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A Research Agenda for the Dutch Mobility System, Energy System and Built Environment 2040

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Authors: Dr. J. van der Vlies jaap.vandervlies@tno.nl
Drs. G.G.C. Mulder guus.mulder@tno.nl

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Purpose

Scenario forecasts for the Dutch mobility system, energy system and built environment in 2040 were performed to investigate which knowledge TNO should develop to support and stimulate future innovation in these fields. Three scenario studies were conducted to investigate the Dutch built environment, the Dutch energy system and the Dutch mobility system. The results serve to strengthen the TNO strategy statement.

Identifying Dutch Research Priorities for Future Mobility, Energy and Built Environment

The *Netherlands Organisation for Applied Scientific Research TNO* is an independent research organisation whose expertise and research make an important contribution to the competitiveness of companies and organisations, to the economy and to the quality of society as a whole. Its activities are split into seven thematic domains: healthy living; industrial innovation; defence, safety and security; energy; transport and mobility; built environment and information society.

TNO needs to update its strategy every four years to announce which societal issues it will address in its next strategy period and how it will apply the funds that are administered by the Dutch government.

TNO used scenario planning in order to test its strategy against multiple possible futures and formulate a strategy that is robust in light of future developments.

Creating a Shared Vision

The objective of the scenario study is threefold:

1) to find what knowledge should be developed to deal with future challenges,
2) to test the TNO strategy against future scenarios,
3) to identify the most important factors influencing the development of technologies in mobility, energy and the built environment and
4) to create a shared vision of future development amongst the participants.

Scenario Method

For the future forecast, TNO applied a scenario method that is based on the original work of Kees van der Heijden for Shell (Heijden, 1996). For each of the three subjects, a separate study was performed based on a series of three workshops. In these workshops, the participants identified the main uncertainties in the future developments in the respective fields. Subsequently, these fields were clustered and scored for importance and level of uncertainty. Based on the two most important/uncertain uncertainties, the participants developed four scenarios to describe the possible future outcomes.

In the scenario process, an average of 25 TNO specialists per subject participated in the scenario develop-

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ment process. Selection of participants was based on coverage of all relevant expertise within the subject area. Furthermore, participants were selected for their ability to overview developments in the entire field.

Specialists on key (emergent) technologies, finance, economy, policy, rules and regulations, and international relations participated.

Clusters of Uncertainties

In the first workshop, the participants were asked to name the most uncertain factors that would determine the future developments in energy, mobility and the built environment. The results were clustered into 6-15 clusters of uncertainties. Which clusters of uncertainties were most influential and uncertain was determined by discussion and vote. The main uncertainties are briefly outlined below:

Governmental control refers to what extent the Dutch government either applies rules and regulations to steer developments or focuses on creating a level playing field and leaving it up to market forces to deal with societal challenges.

International cooperation refers to what extent governments set common goals and deploy shared instruments (such as CO_2 credits) at the European or a global level, or make decisions limited to the national level only.

Economic growth refers to the level of economic prosperity. The optimistic scenarios consider an improvement of the current economic situation (0.5% growth of GDP) and the pessimistic scenarios economic stagnation.

Geographical spread of economic activity refers to the degree to which economic development is mainly situated in dense urban areas (large companies in cities) or is more dispersed (smaller companies throughout the country).

Individualisation refers to the degree to which people focus on fulfilling their individual needs versus tackling problems and sharing benefits collectively.

Risk aversion refers to the degree to which people are willing to try new technologies and ways of living, show a readiness to invest and create, or seek to maintain the current status quo.

For each subject, energy, mobility and the built environment, the project identified two major uncertainties along these lines. These uncertainties resulted in the following dimensions for the three scenarios:

Mobility – Strong governmental control vs. a market-driven development and an individualised society vs. a collective society.

Energy – Governmental control vs. a market-driven development and lack of international cooperation vs. strong international cooperation.

Built environment – An individualised, risk-prone society vs. a collective, risk-averse society, and widespread, low economic growth vs. concentrated, high economic growth.

Within the single projects, the experts developed two to four scenarios in group discussions. The scenarios are based on the two uncertainties that are considered most uncertain/influential in the respective field. In the following sections, we will discuss the results of the scenario studies for the three subjects separately. First, the scenarios are described, then aspects that are relevant to all different scenarios or vary between scenarios are discussed, and finally a draft technological research agenda is compiled.

Mobility: Four Scenarios of Governmental Control and Societal Involvement

Scenario I: Driven by individualism, the government limits its activities to protecting the rights of its citizens. It facilitates market activities by providing a stable environment for economic growth. The scenario shows high economic competition in a European home-market.

Scenario II: The government is strict, yet righteous. It uses its influence by issuing laws and setting norms and standards that are based on firm societal support – after all, these are made in the public interest. Laws and regulations are firmly maintained.

Scenario III: The government has a minor role; market forces are trusted upon to ensure innovation. This way people can vote with their wallets.

Scenario IV: The influence of the government on societal issues is limited. Society is too complex and interests too diverse to find common ground for governmental action. Collective values are shared by joining communities that share one's values and warrant one's interest.

Mobility in the Four Scenarios

The developments in the mobility system are very uncertain. All scenarios are equally conceivable. Therefore, a strategy should be developed that is able to cope with different future developments.

Future developments in transport are highly dependent on the available infrastructure, vehicle and fuel developments, and the effect transport has on the environment and society.

All scenarios point to road-based mobility. Congestion will be a lasting problem. External effects are tackled by

technological solutions. Biofuels, hydrogen and electricity will play a more important role in mobility.

Scenario-specific findings

- Some scenarios include a European network of high-speed rail connections.
- The solutions to congestion are scenario-specific and involve optimisation of infrastructure usage, transport services or smart logistics.
- The solutions to externalities are scenario-specific as well, ranging from efficient drive systems to capture of pollutants.
- Transport and travel volume depend on price and vary by price accordingly. The price may increase due to the internalisation of external costs and high fuel prices or drop because of more fuel-efficient technologies.
- The degree to which biofuels, hydrogen and electricity will play a more important role in mobility depends on governmental regulations (supporting laws, tax incentives etc.) and investments in necessary infrastructure.

In order to tackle the aspects identified in the scenarios, knowledge is needed in the following areas:

- energy efficient vehicles;
- alternative drive systems;
- IT systems for managing mobility issues and traffic; the latter involving communication between vehicles for enhanced safety and flow;
- impact assessment of infrastructure;
- robust infrastructure;
- reliability of infrastructure.

Energy: Two Scenarios of Governmental Control and International Cooperation

Scenario I: Countries form a collective to face the global challenges, such as climate change. The national government firmly takes the initiative to bring about (sustainable) change.

Scenario II: Governments and international organisations are suspicious of each other. Countries compete for available energy sources. The national government is reactive and aims at facilitating change processes initiated by industries and NGOs.

Energy in the Two Scenarios

The entire built environment will be transformed to become energy neutral. More energy production will take place locally with solar (photo voltaic solar panels and heating), aquifer thermal energy storage (ATES) and geothermic energy. While fossil fuels will remain an important source of energy, biofuels and hydrogen will only play a small role in the Dutch energy system.

Scenario-specific findings

- The degree to which societal costs are included in the price of fossil fuels is largely dependent on the degree of governmental control.
- The choice of climate change mitigation or adaptation is largely dependent on the degree of governmental control and international cooperation.
- The degree to which local energy systems are developed, collectively or independently, is largely dependent on the degree of governmental control.
- The emergence of an international smart grid and large-scale energy storage capacity is largely dependent on the degree of international cooperation.
- The large-scale deployment of carbon capture and storage is largely dependent on the degree of international cooperation.
- The substitution of oil by coal or gas is largely dependent on the degree of governmental control.

In order to tackle the aspects identified in the scenarios, knowledge is needed in the following areas:

- ways to include new technology in existing products;
- insulation;
- separate transport systems inside and outside of cities;
- preparing the electricity network for larger fluctuations in supply and demand;
- large-scale storage of electricity and heat;
- small-scale storage of electricity and heat;
- how to deal with the interaction between local networks, national networks and international networks for electricity, gas, heat and CO_2;
- implementation of renewable energy systems;
- mass production of renewable energy systems.

Built Environment: Four Scenarios of Collectiveness and Economic Prosperity

Scenario I: The economy is a self-service economy. It is in a recession, especially in the cities, resulting in more economic activity in the outside regions. Small government has prevailed.

Scenario II: People strive for individual gain and are willing to take risks. The Netherlands is a flourishing and innovative country. The economic growth is concentrated around the Randstad and a limited number of other cities.

Scenario III: People are more dependent on each other because of the fragile economic situation.

Scenario IV: Economic prosperity leads to a collective appreciation of well-being.

Built Environment in the Four Scenarios

End consumers will have more influence on the building process. Buildings will have to become more adaptable to the different phases of life and individual needs. Elderly people will become a more important target group.

Scenario-specific findings

- Dense urban environments and intensive land use are themes that are important in both scenarios, with economic activity concentrated in the Randstad area.

In order to tackle the aspects identified in the scenarios, knowledge is needed in the following areas:

- ways to increase flexibility in the use of buildings;
- conceptual building methods;
- re-use of building materials;
- construction, traffic, fire and individual safety;
- ways to become climate proof;
- closure of material cycles (urban mining);
- virtual building;
- technologies for local energy generation and storage;
- the effects of climate change;
- intensive land use.

Developing Systemic Knowledge

For all three subjects, we found that the development of systemic knowledge is important to successfully implement technological innovations. In this respect, knowledge is needed about

- ways to implement existing innovative technologies;
- ways to improve urban environments;
- the relation between a market-driven society and spatial planning;
- different ways to structure the value chain of the building industry;
- the relation between the physical environment and behaviour;
- the structure, volume and place of economic development.

Sources and References

Heijden (2005): Scenarios – The Art of Strategic Conversation, second edition (first edition 1996), John Wiley & Sons, West Sussex.