolution, future proof flexibility value chain, and system resilience. Valorization: VP Digital Systems' valorization focuses on further embedding the research from the VP's applied research in high-tech industry, the energy domain and in other societal domains including defense and infrastructure. It includes consolidation and dissemination of research results in publicly accessible platforms. To promote the industrial use of VP Digital Systems results, methodologies and tools into high-tech industry practice and thereby growing impact and presence, we scale up the consultancy services as B2B on our system architecting and systems engineering knowledge position with increasing focus on system leadership competences, we target SMEs to accelerate into new application domains, and we expand on consultancy on energy system simulation and modelling, the flexibility value chain, and energy market integration.	

Titel	VP Sleutelmethodeën voor Transitie en Transformatie (P901)
MIB Thema	KIA Maatschappelijk Verdienvermogen / Sleuteltechnologieën
Contactpersonen TNO	Tessa Bruijne (VPM), Lotte de Groen (DM), Anne Fleur van Veenstra (DS)
Programma jaar 2027 - Samenvatting	
De complexiteit van uitdagingen waar de wereld en Nederland voor staan, zoals klimaatverandering, (digitale) soevereiniteit en onafhankelijkheid, schaarste van ruimte, veranderingen in de arbeidsmarkt, sociale ongelijkheid en snel opkomende digitale technologieën, blijft onverminderd hoog. Met deze systemische uitdagingen staat de brede welvaart van Nederland onder druk, maar ontwikkelen zich ook kansen om innovatie en verandering teweeg te brengen.⁶ Innovaties werken door op maatschappij, business modellen en technologieën en door deze dimensies effectief samen te brengen, kunnen vernieuwingen worden opgeschaald en verankerd in de samenleving. Zo kunnen de impact en rendement van innovaties worden benut, ook in tijden van geopolitieke spanningen of wanneer systemen tijdelijk en plotseling falen.	
Het doel van het VP Transitie en Transformatie is om bij te dragen aan maatschappelijke veranderingen en om handelingsperspectieven te ontwikkelen om dergelijke uitdagingen aan te pakken. Hiertoe worden kennis en methodieken ontwikkeld die ingezet kunnen worden voor de volgende diensten: agenda setting, orchestrating innovation, valuechain en scale-up design, economische impact en waarde analyse, maatschappelijke impact assessments, governance en monitoring, en evidence-based beleidsadvies. Middels deze diensten richt het VP zich op het versnellen van impact, integreren van verschillende expertises en disciplines, samenbrengen van publieke als private partijen, en strategisch agenderen van maatschappelijk relevante thema's. Ten behoeve van deze ambitie, onderhouden en ontwikkelen we een kennis- en toepassingsportfolio van Sleutelmethodeën oftewel Key Enabling Methodologies (KEMs). We bouwen hierbij voort op de KEM-onderzoeksagenda (2024-27), onderdeel van de KIA MV.⁷	
Het VP is gelieerd aan TNO Vector, centrum voor maatschappelijke innovatie en strategie. Het centrum faciliteert realisatie van impact door op een strategische wijze innovaties te versterken, te implementeren en op te schalen, mede door de interdisciplinaire aanpak. Daarbij maken we een belangrijke vertaalslag voor overheden, bedrijven en maatschappelijke organisaties, zodat zij weloverwogen beslissingen kunnen nemen om de brede welvaart van Nederland op structurele wijze te bevorderen.	
Het VP richt zich in de periode 2027-2030 op vier impactgebieden en deelproposities, en beoogde resultaten voor 2027 richten zich op kennisopbouw binnen deze gebieden, d.m.v. deelname aan Nederlandse en Europese ecosystemen.	
Innovatie: Innovatiesystemen voor transitie en transformatie, waar kennisopbouw over innovatie-ecosystemen, control points en strategische intelligentie centraal staat.	
Ontwikkeling van een onderscheidende kennisbasis en methodologie voor strategische intelligentie, control points en datagedreven sturing van innovatie-ecosystemen, waarmee TNO Vector nationale en Europese besluitvorming over concurrentievermogen, innovatiekracht en strategische autonomie ondersteunt.	
Opbouw van geïntegreerde kennis over de werking en ontwikkeling van innovatie-ecosystemen, inclusief governance, investeringsdynamiek, ondernemerschap en opschalingsmechanismen, zodat gerichte interventies kunnen worden ontworpen die innovatieversnelling en maatschappelijke impact realiseren.	
Digitaal: Waardengedreven digitale samenleving, waarbij kennisopbouw gericht is op digitale samenleving en de ontwikkeling of adoptie van nieuwe technologieën in lijn met publieke normen en waarden.	

⁶ [Draghi-rapport vertaald naar Nederland: kwetsbaarheden en kansen voor innovatie - TNO Vector](#)

⁷ Zie [De KEM-agenda - CLICKNL](#)

- Kennisontwikkeling rond de verantwoorde ontwikkeling, inzet en opschaling van digitale technologieën, waaronder AI, digitale soevereiniteit en digital trust, resulterend in herbruikbare governance-instrumenten en handelingsperspectieven voor beleidsmakers en organisaties.
 - Ontwikkeling van methoden en datagedreven inzichten om de adoptie, impact en risico's van bestaande en opkomende digitale technologieën te monitoren en te duiden, waarmee het VP en TNO Vector een toonaangevende kennispositie opbouwen in digitale autonomie en waardengedreven digitalisering.
3. **Ruimte: Economische, governance en ruimtelijke strategieën**, waar kennisopbouw gericht is op het verbeteren van de brede welvaart in Nederland door het versnellen van maatschappelijke transitie in steden en regio's.
- Kennisopbouw over maatschappelijke weerbaarheid en opschalen van transitie (met name trajecten die duurzaamheid ondersteunen).
 - Ontwikkelen van systeemgerichte methodologieën en analyses die bijdragen aan betere korte- en lange-termijnbesluitvorming, governance en samenwerking voor de weerbaarheid van fysieke en sociale vitale systemen.
4. **Industrie: Groene en strategisch autonome industrieën**, met een focus in de kennisopbouw over ketenvorming en -opschaling.
- Kennisontwikkeling over opschaling van duurzame, autonome en weerbare, industriële waardeketens, waardenetwerken en ecosystemen.
 - Ontwikkelen van system & value chain analysis, collaborative business models, decision & investment support, en orchestrating innovation & transitions.

Voor het VP als geheel ligt de focus in 2027 op het aanscherpen en valideren van de kennisbasis die onze dienstenportfolio voedt, mede in relatie tot het KEM-portfolio, waarbij specialisatie binnen de vier deelproposities centraal staat. Aanvullend onderscheidt het VP zich door multi- en transdisciplinair te werken: economische, technologische, beleidsmatige en maatschappelijke perspectieven worden geïntegreerd om tot handelingsgerichte kennis en interventies te komen.