

INNOVATE WITH IMPACT



TNO Strategic Plan 2011 – 2014

HEALTHY LIVING	A DYNAMIC SOCIETY	<p><i>Healthy participation in our society</i> Physical and mental health is fundamental to our personal well-being and the quality of our society. Prosperity has brought us longer and more comfortable lives but has also resulted in people outside the employment process, people who consume to excess or consume the wrong things and children and young people that get sidelined. TNO is committed to combining technology and social innovation to enable the more healthy participation of people in our society.</p>
INDUSTRIAL INNOVATION	STRUCTURALLY COMPETITIVE INDUSTRY	<p><i>Strong position of industry in the economy and society</i> Dutch industry is indispensable not only to the (knowledge) economy but also to finding solutions for the scarcity issues that affect society, like energy, safety, care and mobility. This demands technological innovation in the production chain, innovation of products and processes in industry. TNO innovates with a view to transcending the chain and focusing on embedding industrial production in society as a whole.</p>
DEFENCE, SECURITY AND SAFETY	A SAFE AND SECURE SOCIETY	<p><i>A more secure society</i> Security and our sense of security are more than ever subject of emerging threats stemming from the unbalanced distribution of prosperity, conflicting opinions and increasing scarcity of raw materials. All over the world the military, law enforcement agencies and industry are helping to protect us against these, often not so obvious, threats. TNO uses technological innovation in support of these organizations to perform smarter, more efficient and better protected, enhancing the security of our society</p>
ENERGY	SUSTAINABLE ENERGY SUPPLY	<p><i>Sustainably available energy</i> All over the world higher standards of living and emerging economies are causing a rise in demand for energy. However, oil and gas reserves are finite, are becoming increasingly difficult to produce and CO₂ emissions are leading to environmental problems. TNO's technological innovations are geared to making energy available on the basis of energy efficiency, energy storage, more optimal exploration of existing sources and making sustainable energy sources profitable.</p>
MOBILITY	A MOBILE SOCIETY	<p><i>A mobile society</i> Prosperity and urbanisation make increasing demands of mobility: it has to be safer, faster and cleaner. But mobility concerns both technology and human behaviour. So TNO is working with government and industry on technological innovation as well as the influence of human behaviour. Better infrastructure, lower fuel consumption and reduced emissions must go hand in hand with reliable traffic information systems and a restructuring of our mobility patterns.</p>
BUILT ENVIRONMENT	DYNAMIC URBAN ENVIRONMENT	<p><i>Sustainable urban living</i> The urban environment in which we live is increasingly being determined by the interrelationship between design, building and infrastructure. Government, researchers and industry are cooperating to accommodate the changing composition of the population along with health and comfort requirements. Companies within the sector will have to adjust to new issues and sustainability requirements. TNO innovation is geared to both the smarter (re)design of neighbourhoods, the use of methods and materials for sustainable building and construction and the availability of information on the Dutch subsurface.</p>
INFORMATION SOCIETY	A CONNECTED SOCIETY	<p><i>An information structure that connects citizens, industry and government</i> Media and ICT are essential to our society. A new information infrastructure is emerging whereby citizens, industry and government will communicate with each other in new ways. The impact of this on many societal and economic processes will be considerable, though as yet unknown. TNO investigates the impact and new applications of media, supporting government and industry in identifying and applying new communication possibilities. The main challenge is to enable the information society to develop in such a way that it is not only sustainable but can also boost productivity as well as solve a number of social problems without any loss of confidence in ICT.</p>

EXECUTIVE SUMMARY	10
1 THE STRATEGIC PLAN	16
2 SKETCH OF THE ENVIRONMENT AND FUTURE	20
3 MISSION	28
4 CONCENTRATION ON SEVEN THEMES	34
THEMES AND INNOVATION AREAS	36
HEALTHY LIVING	38
INDUSTRIAL INNOVATION	48
DEFENCE, SECURITY AND SAFETY	58
ENERGY	68
MOBILITY	76
BUILT ENVIRONMENT	84
INFORMATION SOCIETY	92
5 IMPACT IN THE MARKET	100
6 TNO AND SMEs	104
7 EXCELLENT KNOWLEDGE	110
8 TNO ORGANISATION	116



FOREWORD

This TNO Strategic Plan for the period 2011-2014 represents the proposal we make to society once every four years. The plan before you has emerged at a time of great uncertainty in which the Netherlands and much of the world are rather hesitantly recovering from the worst economic crisis in many decades.

The knowledge world, and not the least TNO, feels challenged to make a tangible contribution to the economic recovery and necessary transformation to a sustainable knowledge economy in which high-tech employment lies at the basis of prosperity and welfare. We also need a suitable solution to the variety of global and European challenges confronting the world in areas like sustainability, health, scarcity and geopolitical threats. Our Strategic Plan is intended to make clear to our customers and stakeholders where we can make our contributions and what this may imply in concrete terms. We want to substantiate this in the coming period through cooperation and dialogue.

While uncertainties exist, we are certain of one thing: that we won't get there without innovation. We will not wrestle ourselves clear of the crisis by just cutting costs. Investment in innovation and applied research is an absolute necessity for both the short and longer term. That is something the most developed and developing economies, both inside and outside Europe, are doing.

At the same time, the financial position of government and industry must be brought to order. Government has key political choices to make in its weighty responsibility for the future of the Netherlands and Europe following the crisis.

TNO sees its own responsibility in now presenting a plan containing clear choices for the key themes and with tangible goals ... and to put this plan into effect. We will be doing this effectively and efficiently against a background of scarce resources. We also feel the broader responsibility to do our utmost in league with other parties, each on the basis of its distinctive strengths, to work towards a more effectively and efficiently operating knowledge infrastructure in the Netherlands and in Europe.

We want to be able to look back at 2010 in 10 years and say: the investments in innovation during the crisis have paid off. In terms of our competitive strength, our successful steps towards sustainability and the high-tech employment that has benefitted from these successes.

Indeed: innovate with impact!

On behalf of the TNO Board of Management,

Jan Mengelers, chairman

**HOW DO WE ACHIEVE A
SUSTAINABLE SOCIETY?**

**HOW DO WE RETAIN
OUR KNOWLEDGE?**

**HOW DO WE STAY
COMPETITIVE?**

**HOW DO WE ACHIEVE
WELFARE AND PROSPERITY?**

EXECUTIVE SUMMARY

1. STRATEGIC PLAN

Over the years TNO has developed from being a largely government funded research institute into a modern Research & Technology Organisation that supports national and international government and industry customers with practicable knowledge and innovations.

The TNO Act stipulates that TNO's plans must be submitted every four years to the Minister of Education, Culture and Science and thereby to the entire Dutch Cabinet and Dutch society. The Cabinet thus establishes its stance and the level of funding for the coming years in respect of the innovative knowledge programmes and assignments performed for the government. The possibilities TNO thus acquires for innovation and extending and maintaining an internationally competitive position largely determine the effectiveness of TNO and thereby the added value for Dutch society. TNO wants to make this added value as transparent as possible and link up with the national innovation agenda and the agendas of those other players in the innovation system. The Strategic Plan is geared to this.

2. OUR AMBITION

In this Strategic Plan 2011-2014 TNO opts emphatically for impact: to give visible and demonstrable added value to government and industry for the major societal and economic issues. The success of TNO will be explicitly and demonstrably linked to the national and European innovation agenda.

3. OUR ROLE AND POSITION

Research & Technology Organisations

TNO makes scientific knowledge applicable and valuable through business principles for government and Industry customers. This is the task of the applied knowledge infrastructure in the Netherlands and in Europe, in which TNO is the biggest Research & Technology Organisation (RTO) in the Netherlands and the fourth biggest in Europe, and plays a prominent role. These organisations are characterised by their close links to the worlds of industry, government and science.

Role of the government

The government has an essential role to play, not only as policymaker, customer and launching customer, but also in its responsibility for financing of the necessary knowledge development. The government contributes financially to maintaining the applied knowledge infrastructure and provides frequent temporary programme impulses by funding innovation programmes and consortia in which industry, universities and applied knowledge institutions cooperate.

Driven by demand

In recent years the influence of the government – and other stakeholders – has been growing stronger since the existing programme funding has been transformed into a system driven by demand. This enables the knowledge development that is really geared to the issues of major national and European importance to be safeguarded. This led to agreements about the use of the programme funding on twelve themes with national and European priority.

The system will be evaluated in 2010 but experiences so far are positive: they reveal the importance of a continual interaction between demand and supply and the need for intensive – and thus often complex – cooperation among the parties involved.

Future role of TNO

Against the background of the major societal and economic challenges and the experiences to date with demand, TNO feels it is necessary to opt for a stronger initiating role in the coming period to elicit and refine the relevant questions and get new urgent issues on the agenda. By extension, TNO wants to take on a stronger organising and connecting role, where necessary and useful, in getting the required cooperation off the ground.

Strategic discussion partner

To be able to fulfil this role, TNO must strengthen its role as strategic discussion partner for government and industry and play a more visible role in the innovation debate. A key initiative here is the establishment of a TNO-wide policy research and advisory group, Strategy and Change, which is very focused on the major societal and economic issues and on the strategic employment in this of the technology factor.

4. CONCENTRATION ON 7 THEMES

Focus and mass are critical success factors, so in the coming period TNO proposes to concentrate on 7 closely related themes, each of which has a prominent place in the national and European innovation agenda.

- Healthy living
- Industrial Innovation
- Defence, Security and Safety
- Energy
- Mobility
- Built environment
- Information society

The themes are derived from a clustering (based on strong interrelationships) and refined focusing of the twelve themes from the previous strategy period and are thus a logical extension. The seven themes retain strong mutual links, as in sustainability and competitive strength that are key 'drivers' specified in each theme. 85% of the innovation areas is fully or largely geared to sustainability issues.

In (aspects of) each theme TNO already has an acknowledged and internationally distinctive position. In close harmony and cooperation with the other players involved in the knowledge infrastructure, this position will be selectively expanded in the coming years.

5. PROPOSAL FOR 19 INNOVATION AREAS

In this Strategic Plan TNO wants to link its vision of routes to solutions for each theme on the basis of a problem and environment analysis and link this as well as possible to the priorities of the stakeholders involved.

By linking these priorities to the strengths of TNO, we arrive per theme at one or more innovation areas, nineteen in total. Criteria for inclusion remain:

- An urgent social and/or economic need
- Support among stakeholders and customers in the market
- A 'right to play' for TNO, in part based on an excellent knowledge position
- A logical embedding in the national and European knowledge infrastructure

In the Strategic Plan the innovation areas will be detailed as concrete propositions with measurable objectives as much as possible, ratified by stakeholders and the departments involved. These serve as an intrinsic framework for the demand-driven programmes that we will be drafting as the next step in close consultation with the departments involved and other stakeholders.

6. MORE IMPACT IN THE MARKET

The market strategy 2011-2014 is specified per theme, geared to the relevant target groups and stakeholders for each theme. This is detailed in the separate theme sections. Specific market explorations and customer ratification were part of the preparation.

TNO-wide principles and objectives for the market strategy are:

- **more emphasis on the developing and innovating role of TNO and upgrading the products and services portfolio.** More emphasis will lie on co-development, high-tech contract research and the corresponding service. The commercialisation of recurrent and routine services based on mature technology will be accelerated via new

companies. We strive to achieve an income mix of a third demand-driven programmes, a third competitive funding and a third market funding for contract research and advice (excluding income from the newly established companies).

- **strengthened valorisation.** TNO has been establishing new companies since 1986 and supervising them for a limited number of years before disposing of them. These companies form a source of high-tech Dutch employment, especially in the SME sector. The total annual income of these companies was 300 million euros in 2009. The past 10 years have seen the establishment of 95 new companies and the disposal of 55 companies. The coming years will see TNO increasingly geared to establishing new companies, partly high-tech spin-offs and partly new companies based on the recurrent service referred to above. TNO also wants to boost its economic impact by enabling customers to make more and easier use of the patent portfolio of TNO.
- **SME.** TNO reaches some 10,000 SME companies each year, the value of these activities being more than 30 million euros annually, which makes TNO the Dutch knowledge institution with by far the biggest reach and most intensive relationship with SMEs. In the coming period TNO wants to boost that reach among the innovative leaders (around 7,000 in the Netherlands) by 25%. For the developers and users (some 50,000 in the Netherlands) a collective approach is being strongly advocated geared to upgrading clusters and chains to retain and strengthen the position of these companies as suppliers to the major multinationals. Furthermore, new technology will be proactively profiled via theme workshops organised in cooperation with Syntens and

industry associations. The instruments for knowledge transfer will be expanded with one-day consultancies as a logical next step in the primary advisory function of Syntens. Cooperation with the polytechnics in projects for SMEs and knowledge transfer via visiting lectureships will increase. Modifying and expanding the transparency of the General Terms and Conditions will boost the accessibility for SMEs.

- **international.** The knowledge market will become increasingly more international in the coming period and TNO will expand accordingly by explicitly striving for an internationally competitive position in the chosen themes and innovation areas. A key part of the strategy is alliances with fellow RTOs in Europe on specific topics, like the cooperation with the Norwegian Sintef and the French IFP on Carbon Capture and Storage (CCS). The establishing of new companies will see TNO increasingly focus on the international commercialisation of sufficiently mature technologies, particularly in the United States, China, Japan and Korea.

7. EXCELLENT KNOWLEDGE

TNO works from an excellent technology position built up with customers and partners in the government funded research programme. The quality and distinctive capacity are monitored in external technology audits every four years.

Principles and objectives for the coming period are:

- TNO is committed to strengthening participation in national and European programmes geared to 'open innovation'. The basis for this cooperation lies in excellence and distinctive capacity among the partners involved. Further concentration of the TNO technology portfolio

to an excellent knowledge basis is therefore necessary. TNO wants to be leading in Europe in at least 25% of the chosen innovation areas. In the other innovation areas TNO wants at least an authoritative role in specific components.

- Nationally there is close agreement and support in cooperation with fellow LTIs in respect of the themes agreed with the government.
- The current structural cooperation with the universities (20 knowledge centres, 60 visiting professors and 150-200 research assistants) will focus on the chosen themes and innovation areas, with a strengthening of cooperation with prominent foreign universities and RTOs. TNO distinguishes itself from academic research by the exclusive emphasis on valorisation in tangible applications and innovations for customers and through its customer-focused approach.
- The proposed themes and innovation areas have a strong European dimension whereby TNO will expand its strong position in the European framework programme and position itself in the newly established European Institute of Innovation and Technology (EIT). TNO is participating in each of the three selected 'Knowledge and Innovation Communities (KICs)' being started by the EIT, namely the fields of Climate Change, Sustainable Energy and the Information and Communication Society.

8. INCUBATOR AND SPRINGBOARD FOR TALENT

The ambitions of TNO appeal greatly to our employees and bring new challenges that demand top talent. A stimulating climate in which to work is therefore a top priority for our

knowledge economy. Top talent is rare. In several innovation areas TNO is already the most attractive employer for knowledge workers. TNO wants to further strengthen its recruitment and career policy for top talent, with the recruitment bar being raised. In addition to its own resource pool of talent for its own organisation goals TNO is emphatically opting for a role as innovation talent supplier to Dutch society for the coming strategy period. Ex-TNO employees appear to be very attractive employment market candidates; educated and an experience richer, they are competent 'innovators' for the innovation areas needed by the Netherlands in the coming time.

9. STEERING BY IMPACT

For the high aspirations of TNO, an organisation to optimally facilitate this is needed along with a culture that challenges the employees to innovate and cooperate. Organisational and cultural change will go hand in hand in the coming years. To boost the societal and economic impact, the projects will be steered via the themes and innovation areas. For each innovation area a clear responsibility will be assigned for both the knowledge development and market activities. This project steered organisation will boost the cooperation across the core areas and enable TNO even more to focus on complex multidisciplinary problems. The thematic approach also means that achieving the desired impact will be carried out in this way. The impact will be realised in the many projects TNO carries out for government and industry customers. The success of TNO will be judged by the actual difference that TNO makes in projects with and for partners and customers. In assessing the overall impact on an innovation area, it is not just the sum of the project impact that counts but also the extent

to which TNO plays a visible, authoritative and linking role in the (inter)national networks of the respective stakeholders and customers in the innovation area.

10. FINANCIAL DEVELOPMENT

In 2009 TNO was hit hard by the recession, with income loss several tens of percentage points in the Automotive, Semiconductor, Pharma and ICT markets. Tough cost reduction measures were taken along with cuts in staffing at the respective organisational entities. A loss in 2009 was, however, unavoidable. In 2010 the favourable effects of reductions in costs and personnel will become visible. Any initial substantial market recovery will only come in 2011. Based on continued economic recovery, TNO is working according to the following scenario:

- Overall income rise from 600 million euros in 2009 to 700 million euros in 2014.
- Government funding at 2010 level.
- The strengthened participation in national and European programmes geared to 'open innovation' will lead to a considerable increase in 'competitive funding' and a subsequent income mix of a third demand-driven programmes, a third competitive funding and a third market funding for contract research and advice (excluding the income from companies established by TNO). To reach the required level of competitive funding the matching contribution obligations of these programmes from the regular government funding awarded to TNO have to be considerably reduced. In 2003 the Wijffels Commission already advised the Cabinet of such. More recently the AWT and the Health Research Council (RGO) echoed the same. TNO also urges the Cabinet to

take this recommendation on board by annulling the matching obligation or making separate financing available for it.

- A modest profit of 3% of market income reinvested in the organisation.
- TNO Companies will grow in terms of income and profit through the accelerated inclusion and sale of mature technologies from TNO and high-tech spin-offs, with profits being reinvested in the organisation.

11. AGREEMENTS WITH THE GOVERNMENT

- The Cabinet is being asked to take a stance on the seven themes and 19 innovation areas proposed in the Strategic Plan as an intrinsic framework for the demand-driven programmes for 2011-2014. As subjects for the programme Knowledge as Power across the Themes (KaVoT) the following 'enabling technologies' are proposed: Modelling, Sensors, Materials, System Biology, Innovation and Behaviour, and Strategic Policy Research.
- The next step will be to detail concrete programme proposals in close consultation with the orchestrating departments in line with the agreed methods adopted for the introduction of the demand-driven approach.
- Any changes from the forthcoming evaluation of the introduction of the demand-driven approach will be incorporated.
- Funding: to realise the plans contained in this Strategic Plan, TNO assumes the level of government funding applicable for 2010.

THE STRATEGIC PLAN



'In this Strategic Plan TNO opts emphatically for impact: delivering a visible and demonstrable added value to government and industry in response to the major societal and economic issues.'

GUIDE

Section 1 reveals the background and objective of the Strategic Plan. In section 2 we outline the worldwide developments that will affect us and that will steer the position of the Netherlands in Europe and the world in the coming years. Next we describe in section 3 our mission, role and position followed, in section 4, by the seven themes where we will be concentrating in the coming period. Per theme we look at the main trends, the challenges for the future and the contribution TNO can make in this respect. Section 5 considers our impact in the market with special attention for SMEs described in section 6. In section 7 we look at our knowledge development and the agreements made on this with the government. A special focus is our contribution to the European knowledge agenda. Finally, in section 8, we discuss the organisation of TNO: our structure, culture, our talents, our financial prospects and how we profile ourselves through corporate social responsibility.

For 78 years TNO has been successfully making scientific knowledge practicable, having developed from a largely government funded research institute into a modern Research & Technology Organisation that supports national and international government and industry customers with practicable knowledge and innovations. TNO was established during the pre-war economic crisis on the conviction that new knowledge and technology was absolutely necessary to economic growth and social renewal and that it is precisely at such a time of crisis when investment is essential. These principles are more valid than ever in 2010.

The TNO Act stipulates that TNO's plans must be submitted every four years to the Minister of Education, Culture and Science and thereby to the entire Dutch Cabinet and Dutch society. The Cabinet thus establishes its stance and the level of funding for the coming years in respect of the innovative knowledge programmes and assignments performed for the government. The possibilities TNO thus acquires for innovation and extending and maintaining an internationally competitive

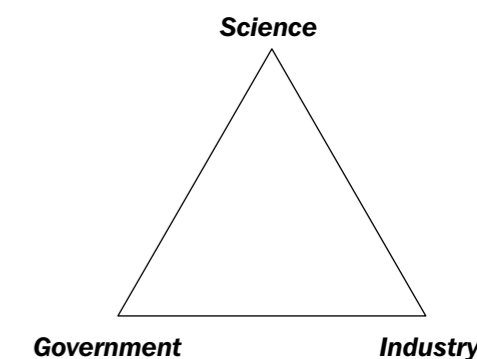
position largely determine the effectiveness of TNO and thereby the added value for Dutch society. TNO wants to make this added value as transparent as possible and link up with the national innovation agenda and the agendas of those other players in the innovation system. The Strategic Plan is geared to this.

Our ambition: innovate with impact

In this Strategic Plan 2011-2014, TNO opts emphatically for impact: a visible and demonstrable added value for government and industry regarding the major societal and economic issues. Where the course for a shift to a stronger demand drive had already been set in progress in the previous period, the bar has now been set even higher. The success of TNO will be explicitly and demonstrably linked to the national innovation agenda. Impact objectives are key and TNO wants to take a leading role in realising this innovation agenda. To have impact in the Netherlands and outside, world-class knowledge is needed. TNO has this world class in house in several fields, in the form of top technology and top talent. In other fields TNO is hooked in to top

TNO Act: article 4

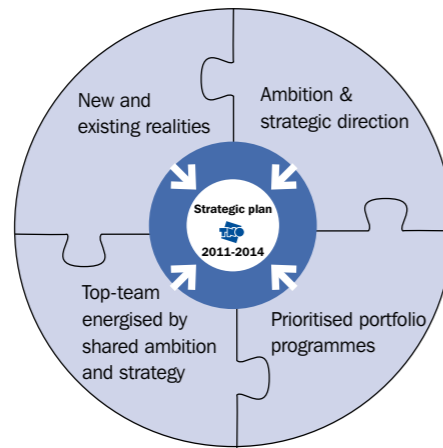
The Organisation aims to ensure that applied technology and scientific research along with the corresponding social-scientific and other applied research can be made effectively serviceable for the general good and the interests contained therein.



knowledge via international networks of and partnerships with excellent researchers. We are a close-knit organisation that cooperates nationally and internationally and excels in specialised research areas. TNO contributes to the solutions to the major issues to which society has no answer yet.

The strategic agenda covers the period 2011-2014, but the underlying analysis and vision go beyond this: the horizon is 2025. Therefore, we first outline in the following section the worldwide developments that will affect us and that will steer the position of the Netherlands in Europe and the world in the coming years.

STRATEGY APPROACH



TNO NOW

Markets

- Manufacturing
- Sustainable chemistry
- Pharma
- Food and nutrition
- Health
- Building and construction
- Energy
- Transport
- Multimedia/telecom
- Business services
- Government

Core areas

- Defence, Security and Safety
- Quality of Life
- Science and Industry
- Built Environment and Geosciences
- Information and Communication Technology

Commercialisation of knowledge

- TNO Companies

Activities:

- Knowledge development
- Knowledge application
- Knowledge commercialisation
- Legal tasks

Personnel:

4572 (end 2008)

Income:

EUR 600 m (2008)

SKETCH OF THE ENVIRONMENT AND FUTURE

'Knowledge and innovation are the primary solution to pre-empt threats and exploit opportunities and thus to strengthen the economy in the core'

Developments in the world, in Europe and in the Netherlands are occurring rapidly. Social changes are sweeping and sometimes elusive. The current economic crisis will have a significant influence in the coming decade and will accelerate the shift of relationships in the world. Ageing, climate crisis, scarcity of energy and raw materials along with new security issues demand measures now to safeguard the long-term basis of our society. These developments also offer opportunities at the same time. Opportunities for new innovations to provide sustainable solutions to our energy and raw materials problems. For new technology that can enable industry to deal with the increasing international competition.

Knowledge and innovation are the primary solution to pre-empt threats and exploit opportunities and thus to strengthen the economy in the core. The potential result is a

prosperous, clean and safe and secure society. TNO wants to play an orchestrating role in this and make a decisive contribution through 'knowledge for a better world'.

Climate change, social instability, the environmental question, loss of economic competitive strength, immigration, ageing, shifting political and economic world relationships... the challenges at the beginning of the 21st century are unprecedented. We live in a time of major changes that are occurring faster than our generation has ever known. Worldwide, socially, economically and environmentally. These drastic changes demand a response from the whole of society: government, science, industry, and citizens. If we want to safeguard our economic competitive strength as well as our social prosperity model and public safety, then innovative solutions are necessary – and an innovative approach.

THE WORLD IN 2025

What will be the key worldwide trends of the next few decades? Various studies have generated several arresting developments¹:

- In 2025 the geopolitical and economic relationships will have seen a fundamental shift. The traditional dominance of the west (US and Europe) will have been diminished by the shift in economic and thus political power to the BRIC² countries, China in particular. These emerging economies will use their newly acquired power pragmatically, boosting their influence, for instance, in countries that supply raw materials and gaining more of a say in international organisations. Moreover, these countries will be in a less mature stage of economic development and can thereby more flexibly adapt to the needs of a modern, global and flexible economy.
- Demographic developments reinforce these shifts: outside Europe populations will grow exponentially, which will see a corresponding growth in consumption and thus the potential for economic growth. This will lead to increasing migration and mobility, pressure on scarce resources (like water, energy and food) and on the climate. Within Europe the population size will decline and ageing will be the key demographic element, the consequences of which will, for instance, be pressure on social provisions like social security systems and care as well as, probably, low economic growth.
- The emergence of new powers, increasing scarcity of energy and raw materials combined with climate change demand a switch to a sustainable economy, one of the main challenges of the coming years.
- The increasing influence of BRIC countries

MAIN TRENDS TO CONSIDER FOR TNOs STRATEGIC PLAN 2011-2014



- **Global mega trends**
10 trends shaping the next decade



- **Business technology trends**
8 business technology trends to watch



- **Greentech**
10 market disruptions likely to create significant growth opportunities



- **Innovation Platform**
6 key areas on which the Dutch economy should focus its innovation efforts



- **Dutch societal issues**
Current top 10 societal issues for the Netherlands

¹ Many of these studies choose 'the world in 2025' as a time horizon. See for instance the American National Intelligence Council, the European Commission and a network of European Parliament think tanks. As for the Dutch context there is the Horizonscan 2007 report into a future-based policy and knowledge agenda by the COS (Committee for Cross-sectoral Consultation, which connects the various advisory councils of the government) and the STT (the Foundation for the Future View of Engineering).

² Brazil, Russia, India and China.

will force the west to embrace more intensive cooperation. At d thus create a seed bed for tension and conflict at all kinds of levels, urban as well as international terrorism and cross-border crime.

TECHNOLOGICAL DEVELOPMENTS

Science and technology are developing rapidly. As a result, knowledge institutions are increasingly operating in a global knowledge community, in which cooperation and competition among high-tech research groups spur on the quality and productivity. This leads to major breakthroughs inside key technologies like ICT, molecular biotechnology and materials technology, including nanotechnology.

Moreover, more and more breakthroughs are reaching the interfaces of knowledge areas

SELECTED GLOBAL MEGATRENDS



Demand for natural resources will grow amidst increasing concern about the environment and security of supply (Water, Energy, Metals)



The battlefields for talent will shift



Centers of economic activity will shift profoundly, not just globally, but also regionally



New economics of knowledge – global sharing and creation of knowledge

³ Non-governmental organisations

⁴ Source: Innovation outlook, TNO

and have an impact on all the themes in which TNO is active. Therefore, we mention a few global technology trends here in which major breakthroughs can be expected⁴:

- Our built environment is becoming more intelligent ('ambient intelligence'). Information is being made available independent of time and place and virtually each product contains components that enable intelligent interaction with the surroundings. Systems are becoming increasingly autonomous (robotisation) and technology used increasingly to reduce the chance of human fallibility.
- Technology is getting smaller, with electromechanical systems possible at nanoscale. This miniaturisation leads not only to smaller products but also to the integration of functionalities (like the 'lab-on-a-chip') and new possibilities (like 'submarines' in the bloodstream).

- Materials are not only becoming stronger and lighter but are also acquiring more functional properties (like self-repairing materials). Alternatives are being sought for scarce materials, and biotechnology enables the industrial processing and production of chemicals, materials and fuels from biological raw materials.

DEVELOPMENTS IN EUROPE

Europe is facing major challenges. Not only those related to the economic recession but also the Grand Societal Challenges like water and food supply, climate change, energy supply, pandemics, ageing and security and safety. The system innovations required for this are driven to a large extent by new technological solutions with research and innovation critical success factors. This is the overriding conviction of the current Lisbon strategy 2010.

Economic growth and jobs.

By mid 2010 the European Council will establish EU2020, the Lisbon strategy post 2010. The Grand Societal Challenges and the Low carbon economic growth will be leading themes. Only by clustering strengths, developing and sharing knowledge and technology, developing specialisations and linking disciplines will innovation reach a sufficient level to grasp climate change, solve the energy crisis, prevent food shortages and pandemics, and maintain biodiversity. It requires more than the efforts of a single research institute, country or even continent. The European research and innovation policy has developed against this background over the past ten years. From joint research and technology development over and above national research and technology programmes, European research

policy is increasingly geared to the Grand Societal Challenges and better harmonisation of national initiatives. Investing in the underlying Key Enabling Technologies is also regarded as indispensable⁵.

The recent developments include the establishing of the European Institute of Innovation and Technology (EIT) and the EU strategy of clustering national research agendas (Joint Programming Initiative). This trend to more international harmonisation and more structural cooperation is evident and irrevocable.

THE LISBON AGENDA

In March 2000 in Lisbon the European Union accepted a strategy to make Europe in 2010 the most competitive and dynamic knowledge economy in the world. The focus in that agenda lies primarily on boosting the competitive strength and economic growth in Europe, partly through making significant efforts in knowledge and innovation. Coupled to this are a social agenda (geared to social cohesion and inclusion) and a focus on sustainability.

In 2010 the Lisbon agenda is more valid than ever. The recent developments and picture of the world in 2025 as sketched above, however, also make it apparent that Europe's positioning in the world needs reassessing⁶. As the end of the Lisbon period approaches, the Netherlands can grab that moment to contribute to a new knowledge and innovation agenda for Europe. The Central Planning Bureau expects, for instance, that productivity in Europe can still grow up until 2020 since, compared with the United States, we have not yet got everything out of our ICT possibilities: so it's a catch-up race.

The Social Economic Council⁷ suggests that the objectives of the Lisbon strategy for the Netherlands after 2010 must stay geared to greater prosperity, and it distinguishes three dimensions: people (social), profit (financial-economic) and planet (environment). The accent for the coming period will lie on more productivity among other things. The challenge is to strengthen both the service and industrial sectors through knowledge and innovation, to improve our labour supply and solve our societal challenges, together, and thus achieve a sustainable knowledge economy.

DEVELOPMENTS IN THE NETHERLANDS

Economic growth is spurred on by technological development and is greatly influenced by demographic growth. The population growth in the coming years will stagnate as will employment participation, partly because the baby-boom generation will retire. This has considerable consequences for the labour market. Economic growth is no longer an assumption and depends on the development of productivity. More than ever,

DUTCH SOCIAL TRENDS – TOP 10 PRIORITIES ACCORDING TO THE DUTCH PEOPLE

Topic	Political priorities %	Problems %	Strengths %
1 Care and ageing	15	7	10
2 Income and economy	14	19	9
3 Crime and safety	13	12	2
4 Immigration and integration	10	11	4
5 Co-existence, standards and values	9	19	14
6 Traffic and physical habitat	7	6	5
7 Youth and family	6	5	0
8 Education innovation, art and culture	6	2	5
9 Politics and governance	6	9	7
10 Nature and the environment	5	2	5

Source: SCP, 'Continuous Survey of Citizen Perspectives' (4th quarter 2008)

⁵ The European Commission in its report 'Preparing for our future: Developing a common strategy for key enabling technologies in the EU (2009)' distinguishes the following key enabling technologies: nanotechnology, micro- and nanoelectronics, photonics, advanced materials and biotechnology.

⁶ In March 2008 government leaders launched the second period of the revised Lisbon strategy, with mankind key in the period 2008-2012. Problems like unemployment, social exclusion and lack of education will be tackled. Much attention also focuses on the environment, whereby the balance between care of citizens and the environment on the one hand and achieving a competitive knowledge economy on the other is important. The free traffic of knowledge and encouraging SMEs are other focal points. Advice for Europe 2020: the new Lisbon strategy, SER, 19 June 2009.

'The challenge is to strengthen both the service and industrial sectors through knowledge and innovation, to improve our labour supply and solve our societal challenges, together, and thus achieve a sustainable knowledge economy.'











investments are needed in knowledge development and innovation, with a significant improvement in the profitability of investing in knowledge, all the more so given the threats to our sustainable prosperity that lie on the horizon: the costs of climate change and its prevention, the costs of the social integration of migration, the expected rise in energy and transport costs, the rising costs of healthcare and increasingly mobile economic activities through ICT. The Cabinet wants the Netherlands to be one of the world's most competitive economies.⁸ But while comparable western countries like Germany, France and the United States⁹ give a substantial boost to their investments in knowledge, research and development, the Netherlands continues to lag behind.

good on our role in peace missions and safeguard our own security, also domestic. Nationally, our task is to realise fundamental innovations in the themes of Healthy Living, the Built Environment and Mobility. Our care system must be qualitatively improved and costs reduced. Our diet that we enjoy as a prosperous country is called into question (like obesity) and this must be tackled in a structural way. The limited space in the Netherlands poses significant challenges in terms of liveability, accessibility and climate resistance. The information society will fully unfold in the coming decades, which will create as many problems as solutions. These topics also offer tangible pretexts for an agenda-setting role for the Netherlands in Europe.

THE INNOVATION TASK FOR THE NETHERLANDS

Our world today is characterised by complexity and uncertainty. Nonetheless, we are compelled at least to tackle the effects of predictable global challenges (like scarcity, climate change, instability of fragile states and youth bulges¹⁰) together with European and national challenges like ageing, immigration, social-political instability, loss of economic competitive strength, congestion and environmental issues. The Netherlands is now confronted by the task of strengthening its international position in areas like industry and services, the key area of Social Innovation Agendas (including energy, care and safety). A real impulse is needed to boost the share of industrial business in the Netherlands. Our energy supply must be safeguarded for the long term and be made resistant to unexpected international developments. Internationally we have to make

GREENTECH TRENDS – TEN MARKET TRENDS WILL CREATE SIGNIFICANT GROWTH OPPORTUNITIES

	1 Shift to hybrid and electric vehicles	<ul style="list-style-type: none"> Advanced electric/hybrid vehicles Smart charging
	2 Carbon capture and sequestration	<ul style="list-style-type: none"> Carbon capture technologies Avoided CO₂ emissions Low carbon energy
	3 Tech enabled behavior	<ul style="list-style-type: none"> Video/connectivity technologies
	4 Bluetech	<ul style="list-style-type: none"> Advanced pipes, pumps, valves Agriculture systems/products Municipal engineering/construction
	5 Biofuels	<ul style="list-style-type: none"> Industrial and municipal membranes and chemicals Biofuel replacement for fuel Biofuel additives
	6 Renewables	<ul style="list-style-type: none"> Solar thermal and PV Off-shore and aerial wind Ocean thermal and wave Advanced geothermal
	7 Sustainable materials	<ul style="list-style-type: none"> Low-energy concrete Alternative packaging
	8 Storage	<ul style="list-style-type: none"> Transmission/distribution equipment Advanced batteries
	9 Smart Grid	<ul style="list-style-type: none"> Smart Grid Smart meters
	10 Energy efficiency	<ul style="list-style-type: none"> Reduced energy consumption in commercial and residential buildings Process improvements in industrial settings

⁷ Advice for Europe 2020: the new Lisbon strategy, SER, 19 June 2009.

⁸ Towards a robust knowledge economy, 15 September 2009 proffered to Parliament by the ministers of Education, Culture and Science and Economic Affairs.

⁹ Source: reports DfI, France, speech Obama

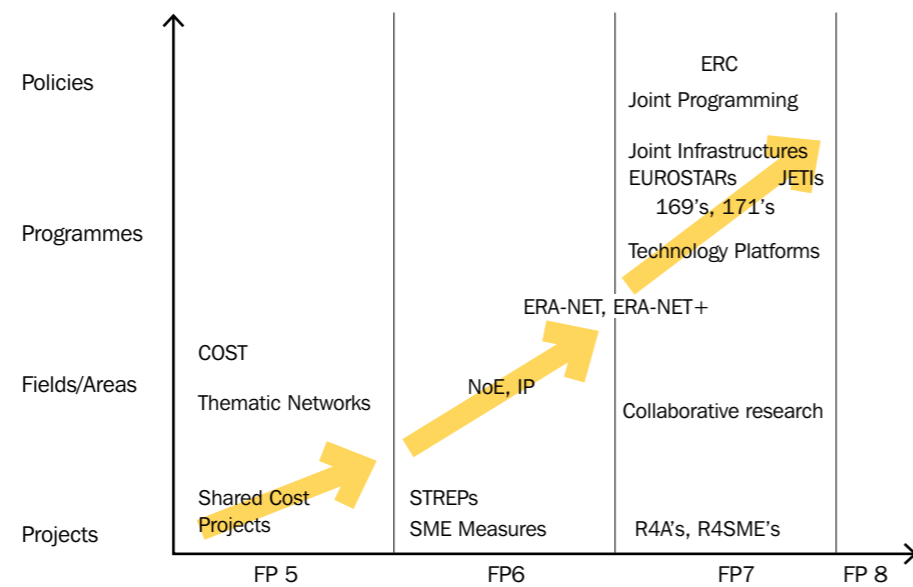
¹⁰ The growing number of children and young people in the population of unstable states.

'The emergence of new powers, the increasing scarcity of energy and raw materials combined with climate change require a shift to a sustainable economy. This shift is one of the main challenges of the coming years.'

CONSEQUENCES FOR THE STRATEGY OF TNO

- Ensure a visible and measurable contribution to solving major societal issues
- Internationalisation in terms of acquiring a distinctive knowledge base and attracting top talent
- Develop into an attractive employer for top talent
- Selectively seek partnerships, combined with a more orchestrating role
- Renewal: further strengthen vital exit channel for mature technologies by new companies, and so make scope continually available for new initiatives
- Ensure that publicly funded R&D has an optimal fit with the needs of companies by developing public and private partnerships

CHANGING ARCHITECTURE OF EU R&D POLICY



MISSION

'The TNO mission is: TNO connects people and knowledge to create innovations that boost the sustainable competitive strength of industry and well-being of society.'

VISION

Innovation has brought progress: a prosperous society and competitive industry. However, shifting relationships around the world and the scarcity of resources in areas like energy, raw materials, space and health require breakthroughs in terms of concepts and action. Technological and social innovation is crucial to this, and the entire range of technologies has a role to play. As the boundaries that separate domains, disciplines and countries fade, national and international cooperation becomes increasingly prominent. TNO wants to be at the axis of this fusion, in the middle of society where its integrated knowledge can be put to optimum use for and with government and industry. We have the people with the right blend of curiosity, creativity and idealism to make it work.

MISSION

TNO connects people and knowledge to create innovations that sustainably boost the competitive strength of industry and well-being of society.

CORE ELEMENTS OF OUR MISSION

Better world through applied research

- (Co)solution for major social problems
- Innovation in industry
- Valorisation: generating economic activity on the basis of high-tech knowledge

Together making more of

- Open cooperation with network of customers and knowledge institutions
- Authoritative and directive (role/attitude)
- Initiating, connecting and orchestrating

RESEARCH & TECHNOLOGY ORGANISATIONS

TNO fulfils this mission by making scientific knowledge practicable through business principles and bringing value to government and industry customers, and thereby helping to realise the Dutch and the European innovation agenda. More broadly, this is the task of the applied knowledge infrastructure in the Netherlands and in Europe, where TNO plays a prominent role as the biggest Research & Technology Organisation (RTO) in the Netherlands and the fourth biggest in Europe. These organisations are characterised by their close connections with the worlds of industry, government and science, enabling knowledge to flow between these worlds as a precondition for innovation for the complex issues confronting society.

In substantiating its mission, four core elements are leading for TNO:

- Better world through applied research where sustainability and boosting competitive strength are the guiding principles.
- Smart solutions for complex problems:

Smart solutions for complex problems

- Combination of breadth and depth of knowledge
- Integrating capacity across disciplines
- Innovating, independent, reliable
- Based on applying scientific knowledge

Incubator and springboard for talent

- Motivated, involved and enthusiastic
- Open to change, creative, enterprising
- With inspiring figureheads, based on teamwork
- Most challenging work environment

excellent multidisciplinary knowledge from an independent position.

- Together making more of: cooperation in open innovation with customers and partners in the knowledge infrastructure.
- Incubator and springboard for talent: attracting, developing and allowing top talent to progress in the knowledge economy.

Role of the government

The government plays an essential role, not only as policymaker, customer and launching customer, but also in being responsible for the funding of the necessary knowledge development. The government makes a financial contribution to maintaining the applied knowledge infrastructure and also provides frequent temporary programme impulses through funding innovation programmes and consortia in which industry, universities and applied knowledge institutions cooperate.

Driven by demand

The influence of the government – and other stakeholders – has been growing in recent years with the programming that existed being transformed into a system governed by demand to ensure that the knowledge development really is geared to the issues of major national and European importance. This resulted in agreements about the use of the programme funding along twelve themes with national and European priority. The system will be evaluated in 2010, but experiences so far have proved positive, revealing the importance of a continuous exchange between demand and supply and the need for intensive – and thus often complex – cooperation among the parties involved.

Future role of TNO

Against a background of major societal and economic challenges and the demand experiences to date, TNO considers it necessary in the coming period to opt for a stronger initiating role in eliciting and refining the relevant issues and also in getting new urgent issues on the agenda. By extension, TNO wants to take on a stronger organising and connecting role, where necessary and permitted, in getting the necessary cooperation under way.

Strategic discussion partner

To be able to fulfil this role, TNO must strengthen its role as strategic discussion partner for government and industry and play a more visible role in the innovation debate. A key initiative in this respect is the establishing of a TNO-wide policy research and advisory group Strategy and Change, fully focused on the major societal and economic issues and on the strategic deployment of the technology factor, building on TNO's experiences in the Hague Centre for Strategic Studies (HCSS) established several years ago. A first initiative by Strategy and Change is geared to launching a national platform to get the urgent matter of the impending scarcity of rare metals higher up on the national and European agenda. Page 32 details this initiative.

APPLIED RESEARCH IN THE NETHERLANDS

As part of the national innovation system the Netherlands has a strong, internationally competitive applied knowledge infrastructure (TNO, LTIs, DLO) that provides professional support through applied research and corresponding service to government and industry (major companies and SMEs) from an independent position. In Europe TNO is the fourth largest RTO after the Fraunhofer Gesellschaft (Germany), CEA (France) and Qinetiq (UK). TNO plays a leading role in EARTO (European Association of Research & Technology Organisations), is winner of the European Innovation Prize 2009, and is the only party to be selected (in competition) for each of the three Knowledge and Innovation Communities (KICs) that signal the start of the newly established European Institute of Innovation and Technology in 2010.

Effective demand drive ensures the focus of TNO, LTIs and DLO on the current societal and economic themes as agreed with the government.

TNO safeguards knowledge and facilities of national importance, and contributes proactively to the necessary innovation in the knowledge infrastructure. Examples in recent years are the incorporation of KPN Research, the National Geological Survey, the Netherlands Metrology Institute, the Health Assets Centre and the transfer of TNO activities to Deltares, Imares, etc. In respect of combating the crisis, TNO has played an initiating role in the creation of the knowledge workers scheme, which sees around 800 researchers from companies being placed temporarily at TNO in 2010.

Cooperation, each from its own strengths: a strong presence in the relevant networks enables TNO to make the necessary links in the innovation chain between universities, government and industry.

AGENDA-MAKING ROLE OF TNO: GETTING METAL SCARCITY ON THE NATIONAL AND EUROPEAN AGENDA

'The rise of new regional great powers will cause a run on energy sources, as well as shortages of water and food. And there is the threat to the climate. (...) As a joint report by the US intelligence services concluded last month, 'the next twenty years of transition to a new system are fraught with risks'. I heard the same message last June when I spoke with Tony Lake, one of Barack Obama's foreign policy advisers. Lake even spoke of 'the most dangerous period ever'. (Minister Verhagen, Conference proceedings 'Challenging uncertainties: the future of the Netherlands armed forces', 16-17 December 2008, The Hague)

Scarcity is a threat to stability, economic growth and prosperity. Material scarcity, especially of metal minerals, gets the least attention of all forms of scarcity, but is expected to have the biggest impact on stability among countries. Scarcity is caused by an imbalance of demand and supply. The demand for materials (for instance, chromium, copper, iron and platinum for various uses) has risen in recent decades as a result of economic growth and high-tech innovations (like demand for gallium for solar cells, neodymium for permanent magnets, platinum for fuel cells and lithium for batteries).

Strong emerging economies like China have an unexpectedly major impact on the demand for materials. At the same time, Chinese export restrictions have limited the availability of rare earth-metals. Currently, rare earth-metals are primarily and virtually exclusively produced in China while China has been keeping to its export quota for rare earth-metals since 2004 and intends to completely stop exports of a portion of these metals for its own economy. Thus, scarcity takes on a key geopolitical dimension, making the supply of raw materials less a trading issue than a power issue. This is compounded by, for instance, the acquisition of raw materials by China in Africa, which creates new dependencies.

The supply of materials is unable to keep pace with this rising demand. The materials that are becoming scarcer are present to a much lesser extent in primary ores while the quantity of energy required to extract these ores is increasing exponentially as primary ores reserves decline. Even if the primary ore situation were to remain the same, it would still become increasingly more expensive to extract the materials because they would have to be extracted at even more remote and deeper sites. However, energy is also scarce (the peak production for mineral oil is around 2010), which drives up the price. This means that the amount of technically and economically extractable materials will decline even faster.

Not only is more energy required to extract metal minerals but, vice versa, the scarcity of metal minerals will also have a powerful

impact on the feasibility of the necessary technological solutions for energy extraction. An example: hydrogen fuel cells require around 20 grams of platinum per car, so to produce 10 million hydrogen-powered cars annually, 200 tonnes of platinum per year is needed. This demand is equivalent to the total current primary annual production, and questions the shift to a sustainable and cleaner economy.

Importance of a national initiative

Dutch industry, especially automotive, aviation, building, packaging, solar energy and energy storage, is almost entirely dependent on the import of materials. The economic success of the Netherlands in exporting high-tech products and technologies, and thus the resulting prosperity, is highly dependent on a stable and reliable supply. Innovation and international policy measures are needed to reduce dependence on the import of scarce metal minerals and obviate the availability of critical materials.

In the US, Japan, Germany and the EU various initiatives have recently been taken and measures prepared while the consequences of impending metal mineral scarcity is being investigated in respect of NATO on the initiative of TNO and partly on behalf of the Dutch Ministry of Defence.

An interdepartmental working group is also active in the Netherlands examining the consequences of metal mineral scarcity. The severity of the economic and social impact, however, requires not only cohesion with European initiatives but also a

national initiative whereby government, industry and knowledge institutions come to a joint national research programme based on a comprehensive approach to this problem so as to reduce the vulnerability to the scarcity in the Netherlands. Key questions are:

- What are the threats to and opportunities for industry and prosperity?
- What is the Dutch position in terms of defending strategic interests, reserves or, in the innovation race, developing alternative materials?
- What measures and innovations can reduce the dependence on the import of scarce metal minerals?

The Netherlands is a country that can be distinctive with its multidisciplinary public-private approach geared to innovation and improving its competitive strength.

This national initiative must comprise three key aspects:

1. Intensive and continuous monitoring of the material scarcity, whereby up-to-date, high-tech data on extractable reserves of raw materials, current material streams and technological innovations are essential to policy and innovation. The data must be interpreted inside a context determined by the policy of the countries that produce the raw materials and that of the biggest raw material consuming countries. This monitoring demands cooperation among experts from various disciplines and social organisations, and effective data exchange.

2. Technological innovations focused on less use, the reuse and the development of alternatives geared to extending the lifetime of products (lifetime prediction, chain analysis), or the full non-use of materials (dematerialisation). The disappearance of photographs through the introduction of the digital camera is an example of this. Reuse can be encouraged by a better recycling infrastructure, such as 'degradation on demand', separation technologies based on nanotags and integration in the logistics chain. Also products can be designed such that recycling is more straightforward. Creativity in science and industry must also be stimulated to think of alternative materials. If the functions of rare elements can be assumed by elements that are present in abundance on Earth (the 'elements of hope'), we can offer fundamental solutions. However, this requires drastic re-industrialisation and risk management of potential performance losses. In system design account will have to be taken of not only costs and the environment but also the future availability of materials.

3. Policy for setting strategic reserves to boost the robustness of the system and safeguard the continuity of the industrial production. Also policy must focus on the specific and controlled influence of consumer behaviour to reduce the use of materials whilst retaining economic power at the same time.

Agenda-making role of TNO

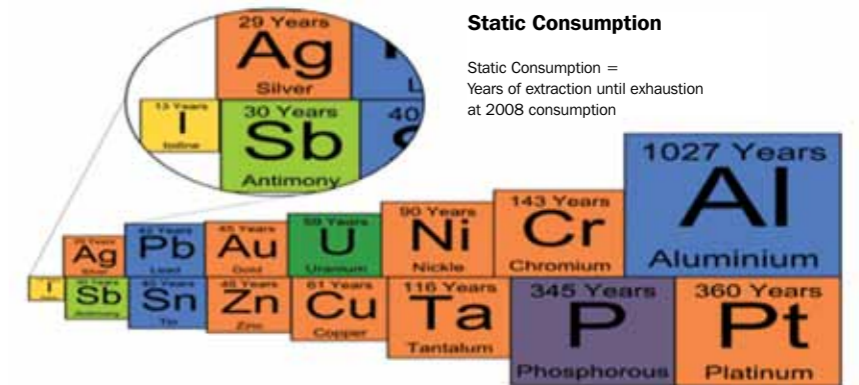
TNO wants to work with the Hague Centre for Strategic Studies HCSS (a TNO subsidiary), which is carrying out a Strategy and Change programme with TNO, to generate a national initiative. Our added value: a comprehensive and multidisciplinary approach inside a complex social and international political context, the capacity to organise public-private solution-specific cooperation and the application of excellent knowledge to arrive at the necessary technological innovations in selective areas, geared to boosting the competitive strength of the Netherlands.

The main stakeholders and cooperation partners in this are government ministries (EZ, VROM, DEF, BZK and BuZa – policy and funding), the industrial companies Shell, Philips, Corus, and the companies affiliated to M2I, Point-One and Holst, the non-technology knowledge institutions Nyenrode, HCSS, University of Leiden and the technology knowledge institutions 3TU. Internationally we are seeking links with KP8, EDA and NATO working groups, and specific universities and NGOs that focus on scarcity-related research. In tangible terms, TNO wants to achieve the following:

- Create a sense of urgency among government and the public, in part via the Strategy and Change programme referred to above.
- By extension, spur on the National Platform for Metal Scarcity that is drafting the national research agenda.
- Direct the public-private consortium undertaking the national research

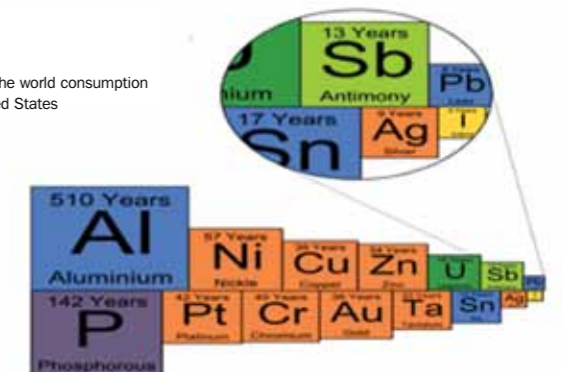
- programme (with government funding).
- Excel with knowledge in the sub-areas: substitute materials based on the Elements of Hope (via M2I), recycling technology, product and process design and influencing behaviour (of consumers).
 - In 2015 sustainable alternatives must be available for at least three critical elements for the applications that have, moreover, led to industrial activities.

SCARCITY OF MATERIALS



Growing Consumption

Growing Consumption = Years of extraction until exhaustion if the world consumption increases to 50% the rate of the United States



Source: HCSS

CONCENTRATION ON SEVEN THEMES

TNO proposes to focus on seven closely interrelated themes during the coming strategy period:

- HEALTHY LIVING
- INDUSTRIAL INNOVATION
- DEFENCE, SECURITY AND SAFETY
- ENERGY
- MOBILITY
- BUILT ENVIRONMENT
- INFORMATION SOCIETY

This section considers the contents of these themes. For each theme TNO wants to base its vision of routes to solutions to a problem and environment analysis and link this as well as possible to the priorities of the stakeholders involved. By linking these priorities to the strengths of TNO, we arrive per theme at one or more innovation areas, nineteen in total, that serve as the intrinsic framework for the demand-driven programmes that we will be drafting in close consultation with the respective departments and other stakeholders.

Criteria for inclusion remain:

- An urgent social and/or economic need
- Support among stakeholders and customers in the market
- A 'right to play' for TNO, in part based on an excellent knowledge position
- A logical embedding in the national and European knowledge infrastructure

The themes are derived from a clustering (based on the strong interrelationships) and refined focusing of the twelve themes from the previous strategy period and are thus a logical extension. The seven themes retain strong mutual links, as in sustainability and competitive strength that are key 'drivers' specified in each theme. 85% of the

'Sustainability and competitive strength are key 'drivers' that are specifically substantiated in each theme. 85% of the innovation areas are wholly or largely geared to sustainability issues.'

innovation areas are wholly or largely geared to sustainability issues.

Compared to the previous Strategic Plan the themes Work & Employment and Food & Nutrition have been incorporated within Healthy Living due to the many synergies and need to focus more on these. For the same reason Defence and Public Safety are brought together in a single theme of Defence, Security and Safety. Constructional and Spatial Development is combined with Natural and Built Environment into Built Environment while the activities in the theme Living with Water have been transferred to the newly formed institute, Deltares. High-tech Systems, Processes and Materials is now known as Industrial Innovation because this better describes the scope and ambition of the theme. We have also proposed a new theme, Information Society, given the societal and economic significance and ambition of TNO to refine its profile in this field. In each of these themes TNO already has an acknowledged and distinctive position in the Netherlands and – in some components – also in Europe. In close consultation with the other players involved in the knowledge infrastructure, this position will be selectively extended in the coming years.

With a view to this, the past six months have seen future and market explorations taking place along with discussions with key figures from government, industry and the knowledge infrastructure. Key questions were: where do the main needs lie for government and industry in the years ahead, how can TNO respond through its technology development and market approach, how can we respond to growing international competition and what alliances will TNO enter into? This approach is governed

not only by TNO wanting to respond to market demand but also pushing beyond this with future-oriented initiatives co-shaped with customers and partners as tangibly as possible through propositions containing the deliverables: knowledge results and applications. This Strategic Plan contains 48 such propositions. As for the choices and details, a new round of consultation will take place with the departments and other stakeholders in the drafting of the demand-driven programmes.

'In each of these themes TNO already has an acknowledged and distinctive position in the Netherlands and – in some components – also in Europe. In close consultation with the other players involved in the knowledge infrastructure, this position will be selectively extended in the coming years.'

THEMES AND INNOVATION AREAS



HEALTHY LIVING



Good health is top of many people's list of happiness factors, and a healthy living means healthy participation in society, healthy lifestyle and good care. Work (paid or otherwise) is, moreover, one of the main factors for useful participation in society. Keys to a healthy lifestyle are aspects like exercise, food and nutrition, habitat and how you work and your working conditions.

Healthy living in the future will require breakthroughs in (the interfaces between) the domains of work, habitat, food and nutrition, medicines, care and recreation, something that requires cooperation among all involved. The manner of innovation in these sectors is developing at a rapid tempo and is occurring more and more interactively with the user (user-led innovation) or in consortia of companies and other organisations (open innovation). While these innovations deserve every possible scope, safety has to be secured.



THEME: HEALTHY LIVING		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> • Vitality for life 	<ul style="list-style-type: none"> • Growing up healthily and safely • Living a long, healthy and active life 	VWS, OCW, EZ
<ul style="list-style-type: none"> • Healthy and safe food and nutrition 	<ul style="list-style-type: none"> • Nutrition concepts that fit a healthy/healthier diet and lifestyle • Efficient development and production of high-quality food and nutrition • Innovations to guarantee the safety of food products and prevent crises 	LNV, VWS, OCW, EZ
<ul style="list-style-type: none"> • Working healthily, safely and productively 	<ul style="list-style-type: none"> • Healthy, vital and safe work • Dealing responsibly with innovative substances and technologies • Employability and social cohesion • Sustainable labour productivity 	SZW, VWS, OCW, EZ
<ul style="list-style-type: none"> • Biomedical innovations 	<ul style="list-style-type: none"> • Prevention and custom-made therapy • Refinement, reduction and replacement of animal testing (3 Rs) 	VWS, OCW, EZ
Markets	Customers	
<ul style="list-style-type: none"> • Food and nutrition 	<ul style="list-style-type: none"> • VWS, LNV, VWA, TI Food & Nutrition, Unilever, FrieslandCampina, Mars, Ajinomoto, Sara Lee, Nestlé, Kraft, Danisco, Danone, DSM, CSM 	
<ul style="list-style-type: none"> • Sustainable chemistry 	<ul style="list-style-type: none"> • SZW, VROM, Dupont, DSM, BASF, Solvay, Honeywell, Sabic, Shell, AKZO 	
<ul style="list-style-type: none"> • Pharma 	<ul style="list-style-type: none"> • VWS, TI Pharma, Pfizer, GSK, Merck, Astrazeneca, Abbott, Crucell, Sanofi, Roche, Actogenix, Bayer 	
<ul style="list-style-type: none"> • Prevention and care 	<ul style="list-style-type: none"> • VWS, NICTIZ, CvZ, RIVM, ZonMW, Achmea, ACTA, EU, Voedingscentrum, Espria 	
<ul style="list-style-type: none"> • Work and employment 	<ul style="list-style-type: none"> • SZW, EU, UWV, RWI, IWI, Achmea, Ohra, SDU, ArboUnie, ZonMW, ExxonMobil 	

WE WANT TO ACHIEVE THE FOLLOWING

GROWING UP HEALTHILY AND SAFELY

The aim is to make the Netherlands again the leader in terms of the health of its children and young people. TNO wants to detect and reduce pregnancy risks using evidence-based methods and thus halve the incidence of infant mortality. Validated tools will allow parents and carers to be better able to recognise psychosocial problems among children earlier.

LIVING A LONG, HEALTHY AND ACTIVE LIFE

To get the Netherlands back to the European top 5 in terms of health, the number of adults exercising sufficiently needs to rise from 68% to 75% and the vitality in respect of major life events (drastic events like operations) increase considerably. TNO will be stimulating this using effective methods for behavioural change and effective means of introducing them.

NUTRITION CONCEPTS THAT FIT A HEALTHY/HEALTHIER DIET AND LIFESTYLE

The positive influence of food and nutrition on public health must be boosted to reduce obesity and thus susceptibility to infection. TNO will develop a method to better measure health based on the 'challenge' concept and so allow the contribution made by food and nutrition to health to be better assessed.

EFFICIENT DEVELOPMENT AND PRODUCTION OF HIGH-QUALITY FOOD AND NUTRITION

The government wants the consumer to choose a healthier and more sustainable diet, with less salt, sugar or wrong fats, for example. The producer wants to retain taste and have smarter and more sustainable processes. In 2014 TNO wants to act as technology partner in the comprehensive development of at least 10 products that fit the healthy, sustainable consumer way of life.

INNOVATIONS TO GUARANTEE THE SAFETY OF FOOD PRODUCTS AND PREVENT CRISES

Our diet will change: for instance, new sustainable proteins are both necessary and in development. TNO wants to contribute to new foods that are safe and cause no new risks like allergies. We will ensure reliable and rapid assessment methods.

HEALTHY, VITAL AND SAFE WORK

If the working population has to remain productive and healthy for an additional two years, their vitality has to be boosted, losses due to ill health must be reduced and more opportunities created for the handicapped to work in modified working conditions. TNO focuses on developing effective interventions and solutions, and preparing these for rollout.

DEALING RESPONSIBLY WITH NEW SUBSTANCES AND TECHNOLOGIES

Industry must be able to innovate at an increasingly rapid speed. TNO wants to enable working conditions to be optimally and safely modified by ensuring timely risk evaluations and safe working processes, for instance in dealing with nanotechnology and green sustainable chemistry.

EMPLOYABILITY AND SOCIAL COHESION

Working together fosters social cohesion. The aim is to reduce by 20% those people not engaged in work, a considerable portion through greater participation among the lower educated. TNO is developing a method that offers work and development for the lower end of the employment market.

SUSTAINABLE LABOUR PRODUCTIVITY

Our level of prosperity depends on a sustainable higher labour productivity. TNO wants to help labour productivity to grow, for example in the prevention and care sector by enabling human potential to be better utilised through innovative forms of organisation, new technology and stimulating workplaces.

PREVENTION AND CUSTOM-MADE THERAPY

A more individualised approach to prevention and curing illness will boost the effectiveness and safety of new medicines. New diagnosis technology and better predictive models will make this possible. TNO will contribute to the development of at least three new combination therapies and an improved diagnostic for metabolic syndrome disorders.

REFINEMENT, REDUCTION AND REPLACEMENT OF ANIMAL TESTING (3 RS)

The number of animal tests in the Netherlands for the research and development of medicines and the evaluation of harmful substances must be cut twice as fast as at present. To this end, TNO will have developed 10 new alternatives to animal testing in 2014.



Below there is more on the future trends and challenges in the field of Healthy Living along with a preferred future scenario outline and the clear TNO answer: innovations focused on four areas: Vitality for life, healthy and safe food and nutrition, healthy, safe and productive work, and biomedical innovations.

THE TRENDS: EXPECTED DEVELOPMENTS THROUGH TILL 2025

Growing up in an ageing society

Children and young people in the Netherlands are generally happy according to international surveys. However, all kinds of trends threaten the health and development of Dutch children and young people. Obesity is increasing strongly among the youth, perinatal mortality in the Netherlands is amongst the highest in Europe, alcohol consumption among Dutch children and young people is high and rising, and a quarter suffers from a chronic illness. Also increasing unsafe behaviour in many areas leads to health risks. And child welfare is fragmented, which means that many problems, like child abuse, remain unnoticed or unsolved. This demands better organisation, better harmonisation and better coordination inside the (youth) care chains.

Consequences of ageing for the balance of care

The Dutch population is ageing without replenishment. In the past century the birth rate has fallen while more hygiene and health have substantially improved, boosting life expectancy and a spectacular rise in healthy longevity. The result is an ageing population. While this can be seen as a social gain, it is also a future challenge that demands care for good health in later life. Also the care demand is shifting to care for (more) chronic age and

prosperity illnesses, also often in combination (co-morbidity). This is a complex care provision; co-morbidity usually requires combinations of therapies that may interfere with each other, and thus drive up the costs of care even more.

In addition, autonomous trends like individualisation, informalisation and computerisation each influence the life style of the Dutch and the care in the Netherlands. While individualisation leaves people more to their own devices, they require as patients excellent care and a lot of privacy. Informalisation diminishes the authority of social authorities like hospitals, ministries and public health inspectorates. Finally, ICT increasingly creates better logistics, registration and research possibilities as well as brings new care concepts within reach, for instance in the field of home care and the empowerment of patients to care properly for themselves.

Food and lifestyle trends

Obesity is public illness number one. It is the result of a different lifestyle, new foods and different diets. Dutch people are exercising less and eating more, more often and more energy-rich food (convenience food). The energy intake is rising but energy consumption falling. The result is obesity that, in turn, leads to a range of health problems, including high blood pressure, arterial damage and heart problems, diabetes, inflammatory disorders, weight problems. This trend is threatening the gains in longevity and health achieved over the past decades. Only if all the factors are tackled together can the tide be turned. Also the food industry is facing international shortages of high-quality ingredients in the coming years through the rising global consumption of meat, fish and dairy products. In 2030 the worldwide

consumption of meat, fish and dairy will be 50% higher than now. The production of these products is adding to climate change and loss of biodiversity – 80% of farming land nowadays is used for the production of meat and dairy.¹¹ This means that demand for sustainable products of high quality is rising and thus a growing need for innovative food products in which biotechnology developments play a key role.

Risks and safety of rapid innovation

Society is globalising, networks among nations becoming closer and tighter, the international traffic of people and goods rising, production chains becoming longer and more international, new technologies like nanotechnology leading to new materials and the increasing speed of innovation accelerating the more rapid introduction of new products and materials. These trends are good for prosperity but also bring new risks.

The spread of pathogens is faster, production chains of food products, for example, become more vulnerable (and thus less safe) and new products and materials can produce new health risks for employees and consumers. The current social attitude is that these risks must be fully exorcised but this attitude neglects the social reality and hinders the speed at which new sustainable products and services can be introduced. The current safety assessment system for the introduction of new medicines, new food products or of new technology-based materials or products can no longer cope with the increasing innovation speed in these areas. Society is disadvantaged, with a delay to the market introduction of products that can give society value and companies responding by reducing their innovation efforts. There is a very urgent need for more intelligent test strategies

that can assess the risks more quickly, with the assessment not merely based on safety but on the balance between potential social harm and social profit of the new materials and products.

Trends in employment and labour productivity

Employment, preferably paid, is critical for the extent to which people experience their lives as meaningful and healthy. While current unemployment levels in the Netherlands are relatively low, a sizeable group of around 1 million people between 18 and 65 years old is inactive. Reasons include insufficient schooling, mental and physical problems and work that does not adequately fit in with the possibilities. This puts this group of citizens outside the loop in terms of participating in paid work and threatens the prosperity of the Netherlands. Moreover, it is a problem for all those individuals that cannot work, with negative consequences for their welfare and health. Finally, the social cohesion of Dutch society is hindered. Work is one of the main uniting factors in our heterogeneous society. Unfortunately, there is much too little scientifically substantiated knowledge about the success factors for (re-)integration trajectories and effective ways of boosting competencies.

At the same time, the manner and conditions of work are changing and we expect the number of flexible forms of contract to increase. Companies are also increasingly operating in networks, thus making the relationship between employer and employee less tangible. The general health of working people is good and constant, but the fall in absence due to illness is receding. Health problems have a growing mental factor: burnout and RSI disorders make up a substantial portion of the illness picture. Health and safety regulations put the responsibility for a healthy and safe workplace

with the employer, so in this respect Healthy Living – as in healthy working in a place that enhances labour productivity – goes together with the theme of Built Environment.

Development in technology and life sciences

The scientific progress of the past twenty years in the life sciences (applied biology) has been spectacular. The emergence of genomics (study of genomes: a set of cell or organism genes) and related disciplines means that we can ask and answer entirely new scientific questions. This offers insight into many, new social applications in areas like food and nutrition, health and sustainability, though much has yet to be achieved here. In the fine chemicals sector (pharmaceutical industry and food industry) more use is being made of biotechnology and biological production processes, and this also leads to fierce global competition.

Medical developments: personalised medication and food

Diagnostics, medicines and 'devices' (as in stents in blood vessels) continue to cross paths, partly because we are literally making technological applications smaller and smaller. Also new sorts of medicines are being developed. Medicines used to be small chemical compounds but are increasingly new medicinal 'biopharmaceuticals' (therapeutic proteins without antibodies). The next generations of therapeutics (gene therapy, cell therapy) will be developed rapidly. We can increasingly individualise health interventions as we boost our knowledge of the human genome and the costs of identifying individual genetic differences decline. For the near future specific individualised therapy may not be achievable

but genetically-based segmentation of patient groups may bring great progress in the relatively short term, a development already under way within oncology. We see the same development with food. Food is vital to human health but here too different individuals react differently to identical food products or patterns. Modern life sciences can adjust food and lifestyle advice to sub-groups and so can be more effective.

THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

Integrating food, lifestyle, working conditions, care and health

The relationship between food, lifestyle, working conditions, care and health is increasingly being laid but the integration of these fields and the cooperation among those involved are more difficult to achieve. What care is needed, for instance, to get people faster to employment? What food can help boost labour productivity and health improvement? What secondary working conditions are needed to enable assistants to give care to those in their vicinity without the risk of becoming ill themselves? These are just a few of the examples that reveal how the integration of different fields is essential to finding solutions for social challenges. In addition to progress inside the various domains, integration is also necessary.

Increase in demand for care, decrease in number of care professionals

If policy remains unchanged, for the current demographic trends in 2025 there will be no professional care for 55 in every 145 patients. One main solution to this problem is to boost labour productivity in the care sector or to limit the demand for care by prevention (encourage healthy lifestyle, realise empowerment among

¹¹ Environmental balance 2009, Central Plan Bureau for the Environment.



patients). One of the problems for the latter solution is that literally and figuratively 'walls' stand between the different sectors involved (like welfare, prevention and care). The views they have of the problem and the solution do not correspond. Also the current law and legislation sometimes forms a barrier to new roles and responsibilities. Moreover, the citizen feels he has a right to care but does not take the responsibility for his own health by a long way.

Healthy and safe food and nutrition

Food is essential to our health. The government therefore wants to draw up a policy that makes it easy for consumers to choose food that fits in with a healthy lifestyle. New foods that are easy to prepare, are tasty and healthy. In addition, the government wants to encourage sustainable choices. The first goal demands faster and more efficient ways of innovating food products, the second goal is to generate models that can predict the health gains and incorporate consumer choice in this. The global food production in the coming decades will come under increasing pressure as the world population increases and farmland decreases. This will drive up raw material prices and demand new raw materials like new food proteins and innovative and sustainable production processes. With new raw materials come new safety risks, such as the allergenicity of new protein sources. But we still want to get new food innovations fast to market so we have to develop new, fast risk assessments for food safety and tools to warn of dangers for (inter)national food safety.

Employment and labour productivity

To hold on to the current level of prosperity and welfare, governments, labour organisations and social partners face key challenges in the coming decades. The size of the working population in

the Netherlands is expected to have fallen by 2040 from 10 to 9 million, while the 'grey pressure' will have doubled from 23% to 47%. The productivity growth in the Netherlands has lagged behind the European Union and OECD average since 2000. Globalisation is putting the competitive strength of Dutch industry under pressure.

Life sciences

In the sustainable chemistry industry the pressure to get products fast to market is considerable. The pharmaceutical industry wants to reduce the time between the development of a medicine and its market introduction. Both developments demand research to predict (more quickly) the effectiveness and safety of products. However, legislation higher and higher requirements for safety, emission and waste management. Also the tighter requirements for purity of raw materials and the development of more complex products set problems. Therefore, we must look for innovation in process and separation technologies that will ensure that the Netherlands and Europe comply with legislation but keep their competitive strength.

Refinement, reduction and replacement of animal testing

The Dutch want a healthy living but increasingly consider it unacceptable for their healthy lives to be at the expense of the quality of life of animals. The social pressure to limit animal suffering, as in laboratory animals, as much as possible is great. This can be achieved by making use of genomics and related technologies but also modern statistical methods offer possibilities to refine, reduce and/or replace animal testing. Also the often poor predictability of animal testing in terms of humans encourages

us to replace animal testing by, for example, in-vitro testing of human material or even in-vivo testing on humans using non-toxic concentrations (microdosing). This development can also accelerate the risk assessment process of new substances.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?

Striving for a meaningful life in good health is, all in all, a broad theme comprising various issues and one that also affects diverse sectors. An all-inclusive vision of what we want to achieve is therefore not easy to define. But there are increasingly more social and policy developments that provide a direction.

Integration of primary care and public health care

First and foremost, we are looking for a lifestyle that the Dutch person of the future¹² can become older and live a longer healthy life. We also want there to be less difference in the health of people. Therefore, there is a policy that (especially for children and young people) combats smoking, alcohol abuse, obesity (sport, exercise and food), diabetes and depression. To this end prevention and care institutions have to cooperate.¹³ Public healthcare is now characterised by fragmentation and lack of scale so the infrastructure has to be adjusted and attention paid to steering by results and funding. Gains can also be made in public healthcare through innovation and more professionalisation. According to the Public Health Department, primary care is already working on prevention but major mutual differences exist and more can be done. More connections between primary care and public healthcare are needed with all parties cooperating to minimise the financial, organisational and mental

obstacles between these systems.

Effective child welfare

A second aim now demanding attention concerns the young, the Dutch of the future. The emphasis lies on prevention in child welfare to prevent illnesses such as obesity, and social problems like rising alcohol consumption among children and young people. This also appears in the report of the Healthcare Inspectorate 'Youth healthcare in motion' (2007).

Effective care for the elderly

Care for the elderly must be effective and efficient, through prevention and proactivity among other things. The report 'Prevention among the elderly: focus on empowerment' by the Health Council (2009) explains the ministerial view. The care must ensure that there is 'less strain, better performance and more empowerment'. The Health Council suggest that there is much to be gained from prevention but it requires all parties to be involved in care for the elderly.

Prevention and care as attractive employer

Part of the ideal picture that emerges from the 'Problem analysis; Innovation in prevention and care'¹⁴, is good, easily accessible and safe care, enjoyable to work in. In other words: 'Dealing efficiently and effectively with the growing and changing demand for care within the requirements of quality and accessibility'. It is important in this that prevention and care is an attractive sector to work in, with good working conditions, for example.

Meaningful and healthy employment

We aim for meaningful and healthy employment. In the Strategic Knowledge Agenda of the respective Ministry (SZW) are five broad policy themes¹⁵ that describe the future of social

cohesion and the future of the system of labour relations and more flexible work and production. An explicit ideal picture or future vision is absent but the wish to boost social cohesion and social mobility and be less dependent on time and place to perform work is present.

Healthy food supply

The food supply must become healthier. In the report 'Measure what we eat' (2004) the RIVM indicates that the government must provide an explicit response together with companies and try to influence consumer behaviour (healthier diet and more exercise). And improve communication on food safety and potential risks. Food safety is generally good in the Netherlands but this must be maintained.

The demand for healthy and sustainable food is linked to this. The Ministry of Agriculture, Nature and Food Quality (LNV) is giving this full attention in 2010.¹⁶ The minister is focusing initially on radical sustainability of production and supply, whereby the entire chain is involved. LNV wants to use an intensive information campaign to take the consumer down the sustainability route. By sustainable the ministry means aspects like use of space and raw materials, emissions, water and energy consumption. But it also concerns less wastage and better welfare for man and animal. In short: production and consumption with respect for animal and environment. The Netherlands must be at the head of the sustainable food field in 2015, an example to the international community.

THE TNO ANSWER: INNOVATE IN FOUR AREAS

TNO wants to contribute to a longer and healthier life, primarily through developing practicable innovative research knowledge. For specific topics TNO can cooperate with other parties on necessary innovation processes. TNO's contribution focuses on topics that are identified as key challenges in this complex field, and where it can also really make the difference. So TNO clusters its expertise to bring about breakthroughs on four innovation areas within the theme Healthy Living.

¹² Based on the memo 'Choose a Healthy Life' by the Ministry of Public Health, Welfare and Sport (2006).

¹³ Memo 'Be healthy, stay healthy; a view of health and prevention' (Ministry VWS, 2007).

¹⁴ 'Social tasks for public health and healthcare', Ministry VWS, April 2009; Problem analysis; Innovation in care, Team Care, June 2008 (a cooperation between the interdepartmental programme board Knowledge and Innovation and the Innovation Platform with the cooperation of VWS, EZ, SenterNovem, OCW, LNV).

¹⁵ Strategic Knowledge Agenda SZW, 2009.

¹⁶ LNV budget for 2010 and memo 'Sustainable food; towards sustainable consumption and production of our food', Ministry LNV, July 2009.



INNOVATION AREA 1: VITALITY FOR LIFE

Focus on:

- Growing up healthily and safely
- Living a long, healthy and active life

Within this innovation area TNO wants to develop, implement, monitor and evaluate scientifically substantiated health interventions (intervene, solve), one of the main areas being Dutch children and young people, from ten months before birth to nineteen years of age. TNO tries to identify risks in the perinatal chain and develops and implements interventions to minimise those risks. And interventions that ensure that 75% of the children with psychosocial problems are identified early (now 40%). We also want to scientifically substantiate the treatment by the paediatricians and nurses. Finally, we are searching for a solution to improve the cooperation in the chain of obstetrics, maternity care, GP, dentist, youth healthcare and child welfare.

TNO also wants to encourage healthy behaviour among broader target groups. To this end we detect the nature and scope of determinants of health and identify critical moments when risk behaviour occurs. Based on these insights we develop effective methods to change behaviour and effective ways of introducing them. Finally, we evaluate and monitor the implemented interventions. Specific target groups are not only children and young people but also employees in risk sectors, fragile elderly people and the chronically ill and handicapped people. The risk behaviours on which TNO focuses are lack of exercise, poor oral hygiene and unhealthy diets.

INNOVATION AREA 2: HEALTHY AND SAFE FOOD AND NUTRITION

Focus on:

- Nutrition concepts that fit a healthy/healthier diet and lifestyle
- Efficient development and production of high-quality food and nutrition
- Innovations to guarantee the safety of food products and prevent crises

Within this innovation area TNO wants to develop concepts to physiologically quantify and substantiate improved health through food and nutrition. Currently, health tends to be defined as the absence of illness. There is no yardstick for establishing whether food and nutrition can contribute to better health, thus a health situation whereby a breach less quickly leads to illness. TNO will develop concepts to quantify health on the basis of the new possibilities created by the life sciences and wants to convince government and industry of these concepts so that they can serve as the basis for product development and assessment.

TNO is also geared to the efficient development and production of high-quality food. The current speed of innovation for new food products is too low. TNO can boost this through developing generic tools to establish the quality parameters of food. We also develop generic modification technology to make products in a more effective and efficient way. Such technologies can boost the innovation speed in the chain. Finally, TNO focuses on food safety within this innovation area. Our high-tech analysis competencies enable us to develop a method to quickly establish the risks of complex food products containing large amounts of unknown compounds and new proteins. We also develop tools that

enable the early warning of hazards for (inter) national food safety and an effective response.

INNOVATION AREA 3: HEALTHY, SAFE AND PRODUCTIVE WORK

Focus on:

- Healthy, vital and safe work
- Dealing responsibly with innovative substances and technologies
- Employability and social cohesion
- Sustainable labour productivity

In this innovation area, too, TNO wants to develop, implement, monitor and evaluate scientifically substantiated interventions (solutions) for several target groups and situations. For instance, to ensure that people can work longer and stay healthy, also in stressful professions (physical and mental). And that people with a health restriction want to and can continue to work. TNO also focuses on boosting the employment of inactive people at the low end of the labour market. We also investigate how we can boost the knowledge and production level of people at the low end of the labour market that may already be in paid employment but often have a low level of education and no formal basic qualification. Furthermore, TNO is geared to the safety of innovative substances and technologies (including nanotechnology) in the work environment. TNO will develop methods to estimate quickly and early the risks of 'low-data' substances, build databases with hazard and exposure information on nanoparticles, predictive models for nanoparticles and models for dealing quantitatively and transparently with uncertainties in the evaluation of risk problems. In this way TNO will contribute to implementing an accepted way of dealing with health risks in

the workplace such that these form no bottleneck for technological innovation.

Finally, TNO focuses on boosting labour productivity, with an emphasis on the public sector, specifically care where we will develop care concepts for the chronically ill. Main focal point: to strengthen the self-management of the patient, an approach that demands care chains to be organised differently and e-health concepts to be developed. TNO will contribute in a consortium with technology suppliers and care institutions to developing a platform for the national rollout of such services.

INNOVATION AREA 4: BIOMEDICAL INNOVATIONS

Focus on:

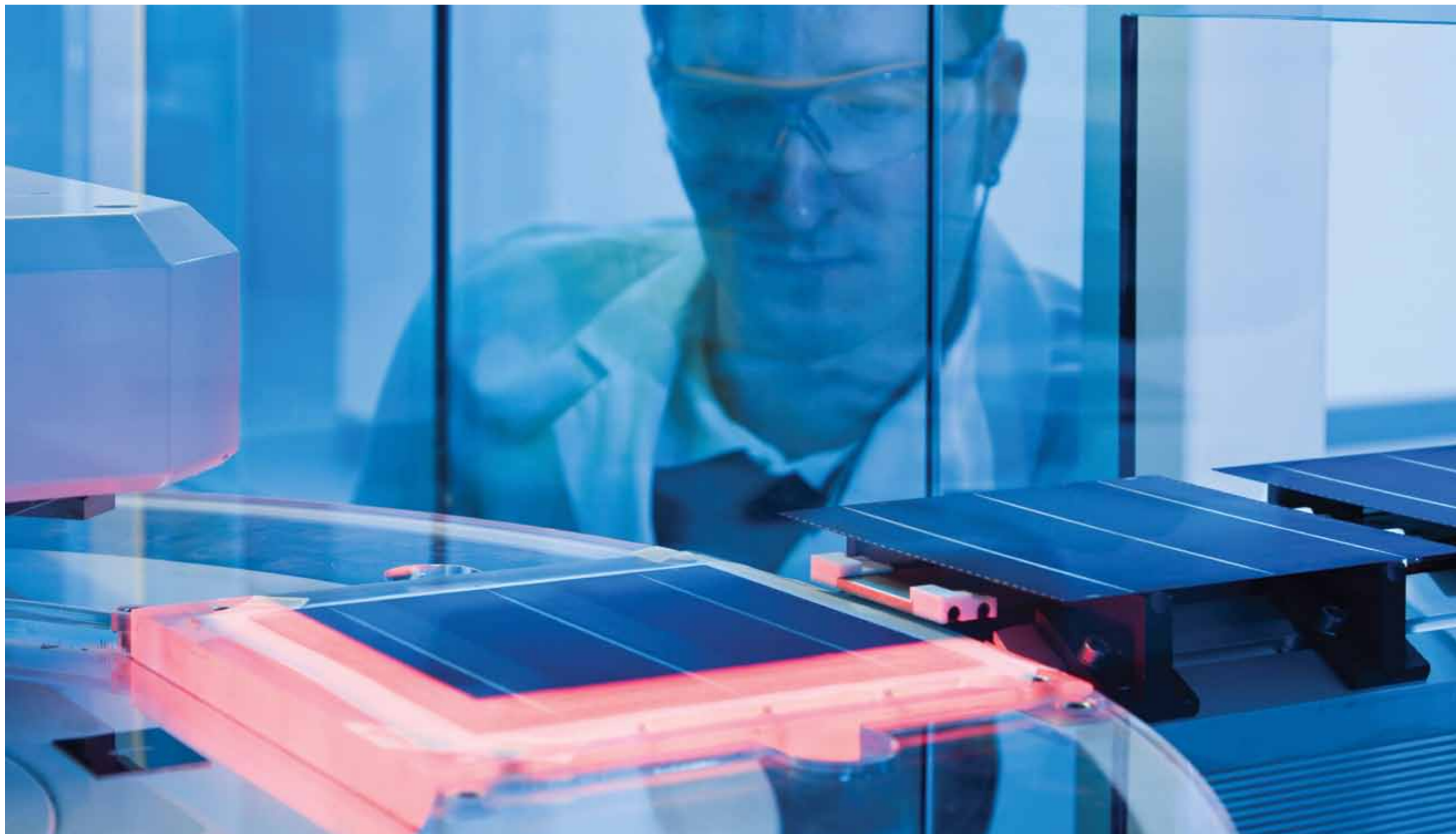
- Prevention and custom-made therapy
- Refinement, reduction and replacement of animal testing (3 Rs)

Recent developments in the life sciences, namely the development of genomics and related disciplines, open the way to new applications in society. The area in which TNO wants to help transform these developments into social applications are: the development of 'custom-made therapies' including existing or new medicines (geared to segmented patient groups) and the application of industrial biotechnology for better and more sustainable production processes for food, medicines and other chemicals. Also TNO wants to reduce animal testing by developing alternatives.

In developing 'custom-made therapies' TNO focuses on the metabolic inflammatory syndrome. We will establish responder and non-responder profiles for key existing medicines that when

implemented will lead to less medicinal use for the non-responders. We will also contribute to combination therapies, again on the basis of segmentation of patient groups. And we will develop system biological in-silico, in-vitro and in-vivo models that can better predict the effectiveness and safety of new medicines for metabolic syndrome. This will enable animal testing to be reduced and replaced. The spearhead in the development of alternatives for animal testing is, for example, in the field of pharmacokinetics. By further development of the patented TIM (TNO Intestinal Model) we can find the best medicinal compound without the need for animal testing. Also microdosing makes the intermediary animal testing stage redundant. This involves testing very small non-toxic quantities of new medicines and foods in people. Another spearhead is the safety of chemical substances. For instance, by revealing chemical affinity we boost the development and acceptance of non-testing strategies.

INDUSTRIAL INNOVATION



Industry in the Netherlands steers economic development and also plays a key role in the societal themes we describe in this Strategic Plan. To tackle the challenges inside those theme areas, we need industry. But that industry is, in its turn, under considerable pressure from the economic crisis and the explosive economic development in countries like Brazil, Russia and China. So it is of utmost urgency that in Europe and the Netherlands a new position is determined in respect of the development of industry where labour productivity must increase and for which knowledge is crucial. By making effective use of and innovating knowledge, new industrial activities can be built up. Also in the industry that already exists, more intensive use must be made of knowledge. Because this can give industry a unique position. This requires innovation efforts to focus on key areas and broad support for the social innovation agenda. The possibilities of the national and European markets can be better utilised for innovation, for instance by using the Dutch market as a field lab for innovations. New cluster policy and SME policy must strengthen each other. Knowledge workers of the future opt for lifelong learning and have to be given opportunities to this end. On these points particularly TNO wants to help industry and support government in the coming strategy period. Through technological innovations and by bringing stakeholders from different industry sectors together. The social transition to solar energy, for instance, demands not only cheaper, more efficient solar cells but also architectural innovations from architects and smart meters to resupply the energy to the grid.

THEME: INDUSTRIAL INNOVATION		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> • High-tech Systems and Materials 	<ul style="list-style-type: none"> • Integrating the semiconductor equipment industry • Equipment for integrated products • Large area electronics • World class instruments for highly demanding environments 	EZ, OCW
<ul style="list-style-type: none"> • Maritime and Offshore 	<ul style="list-style-type: none"> • High-tech maritime and offshore systems 	EZ, OCW, VenW
<ul style="list-style-type: none"> • Chemistry 	<ul style="list-style-type: none"> • Small-scale sustainable chemistry for large-scale production • Innovative industrial risk management • Maximum utilisation of biomass as raw material for chemistry and agro-industrial sector/bio-based economy products 	EZ, OCW, LNV
Markets	Customers	
<ul style="list-style-type: none"> • Semicon 	<ul style="list-style-type: none"> • EZ, ASML, BESI, IMEC, NXP 	
<ul style="list-style-type: none"> • Space 	<ul style="list-style-type: none"> • ESA, TAS, Astrium, ESO, NSO, Dutch Space, Thales, SSTL, Galileo • Cosine Research, ISIS, OHB 	
<ul style="list-style-type: none"> • Maritime 	<ul style="list-style-type: none"> • Bluewater, SBM, Boskalis, Heerema, Allseas, SBM, IHC, Wartsila 	
<ul style="list-style-type: none"> • Chemistry 	<ul style="list-style-type: none"> • Evonik, Vertellus, Dow, Huntsman, Ineos, DSM, Solvay, Merck • GSK, AKZO, Lonza, Clariant, Bronkhorst, Chemtrix, LyondellBasell 	

WE WANT TO ACHIEVE THE FOLLOWING

INTEGRATING THE SEMICONDUCTOR EQUIPMENT INDUSTRY

TNO wants to help strengthen the international position of the Dutch high-end equipment builders in the semiconductor market. We will help to make the integration of new technologies and the required cooperation of companies possible (especially for 3D chips), so that Dutch companies can extend their number one position.

EQUIPMENT FOR INTEGRATED PRODUCTS

The high-tech industrial ecosystem in the Netherlands can be strengthened by responding to the trend of the radical miniaturisation of products and less use of (expensive) material. TNO will develop high-end flexible and economically viable production technology for on-demand manufacture and we want to help build the advanced automatic equipment needed for this.

LARGE AREA ELECTRONICS

Production volumes of efficient, affordable solar cells and highly energy-efficient lighting systems will rise explosively. Intelligent energy and lighting concepts will reduce the (net) energy consumption of buildings by at least 25%. TNO wants to help make the difference through our thin-film methods, roll-to-roll production, print technologies and rapid vapour solutions.

WORLD-CLASS INSTRUMENTS FOR HIGHLY DEMANDING ENVIRONMENTS

Scientists and other users have to be able to use precise tools to solve societal issues concerning the environment (Earth observation), energy (nuclear fusion) and health (diagnostics and therapy). TNO wants to help do this by developing extremely precise, small, light and reliable tools able to function under extreme circumstances.

HIGH-TECH MARITIME AND OFFSHORE SYSTEMS

Industry wants to boost the operational reliability, availability, safety and maintainability of complex high-tech maritime and offshore systems made in the Netherlands. TNO wants to help achieve very high reliability for these systems for deep-sea activities (up to 3 km deep) that are difficult to control and maintain at great distances, as in space systems.

SMALL-SCALE SUSTAINABLE CHEMISTRY FOR LARGE-SCALE PRODUCTIONS

The sustainable chemistry industry can be helped to replace batch production by very controlled flow production, which can operate more safely and cheaply (20% in the coming 5-10 years) and sustainably, with much less energy loss and waste. TNO wants to develop and help introduce technology that enables high-end process intensification solutions.

INNOVATIVE INDUSTRIAL RISK MANAGEMENT

The sustainable chemistry industry wants to have a sustainable transition from 'control of safety' to 'optimisation of production process', also among high-risk companies with a complex production process. TNO will develop methods for the design, control, use and maintenance of large industrial systems, with major investments and a long planned lifetime (30+ years).

MAXIMUM UTILISATION OF BIOMASS AS RAW MATERIAL FOR SUSTAINABLE CHEMISTRY AND THE AGRO-INDUSTRIAL SECTOR / BIO-BASED ECONOMY PRODUCTS

The 'biobased economy' is approaching – in 20 years not 20% but 50% bio-based material will be used in chemical processes. TNO will develop technology for sufficient production of the right types of biomass and help to create sufficient primary conversion capacity to convert this biomass into products that the current sustainable chemistry industry can process.

Below is more on the future trends and challenges in the field of Industrial Innovation followed by an outline of a desired future scenario and the clear TNO answer: a choice for specific innovations in three areas: high-tech systems and materials, maritime and offshore, and sustainable chemistry.

THE TRENDS: EXPECTED DEVELOPMENTS UNTIL 2025

Economies becoming more open

Goods, services, capital, labour and knowledge are becoming easier to exchange internationally, without barriers. This is due to both the unification of markets and technological innovation. This trend means more competition, which boosts international trade and brings more and more foreign employees to the Netherlands and sees companies more often moving to low-wage countries (offshoring).

Production factors becoming scarcer

Scarcity of production factors, both labour as well as energy and raw materials, cannot be compensated in many cases by drilling new sources. Therefore, industry must be more productive and inventive with the sources there are. Transport and production costs will rise mainly due to the expected rising price of fossil fuels and key minerals. CO₂ emission levies are also expected to rise. This all makes it even more important to maintain the existing industry.

Societal issues becoming more complex

The problems we confront as a society (accessibility, safety, environment, energy, health) are becoming more and more complex and obstinate. The government cannot solve these problems on its own but needs others, including entrepreneurs and employees.

Technological developments generate new products and new knowledge

The development of industry is also determined by the following technological developments:

- miniaturisation: products are becoming increasingly smaller and sophisticated through nanotechnology;
- more advanced ICT: faster, smaller and more storage capacity;
- ambient intelligence: high-tech, intelligent products with integrated hardware components and software, able to communicate with each other, offer security and possess new functionalities;
- high-tech materials: smart materials with added properties for more functionality, whereby the material itself measures and takes action, e.g., the 'smart plaster'.
- biotechnology: as alternative for crude oil, more flexible, giving society, including industry, more flexibility of raw material choice.

These technological developments concern both industrial products and production facilities, leading to sophisticated products and knowledge-intensive production facilities. They require companies to have to continually develop knowledge and (entrepreneurial) innovation, and make it possible for industry to compete with products and facilities from low-wage countries.

THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

The main challenges for the near future are to help industry out through new innovations and to diminish the innovation paradox. Focusing on key societal issues offers new opportunities and more effort has to be made in terms of open innovation and cluster policy as well as cooperating nationally and internationally on key technologies.¹⁷ To give Industrial Innovation a real chance, it is crucial to constantly develop and exchange knowledge.

Weakened Dutch competitive strength

Internationally the Netherlands is losing ground despite the presence of several strong industries, strategic location, good level of education, good science culture and several strong economic key areas. In these times of crisis competing countries like the United States, Germany, Finland, Sweden and Canada are investing substantially more in education, research, innovation and entrepreneurship. If we are not to fall further behind, the Netherlands must accelerate efforts in these areas. The knowledge workers scheme and high-tech top projects, implemented in 2009 as temporary crisis measures, form an excellent basis and must therefore be transformed into a continuous cooperation platform for companies and knowledge institutions. Moreover, accumulated knowledge finds it hard to get into market applications. This so-called innovation paradox is a point of concern for the Dutch economy. This means that policy must be geared not only to investing in R&D but also to getting the social pay-off on these investments.

Pressure on production and human capital through economic crisis

The financial and economic crisis that began in 2008 has drastically changed Europe's economic prospects for the near future, with both European prosperity levels and the level of employment declining as a result. Poorly performing companies are downsizing or being dismantled. And large companies risk having to cut back on the R&D facilities they have built up. Another point of concern in industry¹⁸ since the crisis is the shortage of personnel that may not be needed now but will be needed soon. The main capital of a knowledge economy or knowledge society is the talent of the people working in it. This capital 'wears' if it is not used and so needs to be in constant use and be maintained.

Major share of industry in GNP is key to economy and competitive strength

The European Commission's Lisbon agenda (2000) aims to enhance the competitive strength of industry sectors, support companies in major sustainability issues, encourage innovation in Europe and create favourable conditions for SMEs. However, the EC has realised that the targets set in this agenda have been insufficiently achieved. The SER has derived the following focal point for the Netherlands: more accent in the coming years on greater labour productivity. In Dutch industry from 1995 until 2005 in a wrong sense¹⁹ labour productivity increased by 2.9%, which is good compared to other countries in Europe, but its contribution to the gross national product (GNP) fell from 1995 until 2008 from 16% to 15% and the proportion of people working from 16% to 12%.²⁰ A lively debate is under

way on whether economic development is being adversely affected due to the declining share of industrial activities in the GNP. Gerard Kleisterlee, chairman of Philips, argues for a minimum share of 20% for industrial activities as is the case in Singapore. In industrial sectors an increase in labour productivity²¹ is also achievable because every job in industry creates a job in the service sector. The services of advertising agencies, banks and sales organisations are needed to create and sell industry's products. Moreover, industry is the engine behind our export and the cradle of our knowledge economy. This growth of industrial activities is not, however, self-evident since knowledge-intensive industrial activity that does not pollute and helps to solve societal issues can only grow if government and industry invest heavily and specifically in innovation and development.

Need to focus and cluster innovation efforts

To gain a competitive position in the international arena, the Netherlands must focus and cluster its innovation efforts on a national scale. The Dutch economy is the world's fifth largest exporter and second in terms of agro/food. In the petrochemical industry Rotterdam is the world's turntable and in terms of high-tech manufacture Brainport Eindhoven gives the Netherlands a very strong position in complex optical mechatronic systems. The government has called these economic areas key areas. This key area approach has been detailed in innovation programmes established by the government together with industry and TNO. Between 2004 and 2006 the Innovation

Platform assigned six key areas: High-tech Systems and Materials, Water, Chemistry, Flowers and Food, Creative Industry, and Pensions and Social Insurance. The challenge is to strengthen this key area approach and to harmonise the R&D efforts of the various players, giving the pioneers free rein. By focusing on real innovation, those parties that can really make breakthroughs are facilitated.

New innovative partnerships

Knowledge is crucial for industrial innovation but the challenge is to optimise the application of that knowledge. Only knowledge that is consciously clustered at regional level can be quickly translated to the market. The gap between knowledge and application can be bridged by identifying and encouraging innovative SMEs, especially those high-tech SME suppliers that do not have their own R&D facilities. Such routes enable knowledge developers to gain more insight into the needs and wishes of the market and the companies acquire more affinity with new technological possibilities. In new innovative partnerships potentially many new products and new product-service combinations can be developed. The challenge for TNO is to find exciting partners within the key areas with the aim of creating new opportunities for industry.

Societal issues as opportunities for industry

The Social Innovation Agendas (SIAs)²² established by the Ministry of Economic Affairs offer many opportunities to national industry. That industry can play an important role in solving societal issues like energy, mobility, safety, water and health – areas for which SIAs have been made. It is precisely this

¹⁷ Industry letter 2008, Ministry EZ; in addition to concern, accessibility, legislative pressure the international level playing field.

¹⁸ Industry in the sense of 'trade' with the following sectors: mineral production; industry; production and distribution of and trade in electricity, natural gas, steam and water; building and construction.

¹⁹ Source: figures from the CBS, revised by Walter Manshanden (TNO, 2009).

²⁰ NRC, December 2008.

²¹ Advice of SER, June 2009.

²² The Ministry EZ set up Social Innovation Agendas (SIAs) in the first part of 2008 for the themes Energy, Health, Safety and Water. The SIA Education and the SIA Sustainable Agro- and Fishery chains were completed in 2009. Also a SIA Sustainable Mobility has begun.



cohesion between industry and societal issues that offers benefits to the economy and a contribution to society. The challenge is to bring parties together to do this, sometimes across the borders of existing industrial chains so that companies focus not only on developing next generation products. Legislation is crucial here, as is apparent from the enormous encouragement German legislation on energy has given industry for sustainable forms of energy. If the Dutch government presents itself as a (launching) customer that (within the assignment) facilitates innovation in the development and execution of the SIAs, then this will give a considerable boost to the desired industrial innovation.

The Netherlands as field lab

The prosperous market in the Netherlands can be used (much more than it is now) explicitly as a test environment for innovations. The Netherlands has highly educated critical people and is thus a perfect environment to try out and to develop new innovations, for instance in the area of care. The challenge is to gain this unique position by more experimentation, through developing new innovation methods to strengthen this, like 'living labs' and 'fablabs'²³, and by cooperating with other innovation parties. This will bring practice and knowledge closer together and allow the Dutch market to expand as a test environment.

Strengthening the knowledge economy

To give industrial innovation more of a chance, the whole knowledge chain must be strengthened: from pre-school education and life-long learning to excellent scientific research and innovative entrepreneurship involving several ministries, social

organisations and industry. But also industry itself has to work on new forms of knowledge transformation and cross-fertilisation. A good example is knowledge brokerage, the auctioning of knowledge issues via internet. Another effective way of collective learning is to allow knowledge and experience to circulate. R&D experts must be more mobile, their work and experience must not just circulate among the companies themselves but also among universities, research organisations and other companies. To reduce the gap between new knowledge and practical application, the knowledge must also be continually facilitated and strengthened in the SME sector. For TNO, and this theme in particular, it is vital that engineering education becomes popular again so that we can source from a larger employment supply.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?

The future picture we want to see for the theme Industrial Innovation is roughly an enterprising and innovating industry and production and innovation based on social commitment and an eye for sustainability.

An enterprising and innovating industry

The industry of the future²⁴ is enterprising and innovating, and knows how to expand productivity levels. It is also an industry that excels internationally through specialisation. Such an industry is based on a knowledge society. If Dutch industry fully takes up this strategy, the share of industrial activities in the GNP in the Netherlands will increase.

But how will industry become enterprising and innovating? Partly through the continual

exchange between SMEs and knowledge institutions, which will also encourage the practical application of high-tech knowledge. The industry of the future makes optimum use of raw materials and energy, and optimises both the productivity and the quality of its products through the systematic and comprehensive cooperation with other stakeholders in the whole value chain, such as the government, knowledge institutions and industry. At the same time industry is continually focused on the international arena and its competitive strength. If the Netherlands focuses on a number of key areas, it will be able to specialise in a number of niches, and be a leader in them within Europe.

A socially committed industry, producing sustainably and innovating

In addition, the industry of the future responds strongly to societal issues, producing sustainably and innovating in the areas of sustainability, care and general safety. It produces sustainably by constantly improving production processes (green machines), learning from others and cooperating. Also the amount of industry waste will decline because the respective parties will manage to close their cycles. Alternatives will have been developed for the increasingly scarce materials, and the sustainable bio-based economy will come ever closer. TNO acts as a prompter and integrator.

New innovations from industry enable, for example, carers to provide better care with fewer people (see also theme Healthy Living), to reduce the costs of surgery and make solar heating affordable. Innovations in an early stage of development will have a chance in this industry, precisely where key social challenges lie. Intensive cooperation among

industry, the government and knowledge institutions is a prerequisite for this.

For the industry of the future a knowledge society is necessary, with a continual flow of enough qualified personnel. This demands the entire knowledge chain to be strengthened: from pre-school education and life-long learning to excellent scientific research and innovative entrepreneurship.

THE TNO ANSWER: INNOVATE IN THREE AREAS

Bringing knowledge and application closer together: that is what TNO sees as its core business. And so it helps to diminish the innovation paradox. All activities of TNO to support industry and government can be seen in this light. In addition, TNO – together with other players in the value chains – wants to achieve innovations or breakthroughs in the diverse industrial value chains, and transfer those innovations to others in that chain.

TNO wants to focus on the key areas stated by the Dutch government, within which the challenge continues to be to help Dutch companies through innovations to strengthen their positions in the value chains. To achieve this TNO uses its expertise in the following three innovation areas.

²³ In a 'fablab' people can realise their ideas in a prototype or product using high-tech equipment. The fablab concept was developed by Neil Gershenfeld at MIT (US) and stands for fabrication laboratory. The fablab concept is now a worldwide phenomenon.

²⁴ Also based on Industry Letter 2008, Ministry EZ.

INNOVATION AREA 1: HIGH-TECH SYSTEMS AND MATERIALS

Focus on:

- Integrating the semiconductor equipment industry
- Equipment for integrated products
- Large area electronics
- World-class instruments for demanding environment and applications

The Netherlands has a unique position in the world market for complex equipment and high-tech systems. We produce the equipment for the manufacture of electronic goods that are becoming ever smaller and acquiring increasingly the properties of flexible foil. The emergence of flexible solar cells and organic light-emitting diodes (OLEDs) requires entirely new production equipment. In this area Dutch players have to gain a prominent position.

TNO mobilises consortia in this innovation area and puts its multidisciplinary competencies and domain and system knowledge to use for the players in the value chains and other knowledge institutions, offering the following eight core competencies:

1. system architecture: system behaviour/ design, often relating to physical-transport phenomena;
2. optronics (and contamination control): precise control of photon paths in extreme environments;
3. nano-/micro-/organic electronics: precise control of small flows of electrons;
4. flowtronics: flows to precisely control intensive processes (instead of batches);
5. mechatronics (and precision engineering): precise control of moving masses;
6. infotronics (from sensor-electronic

dataflows): determine model-based information;

7. devices, especially sensors (Holst Centre, RF, nanophotonics);
8. materials: for example nano or biomaterials

The added value of TNO lies in our capacity to develop and to introduce new technologies faster based on these competencies. TNO is distinctive in its capacity to achieve paradigm shifts and make the unexpected a new reality. TNO finds it essential that innovative industry also in the Netherlands has sufficient scope and facilities. Large companies with distinctive products, like Philips, ASML, DAF, Shell and Unilever, have less and less of their production in the Netherlands and for their markets Asia is becoming more important. This makes it even more vital for Dutch industry to excel in a knowledge economy in which we can provide a world-class supply chain to these key players. TNO wants to facilitate this through translating ideas or new products into processes that enable equipment makers to design and deliver equipment. Also we want to further develop and convert new ideas into prototypes of, for instance, new tools and process-intensive equipment. Our existence as a player is justified by, among other things, our transformation of value chains by innovation, as we did in EUV (extreme ultraviolet technology in the wafersteppers of ASML), Bluebird (3D stacking of chips) and Holst (polymer electronics).

INNOVATION AREA 2: MARITIME AND OFFSHORE

Focus on:

- High-tech maritime and offshore systems

The maritime sector contains an industrial chain of shipyards, suppliers and operators. The offshore industry explores and produces mainly oil and gas at sea, and also increasingly more wind energy. TNO wants to use the technology it has developed in various markets (high-tech manufacturing, sustainable chemistry, energy and utility companies and building) also in the maritime and offshore market where TNO sees possibilities for new innovations that can help solve societal issues.

The Dutch maritime industry was restructured in the eighties and nineties, resulting in the disappearance of many shipyards. The sector came out of it more strongly but the structure of the industry is quite different. The emphasis has shifted from building to design. Dutch ships have to be smart ships, cheaper, cleaner, safer and easier to operate than other ships.

The Dutch maritime and offshore sector can only remain competitive through supplying sophisticated systems that perform better than vessels and offshore installations of low-wage countries. The main performance indicator in this sector is the total cost of ownership. The objective is for the Dutch maritime industry to be among the world's top three in 2015, so we have to focus on the following (main) goals:

- boost the operational reliability, availability and maintainability of process installations, systems and structures on floating

production platforms, subsea compression and separation skids, orientation, ROVs;

- enable the application of deep-sea activities (up to 3 kilometres deep);
- reduce the 'environmental footprint';
- boost safety in relation to off-spec conditions;
- translate into new designs from a material scarcity perspective;
- quantify safety.

TNO has a leading position in these areas through knowledge, facilities and cooperation with partners (including MARIN in the field of hydrodynamics).

The Maritime Campus The Netherlands (M3), set up through our initiative in Den Helder, will cluster education, research and entrepreneurship in the field of the sea and shipping. This partnership offers a good platform to expand the innovation area 'Maritime and offshore' in the Netherlands.

INNOVATION AREA 3: CHEMISTRY

Focus on:

- Small-scale chemistry for large-scale production
- Innovative industrial risk management
- Maximum utilisation of biomass as raw material for chemistry and agro-industrial sector/ bio-based economy products

Diverse trends are visible in sustainable chemistry. The general trend is that the environmental impact of the industry is being repelled. Moreover, there is the risk of a structural shortage of raw materials like oil and gas. In addition, for special products (from polymers to pharma), including medicines and food ingredients, two key challenges exist:

- get products faster to market;
- be less dependent on raw material prices.

To tackle these challenges, the sector needs new, advanced process technology. To develop this, TNO focuses primarily on the special chemistry and fine chemistry. This is the upper part of the value chain, from polymers to pharma. In this part of the value chain the production volumes are relatively small and there is more often investment in new equipment if this is needed to get new products to market. In that sense, this part of the sector is more innovative than bulk chemistry. Many products in the special chemistry and fine chemistry are produced in generic equipment. In bulk chemistry, by contrast, equipment is specifically designed for one product. This means that the development of that equipment for a company is often of strategic importance. Higher in the value chain generic equipment tends to be used, also

developed in open innovation. The strategic knowledge of the companies is then contained in how this equipment is controlled and connected. The developments for special chemistry and fine chemistry may well lead to spin-offs for bulk chemistry, like pre-connected, small-scale solutions to mix biomass in raw material flows and slight adjustments to save energy.

For high-risk companies with complex production processes it is essential to optimise the design, control, use and maintenance of larger production systems (of more than 100 million euros and with a lifetime of more than thirty years). Therefore, TNO focuses on system modelling for processes where account must be taken of production, safety, maintenance and investments.

DEFENCE, SECURITY AND SAFETY



Throughout the world security and safety are primary concerns for the future. Both at global and local level, the future will be characterised by economic, physical, ecological, territorial, social and political instability. External and internal security are becoming increasingly interrelated.



THEME: DEFENCE, SECURITY AND SAFETY		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> Globally deployable armed forces 	<ul style="list-style-type: none"> Cost effective operations Information superiority As safe as reasonably affordable Better performance with fewer people Coalition operations 	DEF
<ul style="list-style-type: none"> Safe and secure society 	<ul style="list-style-type: none"> Tailor-made security & safety policy Tailor-made surveillance and investigation Professional law enforcement and crisis management Resilient critical infrastructures 	BZK, OCW, DEF, EZ, JUS
Markets	Customers	
<ul style="list-style-type: none"> Defence 	<ul style="list-style-type: none"> DEF, BZK, JUS, BuZa, EZ EU, NATO, EDA, MoDs Thales, EADS, BAE, Rockwell Collins, Northrop Grumman, Blücher, Rheinmetall, Diehl, Oto Melara, Photonis, TenCate, Corus, DSM Law enforcement and Customs 	
<ul style="list-style-type: none"> Security & Safety 	<ul style="list-style-type: none"> DEF, BZK, JUS, BuZa, EZ EU, NATO, EDA, MoDs Thales, EADS, BAE, Rockwell Collins, Northrop Grumman, Blücher, Rheinmetall, Diehl, Oto Melara, Photonis, TenCate, Corus, DSM Law enforcement and Customs 	

THE TRENDS: EXPECTED DEVELOPMENTS UNTIL 2025

Increased uncertainty about security

Various environmental analyses, as performed for the Dutch MoD Strategic Review and the Multiple Futures Project of NATO, make it clear that the coming two decades will be characterised by greater uncertainty about the international and national security situation than has existed over the past fifteen years. The world is certain to undergo major changes but it is uncertain what these will be and what the consequences will be. While the potential for growing conflicts is certain, there is less certainty about whether this will actually result in more conflict and what form such conflicts may take. The uncertainty about future developments is related to the following fundamental factors:

- Globalisation has made mutual dependencies stronger and more complex, combined with a gradual 'dilution' of state power due to the emergence of non-state players.
- The imbalanced growth of the world's population, the increasing scarcity of natural resources, global warming and damage to biodiversity.
- The economic crisis and its possible consequences for the balance of power in the world and international and national security, in both the short and long term. The relative weakening of the power of the West and the emergence of new major powers is also leading to increased uncertainty.
- Power shifts will often be coupled with a higher risk of political, economic and military conflict. A multipolar world order is always less stable than a bipolar (as in the Cold War) or unipolar (post-Cold War) one.

- The role the armed forces and law enforcement agencies play in the protection of national interests will increase. Expeditionary operations in coalitions will be needed as will integration of diplomatic, political, economic and military means in a comprehensive approach geared towards Development, Diplomacy, Defence (3D).
- The financial muscle to respond to increasing threats will be seriously reduced by the current economic crisis and the rising costs of care and ageing.

External security: increasingly complex package of tasks

Against this background is the picture of the threat posed to Western countries like the Netherlands in the coming years. Like (interim) state conflicts, scarcity of raw materials and energy, weapons of mass destruction, digital vulnerability (cyber warfare), terrorism, cross-border crime, piracy, flooding and pandemics. This changing picture of threats has drastic consequences for Dutch security and for the developments regarding the essential operational capacities of Defence. The past decades have seen a radical transformation in the armed forces, which has seen a classic fighting force whose objective is the defence of Dutch territory and that of its NATO allies become a modular professional army carrying out an increasingly complex package of tasks in expeditionary operations far from home. Since the beginning of the 1990s, there has been increased emphasis on operations against asymmetric adversaries, while the apparent need to have escalation dominance remains. Cooperation with governmental and non-governmental organisations must lead to a successful approach focussed on reconstruction and support among the population.

National security: need for a cohesive approach

The attacks of 11 September 2001 in the US and then in Madrid (2004) and London (2005) were a catalyst to review terrorist threats and national security. The realisation has also emerged that – regardless of classic disasters – the huge impact of climate change, scarcity of minerals and energy, and pandemics can pose a significant threat to Dutch vital interests. Increasing independence within our critical infrastructures and public systems can cause relatively small incidents to become a major disruption to society. The security approach must therefore be increasingly geared towards comprehensiveness and cohesion. Coordination and cooperation in the field of national security are becoming stronger. With the appointment of the National Coordinator for anti-Terrorism (NCTb) and the political acceptance of the National Security Strategy (2007) and the National Security Project, attention for national security – that is, anything that could disrupt Dutch society – has been institutionalised. The government has decided to form safety regions in which various bodies and services cooperate. In addition to the police, fire brigade and GHOR (Medical Assistance in Accidents and Disasters), the Ministry of Defence is a permanent security partner. This raises new questions about command and operational responsibilities.

Finally, society is focusing more on issues of public order, like effective enforcement and policing and better surveillance, which directly concern the security of our surroundings. The plea for a zero-risk society has been apparent for some time and will continue.



THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

Defence: seeking optimum balance between ambition, capacity and funding

Defence is confronted by the challenge of finding a sustainable, dynamic balance between ambition (roles, missions and tasks), capacities (composition, equipment and kind of operation) and available financial resources. In the Defence Reconnaissance project policy options have been developed to support the next Cabinet to decide on the future role and structure of the armed forces. The main policy priorities stated in the 'Worldwide Serviceable' memo and detailed in the Strategic Knowledge Agenda (SKA) of 2008 are: financeability, availability of personnel, versatile deployable armed forces, co-player in prevention and peace-keeping, security partner in the Netherlands and international cooperation. The price-performance ratio of military output – in terms of actual operations and 'having' ready-to-deploy armed forces – requires constant attention. (Possible) deployment in a broad spectrum of missions and a large variety of circumstances within a mission demands from the armed forces flexibility, adjustment and robustness. This leads to considerable demands with regard to 'strategic pliancy' and availability and reliability of capacities. It is crucial to be able to cooperate effectively in coalitions that are highly dependent on the effective interoperable deployment of all capacities in respect of integrated policy. In particular, the latest information and communication technology offers opportunities for reinforcing learning and organising capacity both at the individual level and collectively.

Security organisations/Ministry of the Interior and Kingdom Relations: cohesive management and measures

The security organisations are also faced with the challenge of improving their flexibility, adaptability and embedding in partnerships. However, as with Defence, costs are increasing and funds decreasing. Significant efforts will be needed to cope with disaster and crisis management in the coming years, thus necessitating improvement in command and operational management. This requires well-founded choices to be made on alternatives based on cost-effectiveness, anticipated risks and effects.

Given its importance for the social and political stability of the Netherlands, comprehensive safety and security will increasingly have to be a government-wide priority in the coming years, with the challenge of getting control and measures at national level, the level of safety regions and municipalities to link up logically. Security at local level is always essential to reduce the pressure on the whole security chain. The underlying thought is that our surroundings still cannot be rendered free of risk and that social institutions, companies and the individual citizen will have to play an active role in security policy and implementation thereof.

The main priorities in security policy identified in the Innovation Agenda Security & Safety (MIA-V) 2008-2012, are:

- The government has to perform better with fewer people and more diversity, and the role of the citizen and his ability to cope independently must be strengthened. There will be more freedom of policy for municipalities and provinces.

- The organisation of crisis and disaster management must be improved. The safety regions must perform as intended and the police must be more efficiently structured.
- Concrete objectives are a quarter less crime, harassment and corruption, and violence inflicted upon public employees must be tackled.

Intensification of Civil-Military Cooperation (ICMS)

The Ministries of the Interior and Kingdom Relations and Defence have made firm agreements on cooperation between civil authorities and the armed forces to more efficiently combat disasters and crises in the Netherlands. These agreements are clustered in the Intensification of Civil-Military Cooperation (ICMS) and include an extension of deployable military capacity for monitoring and protection, unmanned aircraft for air surveillance and availability of an NBC (Nuclear Biological Chemical) unit in (national) crisis situations. Furthermore, agreements have been made on joint education, scientific research and exercises. Interdepartmental cooperation is also becoming increasingly important in the performance of expeditionary operations.

Defence industry: high-tech material essential

The Ministries of Economic Affairs and Defence have jointly published the Defence Industry Strategy (DIS) (August 2007) containing the main strengths of and opportunities for the Dutch defence-related industry. Defence needs high-tech material for top-quality, high-tech armed forces. High-tech knowledge is needed to purchase, use and maintain this, so the government has to cooperate with research institutes and Dutch defence-related industry

(DGI). These activities have a proven spin-off in the civil market. The Dutch defence-related industry has a distinctive position in the international market in specific fields, including C4I, sensor systems, integrated platforms, electronics & mechatronics, advanced materials and training simulators. The activities of the European Defence Agency bring an open market and a level playing field closer. In the coming period, however, the position of industries will still be strongly influenced by the policy and the tools of national governments, like the defence ordnance process and the tools of Economic Affairs geared towards access to foreign markets and export.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?

High-tech armed forces and security organisations, innovative industry

As a research institute of European stature, operating globally, TNO's top-quality research contributes to high-tech, flexible and cost-effective operational command and security organisations, and thus to armed forces that can be deployed worldwide and to a safe and secure society. In this respect, we focus on optimising processes, enabling people to perform better and helping to develop better and smarter systems. Ultimately, industry supplies the products, services and systems and therefore we want to be a key innovation partner for this industry.

Public-private cooperation for optimum solutions for security innovation issues

In the fields of Defence and national security, there are considerable challenges in enhancing the cost-effectiveness, anticipation capacity and cooperation capacity. Central

to this is an approach based on comprehensiveness and cohesion, which demands a preparedness to innovate at system level and an effective working ecosystem of government (as instigating customer), end users, industry and research institutes.

TNO has firm ambitions in the organisation of such public-private cooperation. We also aspire to create and contribute to solutions to complex security innovation issues based on our independent position, domain knowledge, integration capacity, concept development experience, excellent multidisciplinary knowledge and technologies, and our unique experimental facilities.

Closely interrelated Defence and national security

TNO operates in both the defence domain and national security domain, and is uniquely able to foster the relationship between innovations in both domains. Analysis of the defence domain (SKA) and the national security domain (MIA-V) points to four common innovation needs:

- Comprehensive consideration of deployment options: transitions to a structurally different kind of operation whereby deployment options are objectively considered based on costs, effects and risks.
- Information-driven operation: able to deal with unstable environments, and better policy making and implementation in part through supervision that allows for more flexibility and enables greater effectiveness.
- Better performance with fewer resources: more cost-effective and with fewer people yet still generating more security through the use of technology and more innovative

forms of cooperation.

- Ability to operate in networks and chains: effective net-centric operation in coalitions of defence, security and non-security organisations and citizens, nationally and internationally.

Nevertheless, the implementing organisations in the defence and national security domains still differ greatly in their governance, task, organisation and doctrine and, not least, innovation style (level of centralisation, open innovation, level playing field and investment capacity). Though both domains will become more intertwined in the coming strategy period, they will, for the time being, be treated separately as two TNO areas of innovation: globally deployable armed forces and safe and secure society. The innovation needs of both areas of innovation will concern mutually agreed and complementary knowledge development (see table on page 60), something that also fits in with the intensification of civil-military cooperation. Taking advantage of the dual-use opportunities of technology requires a comprehensive and interdepartmental approach to demand and policy. TNO's ambitions are formed within the framework of demand.

Partnership with Defence is changing

The Ministry has expressed the wish to shape its strategic partnership with TNO differently. In contrast to the previous arrangement, Defence only wants strategic partnership in a pre-agreed/established package of defence-specific areas of expertise that regularly need reassessing. These defence-specific areas of expertise cannot exist without Defence investments, yet Defence cannot find them elsewhere. Therefore, it is necessary from the



perspective of efficiency that Defence continues to exercise influence via the strategic partnership on the manageability of the costs for the related knowledge support. TNO and Defence are in consultation on the portfolio of areas of expertise that Defence wants to maintain or wind down or even stop entirely in the future. The Ministry of Defence also sees a changing role for TNO in the coming years. For Defence, technological knowledge support remains essential to creating high-tech armed forces but this ambition must be achieved with substantially less funding for knowledge development. Defence has proposed reducing the TNO demand-driven research programme funding for the medium to long term from 51 million euros in 2009 to 33 million euros in 2013. TNO and Defence are currently discussing how this will be substantiated in the coming years. The anticipated requirement for knowledge support is leading here. Also being examined are areas in which Defence itself can and must provide for its knowledge needs, including the possible role that the NLDA can play in this. Possibilities for facility sharing between TNO and the LTIs will be explored along with the possibilities of strengthening international cooperation in the coming period. This may have an impact on the knowledge base incorporated at TNO. Defence is employing the criterion of unicity to make a choice among the TNO knowledge areas, focusing initially on the expertise areas essential for Defence and which are not viable without Defence investments. For these 'defence-only' areas, Defence determines the level of ambition of the knowledge development and is responsible for its funding. Defence is thinking of the 'hard' defence technology expertise areas like weapons & ammunition,

weapon target interaction, soldier & platform protection, sensor performance and cyber security. This does not free TNO of the obligation to commercialise the developed knowledge in these areas where possible and thus reduce dependence on Defence investments. Defence houses its external knowledge base in part with TNO to create mass and synergy between defence and civil-driven knowledge development. The ambition of Defence is to maintain these defence-specific areas of expertise as much as possible.

For other (non-unique) areas of knowledge Defence expects these to be viable in the coming strategy period through a combination of civil and Defence investments, so without Defence having to continue to shoulder a major part of the investments. TNO will investigate whether there are enough prospects for these areas to acquire civil investments and assignments, i.e. dual-use and dual funding. The expectation is that Defence wants to reduce R&D investments in these 'dual-use' areas of knowledge in the coming strategy period. Defence refers to expertise areas as personal performance, human-human, machine-machine teaming, education & training, sensors and protection of critical infrastructure, to be designated as dual-use. TNO is consulting with Defence on the basis of business analyses how these knowledge areas can be kept at the required quality level and the further impact of any cutback. If the international market positioning of TNO requires, the knowledge level must rise to a higher level possibly with more civil funds than are strictly necessary to support Defence (thus becoming 'champion' level). Finally, in other areas Defence is thinking of stopping

knowledge investments at TNO because, for instance, these should occur in house (with support from the NLDA). The areas of expertise concerned are likely to be strategic foresight, defence planning, policy analysis and personnel provision. In cases where there are more knowledge providers than TNO, R&D sourcing policy will determine discontinuation. Examples are environmental sciences, operational logistics, composition of forces, generation & deployment and energy supply.

The choice of defence-only areas of expertise and their level of ambition, as well as dual-use areas, is the result of continuous dialogue with Defence. Areas of expertise in which Defence no longer invests can still be catered for at the current level for tangible Defence support.

TNO roles: towards Defence and defence-related industry

From the perspective of knowledge usage, TNO distinguishes the following key roles towards Defence:

- Consultant: the trusted advisor to support Defence as Smart User, Buyer, Maintainer and Specifier.
- CD&E (Concept Development & Experimentation): multidisciplinary solutions for complex problems and focus on capabilities, processes and chains. Based on validated models and domain knowledge, mostly in a public-private context and in a 'brokerage role'. To support Defence as Smart Integrator and self-developed Smart Developer, where required.
- R&D: focus on more fundamental TRL levels, on components and systems. If possible in co-development with the defence-related industry. Results should be

trading stock (quid pro quo) in international cooperation. To support Defence as Smart Developer, where required.

A diminishing defence budget will see the Defence need for external knowledge support increasingly focus on the level of Smart Customer (Buyer/User/Maintainer) and setting the right functional specifications, with the need for this support for the ambition levels of self-specifying (Smart Specifier) and self-developed (Smart Developer) expected to decline in the coming strategy period. Defence has indicated that it will need support only in a select number of knowledge areas in CD&E and R&D roles; for the rest more of a consulting role will be required. Where the Defence ambition as Smart Developer diminishes and that of Smart Buyer/User/Maintainer increases, the R&D role of TNO in the knowledge value chain will shift: TNO will no longer develop technology directly for Defence but for and in co-development with the defence-related industry and at international 'champion' level.

Taking account of the review initiated by Defence as well as our own ambitions and estimates of market prospects outside Defence, TNO wants to fulfil the R&D Champion role in four areas: information superiority, protection of people and platforms, training & simulation and human performance. TNO develops CD&E activities to support coalition operations, ballistic missile defence, material purchasing support and operational concepts, amongst other things.

Partnership with the Ministry of the Interior and Kingdom Relations and Justice continues to take shape

TNO is a knowledge partner for the Ministries of Foreign Affairs and Justice as well as governmental security organisations in the field of anti-terrorism, crisis management and disaster response. The role of TNO in the field of security for the Ministry of the Interior and Kingdom Relations and the new safety regions will continue to take shape in the coming period.



**THE TNO ANSWER:
INNOVATE IN TWO AREAS**

**INNOVATION AREA 1: GLOBALLY
DEPLOYABLE ARMED FORCES**

Focus on:

- Cost-effective operations
- Information superiority
- As safe as reasonably affordable
- Better performance with fewer people
- Coalition operations

Defence faces the challenge of finding a sustainable, dynamic equilibrium between ambition, capacities and available funds. Within this area of innovation TNO focuses on the following five interrelated topics to help support Defence in this challenge.

**1. Cost-effective operations:
from purchase to use**

TNO's ambition is to support the armed forces as preferred and trusted advisor in the cost-effective purchasing of capacities, in developing new operation concepts and assisting in the entire mission chain (planning, preparation, execution, evaluation and aftercare). This enables Defence to operate cost-effectively by objectively weighing up the costs, effectiveness, flexibility and risks. Fundamental to this is a powerful CD&E approach in which new kinds of operation and new capacities can be evaluated.

**2. Information superiority:
from data to impact**

Gaining and maintaining information superiority requires the simultaneous and comprehensive improvement of the observation chain, intelligence process,

decision-making process, command execution and behaviour (acceleration of the OODA loop) where knowledge and development capacity in the field of heterogeneous sensor networks (radar, sonar, electro-optical, chemical and biological) are linked to process and domain knowledge. This creates a better situational awareness among end users. In view of the increase of information needs and reduction in available manpower and budget, extensive automation of the different processes is unavoidable. In respect of high-tech product development, the interaction between TNO and industry is essential.

**3. As safe as reasonably affordable:
mission-effective protection within
the financial scope**

The Dutch comprehensive protection model (including CBRNE) facilitates both thorough analyses for the long-term and rapid, flexible solutions for operational needs. The results link protection, mission goal and costs, and play a key role during planning, establishing need, acquisition and operational deployment. Cost-effective and safe purchasing, maintenance, storage and use of weapons systems and munitions require quantitative insight into use, risks and consequences.

**4. Better performance with fewer people:
personnel**

Sustainable improvement of deployment options, motivation and health of troops are vital. The aim is better selection and lower dropout, linked to more sustainability. This can only be achieved hand in hand with education and training that are better linked to the flexible requirements and better monitoring and prediction of the performance level of individuals and teams. Potentially extreme

operational circumstances require optimum use of health and security solutions from other domains, state-of-the-art responses to specific circumstances like CBRNE, more rapid innovation in terms of equipment, broader deployment of unmanned systems and better aftercare for troops after dispatch.

**5. Coalition operations: cooperate and
operate in networks and chains**

In addition to technological, information-technical and organisational interoperability, social-cultural characteristics play a crucial role in military-civil coalitions in out-of-area operations. Setting up an adequate consultation structure among the partners and a joint implementation plan demands both staying power and in-depth knowledge of forms of cooperation. TNO's ambition is to support Defence in the NEC field, including the abovementioned coalition aspects. The knowledge concerns military cooperation coupled with broad cooperation with civil partners (like the local population and NGOs). Moreover, these situations can become educational resources through the exercise environments and be used to help prepare and evaluate missions.

**INNOVATION AREA 2:
SAFE AND SECURE SOCIETY**

Focus on:

- Tailor-made security & safety policy
- Tailor-made surveillance and investigation
- Professional law enforcement and crisis management
- Resilient critical infrastructures

Security has shifted from a collection of ad hoc reactions to incidents to a cohesive set of measures and effects. The potential impact and the cascading effects of incidents as well as the social cost-benefits profile of security measures requires a comprehensive approach and orchestration based on risk and effect. Perception and acceptance are key to chosen solutions and much has to be seen in the international context. Inside the respective departments BZK (Interior and Kingdom Relations) is the leading department in this innovation area and is fully responsible for the direction knowledge development takes in the propositions described. TNO is undertaking this challenge by focusing on the following four subjects.

**1. Tailor-made security & safety policy:
better return from security policy**

TNO wants to offer policy choices and alternatives along with implementation of security objectives at various levels (municipal, regional, national, international). TNO also wants to determine social ambition and direction, identify uncertainties and attitudes of groups, establish costs, benefits and the effect of measures and solutions beforehand and retrospectively, and set out communication and implementation schedules. Finally, TNO

wants to use security innovations to improve processes and as an economic engine.

**2. Tailor-made surveillance and
investigation: cost-effective surveillance
where needed and acceptable**

Develop innovative concepts for surveillance, enforcement and detection, whereby maximum cost-effective results in surveillance and detection can be achieved by delineating environment, time and resources. This is TNO's aim and TNO wants to implement this together with partners. To this end TNO is looking for faster, more specific actions for enforcement, detection and assistance, better prevention of incidents by building up an information position, lower deployment of professionals through citizen participation and supporting technology, and acceleration of the development cycle for surveillance systems.

**3. Professional law enforcement and
crisis management: more security with
fewer people**

TNO wants to improve equipment and the competencies of personnel and restructure implementation capacity in a revolutionary way, with the goal of more effective, efficient and safe action by the operational security services in the event of incidents, disasters and large-scale crises. This includes cost-effective, multidisciplinary action using optimal means of protection and adequate information management. This should produce better, coordinated decision-making at all levels, greater self-sufficiency among citizens following incidents or disasters, and improved information and availability of knowledge to mobilise government, companies and citizens.

**4. Resilient critical infrastructures:
more reliable critical provisions**

TNO wants to structure societal infrastructures (like neighbourhoods, public transport, vital infrastructure, polders, transport chains, logistics and industrial systems) such that security and safety problems can be prevented, contained or solved in a balanced way, and (security) organisations are able to learn and thus adapt to societal and market dynamics. Electricity, water and transport are priorities. This requires the reconsideration of efficient economic structure and the effective resilience of societal systems, plus restructuring on the basis of properties like resilience, sustainability and graceful degradation.

ENERGY



Worldwide the energy supply picture will change drastically in the coming decades. The demand for energy is rising, reserves of easy-to-produce oil and gas decreasing fast and alternative energy sources in the throes of development. TNO responds through technologies that make fossil fuel production and use more efficient and cleaner and combines this with sustainable energy sources.



THEME: ENERGY		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> • Energy sources in transition • Energy efficiency 	<ul style="list-style-type: none"> • The Netherlands as the gas hub of Europe • Advanced reservoir management and production optimisation • Sustainable (geo)energy: CO₂ capture, transport and storage, and geothermal energy • Smartgrids and decentralised energy supply 	<ul style="list-style-type: none"> EZ, OCW, VROM EZ, VROM, OCW
Markets	Customers	
<ul style="list-style-type: none"> • Energy producers • Oil and Gas • Maritime offshore • Energy network managers • Building and installation 	<ul style="list-style-type: none"> • EU DGE TREN, Ez, VROM, Eneco, Essent, E.ON, RWE, Nuon, Electabel, GasUnie • EZ, Shell, Statoil, BP, ExxonMobil, Total, NAM, Wintershall, Lukoil, Saudi Aramco, Petronas, Schlumberger • Fugro, SBM offshore, Bluewater, Heerema, Allseas • Ez, Stedin, Alliander, Enexis, Tennet, Eneco, Gasterra • EU DGE, VROM, Bouwend-NL, Bouwcompanies, Uneto-VNI, Housing associations, suppliers, processors, engineering firms 	

WE WANT TO ACHIEVE THE FOLLOWING

THE NETHERLANDS AS THE GAS HUB OF EUROPE

TNO's system knowledge and several niche technologies deliver an essential contribution to the ambition of the Netherlands to be a 'gas hub': a key logistical axis in Northwest and West Europe for the production, storage and transport and transshipment of natural gas. TNO's knowledge of complex subsurface fields substantially helps in the production of marginal gas reserves.

ADVANCED RESERVOIR MANAGEMENT AND PRODUCTION OPTIMISATION

TNO develops the technology to enable gas and oil to be produced from less amenable reservoirs and by 2015 at the latest will have undertaken at least 10 successful 'showcases' whereby new gas and oil reserves will emerge to boost security of supply. The opportunities for Dutch suppliers and cooperation with international partners will be boosted.

SUSTAINABLE (GEO)ENERGY: CO₂ CAPTURE, TRANSPORT AND STORAGE, AND GEOTHERMAL ENERGY

TNO helps to significantly increase the capture capacity through Carbon Capture and Storage (CCS), the costs of which will be reduced from 50 to 20 euros per tonne, and the storage capacity increased to 25 megatonnes per year. We deliver the requisite knowledge to substantially boost production of geothermal electricity in the Netherlands, Europe and developing countries.

SMARTGRIDS AND DECENTRALISED ENERGY SUPPLY

TNO helps to build new value chains in which established and new suppliers can offer energy, network and system services. To this end TNO develops and integrates, in cooperation with market parties and government, in-depth knowledge for intelligent energy networks: the cohesive network of energy infrastructures (electricity, gas, heating, cooling) that intelligently integrates users in the network through the addition of a measuring infrastructure and control applications for every network component.



ENERGY

The future Energy trends and challenges are described below, and this is followed by an outline of the desired future scenario with the clear answer from: a choice of specific innovations in two areas: Energy sources in transition and Energy efficiency.

THE TRENDS: EXPECTED DEVELOPMENTS UNTIL 2025

Scenario studies by the International Energy Agency (IEA), Clingendael, Energy Research Centre of the Netherlands (ECN), Shell and ExxonMobil are based on growth in the world's population and global GNP. They suggest that the energy demand in Europe and the US will level out while in rapidly developing countries like China, India, Brazil and Russia (the BRIC countries) an extreme energy-intensive phase will begin. In addition, most third world countries need a lot of energy for their development. ExxonMobil estimates total growth in energy consumption from 2009 to 2030 to be 22%.

At the same time less 'low-cost oil' will be available since OPEC countries are hardly able to develop new oil projects. Exploration and production in areas that are difficult to access (deep sea) or unconventional reserves (tar sands) cause even more environmental pressure and thus the development of new methods. A good start: technological breakthroughs that can boost the energy efficiency of installations, buildings, vehicles and production processes such that energy consumption per unit of GNP can fall by tens of percentage points, with savings of up to 50% possible. While living standards in OECD countries continue to rise, however, per capita energy consumption will, too. Furthermore, the share of renewable sources like wind, sun,

hydropower and biomass will increase. A major benefit of this is local energy generation, which makes new demands of the large-scale energy infrastructure and balance of demand and supply. Moreover, this will increase the diversity of the energy need of end users, with the critical end user demanding customisation in respond to his comfort wishes.

Also even with an increasing share of renewable sources, at 80% the share of fossil fuels in 2030 will continue to dominate. Only through innovative methods for exploration and production of existing oil and gas fields can the associated problem begin to diminish, certainly due to the rising global demand for energy being catered for by coal, with all the harm it does to the environment.

THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

Energy is a theme that permeates all societal themes, so the trends in our energy supply have a substantial impact on all sectors in society. There is considerable concern about climate change partly because of the emissions of CO₂ in the combustion of oil, gas and coal. The need to save energy, reduce the CO₂ emission of fossil sources and boost renewable energy sources is growing. The affordability of energy is also coming under increasing pressure. The major challenge for our carbon-based society in the coming decades is to shift to sustainable energy. We must develop sustainable sources like sun, wind, biomass, hydro power and geothermal energy, applying them large scale and invest in energy-saving measures. Only then can we save substantial energy in all sectors of society. However, we also have to work on the efficient and clean

operation of the remaining fossil sources at the same time.

Flexible energy supply a requirement for energy saving and renewable energy sources

Locally, there are many initiatives to save energy and use renewable energy sources. Decentralised energy is emerging strongly, with striking examples being the energy-generating greenhouse, energy-neutral neighbourhoods and the local energy company. This offers entrepreneurs new opportunities, but also makes new demands of our energy infrastructure. The need for a flexible energy supply is growing, one in which energy demand and supply are optimally matched at the desired time and place. We are also looking at the possibilities for small-scale supply, local energy storage and intelligent systems that regulate the energy use and thus minimise the price.

Oil supply, affordability of energy and the environment under pressure

Energy saving and renewable sources alone are not sufficient. Growing numbers of people are using increasing amounts of energy. The unstable geopolitical situation in the Middle East, Venezuela, Russia and Africa threatens the security of supply of the chief energy carriers (oil and natural gas). Moreover, the reserves of easy-to-produce gas and oil are diminishing and investments in gas and oil production are lagging behind. This will put the gas and oil supply as well as the affordability of energy under pressure in the coming decades. And of course, the environment, the climate, through the CO₂ emissions from the combustion of oil, gas and coal. Enough motivation for the government (and the citizen) to save energy,

reduce the CO₂ emissions from fossil sources and develop or acquire renewable energy sources. In the Netherlands, too, the plentiful gas reserves of the past are declining, although the Netherlands probably has more reserves that are less accessible and so less interesting economically for the larger companies. This presents an opportunity for the smaller companies and suppliers, but only if they have the knowledge to exploit the smaller fields.

Limited development of sustainable energy but focus on CO₂ capture and storage

Innovative methods for the exploration and production of energy can boost the recoverability of remaining fossil reserves. Climate change is an incentive to the government, moreover, to invest significantly in the transition to a sustainable, reliable and affordable energy supply. How and how fast our country will make this transition is as yet unclear. Currently the development of sustainable energy in the Netherlands lags behind other countries, partly because we still have our own natural gas reserves and (cheap) coal via our excellent port facilities. This offers the Netherlands the possibility to export fossil-based energy, so the government is building new coal-fired power plants and investing in CCS (CO₂ capture and storage) while market parties invest to a limited extent in energy saving and sustainable energy.

CCS will also play a key role in Europe in the coming decade. This may reduce the CO₂ concentration in the atmosphere even if the use of fossil energy sources grows. By establishing a price for the emission of greenhouse gases (emission trading), companies can be compelled to lower their CO₂ emission. Support (international) is

needed for this measure, both political and social, since this will mean more costs in the short and medium terms.

Liberalising the energy market creates price-fighters and high-tech service providers

Finally, liberalisation of the European energy market will see much more competition in national markets. Many energy companies have merged and will merge (further) and some Dutch companies are already part of an international consortium. Moreover, the consumer is no longer tied to one supplier. Energy companies have to become very distinctive from their rivals to remain sufficiently identifiable and attractive. In such a landscape price-fighters appear as well as companies that aim at high-tech service.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?

The beckoning future picture is an energy supply that fulfils the requirements of security of supply, sustainability and affordability. A reliable energy supply resistant to geopolitical instability due to the optimum mix of energy carriers in an infrastructure that is able to supply energy to everyone, both locally and centrally. A sustainable energy supply in which energy saving is optimised and renewable energy sources cover most of the energy demand. With the remainder clean energy from fossil sources since sustainable options are not profitable or practicable. An energy supply that innovation and cost reduction keep affordable for the end user.

For this future energy supply people must consciously (learn to) deal with energy; save as much of it as possible. A starting point is energy-neutral (new) buildings that produce as much energy as the user needs. This reduces the energy consumed but not to the detriment of comfort – it generates new functionalities. In addition, electrical transport of goods and people will create clean, quiet and efficient transport in the built environment. Europe has built a prominent knowledge position in the world in these areas, and the Netherlands in particular is the incubator of energy innovations and new economy.



ENERGY

**THE TNO ANSWER:
INNOVATE IN TWO AREAS**

TNO focuses its energy research on sustainable energy generation and how we can use energy consumption systems more efficiently, so we opt to link research to the knowledge of other strong parties involved. On this basis TNO works on the sustainable use and management of the subsurface, energy in the built environment, smartgrids, biofuels and hybrid drive, energy-efficient traffic management, reduction of the CO₂ footprint of logistics, maintenance of offshore wind farms, optimising the development and production of flexible solar cells, CCS and geothermal energy. This occurs in part within the theme Energy and also in the themes Mobility, Built Environment, Industrial Innovation and Information Society, thereby providing a good foundation for complementary programmatic cooperation with ECN and other knowledge parties in Europe.

In recent years TNO has built up a key position in geosciences and industrial technology, accumulating this knowledge partly on the basis of major cooperation projects with large companies. This knowledge enables the more efficient exploitation of existing oil and gas fields and brings less accessible reserves within reach. The relatively small companies economically able to exploit these marginal fields lack the required knowledge and information. We therefore are keen to support these parties with our knowledge. Also TNO develops technology for the capture and storage of CO₂, a key technology for the clean exploitation of fossil reserves. In this way TNO contributes to the sustainability of the energy supply.

Also TNO takes on the role of energy innovation driver within the energy theme. In close cooperation with manufacturing TNO will develop production facilities, materials and constructions needed for reliable wind, solar and hydro energy. In sectors like traffic and transport, building and construction and the process industry TNO is a driver of sustainable innovations, with energy-saving technologies, process intensification and copious knowledge of geothermal energy and green raw materials. Our knowledge helps to support inventive front-runners and the sustainable energy policy of the government.

Energy scenarios reveal that fossil sources currently continue to play a dominant role in our national energy supply. Therefore, TNO wants to achieve an intelligent energy supply that is able to combine the input of sustainable energy (local) with the efficient, centralised supply of clean energy from remaining fossil sources. TNO can also help to realise sustainable energy management, which is especially applicable for the built environment and the mobility sectors. Finally, TNO has a unique position in the (deep) subsurface field where we want to use our knowledge for the better utilisation of geothermal energy for the Dutch energy supply. We are clustering all these fields of expertise in two areas.

**INNOVATION AREA 1:
ENERGY SOURCES IN TRANSITION**

- Focus on:**
- the Netherlands as the gas hub of Europe
 - Advanced reservoir management and production optimisation
 - Sustainable (geo)energy: CO₂ capture, transport and storage, and geothermal energy

In Europe TNO has an acknowledged position in the subsurface and subsurface minerals. Our knowledge covers the total system of natural gas (gas fields, transport, transshipment, storage) and oilfields, and we also do extensive CCS and geothermal energy research. Furthermore, we are a global knowledge leader in clean gas from coal. Good reason, therefore, to search for solutions within this innovation area that will make the energy supply more efficient and fossil fuels more 'climate-neutral'.

Gas hub
This may offer logistical solutions for gas production and supply through our system knowledge and niche technologies whereby we help to realise the ambition of the government to make the Netherlands a 'gas hub': a key logistical axis in Northwest and West Europe for natural gas production, storage, transport and transshipment. Our knowledge of the complex subsurface fields means we can contribute to the production of marginal gas reserves (unconventional reserves). However, the Dutch government also has to hit its CO₂ reduction targets for 2020. To this end TNO is developing CCS technology that will drastically boost the capture and storage capacity and reduce the associated costs.

Sustainable energy supply
In addition, we will be executing at least ten successful 'showcases' before the end of 2015 to show how the production profitability of (well studied) reservoirs can be increased; very interesting for the oil world. We can also produce gas and oil from marginal fields (reserves from highly difficult reservoirs in sometimes extreme circumstances). This will make new gas and oil reserves available and thus boost security of supply. This new knowledge is also important for the Dutch input in international partnerships and for Dutch suppliers.

Clean
As leader of a national research programme, TNO delivers the requisite knowledge on geothermal electricity. In the Netherlands we want to be able to produce 300 MWe by 2030 at the latest. TNO's research and technology is contributing to the production of 2 GWe of geothermal electricity in Europe and in developing countries. In Europe that is almost 5% of the total electricity production. In developing countries like Indonesia, that share can be more in favourable geological conditions.

**INNOVATION AREA 2: ENERGY
EFFICIENCY**

- Focus on:**
- Smartgrids and decentralised energy supply

In the Netherlands substantial energy saving and CO₂ reduction are possible in the built environment. At the same time, the energy demand (more energy-efficient buildings and installations, more demand by ICT, smart homes and electrical transport) and the energy supply (more decentralised energy generation, geothermal power and electricity) at local level are becoming more complex. Also infrastructures for electricity, gas, heating and cooling within Europe are interconnected. TNO wants to support these developments with research and innovations that make our energy use more efficient. TNO has worked with ECN to develop a vision of this with a horizon until 2050. We also work closely in the Dutch Innovation Agenda for the Built Environment and the European developments within the European Construction and Technology Platform.

Intelligent energy networks (smartgrids)
TNO is also working with market parties and the government to develop and integrate knowledge of intelligent energy networks. These are energy infrastructures (for electricity, gas, heating, cooling) that can be intelligently supplemented to all network components through a measurement infrastructure and control applications, and integrate major and minor consumers and producers in the network. This will help to create a reliable, sustainable and efficient energy supply. In 2050 those networks will

have the same security of supply as fossil fuels, especially if the share of sustainable decentralised energy generation (like solar and wind energy, greengas, biogas and syngas) increases.

MOBILITY



Mobility is deeply embedded in our society, giving us the opportunity to meet each other, at work, among friends or family, and to relax. It is also the bearer of our trade nation: we transport raw materials and semi-manufactured goods to producers and end products to consumers. Mobility is a condition for prosperity and welfare, but our mobility system is also harmful to the economy, people and the environment. Think about the daily traffic jams, increasing energy use, emission of CO₂ and particulate matter, problems related to traffic safety and noise pollution. Therefore, TNO is looking for ways to make traffic more reliable, safer, cleaner and quieter.



MOBILITY

THEME: MOBILITY		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> • Reliable traffic systems 	<ul style="list-style-type: none"> • Towards 50% more reliability • Competitive strength through sustainable logistics • People at the centre of mobility innovation 	VenW, VROM, OCW, EZ
<ul style="list-style-type: none"> • Safe and clean transport 	<ul style="list-style-type: none"> • Towards 25% less casualties and 100% more economic activity • Towards 50% less emissions and fuel consumption 	VenW, VROM, OCW, EZ
Markets	Customers	
<ul style="list-style-type: none"> • Automotive 	<ul style="list-style-type: none"> • EZ, DAF, Renault, VDL, Daimler, Ford, Sensata, Continental • Bosch, Grundfoss, Takata, Denso, Automotive OEM 	
<ul style="list-style-type: none"> • Traffic & Transport 	<ul style="list-style-type: none"> • EU DG TREN, VenW, VROM, RWS, Provincies, Gemeenten • Prorail, NS, Schiphol, Vialis, PTV, DHV, Peek, EVO, NDL, Centraal Boekhuis, FloraHolland, Greenery, ANWB, KPN, TomTom, NxP 	

WE WANT TO ACHIEVE THE FOLLOWING

TOWARDS 50% MORE RELIABILITY

Society wants to reduce the costs of an unreliable traffic system to a maximum of 2 billion euros annually and not let it grow to 4 billion euros. TNO will help this goal by the development and accelerated application of a Robust Infrastructure Network and Intelligent Transport Systems (ITS).

COMPETITIVE STRENGTH THROUGH SUSTAINABLE LOGISTICS

A more efficient, more reliable and thus safer logistics Dutch infrastructure can reduce the CO₂ footprint by 15%. TNO wants to help make this happen by management and service from the virtual logistics chain and so enable the Netherlands to an internationally leading position in terms of orchestrating the flow of goods in 2020.

PEOPLE AT THE CENTRE OF MOBILITY INNOVATION

The challenge is, in addition to using the latest technology, to solve mobility problems from the perspective of user/traveller needs. TNO wants to contribute to this by influencing behaviour through the provision of personal travel information and through maximising the acceptance and use of (information) systems and supporting products.

TOWARDS 25% FEWER CASUALTIES AND 100% MORE ECONOMIC ACTIVITY

By 2030 the Netherlands can reduce the number of traffic casualties by 25% and the related costs by 2.5 billion euros. TNO wants to contribute to this aim by helping to introduce more quickly smart vehicle technology and cooperative systems and thus halve the traffic jams in the Netherlands, and so relieve the environment as well as create opportunities for Dutch companies.

TOWARDS 50% LOWER EMISSIONS AND FUEL CONSUMPTION

The emissions of greenhouse gases and fuel consumption by transport can be halved at least during the coming 15 years. TNO wants to help to make this happen by developing clean vehicle technology and intelligent transport systems, supporting the implementation of new technology, like electric drive and biofuels, and advising on legislation and policy.



MOBILITY

The future Mobility trends and challenges are described below, and this is followed by an outline of the desired future scenario with the clear answer from: a choice of specific innovations in two areas: **Reliable traffic system** and **Safe and clean transport**.

THE TRENDS: EXPECTED DEVELOPMENTS UNTIL 2025

Sustainable urban accessibility under pressure

It is important that the major urban areas continue to be accessible in the long term. Forecasts suggest, however, that urban populations will continue to grow while other regions 'depopulate'. Even more people want to live and work in urban agglomerations; a demographic trend that we not only see in a small, densely populated country like the Netherlands, but also in all urban regions throughout the world, a shift that endangers the accessibility of urban areas.

Complex traffic and transport system quickly disrupted

Our mobility system is, therefore, highly vulnerable since its complexity and the increasing load it has to bear means that it is quickly disrupted. The traffic and transport system has come to function as a cohesive unit, with no longer isolated connections and organisationally separate road authorities. A local accident can affect an entire region. Additional infrastructure may reduce local bottlenecks but may also reinforce bottlenecks elsewhere in the system. That also applies to road and rail transport.

Climate change stimulates minimisation of energy use and emission

The increasing focus on climate change is coupled with pressure on the traffic and transport sector to substantially cut energy use and CO₂ emissions. The Cabinet's Clean and Efficient programme sets specific targets for this and incorporates measures relating to source policy (CO₂ standardisation), stimulation of alternative (bio-)fuels, green taxes, road-user pricing and influencing behaviour. In 2010 the Cabinet is evaluating the viability of the goals of the programme. Depending on the outcome, the Cabinet may intensify or supplement existing policy.

ICT makes traffic and transport systems more efficient and intelligent

Advances in information and communication technology (ICT) support the development of our mobility system. Various technologies enable ICT to make the (logistics of) traffic and transport systems more efficient and intelligent. Examples include new sensor technology to make a lot of extra information available, wireless communication technology that will enable communication between vehicles and with the infrastructure and new information processing possibilities will provide better control of vehicles and traffic flows. Other applications focus on the user. The public transport chip card allows the user to opt for and combine different modes of transport (car, train, bus). Some entrepreneurs are even thinking of more extensive use of this technology and infrastructure: a mobility card for all forms of transport where, for instance, even the fuel can be registered and paid for.

THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

Entrepreneurs getting to work on mobility concepts

The trends described above go hand in hand with a number of stiff challenges. Entrepreneurs in the car industry, traffic industry, logistics sector and shipbuilding have to become more innovative with mobility concepts that respond to these trends. Car producers and their suppliers in particular have to gear their innovation programmes to this. There are opportunities in many areas for Dutch (supply) companies to build a distinctive position, for example in the field of efficient vehicles and vessels, the transition to sustainable fuels and the introduction of new mobility concepts.

The Netherlands seeks to orchestrate international transport

The challenge for the logistics sector is to position the Netherlands as the orchestrator of (worldwide) transport flows, making maximum use of the ICT possibilities to make the logistics services more efficient and better. Opportunities also lie in the development of efficient (smart) distribution systems that are able to penetrate the whole urban area without making concessions to quality (time, reliability, retention of liveability).

Keep cities accessible and liveable

The accessibility and liveability in cities are key issues. In terms of urban living environment the EU has set requirements for NO_x and particulate matter emissions, and traffic noise. Since mobility is increasing, the Dutch government is finding it difficult to keep to these increasingly tougher standards. The requirements have recently led to the stagnation of new building development close to major traffic arteries in the Netherlands. The EU also wants to make urban transport zones, which will hinder the supply of goods. In a number of cities in the Netherlands and Germany, for example, there are already zones that only trucks with a particulate filter may access.

The accessible and liveable city can only be realised in association with spatial, economic and environmental aspects. The spatial management task in the Netherlands is complex: a relatively modest area in which many different social functions are combined. The government, therefore, takes an increasingly regional approach: a comprehensive approach of regional development. Inside this theme there are various awkward considerations to be made in an arena containing many vested interests and stakeholders, so a good information basis is essential. Experience of new forms of cooperation, like the Rotterdam traffic company, is also needed to link spatial planning and the transport system.

Biggest challenge: social innovation processes

The biggest challenge of all, hidden behind the challenges above, is to establish ambitious yet realistic and viable social innovation processes. This demands cohesion between government, the market and knowledge

institutions. In short, a structural innovation system shift in the mobility domain whereby the cooperation structure must change, for example by working on innovation and application in new coalitions, as well as the financial structures, for example, by internalising the external transport system costs and ensuring that the user rather than owner pays for the transport.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?

The future picture of the mobility system is 'carefree mobility': fast, reliable, amenable, clean and safe transport. The aim: to keep large urban areas sustainably accessible. The Ministry of Transport, Public Works and Water Management (VenW) will build, utilise and price to this end.

Lubricated infrastructure: a fast and reliable mobility system

A fast and reliable traffic and transport system is a key to our economic vitality. The motto of VenW in its strategic knowledge agenda is appropriate: 'Lubricating our mobility.'²⁵ Raw materials, semi-manufactured goods and end products must be delivered fast and without hitches at home and abroad, certainly if we want to retain our international (logistics) competitive strength. Fast and reliable transport of people helps to support, moreover, business and personal relationships. Better travel information, more infrastructure reserve capacity and better traffic jam prediction will contribute to this.

Amenable and clean travel

Amenable relates to the perception value of mobility; the experience a person has en route

of social safety, autonomy, pleasant travel environment, inventive transport hubs and enjoyment. This an often underrated part of the 'human measure' of transport, despite it being a dominant factor in the acceptance of innovations. But the mobility system of the future must also be clean: fewer emissions, less noise and less use of space, but with the same result.

Retain safety

The Netherlands is one of the safest European countries for traffic and we want to keep it that way. The number of traffic fatalities in our country is falling gradually year on year: from more than 3,000 in 1973 to about 800 now. And the government want a further fall; from an ethical viewpoint and also because the economic costs of unsafe traffic are considerable. Therefore, the Strategic Plan for Traffic Safety 2008-2020 has been drafted. Focal issues are behaviour (speed, drink, drugs), vulnerable traffic participants (pedestrians, cyclists, motorcyclists, moped users, children and senior citizens), sustainable safe infrastructure and vehicle technology (adaptive cruise control, electronic stability control, speed alert).

The Netherlands will be the fieldlab for mobility management

With VenW employing the build, utilise and price triple approach, the ministry wants to keep densely populated urban areas accessible. This intricate mobility system with high-tech hubs guarantees the flow of traffic even in the event of local obstructions and jams. The ministry also wants to make maximum use of the existing infrastructure by optimising cohesion between the vehicles, road users and infrastructure. Finally, the

²⁵ Strategic Knowledge Agenda Mobility and Water.



MOBILITY

ministry wants to price the mobility system to make the users aware of and responsible for the social costs of their actions. This triple approach will enable the government to develop the mobility system of the future. This sets economic challenges and an exceptional opportunity for a strong international (knowledge) position for our prosperous, knowledge-intensive Dutch society. Think of the Netherlands as a fieldlab for dynamic mobility management able to make maximum use of the existing infrastructure and help users to get to their destinations quickly, reliably and safely. Or as a fieldlab for the introduction of clean and attractive mobility concepts that induce sustainable mobility behaviour and boost the perceived value of mobility.

**THE TNO ANSWER:
INNOVATE IN TWO AREAS**

TNO has a lot of knowledge and experience in vehicles, traffic management, logistics, infrastructure, fuels, ICT, people-machine interactions, spatial planning, liveability, economy and (mobility) policy. Separating these expertise fields would not make TNO really distinctive from other leading knowledge institutes in Europe. By combining these knowledge fields, we can make maximum use of our ICT possibilities for the mobility system and together with government and industry innovate and experiment in a pioneering fashion. This gives our research and innovations maximum impact on the mobility system. TNO will thus strengthen its position as a European top institute for mobility issues. Our comprehensive approach can solve complex accessibility issues.

TNO also wants to extend its strong position in specific areas. Finding solutions for the mobility need of individuals and organisations. Technological innovation alone is not enough. If we want to change the behaviour of individuals and organisations, we also have to allow these users to experience the benefits of new mobility services. So allow entrepreneurs to develop new services and encourage users to become familiar with these new possibilities. New possibilities developed by TNO in cooperation with entrepreneurs and users. Innovations like intelligent transport systems, robust infrastructure networks, clean transport (electric vehicles, sustainable fuels), dynamic traffic management and sustainable logistics. We have incorporated these developments in two innovation areas.

**INNOVATION AREA 1:
RELIABLE TRAFFIC SYSTEM**

- Focus on:*
- Towards 50% more reliability
 - Competitive strength through sustainable logistics
 - People at the centre of mobility innovation

You do not create a reliable traffic system in one day. We want fewer traffic jams, less environmental pollution and fewer traffic accidents. In this innovation area TNO wants to contribute to a better system of traffic, transport and logistics. To this end we will develop and realise a robust infrastructure network in which local disruptions do not disturb the whole network. And in which there is more synergy between the road traffic and high-tech public transport. Only then will heavily urban areas remain reliably accessible. We will also develop and apply Intelligent Transport Systems (ITS) whose sensors and other ICT options enable users to choose the means of transport they want to take (with travel information on all means of transport) and steer their mobility behaviour. This will help the total traffic system to be better managed (dynamic traffic management) and used. Also price incentives make the traffic system more reliable. In time there will be cooperative systems of intelligent vehicles that communicate with the intelligent infrastructure. We will also be developing sustainable logistics solutions that incorporate reliability, efficiency and less environmental pollution. Here, too ICT provides many new options for more efficient transport and fruitful cooperation. The Dutch logistics sector will thus build a strong orchestrating function in international logistics.

**INNOVATION AREA 2:
SAFE AND CLEAN TRANSPORT**

- Focus on:*
- Towards 25% less casualties and 100% more economic activity
 - Towards 50% less emissions and fuel consumption

Smart vehicle technology will enable the number of traffic victims as well as emissions and fuel consumption to be reduced. If existing navigation and safety systems are extended with communication to infrastructure and other vehicles (cooperative systems), smart vehicles can also enable better traffic flow. This requires in-car systems and applications: an opportunity for Dutch business. If they develop these systems, they can double the economic activity.

Despite the energy scarcity and the imminent climate crisis, the demand for mobility is increasing. Therefore, the transport system worldwide must be made sustainable. In the coming decades we therefore want to develop the necessary new technologies and link them to policy frameworks. We are thinking of a fieldlab for electric transport, high-blend biofuels and Intelligent Transport Systems (ITS). And making the source, the means of transport, cleaner, quieter and more efficient. In the western world the coming five to ten years will be crucial for the transition to sustainable mobility; in this period the foundations for the future will be laid. If we want enough sustainable vehicles on the road by 2040/2050, then we have to begin now to field-test and within five to ten years begin laying the energy infrastructure and market introduction.

BUILT ENVIRONMENT



Just as in many other western countries, the Netherlands is faced with a complex spatial task: to improve the economic vitality, liveability, safety and spatial quality in a time of an ageing population, increasing mobility and international competition, climate change, an economy under pressure and more people wanting to live in cities. Only by taking a comprehensive approach to this task can we develop the built environment properly. Which means that we have to weigh up the many vested interests and stakeholders in the arena. Whether this concerns the revitalisation of run-down company premises or gaining a new economic impulse to industrial cities with a low-educated labour force and increasing unemployment. How do we want to work, learn and move around in the future and what will that mean in terms of designing future homes, offices and infrastructure?



BUILT ENVIRONMENT

THEME: BUILT ENVIRONMENT		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> • <i>Dynamic urban areas</i> 	<ul style="list-style-type: none"> • Quality of urban living environment • City and climate (change) • Societal and spatial innovation 	VROM, VenW, VWS, OCW, EZ
<ul style="list-style-type: none"> • <i>Sustainable building and infrastructure</i> 	<ul style="list-style-type: none"> • Improved sustainability of building materials • Build(ing) smart • Robust infrastructure • Energy-producing built environment 	VROM, VenW, OCW, EZ
<ul style="list-style-type: none"> • <i>Subsurface information</i> 	<ul style="list-style-type: none"> • Geodata and information management of the Dutch subsurface 	OCW, EZ, VROM
Markets	Customers	
<ul style="list-style-type: none"> • <i>Building and installation</i> 	<ul style="list-style-type: none"> • EU DG VROM, Bouwend-NL, Building companies, Uneto-VNI, • Housing associations, suppliers, processors, engineering firms 	
<ul style="list-style-type: none"> • <i>Infrastructure construction</i> 	<ul style="list-style-type: none"> • VenW, Municipalities, Provinces, GWW companies, building companies 	
<ul style="list-style-type: none"> • <i>Environment</i> 	<ul style="list-style-type: none"> • EU DGE, VROM, VenW, Provinces, Municipalities • Project developers, mainports, housing associations 	
<ul style="list-style-type: none"> • <i>Subsurface and water</i> 	<ul style="list-style-type: none"> • EU, VROM, VenW, LNV, water boards, Provinces, Municipalities 	
<ul style="list-style-type: none"> • <i>Oil and gas</i> 	<ul style="list-style-type: none"> • EZ, Provinces, NAM, Dutch oil community 	

WE WANT TO ACHIEVE THE FOLLOWING

QUALITY OF URBAN LIVING ENVIRONMENT

Currently more than 50% of the world's population and 90% of the Dutch population live in urban environments. TNO's innovative tools and knowledge of local measures help to realise spatial claims in a clean, safe and healthy way, and thus help to strengthen the international competitive strength of cities.

CITY AND CLIMATE (CHANGE)

TNO quantifies emissions and the aerosol effect on the climate as well as develops and implements decentralised water systems in the built environment to optimise the social costs. For 2015 TNO is working with major municipalities and the state to develop concepts for climate-resistant design of the urban area and infrastructure.

SOCIETAL AND SPATIAL INNOVATION

In stubborn social problem areas (like climate change, energy use by the built environment and urban renewal) TNO wants to have a key role in successful breakthrough programmes, making the difference by undertaking system explorations and economic analyses of innovation and spatial processes.

IMPROVED SUSTAINABILITY OF BUILDING MATERIALS

Together with market parties TNO will ensure that the building and construction sector in 2015 uses much less energy in the construction of buildings and greenhouses, substantially fewer materials and much lower CO₂ emissions. These reductions will be realised in pilot projects with new building materials developed by TNO with external parties.

BUILD(ING) SMART

TNO and external partners will have developed in 2015 a number of new concepts for constructing, managing, renovating and maintaining buildings and neighbourhoods that will demonstrably boost environmental performance, shorten building and construction time, improve the quality for users and lower the total costs over the entire lifecycle. System integration will play a decisive role here.

ROBUST INFRASTRUCTURE

Through the development of new materials and constructions and improved test methods, TNO wants to help improve the existing infrastructure, extend its lifetime and give the new infrastructure a more sustainable character. TNO wants to develop a worldwide trendsetting approach to sustainable and climate-neutral (new and existing) infrastructure.

ENERGY PRODUCING BUILT ENVIRONMENT

TNO develops technologies and methods to enable in 2050 an energy-producing built environment with a comfortable and healthy indoor climate. This concerns the development of energy-efficient buildings and installations at building and neighbourhood levels and using sustainable energy sources as effectively as possible, efficiently managing the required conventional energy, and boosting comfort and health perception.

GEODATA AND INFORMATION MANAGEMENT OF THE DUTCH SUBSURFACE

TNO's innovation and research caters for the various spatial and temporal scales used to characterise the subsurface in four dimensions. To this end new data acquisition methods and ICT systems will also be developed.



BUILT ENVIRONMENT

The future Built Environment trends and challenges are described below, and this is followed by an outline of the desired future scenario with the clear answer from: a choice of specific innovations in three areas: Dynamic urban areas, Sustainable building and infrastructure and Subsurface information.

THE TRENDS: EXPECTED DEVELOPMENTS UNTIL 2025

Decreasing population

Ageing ensures a population decrease on the periphery of the Netherlands and in less prosperous inner cities. We already see this happening in Limburg, Zeeland and Northeast Groningen. Ageing also means that people are modifying their requirements in terms of where they live, looking at the healthcare provisions, for example. High prosperity and mobility also mean that natural spatial characteristics are less influential on the choices citizens and companies make about location. People live and work how, when and where they want. Companies are also becoming more mobile in where they locate according to the merits of the economy.

Cities are growing

The growth and compression of cities is one of the main developments of the twenty-first century. Not only the large cities but also urban areas of fewer than 500,000 residents. In the Netherlands large-scale, complex developments are found in the economic core areas (the North and South Wing, the Randstad), the key projects (South Axis, City Ports, Southeast Brabant), the mainports (Rotterdam and Amsterdam), but also in the greenports (Westland, Aalsmeer). Urban compression also means more multifunctional use of

space, resulting in other and new forms of high-rise buildings and utilisation of the subsurface.

More need for space

High prosperity levels along with individualisation in the Netherlands are also creating more per capita need for space. Not only for wealthy groups but also the middle classes and families with children are increasingly looking to live in the countryside. In the cities particularly with industrial origins (like Rotterdam with its port) the level of education of the labour force remains low as a consequence. And these cities have to integrate many nationalities in their community, creating a tension whereby social cohesion declines and the need for social safety grows.

Climate change

In urban development more account increasingly has to be taken of the consequences of climate change and subsidence. The more sea levels rise, the more precipitation there is and the more water that rivers transport from the hinterland, safety must be secured and damage to buildings and infrastructure prevented. This poses the question about where to build, and the robustness of the design and structure. At the same time, the climate change focus leads to new development in building and construction: sustainable building and infrastructure, building on water and energy-saving innovations for buildings, neighbourhoods and areas.

THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

The trends referred to above do not make the area development task any easier. Below we list some key problems.

Spatial quality under pressure

Open spaces and the subsurface are being used more intensively. Inside the urban area various functions compete and the space risks becoming jumbled. Not only in a small and densely populated country like the Netherlands, but in urban regions worldwide. The task in this increasing intensity is to safeguard quality: the liveability and sustainability of the urban system and the vitality of the urban economy. For the government that means difficult decisions at local, regional, national and international level. In a broader perspective the city is just the hub of a much larger network.

Monodisciplinary, centralised approach is no longer adequate

The Dutch government is responsible for the basic quality of our environment – the frameworks of safety, environment, urbanisation, parkland and water. At decentralised (urban and regional) levels these general frameworks are elaborated and substantiated, a process involving many parties with different vested interests, like private parties with land concerns or a stake in building and construction, and the building and construction sector. Top-down plans based on monodisciplinary regulations and models no longer provide the best solutions in this context. For spatial planning processes a multidisciplinary, more comprehensive approach is needed, not only in new developments but also in the long-term vital and sustainable maintenance of an area:

a 'lifecycle approach' for new and existing area development.

Building and construction sector must innovate

The building and construction sector is especially susceptible to economic cycles, and is now struggling with stagnating production. The future of this sector is uncertain, partly due to a number of problems that are characteristic of this sector. It is still a strongly supply-driven sector in which changing alliances work on building and construction projects acquired by competing on price. The innovative capacity of the sector as a whole falls short, the price-quality ratio must be improved and international competitive strength is a fragile quality. How can we, for example, ensure that the task of buildings with a health function can be calculated for sustainability? In these buildings more complex and technology-intensive care must be provided safely to a growing group of people requiring care and citizens that are less self-capable.

Influence of the recession

The recession will not have a favourable impact on the market prospects for building and construction. The government wants to further restrict the costs for building and construction and maintenance of infrastructure. The huge annual costs of managing and maintaining the infrastructure are likely to be restricted to the minimal 'lifecycle costs' needed to maintain the quality in the longer term.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?²⁶

A sustainable living environment

We want a clean, vital, comfortable and safe living environment that responds to individual wishes, ensures social cohesion and cultural heritage, and encourages economic activity. Parkland in the very compressed urban areas is essential and abundant. Living, working and relaxing are well balanced and well linked by a robust infrastructure.

A dynamic building and construction sector

The ideal building and construction sector can add social added value by developing creative and innovative solutions for the needs of society in respect of the built environment and sustainability.²⁷ There is better cooperation in the building and construction process chain, and more focus on sustainable quality and new building concepts that are energy-neutral and sustainable. Knowledge, experience and the power of innovation are mobilised to boost the vitality of the economy and the accessibility and liveability in our highly populated delta. The result: a built environment that complies with the requirements for high quality. Buildings are flexible, lifetime-resistant and multifunctional. The built environment is varied.

High-tech building and use of land

In the future buildings are increasingly self-sufficient and made of sustainable, reusable materials. In addition, buildings produce the daily energy needs. Far-reaching urban compression is catered for by high-tech, high-rise building and utilisation of the subsurface, with facilities and the transport infrastructure largely below ground. Optimal accessibility with clean transport concepts and

high-tech public spaces that respond to the ideas and wishes of citizens contribute to the urban quality of life.

THE TNO ANSWER: INNOVATE IN THREE AREAS

TNO wants to play a key role in the necessary innovations for the built environment. Within the Netherlands we facilitate comprehensive area development with high-tech information, advanced tools and process knowledge. We make future consequences of decisions visible and support parties in complex decisions. As an independent party we combine specialist knowledge on the quality of water, soil, subsurface and environment into a total picture.

Human behaviour influences the safety of processes. Where safe building is concerned – for care and other purposes – TNO can translate its knowledge about the crucial safety aspects like no other into innovative solutions for the design of the physical environment. TNO develops buildings that ensure safety in crucial social sectors like healthcare. TNO is also the number one player in terms of initiating innovations in building and construction and helps shape sustainable and energy-efficient building. Technical along with process and system knowledge means that TNO contributes to the development of new building concepts and new forms of cooperation within the building and construction process chain, thereby playing a decisive role in the development of an innovative building and construction sector that has a good price-quality ratio and a robust international competitive position. Finally, TNO has a vital role to play in exploring and developing solution strategies for the considerable dynamics that characterise the

²⁶ This ideal picture is based on various future pictures for the built environment, as expressed in government papers such as the Spatial Development Paper (VROM, LNV, EZ, VenW, 2004), The Beautiful Netherlands (VROM, 2008) and the MIRT Projects Book 2009 (VROM, VenW, LNV, EZ, 2008).

²⁷ See the strategic vision of the Dutch building and construction sector of the Regieraad Bouw (2005).



BUILT ENVIRONMENT

built environment. To maintain this social dynamic, innovation policy is needed: policy for the built environment that does not yet exist. For this we have to anticipate the major crises that will have an adverse impact on the built environment in the coming decades: the climate crisis and the economic recession. By signalling problems early on and creating opportunities with others for new, sustainable economic activities, TNO can be a key player in societal and spatial innovation for the built environment.

INNOVATION AREA 1: DYNAMIC URBAN AREAS

- Focus on:*
- Quality of urban living environment
 - City and climate (change)
 - Societal and spatial innovation

How must the urban area be developed in the future? The Netherlands faces the complex task of a comprehensive approach to the factors that are important for area development, in which many different disciplines play a role: environment, water, future oriented building, regional economy, mobility and accessibility. In new and existing area development it is vital to think in terms of lifecycle. Through innovation and research TNO contributes to dynamic urban areas in the following ways.

Clean, healthy and safe living environment

Currently more than 50% of the world's population and 90% of the Dutch population live in urban environments. How can we optimally deal with the various claims on the available space and still comply with the demand for a high-tech quality living environment? TNO supports this social demand

with innovative tools and knowledge of local measures so that the spatial claims are realised in a clean, safe and healthy way. TNO also works with others to make the competitive strength of cities stronger internationally. We also respond to the question of what interventions are needed in the physical living environment to protect citizens and boost liveability in the urban environment.

Climate-resistant cities and infrastructures

TNO also quantifies emissions and the effect on the climate in Europe. This provides clear principles for the required urban, regionally differentiated, modifications. For 2015 TNO is working with major municipalities and the state to develop concepts for climate-resistant urban and infrastructure design. By 2050 at the latest urban areas must be designed and modified such that damage and disruption to the liveability is minimal as a result of climate change. The use of (fossil) energy in cities is then minimised. TNO is also developing and implementing decentralised water systems in the built environment so as to optimise the social costs.

Societal breakthroughs

In obstinate societal problem fields (like climate change, energy use for the built environment and urban renewal) TNO has a key role in successful breakthrough programmes. TNO ensures that societal innovation gets off the ground and change process does not get stuck. TNO performs system explorations and economic analyses of innovation processes and spatial processes.

INNOVATION AREA 2: SUSTAINABLE BUILDING AND INFRASTRUCTURE

- Focus on:*
- Improved sustainability of building materials
 - Build(ing) smart
 - Robust infrastructure
 - Energy-producing built environment

The built environment is a crucial sector for sustainable objectives like CO₂ reduction, less use of and more sustainability of materials, and improving the lifecycle of buildings and infrastructure. Through innovation and research TNO contributes to sustainable building and infrastructure in the following ways.

Reducing use of material, CO₂ emissions and energy use

Together with market parties TNO will ensure that the building and construction sector in 2015 uses much less energy in the construction of buildings and greenhouses, substantially fewer materials and much lower CO₂ emissions. In 2015 a significant reduction will be realised for all three aspects through pilot projects with new building materials developed by TNO together with external parties.

Better building and construction, management, renovation and maintenance

TNO and external partners will have developed in 2015 a number of new concepts for constructing, managing, renovating and maintaining buildings and neighbourhoods that will demonstrably boost environmental performance, shorten building and construction time, improve the quality for users and lower the total costs over the entire lifecycle. System integration will play a decisive role here.

Improving the infrastructure

The materials, constructions and better test methods developed by TNO can improve the existing infrastructure and extend its lifetime. The new infrastructure becomes more sustainable. TNO is developing a worldwide trend-setting approach for a sustainable and climate-neutral (new and existing) infrastructure (car, rail and waterway routes and pipelines), which means better maintenance, less contamination, better material and energy use, more flexibility and less environmental disruption in building and construction and use.

Energy-producing built environment

TNO develops technologies and methods, for instance, that will enable an energy-producing built environment before 2050. The criterion: a comfortable and healthy indoor climate. The goal is to develop energy-efficient buildings and installations, using sustainable energy sources as effectively as possible and use the required conventional energy as efficiently as possible.

INNOVATION AREA 3: SUBSURFACE INFORMATION

- Focus on:*
- Geodata and information management of the Dutch subsurface

The government has assigned various tasks to TNO in respect of information on the Dutch subsurface. TNO acts (internationally) as the Geological Survey of the Netherlands and we manage data and information supplied by mining companies to the Minister of Economic Affairs. TNO has the legal task of making information on the Dutch subsurface available to Dutch society so as to enable the sustainable use and management of the subsurface and the mineral resources it contains. This information is needed to make comprehensive decisions concerning the organisation of the space above and below ground.

INFORMATION SOCIETY



Media and ICT are indispensable in our society. The innovating power of ICT enables us to do things differently: more efficiently, better, faster, smarter and more sustainably. Smart ICT innovations can help solve complex societal issues like climate change, demographic ageing, scarcity, education, mobility, care and safety. In fact, the smart application of ICT is a precondition for this. ICT and media are also the 'backbone' of societal and economic processes. We are using the new technology more and more for social purposes, for example via Hyves, Twitter and YouTube. In brief: if the Netherlands wants to be among the best knowledge economies in the world in a few years, ICT and new media are indispensable.



INFORMATION SOCIETY

THEME: INFORMATION SOCIETY		
Innovation areas	Propositions	Ministries
<ul style="list-style-type: none"> • <i>Future internet use</i> 	<ul style="list-style-type: none"> • Future internet use 	EZ, OCW, BZK
<ul style="list-style-type: none"> • <i>Societal impact of ICT developments</i> 	<ul style="list-style-type: none"> • Societal impact of ICT developments • Sustainable learning in an open information society 	EZ, OCW, BZK OCW
<ul style="list-style-type: none"> • <i>Vital ICT infrastructures</i> 	<ul style="list-style-type: none"> • Vital ICT infrastructures 	EZ, OCW, BZK, VROM, VenW
Markets	Customers	
<ul style="list-style-type: none"> • <i>Telecom</i> 	<ul style="list-style-type: none"> • KPN, Vodafone, T-Mobile, Tele2, Online, Delta, Ziggo, UPC • Ez, Telecom Austria, TDC, Telenet, Sunrise, ETIS, GSM-A, FIST, OPTA, AT 	
<ul style="list-style-type: none"> • <i>Education & Media</i> 	<ul style="list-style-type: none"> • Kennisnet, Surfnet, NOS, NPO, OCW, IBG, CBP, SRN, AKN • NUV, KGV, Noordhoff, polytechnics, Open University 	
<ul style="list-style-type: none"> • <i>eGovernment</i> 	<ul style="list-style-type: none"> • Az, BzK, FIN, Logius, ICTU, Tax Authorities • DEF, VenW, EU, jUS, Ez, zBO's, Municipalities, IPTS, SBO 	
<ul style="list-style-type: none"> • <i>Business Services</i> 	<ul style="list-style-type: none"> • DNB, Holland Financial Center, Rabobank, ING, ABU • TNT, RVS, SME, NvB, Industry Associations, Utilities 	

WE WANT TO ACHIEVE THE FOLLOWING

FUTURE INTERNET USE

TNO wants to focus on new technology and functionality (internet 3.0) for productivity improvement and new services in the digital economy as well as innovation of the internet infrastructure to be able to respond to the requirements that increasing data streams will place on for example, capacity and reliability.

SOCIETAL IMPACT OF ICT DEVELOPMENTS

For a more effectively performing eSociety (knowledge society), with special emphasis on education, TNO focuses on societal issues, the desired social conditions and the necessary innovation and ICT policy.

VITAL ICT INFRASTRUCTURES

TNO wants to help create solutions that make ICT infrastructures a real social basic provision ('utility'), like gas, water and electricity. Sustainable, available, of good quality and safe; vital ICT infrastructures that determine social and economic traffic.



THE TRENDS: EXPECTED DEVELOPMENTS UNTIL 2025

ICT and internet are the basis for solving complex societal issues and thus for our social and economic development. ICT is becoming ever faster and smaller as well as acquiring ever greater (storage) capacity. The exponential growth of internet has seen ICT penetrate all aspects of our society. And internet is still developing rapidly. Trends for the coming years are:

- even more internet-based services, making them more simple and efficient (semantic web);
- more sensors and equipment linked to internet ('Internet of Things');
- greener internet (sustainability);
- media that is accessible immediately to everyone everywhere (real-time internet);
- the disappearance of the division between new media (online media) and traditional media.

These trends generate many opportunities for business: for better and new services and for different business models. But they also place great demands on the internet itself as the underlying infrastructure.

Internet continues to develop and improves productivity

Internet is crucial for many economic sectors, laying the basis for the (inter)national economy. In the future, services will account for some 70% of the gross national product. Social networks are growing, new media forms are emerging and the mobile internet and the 'Internet of Things' are in the full throes of development. Internet continues to develop, with enormous innovation and growth potential

for new functionalities and services. The service economy is a particular beneficiary, but in other sectors too productivity can be improved (internet-driven innovation).²⁸

Impact of ICT is increasing

ICT was originally intended as an 'enabler' to simplify processes. The real impact now seems to be much more radical, however; the impact of ICT and media is often irrevocable. Where this technology becomes embedded in behaviour, processes of institutional structures, we see that behaviour, processes and structures also fundamentally change. In this way ICT influences the direction that society and the economy take. The influence of this change is often underestimated, which means that undesired effects have to be catered for at a later stage.

Convergence of media and internet

Within the development of internet, media has gained a key role, such as in the strong surge of user-generated content. In the new generation, internet semantics to decipher media will play an increasingly key role. Methods for automatically indexing video are being developed, enabling new forms of service provision like personalised media and better reuse of media. This will enrich and make more dynamic the application of media in internet. Also the increasing quality of media will place a greater strain on internet, which will lead to new forms of media distribution.

We are increasingly more dependent on media and ICT

For policymakers and entrepreneurs, it is clear that they will have to link ICT and media to a vision for change whereby they take account of future effects (sustainability). Strategic

issues in this area are increasingly part of the agenda. Now that we really do live in an information society, greater connection is necessary between the 'hard' (technical) and 'soft' (social sciences) dimensions of ICT. Society has become dependent on ICT, but the 'robustness' of the technology leaves much to be desired, leaving the trust of companies and citizens in ICT trailing behind in the form of dependency.

THE CHALLENGES: WHAT ARE THE IMMINENT PROBLEMS?

The main challenge to the information society is sustainable development and the development and stimulation of productivity (decisiveness). And how do we use ICT to solve different societal issues without losing the trust?

Better utilisation of ICT possibilities

Internationally, the Netherlands scores high in respect of ICT infrastructure: almost everyone has broadband and new media and the Netherlands has the fastest network for research (SURFnet) and the world's largest Internet hub (the Amsterdam Internet Exchange). We must not lose this leading position. However, CPB and CBS studies²⁹ reveal that Dutch ICT, compared with other countries including the US, has made insufficient efforts to stimulate productivity and so become more decisive. This 'deficit' can be seen mainly outside the ICT-producing sector, like retail, wholesale, banking and insurance. The main challenges for productivity are revealed in the pan-governmental ICT agenda.³⁰ The question is how the Netherlands can also become (and stay) leader in this terrain. What succeeds in other countries but not here? Why? How can

ICT help to solve societal bottlenecks³¹ and be a driving force behind the service economy?

Controlling societal effects

Personal and business use of ICT is increasing rapidly and, consequently, so is dependency. This 'vital social infrastructure' works like a strong 'transforming force' on existing structures and processes within our society. The question now is how to deal with the strong, often disruptive impact of ICT. How do we control the influence of ICT on the structure of society and the economy, and therefore human behaviour? And how do we ensure that we keep trust in all the possibilities, despite all the emerging privacy and security risks of new media?

Infrastructure dependency

Since we are becoming more and more dependent on ICT, we have to be able to trust in the 'robustness', safety and resilience of the ICT infrastructure and of large ICT systems. Increasingly, however, ICT systems appear hypersensitive to external disruptions and the quality of large ICT systems leaves much to be desired, especially in the public sector.³² In both the private and the public sectors, we can look back at many failed ICT innovations, substantial investments that not only deliver too little but make vital functions extremely vulnerable. This puts the trust of consumers and citizens in industry and government at risk.

Sustainability

With the explosive growth of ICT use, the question arises of how we can use ICT sustainably, especially in terms of its impact on the environment, a priority agenda item. The CO₂ emissions of the ICT industry are, according to the research agency Gartner,

equivalent to those in the aviation industry. So government and industry³³ are trying to reduce energy consumption by the sector and, at the same time, use ICT applications to make other sectors more sustainable.

THE IDEAL PICTURE: WHAT DO WE WANT TO ACHIEVE?

In June 2008 the Dutch government outlined its future vision for 2030 in the paper 'Towards an agenda for sustainable growth in productivity'.³⁴ The ICT board³⁵ and the ICT research platform Nederland (IPN)³⁶ elaborated this vision through future scenarios for the development of ICT and internet in the Netherlands and Europe. They also describe how that ICT and internet development contributes to the development of the key areas stated. They see ICT as an engine and a driver of innovation, with ICT and internet fully entwined in our daily lives. This is possible because the ICT is so robust that society has trust in it and economic and societal processes can be dependent on it. In addition, internet will grow to many billion connections. Wireless, high-tech access combined with fibre-optic connections make services possible that use context and so allow the interaction with users to be entirely natural and simple. Media are independent of place and time and accessible for everyone, including producers. Sensors and equipment linked to internet provide data to intelligent programs that take care of and monitor our affairs, thereby making operations more efficient and sustainable and creating sustainable solutions for societal problems like demographic ageing, care, safety and mobility. Societal innovation, too, flourishes through the development of ICT and internet

and will generate changes of lifestyle (more sustainable, healthier), processes and structures in the future. Identity and privacy on internet are safeguarded in the right balance with economic and societal interests. Undesired side effects in major industry and government projects can be prevented by well-designed ICT. The power of innovation in education and training is significantly enhanced and the integration of learning and working much improved.

²⁸ Viviane Reding 2009: Internet of the future: Europe must be a key player.

²⁹ See, for example: Productivity effects of innovation modes, CBS, July 2009.

³⁰ The pan-governmental ICT agenda coordinated by the Ministry EZ: www.ez.nl/Onderwerpen/Betrouwbare_telecom/ICT_beleid/Rijksbrede_ICT_Agenda.

³¹ See, for example, the NWO dossier on the economic effects of ICT (http://nwo-domino.sara.nl/nwohome.nsf/pages/NWOA_6U2AQB) and various ESB news items (http://esbonline.sdu.nl/esb/ict_en_economische_groei.html) and ICT as Innovation axis of the Innovation Platform (<http://nirict.3tu.nl/documenten/ictalsinnovatieas.pdf>), especially appendix II.

³² See, for example, study by the Rekenkamer: www.rekenkamer.nl/Actueel/Onderzoeksrapporten/Introducties/2007/11/Lessen_uit_ICT_projecten_bij_de_overheid.

³³ <http://www.gartner.com/it/page.jsp?id=503867>.

³⁴ Netherlands as enterprising innovation country, Ministry EZ, 2008.

³⁵ ICT2030.nl, ICT agenda for the future of the Netherlands, ICT Board, May 2009.

³⁶ ICT Masterplan, IPN, May 2009.



INFORMATION SOCIETY

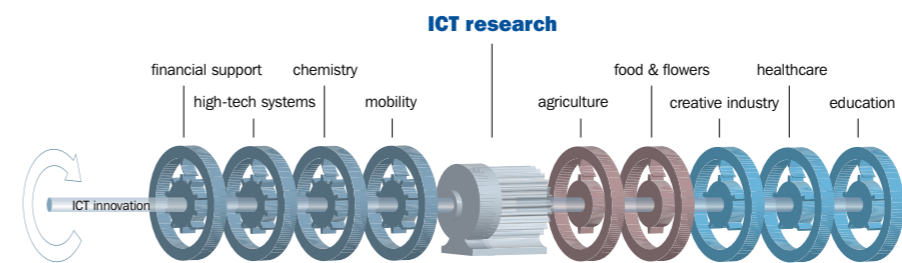


Figure 1

Source: ICT-Regie

THE TNO ANSWER: INNOVATE IN THREE AREAS

TNO has expertise in the technical, societal and policy aspects of ICT and internet, and we want to use this to help boost the social yield of ICT developments. We focus on applied research for the innovation of ICT itself and for ICT as innovation axis in key economic areas and sectors of society (see figure 1). To be able to achieve our ambitions within this theme, we work very closely with government, industry, social organisations and national and international knowledge institutions. In order to build up knowledge and transfer this quickly and effectively, TNO has to succeed nationally and internationally in shaping and substantiating this cooperation. That we are able to do this can be seen in our participation in the coalition for the ICT Knowledge and Innovation Centre of the European Institute for Innovation and Technology and our high success factor in European 7th framework programme applications (30%). Based on these aspects, TNO has selected three innovation areas for the theme Information Society. We focus on research in areas where TNO has proven excellence³⁷ or can build this up very quickly. TNO thereby enables government and social institutions to exercise policy with a visible impact. TNO also enables industry to boost the economic impact in a socially responsible way.

INNOVATION AREA 1: FUTURE INTERNET USE

Focus on:

- Making new services practicable
- Internet of Things
- Development of technology for the future internet-based information society

This innovation area focuses on new internet technology and functionalities that improve the productivity and enable new services in the digital economy. We also work within this area on a new internet infrastructure able to cope with the requirements set by increasing data streams in terms of capacity and reliability. The topics of focus for this innovation area (see box) link up to the key themes sketched by the Future Internet Alliance³⁸, themes in which breakthroughs are needed in the coming years.

Make new services practicable

We develop new principles to boost the innovative capacity of these organisations, with specific attention to media use, adoption by and interaction with users (interfaces, mobile platforms) and new derivative business concepts. We develop standards and design new internet services, contributing to policy and strategy concerning the internet of the future. This helps to increase trust among users and organisations in internet as a communication medium. The goal: in 2014 to increase this trust by 50% (source: research Insites consulting).

Help to monitor and control our environment (Internet of Things)

We want to develop new possibilities for actively managing our physical world through the use of sensors and internet connectivity. This will enable systems, equipment and

sensors to exchange data interactively with the physical world and each other. This requires, among other things, secure access and large-scale data processing. This technological development and communication about it will enhance the sense of security among citizens and boost the competitive strength of the Netherlands.

Development of technology for a stable growing internet

The underlying structure of internet has hardly changed over the past forty years (protocols, architecture), and this causes obstacles; innovation is needed to comply with the increasing requirements. Therefore, TNO wants to have made a measurable contribution by 2014 to the internet infrastructure in terms of growth (mobile, Internet of things), continuity (IPv6) and reliability (security, privacy).

INNOVATION AREA 2: SOCIETAL IMPACT OF ICT DEVELOPMENTS

Focus on:

- Monitoring of policy
- User empowerment
- Management of privacy- and e-Identity
- Sustainable learning

In this innovation area we look for ways to enable the knowledge eSociety, and in particular education, to perform more effectively. We focus on demand issues, desired societal conditions and required innovation and ICT policy. We want to promote the involvement and competencies of and trust among citizens, consumers, companies and public organisations and so bring a sustainable knowledge society closer. Support policy development and decisions through monitoring. Corporate and government

policy is increasingly based on facts, monitoring and feedback. By signalling societal trends early, we gain a better picture of what concerns the population. By building better knowledge about attitudes and opinions about ICT and ICT use, the government and industry can formulate policy more effectively. This translates into the retention of a high position (top 5) on the e-readiness indices.

Research into the respective consumer/citizen (user empowerment)

By involving users in shaping work processes and new services, users often accept these changes more readily, which makes them more effective. The art is to shape the participation such that it responds to the diversity of wishes and interests. We research the possibilities in this area. Integrating the knowledge and competencies of users brings us closer to the socially preferred information and communication systems. This increases satisfaction with the systems.

Gaining trust³⁹ through better privacy and e-Identity management

How can we shape and safeguard privacy and identity in the future in new developments like the electronic patient dossier, the child dossier, the public-transport chip card, RFID and road tolls? We want to boost trust in using e-Identity management systems by 25%, for example by taking account of privacy issues right from the design stage of e-Identity management systems.

Innovative and sustainable improvement of education⁴⁰

New technology offers possibilities to boost the innovative capacity of education and give individuals control over their learning. We will therefore design (and evaluate) a scientific and empirically founded comprehensive method to enable people to learn sustainably. This must visibly boost the innovation capacity of both education and training, and substantially improve the integration of learning and working.

INNOVATION AREA 3: VITAL ICT INFRASTRUCTURES

Focus on:

- Technical reliability
- Operation and risk management
- Greening

For many economic sectors, a reliable and secure infrastructure is an absolute must, for example in payment transfers and online banking. Since these networks often comprise long chains, it is particularly complex to safeguard the continuity. Within this innovation area we work on solutions that make a real basic social provision (utility) of ICT infrastructures, like gas, water and electricity.

Sustainable, available, good quality and secure; vital ICT infrastructures that determine social and economic traffic. This innovation area includes broadband provision and telecom networks and the IT systems, databases and application that use them to make service provision possible.

More technical reliability and safety

By designing and analysing robust ICT architectures and infrastructures we can ensure that ICT services are reliable and secure. By 2014, trust in ICT in our society must increase by 100%. The robustness of ICT infrastructures must increase by 25%.

Operation and risk management

We look at how we can safeguard the continuity of ICT services at an acceptable, pre-defined level. Agreements about quality and reliability are key here. We are also developing a frame of reference for the governance of chains for the financial management, setting costs against risks. The objective is to reduce the economic damage of ICT disruption by 25% by 2014.

More sustainable ICT

We want to develop architectures, technology, standards and monitoring methods that make ICT resources more sustainable. Intention: in 2014 to have reduced the energy consumption by ICT resources in the EU by 25% and CO₂ emissions by 50% (as measured by Gartner and others).

³⁷ TNO ICT technology audit

³⁸ Toward the Future Internet – a European Research Perspective, IOS Press, 2009.

³⁹ European Commission 2009, Online trust: a Safe and Secure Digital World (from: A green knowledge society).

⁴⁰ See also: Social Innovation Agenda Education (EZ, OCW).

IMPACT IN THE MARKET



'Valorisation: the total annual income in 2009 of companies established by TNO was around 300 million euros.'

Of TNO's market income in 2008, 102 million euros came from Dutch industry and 84 million from the Dutch government. Dutch SMEs⁴¹ accounted for 30 million euros. TNO works for most industry sectors, with manufacturing (biggest customer ASML) and Multimedia and ICT (biggest customer KPN) key sectors.

In 2009 TNO was hard hit by the recession, especially in the automotive, semiconductors, pharma and ICT markets where income fell by some tens of percentage points. Only in 2011 is any substantial market recovery expected.

STRATEGY 2011-2014

The market strategy 2011-2014 is thematic, geared to the relevant target groups and stakeholders for each theme. See the theme sections. Specific market explorations and ratification among customers were part of the preparation. TNO-wide principles and objectives for the market strategy are:

- More emphasis on the development and

innovating role of TNO and upgrading the products and services portfolio as well as on co-development, high-tech contract research and related service.

The commercialisation of recurrent and routine service based on matured technology will be accelerated via new companies. We aim for an income mix of a third demand-driven programmes, a third competitive funding and a third market funding for contract research and consultancy (excluding income from newly established companies).

- **Strengthen valorisation:**

TNO has established new companies since 1986 and supervises these for a few years after which they are disposed. These companies are a source of high-tech Dutch employment, especially SMEs. The total annual income of the companies established was around 300 million euros in 2009. In the past 10 years 95 new companies have been established and 55 companies disposed of. In the coming years TNO will be more

geared towards establishing new companies, high-tech spin-offs and new companies based on the recurrent service referred to above. TNO also wants to boost its economic impact by enabling customers to make more and easier use of the patent portfolio of TNO (see the paragraphs on Knowledge Protection and Intellectual Property in the Excellent Knowledge section).

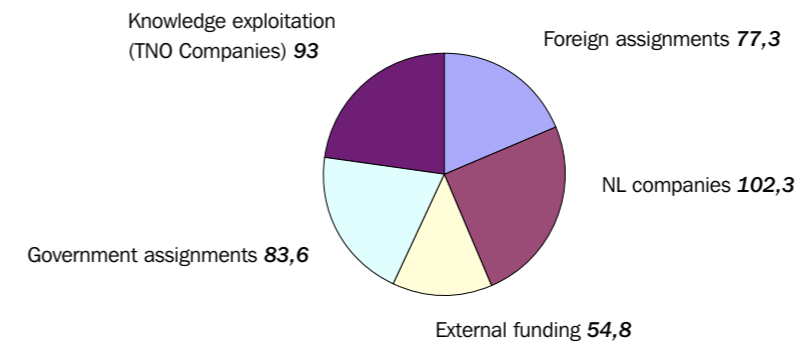
- **SME:**

Further expansion and reinforcement of the transfer of knowledge to SMEs in a TNO-wide programme. See the separate SME section of the Strategic Plan.

- **International:**

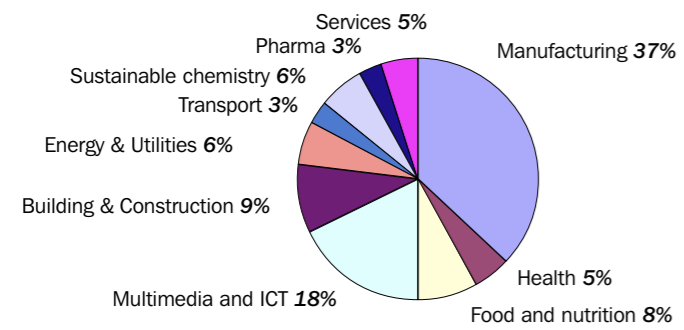
The knowledge market will become more and more international in the coming period. TNO will grow in this respect by explicitly striving for an internationally competitive position in the selected themes and innovation areas. A key component of the strategy is to enter into alliances with fellow RTOs in Europe on specific topics. Like the cooperation with the Norwegian Sintef and French IFP on Carbon Capture and Storage (CCS). TNO Companies will increasingly focus on the international marketing of matured technologies, geared to the United States, China, Japan and Korea.

TNO MARKET INCOME 2008 (EUR 411 M)

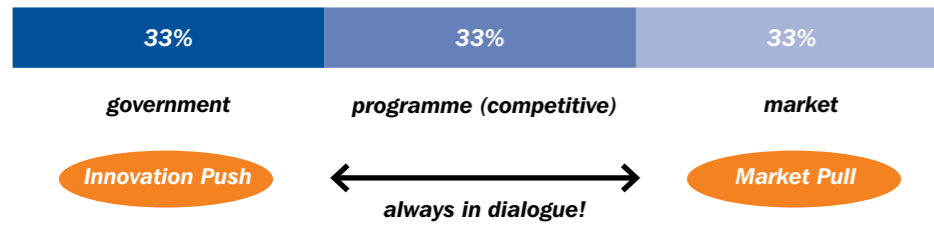


⁴¹Companies ≤ 250 employees and not part of a larger group.

INCOME FROM DUTCH COMPANIES PER MARKET CLUSTER (EUR 102 M)



**PREFERRED INCOME MIX FOR TNO FUNDING
(33% GOVERNMENT , 33% PROGRAMME (COMPETITIVE) AND 33% MARKET)**



Inside - Out

- New know-how as starting point
- Scouting for markets outside

Outside - In

- Market as starting point
- Scouting for solutions inside

TNO AND SMEs

TNO reaches around 10,000 SMEs each year, with a value of more than 30 million euros, giving TNO by far the biggest reach and most intensive relationship with SMEs of all Dutch knowledge institutions. For the coming period TNO wants to extend its reach among the innovative forerunners. For the developers and users, much effort will be devoted to a collective approach geared to upgrading clusters and chains, retaining and strengthening the position of these companies as suppliers to the major multinationals. Furthermore, new technology will be brought to their attention proactively through organising theme workshops in cooperation with Syntens and industry organisations. The set of tools for knowledge transfer will be extended with one-day consultancies as a logical next step to the primary advisory function of Syntens. Cooperation with the polytechnics in projects for SMEs and knowledge transfer via visiting lectureships will increase. Modifying and enhancing the transparency of the General Terms and Conditions will boost accessibility for SMEs.

Innovation support for SMEs is and remains one of the main reasons for TNO's existence. The establishment of TNO in the crisis years following the First World War was based on the conviction that the government was responsible for objectively structuring the knowledge infrastructure. In these times of recession such a need is unchanged today.

'In the sectors where TNO is active (manufacturing, building and construction (incl. energy applications), food and nutrition, sustainable chemistry, pharma and the communication sector) we reach annually some 10,000 SMEs (ca. 2,400 individually and ca. 7,500 via branches and collectives).'

APPROACH

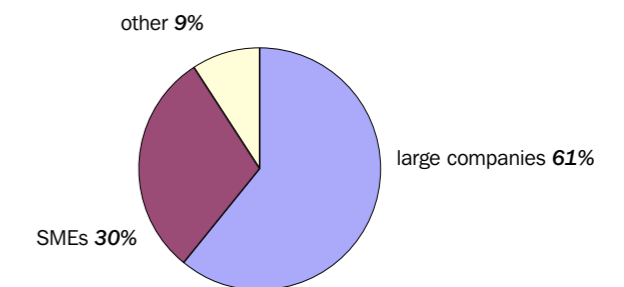
In the past SMEs were largely catered for by organisational entities specially established for this purpose. The rapid technological development and increasing international orientation of Dutch industry make it necessary, however, to offer only internationally competitive top knowledge and technology. This can best be done from the specialised technology entities of TNO that also work for other market parties, including many major Dutch and foreign companies. This way TNO can serve not only individual SMEs but also contribute to upgrading entire chains and clusters, in which increasingly higher requirements are made of the suppliers in terms of their technological competitive strength.

The SME sector in the Netherlands comprises 700,000 companies⁴², of which around 120,000 companies are regarded as innovative forerunners (15,000), developers (46,000) or users (57,000)⁴³. In the sectors where TNO is

active (manufacturing, building and construction (incl. energy applications), food and nutrition, sustainable chemistry, pharma and the communication sector) we reach annually some 10,000 SMEs (ca. 2,400 individually and ca. 7,500 via branches and collectives) with an annual value of 30 million euros, or some 30% of the work for Dutch industry. For the main part (21 million euros) this involves single assignments in addition to assignments for collectives of companies (4 million euros). The remainder comprises co-funding of companies by the special TNO programmes financed by the Ministry of Economic Affairs and partly geared to innovative SMEs and partly to so-called users and followers:

- Technological cooperation: in this programme companies can participate at 10, 25, or 50% of the costs and gain corresponding rights to the developed knowledge. On average 1 euro of the EZ contribution to the TNO programme for Technological Cooperation generates 7-10 euros to the participating

TNO WORK FOR DOMESTIC INDUSTRY (2008: EUR 102 M)



⁴² Source: CBS.

⁴³ EIM study October 2008: 'Innovation pyramid, a segmentation of the SME sector'.

'On average 1 euro of the EZ contribution to the TNO programme for Technological Cooperation generates 7-10 euros to the participating companies in the form of more income and profit and/or cost savings'

companies in the form of more income and profit and/or cost savings

- Commercialisation by TNO of developed knowledge: the Small Business Innovation Research Programme (SBIR) enables SMEs financially to commercialise the knowledge developed and made available by TNO. Product ideas of TNO are advertised and SMEs can make a bid by submitting business plans.
- TNO Challenge: for a team of TNO specialists to solve a problem of a representative company for a sector or a group of companies within one week.
- Collective knowledge transfer: technology-following companies and users are served by a programme for collective knowledge transfer, geared to sectors and technology chains and clusters.
- Vouchers: much of the accessible advice in the form of knowledge vouchers made available by the Ministry of Economic Affairs to SMEs is via TNO.

In addition to existing tools and forms of cooperation, more use will be made of so-called fieldlabs. For SMEs this means facilities made available for research.

Examples are:

- The Machine Fieldlab, where TNO state-of-the-art-knowledge of a sophisticated 5-axial milling machine is transferred to end users. TNO plays a bridging role between the Dutch manufacturer and the end users.
- The Horticultural Greenhouse Fieldlab in Westland, a cooperation between TNO, Hogeschool INHolland, Fytagoras and DLV Plant, in which growers, researchers and suppliers cooperate closely on new technology for the greenhouse in a practical way.
- The recently opened Van Leeuwenhoek Laboratory in which TNO and the TU Delft make facilities in the field of nanotechnology (cleanrooms, electron microscopy, analysis) accessible for SMEs.

In consultation with the Ministry of Economic Affairs TNO is aiming to double the SBIR programme that attracts great interest from innovative SME companies. The aforementioned co-development programme geared to technological cooperation between SMEs and TNO will be continued and aim at further growth, in part through making the scheme (in consultation with EZ) more accessible to SMEs.

- For developers and users (ca. 50,000 in the sectors where TNO has a position) much effort will be devoted to a collective approach geared to upgrading clusters and chains to retain and strengthen the position of these companies as suppliers to the major multinationals. Also here TNO aims to boost reach by 25%.

This approach will enhance the cohesion between new knowledge development and knowledge transfer in a sector and the sector as a whole will achieve a technologically higher level via the breadth of such clusters and chains. Examples are:

- the development of a technology to make components ultra clean in the lithography sector. TNO has developed this R&D technology in 8 years for ASML and itself and is now helping suppliers that want to implement the technology in their production process.
- the cooperation with a group of tomato growers where TNO is researching which CO₂ capture technologies comply with new legislation. Thereafter TNO will work with both suppliers and OEMs⁴⁴ of this equipment to develop a new generation of products. Also a regional approach will be taken more and more. The policy agreement between Provinces and the State shifts the regional economic (social) policy more towards the provinces. Regional networks thus are more determinative for innovation investments. The approach that has been successful for the Eindhoven region is being pursued in the Rotterdam-Rijnmond region.

The regional approach also crosses national borders. Examples:

- Nanotechnology triangle of Eindhoven, Leuven and Aachen.
- Healthcare Euregio Enschede-Gronau.
- Maintenance Valley Woensdrecht, Schiphol, Zaventem
- Furthermore, new technology will be proactively profiled through thematic workshops co-organised with Syntens and industry organisations. There is a cooperation

agreement with Syntens for this. In close consultation with the respective industry organisations there will be a programme of tens of workshops.

Together with SME Netherlands and Syntens a programme will be set up and carried out for the retail sector to produce a better approach to problems concerning accessibility, logistics, energy efficiency and security. The SMEs working in these areas will also be involved.

- The set of tools for knowledge transfer will be extended with one-day consultancies as a logical next step to the primary advisory function of Syntens.

Mkb blijft investeren in innovatie ondanks crisis

Tel 819 Van een onzer verslaggeefsters
EINDHOVEN – Het midden- en kleinbedrijf is nog steeds de motor voor innovatie in Nederland. Deze ondernemingen vinden innovatie zelfs in tijden van crisis van essentieel belang voor hun voortbestaan. Ze durven nu te investeren terwijl grotere organisaties voorzichtiger zijn.

Dat blijkt uit een grootschalig onderzoek onder 600 'beslissers' naar de staat van innovatie in Nederland van innovatiebureau Six Fingers in samenwerking met onderzoeksbureau DBMI.

Er is een groot verschil tussen succesvolle organisaties op het gebied van innovatie en de minder succesvolle. Succesvolle bedrijven geven aan dat het innovatiebudget gelijk zal blijven (32%) of zelfs gaat stijgen (57%). Slechts één op de tien geeft aan dat het budget in 2010 minder zal worden.

Ook zijn kleine organisaties succesvoller in innovatie dan grote organisaties. Van de kleine bedrijven in Nederland behoort 45% tot de succesvolle innovatieve bedrijven, van de grote maar 17%. Concurrentievoordeel in de markt, maar ook het vermogen te reageren op veranderende klantbehoeften of regelgeving, worden vaak toegeschreven aan de innovatiekracht van een onderneming.

Uit het onderzoek komt een aantal factoren naar voren dat bepaalt of een organisatie wel of niet succesvol is op het gebied van innovatie. Zo kijken

succesvolle bedrijven niet teveel naar wat de concurrentie doet en houden zij het poldermodel buiten de deur. Daarmee voorkomen zij dat ideeën op de plank blijven liggen. Verder blijkt ook dat deze organisaties toestaan dat er fouten worden gemaakt.

Source: Telegraaf 2009

⁴⁴Original Equipment Manufacturer

In consultation with the Ministry of Economic Affairs the exact conditions and scope of this scheme will be decided in 2010. Collective knowledge transfer using industry sector innovation contracts will be continued. TNO also argues for an extension of the number of knowledge vouchers available for SMEs.

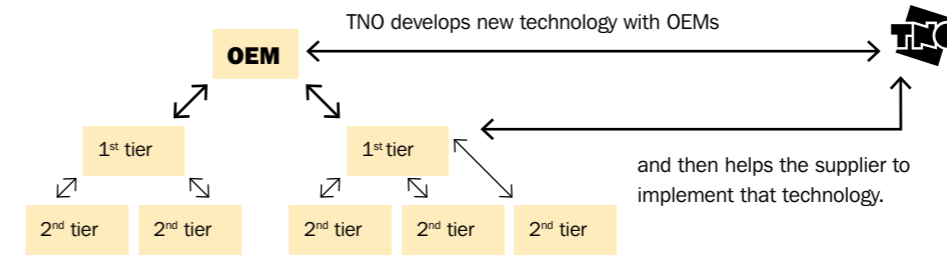
partners like Syntens, VNO-NCW, SME Netherlands and the HBO council in the Innovation Alliance Association (SIA) and therefore with regional networks. The respective parties will consult on the necessary extension of funding options for this purpose.

- Modifying and enhancing the transparency of the General Terms and Conditions will boost accessibility for SMEs.

Agreements on this will be made with the Ministry of Economic Affairs, VNO-NCW and SME Netherlands in 2010.

- Cooperation with the polytechnics in projects for SMEs and knowledge transfer via visiting TNO lectureships will increase. The 40 Dutch polytechnics want to become more involved in regional innovation with SMEs through the development of 'research specifically geared to professional practice'. TNO is working with

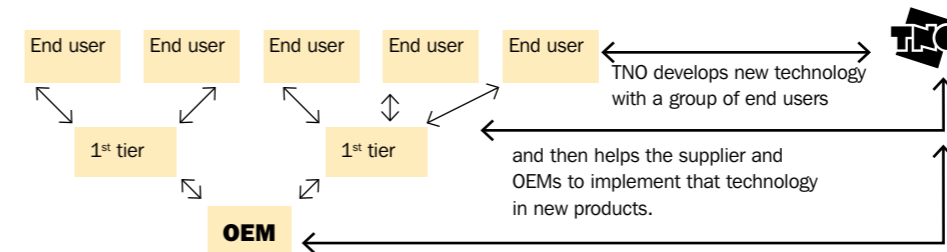
CHAIN INNOVATION TOP-DOWN



EXAMPLE:

TNO R&D has developed a technology in 8 years for ASML for 'making components extremely clean' and is now helping suppliers that want to implement the technology in their production process, thereby boosting competitive strength in respect of foreign companies

CHAIN INNOVATION BOTTOM-UP



EXAMPLE:

In cooperation with a group of tomato growers TNO is researching which CO₂ capture technologies comply with new legislation and will then work with suppliers and OEMs to develop new equipment.

INNOVATION THROUGH B2B ASSIGNMENT

EXAMPLE:

TNO has developed cow-ear sensors with AGIS. Via innovation vouchers a proof-of-concept has been made and then a major research programme resulted in 'carefree dairy cattle'. In 2008 AGIS received the Herman Wijffels award for this and is now global market leader in the field of 'cow fitness'.



EXCELLENT KNOWLEDGE

TNO works from an excellent technology position created in cooperation with customers and partners in the government funded research programme. Customers are only content with top knowledge, measured by international standards. The quality and distinctive capacity are monitored by external technology audits every four years. Cooperation in 'open innovation', national and European, is an absolute must to successfully tackle the global and European challenges. The basis for this cooperation is shaped by excellence and a distinctive capacity among the partners involved. Further concentration of the TNO technology portfolio to an excellent knowledge basis is therefore necessary. In at least 25% of the selected innovation areas TNO wants to be leading in Europe. In the other innovation areas TNO wants at least to be authoritative in specific components. Nationally in terms of the themes agreed with the government, there is close agreement as well as support and cooperation with fellow LTIs. In Europe the aim is for stronger alliances in specific topics with fellow Research & Technology Organisations.

The current structural cooperation with the universities (20 knowledge centres, 60 visiting professors and 150-200 research assistants) focuses on the selected themes and innovation areas. More effort will be made to cooperate with prominent foreign universities and RTOs. TNO is distinctive from academic research through its exclusive emphasis on valorisation in tangible applications and innovations for customers, and its customer-gearred approach. Funding: TNO takes the available level of government funding for 2010 as the basis for realising the plans incorporated in this Strategic Plan.

'The current structural cooperation with the universities will be strengthened and focused on the selected themes and innovation areas.'

AGREEMENTS WITH THE GOVERNMENT: DEMAND-DRIVEN PROGRAMMES

At the start of the strategy period 2007-2011 the system of demand-driven programming was introduced for the government funded programmes of TNO and the LTIs. The basis for this was the Cabinet opinion of the report by the ad-hoc committee 'Bridging function of TNO and the LTIs' whose aim was to boost the involvement of government, industry and social organisations in the research of TNO and the LTIs.

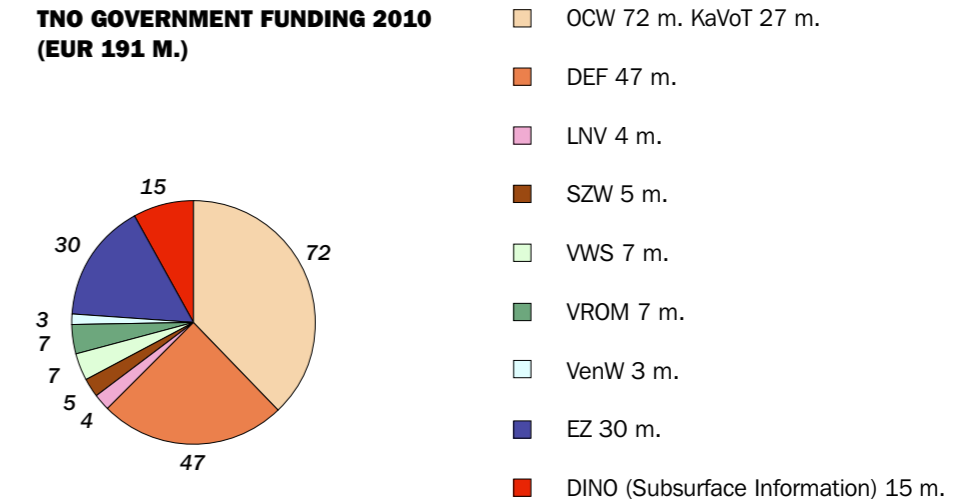
At TNO this resulted in the Strategic Plan 2007-2010 in 38 demand-driven programmes for the 12 themes agreed with the government. These are already being executed. There was intensive interaction with the stakeholders involved in each programme, as in annual knowledge arenas. The results of the programmes are reported annually to the respective departments. In 2011 TNO will produce a comprehensive report, including an

impact assessment. In terms of the demand-driven system, an interim evaluation took place in 2008 on behalf of the government, which was generally positive. In 2010-2011 the final evaluation will take place.

DEMAND-DRIVEN PROGRAMMES 2011-2014

For the period 2011-2014 TNO uses the current system of programming and accountability. Any changes as a result of the forthcoming final evaluation will be incorporated. Intrinsically the demand-driven programmes will be linked to the proposed themes and innovation areas and derive directly from the priority addressing of the knowledge issues. Tangible programme proposals will be detailed in close consultation with the respective departments and verified in the knowledge arenas. In the run-up to this Strategic Plan the necessary ratification has already occurred among departments and other stakeholders. The annual reporting will also take place for the departments most concerned.

TNO GOVERNMENT FUNDING 2010 (EUR 191 M.)



KNOWLEDGE AS CAPACITY ACROSS THE THEMES (KAVOT); ENABLING TECHNOLOGIES 2011-2014

A programme 'Knowledge as Capacity across the Themes' (KaVoT) has been running in the period 2007-2010 for more generic cross-thematic knowledge development and the development of new initiatives. It involves the following:

- Renewing innovation
- Innovation that works
- Innovation in life sciences
- Personalised health
- The Earth as a system
- Intelligent sensor networks
- Materials technology
- MiReCol

These programmes will be completed and evaluated during 2010. Viewed from the need of the proposed themes and innovation areas for 2011-2014, it is proposed to gear the KaVoT programme in the coming period to the following enabling technologies:

- Models
- Sensors
- Materials
- System biology
- Innovation and behaviour
- Strategic policy research⁴⁵

This concerns generic technologies for all themes. It is vital that the knowledge development within the themes remains linked to the latest international developments in these technologies.

TNO CONTRIBUTION TO THE EUROPEAN KNOWLEDGE AGENDA

The themes and innovation areas on which TNO will focus in the coming period have a strong European dimension, thereby enabling TNO to extend its strong position in the European framework programme and also position itself in the newly established European Institute of Innovation and Technology (EIT). TNO has been selected for each of the three Knowledge and Innovation Communities (KICs) in which the EIT is being launched: climate change, sustainable energy and information and communication society.

The role of Research and Technology Organisations

The problem-solving character of the research of Research and Technology Organisations and their close contacts with industry ensure that there is a good nutrient for multidisciplinary research geared to applications. Within the European Association of Research and Technology Organisations (EARTO) particularly RTOs play a significant role in bridging research and industrial application. Their unique positioning in the route from research to application means that RTOs make an essential contribution to industrial and social innovation. In the European research programmes, especially the framework programmes, RTOs are prominent. The evaluation of the sixth framework programme reveals that institutes for applied technology – with some 30% participation – are substantial participants in framework programmes.

RTOs inside Europe are united in the European Association of Research and Technology Organisations (EARTO) within which the most prominent RTOs together form the EUROTECH group. TNO is a member along with Fraunhofer Gesellschaft (Germany), VTT (Finland), CEA (France), QinetiQ (United Kingdom) and Sintef (Norway). There is intensive cooperation among the RTOs in European research programmes. Outside of this, too, we see increasingly more strategic alliances emerging. The EUROTECH group has been cooperating more intensively since 2008 in the ERANET project: Associated European Research and Technology Organisations (AERTOS). Explorations in Carbon Capture and Storage, Energy Neutral Building, Offshore Wind Energy, Security, Innovation in the SME sector and Human Resources Management led to the start in 2009 of cooperation projects in the areas of Energy Neutral Building and Offshore Wind Energy.

TNO is currently working in structural cooperation with fellow European RTOs on the following initiatives: Carbon Capture and Storage with Sintef (Norway) and IFP (France), Joint Institute for Innovation Policy with Joanneum/JIIP (Austria), VTT (Finland) and Tecnalia (Spain) and Holst Centre with IMEC (Belgium).

The role of TNO

After Philips TNO is the biggest Dutch participant in European research programmes. TNO thus makes a substantial contribution to the position of the Netherlands in the European research programmes. Also from a European perspective TNO has gained a visible place in the European knowledge arena. TNO and Fraunhofer were especially cited as hubs in major international

knowledge networks. In the seventh framework programme TNO is mainly active in the themes of ICT, Security, Transport and NMP (nanosciences, nanotechnology, materials and new process technology). With a success rate of 31% of submitted project proposals, TNO scores high compared to the European (19%) and Dutch (28%) averages.

It is increasingly necessary to be involved in the preparatory stages of European programmes by participating in European Technology Platforms (ETPs), public-private partnerships (PPPs), the European Institute of Innovation and Technology (EIT) and other (ad-hoc) initiatives. TNO has played a key role in the creation of the European programme for Security. To strengthen and improve this role TNO has permanent representation in Brussels. In 2008 TNO also set up with RTO partners from Austria, Finland and the Spain Joint Institute of Innovation Policy (JIIP) located in Brussels.

Intentions for 2011-2014

The themes and innovation areas selected by TNO have a strong European dimension, which will enable TNO to reinforce and extend its good position in the European framework programme, position itself in new European initiatives and facilitate structural cooperation among RTOs. In the recently established European Institute of Innovation and Technology (EIT) TNO was selected to participate in each of the three Knowledge and Innovation Communities (KICs) being launched by the EIT: climate change, sustainable energy and information and communication society.

- In the theme Defence, Security and Safety TNO has acquired a prominent place in the European Security programme, which offers good prospects to be a prominent European player in this field. TNO also takes initiatives of its own focusing on the development of a limited number of partnerships with organisations and companies from other EU countries. Via EU programmes and together with the European Defence Agency (EDA) TNO will look to establish a Defence theme in the eighth framework programme, a partnership for Human Factors inside EDA, cooperation for CD&E facilities in Europe and the establishment of Joint Programming activities for Security.
- In the theme Healthy Living TNO is mainly active in contract research outside the Netherlands. Many new possibilities will occur if the development continues to get health-related issues higher up on the European research and innovation agenda, as illustrated by the Dutch-led Joint Programming Initiative in the theme of Health. TNO wants to make a telling contribution in the elaboration of this.
- In the themes Energy and Built Environment TNO is active in European programmes, as in the establishment of a public-private partnership (PPP Efficient Buildings) and in the selected KICs of the EIT. TNO profiles itself in the areas Carbon Capture and Storage (CCS) and Energy Efficient Buildings. The cooperation in the field of CCS with IFP (France) and Sintef (Norway) must lay the basis for more thematic international cooperation among RTOs in the future.
- In the theme Built Environment TNO is firmly embedded in international associations (EuroGeoServeys). This fruitful cooperation

⁴⁵Also linked to the Strategy & Change initiative referred to in this Strategic Plan

with geological surveys within Europe will be continued in the coming years.

- For the technological component of the theme Mobility (safe and clean transport means) TNO is well connected in European programmes. Mobility issues are gaining more and more European attention as apparent from the Joint Programming Initiatives. Through active participation in ETPs TNO is working on further profiling in the area of reliable traffic systems.
- TNO's activities in the theme Industrial Innovation are well embedded in European partnerships thanks to many years of effort. TNO will try to ensure that in forthcoming European programmes the cooperation with industry, especially SMEs, is better facilitated. TNO has opted here for five areas: high-tech systems and materials, sustainable chemistry (oil and gas), food and flowers, advanced materials enabling and adaptive multi-sensor and control systems enabling. In the field of high-tech systems TNO has a vanguard position and will extend this through active involvement in the emergence of the PPP Factories of the Future. The theme Industrial Innovation also contains TNO's space related technology developments with continued embedding in the research programmes of ESA in the coming years. Application specific research – applications in telecommunication and Earth observation in the field of environment and energy will become more important. TNO's contribution will mainly come from the separate themes.

- The Information Society is a key theme for Europe. In the three innovation areas within this theme TNO works with foreign partners within EU projects (framework programmes and tenders) but TNO wants to extend its role as a European player. The establishment of an EIT KIC for the Information and Communication Society is a key incentive for international cooperation. TNO also wants to profile itself in the new PPP Future Internet, playing a management role in addition to project participation.

KNOWLEDGE PROTECTION AND POLICY CONCERNING INTELLECTUAL PROPERTY

Economic impact through innovations will be increasingly dependent on adequate knowledge protection in the international competitive arena. The patent is the strongest tool to protect intellectual property (IP). TNO also wants to optimise knowledge valorisation through patent protection and thus boost the economic impact. In the last four years TNO has submitted 528 premier depots for patent applications. Looking at 2007 for all the Dutch knowledge institutions together TNO stood top with 42% of all premier depots submitted.⁴⁶

In terms of other European knowledge institutions TNO stood fifth in 2007:

European RTOs ⁴⁷	PDs 2007
Fraunhofer	650
CEA	447
CNRS	210
IFP	159
TNO	158
VTT	100
SINTEF	37

Compared with multinationals all the Dutch knowledge institutions have a modest IP portfolio⁴⁸. The respective strategies differ, of course. Acknowledged IP positions contribute to the TNO knowledge profile and support the policy of being an attractive partner for cooperation in open innovation and participant

in innovative networks. A consistent IP policy makes TNO attractive to investors in start-ups and for research outsourcing by industry. The TNO IP policy is therefore based on making knowledge broadly available and keeping it usable.

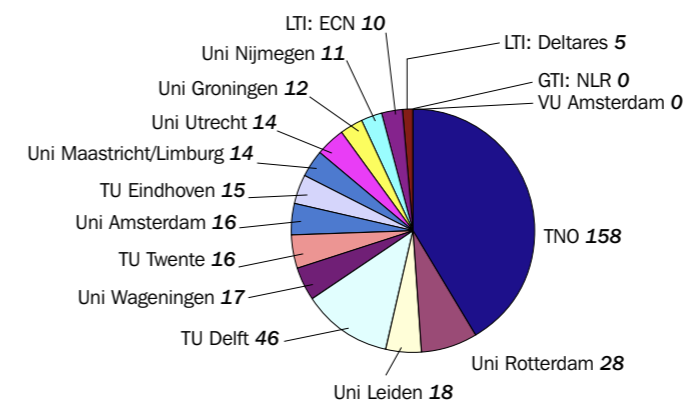
To strengthen the competitive strength of industry TNO's aim is to allow as many companies as possible to acquire exclusive rights to the IP portfolio, which creates a growing number of stakeholders in TNO's IP policy. Good communication to the market about the conditions and regulations is increasingly important. In consultation with EZ and SME stakeholder representatives action has been taken to improve communication about the IP policy and its transparency.

Specific regulations have been created, including the Small Business Innovation Research Programme (SBIR), to enable SMEs as a key target group to develop innovations more quickly and to acquire exclusive IP positions.

GOALS FOR 2011-2014

The IP policy will have to have even greater impact in the new strategy period. It is expected that the number of patent applications submitted each year will come to around 150 premier depots. Valorisation capacity efforts will be intensified with greater transparency and supply of the available IP, with the accent on accelerating the turnaround of IP protected innovations for the market.

REGISTERED PREMIER DEPOTS IN 2007



Source: organisations and public databanks involved

⁴⁶ The figures are based in part on public annual reports of the institutions and partly on patent publications acquired using Aureka that suggest the cited knowledge institutions submitted a total of 380 patent applications, 158 of which came from TNO.

⁴⁷ This concerns research institutions with the same focus on application geared research, and known to have a proactive policy to protect knowledge. The figures are also based on public sources: annual reports and/of patent publications acquired using Aureka.

⁴⁸ For example, Philips with 55,000 patents (HBR, November 2009, page 29).

TNO ORGANISATION

'The success of TNO will be measured by the actual difference TNO makes in projects with and for partners and customers.'

The ambitions of TNO for the coming strategy period cannot be achieved without an appropriate organisation form and culture, talented and motivated employees, and suitable financial resources. And TNO also wants to help make the world a better place through corporate social responsibility.

STEERING BY IMPACT

The high ambitions of TNO require an organisation form that optimally facilitates this aim and a culture that challenges its employees to innovate and cooperate. Organisation and culture change will go hand in hand in the coming years. To strengthen the societal and economic impact of the projects, these will have to be steered via the themes and innovation areas. For each innovation area there will be clear responsibility for both the knowledge development and market activities. This project-steered organisation enhances cooperation across the core areas and gives TNO even more opportunity to focus on complex multidisciplinary problems. The approach via themes also means that achieving the desired impact will also be steered along this line. The impact will be realised in the many projects TNO carries out for government and industry customers and the success will be measured by the actual difference TNO makes in projects with and for partners and customers. In assessing the overall impact on an innovation area, it is not just a matter of counting up the project impact, but also the extent to which TNO plays a visible, authoritative and connecting role in the (inter) national networks of the stakeholders and customers involved in that innovation area.

INCUBATOR AND SPRINGBOARD FOR TALENT

TNO: attractive employer for starters and experienced professionals

In recent years TNO has been able to strengthen its position as an attractive employer for starters in the employment market inside (and increasingly outside) the Netherlands and will continue along this route. The employment market proposition of TNO for starters is geared to social commitment, personal and professional development and innovation. The bar is high; the requirements we set for our professionals rise steadily. In addition to intrinsic excellence, commercial, project, leadership and cooperation, competencies are required. This calls for professionals that deal with complex dilemmas in their daily work with integrity and commitment. TNO offers a challenging working environment with demanding professional requirements and also scope for personalised professional-private balance, home and teleworking, supported by modern ICT facilities and a flexible package of working terms and conditions. Our operation with a focus on CSR and development cooperation offers starters attractive extras. Within TNO graduate starters undergo a Talent Development Programme, after which they can opt for one of the development lines and a starting job within one of the innovation areas. More experienced professionals help strengthen the different development profiles and boost our impact among customers. We focus increasingly on international intake.

The TNO ambitions appeal a lot to our employees and bring new challenges requiring top talent. To be able to offer a stimulating working environment is therefore a top priority for our knowledge economy.

Top talent is scarce. In some innovation areas TNO is already the most attractive employer for knowledge workers. TNO will be strengthening its recruitment and career policy for top talent, raising the recruitment bar. In addition to TNO employees as a source of talent for organisational goals, TNO is also expressly opting for a role as supplier of innovation talent to Dutch society for the coming strategy period. Former TNO people are particularly attractive employment candidates. Educated and an experience richer, these competent 'innovators' are ripe for the innovation areas the Netherlands needs in the coming time.

Knowledge workers scheme

Vice versa, researchers from industry make the step to TNO. This has been given an added dimension by the recession. In 2009 and 2010 TNO has housed 476 knowledge workers in the framework of the Knowledge Workers Scheme that has put these professionals, whose work at their companies has come under threat from the recession, into projects of national importance. In a second scheme TNO is participating in consortia in High-Tech Top Projects (HTTP), whereby 980 knowledge workers from companies are engaged. TNO is co-initiator of these schemes. While they are temporary, these schemes will certainly help to form, in the longer term, networks and cooperation among companies and public knowledge institutions.

‘Educated and an experience richer, these competent ‘innovators’ are ripe for the innovation areas the Netherlands needs in the coming time.’

FINANCIAL OUTLOOK

TNO’s financial policy is founded on a healthy operation based on generally acceptable economic principles: moderate growth of return, safeguarding the funding of the organisation, controlled cost-price development and investments that do not undermine the solvency and liquidity position of the organisation:

- The income of TNO comprises turnover from work performed, return above cost price in the turnover from assignments and Intellectual Property revenue.
- As an independent not-for-profit organisation moderate growth of return is essential to safeguard the continuity of the organisation. Positive results are used to improve the equity position of the organisation.
- Investments are of a general business nature and are not, in principle, higher than depreciation costs.
- TNO is conservatively funded with a very limited amount of loan equity. The solvency at the end of 2009 was around 45%. This manner of funding is necessary to safeguard the continuity of the organisation.

Based on an ongoing recovery of the economy, TNO is anticipating the following scenario:

- Overall income rise from 600 million euros in 2009 to 700 million in 2014.
- Government funding at the level of 2010.
- An income mix of a third demand-driven

programmes, a third competitive funding and a third market funding for contract research and consultancy (excluding income from new companies to be established by TNO). To achieve the desired level of competitive funding, the obligation to match amounts from the programmes from the government funding permanently assigned to TNO must be significantly reduced. In 2003 the Wijffels Committee advised the Cabinet of such.

- More recently the AWT and Health Research Council (RGO) urged the same. TNO also urges the Cabinet to take this recommendation on board by annulling the matching obligation or making separate funding available for this.
- A modest return of 3% of market income for reinvestment in the organisation.
- TNO Companies will grow in terms of income and return through the accelerated incorporation and sale of mature technologies from TNO and high-tech spin-offs. The returns will be reinvested in the organisation.

CORPORATE SOCIAL RESPONSIBILITY

Corporate social responsibility (CSR) is about sustainability: the balance between people, planet and profit. Corporate social responsibility and TNO are a marriage. Sustainability is not a separate theme in the research of TNO but is a key ‘driver’ in all the themes. Like innovations to reduce the ecological footprint of building and construction, safe and cleaner transport means, a clean climate-neutral energy supply, dealing with material scarcity and encouraging a healthy lifestyle. Since 2007 we have been tackling corporate social responsibility in a structural way, with our own programme for development cooperation. We also want to operate more sustainably with a focus on our employees and a better environment. For these

internal sustainability purposes we use the knowledge we have ourselves in house. Our ambition in all these steps is to play a prominent role in sustainability. To be accountable to CSR, in 2008 TNO published a separate social annual report for the first time along the lines of the Global Reporting Initiative. In the coming period TNO will include the social report component within its annual report.

A better environment starts at TNO

In corporate social responsibility a focus on the environment is key. TNO has identified its environmental impact and is working on improvements through a number of focal areas, like:

- Energy and buildings: Energy Performance Recommendations enables energy efficiency in TNO buildings by taking account of sustainability options in new building or major renovation. TNO invests, for instance, in geothermal heating to make the energy supply of its premises in Leiden more sustainable. In the coming strategy period sustainability will be a major factor in decisions on new lease contracts.
- Mobility: in the short term the possibilities for videoconferencing at TNO will be extended and a pilot will start up to offer alternative business travel options to the car by a combination of train, public transport, bicycle (perhaps in combination with bus or taxi). In the strategy period mobility management will be substantiated with concepts that suit ‘the new ways of working’ that reduce the number of business trips.
- Sustainable purchasing is important in making TNO more sustainable since the environment footprint of TNO is predominantly determined by what we purchase. Sustainable purchasing is now embedded in all TNO-wide

purchases whereby pre-set sustainability requirements are a key criterion for awarding the purchase tender. TNO will be purchasing green energy, FSC paper and sustainable coffee in the coming strategy period. TNO thus fully complies with the purchasing objectives as set out by the government.

DEVELOPMENT COOPERATION

Since 2007 TNO has (again) focused on innovations in developing countries with the conviction that technology and innovation can promote economic growth and prosperity. Innovation offers solutions to complex issues of water, food and nutrition, energy and climate, thus raising the level of welfare. Innovation also makes use of the societal and economic potential of the very poorest (4 billion people, mainly in Africa and Asia) if new technology can be locally produced and marketed. Key to these innovative products and services is that they are made affordable and available for the poorest. Ongoing initiatives have taught us that it is not easy to be successful in this market. It demands new knowledge, scope to experiment and intensive cooperation with new partners. From its principle of corporate social responsibility TNO has in recent years developed technological and social innovations and supervising innovation processes in developing countries. We will continue to do this in the future so as to contribute to the sustainable fight against poverty.

Cooperation among companies, local development organisations, local community leaders, authorities and knowledge institutions is necessary to define the demands and wishes of the target group, develop and test innovative solutions, and guarantee the innovation in the specific context. TNO has set up cooperation

links with various organisations, especially in India, Ghana, Zambia, Ethiopia, Uganda and the Netherlands. We supply knowledge and experience, both intrinsic and systematic, in 25 projects, focusing mainly on energy and climate, food and agriculture, ICT and monitoring. The projects are led by a team of twenty professionals from TNO: the TNO Flying Innovation Team. The activities of TNO are funded in part by TNO and in part by other partners from consortia.

PLANS FOR 2011-2014

In the coming strategy period TNO will continue its activities in developing countries. We are working on existing innovations to get these successfully embedded in the local market and on new problems and innovative solutions, entering into new partnerships and forming new consortia to this end. These activities are funded by TNO and the market. The return on investment is the socio-economic impact in developing countries, management development and employee commitment within TNO, access to the (partly future) growth in knowledge wealth in developing countries and emerging markets, which is not to be underestimated, and business development for the marketing of knowledge developed by TNO.

Rural electrification

In remote areas people use wood for cooking and light their houses with oil lamps or kerosene. This is expensive, is environmentally damaging and harmful to health. Use of biogas or a solar parabola provides a sustainable alternative for cooking. TNO has developed an application to generate electricity from the solar parabola or biogas fermenter. Apart from cooking, this energy can be used for lighting in the evenings or for charging batteries. A lab model is currently available. Consortia will be formed to introduce the innovation in India and Madagascar.

Farming in the Sahel

In the world’s arid areas people live off the crops they grow around their houses. This soil does not hold moisture well and growing is only possible through intensive irrigation. Water is scarce and expensive in these areas. TNO has found an innovative way for the soil to retain more moisture: rock wool, as we have in greenhouses in the Netherlands. In India we use this for mango trees and in Ethiopia for olive trees. The initial results with mangoes are very promising; 50% less water is needed for irrigation, which corresponds with 50% lower costs, 50% less time spent by farmers on irrigation, and 30% higher survival rate for young plants. We are currently working on the business case for the local production and distribution of rock wool.

FINALLY

What is needed to realise the intentions expressed in the Strategic Plan 2011-2014?

First and foremost, commitment from our business relations and, secondly and equally importantly, the commitment and input of our employees. If TNO wants to perform optimally in the social, scientific and economic international arenas that will dominate in the coming years, these are preconditions. But also our core values – integrity, independence, professionalism, social responsibility – combined with our market and customer focus, our readiness to cooperate and our focus on people, will remain essential. All of this will enable us to really innovate with impact and work on Innovation for Life.

CREDITS

Text, editing and production

TNO

Design

Barlock, The Hague

Photography

GettyImages

Hollandse Hoogte

Ilya van Marle, The Hague

TNO

TNO.NL

infodesk@tno.nl

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LIST OF ACRONYMS

ACTA	Academic Centre for Dentistry Amsterdam
BESI	BE Semiconductor Industries N.V.
BRIC	Brazil, Russia, India and China
BUZA	Ministry of Foreign Affairs
BZK	Ministry van Internal Affairs and Kingdom Relations
CBRN	Chemical, biological, radiological and nuclear
CBS	Central Bureau for Statistics
CCS	Carbon Capture and Storage
CD&E	Concept Development & Experimentation
CPB	Central Planning Bureau
CSR	Corporate Social Responsibility
CVZ	Association of Health Insurers
DEF	Ministry of Defence
DGI	Defence Related Industry
DIS	Defence Industry Strategy
DLO	Agricultural Research Department
EARTO	European Association of Research Technology Organisations
ECN	Energy Research Centre
EDA	European Defence Agency
EIT	European Institute of Innovation and Technology
ETD	European Technology Platform
EU	European Union
EZ	Ministry of Economic Affairs
FIN	Ministry of Finance
GHOR	Medical Assistance for Accidents and Disasters
HCSS	Hague Centre for Strategic Studies
ICMS	Civil-Military Cooperation
ICT	Information and Communication Technology
IEA	International Energy Agency
ITS	Intelligent Transport Systems
JGZ	Healthcare for children and young people
JUS	Ministry of Justice
KaVoT	Knowledge as Capacity over the Themes
KIC	Knowledge and Innovation Communities
LNV	Ministry of Agriculture, Nature and Food Quality
LTI	Large Technology Institute
MIRT	Multi-annual programme for Infrastructure, Space and Transport
MOD	Ministry of Defence
NATO	North Atlantic Treaty Organisation
NBC	Nuclear Biological Chemical
NCTb	National Anti-terrorism Unit
NGO	Non-Governmental Organisation
NLDA	Dutch Defence Academy
OCW	Ministry of Education, Culture and Science
OECD	Organisation for Economics Cooperation and Development
OEM	Original Equipment Manufacturer
OODA	Observe, orient, decide and act
R&D	Research & Development
RGO	Health Research Council
RIVM	National Institute for Public Health and the Environment
RTO	Research and Technology Organisation
SBIR	Small Business Innovation Research Programme
SDU	Staatsdrukkerij and Uitgeverij
SIA	Innovation Alliance Association
SIA	Social Innovation Agenda
SKA	Strategic Knowledge Agenda
SME	Small and Medium-sized Enterprises
SZW	Ministry of Social Affairs and Employment
Ti	Food and Nutrition Top Institute Food
Ti	Pharma Top Institute Pharma
US	United States
VenW	Ministry of Transport, Public Works and Water Management
VROM	Ministry of Housing, Spacial Planning and the Environment
VWS	Ministry of Health, Welfare and Sport

>> THE IMPACT OF TNO

We create innovative solutions focused on the future of our society. A future in which the sustainability of prosperity and welfare are safeguarded. And in which industry has and retains a strong level of competitive strength. For years we have been making significant contributions in the following fields.

1. Reduction of harmful airborne emissions

Active in reducing CO₂ and other emission components such as industrial noise and vehicle exhaust emissions. Advising EU on vehicle categories, determining viable maximum future emission and environmental zones in cities are tangible examples of this. Active role in developing and monitoring methods to capture, transport and store (subsurface) CO₂. TNO developed Urban Strategy, a unique integration of simulation tools able to make real-time and visual liveability analyses of the urban environment.

2. Observation systems

Since the 1930s we have been at the heart of military radar technology and, more recently, in civil applications for security. By linking various sophisticated observation systems through smart image and information processing, we boost the performance.

3. High-tech instrumentation

An electron microscope co-developed by TNO in 1944 was so good that it gave Philips a flying start in this field after the war. Now TNO focuses more on tools for ultraprecise lithography for chip production (ASML) and is involved in the emergence of integrated analysis systems for laboratories and healthcare. Scientific tools for observation and navigation equipment for the international space industry.

4. Traffic safety

Since the 1960s active in improving the safety of road users. The instrumented crash-test dummy and the MADYMO software to calculate the forces exerted on the vehicle and its occupants in the event of a collision are both TNO inventions. After decades of refinement, they are still the world standard for passive safety. In active safety TNO has unique methods to develop intelligent

vehicle systems. In the testing of seatbelts, helmets, airbags, etc. attention has shifted in recent years to the development of even better alternatives and better test procedures. Together with Euro NCAP, TNO is now also working as an independent party on pedestrian and cyclist safety along with the corresponding protocols and tests.

5. Healthcare for children and young people

TNO has contributed to the health of children and young people for many years, starting with training paediatricians. Recommendations in the 1950s to add fluoride to drinking water led to a significant reduction in caries and recommendations for young parents helped cut back cot deaths in the Netherlands between 1985 and 2006 from 200 to 11 a year. Perinatal care is another focal area for TNO that is intended not only to reduce the incidence of cot deaths but also to improve care for premature babies. TNO is closely involved in the governmental vaccination programme.

6. Alternatives for animal testing

TNO has taken it upon itself for many years to help develop and use alternatives for animal testing, the so-called three Rs: Replacement, Reduction, Refinement. And in the 1980s TNO's alternative for the testing of irritants in the eyes of rabbits was acknowledged by the OESO as a fully-fledged alternative. For the Netherlands that meant no distress for 4,500 rabbits. For 20 years a method was used in which a validated TNO in-vitro dog model can test the digestion and nutritional value of dog food. TNO took this further and built a similar model for the human digestive tract. A recent acquisition of the necessary technology to measure the behaviour of prospective medicines in the human body means that the need for laboratory animals for (pre-clinical) research will decline drastically.

7. CBRN protection

Since World War II, TNO has supported Defence in the protection against chemical and, later, biological, radiological and nuclear weapons. World-class knowledge in detection, identification and protection. Due in part to

this, the OPCW is located in the Netherlands. A good example is consultation by the Japanese authorities asking TNO to determine the substance used in the 1995 gas attack in the Tokyo subway. TNO is prominent in the world when it comes to its portable detection and identification equipment and distribution models that can quickly assess risk and help determine the appropriate protection measures.

8. Geological Survey of the Netherlands

The Geological Survey of the Netherlands (GSN) of TNO is the central geoscientific information and research centre of the Netherlands for the sustainable management and use of the subsurface and subsurface minerals found there. The statutory task is to make the geological knowledge on the subsurface accessible. The knowledge is online and available realtime for policymakers as well as for anyone concerned with the subsurface. From contractors to companies for environmental advice and cable-laying. But also for the general public. The GSN generates all kinds of publications, like maps and books, as well as popular publications.

9. Optimisation of digital infrastructure

The digital revolution and the position of the Netherlands as a country with a very high coverage of broadband connections would not have been possible without the knowledge of TNO to keep boosting the capacity of phone lines and cable for new services and improved quality for customers. The importance of mobile datatraffic is growing. Together with KPN and Ericsson TNO enabled the successful introduction of UMTS. Complex digital data processing is just around the corner in recent projects such as the IJkdijk, where sensors and digital modelling that analyse the failure factors for dike breach will be made ready for use in the rest of the Dutch delta.

10. Healthy and vital employees on the work floor

Along with the CBS, TNO has been keeping a finger on the pulse of the working Netherlands. This monitoring provides insight into trends and health aspects on the work floor. These are separated into

sub- and detailed analyses whereby the risk factors can be identified and then are tackled using suitable policy. The result is that people remain in work longer and healthier. Recently a measuring tool was developed for the diagnosis, assessment and wage value for people at the periphery of the employment market. This is such a success that the independent TNO company 'Dariuz' now advisees 30% of the social services.

11. Valorisation

Societal and economic impact by opening up knowledge in the form of patents or own companies. TNO knowledge does not remain on the shelf but gets used. The successes in the SBIR scheme are an example of this. Compared to all the knowledge institutions in the Netherlands together, TNO has the largest contribution of new protected rights. During the recent publicly disclosed reference year 2007 TNO's share was an estimated 40% of all premier depots submitted by all the knowledge institutions and universities. Since 1986 TNO has privatised corporate entities. These companies are part of the private limited holding TNO Companies BV and contribute to the development of high-tech, innovative Dutch SMEs. In the past 10 years 95 new companies have been established and 55 companies disposed of. To date no company has gone bankrupt. The total income of TNO Companies BV and the companies already disposed of comes to around 200 million euros. The size of this valorisation is greater than the valorisation of the holdings of all the Dutch universities together.

12. Knowledge transfer

TNO is very active especially in bringing SMEs up to date on the latest developments in their field. This occurs mainly in cooperation with (local) industry and professional associations. TNO invests in giving a broad public insight into its work, by happily cooperating with public media requests as well as with, for example, the 2007 publication 'Snap jij het, ik wel' (Understand it? Well, I do), a cheerful book that answers questions from children about the world around them. TNO also recently worked on the School Atlas of the Dutch subsurface.

